ADBI Working Paper Series

Impact of Production Linkages on Industrial Upgrading in ASEAN, the People's Republic of China, and India: Organizational Evidence of a Global Supply Chain

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No. 399
November 2012

Asian Development Bank Institute

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This paper is based on discussions at two inception workshops—held on 24–25 January 2011 in Tokyo and 18–20 August 2011 in Delhi—as part of ADBI's research project, Role of Key Emerging Economies—ASEAN, the People's Republic of China (PRC), and India—for a Balanced, Sustainable, and Resilient Asia. The authors especially acknowledge support from the Economic Research Institute for the Association of Southeast Asian Nations (ASEAN) and East Asia for conducting research. This project has also been carried out with cooperation from the Center for Strategic and International Studies of Indonesia, the Philippine Institute for Development Studies, the Sirindhorn International Institute of Technology of Thammasat University (Thailand), and the Institute for Industry Policy and Strategy of the Ministry of Industry and Trade of Viet Nam. The authors also thank Fukunari Kimura and So Umezaki for their continuous support.

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Suggested citation:

Machikita, T and Y. Ueki. 2012 Impact of Production Linkages on Industrial Upgrading in ASEAN, the People's Republic of China, and India: Organizational Evidence of a Global Supply Chain. ADBI Working Paper 399. Tokyo: Asian Development Bank Institute. Available: http://www.adbi.org/working-paper/2012/11/30/5343.impact.prod.linkages.upgrading.asean.prc.india/

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Abstract

This paper presents a simple model of industrial upgrading as a result of backward and forward information linkages between upstream and downstream relations. It also serves as an empirical investigation of the impact of mutual knowledge exchange on the knowledge production function using data on firms' self-reported customers and suppliers. Evidence from interconnected firms in Indonesia, Thailand, Philippines, and Viet Nam suggests that there are strong spillover effects between downstream and upstream firms in terms of international standard certification. The degree of product and process innovation is quite diverse across manufacturing firms within a local supply chain and within a global supply chain. Firms are likely to achieve product innovation if they have customers in foreign countries. Customers in Japan and the People's Republic of China play an important product innovation role for firms in Association of Southeast Asian Nations (ASEAN) economies, and customers in the United States or Europe play an important industrial upgrading role in connecting ASEAN firms with the global market.

JEL Classification: O31, O32, R12

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1. INTRODUCTION

What drives product and process innovation? Based on the fact that most production processes are sequential, our answer here is that product and process innovation do not happen within a firm—they should happen between (final-good) producers and suppliers within a supply chain. Furthermore, since manufacturing processes have become global and location of production processes has been fragmented across developed economies and across developing economies, product and process innovation might happen across firms in developed and emerging economies such as the Association of Southeast Asian Nations (ASEAN) economies, the People's Republic of China (PRC), and India (hereafter ACI).

Since research and development (R&D) within a single firm is experimental to the firms, it is not enough to introduce new goods and processes to the firms or to the market. In addition, the fact that firms are interconnected and interdependent makes us think about the impacts of external resources on product and process innovation. New technologies or products for firms usually come from (i) interfirm transfers through employee mobility across firms, or (ii) interfirm learning within pairs of firms working together in a vertical contracting relationship.

A few empirical papers test whether interfirm learning is relation-specific. Kellogg (2011) finds that productivity of an oil production company and its drilling contractor increases with the joint experience. The productivity of such relation-specific learning is closely related to the contracting behavior of two parties. Relation specificity also applies to the pattern of trade. Nunn (2007) finds that countries with good contract enforcement can specialize in the manufacturing production processes for which relation-specific investments are most important. This suggests that countries with good contract enforcement can add more value to production processes.

Interfirm transfers of knowledge should be analyzed within a framework of industrial upgrading. Testing such a framework in the context of ACI countries, we find that there are significant and sizable impacts of people flows on product and process innovation among firms in ASEAN economies. Contrary to empirical work, using the case of the Nordic information technology industry by Møen (2005, 2007)—which tests whether (i) technical staff in R&D-intensive firms receive lower wages in the early stages and higher wages in the later stages, and (ii) subsidies to firms that fail stimulate growth elsewhere through labor mobility—we do not rely on human capital and employee flow across firms. Recent empirical works by Agarwal, Echambadi, Franco, and Sarkar (2004), and Franco and Filson (2006), examine the relationship between knowledge diffusion through employee mobility across employers and firm formation. But this paper does not consider entrepreneurial ventures of former employees.

Our focus here is vertical linkages between upstream and downstream firms which have an incentive to send and receive own employees to achieve product and process innovation within a (global) supply chain. Among several channels of technology transfer, vertical linkages have been emphasized in the recent empirical research into the knowledge transmission mechanism between upstream and downstream firms, in the context of developing and emerging economies.

For example, Aitken and Harrison (1999) show positive impacts of foreign equity participation on plant productivity for small enterprises using data on Venezuelan plants. They also find foreign investment negatively affects the productivity of domestic plants. They conclude that the net gain from foreign direct investment is quite small if we take into account the two offsetting effects. On the other hand, Javorcik (2004) and Blalock and Gertler (2008) find backward linkage impacts in terms of productivity growth for local suppliers from multinational enterprise

(MNE) customers by using the share of MNEs in downstream sectors as an explanatory variable. Blalock and Gertler claim that there is a sizable technology transfer to upstream firms from downstream MNEs behind empirical estimates of the relationship between the share of MNEs in downstream firms and productivity growth.

Contrary to Aitken and Harrison (1999), Javorcik (2004), and Blalock and Gertler (2008), this paper surveys direct evidence that precisely captures the knowledge transmission mechanism through interaction among local producers and MNEs. We can infer who transfers technologies to whom. Our paper attempts to fill the gap, utilizing firms' self-reported data on customer–supplier relationships. Machikita and Ueki (2011a and 2011b) also utilize the firm's self-reported customers and suppliers data to study the knowledge flows within a supply chain. First, Machikita and Ueki (2011a) finds that more varieties of information linkages achieve more types of innovations showing complementarities between internal and external sources of knowledge. In-house R&D activities, internal resources, and linkages with local firms and foreign firms play a role in reducing the costs of product and process innovation and search costs for finding new suppliers and customers. Second, Machikita and Ueki (2011b) shows firms that dispatched engineers to customers achieved more product and process innovations than firms that did not. Just-in-time relationship is effective for dealing with process innovation, but such strong complementarities as Just-in-time are not effective for product innovation.

The developing economies in ASEAN, the PRC, and India have undergone a major transformation over the past three decades. Foreign direct investment has grown while aggregate output and market size have increased. Despite huge urban congestion, it appears that agglomerations of industry have grown. These changes in spatial economy have been accompanied by declining transport and service link costs within and across agglomerations, leading to economic integration. As economies integrate, firms and plants may extend their channel to global markets or sources. At the same time, economic integration has led to a pro-competitive effect amongst middle-income countries in ASEAN such as Indonesia, the Philippines, Thailand, and Viet Nam that compete with lower-price and large home-market countries such as the PRC and India. As competition grows within an integrated economy, firms and plants with less productivity are forced to exit and/or upgrade to remain profitable. The key is industrial upgrading through product and process innovation in developing economies, especially countries in ASEAN.

How do industries upgrade in ASEAN countries? Our focus to this question concentrates on production linkages. For instance, utilizing networks allows industries to sustain higher levels of production processes and profits. That is, the degree of innovation may be expressed with varying degrees of management practice on utilizing production networks. The issue of how to enhance innovation capability with internal and external resources in a networked economy remains unsolved. This empirical research provides microeconomic evidence of the relationship between innovation and linkages. This framework also helps to evaluate public policy related to industrial upgrading in a networked economy.

This paper focuses on the dynamics of two-way information flow from downstream to upstream (backward linkage) and from upstream to downstream (forward linkage). If production partners have a global market and knowledge, they set out to share their technical knowledge of the production process, and respondent firms try to meet the requirement and learn or upgrade. For example, dispatching engineers to partners seems to be teaching the activities for the firms. If these firms are able to gain professional knowledge through partners, then the learning strategy is a better choice. To identify which flows become learning and which become teaching, direct information from the "teachers" and "students" is helpful. Due to the limitations of this paper, it is assumed that the teacher receives benefits from the student. On the other hand, the student

learns about new production processes, materials, and markets from the teacher. This has been tested to determine the implication for upstream–downstream relations.

Our testable implications are as follows. First, there is a chain reaction of upgrading from producers to suppliers within a production chain. Second, compared to less productive producers, more productive producers require higher levels of process upgrading to suppliers for ensuring and selling higher quality outputs toward the larger and developed market. Third, more productive suppliers also require higher levels of process upgrading to final-good producers for ensuring and maximizing the market size. This also increases surplus division for higher productive suppliers in vertical market. Finally, the investment and innovation behavior of suppliers is increasing their market size.

We find the following four results. First, manufacturing firms are more likely to require or be required to comply with International Standard (ISO9000 or 14001) if they have MNE or joint-venture production partners. Second, we find backward information linkages. When MNEs or joint-venture customers require ISO compliance of respondent firms, they also require ISO compliance of upstream suppliers. Third, we find forward linkages. Firms are likely to require ISO compliance of customers and dispatch their own workers to customers if they have MNE or joint-venture suppliers. These three results support our testable predictions. Finally, firms are likely to achieve product innovation in the domestic market if they have customers in ASEAN. On the other hand, firms are likely to achieve product innovation based on new technologies or product innovation in the outside market, especially the United States (US) and European Union (EU), if they have customers outside Indonesia, the Philippines, Thailand, and Viet Nam. This also clearly supports our testable prediction.

The next section provides a brief review of the literature. Section 2 presents background evidence, theoretical framework, and testable implications. Section 3 describes the data on firms' self-reported customers and suppliers. This data set provides the evidence for organizational changes in the global value chain network. Section 4 presents the results of information flows within a global supply chain. We demonstrate the information spillovers from downstream to upstream and vice versa. Sections 5 and 6 provide the evidence of product and process innovation. Section 7 discusses the evidence-based policymaking. Section 8 concludes the paper.

2. RELATED LITERATURE

This paper is related to three fields of literature. The first is the theory of knowledge creation through mutual learning. The theoretical background of this paper explains a model of learning and knowledge creation through face-to-face communication among different types of agents, as described by Berliant and Fujita (2008, 2009); Fujita (2007); and Berliant, Reed, and Wang (2006). The central concern of these models is how diversity of knowledge among members could affect the decision on collaboration and its outcome. Their fundamental modeling approach has been applied to the question of how the cultural background of members affects a city system (Ottaviano and Prarolo 2009). In that sense, diversity of knowledge among firms and exchange of knowledge between firms could have aggregate implications.

Goyal (2007) and Jackson (2008) showed the measuring and theoretical framework of information diffusion through networks. However, it has been difficult to capture and quantify the information flow between agents—one of most important research areas in development economics, labor economics, and industrial organization—specifically the study of the network impact of productivity growth. In particular, Conley and Udry (2010) provides the framework and

evidence to study the information channels of productivity growth for pineapple farmers in Ghana.

Second, this paper is related to international technology transfer. Productivity growth could differ between firms depending on the types of production or intellectual linkages that they have. It is also true that productivity changes on market entry or market exit, especially when the firm is located central to the production network. Given this situation, the dense network in East Asia could provide a new insight into causes and consequences of information diffusion among local firms. This paper aims to study the innovation impacts of mutual knowledge exchanges among interconnected firms in the field of industrial development.

This paper is also related to the field of international technology diffusion and international knowledge production. Keller (2004) gave an overview of the cause and consequences of technology diffusion across countries. Kerr (2008, 2010) and Kerr and Lincoln (2010) studied the role of ethnic scientific communities in technology diffusion to match ethnic scientists' names with individual patent records. Information of demand and technologies could be easily exchanged between manufacturers and suppliers within a (international) production chain, but information exchanges are not always in "encoded" form (Polanyi 1966, 1967). Communication between firms and their partners are not well facilitated when demand and technologies become complicated. The same applies to knowledge production within academia. First, team production achieves more cited research than do individuals (Wuchty, Jones, and Uzzi, 2007) across all fields of natural science, social science, and the arts and humanities. Second, teamwork in science is done by not only multiuniversity collaborations but also stratified groups (Wuchty, Jones, and Uzzi, 2008). Rosenblat and Mobius (2004) studied the impacts of the rise of the internet on international collaboration.

Third, this paper is related to organizational economics and industrial organization in networked economies. Bloom and van Reenen (2007) emphasize that differences in management practices play a crucial role in productivity dispersion within a country and across countries. Bloom et al. (2010) also provide the evidence of modern management practices on productivity upgrading by running a management field experiment on large Indian textile firms. Based on random assignment of providing free consulting on management practices, their findings showed that treated factories not only achieved product upgrading but were also more profitable than control factories. This study concludes that informational barriers can explain the lack of adoption of profitable practices.

Hortacsu and Syverson (2009) used the importance of intangible inputs, such as managerial oversight within the firm, to show that vertical ownership is not usually used to facilitate transfers of goods in the production chain. They concluded that the central motivation for owning production chains is the more efficient transfer of knowledge of production and information on markets. This motivation is closely related to the concept of "adaptive organization." Dessein and Santos (2006) theoretically analyze the complementarities between the level of adaptation to a changing environment, coordination, and the extent of specialization. Production chains within firms help the firm to collect information on markets and use it for production, and vice versa. Therefore, since managerial abilities have centralized local information, these abilities play a key role in product and process innovations within the firm.

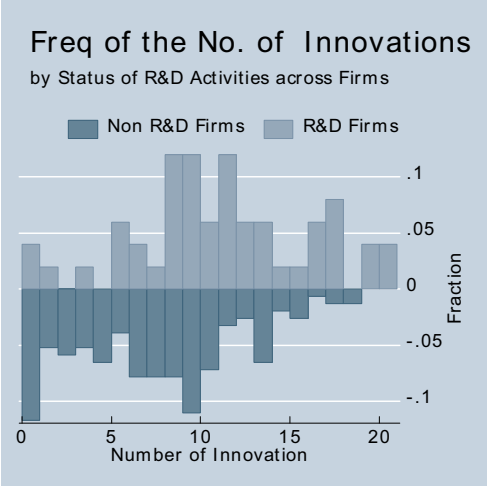
3. BACKGROUND EVIDENCE, THEORETICAL FRAMEWORK, AND TESTABLE IMPLICATIONS

We briefly review the background evidence of the relationship between industry upgrading and production networks in ASEAN. Studying the relationship between external linkages and industrial upgrading proposes a new mechanism linking external linkages and organizations in product and process innovation in East Asia. In a model with research and development (R&D), it is not easy to capture the innovation and industry upgrading among small and medium-sized or local firms which have not carried out in-house R&D. Based on the firm-level survey of innovation in Indonesia, the Philippines, Thailand, and Viet Nam, we ascertained that firms with external linkages have higher probability of achieving a specific type of product and process innovation and greater variety of product and process innovations. The degree of innovation also varies with the management of the network.

Before showing our four results, we provide two types of background information ruling out our empirical work. There is a small difference in the number of innovations between firms with in-house R&D activities and those without in-house R&D activities in Indonesia, the Philippines, Thailand, and Viet Nam (Figure 1). On the other hand, the number of information linkages significantly determines the number of innovations (Figure 2). These two figures clearly suggest that the innovation impact of a variety of linkages is large, as is the impact of in-house R&D, which previous works have studied very intensively.

Figure 1:

Frequency of the Number of Innovation across Firms with R&D and without R&D

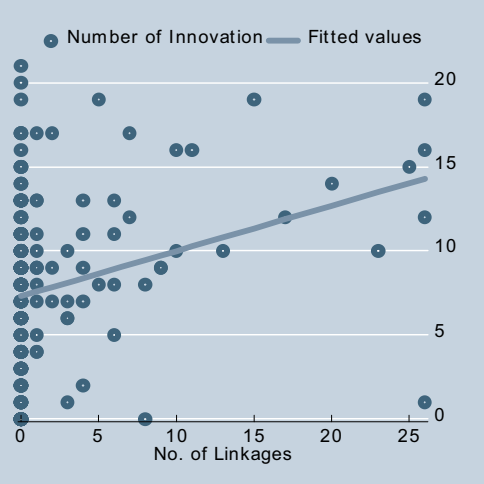


Note: Number of innovation in this figure means the variety of product and process innovation.

Source: ERIA Establishment Survey 2009.

Figure 2:

The Relationship between Number of Innovation and Number of Linkages



Notes: Number of innovation in this figure means the variety of product and process innovation. Number of linkages in this figure also represents the variety of production and intellectual linkages which firm own.

Source: ERIA Establishment Survey 2009.

The most recent contribution is from (i) Costinot, Vogel, and Wang (2011), who emphasize how production quality across upstream and downstream firms could shape specialization patterns of countries; and (ii) Antras and Chor (2011), who focus on how the sequential nature of production processes could shape the boundaries of firms and the allocation of control rights. Even though the implications of sequential production have been found in many other papers, there is a lack of empirical study on how production chains upgrade themselves and how information spills over between upstream and downstream firms within a chain.

The theoretical framework of this paper is quite simple. Motivated by the background evidence of firms in ASEAN, we develop a theoretical framework and assume that three distinct features account for a firm's innovation decisions. First, we focus on the determinant of technology transfer and introduction of new goods and processes to the firms, so as to study how to achieve product and process innovations. Second, we take into account differences in degree of information sharing across firms within a supply chain, so as to consider the firm-level heterogeneity in innovation achievement. Finally, we allow for not only backward but also forward linkages of information spillovers within a supply chain, so as to account for a new fact about resource reallocation across borders—that suppliers in developed economies tend to send information to final-good producers in developing economies. It will be helpful to assume MNEs or joint-ventures are more productive than local enterprises. Based on the framework, we derive the following four predictions:

1. There is a chain reaction of upgrading from producers to suppliers within a production chain.
2. Compared to less productive producers, more productive producers require higher levels of process upgrading to suppliers for ensuring and selling higher quality outputs toward the larger and developed market

3. More productive suppliers also require higher levels of process upgrading to final-good producers for ensuring and maximizing the market size.
4. Suppliers' investment in innovation increases as their market size increases.

The main goal of this paper is to test these four qualitative predictions. Our data set, testing strategy, and empirical results are given in the following sections.

4. DATA ON FIRM'S SELF-REPORTED CUSTOMERS AND SUPPLIERS

4.1 Sampling, Firm Characteristics, Industrial Upgrading, and Information Sharing

The sample industries are in the manufacturing sector currently operating in developing and emerging economies. In December 2009, we create a firm-level data set for Indonesia, the Philippines, Thailand, and Viet Nam. The sample population is restricted to metropolitan areas in each country—Jakarta, Bogor, Depok, Tangerang, and Bekasi in Indonesia; Cavite, Laguna, Batangas, Rizal, and Quezon in the Philippines; the Greater Bangkok area in Thailand; and the Hanoi and Ho Chi Minh City area in Viet Nam. A total of 864 firms agreed to participate in the survey: 183 firms in Indonesia, 203 in the Philippines, 178 in Thailand, and 300 in Viet Nam.

Table 1 presents a summary of firm characteristics. The average age of a firm is 16.8 years, with a standard deviation of 13.9 years. Firm size also varies widely, averaging 340 employees, with a standard deviation of 499. Since the sampling strategy covers the whole industry in each country, some firms have more than 2,000 employees while others have less than 20. Of the firms surveyed, approximately 68% are local firms, 15% are joint ventures, and 17% are MNEs.

Table 1: Summary Statistics of Firm Characteristics

Item	Mean	Std. Dev.
R&D activities (1 if yes, 0 otherwise)	0.501	0.500
Age	16.796	13.922
Full-time employees	340.198	514.347
Local firms	0.675	0.469
Joint-venture firms	0.145	0.352
Food	0.111	0.314
Textiles	0.053	0.225
Apparel	0.053	0.225
Wood	0.043	0.203
Paper	0.051	0.220
Chemical	0.049	0.215
Plastic	0.080	0.271
Nonmetal	0.015	0.122
Iron	0.047	0.213
Metal	0.063	0.242
Machinery	0.063	0.242
Computers	0.023	0.150
Electronics	0.095	0.293
Precision	0.019	0.135
Auto	0.058	0.234
Transport	0.009	0.096
Indonesia	0.212	0.409
Philippines	0.235	0.424
Thailand	0.206	0.405
Hanoi	0.174	0.379
Ho Chi Minh City	0.174	0.379

Note: Std.Dev. in this table suggests standard deviation of the sample.

Source: ERIA Establishment Survey 2009.

To compete domestically and globally, firms introduce new products to avoid price competition and improve production processes to reduce costs. Table 2 shows the main areas of interest—product and process innovation. Innovative activities reflect several dimensions of industry upgrading. There is large variation across firms.

Table 2: Summary Statistics of Product and Process Innovation

Item	Mean	Std. Dev.
Product Innovations		
Development of new product based on existing technologies	0.692	0.462
Development of new product based on new technologies	0.573	0.495
New product to existing market	0.845	0.362
New product to new market	0.712	0.453
Upgrading Production Process		
Decreased defection	0.727	0.446
Decreased inventories	0.580	0.494
Decreased materials	0.506	0.500
Reduced labor inputs	0.334	0.472
Reduced lead time	0.503	0.500
Increased domestic market	0.606	0.489
Increased foreign market	0.350	0.477
Reduced pollution	0.612	0.488

Note*:* Std.Dev. in this table suggests standard deviation of the sample.

Source: ERIA Establishment Survey 2009.

Almost 70% of the firms develop new products based on existing technologies, while 57% utilize new technologies. This suggests that it is more difficult to innovate with new technologies. Eighty-five percent of firms are able to sell new products to the existing market, while 71% sell new products to new markets. This also implies that creating new markets is difficult and costly. The situation of process innovations is more diverse. The proxies of process innovation ranges from reduction of defects, decrease in inventories to reduction of pollution. We have following eight types of process improvement: (i) 72% of sample firms reduced fraction defective, (ii) 58% of firms decreased inventories, (iii) 50% of firms decreased materials for input, (iv) 33% of firms reduced labor input, (v) 50% of firms reduced lead time, (vi) 60% of firms increased domestic market size, (vii) 35% of firms increased export market size, and (viii) 61% of firms reduced pollution.

Table 3 suggests that firms exchange information among production partners for industrial upgrading. Adoption of new technologies and improvement of organizational practices, particularly technology transfer, are more likely to happen in response to the demands of the external environment. First, 54% of firms adopt engineers from their main customer; 43% of firms send engineers to their main customer. Total quality management is one of the incentives for mutual knowledge flows between firms. Twenty-eight percent of firms are provided with quality control by their customer, and customers provide cost control for 7% of firms; 47% of firms provide quality control to customers. Thirty percent of firms are granted a license by their customer; 36% of firms grant a license to their customers. Forty-three percent of firms are required to be ISO compliant by their customers; almost 35% of firms require customers to have be ISO compliant. Fifty-five percent of firms form joint ventures with customers.

Second, relationships with suppliers are different to relationships with customers. Forty-five percent of firms dispatch engineers to their main supplier. Total quality management is also an incentive for mutual knowledge flows between firms and suppliers. Thirty-seven percent of firms are provided with quality control by their suppliers; 35% of firms receive quality control from their suppliers. Thirty percent of firms in the sample are granted a license by their supplier; 28% of firms grant a license to their suppliers. Thirty-three percent of firms are required to be ISO compliant by their suppliers; almost 44% of firms require suppliers to be ISO compliant. Fifty percent of firms form joint ventures with suppliers.

Table 3: Summary Statistics of Information Sharing with Production Partners

Item	Mean	Std. Dev.
JIT with customer	0.553	0.497
JIT with supplier	0.507	0.500
Action of Customer to Respondent		
Customer requires ISO	0.433	0.496
Customer grants license	0.299	0.458
Customer provides quality control	0.278	0.448
Customer dispatch engineers	0.541	0.499
Action of Respondent to Supplier		
Respondent requires ISO	0.442	0.497
Respondent grants license	0.287	0.453
Respondent provides quality control	0.332	0.471
Respondent dispatches engineers	0.459	0.499
Action of Supplier to Respondent		
Supplier requires ISO	0.328	0.470
Supplier grants license	0.314	0.464
Supplier provides quality control	0.358	0.480
Supplier dispatch engineers	0.476	0.500
Action of Respondent to Customer		
Respondent requires ISO	0.348	0.477
Respondent grants license	0.365	0.482
Respondent provides quality control	0.473	0.500
Respondent dispatches engineers	0.432	0.496

Notes: JIT in this table signifies adoption of just-in-time system and ISO also means adoption of international standard. Std.Dev. in this table suggests standard deviation of the sample.

Source: ERIA Establishment Survey 2009.

4.2 Production Partner Characteristics, Location, and Assortative Matching

Table 4 presents the characteristics and location of customers and suppliers. Production partners are classified as local firms, joint-venture firms, and MNEs. Findings show that more than 20% of respondents sell products to MNEs, including MNEs in foreign countries. More than 16% of respondents sell products to joint ventures, and more than 65% of respondents have local customers. More than 70% of firms sell their products within these four countries (17.25% of respondents have customers in Indonesia, 15.51% have customers in the Philippines, 11.92% have customers in Thailand, and 25.69% have customers in Viet Nam). Table 4 also suggests that customers in Japan, the US, and Europe have a substantial share in East Asia. The total share of Japan (5.69%), the US (6.25%), and Europe (4.63%) is 17.57%. They play an important role in creating global value chains in these four countries.

On the supplier side, Table 4 shows that more than 20% of respondents buy intermediate inputs from MNEs, including MNEs in foreign countries, more than 19% of respondents procure from joint ventures, and more than 61% of respondents have local suppliers. The location pattern of suppliers is quite varied. More than 64% of firms buy intermediate inputs from suppliers within these four countries (16.67% of respondents have suppliers in Indonesia, 12.73% have suppliers in the Philippines, 10.88% have suppliers in Thailand, and 23.84% have suppliers in Viet Nam). Suppliers in Japan, the PRC, and the Republic of Korea play an important role in making a global value chain within East Asia. Suppliers in the US and Europe have a substantial share within East Asia. In summary, Table 4 shows that at least one-third of firms in developing economies in East Asia have committed to a global buyer–seller network, i.e., a global value chain.

Table 4: Characteristics and Location of Production Partners

Item	Customer		Supplier	
	Number	%	Number	%
MNE	175	20.25	181	20.95
Joint venture	139	16.09	167	19.33
Indonesia	149	17.25	144	16.67
Philippines	134	15.51	110	12.73
Thailand	103	11.92	94	10.88
Viet Nam	222	25.69	206	23.84
PRC	8	0.93	49	5.67
Japan	48	5.56	70	8.10
Republic of Korea	11	1.27	19	2.20
India	3	0.35	2	0.23
Australia and New Zealand	6	0.69	5	0.58
United States	54	6.25	20	2.31
Europe	40	4.63	29	3.36
Other	86	0.10	116	0.13
Total	**864**		**864**	

Notes: MNE = multinational enterprise, PRC = People's Republic of China.

Source: ERIA Establishment Survey 2009.

Finally, Table 5 shows production partners sorted by type of respondent firms, their main customers, and their main suppliers. More than 77% of MNEs with MNE customers have MNE suppliers. On the other hand, more than 78% of local firms with local customers also have local suppliers. This clearly suggests that there is simple and strong assortative matching by types of firms such as MNE, joint venture, and local firm.

Table 5: Sorting Production Linkages between Global and Local Supply Chains

Respondent Type	Customer Type	Supplier Type		
		MNE	Joint Venture	Local
MNE	Total	0.605	0.197	0.151
	MNE	0.774	0.140	0.075
	Joint Venture	0.357	0.571	0.071
	Local	0.370	0.037	0.519
Joint Venture	Total	0.240	0.480	0.232
	MNE	0.567	0.233	0.167
	Joint Venture	0.059	0.863	0.078
	Local	0.270	0.189	0.541
Local	Total	0.101	0.130	0.705
	MNE	0.269	0.173	0.558
	Joint Venture	0.083	0.450	0.467
	Local	0.086	0.089	0.783

Note: MNE = multinational enterprise.

Source: ERIA Establishment Survey 2009.

5. INFORMATION FLOWS WITHIN A GLOBAL SUPPLY CHAIN

The impacts of exchanges of workers and technology transfer on innovations are described in this section. The internal effects of the determinant of product and process innovations are discussed in order to understand the knowledge flow through upstream–downstream production linkages. First, exchanging engineers, trainers, and trainees could stimulate knowledge flow based on face-to-face communication, and this appears to be the case. This experience validates the importance of face-to-face communication. Technology transfer could require face-to-face communication between suppliers and customers. Since this paper aims to focus on tacit knowledge exchange impacts of product and process innovations, direct information flow through upstream–downstream linkages is considered. Before estimating the impact of

knowledge flows on industry upgrading, we have to detect the main drivers of knowledge exchange and spillovers in this section.

$$\Pr(Collaborations_i = 1) = \alpha + \beta Z_i + \gamma x_i + u_i$$

where the variable *Collaborations* serves as proxy for information and knowledge flows between firms (forms of guidance through exchanging engineers, trainers, and trainees, and incidence of receiving technical assistances), *Z* is the factors indicating a local/global value chain, *x* is firm characteristics, and *u* is the unobserved firm characteristics.

5.1 Backward Linkages of Technology Transfer from Downstream to Upstream

Table 6 shows the impacts of a customer's characteristics on their action towards respondent firms. These backward linkage effects include information flows or technology transfer from customers. We have six different types of actions to respondent firms by customers. The dependent variable is equal to 1 if each customer takes the following action with regard to respondent firms: (i) requires ISO compliance, (ii) grants a license or know-how, (iii) provides quality control information, (iv) dispatches own engineers, (v) dispatches own trainers, or (vi) dispatches own trainees. The main independent variable is whether customers are MNEs or joint ventures; the reference group is local firms. We also control the characteristics of respondent firms. Our focus is the impacts of the characteristics of customers on local firms.

Empirical findings from Table 6 suggest that the probability that technology transfer from downstream is higher if customers are MNEs or joint ventures. If customer are MNEs, they required ISO compliance of respondent firms, with a 1% statistical significance. This is also true if customers are joint ventures (column 1). We cannot find clear results for the case of granting a license or transferring quality control information (columns 2 and 3). We cannot find any clear results for the case of technology transfers due to employee mobility within a production chain, i.e., there is no strong propensity for firms to dispatch own engineers and trainees to their suppliers if they have MNE or joint-venture customers (column 4, 5, and 6). In summary, technology transfer from customers is higher for MNE or joint-venture customers rather than for local customers where there is a requirement for ISO compliance.

Table 6: Determinants of Respondent's Request to the Supplier (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
Respondent → Supplier	**Require ISO**	**Grant License**	**Provide Quality**	**Dispatch Engineers**	**Dispatch Trainers**	**Dispatch Trainees**
Main customer is MNE	0.129*	-0.044	0.050	(0.045)	0.049	-0.045
	[0.057]	[0.049]	[0.053]	[0.062]	[0.055]	[0.052]
Main customer is Joint Venture	0.162**	0.001	0.018	0.089	0.02	0.033
	[0.061]	[0.052]	[0.057]	[0.065]	[0.058]	[0.056]
Main supplier is MNE	0.157**	0.040	0.016	0.058	-0.037	0.066
	[0.056]	[0.053]	[0.051]	[0.060]	[0.051]	[0.054]
Main supplier is Joint Venture	0.215**	0.165**	0.023	0.069	0.056	0.07
	[0.055]	[0.056]	[0.054]	[0.064]	[0.055]	[0.055]
Number of observations	828	828	828	828	828	828

Notes: ISO = adoption of international standard, MNE = multinational enterprise. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables.

Source: ERIA Establishment Survey 2009.

Table 7 shows the diagnostics for the above results. It sheds light on the relationship between innovation and collaboration across firms with specified information within a single production chain, presenting spillover effects from downstream to upstream firms with specified covariates of locations of firms' self-reported main customers and main suppliers. Empirical findings from column 1 of Table 7 suggest that respondent firms require ISO compliance of their suppliers if the firm's customers are in the PRC. This is also true for firms with Japanese suppliers. On the other hand, firms do not require their suppliers to have ISO compliance if the firm's customers are in Cambodia, Lao People's Democratic Republic (Lao PDR), or Myanmar. Column 2 of Table 7 shows firms do not grant license to their main supplier if the firm's customers are in the Republic of Korea. Column 3 of Table 7 suggests that firms provide quality management to their main supplier if the firm's customers are in the US. Column 4 of Table 7 suggests that firms dispatch engineers to their suppliers if they have customers in the PRC, India, Japan, Malaysia, and Singapore. Finally, column 6 of Table 7 suggests that firms dispatch trainees to their suppliers if they have customers in Japan.

Table 7: Determinants of Respondent's Request to Supplier (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
Respondent → Supplier	**Require ISO**	**Grant License**	**Provide Quality**	**Dispatch Engineers**	**Dispatch Trainers**	**Dispatch Trainees**
Customer located in						
Singapore or Malaysia	-0.001	0.000	-0.001	0.141*	0.084	-0.082+
	[0.056]	[0.050]	[0.051]	[0.061]	[0.054]	[0.048]
Cambodia, Lao PDR, Myanmar	-0.128*	-0.023	-0.024	-0.005	0.028	0.087
	[0.065]	[0.061]	[0.059]	[0.075]	[0.062]	[0.063]
People's Republic of China	0.161*	0.102	0.031	0.154*	0.005	0.078
	[0.073]	[0.068]	[0.064]	[0.073]	[0.064]	[0.069]
Japan	0.001	-0.050	0.075	0.149*	0.056	0.160**
	[0.053]	[0.045]	[0.050]	[0.058]	[0.052]	[0.052]
Republic of Korea	0.091	-0.099+	-0.030	-0.058	-0.035	0.068
	[0.073]	[0.055]	[0.060]	[0.073]	[0.061]	[0.066]
Taipei,China	0.032	0.076	-0.105	-0.122	0.006	-0.027
	[0.094]	[0.083]	[0.068]	[0.090]	[0.080]	[0.078]
India	0.000	0.091	-0.018	0.156+	-0.056	0.062
	[0.086]	[0.086]	[0.084]	[0.094]	[0.079]	[0.090]
United States	0.087	-0.069	0.117*	-0.078	0.09	-0.024
	[0.061]	[0.050]	[0.059]	[0.067]	[0.062]	[0.056]
Europe	-0.068	0.012	-0.051	0.074	0.046	-0.026
	[0.056]	[0.051]	[0.049]	[0.063]	[0.055]	[0.052]
Main supplier located in						
People's Republic of China	0.095	0.081	-0.122+	-0.067	-0.082	0.017
	[0.079]	[0.074]	[0.063]	[0.085]	[0.068]	[0.073]
Japan	0.199*	0.026	-0.051	-0.123	-0.008	-0.077
	[0.078]	[0.066]	[0.062]	[0.078]	[0.070]	[0.060]
Republic of Korea	-0.012	0.094	0.007	0.06	0.154	0.058
	[0.125]	[0.108]	[0.116]	[0.127]	[0.115]	[0.123]
United States	0.058	0.076	0.023	-0.104	0.065	0.209
	[0.124]	[0.115]	[0.114]	[0.140]	[0.119]	[0.131]
Europe	-0.038	-0.083	-0.138+	0.02	-0.172**	-0.031
	[0.099]	[0.084]	[0.072]	[0.117]	[0.067]	[0.087]
Number of observations	828	828	828	828	828	828

Notes: ISO = adoption of international standard, Lao PDR = Lao People's Democratic Republic. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables. *Source*: ERIA Establishment Survey 2009.

5.2 Forward Linkages of Technology Transfer from Upstream to Downstream

We show the spillover effects of respondents' suppliers to respondents' customers, which provides information flows from upstream to downstream firms. Column 1 of Table 8 suggests that respondent firms require their customers to have ISO compliance if the firm's suppliers are joint ventures under controlling whether main customer is MNEs, joint ventures, or local firms Venture. Respondent firms also grant licenses if their suppliers are joint ventures (column 2). Respondent firms dispatch engineers, trainers, and trainees to their customers if the respondent's suppliers are MNEs and joint ventures (columns 4, 5, and 6).

Table 8: Determinant of Respondent Request to Customer (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
Customer ←Respondent	**Require ISO**	**Grant License**	**Provide Quality**	**Dispatch Engineers**	**Dispatch Trainers**	**Dispatch Trainees**
Main customer is MNE	0.166**	0.036	0.028	0.03	-0.036	0.009
	[0.058]	[0.057]	[0.058]	[0.066]	[0.069]	[0.046]
Main customer is Joint Venture	0.140*	0.075	0.051	0.068	0.083	0.066
	[0.060]	[0.059]	[0.059]	[0.064]	[0.069]	[0.052]
Main supplier is MNE	0.037	0.018	-0.038	0.149*	0.115+	0.065
	[0.056]	[0.055]	[0.055]	[0.059]	[0.062]	[0.051]
Main supplier is Joint Venture	0.178**	0.198**	0.000	0.173**	0.023	0.128*
	[0.059]	[0.056]	[0.057]	[0.060]	[0.068]	[0.053]
Number of observations	828	828	828	828	828	828

Notes: ISO = adoption of international standard, MNE = multinational enterprise. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables.

Source: ERIA Establishment Survey 2009.

Table 9 shows the diagnostics of Table 8. It demonstrates that firms tend to grant licenses to customers if they have suppliers in the Republic of Korea. Firms provide quality control if they have suppliers in Singapore or Malaysia. This is also true if they have US suppliers. Respondents are likely to dispatch engineers to their customers if they have suppliers in the PRC and Japan, but they are not likely to dispatch engineers to their customers if they have suppliers in India. Respondents are likely to dispatch trainers to their customers if they have suppliers in Japan.

Table 9: Determinant of Respondent Request to Customer (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
Customer ←Respondent	**Require ISO**	**Grant License**	**Provide Quality**	**Dispatch Engineers**	**Dispatch Trainers**	**Dispatch Trainees**
Supplier located in						
Singapore or Malaysia	0.084	0.114+	0.163*	0.071	-0.09	0.085
	[0.063]	[0.066]	[0.065]	[0.072]	[0.077]	[0.062]
People's Republic of China	-0.039	-0.064	-0.024	0.085+	-0.042	-0.070+
	[0.046]	[0.043]	[0.046]	[0.050]	[0.053]	[0.037]
Japan	0.034	0.044	-0.064	0.097+	0.132*	-0.002
	[0.047]	[0.049]	[0.050]	[0.057]	[0.061]	[0.041]
Republic of Korea	0.022	0.236**	-0.014	-0.056	-0.105	-0.092+
	[0.076]	[0.080]	[0.083]	[0.095]	[0.092]	[0.055]
Taipei,China	-0.069	-0.021	0.055	0.022	0.061	-0.004
	[0.054]	[0.057]	[0.060]	[0.068]	[0.069]	[0.049]
India	0.043	-0.101	-0.114	-0.258*	0.036	-0.038
	[0.109]	[0.089]	[0.101]	[0.113]	[0.108]	[0.077]
United States	-0.076	0.050	0.130+	0.098	0.093	0.101
	[0.065]	[0.079]	[0.077]	[0.080]	[0.077]	[0.075]
European Union	0.040	-0.047	0.049	0.099	0.097	-0.056
	[0.055]	[0.050]	[0.054]	[0.061]	[0.062]	[0.041]
Main customer located in						
People's Republic of China	0.271+	0.358*	0.008	-0.032	-0.117	-0.149+
	[0.157]	[0.161]	[0.180]	[0.210]	[0.192]	[0.088]
Japan	0.106	-0.052	0.030	0.009	0.085	0.074
	[0.081]	[0.076]	[0.085]	[0.096]	[0.093]	[0.079]
Republic of Korea	0.103	-0.174	-0.262*	0.055	0.072	0.046
	[0.144]	[0.118]	[0.130]	[0.153]	[0.196]	[0.141]
United States	-0.026	-0.086	-0.001	-0.125	-0.112	-0.092
	[0.074]	[0.073]	[0.081]	[0.081]	[0.086]	[0.059]
European Union	0.130	-0.060	-0.079	0.073	0.021	0.039
	[0.094]	[0.083]	[0.084]	[0.098]	[0.104]	[0.081]
Number of observations	828	828	828	828	828	828

Notes: ISO = adoption of international standard. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables.

Source: ERIA Establishment Survey 2009.

6. PRODUCT INNOVATION WITHIN A GLOBAL SUPPLY CHAIN

We detect a firm's knowledge production function using the estimated equation, and regress innovation to the proxy of knowledge flows, as follows:

$$\Pr(y_i = 1) = \alpha + \beta Z_i + \gamma x_i + u_i$$

where *y* is the outcome of product innovation for each firm (*i*) located in each country (*c*), and a cross-sectional error term is shown by *u*. To simply regress innovation outcome to covariates, focus is given on the estimated coefficient of *Z* as the degree of innovation management technology across firms. We present empirical findings from customer (supplier)-driven products and process innovation.

6.1 Foreign Customer- and Supplier-Driven Product Innovation

Both of Tables 10 and 11 show the effects of the characteristics of customers and suppliers on industrial upgrading for respondent firms within a global supply chain. As a previous section showed the relationship between a production partner's characteristics and information flows from downstream (upstream) to upstream (downstream) firms, we expect that customers or suppliers in foreign countries bring information to respondent firms in Indonesia, the Philippines, Thailand, and Viet Nam.

The dependent variable is equal to 1 if each respondent firm achieves product innovations. We have six different types of product innovations: (i) development of new products based on new technologies, (ii) new product to new market, (iii) new product to domestic market, (iv) new product to ASEAN market, (v) new product to market in East Asia, and (vi) new product to US and/or European Union (EU) market. The main explanatory variables are the country of the customer and supplier. The theoretical framework suggests that such information flow from customers could stimulate learning and innovation processes for each firm utilizing production linkages. The marginal effects are presented in Table 10.

We will look at the empirical results of the impacts of customers by customer location. As reported in Table 10, the positive impacts of MNE and joint-venture suppliers are statistically significant in introducing new products based on new technology for respondent firms (column 1 of Table 10). The impacts of MNE suppliers are statistically significant in introducing new products to new markets. On the other hand, respondents are not likely to introduce new products to domestic markets if they have MNE or joint-venture customers. This implies market segmentation between firms related to foreign companies and firms without any production linkages with foreign companies. Firms are likely to introduce new goods to ASEAN markets if they have MNE customers or joint-venture suppliers. If respondents have MNE customers, they tend to introduce new goods to East Asian markets. Finally, respondents are likely to introduce new products to the US and/or EU markets if they have MNE or joint-venture customers.

Table 10: Impacts of Input–Output Linkages with MNE or Joint Venture on Product Innovation and Market Exploration (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables: Product Innovation and Market Exploration (Yes/No)	**Based on New Tech**	**To New Market**	**To Domestic Market**	**To ASEAN Market**	**To East Asian Market**	**To US or EU Market**
Main customer is MNE	-0.051	-0.034	-0.402**	0.060*	0.039+	0.221**
	[0.059]	[0.053]	[0.053]	[0.030]	[0.021]	[0.050]
Main customer is Joint Venture	0.004	0.073	-0.113+	0.035	0.002	0.094*
	[0.060]	[0.047]	[0.063]	[0.036]	[0.017]	[0.044]
Main supplier is MNE	0.145**	0.079+	-0.04	0.032	0.024	-0.003
	[0.052]	[0.045]	[0.056]	[0.031]	[0.017]	[0.027]
Main supplier is Joint Venture	0.133*	0.011	0.023	0.063+	0.001	-0.025
	[0.053]	[0.052]	[0.057]	[0.037]	[0.013]	[0.026]
Number of observations	828	828	828	828	828	828

Notes: ASEAN = The Association of Southeast Asian Nations, EU = European Union, MNE = multinational enterprise, US = United States. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables.

Source: ERIA Establishment Survey 2009.

Table 11 presents the impacts of a customer's nationality on product innovation within a global supply chain. Firms are likely to introduce new goods based on new technologies if they have customers in Singapore or Malaysia. This is also true for firms with customers in other ASEAN countries such as Cambodia, Lao PDR, and Myanmar (column 1). Column 2 of Table 11 demonstrates the similar results in the case of introduction of new goods to new markets. Firms tend to introduce new goods to new markets if they have customers in developed economies in ASEAN (Singapore and Malaysia) and emerging economies in ASEAN (Cambodia, Lao PDR, and Myanmar). The magnitude of coefficient of customers in Cambodia, Lao PDR, and Myanmar is double that of customers in developed economies in ASEAN. Respondents firms are not likely to introduce new products to new markets if they have customers in the PRC, but are likely to do so if they have customers in Japan or suppliers in the PRC. Respondents are less likely to introduce new products to domestic markets if they have customers in Singapore, Malaysia, and Japan (column 3).

The impacts of customers in the US and EU are also negative for introducing new products to domestic markets. However, firms with customers in Taipei,China do introduce new goods to domestic markets. Firms related to suppliers in Singapore, Malaysia, and Japan are also likely to introduce new goods to domestic markets. The impacts of customers in developing economies in ASEAN and in Japan positively explain the introduction of new goods to ASEAN markets, while the impacts of customers in Taipei,China and the US are negative (column 4).

The case of impacts of customers in the US and the EU gives different results. Finally, column 6 of Table 11 shows that firms are likely to introduce new goods to US or EU markets if they have customers in the US or EU, but respondents are less likely to introduce new products to US or EU markets if they have customers in the PRC, India, and in developing ASEAN countries (Cambodia, Lao PDR, and Myanmar). The impact of having suppliers in Japan on introducing new products to US or EU markets is negative.

Table 11: Impacts of Input–Output Linkages with Foreign Countries on Product Innovation and Market Exploration (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables: Product Innovation and Market Exploration (Yes/No)	**Based on New Tech**	**To New Market**	**To Domestic Market**	**To ASEAN Market**	**To East Asian Market**	**To US or EU Market**
Customer in						
Singapore or Malaysia	0.144**	0.074+	-0.135*	0.042	0.02	-0.019
	[0.054]	[0.045]	[0.065]	[0.031]	[0.017]	[0.021]
Cambodia, Lao PDR, Myanmar	0.165**	0.198**	-0.009	0.112*	-0.001	-0.037*
	[0.057]	[0.041]	[0.071]	[0.055]	[0.012]	[0.019]
People's Republic of China	0.006	-0.127+	-0.114	0.076+	0.007	-0.034+
	[0.071]	[0.076]	[0.077]	[0.044]	[0.012]	[0.019]
Japan	0.082	0.078+	-0.167**	0.096**	0.006	0.036
	[0.051]	[0.044]	[0.055]	[0.032]	[0.010]	[0.027]
Republic of Korea	0.072	-0.057	0.025	-0.017	-0.008	0.013
	[0.068]	[0.070]	[0.068]	[0.023]	[0.009]	[0.027]
Taipei,China	0.010	-0.028	0.165*	-0.040**	0.015	-0.017
	[0.089]	[0.084]	[0.066]	[0.015]	[0.021]	[0.028]
India	-0.129	-0.014	0.114	0.02	-0.008	-0.047*
	[0.092]	[0.089]	[0.081]	[0.039]	[0.012]	[0.019]
United States	0.041	0.068	-0.236**	-0.037*	0.016	0.171**
	[0.060]	[0.047]	[0.065]	[0.017]	[0.015]	[0.049]
European Union	-0.017	0.023	-0.133*	-0.026	-0.001	0.073*
	[0.060]	[0.052]	[0.058]	[0.018]	[0.009]	[0.036]
Supplier in						
Singapore or Malaysia	0.078	-0.040	0.186**	-0.007	-0.014+	-0.025
	[0.066]	[0.063]	[0.052]	[0.021]	[0.007]	[0.023]
People's Republic of China	-0.025	0.125**	0.071	-0.031+	0.014	-0.007
	[0.046]	[0.036]	[0.046]	[0.017]	[0.010]	[0.019]
Japan	-0.029	0.065	0.113*	0.015	0.013	-0.060**
	[0.052]	[0.040]	[0.048]	[0.023]	[0.011]	[0.015]

Republic of Korea	0.031	-0.008	-0.051	0.088	-0.004	0.001
	[0.078]	[0.070]	[0.096]	[0.055]	[0.013]	[0.035]
Taipei,China	-0.070	-0.050	0.017	-0.016	-0.002	0.007
	[0.060]	[0.055]	[0.060]	[0.019]	[0.009]	[0.029]
India	0.069	0.059	0.103	-0.028	0.002	-0.039
	[0.112]	[0.075]	[0.104]	[0.033]	[0.022]	[0.030]
United States	-0.022	-0.028	-0.093	0.029	-0.017*	0.045
	[0.080]	[0.065]	[0.090]	[0.042]	[0.007]	[0.042]
European Union	0.025	-0.034	-0.092	-0.028	0.013	0.096*
	[0.055]	[0.052]	[0.061]	[0.018]	[0.012]	[0.038]
Number of observations	828	828	828	828	828	828

Notes: ASEAN = The Association of Southeast Asian Nations, EU = European Union, MNE = multinational enterprises, US = The United States of America. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables.

Source: ERIA Establishment Survey 2009.

6.2 Product Innovation within a Local Supply Chain

In turn, we investigate product innovation within a local supply chain. Column 1 of Table 12 suggests that firms are likely to introduce new goods based on new technologies if firms have customers in Thailand, but this is not true if firms have suppliers in Thailand. Columns 2, 3, and 4 of Table 12 suggest that firms are likely to achieve product innovation in domestic markets, ASEAN markets, and new markets (probably, developing economies in ASEAN such as Cambodia, Lao PDR, and Myanmar) within a local supply chain in the four countries we study. Column 6 of Table 12 demonstrates that firms within a local supply chain have a lower propensity to introduce new goods to US or EU markets.

Table 12: Impacts of Input–Output Linkages within Countries in ASEAN on Product Innovation and Market Exploration (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables: Product Innovation and Market Exploration (Yes/No)	**Based on New Tech**	**To New Market**	**To Domestic Market**	**To ASEAN Market**	**To East Asian Market**	**To US or Europe Market**
Customer in						
Indonesia	0.043	-0.025	-0.005	0.107+	-0.005	-0.095**
	[0.078]	[0.069]	[0.081]	[0.061]	[0.015]	[0.018]
Philippines	-0.082	-0.019	0.098	0.004	-0.020*	-0.052*
	[0.065]	[0.055]	[0.063]	[0.032]	[0.008]	[0.025]
Thailand	0.121*	-0.014	0.095+	0.005	0.03	-0.058*
	[0.056]	[0.052]	[0.057]	[0.030]	[0.021]	[0.023]
Viet Nam	0.121	0.186**	-0.084	0.073	0.002	0.008
	[0.088]	[0.062]	[0.093]	[0.049]	[0.014]	[0.052]
Supplier in						
Indonesia	0.002	0.115*	0.012	-0.01	-0.006	0.032
	[0.083]	[0.054]	[0.078]	[0.035]	[0.012]	[0.044]
Philippines	0.104	0.092+	0.066	0.002	0.029	-0.061*
	[0.075]	[0.054]	[0.074]	[0.033]	[0.025]	[0.024]
Thailand	-0.167**	-0.072	0.073	0.018	-0.004	-0.044*
	[0.057]	[0.052]	[0.052]	[0.026]	[0.010]	[0.022]
Viet Nam	0.009	0.075	0.031	-0.064+	0.009	0.069
	[0.097]	[0.081]	[0.095]	[0.037]	[0.018]	[0.044]
Number of observations	828	828	828	828	828	828

Notes: ASEAN = The Association of Southeast Asian Nations, EU = European Union, MNE = multinational enterprise, US = United States. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables.

Source: ERIA Establishment Survey 2009.

7. PROCESS INNOVATION ACROSS GLOBAL AND LOCAL SUPPLY CHAINS

We expect that production partners affect firms' process innovation decisions. Tables 14 and 15 show six different proxies for upgrade of production processes: (i) decreased defection, (ii) decreased inventories, (iii) reduced labor input, (iv) reduced lead time, (v) increased domestic market, and (vi) increased foreign market. The estimated coefficients of characteristics of customers and suppliers are in Table 13. However, the impacts of MNE customers on increasing the domestic market are negative; firms are likely to reduce inventory and increase the share of foreign markets if firms have MNE or joint-venture customers.

Table 13: Impacts of Input–Output Linkages with MNE or Joint Venture on Process Innovation (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
	Decrease in				**Increase in**	
Dependent variables: Upgrading Management Quality (Yes/No)	**Defection**	**Inventory**	**Labor Inputs**	**Lead Time**	**Domestic Market**	**Foreign Market**
Main customer is MNE	0.027	0.137**	-0.086+	0.018	-0.108+	0.132*
	[0.049]	[0.053]	[0.051]	[0.059]	[0.059]	[0.057]
Main customer is Joint Venture	0.044	0.02	-0.121*	0.077	-0.061	0.102+
	[0.050]	[0.059]	[0.049]	[0.060]	[0.061]	[0.059]
Main supplier is MNE	-0.060	-0.009	0.012	-0.072	0.026	0.014
	[0.052]	[0.055]	[0.053]	[0.057]	[0.053]	[0.054]
Main supplier is Joint Venture	-0.066	0.039	0.085	-0.032	0.047	-0.018
	[0.054]	[0.056]	[0.057]	[0.059]	[0.056]	[0.054]
Number of observations	828	828	828	828	828	828

Notes: MNE = multinational enterprise. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables.

Source: ERIA Establishment Survey 2009.

Table 14 presents several impacts of geography on production linkages (customers and suppliers). Firms have a lower propensity to reduce lead time if they have customers in Singapore and Malaysia. On the other hand, they have a higher propensity to reduce lead time if they have customers in emerging ASEAN economies (Cambodia, Lao PDR, and Myanmar). With regard to customers in East Asia, firms do not have any process upgrading if they have customers in the PRC, Republic of Korea, and Taipei,China. This result is clearly different from the case where firms have customers in Japan, when they are likely to reduce inventory and

lead time and increase the share of foreign markets. The impacts of customers in India on process innovation are negative but statistically insignificant.

Table 14: Impacts of Input–Output Linkages with Foreign Countries on Process Innovation (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
	Decrease in				Increase in	
Dependent variables: Upgrading Management Quality (Yes/No)	**Defection**	**Inventory**	**Labor Inputs**	**Lead Time**	**Domestic Market**	**Foreign Market**
Customer located in						
Singapore or Malaysia	-0.007	-0.069	-0.016	-0.124*	0.026	0.006
	[0.051]	[0.059]	[0.051]	[0.057]	[0.056]	[0.054]
Cambodia, Lao PDR, Myanmar	-0.052	0.092	-0.026	0.205**	0.086	0.089
	[0.059]	[0.061]	[0.060]	[0.061]	[0.064]	[0.066]
People's Republic of China	-0.014	-0.055	0.067	-0.009	0.058	-0.006
	[0.064]	[0.071]	[0.067]	[0.073]	[0.068]	[0.066]
Japan	0.049	0.097+	-0.032	0.156**	0.064	0.142**
	[0.044]	[0.052]	[0.048]	[0.052]	[0.052]	[0.052]
Republic of Korea	-0.079	-0.086	-0.100+	-0.167**	-0.033	-0.052
	[0.065]	[0.070]	[0.058]	[0.065]	[0.070]	[0.061]
Taipei,China	-0.012	-0.102	-0.046	-0.039	-0.003	-0.008
	[0.075]	[0.090]	[0.076]	[0.091]	[0.083]	[0.083]
India	0.081	-0.031	-0.080	-0.019	-0.119	-0.003
	[0.070]	[0.096]	[0.075]	[0.098]	[0.092]	[0.088]
United States	0.073	0.003	0.066	-0.119+	0.024	0.07
	[0.051]	[0.063]	[0.060]	[0.063]	[0.061]	[0.062]
European Union	0.013	0.096+	-0.002	0.073	-0.039	0.048
	[0.053]	[0.058]	[0.054]	[0.059]	[0.061]	[0.055]
Supplier located in						
Singapore or Malaysia	0.100*	-0.030	0.098	0.02	0.09	0.095
	[0.050]	[0.068]	[0.068]	[0.071]	[0.063]	[0.069]
People's Republic of China	0.005	0.041	-0.059	-0.065	0.029	0.006
	[0.041]	[0.046]	[0.044]	[0.048]	[0.046]	[0.044]
Japan	-0.028	0.147**	0.033	-0.002	0.033	0.042
	[0.047]	[0.050]	[0.049]	[0.054]	[0.052]	[0.050]
Republic of Korea	0.049	-0.054	-0.045	0.128	-0.048	0.051
	[0.066]	[0.079]	[0.072]	[0.079]	[0.080]	[0.082]

Taipei,China	0.051	0.058	0.076	0.091	-0.042	-0.08
	[0.049]	[0.060]	[0.060]	[0.061]	[0.060]	[0.050]
India	-0.002	-0.077	0.053	0.029	-0.007	0.125
	[0.100]	[0.113]	[0.112]	[0.110]	[0.114]	[0.114]
United States	-0.205*	-0.254**	0	0.083	-0.143+	-0.071
	[0.081]	[0.076]	[0.075]	[0.081]	[0.084]	[0.068]
European Union	0.074+	0.077	-0.053	-0.018	0.082	0.038
	[0.043]	[0.053]	[0.050]	[0.059]	[0.052]	[0.054]
Number of observations	828	828	828	828	828	828

Notes: Lao PDR = Lao People's Democratic Republic. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables.

Source: ERIA Establishment Survey 2009.

Finally, Table 15 shows the impact of local production chains on process improvement. There is clear difference in the impact of customers between Viet Nam and other economies in Indonesia, the Philippines, and Thailand—firms are less likely to reduce inventory if they have customers in Indonesia or the Philippines. In addition, if firms have customers in the Philippines, they are less likely to reduce lead time and to increase the share of foreign markets. On the other hand, firms are likely to reduce inventory if they have customers in Viet Nam. Firms also tend to reduce their fraction defective and increase the share of foreign markets if they have customers in Viet Nam.

Table 15: Impacts of Input–Output Linkages with Countries in ASEAN on Process Innovation (Probit Model, Marginal Effects)

	(1)	(2)	(3)	(4)	(5)	(6)
	Decrease in				Increase in	
Dependent variables: Upgrading Management Quality (Yes/No)	**Defection**	**Inventory**	**Labor Inputs**	**Lead Time**	**Domestic Market**	**Foreign Market**
Customer in						
Indonesia	-0.104	-0.142+	-0.043	0.077	0.111	-0.004
	[0.081]	[0.080]	[0.072]	[0.082]	[0.077]	[0.075]
Philippines	0.003	-0.145*	0.039	-0.181**	0.109+	-0.098+
	[0.059]	[0.066]	[0.059]	[0.063]	[0.064]	[0.058]
Thailand	0.043	0.017	0.023	-0.084	-0.042	0.006
	[0.047]	[0.058]	[0.057]	[0.061]	[0.061]	[0.058]
Viet Nam	0.168*	0.176*	0.052	0.153+	0.092	0.238**
	[0.070]	[0.078]	[0.081]	[0.085]	[0.087]	[0.085]
Supplier in						
Indonesia	0.006	0.143+	-0.049	0.068	-0.026	0.007
	[0.076]	[0.075]	[0.071]	[0.081]	[0.087]	[0.076]
Philippines	-0.027	0.017	-0.008	0.053	0.049	-0.009
	[0.078]	[0.076]	[0.071]	[0.077]	[0.076]	[0.073]
Thailand	0.042	0.045	0.124*	0.035	-0.013	0.061
	[0.045]	[0.054]	[0.058]	[0.057]	[0.057]	[0.055]
Viet Nam	0.034	0.054	-0.066	0.154+	0.152+	0.004
	[0.074]	[0.089]	[0.091]	[0.094]	[0.087]	[0.090]
Number of observations	828	828	828	828	828	828

Notes: ASEAN = The Association of Southeast Asian Nations. Robust standard errors in square brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Other control variables are R&D activities; age; local; joint venture; number of employees; three types of industries such as light, material, and machinery; and four country dummy variables.

Source: ERIA Establishment Survey 2009.

8. SUMMARY AND DISCUSSION OF EVIDENCE-BASED POLICYMAKING

In summary, we find the following results. First, manufacturing firms are more likely to require or be required to comply with International Standard (ISO9000 or 14001) if firms have MNE or joint-venture production partners. Second, we find backward information linkages. If MNE or joint-venture customers require ISO compliance of respondent firms, they also require ISO compliance of upstream suppliers. Third, we find forward linkages. Firms are likely to require ISO compliance of customers and dispatch their own workers to customers if they have MNE or joint-venture suppliers. These three results support the above testable predictions. Finally, firms are likely to achieve product innovation based on existing technologies or product innovation to domestic markets if they have customers in ASEAN. On the other hand, firms are likely to achieve product innovation based on new technologies or product innovation to outside markets, especially the US and EU, if they have customers outside of ASEAN. These two findings also clearly support the final testable prediction.

What is the relationship between the empirical exercises above and policy implications for the PRC and India based on ASEAN experience? The case of Viet Nam in Table 16 gives us a good starting point for deriving the policy implications of greater deepening and integration and movement up the value chain for two big emerging economies such as the PRC and India. Table 16 shows that higher tariffs on equipment and materials are bottlenecks for innovation in firms in Viet Nam. Higher tariffs of intermediates and rigid mobility of labor input work are against innovation. In addition, the variety of linkages also affects the managerial evaluation. This result suggests there should be a policy target of tariff reductions for innovation, especially for Viet Nam, which has greater demand for inputs from foreign countries. Firms within a global supply chain should feel that higher tariffs are bottlenecks to innovation in products and processes. Firms within a global production process should feel that rigid labor mobility across firms is a bottleneck to information spillovers and gains from technology transfer within a global chain. This result suggests the need for a policy that reduces tariffs and fosters engineer (technician) mobility within a chain for innovation and upgrading, especially for Viet Nam.

Table 16: Most Serious Obstacles to Achieving Product and Process Innovation for Firms Within and Across ASEAN Countries

(%)

Item	Viet Nam	Indonesia	Philippines	Thailand	Total
High tariffs on equipment and materials necessary for innovation	61.0	14.7	21.6	7.2	**27.8**
Price of R&D support services is high	5.9	17.5	22.3	30.1	**17.8**
No R&D supporting industry such as consulting and financing	6.6	23.8	22.3	14.5	**17.3**
Labor mobility is too rigid for workers to bring with them technologies acquired from previous employer	19.1	6.3	4.7	16.9	**11.0**
No business organization or chamber of commerce which provides training courses, seminars, or testing facilities	19.1	14.7	10.8	7.2	**8.8**
Number of observations	136	143	148	83	**510**

Notes: ASEAN = The Association of Southeast Asian Nations. R&D = research and development.

Source: ERIA Establishment Survey 2008.

9. CONCLUSION

This paper presents empirical evidence that production partners play an important part in product and process innovation in the manufacturing sector in ASEAN. We study the determinants of product and process innovation of firms in Indonesia, the Philippines, Thailand, and Viet Nam among countries in ASEAN. This paper uses data that combines firm-level information of product creation and quality upgrading with firm-level relationships between counterparts (i.e., upstream and downstream firms). Based on the data on firms' self-reported customers and suppliers, we can estimate the magnitudes of tacit knowledge exchanges across connected firms in ASEAN and East Asia.

Our novel and original survey information suggest the following three results, which are new to the literature and evidence-based policymaking. First, there is strong assortative matching between firms; almost 80% of MNEs with MNE customers have MNE suppliers. On the other hand, almost 80% of local firms with local customers have local suppliers.

Second, findings from regression results show that manufacturing firms are more likely to require or be required to have ISO compliance if firms have MNE or joint-venture production partners. This is true for the case of dispatching engineers, trainers, and trainees. We also find the spillover effects from the impacts of downstream customers to upstream suppliers. If MNE or joint-venture customers require ISO compliance of respondent firms, they also require ISO compliance of upstream suppliers. This is sharp evidence of backward information linkages. Evidence of forward linkages is also observed. Firms are likely to require ISO compliance of

customers and dispatch their own workers to customers if they have MNE or joint-venture suppliers. In addition, firms are less likely to require ISO compliance of their suppliers if they have customers in less-developed economies in ASEAN (Cambodia, Lao PDR, and Myanmar).

Third, our findings show that the achievement of product and process innovation is quite different across manufacturing firms which have production partners within a country and foreign countries outside Indonesia, the Philippines, Thailand, and Viet Nam. That is, product and process innovation varies between local and global supply chains. However, product innovation is likely to occur within a local supply chain in each country and within a global supply chain with ASEAN (Singapore and Malaysia), East Asia (the PRC, Japan, Republic of Korea, and Taipei,China), the US, and the EU. Process innovation is not likely to occur within a local supply chain in the four countries. These results suggest that customers in the PRC and Japan in particular play an important role in product innovation for firms in ASEAN, and that customers in the US and EU play a key role in connecting firms in ASEAN with the US and EU markets.

In this paper, we have to address the issue of shifting to new low-cost countries for labor-intensive activities. We also study the issue of intersector resource reallocation in the context of productivity growth or technology transfer in Asian countries. Based on empirical results, we discuss the development of South–South trade within ASEAN, and industrial corridors imply deepening complementary relationships within the Mekong River basin region, for example. In general, rapid increases in inflows of goods, foreign direct investments, and people from abroad often pose threats to the people in less-developed countries. Nonetheless, there have been a number of studies that report the positive effects of such phenomena, e.g., industrial upgrade, diversification of industrial activities and customer bases, and technological upgrade of existing industrial capabilities in developing countries.

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