ERIA-DP-2013-26

ERIA Discussion Paper Series

Who Disseminates Technology to Whom, How, and Why: Evidence from Buyer-Seller Business Networks[*]

Tomohiro MACHIKITA[†]
Institute of Developing Economies and Stanford University

Yasushi UEKI[‡]
Institute of Developing Economies

November 2013

Abstract: *This paper investigates the relationship between firm-level upgrading and buyer-seller business networks in order to better understand how and to whom technology transfer occurs. Using firm's self-reported buyer and supplier network data from business–to–business (B2B) markets in Southeast Asia, this paper finds the following results: (1) Firms are more likely to achieve product and process innovation if they invest in in-house R&D and transfer technology from their production partners; (2) product and process innovation varies considerably across different types of buyers and suppliers; (3) negative impacts of local suppliers suggest the importance of input quality for product and process innovation; and (4) large differences in product and process innovations among firms with similar buyers and suppliers can be explained by differences in embodied technology transfer even within narrowly defined production partners' ownership. Data from technology transfer in buyer-seller business networks provide the basis for detecting the key drivers of industrial upgrading in the context of B2B markets in emerging economies.*

Keywords: embodied technology transfer; linked manufacturer–supplier analysis.
JEL classification: O12, O14, O32, L14, F14

---

[*] This paper benefitted from conversations and discussions with Yuji Akematsu, Saraswathy Beena, Anthony D'Costa, Christian Fons-Rosen, Masa Fujita, Kazunobu Hayakawa, Ponciano S. Intal, Jr., Patarapong Intarakumnerd, Ikumo Isono, Fuku Kimura, Archanun Kohpaiboon, Ari Kokko, Takashi Kurosaki, Kristina McElheran, Sunil Mani, Yukichi Mano, Dana Minbaeva, Tsutomu Miyagawa, Kentaro Nakajima, Donny Narjoko, Ayako Obashi, Keijiro Otsuka, Sothea Oum, Hideo Owan, Rajah Rasiah, Tetsushi Sonobe, Yasu Sawada, Henry Sauermann, Kensuke Teshima, Masatsugu Tsuji, Tsuyoshi Tsuru, So Umezaki, and Fernando Vargas. This project could not have been carried out without cooperation from the Indonesian Institute of Sciences (LIPI) of Indonesia, the Philippine Institute for Development Studies (PIDS), the Sirindhorn International Institute of Technology (SIIT), Thammasat University of Thailand, and the Institute for Industry Policy and Strategy (IPSI), Ministry of Industry and Trade of Vietnam. Since this paper was written while Machikita stayed in the Asia Research Centre, Department of International Economics and Management, Copenhagen Business School, we express our appreciation for the research environment and hospitality of the school. We are solely responsible for any errors that may remain.

[†] Address: Visiting Scholar of Department of Economics, Stanford University, Room 349, Landau Economics Building, Serra Mall 579, Stanford CA, 94305-6027 and Institute of Developing Economies (IDE-JETRO), Japan. Email: tomohiro_machikita@ide.go.jp.

[‡] Interdisciplinary Studies Center, Institute of Developing Economies (IDE-JETRO), 3-2-2 Wakaba, Mihama, Chiba 261-8545, Japan. E-mail: yasushi_ueki@ide.go.jp.

1. Introduction

Firms in developing or emerging economies have been forced to run after two hares and catch both without fail. They must cut prices to the bone while simultaneously offering newer and better quality products and services. Flexibility and speed are key elements in a firm's ability to survive in competitive markets. In this situation, inter-firm collaborations have become increasingly important in the promotion of innovation. However, factors encouraging firms to enter into collaborations with their buyers or suppliers have not been investigated sufficiently for developing or emerging economies, especially in Southeast Asia. That region has many types of fragmented production chains, from food products and textile to machinery and automobiles. This paper investigates the relationship between firm-level upgrading and buyer-seller networks in the region. Our study concerns three main elements: fragmentation of production processes, technology transfer, and innovation capability. The next section will give a review of the current literature on these elements. There have been many important empirical studies on the three individual elements, but there has been little research combining them. The integration of these three elements is necessary to gain a deeper understanding of the impact that technology transfer and innovation capability within and across production chains has on innovation in Southeast Asia.

As discussed in the next section, recent literature on international economics, industrial development, organizational economics, and management has paid a great deal of attention to global supply. However, there are several unsolved research questions regarding the mechanism by which innovation occurs in inter-firm collaborations, especially the question of to whom and how technology is transferred. The intangible nature of knowledge and limited data availability have prevented researchers from tackling these questions. We use several lines of research in order to combine the concepts of production chains with those of technology transfer and innovation capability. This helps us to acquire empirical evidence that can be used to make practical policy decisions. To develop solid evidence, we construct a unique and novel dataset using a survey conducted in the ASEAN countries of Indonesia, the Philippines, Thailand, and Vietnam. This survey of manufacturers puts a special emphasis on buyer-manufacturer-supplier relationships, considering the positive influence of supplier development and supply chain collaboration in firm-level supply chain performance (see Ueki, 2013 for recent evidence from Thailand) and the importance of manufacturing industries in the survey regions.

The conceptual framework of this paper is simple. Our main assumption is that embodied technology transfers within fragmented production chains through inter-firm trades. The first hypothesis based on this assumption is that firm-level variation in transferred technology can explain the variation in firm-level organizational and technological changes in areas such as product and process innovation. In addition, we assume that input quality and output quality are closely related, especially for firms in emerging economies where managerial skill is likely to be low. From this, we can derive our second hypothesis, which states that sources of inputs can have an impact on the choice of firm-level organizational and technological changes. Our study seeks to test these hypotheses.

To be precise, we seek to extend the empirical framework under which Gorodnichenko, *et al.* (2010), Lee (2011), and Machikita and Ueki (2011a, 2011b, 2012a, 2012b, and 2013) analyzed the impact of embodied technology transfer on product and process innovation conditioning and the characteristics of three-party relationships. We ask manufacturing establishments about their achievements in product and process innovation, as well as their sources for technology and information. In addition, respondents are asked to report details on their main downstream buyer and upstream supplier. By doing so, we can record data on business networks that link ASEAN firms to global production networks, as well as illustrate chain reactions among the parties and inter-firm learning and technology transfer within the buyer-supplier relationship.

This paper obtains four results including not found in the previous literature. First, firms are likely to achieve product and process innovation if they invest in in-house R&D and transfer technology from production partners. Second, product and process innovation varies considerably across different types of upstream or downstream business networks. Third, the negative impact of local suppliers suggests the importance of input quality for product and process innovation. Finally, large differences in product and process innovation among firms with similar business networks can be explained by differences in embodied technology transfer. Evidence on technology transfer in buyer-seller business network provides the basis for detecting the key drivers of industrial upgrading in the context of business–to–business (B2B) markets in emerging economies.

The main contribution of this paper is as following twofolds. First, this paper contributes to the empirical matching literature asking who match with whom, how, and why. Since understanding the working mechanism of firm–to–firm trade has been one of most important questions in international economics and industrial development, the evidence of this paper is also useful for understanding the relationship between B2B matching and incoming/ outgoing knowledge. Second, this paper also contributes to the empirical study of the strategic role of embodied technology transfers within a production chain in achieving firm-level innovation located in emerging economies. This paper shows the extent to which channels of technology transfers from production partners enable firms to achieve product and process innovation. Detailed and unique firm-level information regarding the chosen channels of technology transfers from production partners allows us to empirically study differences in firm's strategic use of incoming technologies for product and process innovation. Furthermore, firm-level product and process innovations in emerging economy are also a good proxy for engaging in global production chains. This paper addresses the innovation and firm-to-firm trade nexus through transferred technologies within a production chain.

The next section provides a brief review of the literature. Section 3 presents a dataset from Southeast Asia and summary statistics of product and process innovation and channels of technology transfer. Section 4 provides a first look at the relationship between innovation and channels for embodied technology transfer. Section 5 shows empirical results. Section 6 concludes with a discussion and a summary of results.

2. A Brief Review of Literature

2.1. Fragmentation of Production Networks

Inter-firm collaborations are attracting ever greater attention in the field of international economics. This is in addition to the study of fragmented production networks, particularly those of East and Southeast Asia, two key regions in global supply chains. Kimura and Ando (2003 and 2005), Ando and Kimura (2005), Kimura (2006 and 2009), Kimura, *et al.*, (2007), Kimura and Obashi (2010 and 2011), and Obashi (2009, 2010a, and 2010b) search for patterns of economic fragmentation and vertical integration in assembly and input production in East Asia. As Antras and Rossi-Hansberg (2009) summarizes, Jones and Kierzkowski (1990) provides a theoretical framework on observed fragmentation, explaining the balance between the gains from fragmentation, when the economic advantages of cross-border production are utilized, and the costs of disintegration from cross-border production. Hummels, *et al.*, (2001), Fally (2012), and Johnson and Noguera (2012a, 2012b, and 2012c) provides the seminal evidences of production fragmentation across borders. Most recently, to explain the sequential nature of global production, Costinot, *et al.,* (2013) and Antras and Chor (2013) have developed theoretical frameworks based on matching–sorting and allocation of control rights, respectively. These fragmentation theories form a theoretical foundation for this paper to combine firm heterogeneity in trade with organizational choice on who specializes in what and how.

2.2. Technology Transfer within a Chain

The growing fragmentation of production networks allows firms to achieve innovation through linkages, collaborations and technology transfer between buyer and supplier. Our work explores technology transfer from multinationals to local enterprises in developing economies. Technology transfer research has explored how upstream local suppliers can achieve productivity spillovers from downstream multinational enterprises; theories about this have been tested by Aitken and Harrison (1999), Javorcik (2004), and Blalock and Gertler (2008). It is expected that fragmentation would increase opportunities for local firms in developing countries to benefit from technology transfer. However, local firms in developing countries can experience difficulty participating in production networks dominated by multinational enterprises. It is important to detect the factors that bring together the firms in a supply chain and promote collaboration among them.

There are several factors which can enable local firms to participate in these types of networks. Organizational characteristics and intangible assets could increase heterogeneity in terms of the firm's internationalization and allow entry into global supply chains as discussed in Bloom and Van Reenen (2007) and Atalay, *et al.* (2013). Jordaan (2011) finds that type of ownership may affect the dynamics of local linkages in Mexico, where suppliers of foreign direct investment (FDI) firms have improved their production processes. Most recently, Ueki (2013) discusses how supplier evaluation and audits stimulate the formation of supply chain collaboration in the Thai automotive sector, while competitive pressure accomplishes this in the Thai electronic sector.

However, further investigation into the factors influencing the creation of supply chain collaborations is essential. In particular, specific managerial practices rather than the characteristics of firms should be emphasized to derive more concrete policy implications for developing economies. Technology transfer is an indispensable process by which developing countries can foster and enhance their fundamental industrial capabilities. While industrial policy in developing countries has emphasized the importance of technology transfer, much of the relevant policy has been discussed without a thorough understanding of the mechanisms behind such transfer.

2.3. Innovation Capacity

The buyer-supplier relationship is a firm-specific mechanism that complements market-based transactions. Firm-level perspectives on innovation are indispensable to our understanding of technology transfer and adaptations to the new technology-based environment in developing countries. Management literature can provide policy implications because it has covered firm-level organization that can spur learning, capability building, and innovation. This literature has discussed the antecedents of innovation capability, which is needed to successfully collaborate along international supply chains. Along with several other influential studies, Cohen and Levinthal (1990) conceptualized absorptive capacity, defined as the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends. According to their discussion, this is critical to a firm's innovative capabilities and is affected by the capabilities of its individual members, the diversity of expertise within an organization, and the firm's level of prior related knowledge. Zahra and George (2002) redefined absorptive capacity as a set of organizational routines and strategic processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability. Even though the literature has proposed various innovative and absorptive capacity constructs, since the Cohen and Levinthal (1990) work empirical studies have focused on investments in R&D that contribute to absorptive capacity. However, R&D alone cannot fully account for the variety of factors that may influence an organization's absorptive capacity, including both internal and external organizational knowledge and the management practices that integrate such knowledge (Tsuji, *et al.*, 2013).

One of the causes of the difficulty in measuring innovation capacity is the invisibility of that capacity and the knowledge flows that create it. Previous studies have focused on observable potential channels of technology transfer from external organizations as proxies for knowledge flow. These proxies included things such as trade that promotes learning through exporting and importing, FDIs that generate knowledge spillover (Hayakawa, *et al.*, 2012), and patent citation (Jaffe, *et al.*, 1993; Almeida and Kogut, 1999). Recent studies emphasize labor mobility or migration (Almeida and Kogut, 1999; Hiller, 2013; Hunt and Gauthier-Loiselle, 2010) and business trips (Andersen and Dalgaard, 2011; Dowrick and Tani, 2011) because face-to-face interactions can be cost-effective in the transfer of intangible and non-codifiable knowledge. The other limitation in empirical studies is the limited availability of data on the external organizations that affect a focal firm's capability through their shared interactions. Because of the intangibility and non-codifiability of such knowledge, non-market mechanisms would be preferred by the focal firm in selecting its partners and how it collaborates with them. Therefore, non-price signals or data on the attributes of external partner organizations and relation-specific information are useful for investigating the matching mechanism.

3. The Firm's Self-reported Buyer and Supplier Data

3.1. Survey

The data used in this paper was constructed from the responses to a questionnaire survey conducted in four ASEAN countries. The sample population is restricted to manufacturing sector firms currently operating in the main industrial districts in four ASEAN countries—the Jabodetabek area, including Jakarta, Bogor, Depok, Tangerang, and Bekasi, in Indonesia; Calabarzon, comprising Cavite, Laguna, Batangas, Rizal, and Quezon, in the Philippines; the Greater Bangkok area in Thailand; and the Hanoi and Ho Chi Minh City areas in Vietnam. Our questionnaire comprises four parts. The first part asks the respondent establishment's basic characteristics, such as the year of establishment, ownership type (local, multinational enterprise (MNE), or joint venture (JV)), and size (in terms of employees and assets). The second part includes questions on the firm's achievements in terms of product and process improvements as well as the sources of the technologies and information used by the establishment to conduct innovative activities. The third part attempts to obtain information on the respondents' main buyer and supplier, while the fourth part seeks to capture the geographic extent of the respondents' production network and its evolution. The unique feature and advantage of this survey are in the third part, where respondents are asked about their main buyer and supplier and the management practices performed jointly with these upstream and downstream production partners. This enables us to establish a dataset linking a manufacturer (focal establishment) with its downstream buyer and upstream supplier.

The survey was begun in November 2012. Responses were collected by mail, phone interviews, and face-to-face interviews. Finally, a total of 979 establishments agreed to participate in the survey: 157 establishments in Indonesia (16% of the total); 218 in the Philippines (22%); 284 in Thailand (29%); and 320 in Vietnam (33%). From the 979 raw observations, we were able to use 921 observations for this paper to answer questions on ownership type and size. As shown in Table 1, 55% of the responded establishments are 100% locally owned (hereafter, local), and 53% of them are small-to-medium enterprises (SMEs) that hire fewer than 200 employees. The observations for Vietnam are biased to MNE/JV and large establishments.

This section discusses the descriptive statistics calculated from the dataset in order to understand how and to whom technology is transferred. The data will show process and product improvements achieved by the respondent establishments in 2011 and 2012. We also summarize the sources of technology and the technology transfer channels respondents utilized to achieve improvements. These simple observations provide fundamental information that will be useful for performing regression analyses.

Table 1: The Sample

	N	%	Local	SME
Jabodetabek	157	17%	68%	67%
CALABARZON	213	23%	48%	73%
Bangkok, Thailand	231	25%	75%	59%
Hanoi, HCM	320	35%	38%	29%
Total	921	100%	55%	53%

Note: Local is a 100% locally owned respondent. SME defined establishment hire less than 200 employees.

Source: Survey 2012.

3.2. Product and Process Innovations

We defined the following four types of product improvements: (1) packaging or appearance redesign; (2) significant improvement in existing products; (3) new products based on existing technologies; and (4) new products based on new technologies. Respondents were asked whether they had made any such improvements during the period of 2011–2012. Based on these questions, we also defined a variable for stage of product development, a technological ladder ranging from the lowest level of packaging or appearance redesign to the top level of a new product based on new technologies. The variable takes a value of 0 if the respondent did not achieve any type of product improvement and 4 if they introduced a new product based on new technologies.

We also asked about various types of process improvements. For the analysis presented in this paper, we use the following 10 indicators of process improvement: (1) decrease in production of defective products; (2) decrease in defective products shipped; (3) reduced raw materials and energy usage; (4) reduced labor input; (5) reduced lead time to introduce a new product; (6) reduced unscheduled line stoppage; (7) reduced worker injuries or plant accidents; (8) reduced delivery delay; (9) reduced prices of main products; (10) reduced variation in product quality. All of these were coded as dummy variables and summed to define the number of process improvements by type, ranging from 0 to 10. Because there may be trade-offs between certain types of process improvements (for example, stricter quality control may also increase costs), we assume that an establishment which achieves a greater variety of process improvements has higher innovation capacity.

Table 2 shows that 30.6% of respondents achieved packaging or appearance redesign; 33.7% made significant improvements in existing products; 25.7% introduced a new product based on existing technologies; 15.2% introduced a new product based on new technologies. The average product improvement capacity is 1.3. In the same way, Table 2 indicates that 79.2% of respondents decreased production of defective products and 68.5% reduced variation in product quality. On average, respondents achieved 6.5 types of process improvements.

MNEs/JVs are said to have a greater capacity for innovation than local firms. To test this, the sample was divided into local establishments and MNEs/JVs. Means-comparison tests, or t-tests on the equality of means, were performed to investigate if the percentage of respondents who made improvements was the same between the two grouped subsamples. The asterisks in Table 2 indicate a significant difference at the 1% (***), 5% (**), and 10% (*) level. Table 2 show that with the exception of the introduction of new products based on new technologies, MNEs/JVs are more likely to make product improvements and had higher product development capacities than local establishments. However, there is no significant difference in the number of process improvement types, although differences are observed in the specific types of process improvements.

Table 2: Differences in Product and Process Innovation between Local and Foreign Firms

	Whole	Local	MNE/JV
Panel A. Product Improvement			
Redesigning packaging or appearance	30.6%	26.2%	36.0%***
Significant improvement in existing products	33.7%	29.6%	38.6%***
New Product based on existing technologies	25.7%	23.6%	28.3%***
New Product based on new technologies	15.2%	14.9%	15.6%
Stage of product development (max=4)	1.3	1.1	1.4***
Panel B. Process improvement			
Decrease in production of defective products	79.2%	79.6%	78.7%
Decrease in shipping defective products	68.7%	72.0%***	64.7%
Reduced raw materials and energy usage	65.7%	59.1%	73.6%***
Reduced labor input	50.6%	45.6%	56.6%***
Reduced lead time to introduce a new product	44.6%	46.0%	42.9%
Reduced unscheduled line stoppage	68.8%	64.1%	74.6%***
Reduced worker injuries or plant accidents	80.5%	84.7%***	75.3%
Reduced delivery delay	78.7%	81.7%***	75.1%
Reduced prices of main products	39.7%	35.1%	45.3%***
Reduced variation in product quality	68.5%	67.5%	69.8%
No. of Process improvement type (max=10)	6.5	6.4	6.6*
N	921	504	417

Note: Each asterisk indicates a statistical significant difference at the 1% (***), 5% (**), and 10% (*) level between two groups–local and MNE/JV.

Source: ERIA Establishment Survey 2012.

We also examine the influence of R&D expenditure on the probability of process and product improvement. We divided the subsample of local establishments and MNEs/JVs into those with and without R&D expenditures respectively and performed the same means-comparison tests. The results in Table 3 show significant differences in the stage of product development and the number of process improvement types between local establishments with and without R&D expenditures and between MNEs/JVs with and without such investments. We also find no significant difference in the percentages of MNEs/JVs that introduced new products based on existing and new technologies. This result may indicate that foreign affiliates of MNEs depend on R&D conducted by headquarters overseas when they introduce new products that require advanced technologies.

Table 3: Differences in Product and Process Innovation by R&D Expenditure

	Local R&D exp.	No R&D	MNE/JV R&D exp.	No R&D
Panel A. Product Improvement				
Redesigning packaging or appearance	33.1%***	18.0%	43.2%***	25.0%
Significant improvement in existing products	39.7%***	18.0%	42.8%**	31.8%
New Product based on existing technologies	30.1%***	15.8%	30.1%	25.0%
New Product based on new technologies	18.0%**	11.4%	15.7%	15.3%
Stage of product development (max=4)	1.5***	0.7	1.6***	1.2
Panel B. Process improvement				
Decrease in production of defective products	83.1%**	75.0%	85.2%***	70.5%
Decrease in shipping defective products	71.0%	72.8%	65.3%	63.1%
Reduced raw materials and energy usage	66.5%***	50.0%	79.2%***	65.9%
Reduced labor input	48.9%*	41.7%	60.2%*	52.8%
Reduced lead time to introduce a new product	51.1%***	39.5%	45.8%*	38.6%
Reduced unscheduled line stoppage	70.2%***	56.6%	73.3%	75.6%
Reduced worker injuries or plant accidents	83.8%	85.5%	76.3%	73.3%
Reduced delivery delay	82.4%	81.1%	77.1%	71.6%
Reduced prices of main products	41.2%***	28.1%	50.8%***	37.5%
Reduced variation in product quality	71.3%**	62.7%	73.3%**	65.3%
No. of Process improvement type (max=10)	6.7***	5.9	6.9***	6.1
N	272	228	236	176

Note: Each asterisk indicates a statistical significant difference at the 1% (***), 5% (**), and 10% (*) level between two groups–local and MNE/JV.

Source: ERIA Establishment Survey 2012.

3.3. External Information Sources

To gain a broader understanding of “who" provides technology and information to the respondents, we constructed a question about the external source of technologies and information. The respondents were asked to evaluate the importance of the following 13 sources individually by a Likert scale ranging from 0 (not at all important) to 4 (very important): (1) final consumer; (2) competitor; (3) buyer or trading company; (4) consultant; (5) local buyer; (6) local supplier; (7) domestic MNE/JV buyer; (8) domestic MNE/JV supplier; (9) MNE/JV buyer in a foreign country; (10) MNE/JV supplier in a foreign country; (11) public organization; (12) local business organization; and (13) university or public research institute. We converted each Likert scale variable into a dummy variable coded 1 if a technology source is very important for the respondent. The 13 dummy variables were then summed to calculate the number of very important sources (min=0 and max=13).

Table 4 shows that the final consumer is a very important external source for the 58% of respondents while 8.4% of them consider university or public research institutes as very important. On average, respondents had 3.9 very important external sources of technology. We also compared local establishments and MNE/JVs. Local establishments are more likely to depend on local business organizations, universities, or public research institutes than MNEs/JVs. On the other hand, MNE/JV respondents tend to be more strongly linked with MNE/JV buyers and suppliers. We found no significant difference in the average number of very important sources.

Table 5 summarizes the differences between local establishments with and without R&D expenditure and between MNEs/JVs with and without R&D expenditure. We find that R&D expenditures have a greater impact on local establishments than on MNEs/JVs. Local establishments that invested in R&D had closer relationships with MNE/JV buyers and suppliers and had access to a greater variety of technologies and information.

Table 4: Very Important External Information Sources

	Whole	Local	MNE/JV
Final Consumer	58.8%	60.9%	56.4%
Competitor	38.1%	39.9%	36.0%
Buyer or trading company	30.1%	30.6%	29.5%
Consultant	25.4%	26.4%	24.2%
Local buyer	48.0%	50.2%	45.3%
Local supplier	40.7%	41.9%	39.3%
Domestic MNE/JV buyer	35.6%	29.0%	43.6%***
Domestic MNE/JV supplier	23.9%	19.2%	29.5%***
MNE/JV buyer in a foreign country	25.5%	17.7%	35.0%***
MNE/JV supplier in a foreign country	19.4%	13.3%	26.9%***
Public organization	16.6%	17.7%	15.3%
Local business organization	18.3%	22.2%***	13.7%
University or Public Research Institute	8.4%	10.7%***	5.5%
Ave. number of very important sources (Max: 13)	3.9	3.8	4.0
N	921	504	417

Note: Each asterisk indicates a statistical significant difference at the 1% (***), 5% (**), and 10% (*) level between two groups–local and MNE/JV.

Source: ERIA Establishment Survey 2012.

Table 5: Very Important External Information Sources by R&D Expenditure

	Local R&D Exp.	No R&D	MNC/JV R&D Exp.	No R&D
Final Consumer	66.2%***	54.8%	60.6%**	49.4%
Competitor	42.3%	36.4%	31.4%	40.9%**
Buyer or trading company	29.0%	32.5%	30.5%	27.3%
Consultant	30.1%**	21.5%	22.5%	25.6%
Local buyer	51.8%	48.2%	43.6%	47.2%
Local supplier	44.5%*	38.2%	36.0%	43.8%*
Domestic MNE/JV buyer	35.3%***	21.1%	46.2%*	39.8%
Domestic MNE/JV supplier	23.5%***	13.6%	34.3%***	23.3%
MNE/JV buyer in a foreign country	20.6%**	13.6%	38.6%**	29.5%
MNE/JV supplier in a foreign country	14.7%	11.0%	26.3%	27.3%
Public organization	18.8%	16.2%	14.0%	16.5%
Local business organization	21.7%	21.9%	14.4%	11.9%
University or Public Research Institute	11.0%	9.6%	5.9%	5.1%
Ave. number of very important sources (Max: 13)	4.1***	3.4	4.0	3.9
N	272	228	236	176

Note: Each asterisk indicates a statistical significant difference at the 1% (***), 5% (**), and 10% (*) level between two groups–local and MNE/JV.

Source: ERIA Establishment Survey 2012.

3.4. How? Channels for Technology Transfer

We now turn our focus to the methods of technology transfer used by the respondents and their partner firms. We asked respondents whether (1) their buyer conducts supplier audits; (2) they accept engineers from their suppliers; (3) they send engineers to their suppliers; (4) they accept engineers from their buyers; (5) they send engineers to their buyers; (6) they collaborate with capital goods producers; (7) they receive training from capital goods producers; or (8) they have received a license for intellectual property rights (IPR) from others, without specifying the type of partner.

Table 6 shows that while 55.8% of respondents have a buyer who conducts supplier audits, and about half of them have face-to-face interactions with their buyer or supplier, only 23.3% of them received an IPR license from another organization. There are significant differences between local establishments and MNE/JVs in the percentage of face-to-face interactions with buyer or supplier engineers. More than 55% of MNEs/JVs have in-person meetings with buyer or supplier engineers. MNEs/JVs also make greater use of licensing to introduce new technologies from outside.

R&D expenditure can be significant for both local establishments and MNEs/JVs in their decisions to introduce technologies from or exchange information and ideas with buyers, suppliers, and other organizations. Local establishments who made investments in R&D were more likely to adopt all eight practices in Table 7 than those who did not make R&D expenditures. We find exceptions, however, in the case of MNE/JVs. Supplier audits are not related to R&D expenditure. MNEs/JVs that have no R&D expenditures are more likely to accept engineers from their buyers and receive training from capital goods producers than those that have such expenditures.

Table 6: Practices for Technology Transfer

	Whole	Local	MNE/JV
Buyer conducts supplier audit	55.6%	53.6%	58.6%*
Accept engineers from supplier	50.2%	43.2%	58.6%***
Send engineers to supplier	44.8%	34.0%	57.8%***
Accept engineers from buyer	49.1%	38.5%	61.9%***
Send engineers to buyer	49.0%	42.8%	56.4%***
Collaborate with capital goods producers	42.2%	43.7%	40.4%
Receive training from capital goods producers	54.9%	52.5%	57.8%*
Receive an IPR license from others	23.3%	17.5%	30.2%***

Note: Each asterisk indicates a statistical significant difference at the 1% (***), 5% (**), and 10% (*) level between two groups–local and MNE/JV.

Source: ERIA Establishment Survey 2012.

Table 7: Practices for Technology Transfer by R&D Expenditure

	Local R&D Exp.	No R&D	MNC/JV R&D Exp.	No R&D
Buyer conducts supplier audit	58.1%**	47.8%	60.2%	55.8%
Accept engineers from supplier	51.8%***	33.6%	63.7%**	53.4%
Send engineers to supplier	43.4%***	23.3%	65.0%***	48.9%
Accept engineers from buyer	43.4%**	33.3%	58.5%	68.2%
Send engineers to buyer	52.9%***	31.4%	63.7%***	45.5%
Collaborate with capital goods producers	52.4%***	32.3%	44.9%***	33.1%
Receive training from capital goods producers	55.9%**	47.6%	53.4%	63.1%**
Receive an IPR license from others	21.2%***	12.8%	37.2%***	21.4%

Note: Each asterisk indicates a statistical significant difference at the 1% (***), 5% (**), and 10% (*) level between two groups–local and MNE/JV.

Source: ERIA Establishment Survey 2012.

3.5. Who? Attributes of Main Partners Practicing Technology Transfer

The data shown above suggest the practices emphasized would results in the transfer of technology necessary for process and product improvements. This section discusses the characteristics of buyers and suppliers who have face-to-face interactions and collaborations with the focal respondent. We focus on the main partner's location (domestic or foreign), ownership type, capital ties, R&D, and size (SME having less than 200 employees or large firm). Table 8 shows that 44.1% of respondents whose main buyer is domestic send engineers to their buyers while 50.6% of those whose main buyer is located in a foreign country do so. The means-comparison test indicates that the focal firm whose main buyer is foreign is more likely to send an engineer than one who has a main domestic buyer. In other words, a foreign buyer is more likely to transfer technology to the focal firm than a domestic buyer is.

As shown in Table 8, the respondent has a higher chance of technology transfer from partners in a foreign countries, MNE/JV partners, partners conducting R&D, and larger partners with 200 or more employees. Conversely, one might say that such production partners have a higher chance of transferring technologies to the respondent. This is especially true of main buyers with these attributes. Technology transfer from partners with capital ties or intra-firm/business-group technology transfer is more likely to be achieved through face-to-face interaction between engineers or through licensing agreements with main suppliers. On the other hand, training, the dispatch of experts for inspection, and co-design of new products are methods of technology transfer utilized by main partners without capital ties.

Table 8: Attribute of Main Partner Practicing Technology Transfer

	Domestic	Foreign	Local	MNE/JV	With capital tie	W/O capital tie	R&D	No R&D	SME (<200)	Large
Panel A. With buyer										
Send an engineer to buyer	44.1%	50.6%**	35.4%	55.4%***	55.8%***	42.9%	53.8%***	40.2%	28.8%	55.6%***
Buyer sends an engineer	47.9%	54.1%**	36.5%	61.4%***	73.2%***	42.6%	53.6%**	47.1%	33.8%	58.7%***
Buyer grants license	27.7%	32.9%*	20.2%	37.3%***	25.6%	30.0%	41.1%***	19.3%	19.8%	34.5%***
Receive training from buyer	35.7%	49.8%***	25.8%	52.0%***	30.4%	41.7%***	54.3%***	27.4%	26.9%	46.7%***
Buyer sends expert to inspection	46.6%	58.6%***	46.9%	52.6%**	40.9%	52.1%***	68.8%***	33.3%	43.8%	53.4%***
Collaboration for new product with buyer	37.8%	45.0%**	37.3%	42.0%*	26.9%	43.1%***	67.7%***	16.8%	37.7%	40.9%
Panel B. With supplier										
Send an engineer to supplier	33.3%	44.8%***	28.9%	45.2%***	47.3%***	35.3%	43.2%**	35.9%	25.8%	47.3%***
Supplier sends an engineer	32.8%	39.3%**	36.4%	34.8%	52.5%***	30.3%	47.8%***	29.4%	32.4%	37.9%**
Supplier grants license	20.7%	18.3%	20.4%	19.2%	27.2%***	17.3%	40.4%***	9.3%	21.3%	18.5%
Receive training from supplier	31.7%	39.4%***	35.2%	34.8%	35.6%	34.6%	52.7%***	25.7%	31.5%	37.5%**
Supplier sends expert to inspection	45.5%	47.7%	46.0%	46.7%	39.3%	48.2%**	66.4%***	35.9%	45.0%	47.4%
Collaboration for new product with supplier	26.5%	25.7%	28.2%	24.6%	20.3%	27.5%**	58.0%***	9.7%	28.6%	24.3%*

Note: Each asterisk indicates a statistical significant difference at the 1% (***), 5% (**), and 10% (*) level between two groups.

Source: ERIA Establishment Survey 2012.

4. How Embodied Technology Transfers Play a Role: A First Look

Table 9 is a cross tabulation created to observe the relationship between technology transfer practices and product/process improvement. For process improvement, we report only the number of process improvement types achieved by the respondents. Table 9 shows that 34.8% of the respondents whose buyer conducts supplier audits made improvements in packaging or appearance design. On the other hand, 25.5% of those whose buyer did not conduct supplier audits made such improvements. The means-comparison test shows a significant difference between the percentages of those whose buyer does and does not conduct supplier audits.

The stage of product development can be affected by supplier audits, face-to-face interactions between engineers from either the supplier or the buyer (except in the case of acceptance of engineers from the buyer), collaboration with capital goods producers and IPR license agreements. However, there can be different technology transfer practices that have different effects on different types of product improvement. Of particular interest is that establishments that send engineers to their buyers or that receive IPR licenses from outside tend to make relatively simple product improvements such as redesigns or improvements in existing products. Face-to-face contacts with suppliers and capital goods producers tend to increase the probability of introducing relatively complex new products.

The number of types of process improvements can be affected by the dispatch of engineers to buyers. Respondents whose buyer conducts supplier audits are more likely to make a greater variety of process improvements. These findings suggest that buyers encourage focal establishments to make process improvements. Establishments than do not receive an IPR license achieve more types of process improvements than those who do. This finding as well as IPR's influence on product improvement indicates that IPR generally relates to product-oriented technologies.

Table 9: Product and Process Innovation by Transfer Channels

Panel A: Change for existing product

	Redesigning		Improvement	
Transfer channel	Yes	No	Yes	No
Buyer conducts supplier audit	38.8%***	25.5%	33.9%	33.7%
Accept engineers from supplier	36.3%***	24.7%	38.3%***	29.1%
Send engineers to supplier	36.3%***	25.8%	41.4%***	27.4%
Accept engineers from buyer	31.9%	29.4%	33.8%	33.5%
Send engineers to buyer	35.4%***	25.9%	38.8***	28.8%
Collaborate with capital goods producers	37.2%***	25.8%	32.6%	34.5%
Receive training from capital goods producers	32.3%	28.7%	33.9%	33.6%
Receive an IPR license from others	35.4%**	28.9%	46.9%***	29.5%

Panel B: Development of new product

	Existing tech		New tech	
Transfer channel	Yes	No	Yes	No
Buyer conducts supplier audit	29.5%***	20.8%	18.2%***	11.4%
Accept engineers from supplier	30.0%***	21.4%	16.5%	13.8%
Send engineers to supplier	30.2%***	22.1%	14.6%	15.6%
Accept engineers from buyer	25.7%	25.8%	13.9%	16.4%
Send engineers to buyer	27.6%	23.9%	14.7%	15.6%
Collaborate with capital goods producers	32.0%***	21.1%	21.7%***	10.4%
Receive training from capital goods producers	28.6%**	22.5%	18.1%***	11.8%
Receive an IPR license from others	23.9%	26.0%	14.8%	14.9%

Panel C: Novelty of product and process innovation

	Product innovation stage		No. of process types	
Transfer channel	Yes	No	Yes	No
Buyer conducts supplier audit	1.4**	1.1	6.8***	6.1
Accept engineers from supplier	1.5***	1.1	6.6*	6.3
Send engineers to supplier	1.4***	1.1	6.6*	6.3
Accept engineers from buyer	1.3	1.3	6.4	6.5

Send engineers to buyer	1.4***	1.1	6.8***	6.2
Collaborate with capital goods producers	1.5***	1.1	6.9***	6.1
Receive training from capital goods producers	1.3*	1.2	6.5	6.4
Receive an IPR license from others	1.5***	1.2	6.2**	6.5

Note: Each asterisk indicates a statistical significant difference at the 1% (***), 5% (**), and 10% (*) level between two groups–local and MNE/JV.

Source: ERIA Establishment Survey 2012.

5. Results: The Impact of “Who" and “Which" Channels

To understand why technology is transferred and adopted, this section looks at how embodied technology transfers can contribute to product and process innovation. Since this section focuses on technology transfer channels in arm’s length relationships among manufacturers, downstream buyers, and upstream suppliers, we first look at how the different types of main buyer and main supplier within a production chain affect internal investment (R&D sales ratio), the degree of activation of channels of technology transfer, and our main point of interest, product and process innovation. Second, we investigate how technology transfer channels impact product and process innovation when we control for firm characteristics, types of main buyers, and types of main supplier.

5.1. Formation of Production Chains

We start by describing the formation of buyer-supplier relationships in the sample before going on to estimate the impact of these relationships. We use data on three agents: respondents, respondents’ main buyers in their downstream sides, and respondents' main suppliers in their upstream sides in B2B markets. We also classify firms into one of three types for each respondent, main buyer, and main supplier: (1) local firm; (2) MNE; and (3) JV. We therefore have 27 (3^3=27) different combinations that make up the production chains.

Table 10 shows the 27 different combinations of buyer-supplier relationships within and across production chains. Local firms have three possible customer types for their products; local buyers, MNE buyers, and JV buyers. Local firms also have three possible types of sources of intermediate inputs as main suppliers–local suppliers, MNE suppliers, and JV suppliers. Table 10 highlights five points about the matching process between producers, buyers, and suppliers. First, more than one-quarter of firms in the sample, or 27.79%, established locally oriented production chains consisting solely of local producers, including local manufacturers, buyers, and suppliers. Since the probability of local producers having local buyers is 0.3768, approximately three quarters of local firms (0.7375= 0.2779/0.3768) seek out local suppliers if they have local buyers. Second, linkages between local producers and MNE buyers are thin, with only 9.55% of local respondents having MNE buyers as their main customers. Linkages between local producers and JV buyers are still few (7.49% of local respondents have JV buyers as their main buyers). Although these shares are small, we note that the sum of the two linkages with MNEs and JVs for local producers accounts for 16–17% of the share of total firms. Local producers may also extend their linkages with nonlocal partners.

Our final three points concern nonlocal firms. MNE producers are likely to have MNE buyers (22.58% of respondents in total firms) as their main buyer. More than half of these MNEs (0.5434=0.1227/0.2258) use MNEs as their main supplier. MNE producers are likely to have MNE suppliers if they have MNE buyers in the downstream. JVs also match with JV suppliers if they have JV buyers as well as local chains or MNE chains. Although only 10% of respondents are JV producers, two-thirds of JV firms (0.0430/0.0630) seek out JV suppliers if they have JV buyers. Finally, we observe that more than half of suppliers for respondents are nonlocal suppliers: 30.73% of respondents have MNE suppliers and 25.62% of respondents have JV suppliers. We expect to see disembodied technology transfer from MNEs and JVs to local firms as long as local firms have direct transaction linkages with these firms. We will now test how the different types of main buyers and suppliers impact product and process innovation as well as R&D and technology transfer.

Table 10: Formation of Production Chains: Matching with Buyers and Suppliers

		Supplier			
Own	*Buyer*	Local	MNEs	JVs	Total
	Local	0.278	0.046	0.053	0.377
Local	MNE	0.039	0.037	0.020	0.096
	JV	0.023	0.016	0.036	0.075
	Local	0.008	0.042	0.022	0.072
MNE	MNE	0.049	0.123	0.054	0.226
	JV	0.007	0.012	0.021	0.039
	Local	0.020	0.005	0.003	0.028
JV	MNE	0.007	0.014	0.004	0.025
	JV	0.008	0.012	0.043	0.063
		0.437	0.307	0.256	1

Note: N=921.

Source: ERIA Establishment Survey 2012.

5.2. Differences in R&D and Technology Transfer across Production Chains

This subsection discusses the results of questions about the impact of production chains on R&D and technology transfer and how they can change product and process innovation. The two panels in Table 11 show estimates of a firm's investment in R&D (Panel A) and the degree of technology transfer (Panel B). Each panel has five columns. The first three columns in each panel show the impact of respondent type, respondent main buyer type, and respondent main supplier type. Since the benchmark case is MNEs, we use the cases of two local firms and JVs for comparison. The fourth and final columns for each panel show the impact of production chain controlling characteristics of respondent, main buyers, and third parties respectively. We run an ordinary least squares (OLS) estimation, and the control variables are pre-determined characteristics such as firm age, firm size, industry, and country.

Columns 1 of Panel A of Table 11 presents evidence for whether a firm's status as a local establishment or a joint venture has a significant and sizable impact on investment in R&D compared to MNEs. JV firms are more likely to make investments in R&D at the 1% level of significance compared to MNEs. The impact of local firm is only a third of the magnitude of JVs. Both Column 2 and 3 of Panel A of Table 11 show the impact of main buyer and main supplier on a firm's investment in R&D. Column 2 suggests that the impact of main buyer is significant and sizable. Firms are also likely to invest in R&D if firms sell their product to local buyers, but the impact is smaller than in the case of firms with JV buyers. Column 3 suggests that main supplier has no sizable or significant impact on R&D compared to MNE suppliers. Column 4 and 5 of Panel A show that the impacts of main buyers on investment in R&D remain positive when we control for respondent characteristics or main supplier characteristics. Firms are likely to invest in R&D if they have local firms or JVs as their main buyer compared to those with MNE buyers. The impact of supplier is not as large. The positive impacts from local or JV buyers decline if the respondent has local suppliers.

Table 11: Differences in R&D and External Information Sources across Chains (OLS)

Panel A: R&D sales ratio	(1)	(2)	(3)	(4)	(5)
Own type					
Local	0.001			0.000	0.003
	(0.000)			(0.000)	(0.000)
JV	0.002***			0.001**	0.001**
	(0.001)			(0.005)	(0.000)
Main buyer's type					
Local		0.001***		0.001***	0.001***
		(0.003)		(0.000)	(0.000)
JV		0.002***		0.001***	0.001***
		(0.000)		(0.000)	(0.000)
Main supplier's type					
Local			-0.001*		-0.001**
			(0.000)		(0.000)
JV			9.55e-05		-0.000
			(0.000)		(0.000)
Constant	0.004***	0.003***	0.004***	0.003***	0.004***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
N	875	875	875	875	875
R2	0.123	0.130	0.116	0.136	0.141
Panel B: Technology transfer	(1)	(2)	(3)	(4)	(5)
Own type					
Local	-0.169			-0.244	-0.182
	(0.158)			(0.163)	(0.165)
JV	0.199			-0.038	-0.010
	(0.241)			(0.256)	(0.256)

	(1)	(2)	(3)	(4)	(5)
Main buyer's type					
Local		0.089		0.170	0.205
		(0.157)		(0.163)	(0.165)
JV		0.575***		0.600***	0.600***
		(0.192)		(0.204)	(0.207)
Main supplier's type					
Local			-0.370**		-0.315*
			(0.166)		(0.170)
JV			-0.075		-0.195
			(0.168)		(0.171)
Constant	3.555***	3.372***	3.695***	3.475***	3.625***
	(0.295)	(0.288)	(0.300)	(0.300)	(0.314)
N	881	881	881	881	881
R2	0.170	0.176	0.172	0.178	0.181

Note: Control variables for each regression are firm age, firm size, industry, and country. Robust standard errors in brackets.***p<0.01, **p<0.05, *p<0.1.

Source: ERIA Establishment Survey 2012.

Panel B of Table 11 presents data showing whether main buyers and main suppliers or respondent characteristics can impact the adoption of technology transfer. The outcome of interest is the simple sum of eight different technology transfer channels. We do not use weights. Columns 1 to 3 of Panel B suggest that local firms are less likely to transfer technology from production partners, capital goods producers, or third parties (Column 1). Firms are more likely to adopt technology transfers if they sell their products to JV buyers than to MNE or local firm buyers (Column 2). On the other hand, firms are less likely to adopt technology transfer if they buy intermediate inputs from local suppliers (Column 3). These results hold even if we control for respondent characteristics, including main buyers and main suppliers (Columns 4 and 5). JV buyers have a sizable impact on the adoption of technology by upstream producers, but this positive effect declines if the respondent is local. This effect from JV buyers is also likely to decline if the respondent buys an intermediate input mainly from local suppliers. The evidence from Panel A and Panel B of Table 11 emphasizes that understanding the incentive and decision making of firms who buy their intermediate inputs from local suppliers is a key to removing barrier of investment in R&D and technology transfer. As shown in Table 10, 43.65% of the sample used local suppliers are their main supplier. Although there is a great deal of heterogeneity among firms who buy intermediate inputs from local suppliers, this number is large enough to see the role of partners in the incentive to investment in R&D and embodied technology transfer.

5.3. Differences in Innovation across Production Chains

We now investigate the impact of production chains on product and process innovation. Table 12 has two panels. Panel A shows an index of firm-level product innovation showing the stage of product development, from easiest to most difficult. A simple design change is considered the easiest innovation to achieve while the development of a new product based on new technology is the most difficult. Panel B shows an index of firm-level process improvement summarizing four components: production, quality, cost, and delivery. Both Panel A and B of Table 12 have five columns. Columns 1 through 3 of Table 12 demonstrate the impact of respondent, main buyer, and main supplier type on production chains in the index of stage of product development, respectively. Column 1 of Panel A shows that local or JV firms are no significant difference from MNEs in the upper stages of product development. Column 2 of Panel A shows no significant difference in the stage of product development among buyer firm types. Column 3 emphasizes that firms are less likely to reach the upper stages of product development if they bought an intermediate input from JVs or locals than if they bought from MNEs.

Column 4 controls for both respondent and main buyer characteristics. There are still no significant differences in the stage of product development among locals, JVs, and MNEs when we control for the impact of downstream buyers. Although respondent type does not have a significant effect, Column 5 of Panel A shows that the impacts of main supplier are still negative. That is, firms are less likely to have a higher index of product development stage if they depend on mainly local suppliers and JVs suppliers. On the other hand, Column 5 of Panel A shows that local and JV buyers have sizable and significant impacts on the stage of product development when compared to MNE buyers.

Let us move on to process innovation. We are interested in the index of process innovation, which is expressed as a sum of ten different cases of improvement in production process, quality improvement, cost reduction, and changes in delivery efficiency. Panel B of Table 12 shows evidence about the impact of production chains on product development. First, main supplier type has a significant impact. Firms are less likely to achieve a variety of process innovations if they use a local firm as their main supplier compared to firms with MNE suppliers. Second, main buyer type also matters. Firms are more likely to realize process innovations if they sell their products to JV buyers. The impacts of the respondent's own characteristics disappear when we look at production chains.

Table 12: Differences in Innovation across Production Chains (OLS)

Panel A: Product Innovation	(1)	(2)	(3)	(4)	(5)
Own type					
Local	-0.103			-0.183	-0.144
	(0.129)			(0.135)	(0.138)
JV	0.007			-0.099	-0.059
	(0.198)			(0.212)	(0.214)
Main buyer's type					
Local		0.153		0.213	0.242*
		(0.131)		(0.137)	(0.135)
JV		0.238		0.274	0.376**
		(0.163)		(0.172)	(0.178)
Main supplier's type					
Local			-0.279*		-0.268*
			(0.143)		(0.149)
JV			-0.386***		-0.451***
			(0.139)		(0.143)
Constant	1.475***	1.303***	1.645***	1.388***	1.571***
	(0.229)	(0.226)	(0.231)	(0.235)	(0.247)
N	881	881	881	881	881
R2	0.062	0.064	0.070	0.066	0.077

Panel B: Process innovation	(1)	(2)	(3)	(4)	(5)
Own type					
Local	-0.016			-0.068	0.067
	(0.202)			(0.210)	(0.210)
JV	0.431			0.170	0.222
	(0.280)			(0.295)	(0.299)
Main buyer's type					
Local		0.073		0.096	0.169
		(0.190)		(0.200)	(0.201)
JV		0.695***		0.657***	0.622**
		(0.227)		(0.239)	(0.250)
Main supplier's type					
Local			-0.670***		-0.662***
			(0.225)		(0.236)
JV			-0.150		-0.310
			(0.204)		(0.209)
Constant	6.454***	6.391***	6.895***	6.400***	6.696***
	(0.398)	(0.374)	(0.416)	(0.398)	(0.429)

N	881	881	881	881	881
R2	0.046	0.054	0.056	0.055	0.065

Note: Control variables for each regression are firm age, firm size, industry, and country. Robust standard errors in brackets.***p<0.01, **p<0.05, *p<0.1.

Source: ERIA Establishment Survey 2012.

We now turn our discussion to the impact of buyers and suppliers on each category of firm-level product and process innovation. Panel A of Table 13 consists of four different types of product innovation: (1) design changes; (2) improvements of existing products; (3) development of new products based on technologies already known to the firm; and (4) development of new products based on technologies new to the firm. Panel A has four columns. Each column covers one of the above categories. Panel A of Table 13 tests how each case of product innovation responds to production chains. Column 1 of Panel A shows that firms are less likely to change their product design or packaging if they have local or JV suppliers compared to firms having MNE suppliers. Column 2 of Panel A shows that firms are likely to improve their existing product lineup if they have local or JV buyers, but are less likely to do so if they have JV suppliers. Since the negative impact of JV suppliers is small, the total impact of JV buyers and suppliers on improvements to existing products is positive. Column 3 of Panel A shows a similar result as in Column 2. Firms are likely to develop products using existing technologies if they have JV buyers, but this effect declines if they have local suppliers or JV suppliers at the same time. The total effect could be negative if firms have both JV buyers (estimate is 0.165 with standard error of 0.0573) and JV suppliers (estimate is -0.168 with standard error of 0.0320).

Finally, the chance to introduction of a new product based on new technology responds negatively to the firm's main supplier if firms have local or JV suppliers. Although local and JV buyers play a positive role, evidence from Panel A of Table 13 implies the importance of MNEs supplier in achieving product innovation.

Each type of process innovation also responds quite differently to different types of buyers and suppliers. Column 1 of Panel B, Production shows results related to production process improvement. These process improvements include the reduction of lead-time to introduce a new product, the reduction of unscheduled line stoppage, and the reduction of worker injuries or plant accidents. Column 2 of Panel B, Quality refers to improvements in product quality resulting in a decrease in the production of defective products or the reduction of variation in product quality. Column 3 of Panel B, Cost includes the reduction of raw materials and energy usage, the reduction of labor input, and the reduction of prices of main products. Finally, Column 4 of Panel B, Delivery includes decreases in defective products shipped and reductions in delivery delays.

Evidence from Panel B of Table 13 suggests that local buyers (or JV buyers) and local suppliers (or JV buyers) play different roles between the first two types of process innovation (production process, quality) and the latter two process innovations (cost, delivery). Column 1 shows that firms are less likely to make production process improvements if they have local or JV buyers. However, firms are likely to make these improvements if they have JV suppliers. Column 2 also shows that firms are likely to achieve quality improvement if they have local or JV suppliers. Columns 3 and 4 demonstrate that local and JV buyers can positively affect a firm's process improvements on cost and delivery, respectively. At the same time, the local or JV suppliers have negative impacts on cost and delivery when compared to the impact of MNE suppliers. Although the total impact from buyers and suppliers depends fundamentally on the precise matching of buyers and supplies, MNE suppliers also play a role in process improvements regarding cost and delivery.

Table 13: Differences in Types of Innovation across Chains (Probit, Marginal Effects)

Panel A: Product Innovation	(1)	(2)	(3)	(4)
	Design	*Improve*	*Old tech*	*New tech*
Own type				
Local	-0.043	-0.054	-0.013	0.018
	(0.043)	(0.045)	(0.040)	(0.034)
JV	0.002	-0.042	0.001	0.051
	(0.061)	(0.061)	(0.056)	(0.049)
Main buyer's type				
Local	0.066	0.127***	0.019	0.025
	(0.041)	(0.044)	(0.040)	(0.032)
JV	0.115*	0.137**	0.165***	0.013
	(0.059)	(0.060)	(0.057)	(0.041)
Main supplier's type				
Local	-0.090**	-0.034	-0.083**	-0.072**
	(0.041)	(0.044)	(0.040)	(0.030)
JV	-0.116***	-0.100**	-0.168***	-0.088***
	(0.037)	(0.040)	(0.032)	(0.025)
N	881	881	881	881

Panel B: Process innovation	(1)	(2)	(3)	(4)
	Production	*Quality*	*Cost*	*Delivery*
Own type				
Local	0.021	-0.035	-0.061*	-0.007
	(0.023)	(0.023)	(0.343)	(0.027)
JV	0.020	-0.0005	0.030	-0.014
	(0.022)	(0.030)	(0.044)	(0.043)
Main buyer's type				

Local	-0.086***	-0.023	0.082**	0.089***
	(0.023)	(0.021)	(0.033)	(0.024)
JV	-0.077*	-0.009	0.096***	0.082***
	(0.043)	(0.030)	(0.027)	(0.022)
Main supplier's type				
Local	0.013	0.039**	-0.065*	-0.053*
	(0.020)	(0.020)	(0.039)	(0.031)
JV	0.038**	0.047***	-0.016	-0.074**
	(0.016)	(0.017)	(0.038)	(0.035)
N	881	881	881	881

Notes: Control variables for each regression are firm age, firm size, industry and country. In panel B: First, *Production* consists of the reduction in lead time to introduce a new product, the reduction of unscheduled line stoppage, and reduction of worker injuries or plant accidents. Second, *Quality* consists of the decrease in the production of defective products and the reduction of variation in product quality. Third, *Cost* consists of the reduction of raw materials and energy usage, the reduction of labor input, and the reduction of prices of main products. Finally, *Delivery* consists of the decreases in shipping of defective products and the reduction of delivery delay. Robust standard error in brackets. ***p<0.01, **<0.05, *<0.1.

5.4. Mechanisms: “Which" Channels Are Important within Similar Chains

Finally, we investigate the mechanisms behind the relationships between the different types of production chain, product, and process innovation to look at the impacts of technology transfer channels. We show the impact of several channels of embodied technology transfer after controlling for the ownership type of buyers and suppliers with other control variables. We examine which channels of embodied technology transfer are effective using the index of product and process innovation in Table 14. We also have five columns for product innovation (Panel A) and process innovation (Panel B). The first three columns look at the impact of channels of technology transfer when we control for respondent’s own type, main buyer type, and main supplier type, respectively. The fourth column controls respondent's own type and main buyer type. The final column controls for the ownership characteristics of buyer and supplier within production chains. We show our eight different channels of embodied technology transfer again as follows: (1) buyer conducts supplier audit; (2) accept engineers from supplier; (3) send engineers to supplier; (4) accept engineers from buyer; (5) send engineers to buyer; (6) collaborate with capital goods producers; (7) receive training from capital goods producers; and (8) receive an IPR license from others.

Panel A of Table 14 presents clear evidence that in-house R&D and some channels of embodied technology transfer can have positive impacts on the stage of product innovation. As many previous studies have found, an increase in R&D to sales ratio always raises the probability of reaching upper stage product development. Panel A shows certain positive impacts of embodied technology transfers. First, accepting engineers from a supplier always has a sizable and significant effect on the stage of product innovation. Second, collaboration with capital goods producers and receiving training from capital goods producers has a significant impact. At the same time, accepting engineers from a buyer has a negative impact on a firm's chances of reaching the upper levels of product innovation.

We move on to Panel B of Table 14, investigating whether process innovation responds to different channels of embodied technology transfer. Panel B also has a clear set of results: process innovation always responds positively to in-house R&D, downstream buyer audits, and the dispatch of engineers to a buyer. The impact of collaboration with capital goods producers is also sizable and significant. At the same time, accepting engineers from the buyer and receiving a license on intellectual property rights from a third party a negative role in firm-level process improvement. We can interpret these results as showing that firms are more likely to accept engineers from a buyer or receive an IPR license from others because they have not yet been able to make any process innovations.

Table 14: Impacts of Technology Transfer within Similar Production Chains (OLS)

Panel A: Product Innovation	(1)	(2)	(3)	(4)	(5)
R&D	52.47***	50.59***	50.88***	51.80***	51.04***
	(16.20)	(16.31)	(16.17)	(16.32)	(16.31)
Buyer conducts supplier audit	0.111	0.108	0.058	0.111	0.053
	(0.115)	(0.115)	(0.117)	(0.115)	(0.117)
Accept engineers from supplier	0.357***	0.342***	0.333**	0.349***	0.326**
	(0.129)	(0.129)	(0.129)	(0.129)	(0.130)
Send engineers to supplier	0.074	0.085	0.049	0.069	0.031
	(0.132)	(0.132)	(0.130)	(0.133)	(0.132)
Accept engineers from buyer	-0.505***	-0.487***	-0.508***	-0.490***	-0.504***
	(0.140)	(0.143)	(0.141)	(0.144)	(0.147)
Send engineers to buyer	-0.010	-0.018	0.051	-0.020	0.053
	(0.134)	(0.136)	(0.136)	(0.136)	(0.139)
Collaborate with capital goods	0.220*	0.214*	0.237*	0.217*	0.238*
	(0.122)	(0.123)	(0.122)	(0.122)	(0.122)
Receive training from capital goods	0.221*	0.227**	0.212*	0.223*	0.207*
	(0.115)	(0.115)	(0.114)	(0.115)	(0.115)
Receive an IPR license from others	0.127	0.127	0.177	0.128	0.186
	(0.133)	(0.133)	(0.134)	(0.133)	(0.135)
Constant	0.955***	0.836***	1.058***	0.932***	1.113***
	(0.263)	(0.261)	(0.270)	(0.269)	(0.284)
R2	0.116	0.114	0.123	0.116	0.125
Panel B: Process Innovation	(1)	(2)	(3)	(4)	(5)
R&D	50.69**	50.48**	50.03**	50.08**	48.02**
	(22.65)	(22.79)	(22.90)	(22.77)	(22.93)
Buyer conducts supplier audit	0.599***	0.571***	0.565***	0.569***	0.526***
	(0.170)	(0.172)	(0.170)	(0.172)	(0.173)
Accept engineers from supplier	-0.021	-0.042	-0.018	-0.043	-0.052
	(0.178)	(0.179)	(0.175)	(0.180)	(0.179)
Send engineers to supplier	-0.090	-0.062	-0.079	-0.077	-0.089
	(0.188)	(0.186)	(0.187)	(0.187)	(0.189)
Accept engineers from buyer	-0.381**	-0.398**	-0.355*	-0.391**	-0.357*
	(0.179)	(0.185)	(0.181)	(0.184)	(0.187)
Send engineers to buyer	0.550***	0.547***	0.498***	0.550***	0.530***
	(0.182)	(0.183)	(0.188)	(0.184)	(0.191)
Collaborate with capital goods	0.541***	0.535***	0.537***	0.538***	0.542***
	(0.180)	(0.179)	(0.181)	(0.179)	(0.180)

Receive training from capital goods	-0.153	-0.160	-0.147	-0.164	-0.163
	(0.175)	(0.177)	(0.176)	(0.177)	(0.178)
Receive an IPR license from others	-0.610***	-0.582***	-0.594***	-0.587***	-0.564***
	(0.181)	(0.182)	(0.182)	(0.182)	(0.184)
Constant	5.736***	5.757***	5.986***	5.799***	6.021***
	(0.418)	(0.401)	(0.445)	(0.422)	(0.457)
R2	0.109	0.113	0.113	0.113	0.117
Controlling for ownership of respondent	√			√	√
Controlling for main buyer's ownership		√		√	√
Controlling for main supplier's ownership			√		√

Note: N=875. Control variables for each regression are firm age, firm size, industry, and country. Ownerships are classified by local, MNE, and JV. Robust standard errors in brackets. ***<0.01, **<0.05, *<0.1.

Source: ERIA Establishment Survey 2012.

Table 15 examines which channels are effective for different types of product and process innovation. We will demonstrate the relationship between eight different channels of embodied technology transfer and four categories of product and process innovation respectively. We run a Probit analysis to test the marginal effects of in-house R&D and channels of technology transfer. Panel A of Table 15 shows that channels of technology transfer have different impacts on different types of categories when compared to in-house R&D. In-house R&D always has a positive impact on every type of product innovation, no matter the difficulty. Columns 1 and 2 of Panel A of Table 15 shows that relatively easy-to-achieve product innovation (e.g., design changes and improvements to existing products) responds positively to the acceptance of engineers from a supplier, collaboration with capital goods producers, training from capital goods producers, and the use of IPR licenses. However, these channels are not necessarily effective for relatively difficult–to–achieve innovation (e.g., introduction of new product based on existing- and new technologies). Columns 3 and 4 of Panel A show that collaboration with capital goods producers has a positive and sizable impact on difficult-to-achieve product innovation. However, accepting engineers from a buyer has a negative impact on design changes, improvement of existing products, and the introduction of a new product based on existing technologies.

Panel B of Table 15 also shows that in-house R&D and channels of technology transfer are not necessary to be effective for every type of process innovation. For example, in-house R&D does affect improvements in quality and cost, but improvements in production and delivery do not respond to an increase in the in-house R&D to sales ratio. Panel B shows that improvements in production does not respond to any in-house R&D and technology transfer after controlling for the characteristics of production chains. This means that the variation of production chains can fully explain the variation in improvements in production. Other categories of process innovation such as quality, cost, and delivery have impacts on the channels of technology transfer after controlling for firm-level variation in production chains in which the respondent firms participate. Improvement in product quality responds positively to receiving an IPR license from others while it responds negatively to the acceptance of engineers from a buyer. A reduction of production cost responds well to channels of technology transfer. Sending engineers to a buyer and collaboration with capital goods producers have sizable and significant impacts on the reduction of production costs. At the same time, Column 3 of Panel B shows that firms are less likely to reduce production costs if they receive an IPR license. Finally, improvements in delivery technologies are negatively correlated with some channels of technology transfer. Column 4 of Panel B shows that accepting engineers from a buyer or receiving an IPR license from others have negative and sizable impacts on improvements in delivery technologies. We should interpret these results to mean that firms are likely to accept engineers from outside because they have great potential to improve the delivery of their product.

In sum, we find that there are large differences in product and process innovations across firms even within narrowly defined production partner's ownership type. We also find that these differences can be explained by differences in embodied technology transfer from production partners.

Table 15: Technology Transfers and Types of Innovation (Probit, Marginal Effects)

Panel A: Product Innovation	(1)	(2)	(3)	(4)
	Design	*Improve*	*Old tech*	*New tech*
R&D	18.25***	12.02**	12.37***	7.091**
	(4.681)	(5.052)	(4.374)	(3.204)
Buyer conducts supplier audit	0.039	0.013	0.020	-0.019
	(0.035)	(0.038)	(0.033)	(0.025)
Accept engineers from supplier	0.099***	0.073*	0.050	0.047*
	(0.038)	(0.042)	(0.037)	(0.028)
Send engineers to supplier	0.026	0.020	0.059	-0.006
	(0.040)	(0.043)	(0.039)	(0.031)
Accept engineers from buyer	-0.093**	-0.153***	-0.085**	-0.037
	(0.042)	(0.046)	(0.041)	(0.032)
Send engineers to buyer	0.021	0.022	-0.023	-0.015
	(0.041)	(0.044)	(0.038)	(0.030)
Collaborate with capital goods	0.094**	-0.012	0.072**	0.059**
	(0.037)	(0.038)	(0.034)	(0.026)
Receive training from capital goods	0.042	0.099***	0.032	0.017
	(0.036)	(0.038)	(0.034)	(0.025)
Receive an IPR license from others	0.037	0.154***	-0.037	0.027
	(0.041)	(0.046)	(0.037)	(0.031)
Panel B: Process innovation	(1)	(2)	(3)	(4)
	Production	*Quality*	*Cost*	*Delivery*
R&D	0.428	3.094*	6.564**	1.330
	(2.186)	(1.770)	(3.306)	(3.055)
Buyer conducts supplier audit	-0.017	0.010	0.015	0.037
	(0.016)	(0.015)	(0.027)	(0.024)
Accept engineers from supplier	0.022	0.013	-0.042	-0.027
	(0.016)	(0.015)	(0.027)	(0.023)
Send engineers to supplier	-0.022	-0.006	0.030	0.031
	(0.019)	(0.018)	(0.029)	(0.025)

Accept engineers from buyer	-0.010	-0.028*	-0.032	-0.074***
	(0.016)	(0.016)	(0.031)	(0.025)
Send engineers to buyer	-0.013	-0.011	0.089***	0.038
	(0.018)	(0.018)	(0.029)	(0.024)
Collaborate with capital goods	0.007	-0.003	0.083***	-0.041
	(0.015)	(0.014)	(0.023)	(0.025)
Receive training from capital goods	-0.024	0.015	-0.035	0.047*
	(0.016)	(0.016)	(0.026)	(0.025)
Receive an IPR license from others	0.012	0.059***	-0.095***	-0.068**
	(0.018)	(0.017)	(0.037)	(0.029)
Controlling for ownership of respondent	√	√	√	√
Controlling for main buyer's ownership	√	√	√	√
Controlling for main supplier's ownership	√	√	√	√

Note: N=875. Control variables for each regression are firm age, firm size, industry, and country. Ownerships are classified by local, MNE, and JV. Robust standard errors in brackets. ***<0.01, **<0.05, *<0.1.

Source: ERIA Establishment Survey 2012.

6. Discussion and Conclusion

6.1. Face–to–face Contacts through Embodied Technology Transfers

As Keller (2012) suggested, which type of knowledge transfer occurs in-house versus through a partner seems to be a promising and important question when we also look at innovation. This paper has investigated three items: (1) the detection of matching patterns between buyers and suppliers; (2) the presentation of differences in innovation across production chains; and (3) an analysis of the impacts of technology transfer on product and process innovation across similar chains. Simple descriptive statistics indicate a large gap between locally owned establishments and MNEs or JVs in the product and process improvements made and the technology sources used. However, more significant gaps can be found between local establishments by whether or not they conduct R&D. Local establishments that invest in R&D are more likely to be linked to international production networks and achieve more types of product and process improvements. Regression results find that there are huge differences in product and process innovation across production chains. In addition, these differences persist even within narrowly defined production partner's ownership. That is, the remaining factors which are usually hard–to–get could make a difference. In our setting, the differences in channels of embodied technology transfer are still important in explaining differences in product and process innovation.

Our investigation also suggests management practices taken by the respondents that may be effective in promoting process and product improvements. Among other practices, the introduction of new technology through licensing can create a difference in the chance for product improvement. IPRs are codified, so the transaction cost for IPRs can be cheaper than intangible knowledge. Paying IPR licensing fee contributes to quality improvement in existing product line-up and quality upgrading in current production management (see Column 2 of Panel A and Column 2 of Panel B of Table 15 again), but paying licensing fee for quality improvement means paying less attention to other functions, that is, there are negative impacts of IPR licensing on improvements in costs and delivery. We interpret this as a result of serious trade-off between two competing types of process innovation improvement in quality of production process and costs or delivery.

However, many establishments use in-person contacts to transfer or exchange technologies. The descriptive statistics show the effectiveness of face–to–face contacts including supplier audits and collaboration. We should emphasize that face–to–face contacts are important not only in the buyer-supplier relationship but also in relationships with capital goods producers, especially in the introduction of new products.

6.2. The Rationality of Depending on Face–to–face Contacts

The availability of face-to-face contacts can be affected not only by the respondent but also by their partners. The location of the partner could be a factor because technologies gained through face-to-face contacts are often intangible and non-codifiable. Almeida and Kogut (1999) and other studies suggest a high transaction cost of intangible knowledge tends to concentrate knowledge in a narrow geographical space. Our data shows that establishments with foreign partners are more likely to have face–to–face interactions. This does not, however, necessarily indicate that the establishment has overcome the physical distance. The lack of agglomeration of capable firms in the survey countries could necessitate international face–to–face transactions. Establishments with partners that conduct R&D, who are owned by foreign interests, or who have 200 or employees are more likely to interact with their partners face to face. Capital ties also affect the amount of face–to–face contact. On the other hand, supplier audits and training provided by partners are important opportunities for establishments without capital ties, which are less capable of making improvements.

6.3. Implications for Industrial Policy

The data from this survey enable us to investigate to whom and how is technology transferred and make policy recommendations for accelerating technology transfer in the ASEAN Economic Community. These findings suggest a demand for policies that serve to develop a business environment for local firms that allows them to invest R&D and other innovative activities, as well as to decrease the cost of moving people in geographical space. More rigorous econometric analysis is indispensable for evidence–based policy–making. Our findings emphasize the necessity of policies that promote R&D and other innovative activities by local firms and that decrease the cost of moving engineers in geographical space. This paper also provides the basic framework for analyzing the relationship between innovation and technology transfer in B2B markets. It is also necessary for us to increase our understanding of technology sourcing patterns in local–local–local linkages, the characteristics of local firms which invest in R&D, and the role of public institutions that serve local firms both with and without R&D. Although we control for industry and country differentials in our regression, we should strive for a deeper understanding of variations within individual industries or countries.

In addition to these, it is crucial to address the issue how knowledge transfers *within and across* borders could happen differently with firm–to–firm trade. The dataset of this paper also enables us to study an underlying mechanism of international technology diffusion which firm–to–firm trade drives incoming and outgoing knowledge transfers and how these knowledge diffusions lever firms in emerging economies more innovative (see Keller 2004). All of these issues will be investigated in the next step of the research.

References

Aitken, B. J. and A. E. Harrison (1999), 'Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela', *American Economic Review* 89(3), pp.605–18.

Almeida, P., and B. Kogut (1999), 'Localization of Knowledge and the Mobility of Engineers in Regional Networks', *Management Science*, 45(7), pp.905–917.

Andersen, T. B., and C. J. Dalgaard (2011), 'Flows of People, Flows of Ideas, and the Inequality of Nations', *Journal of Economic Growth*, 16(1), pp. 1–32.

Ando, M. and F. Kimura (2005), 'The Formation of International Production and Distribution Networks in East Asia', NBER Chapters in *International Trade in East Asia*, NBER-East Asia Seminar on Economics, 14, pp.177–216.

Antras, P. and D. Chor (2013), 'Organizing the Global Value Chain', (Forthcoming), *Econometrica.*

Antras, P. and E. Rossi-Hansberg (2009), 'Organizations and Trade', *Annual Review of Economics*, 1, pp.43–64.

Atalay, E., Hortacsu, A. and C. Syverson (2013), 'Vertical Integration and Input Flows', forthcoming, *American Economic Review*.

Blalock, G. and P. J. Gertler (2008), 'Welfare Gains from Foreign Direct Investment through Technology Transfer to Local Suppliers', *Journal of International Economics* 74, pp. 402–21.

Bloom, N. and J. Van Reenen (2007), 'Measuring and Explaining Management Practices across Firms and Countries', *Quarterly Journal of Economics* 122(4), pp.351–408.

Cohen, W. M., and D.A. Levinthal (1990), 'Absorptive Capacity: A New Perspective on Learning and Innovation', *Administrative Science Quarterly*, 35(1), pp. 128–152.

Costinot, A., J. Vogel, and S. Wang (2013), 'An Elementary Theory of Global Supply Chains', The *Review of Economic Studies,* 80(1), pp.109–144.

Dowrick, S., and M. Tani (2011), 'International Business Visits and the Technology Frontier', *Economic Letters*, 110 (3), pp. 209–212.

Fally, T. (2012), 'Production Staging: Measurement and Facts', *mimeo*.

Gorodnichenko, Y., J. Svejnar, and K. Terrell (2010), 'Globalization and Innovation in Emerging Markets', *American Economic Journal*, 2(2), pp. 194–226.

Hayakawa, K., T. Machikita, and F. Kimura (2012), 'Globalization and Productivity: A Survey of Firm-Level Analysis', *Journal of Economic Surveys*, 26(2), pp. 332–350

Hiller, S. (2013), 'Does Immigrant Employment Matter for Export Sales? Evidence from Denmark', *Review of World Economics*, 149(2), pp. 369–394.

Hummels, D., J. Ishii, and K. M. Yi (2001), 'The Nature and Growth of Vertical Specialization in World Trade', *Journal of International Economics*, 54(1), pp.75–96.

Hunt, J., and M. Gauthier-Loiselle (2010), 'How Much Does Immigration Boost Innovation?', *American Economic Journal: Macroeconomics*, 2(2), pp. 31–56.

Jaffe, A. B., M. Trajtenberg, and R. Henderson (1993), 'Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations', *Quarterly Journal of Economics*, 108 (3), pp.577–598.

Javorcik, B. (2004), 'Does Foreign Direct Investment Increase the Productivity of Domestic Firms? In Search of Spillovers through Backward Linkages', *American Economic Review* 94(3), pp. 605–27.

Johnson, R. C., and G. Noguera (2012a), 'Proximity and Production Fragmentation', *The American Economic Review: Papers and Proceedings*, 102(3), pp. 407–411.

Johnson, R. C., and G. Noguera (2012b), 'Accounting for Intermediates: Production Sharing and Trade in Value Added', *Journal of International Economics*, 86(2), pp. 224–236.

Johnson, R. C., and G. Noguera (2012c), 'Fragmentation and Trade in Value Added over Four Decades', NBER Working Paper No. 18186.

Jones, R. W., and H. Kierzkowski (1990), 'The Role of Services in Production and International Trade: A Theoretical Framework', in Jones, R. W. and A. O. Krueger (eds.) *The Political Economy of International Trade: Essays in Honour of Robert E. Baldwin*. Oxford: Basil Blackwell.

Jordaan, J. A. (2011), 'FDI, Local Sourcing, and Supportive Linkages with Domestic Suppliers: The Case of Monterrey, *Mexico'*, *World Development*, 39(4), pp. 620–632.

Keller, W. (2004), 'International Technology Diffusion', *Journal of Economic Literature*, 42(3), pp. 752–782.

Keller, W. (2012), 'The Transfer of Knowledge across Countries', *NBER Reporter*, No.1, 2012.

Kimura, F. (2006), 'International Production and Distribution Networks in East Asia: Eighteen Facts, Mechanics, and Policy Implications', *Asian Economic Policy Review*, 1(2), pp. 326- 344.

Kimura, F. (2009), 'The Spatial Structure of Production/ Distribution Networks and Its Implication for Technology Transfers and Spillovers', ERIA Discussion Paper 2009-02, Jakarta: Economic Research Institute for ASEAN and East Asia (ERIA).

Kimura, F. and A. Obashi (2010), 'International Production Networks in Machinery Industries: Structure and Its Evolution', ERIA Discussion Paper 2010-09, Jakarta: Economic Research Institute for ASEAN and East Asia (ERIA).

Kimura, F. and A. Obashi (2011), 'Production Networks in East Asia: What We Know So Far', ADBI Working Papers 320, Manila: Asian Development Bank Institute.

Kimura, F. and M. Ando (2003), 'Fragmentation and Agglomeration Matter: Japanese Multinationals in Latin America and East Asia', *The North American Journal of Economics and Finance*, 14(3), pp. 287–317.

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

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

Lee, C. (2011), 'Knowledge Flows, Organization and Innovation: Firm-Level Evidence from Malaysia', in Hahn, C. H. and D. Narjoko (eds.), *Globalization and Innovation in East Asia*. ERIA Research Project Report 2010-04, Jakarta: ERIA, pp.370-409.

Machikita, T., and Y. Ueki (2011a), 'Innovation in Linked and Non-linked Firms: Effects of Variety of Linkages in East Asia', *International Journal of Institutions and Economies*, 3(1), pp. 77–102.

Machikita, T., and Y. Ueki (2011b), 'The Impacts of Face-to-face and Frequent Interactions on Innovation: Upstream-Downstream Relations', *International Journal of Institutions and Economies*, 3(3), pp. 519–548.

Machikita, T., and Y. Ueki (2012a), 'Interactive Learning-driven Innovation within Production Chains in Developing Economies', *International Journal of Technological Learning, Innovation, and Development*, 5(4), pp.346–366.

Machikita, T., and Y. Ueki (2012b), 'Impacts of Incoming Knowledge on Product Innovation: Econometric Case Studies of Technology Transfer of Auto-related Industries in Developing Economies', *Asian Journal of Technology Innovation*, 20(S1), pp. 9–27.

Machikita, T., and Y. Ueki (2013), 'Knowledge Transfer Channels to Vietnam for Process Improvement', *Management Decision*, 51(5), pp. 954–972.

Obashi, A (2010b), 'Stability of International Production Networks: Is East Asia Special?', *International Journal of Business and Development Studies*, 2(1), pp. 63–94.

Obashi, A. (2009), 'Resiliency of Production Networks in Asia: Evidence from the Asian Crisis', ERIA Discussion Paper 2009-21, Jakarta: Economic Research Institute for ASEAN and East Asia (ERIA).

Obashi, A. (2010a), 'Stability of Production Networks in East Asia: Duration and Survival of Trade', *Japan and the World Economy*, 22(1), pp. 21–30.

Tsuji, M., H. Idota, Y. Akematsu, and T. Bunno (2013), 'Innovation in ASEAN Economies: Internal Capability, External Linkages and Funding Sources', *mimeo*, ERIA.

Ueki, Y. (2013), 'Supply Chain Collaboration and Responsiveness: A Comparison between Thai Automotive and Electronics Industries', IDE DP No.416.

Zahra, S. A., and G. George (2002), 'Absorptive Capacity: A Review, Reconceptualization, and Extension', *The Academy of Management Review*, 27(2), pp. 185–203.

ERIA Discussion Paper Series

No.	Author(s)	Title	Year
2013-26	Tomohiro MACHIKITA and Yasushi UEKI	Who Disseminates Technology to Whom and Why: Evidence from Buyer-Seller Business Networks	Nov 2013
2013-25	Fukunari KIMURA	Reconstructing the Concept of "Single Market a Production Base" for ASEAN beyond 2015	Oct 2013
2013-24	Olivier CADOT Ernawati MUNADI Lili Yan ING	Streamlining NTMs in ASEAN: The Way Forward	Oct 2013
2013-23	Charles HARVIE, Dionisius NARJOKO, Sothea OUM	Small and Medium Enterprises' Access to Finance: Evidence from Selected Asian Economies	Oct 2013
2013-22	Alan Khee-Jin TAN	Toward a Single Aviation Market in ASEAN: Regulatory Reform and Industry Challenges	Oct 2013
2013-21	Hisanobu SHISHIDO, Shintaro SUGIYAMA, Fauziah ZEN	Moving MPAC Forward: Strengthening Public-Private Partnership, Improving Project Portfolio and in Search of Practical Financing Schemes	Oct 2013
2013-20	Barry DESKER, Mely CABALLERO-ANTHONY, Paul TENG	Thought/Issues Paper on ASEAN Food Security: Towards a more Comprehensive Framework	Oct 2013
2013-19	Toshihiro KUDO, Satoru KUMAGAI, So UMEZAKI	Making Myanmar the Star Growth Performer in ASEAN in the Next Decade: A Proposal of Five Growth Strategies	Sep 2013
2013-18	Ruperto MAJUCA	Managing Economic Shocks and Macroeconomic Coordination in an Integrated Region: ASEAN Beyond 2015	Sep 2013
2013-17	Cassy LEE and Yoshifumi FUKUNAGA	Competition Policy Challenges of Single Market and Production Base	Sep 2013
2013-16	Simon TAY	Growing an ASEAN Voice? : A Common Platform in Global and Regional Governance	Sep 2013
2013-15	Danilo C. ISRAEL and Roehlano M. BRIONES	Impacts of Natural Disasters on Agriculture, Food Security, and Natural Resources and Environment in	Aug 2013

No.	Author(s)	Title	Year
		the Philippines	
2013-14	Allen Yu-Hung LAI and Seck L. TAN	Impact of Disasters and Disaster Risk Management in Singapore: A Case Study of Singapore's Experience in Fighting the SARS Epidemic	Aug 2013
2013-13	Brent LAYTON	Impact of Natural Disasters on Production Networks and Urbanization in New Zealand	Aug 2013
2013-12	Mitsuyo ANDO	Impact of Recent Crises and Disasters on Regional Production/Distribution Networks and Trade in Japan	Aug 2013
2013-11	Le Dang TRUNG	Economic and Welfare Impacts of Disasters in East Asia and Policy Responses: The Case of Vietnam	Aug 2013
2013-10	Sann VATHANA, Sothea OUM, Ponhrith KAN, Colas CHERVIER	Impact of Disasters and Role of Social Protection in Natural Disaster Risk Management in Cambodia	Aug 2013
2013-09	Sommarat CHANTARAT, Krirk PANNANGPETCH, Nattapong PUTTANAPONG, Preesan RAKWATIN, and Thanasin TANOMPONGPHANDH	Index-Based Risk Financing and Development of Natural Disaster Insurance Programs in Developing Asian Countries	Aug 2013
2013-08	Ikumo ISONO and Satoru KUMAGAI	Long-run Economic Impacts of Thai Flooding: Geographical Simulation Analysis	July 2013
2013-07	Yoshifumi FUKUNAGA and Hikaru ISHIDO	Assessing the Progress of Services Liberalization in the ASEAN-China Free Trade Area (ACFTA)	May 2013
2013-06	Ken ITAKURA, Yoshifumi FUKUNAGA, and Ikumo ISONO	A CGE Study of Economic Impact of Accession of Hong Kong to ASEAN-China Free Trade Agreement	May 2013
2013-05	Misa OKABE and Shujiro URATA	The Impact of AFTA on Intra-AFTA Trade	May 2013
2013-04	Kohei SHIINO	How Far Will Hong Kong's Accession to ACFTA will Impact on Trade in Goods?	May 2013
2013-03	Cassey LEE and Yoshifumi FUKUNAGA	ASEAN Regional Cooperation on Competition Policy	Apr 2013
2013-02	Yoshifumi FUKUNAGA	Taking ASEAN+1 FTAs towards the RCEP:	Jan

No.	Author(s)	Title	Year
	and Ikumo ISONO	A Mapping Study	2013
2013-01	Ken ITAKURA	Impact of Liberalization and Improved Connectivity and Facilitation in ASEAN for the ASEAN Economic Community	Jan 2013
2012-17	Sun XUEGONG, Guo LIYAN, Zeng ZHENG	Market Entry Barriers for FDI and Private Investors: Lessons from China's Electricity Market	Aug 2012
2012-16	Yanrui WU	Electricity Market Integration: Global Trends and Implications for the EAS Region	Aug 2012
2012-15	Youngho CHANG, Yanfei LI	Power Generation and Cross-border Grid Planning for the Integrated ASEAN Electricity Market: A Dynamic Linear Programming Model	Aug 2012
2012-14	Yanrui WU, Xunpeng SHI	Economic Development, Energy Market Integration and Energy Demand: Implications for East Asia	Aug 2012
2012-13	Joshua AIZENMAN, Minsoo LEE, and Donghyun PARK	The Relationship between Structural Change and Inequality: A Conceptual Overview with Special Reference to Developing Asia	July 2012
2012-12	Hyun-Hoon LEE, Minsoo LEE, and Donghyun PARK	Growth Policy and Inequality in Developing Asia: Lessons from Korea	July 2012
2012-11	Cassey LEE	Knowledge Flows, Organization and Innovation: Firm-Level Evidence from Malaysia	June 2012
2012-10	Jacques MAIRESSE, Pierre MOHNEN, Yayun ZHAO, and Feng ZHEN	Globalization, Innovation and Productivity in Manufacturing Firms: A Study of Four Sectors of China	June 2012
2012-09	Ari KUNCORO	Globalization and Innovation in Indonesia: Evidence from Micro-Data on Medium and Large Manufacturing Establishments	June 2012
2012-08	Alfons PALANGKARAYA	The Link between Innovation and Export: Evidence from Australia's Small and Medium Enterprises	June 2012
2012-07	Chin Hee HAHN and Chang-Gyun PARK	Direction of Causality in Innovation-Exporting Linkage: Evidence on Korean Manufacturing	June 2012
2012-06	Keiko ITO	Source of Learning-by-Exporting Effects: Does Exporting Promote Innovation?	June 2012
2012-05	Rafaelita M. ALDABA	Trade Reforms, Competition, and Innovation in the	June

No.	Author(s)	Title	Year
		Philippines	2012
2012-04	Toshiyuki MATSUURA and Kazunobu HAYAKAWA	The Role of Trade Costs in FDI Strategy of Heterogeneous Firms: Evidence from Japanese Firm-level Data	June 2012
2012-03	Kazunobu HAYAKAWA, Fukunari KIMURA, and Hyun-Hoon LEE	How Does Country Risk Matter for Foreign Direct Investment?	Feb 2012
2012-02	Ikumo ISONO, Satoru KUMAGAI, Fukunari KIMURA	Agglomeration and Dispersion in China and ASEAN: A Geographical Simulation Analysis	Jan 2012
2012-01	Mitsuyo ANDO and Fukunari KIMURA	How Did the Japanese Exports Respond to Two Crises in the International Production Network?: The Global Financial Crisis and the East Japan Earthquake	Jan 2012
2011-10	Tomohiro MACHIKITA and Yasushi UEKI	Interactive Learning-driven Innovation in Upstream-Downstream Relations: Evidence from Mutual Exchanges of Engineers in Developing Economies	Dec 2011
2011-09	Joseph D. ALBA, Wai-Mun CHIA, and Donghyun PARK	Foreign Output Shocks and Monetary Policy Regimes in Small Open Economies: A DSGE Evaluation of East Asia	Dec 2011
2011-08	Tomohiro MACHIKITA and Yasushi UEKI	Impacts of Incoming Knowledge on Product Innovation: Econometric Case Studies of Technology Transfer of Auto-related Industries in Developing Economies	Nov 2011
2011-07	Yanrui WU	Gas Market Integration: Global Trends and Implications for the EAS Region	Nov 2011
2011-06	Philip Andrews-SPEED	Energy Market Integration in East Asia: A Regional Public Goods Approach	Nov 2011
2011-05	Yu SHENG, Xunpeng SHI	Energy Market Integration and Economic Convergence: Implications for East Asia	Oct 2011
2011-04	Sang-Hyop LEE, Andrew MASON, and Donghyun PARK	Why Does Population Aging Matter So Much for Asia? Population Aging, Economic Security and Economic Growth in Asia	Aug 2011
2011-03	Xunpeng SHI,	Harmonizing Biodiesel Fuel Standards in East Asia:	May

No.	Author(s)	Title	Year
	Shinichi GOTO	Current Status, Challenges and the Way Forward	2011
2011-02	Hikari ISHIDO	Liberalization of Trade in Services under ASEAN+n : A Mapping Exercise	May 2011
2011-01	Kuo-I CHANG, Kazunobu HAYAKAWA Toshiyuki MATSUURA	Location Choice of Multinational Enterprises in China: Comparison between Japan and Taiwan	Mar 2011
2010-11	Charles HARVIE, Dionisius NARJOKO, Sothea OUM	Firm Characteristic Determinants of SME Participation in Production Networks	Oct 2010
2010-10	Mitsuyo ANDO	Machinery Trade in East Asia, and the Global Financial Crisis	Oct 2010
2010-09	Fukunari KIMURA Ayako OBASHI	International Production Networks in Machinery Industries: Structure and Its Evolution	Sep 2010
2010-08	Tomohiro MACHIKITA, Shoichi MIYAHARA, Masatsugu TSUJI, and Yasushi UEKI	Detecting Effective Knowledge Sources in Product Innovation: Evidence from Local Firms and MNCs/JVs in Southeast Asia	Aug 2010
2010-07	Tomohiro MACHIKITA, Masatsugu TSUJI, and Yasushi UEKI	How ICTs Raise Manufacturing Performance: Firm-level Evidence in Southeast Asia	Aug 2010
2010-06	Xunpeng SHI	Carbon Footprint Labeling Activities in the East Asia Summit Region: Spillover Effects to Less Developed Countries	July 2010
2010-05	Kazunobu HAYAKAWA, Fukunari KIMURA, and Tomohiro MACHIKITA	Firm-level Analysis of Globalization: A Survey of the Eight Literatures	Mar 2010
2010-04	Tomohiro MACHIKITA and Yasushi UEKI	The Impacts of Face-to-face and Frequent Interactions on Innovation: Upstream-Downstream Relations	Feb 2010
2010-03	Tomohiro MACHIKITA and Yasushi UEKI	Innovation in Linked and Non-linked Firms: Effects of Variety of Linkages in East Asia	Feb 2010

No.	Author(s)	Title	Year
2010-02	Tomohiro MACHIKITA and Yasushi UEKI	Search-theoretic Approach to Securing New Suppliers: Impacts of Geographic Proximity for Importer and Non-importer	Feb 2010
2010-01	Tomohiro MACHIKITA and Yasushi UEKI	Spatial Architecture of the Production Networks in Southeast Asia: Empirical Evidence from Firm-level Data	Feb 2010
2009-23	Dionisius NARJOKO	Foreign Presence Spillovers and Firms' Export Response: Evidence from the Indonesian Manufacturing	Nov 2009
2009-22	Kazunobu HAYAKAWA, Daisuke HIRATSUKA, Kohei SHIINO, and Seiya SUKEGAWA	Who Uses Free Trade Agreements?	Nov 2009
2009-21	Ayako OBASHI	Resiliency of Production Networks in Asia: Evidence from the Asian Crisis	Oct 2009
2009-20	Mitsuyo ANDO and Fukunari KIMURA	Fragmentation in East Asia: Further Evidence	Oct 2009
2009-19	Xunpeng SHI	The Prospects for Coal: Global Experience and Implications for Energy Policy	Sept 2009
2009-18	Sothea OUM	Income Distribution and Poverty in a CGE Framework: A Proposed Methodology	Jun 2009
2009-17	Erlinda M. MEDALLA and Jenny BALBOA	ASEAN Rules of Origin: Lessons and Recommendations for the Best Practice	Jun 2009
2009-16	Masami ISHIDA	Special Economic Zones and Economic Corridors	Jun 2009
2009-15	Toshihiro KUDO	Border Area Development in the GMS: Turning the Periphery into the Center of Growth	May 2009
2009-14	Claire HOLLWEG and Marn-Heong WONG	Measuring Regulatory Restrictions in Logistics Services	Apr 2009
2009-13	Loreli C. De DIOS	Business View on Trade Facilitation	Apr 2009
2009-12	Patricia SOURDIN and Richard POMFRET	Monitoring Trade Costs in Southeast Asia	Apr 2009
2009-11	Philippa DEE and Huong DINH	Barriers to Trade in Health and Financial Services in ASEAN	Apr 2009

No.	Author(s)	Title	Year
2009-10	Sayuri SHIRAI	The Impact of the US Subprime Mortgage Crisis on the World and East Asia: Through Analyses of Cross-border Capital Movements	Apr 2009
2009-09	Mitsuyo ANDO and Akie IRIYAMA	International Production Networks and Export/Import Responsiveness to Exchange Rates: The Case of Japanese Manufacturing Firms	Mar 2009
2009-08	Archanun KOHPAIBOON	Vertical and Horizontal FDI Technology Spillovers:Evidence from Thai Manufacturing	Mar 2009
2009-07	Kazunobu HAYAKAWA, Fukunari KIMURA, and Toshiyuki MATSUURA	Gains from Fragmentation at the Firm Level: Evidence from Japanese Multinationals in East Asia	Mar 2009
2009-06	Dionisius A. NARJOKO	Plant Entry in a More LiberalisedIndustrialisationProcess: An Experience of Indonesian Manufacturing during the 1990s	Mar 2009
2009-05	Kazunobu HAYAKAWA, Fukunari KIMURA, and Tomohiro MACHIKITA	Firm-level Analysis of Globalization: A Survey	Mar 2009
2009-04	Chin Hee HAHN and Chang-Gyun PARK	Learning-by-exporting in Korean Manufacturing: A Plant-level Analysis	Mar 2009
2009-03	Ayako OBASHI	Stability of Production Networks in East Asia: Duration and Survival of Trade	Mar 2009
2009-02	Fukunari KIMURA	The Spatial Structure of Production/Distribution Networks and Its Implication for Technology Transfers and Spillovers	Mar 2009
2009-01	Fukunari KIMURA and Ayako OBASHI	International Production Networks: Comparison between China and ASEAN	Jan 2009
2008-03	Kazunobu HAYAKAWA and Fukunari KIMURA	The Effect of Exchange Rate Volatility on International Trade in East Asia	Dec 2008
2008-02	Satoru KUMAGAI, Toshitaka GOKAN, Ikumo ISONO, and Souknilanh KEOLA	Predicting Long-Term Effects of Infrastructure Development Projects in Continental South East Asia: IDE Geographical Simulation Model	Dec 2008

No.	Author(s)	Title	Year
2008-01	Kazunobu HAYAKAWA, Fukunari KIMURA, and Tomohiro MACHIKITA	Firm-level Analysis of Globalization: A Survey	Dec 2008