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The Impact of Face-to-face and Frequent Interactions on Innovation: Evidence from Upstream-Downstream Relations

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Abstract: This paper proposes a new mechanism linking innovation and networks in developing economies to identify explicit production and information linkages. We investigate the testable hypotheses of these linkages using survey data gathered from manufacturing firms in East Asia: Indonesia, Thailand, the Philippines, and Vietnam. We found that 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. We found that such strong complementarities as Just-in-time are not effective for product innovation. These findings support the hypothesis that face-to-face communication and strong complementarities among buyer-seller networks have different roles in product and process innovation.

Keywords: exchanges of engineer, innovation, insider econometrics, just-in-time, status quo

JEL classifications: O31, O32, R12

1. Introduction

This paper proposes a new mechanism linking innovations and networks in developing economies. It identifies explicit linkages between production and information. It also investigates the empirical implications of this new mechanism using survey data gathered from manufacturing firms in four megacities in East Asia. Our survey countries are Indonesia, the Philippines, Thailand, and Vietnam. We collected firm level evidence on innovations, linkages between production and information, and the respondent firms' own characteristics using mail surveys and field interviews.

How do face-to-face communication or tacit knowledge exchanges matter for product and process innovation? What are the consequences of frequent communications on innovation trials? This paper tries to quantify these questions about knowledge transmission in relation to production linkages, leading to higher innovation performance. The estimates will be useful in discussing the impact of small (and hypothetical) subsidies on the extent of upgrading knowledge-exploiting and knowledge-creation (or knowledge-exploring) activities for firms in production networks. Likewise, it discusses the policy implications of these findings and some theoretical background to evaluate the extent of production-related knowledge on industry upgrading.

There is a dearth of empirical research that precisely captures the knowledge transmission mechanism through inter-firm communication. Two exceptions are Javorcik (2004) and Blalock and Gertler (2008) who investigate the backward linkages impacts of productivity upgrading by upstream suppliers on MNCs customers. There is also a lack of quantitative evidence that rigorously identifies the effects of production knowledge and the form of communications through upstream-downstream relations. Since we need to quantify the contribution of production networks on innovation, this paper collects detailed information about production linkages, product and process innovation, and creation of new markets. Cassiman and Veugelers (2002, 2006), Vega Jurado *et al*. (2008), Frenz and Ietto-Gilles (2009), and Machikita and Ueki (2011) clearly suggest that the combination of two different sources of knowledge is valuable for innovation. Saxenian (1996) emphasizes the importance of information externalities within an agglomeration area, leading to a higher cycle of knowledge creation based on evidence from Silicon Valley. Saxenian (2006) shows that Indian or Chinese technicians coming back from Silicon Valley combine the knowledge they have gained with local knowledge to create new businesses. This field survey-based information provides findings that are lacking in previous studies.

Most of the previous studies on the effects of geographic proximity on innovation used the local average of R&D expenditures or the number of R&D engineers as an explanatory variable. These studies assumed that all firms in a local area benefit equally from the local average of R&D activities. Even if this assumption were plausible on average, it is natural that the role of knowledge flows in production linkages and the volume of interactions would vary among linkages. That is why we have to go beyond geographic proximity, collect information about linkages directly, and carefully investigate the effects of each type of production linkage on innovation.

To examine the role of local production linkages on product innovations, we need to identify the extent of companies' investment in R&D, the exact channels used to upgrade existing products, the geographic extent of new-market creation, and the emergence of local alliances to introduce a new product. We will build a simple model to explain the large variation of product innovation across firms with and without R&D activities or multiple production linkages. This simple theoretical framework will be based on the reduced-form regression model and will provide some interpretations of the empirical estimates of the effect of two factors, i.e., the variety of production linkages and engineer-level communications, on innovations. Estimating the empirical elasticity of production linkages or micro-level communications on innovation would enable us to detect the exact channels of process and product innovation, and the creation of new markets.

This paper will investigate the role of production networks in industry upgrading by documenting the spatial architecture of upstream and downstream firms in developing economies, and examining the network effects on innovation. Local network externalities are a mechanism for understanding the relationship between production networks and innovation. Endogenous growth theory, in particular Romer (1986, 1990), emphasizes the importance of innovation in economic growth, but the inside mechanism is almost a black-box. Lucas (1988) identified local knowledge spillovers as important sources of economic growth. Glaeser *et al*. (1992) showed city-level evidence of the role of knowledge spillovers. Foster and Rosenzweig (1995) developed the Bayesian framework of learning by doing and learning from others in a village, and estimated the neighborhood impacts of introducing HYV (which is a risky project in the initial stages). They showed the significant impacts of neighbourhood experience in updating information about optimal input volume. Conley and Udry (2010) studied the role of communication networks in determining the importance of learning from others.

Finally, Almeida and Kogut (1999) found that local transfer of knowledge is stimulated by inter-firm mobility of engineers, technicians and other professional and technical personnel (see Rasiah, 1994, 1995). Song *et al*. (2003) showed the occurrence of inter-firm knowledge transfer that emanates from hired engineers, who possess technological expertise distant from that of the hiring firm. This literature suggests that engineers are expected to bring fresh ideas to a firm, though the flow of knowledge seems to be geographically embedded.

Theory also has developed. Jovanovic and Rob (1989) and Keely (2003) provide some microeconomic explanations of knowledge exchanges over time. Most recently, Berliant and Fujita (2008, 2009) formalize in detail that knowledge creation needs appropriate diversity of knowledge between two persons. This paper is a new attempt to open the black box of local interactions-driven innovation to detect the knowledge exchanges using the case of upstream-downstream relations.

This paper also focuses on production networks to quantify the extent to which information flows with customers or suppliers motivate a firm to innovate. The lack of empirical studies and the potential heterogeneity in production-network availability provide several empirical questions about the effects of innovation networks. The specific question we are trying to answer is how production networks affect firms' incentive to innovate when inter-firm linkages become dense. How do firms innovate if communication with their suppliers increases? Should firms respond to information flows from their consumers? This paper empirically explores these questions.

To summarize our introduction, we present the following two findings that this paper will attempt to explain. These findings are basically consistent with the network-based theory of innovation. First, firms with face-to-face communications at the engineer level and firms with frequent interactions with production partners are successful in implementing innovation, particularly organizational change directed towards external markets, and process innovations like the creation of new markets and securing new sources of input. Second, however much the "Just In Time" system (JIT hereafter) is effective in dealing with disequilibria, strong complementarities like JIT lead to attitudes that encourage the maintenance of the status quo.

The next section provides our theoretical framework. Data will be described in section 3. Section 4 shows the results. The discussion of the results, and our conclusions, are in section 5.

2. Framework

We discuss the reasons why firms with direct information flows, especially face-to-face communication and frequent exchanges of information, play an important role in achieving product and process innovations. In our empirical setting, we focus on exchanges of engineers and JIT information between upstream- and downstream-firms. In particular, compared to firms that do not accept engineers from main partners or dispatch engineers to main partners, firms that interact with main partners are more likely to introduce new product varieties, organizational changes in response to changes in the market environment, and market-based process innovations. Inter-firm linkages take various forms of guidance and learning such as exchanges of engineers. The sources of inter-firm guidance and learning may exist in controlling quality, costs, delivery, and environment management (QCDE) within the firm as well as within the (international) production chain. Such total quality management plays an important role of knowledge exchanges between upstream-downstream firms. Not only customer but also supplier takes guidance from the partner firm. That is, firms learn about demand for specific products from their customers while firms receive technical information from their supplier in the face of new demand. We assume that each firm requires such information spillovers through backward and forward linkages to meet the demand. Therefore, information exchanges between demand and technologies spillover within the (international) production chain. Information exchanges may not take the form of "encoded" in terms of Polanyi (1966, 1967). More concretely, communication between firms and their partners are not transcribed for each other when the specific features demand and technologies become complicated.

We derive the organizational (upstream and downstream relationship) implications of Berliant and Fujita (2008, 2009) here. They emphasized the dynamic implications of knowledge creation based on face-to-face and frequent communications over time. These build a microeconomic model of knowledge creation and study its dynamic implications on long-term relationships. Their model rationalizes the optimal level of diversity for collaborations. There are two key assumptions: (1) a low level of diversification does not create any new knowledge; (2) diversification makes communications costly. These assumptions lead to the following three implications. First, knowledge exchanges through face-to-face and frequent interactions make two agents homogeneous and efficient in communicating with each other. Second, cooperation and strong complementarities lead to attitudes that encourage maintaining the status quo. Finally, the knowledge creation from frequent communications will diminish over time. We test the implications of this model using the setting of information flows from upstream and downstream linkages.

Firms with direct information flows from partners tend to be more successful because of the value brought by face-to-face and frequent interaction. Accepting engineers from the main supplier ensures the transfer of knowledge relating to raw materials, parts, and components. If the suppliers are based in a more competitive market, the main supplier has to pay the costs of knowledge transfer, i.e., dispatching engineers to the main customer. Dispatching engineers to the main customer also ensures the transfer of knowledge about production processes and market changes. Since it is critically important for firms to acquire the most accurate information about market changes, the supplier dispatches the engineers from an upstream to a downstream level. The empirical results suggest that there are also backward linkages leading to information flows from customer to supplier. Because most suppliers are keen to acquire ISO certification to help them expand their market, they need to communicate face to face with their main customer to pay the costs of dispatching engineers. The JIT system also provides an opportunity for frequent interactions between customers and suppliers. Frequent interactions ensure the accuracy of information about market changes. JIT is effective for dealing with disequilibria. This seems to be consistent with Schultz (1975). Although there are benefits from strong complementarities, such strong complementarities as JIT lead to attitudes that encourage maintenance of the status quo, leading to lower levels of product innovation. We test these implications in section 4.

3. Data

This section presents the survey data, sampling, firm characteristics, summary statistics of dependent and independent variables, and geographic features of production networks. The data used are sourced by the authors from an original survey of manufacturers in Southeast Asia. The data encompasses local firms, MNCs and joint ventures in Indonesia, the Philippines, Thailand and Vietnam. Our dataset covers variables that relate to different types of product and process innovations, as well as unique variables of management practices inside the firm and management practices that support personnel interactions of firms to external linkages. In contrast to the standard administrative data, these variables enable us to draw a new combination of industry upgrading and personnel interactions across firms.

A. Sampling

We used the dataset from the establishment survey on innovation and production network for selected manufacturing firms in four countries in East Asia. We created this dataset in December 2008 in Indonesia, the Philippines, Thailand, and Vietnam. The sample population is restricted to selected manufacturing hubs in each country (JABODETABEK area, i.e., Jakarta, Bogor, Depok, Tangerang and Bekasi for Indonesia, CALABARZON area, i.e., Cavite, Laguna, Batangas, Rizal, and Quezon for the Philippines, Greater Bangkok area for Thailand, and Hanoi area for Vietnam). A total of 600 firms agreed to participate in the survey: (1) 149 firms in Indonesia; (2) 203 firms in the Philippines; (3) 112 firms in Thailand; and (4) 137 firms in Vietnam.

The sample industries consist of 17 manufacturers for each country. Since the aggregate composition of industries is different among the four countries, we focused on just three major industries for each of the four countries: food processing, apparel, and wood products for Indonesia; food processing, apparel, and electronics for the Philippines; food processing, apparel, and chemical products for Thailand; chemical products, machinery, and electronics for Vietnam.

B. Firm Characteristics

Table 1 presents the summary statistics of the main variables. The average age of a firm is 14 years, with a standard deviation of 12 years. Firm size is also much dispersed. Average size is 293 employees, with a standard deviation of 456. Since our sampling strategy covers the whole of manufacturing in each country, some firms have more than 2,000 employees while some firms are very small, with less than 20 employees. Of the total number surveyed,

Table 1: Summary Statistics of Firm Characteristics

	Mean	Std. Dev.	Min	Max
Firm Characteristics				
Age	14.202	12.392	0	80
Full-time Employees	293.879	456.483	10	2000
Local Firms	0.617	0.487	0	1
Joint Venture Firms	0.132	0.339	0	1
Multinational Enterprise	0.251	0.434	0	1
Production (raw material processing)	0.463	0.499	0	1
Production (components and parts)	0.281	0.450	0	1
Production (final products)	0.712	0.453	0	1
Procurement of raw materials, parts, or supplies	0.250	0.433	0	1
Marketing, sales promotion	0.433	0.496	0	1
R&D activities (1 if Yes, 0 otherwise)	0.221	0.416	0	1

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

approximately 60 per cent are local firms, 13 per cent are joint-venture firms and 25 per cent are MNEs.

Firm function is classified into one of five categories here. Forty-six per cent of the firms process raw materials. Twenty-eight per cent produce components and parts while 71 per cent produce final goods. A total of 24 per cent procure raw materials while 43 per cent carry out marketing activities.

C. Dependent Variables

Tables 2a and 2b present our main interest – innovation. Innovative activities reflect several dimensions of industry upgrading. There is no single measure to evaluate the success or failure of a firm's policy in industry upgrading. We drew up four different groups of measures: new goods, adoption of new technologies and organizational structures, new sources of procurement, and creation of new markets. We classified innovations into the following three categories: (1) product innovation (introduction of new goods); (2) process innovations, including adoption of new technology and organizational changes to improve product quality and cost efficiency; and (3) securing new customers to sell to, and new suppliers to procure existing products from, efficiently.

While approximately 45 per cent of the sample firms, on average, are able to make product innovations in general, it appears that more firms find

Table 2a: Summary Statistics of Product, Process, and Organizational Innovations

	Mean	Std. Dev.	Min	Max
Product Innovations				
(1) Introduction of New Good	0.458	0.499	0	1
(2) Introduction of New Good to New Market	0.096	0.295	0	1
(3) Introduction of New Good with New Technology	0.117	0.322	0	1
Production Process Innovations				
(1) Bought New Machines	0.529	0.500	0	1
(2) Improved Existing Machines	0.673	0.470	0	1
(3) Introduced New Know-how on Production Methods	0.550	0.498	0	1
Organizational Innovations				
(1) Adopted an international standard (ISO or others)?	0.531	0.499	0	1
(2) Introduced ICT and reorganized business processes?	0.342	0.475	0	1
(3) Introduced other internal activities to respond to changes in the market?	0.597	0.491	0	1

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

it difficult to achieve certain kinds of product innovations. Only 9 per cent said they were able to introduce new goods to new markets, while only 11 per cent were able to introduce new goods using new technology. This situation may be due to the higher fixed costs of creating new markets and using new technology, in addition to the typical costs associated with product innovations.

In contrast, more than 50 per cent of the firms were able to introduce process innovations, such as (1) buying new machines; (2) improving existing machines; (3) introducing new know-how on production processes; (4) earning certification from the International Standards Organization (ISO); and (5) introducing internal activities to respond to changes in the markets.

Table 2b shows that firms reported different experiences in the task of securing new customers and suppliers, depending on the locations and characteristics of the customers and suppliers. The probability of securing a new local supplier or customer in a metropolitan area in which the respondent is also located is higher (63 per cent for securing a new supplier and 65 per

Table 2b: Summary Statistics of Market-based Innovations

	Mean	Std. Dev.	Min	Max
Procurement Innovations				
(1) Secured a new local supplier (100% local capital) in survey city	0.636	0.481	0	1
(2) Secured a new local supplier (100% local capital) in the country outside survey city	0.567	0.496	0	1
(3) Secured a new Multinational Company (MNC) (100% foreign capital) or joint venture (JV) supplier in survey city	0.174	0.379	0	1
(4) Secured a new MNC or JV supplier in the country outside survey city	0.162	0.369	0	1
(5) Secured a new supplier in other ASEAN countries	0.327	0.470	0	1
(6) Secured a new supplier in other countries in East Asia (China, Japan, Korea, Taiwan)	0.380	0.486	0	1
(7) Secured a new supplier in other foreign countries	0.302	0.460	0	1
Market Creating Innovations				
(1) Secured a new local customer (100% local capital) in survey city	0.653	0.476	0	1
(2) Secured a new local customer (100% local capital) in the country	0.580	0.494	0	1
(3) Secured a new MNC or JV customer in survey city	0.307	0.462	0	1
(4) Secured a new MNC or JV customer in the country	0.218	0.413	0	1
(5) Secured a new customer in other ASEAN countries	0.271	0.445	0	1
(6) Secured a new customer in other countries in East Asia (China, Japan, Korea, Taiwan)	0.347	0.476	0	1
(7) Secured a new customer in other foreign countries	0.365	0.482	0	1

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

cent for securing a new customer) than the probability of securing a new supplier or customer outside the metropolitan area (56 per cent for securing a new supplier and 58 per cent for securing a new customer). Securing a new supplier or customer in other ASEAN countries is more difficult for the four countries involved in the study (32 per cent for securing a new supplier and 27 per cent for securing a new customer). Sample firms also found it difficult to buy inputs from, or sell products to, MNEs. Only 17 per cent of the firms successfully secured new multinational suppliers within a metropolitan area while only 16 per cent were able to do so outside the metropolitan area. Between the two tasks, however, firms found it easier to sell products to MNEs than to buy inputs from them. Nearly 30 per cent of the firms successfully secured new multinational customers within an agglomeration area, while 21 per cent did so outside.

D. Independent Variables Explaining Innovation Performance

Industries in the sample are primarily involved in manufacturing and exporting and are currently operating in East Asia. To keep pace with domestic demand and stay on top of international competition, the firms adopt new technologies, acquire new organizational forms to adapt to market changes, create new markets, find new inputs to improve product quality and cost efficiency, and introduce new products. They utilize the external environment and local/international markets to upgrade themselves. Therefore, it is reasonable to say that they are more likely to adapt new technology and undertake organizational changes in response to the external environment and the demands made by their respective local and international markets. Forty five per cent of firms adopt the JIT system with their main customer. Thirty four per cent of firms accept engineers from their main customer, while 21.5 per cent of firms dispatch engineers to their main customer. On the other hand, 36 per cent of firms adopt the JIT system with their main supplier, 27 per cent of firms accept engineers from their main supplier, and 17 per cent of firms dispatch engineers to their main supplier.

E. Production Networks in Space

We also focus on two issues related to production linkages between the main customer and supplier in a spatial economy: (1) exchange of engineers; (2) JIT. We have two competing theories of the spatial architecture of production networks to explain co-location between two firms. First, if fixed search costs for production partners (or setup and coordination costs of alliances) decrease with capital structure between firms, it is efficient for firms with capital tie-ups to form production linkages with their affiliates. Second, if communication

Table 3: Summary Statistics of the Relationship with Main Customer and Supplier

	Mean	Std. Dev.	Min	Max
Relationship with Customer				
(1) Main Customer makes Customized Good	0.638	0.481	0	1
(2) Geographic Proximity to Customer (km)	400.069	438.087	5	1000
(3) JIT with Customer	0.451	0.498	0	1
(4) Capital Tie-up with Customer	0.107	0.310	0	1
(5) Duration of the Relationship with Customer (year)	6.412	3.489	0.5	10
(6) Accept Engineers from Customer	0.339	0.474	0	1
(7) Dispatch Engineers to Customer	0.215	0.411	0	1
(8) Customer is Important Partner for Innovation	0.668	0.471	0	1
Relationship with Supplier				
(1) Main Supplier makes Customized Good	0.554	0.498	0	1
(2) Geographic Proximity to Supplier (km)	343.418	413.176	5	1000
(3) JIT with Supplier	0.362	0.481	0	1
(4) Capital Tie-up with Supplier	0.112	0.316	0	1
(5) Duration of the Relationship with Supplier (year)	6.233	3.587	0.5	10
(6) Accept Engineers from Supplier	0.273	0.446	0	1
(7) Dispatch Engineers to Supplier	0.170	0.376	0	1
(8) Supplier is Important Partner for Innovation	0.117	0.322	0	1

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

costs for meetings and information exchanges increase with geographic distance between firms, these two firms will form production linkages that will tend to co-locate in one area. Capital tie-up with affiliates is a good proxy for the existence of production linkages. If both of the first and second conjectures are appropriate in East Asia, firms with capital tie-ups will tend to locate nearer each other than firms without capital tie-ups.

That is, the geographic extent of input-output linkage is more locally limited for firms with capital tie-ups than firms without tie-ups due to the needs of the JIT system or frequent information exchanges for quality upgrading. This is a transport costs-based theory of co-location. This explanation is also derived from standard spatial economy. Less productive firms or less differentiated goods production forges local or nearby alliances while more productive firms do it globally. For given variable communication costs of alliances, the geographic extent of input-output linkages should be ruled out by productivity. If communication costs increase, the probability of network formation with remote firms could decrease.

Second, there is the enforceability-based theory of agglomeration. This theory emphasizes the monitoring effect of production networks from buyer to seller. If buyers do not have a long-term or tight relationship with the producers, such buyers would have to frequently monitor and check product quality. The cost of communication is an increasing function of geographic distance between buyers and sellers. If this conjecture is right, for example, firms with capital tie-ups need not be co-located because these buyers and sellers would already know each other. The geographic extent of input-output linkage is locally limited for firms without capital tie-ups compared to firms with capital tie-ups, because of these monitoring needs. This section answers the following questions relating to production networks in space: (1) are there any differences in the input-output linkages across firms and countries in East Asia; (2) how strong are the linkages between customers and suppliers; and (3) are firms with production linkages also important partners in innovation?

Exchanging engineers between firms is also a main proxy of exchanging production-related knowledge through production linkages. Table 4 compares the geographic proximity of firms that accept engineers from their main trading partners with the geographic proximity of firms that choose not to do so with their main partners. The results show that firms that decide to accept engineers from their main customers and suppliers tend to be located farther away from these trading partners (669 km from customer and 567 km from supplier for firms that accept engineers versus 318 km from customer and 237 km from supplier for firms that do not accept engineers).

Table 5 compares the geographic proximity of firms that dispatch engineers to their main customers and suppliers with the geographic proximity of firms that do not dispatch engineers to their main partners. Firms save on communication costs to remote areas by accepting engineers from their main customers and suppliers if these trading partners are located far from them. This is also true for firms that decide to dispatch engineers to their main partners. By doing this, firms can save on communication costs, especially if the partners are located in remote areas (500 km from customer and 348 km from supplier for firms that dispatch engineers versus 391 km from customer and 342 km from supplier for firms that do not dispatch engineers).

Table 4: Geographic Proximity to Customer/Supplier by Accept Engineers from Customer/Supplier

From Customer	From Supplier	Variable (km)	Obs	Mean	S.D.	Min	Max
No	No	Geographic Proximity to Consumer	359	318.5	403.2	5	1000
		Geographic Proximity to Supplier	331	237.6	340.1	5	1000
Yes	No	Geographic Proximity to Consumer	64	319.3	404.1	5	1000
		Geographic Proximity to Supplier	57	368.6	404.7	5	1000
No	Yes	Geographic Proximity to Consumer	23	282.8	389.2	5	1000
		Geographic Proximity to Supplier	23	501.4	454.1	5	1000
Yes	Yes	Geographic Proximity to Consumer	138	669.4	443.5	5	1000
		Geographic Proximity to Supplier	134	567.0	474.8	5	1000

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

Table 5: Geographic Proximity to Customer/Supplier by Dispatch Engineers to Customer/Supplier

To Customer	To Supplier	Variable (km)	Obs	Mean	S.D.	Min	Max
No	No	Geographic Proximity to Consumer	439	391.4	434.3	5	1000
		Geographic Proximity to Supplier	407	342.2	409.5	5	1000
Yes	No	Geographic Proximity to Consumer	48	295.5	397.3	5	1000
		Geographic Proximity to Supplier	41	361.1	418.8	5	1000
No	Yes	Geographic Proximity to Consumer	20	454.0	463.7	18	1000
		Geographic Proximity to Supplier	23	315.8	406.0	5	1000
Yes	Yes	Geographic Proximity to Consumer	77	500.6	464.3	5	1000
		Geographic Proximity to Supplier	74	348.7	439.9	5	1000

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

Table 6: Geographic Proximity to Customer/Supplier by JIT with Customer/Supplier

From Customer	From Supplier	Variable (km)	Obs	Mean	S.D.	Min	Max
No	No	Geographic Proximity to Consumer	307	448.9	445.9	5	1000
		Geographic Proximity to Supplier	289	442.8	435.4	5	1000
Yes	No	Geographic Proximity to Consumer	71	391.3	442.4	5	1000
		Geographic Proximity to Supplier	45	172.5	341.9	5	1000
No	Yes	Geographic Proximity to Consumer	15	294.6	440.9	5	1000
		Geographic Proximity to Supplier	18	369.2	439.9	5	1000
Yes	Yes	Geographic Proximity to Consumer	191	333.1	415.9	5	1000
		Geographic Proximity to Supplier	193	232.0	348.1	5	1000

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

It is natural for firms to create a JIT system with locally concentrated partners. Table 6 relates the geographic proximity of a firm to its main customer and supplier and the use of a JIT system. Firms who have a JIT system with their main customer and supplier tend to be located nearer to their main trading partners than firms who have no JIT system with their main partners (333 km from customer with JIT, 232 km from supplier with JIT versus 448 km from customer without JIT, 442 km from supplier without JIT). The formation of the JIT system justifies co-location based on transport costs.

4. The Impact of Knowledge Exchanges on Innovation

We describe the empirical content of face-to-face and frequent communications and frequency of communications on innovations in this section. We report the following internal effects of linkages in order to understand the information flow through production linkages. First, exchanging engineers could stimulate information flow based on face-to-face communication. Second, the formation of a JIT system could provide the opportunity for frequent communication between suppliers and customers. Since the last section reports on the effect of the variety of linkages on product and process innovations, we relate the internal information flow through linkages to product and process innovations. This paper seeks to derive the firm's knowledge production function.

We set the estimated equation as follows:

$$\Pr(y_{ic} = 1) = \alpha INSIDE\_LINK_{ic} + \beta x_{ic} + u_{ic}$$

where y means the outcome of innovation and upgrading for each firm i located in each country c, the variable *INSIDE_LINK* proxies the meaning of information and knowledge flows between firms (exchanging engineers and using a JIT system), x is other controls, i.e., age, size, status of exporting goods to foreign countries, status of importing intermediate goods from foreign countries, country dummy variables, and a cross-sectional error term is shown by u. To simply regress innovation outcome to covariates, we focus on the estimated coefficient of *INSIDE* as the degree of innovation management technology across firms.

Table 7 reports the effects of accepting engineers from customers and suppliers on the product and process innovation. The dependent variable is equal to one if each firm has carried out product and process innovation (for example, introduction of new good or adoption of ISO) and is zero otherwise. The independent variable, accepting engineers from customers or suppliers, is equal to one if each firm accepts engineers from their main customer or supplier. Marginal effects are presented. Other control variables are MNEs (or joint venture/locals), age, firm size, industry, and country dummy variables.

Table 7: The Relationship between Accepting Engineers and Product/Process Innovation

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Product and Process Innovation (Yes/No)	Introduction of New Good	Introduction of New Good to New Market	Improved Existing Machines	Introduced New Know-How on Production Methods	Adopted ISO	Introduced ICT to Reorganize Business Process	Introduced Internal Activities to Respond to Changes in the Market
Accept Engineers from Customer	-0.013	0.010	0.023	0.018	0.026	-0.025	0.030
	[0.069]	[0.037]	[0.065]	[0.074]	[0.071]	[0.066]	[0.070]
Accept Engineers from Supplier	0.076	-0.030	-0.050	**0.124**$^{+}$	**0.244****	**0.202****	**0.336****
	[0.071]	[0.032]	[0.066]	[**0.074**]	[**0.064**]	[**0.070**]	[**0.054**]
Multinational Enterprises	-0.200**	-0.062*	-0.263**	-0.160*	0.217**	0.114^{+}	0.119^{+}
	[0.062]	[0.026]	[0.064]	[0.069]	[0.062]	[0.063]	[0.064]
Age	0.001	0.001	0.003	0.005*	-0.002	0.003^{+}	-0.001
	[0.002]	[0.001]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Full-time Employees	0.000**	0.000	0.000**	0.000**	0.000**	0.000**	0.000**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Food	0.146^{+}	0.033	0.105^{+}	0.010	-0.042	-0.109	0.040
	[0.077]	[0.046]	[0.063]	[0.080]	[0.080]	[0.066]	[0.076]
Apparel	-0.028	0.004	0.002	-0.037	-0.217**	-0.111^{+}	-0.098
	[0.073]	[0.038]	[0.067]	[0.078]	[0.081]	[0.066]	[0.083]
Wood and coal	0.110	0.078	0.137^{+}	-0.041	0.012	0.038	0.159*
	[0.105]	[0.073]	[0.074]	[0.106]	[0.109]	[0.108]	[0.075]
Chemical	0.035	-0.026	0.173**	0.103	0.192*	0.097	0.141^{+}
	[0.084]	[0.040]	[0.054]	[0.083]	[0.075]	[0.085]	[0.074]

Table 7: (continued)

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Product and Process Innovation (Yes/No)	Introduction of New Good	Introduction of New Good to New Market	Improved Existing Machines	Introduced New Know-How on Production Methods	Adopted ISO	Introduced ICT to Reorganize Business Process	Introduced Internal Activities to Respond to Changes in the Market
Iron, non ferrous, and metals	-0.145^{+}	-0.008	0.170^{**}	0.019	0.193^{**}	0.092	0.141^{*}
	[0.079]	[0.045]	[0.058]	[0.089]	[0.073]	[0.084]	[0.071]
Machinery	0.277^{**}	-0.031	0.161^{*}	0.192^{*}	0.167	0.125	0.112
	[0.099]	[0.052]	[0.070]	[0.097]	[0.105]	[0.111]	[0.109]
Electronics, computers, and precision	0.162^{+}	0.185^{*}	0.213^{**}	0.072	0.212^{**}	0.177^{+}	0.163^{*}
	[0.087]	[0.092]	[0.053]	[0.092]	[0.082]	[0.091]	[0.078]
Auto and transportation	0.026	-0.004	0.170^{**}	-0.029	0.178^{*}	0.120	0.109
	[0.101]	[0.052]	[0.062]	[0.101]	[0.088]	[0.092]	[0.084]
Indonesia	-0.209^{**}	0.010	0.001	-0.265^{**}	-0.298^{**}	-0.381^{**}	-0.594^{**}
	[0.062]	[0.033]	[0.067]	[0.068]	[0.067]	[0.036]	[0.055]
Philippines	-0.079	-0.012	-0.055	-0.135^{+}	-0.323^{**}	-0.375^{**}	-0.370^{**}
	[0.064]	[0.030]	[0.066]	[0.069]	[0.064]	[0.044]	[0.066]
Vietnam	-0.272^{**}	-0.047	-0.298^{**}	-0.537^{**}	-0.294^{**}	-0.349^{**}	-0.422^{**}
	[0.070]	[0.032]	[0.085]	[0.058]	[0.078]	[0.042]	[0.081]
Observations	587	587	587	587	587	587	587

Notes: Robust standard errors in brackets. $^{+}$ significant at 10%; * significant at 5%; ** significant at 1%.
Reference country is Thailand.

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

As reported in column (4) of Table 7, the coefficient for accepting engineers from suppliers is 0.124 with a standard error of 0.074, and it is statistically significant at the 10 per cent level. Thus, firms that accept engineers from main suppliers are likely to experience a significantly higher probability of introduction of new know-how on production methods than firms that do not accept engineers from main suppliers. The effects of engineers are prevalent across several types of process innovation. As reported in column (5) of Table 7, the coefficient for accepting engineers from suppliers is 0.244 with a standard error of 0.064, and it is statistically significant at the 1 per cent level. Thus, firms that accept engineers from main suppliers are likely to experience a significantly higher probability of adoption of ISO than firms that do not accept engineers from main suppliers. As reported in column (6) of Table 7, the coefficient for accepting engineers from suppliers is 0.202 with a standard error of 0.070, and it is also statistically significant at the 1 per cent level. Thus, firms that accept engineers from main suppliers are likely to experience a significantly higher probability of introduction of ICT to reorganize business process than firms that do not accept engineers from main suppliers. Finally, column (7) of Table 7 suggests that the coefficient for accepting engineers from suppliers is 0.336 with a standard error of 0.054, and it is statistically significant at the 1 per cent level. Since making investments to deal with disequilibria has been another kind of process innovation, then firms that accept engineers from main suppliers are likely to experience a significantly higher probability of introduction of internal activities to respond to changes in the market than firms that do not accept engineers from main suppliers. Overall, only process innovation is positively related to accepting engineers from main suppliers. But accepting engineers from main customer and supplier which we can call *passive* knowledge exchanges does not affect product innovation at all.

Table 8 presents the innovation impacts of dispatching engineers to main customers and suppliers. We can describe dispatching engineers as *active* knowledge exchanges. The dependent variable is also product and process innovation as shown in Table 7. The independent variable, dispatching engineers to customers or suppliers, is equal to one if each firm dispatches engineers to the main customers or suppliers. As reported in column (1) of Table 8, the coefficient for dispatching engineers to main customers is 0.145 with a standard error of 0.069, and it is also statistically significant at the 5 per cent level. This suggests that there is positive relationship between introduction of new good and dispatching engineers to main customers. Dispatching engineers to main customers also has positive relationship with process innovation (adoption of ISO and adjustment with market turbulences). Column (5) of Table 8 shows that the coefficient for dispatching engineers to main customers is 0.156 with a standard error of 0.071, and it is also statistically significant at the 5 per cent level. As reported in column (7) of Table 8, the coefficient for dispatching engineers to main customers is 0.193 with a standard error of 0.062, and it is also statistically significant at the 1 per cent level. Turn to the innovation impacts of dispatching engineers to supplier, column (4) of Table 8 suggests that the coefficient for dispatching engineers to main suppliers is 0.164 with a standard error of 0.096, and it is also statistically significant at the 10 per cent level. Column (6) and (7) of Table 8 shows that the positive impacts of dispatching engineers to main customers is statistically significant at the 10 per cent level. Overall, product and process innovation are positively related to active knowledge exchanges which is dispatching engineers to main customers and suppliers.

In short, empirical results of Table 7 and 8 suggest that both the types of knowledge exchanges with partners (accepting and dispatching engineers) have positive impacts not only product innovation, but also process innovation in the face of market disequilibria or market turbulence. Process innovation aimed at enabling a firm to respond to changes in the external market environment is positively related to the practice of accepting engineers from suppliers and dispatching engineers to main customers.

Finally, the formation of a JIT system is also a proxy of information exchanges through production linkages. Table 9 reports the impacts of forming a JIT system with the main customer and supplier, on several types of product and process innovation, especially some combinations of product innovations and market-creating innovations. All the dependent variables are the same as in Tables 7 and 8.

The independent variables of forming a JIT system with the customer or supplier are equal to 1 if a firm forms a JIT system for production and distribution with its main customer or supplier, respectively, and are zero otherwise. To examine the impact on combinations of product innovations and market-creating innovations, we regress introduction of new good to new market to JIT system variables. Column (2) of Table 9 shows that the coefficient for a JIT system with the customer is -0.088 with a standard error of 0.033, and it is also statistically significant at the 1 per cent level. This result indicates that JIT with customer does not stimulate the introduction of new goods to new markets.

On the other hand, we show the results for non-R&D firms which have not been carrying out in-house R&D activities by themselves. The empirical question here is whether a JIT system provides information flows relevant to market changes or market turbulence. Column (5) of Table 10 shows that the coefficient for a JIT system with the customer has positive impacts on adoption of ISO. The coefficient for a JIT system with the customer is 0.161 with a standard error of 0.081, indicating that the firm that forms a JIT system with a customer has a higher probability of adoption of ISO. As reported

Table 8: The Relationship between Dispatching Engineers and Product/Process Innovation

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Product and Process Innovation (Yes/No)	Introduction of New Good	Introduction of New Good to New Market	Improved Existing Machines	Introduced New Know-How on Production Methods	Adopted ISO	Introduced ICT to Reorganize Business Process	Introduced Internal Activities to Respond to Changes in the Market
Dispatch Engineers to Customer	**0.145***	0.001	0.099	0.128	**0.156***	0.036	**0.193****
	[**0.069**]	[0.034]	[0.064]	[0.091]	[**0.071**]	[0.067]	[**0.062**]
Dispatch Engineers to Supplier	0.108	0.013	0.119^{+}	**0.164**$^{+}$	0.056	**0.134**$^{+}$	**0.132**$^{+}$
	[0.078]	[0.042]	[0.065]	[**0.096**]	[0.086]	[**0.077**]	[**0.074**]
Multinational Enterprises	-0.174**	-0.068**	-0.275**	0.008	0.300**	0.185**	0.245**
	[0.059]	[0.025]	[0.062]	[0.104]	[0.056]	[0.060]	[0.055]
Age	0.000	0.001	0.002	0.001	-0.002	0.003+	-0.002
	[0.002]	[0.001]	[0.002]	[0.003]	[0.002]	[0.002]	[0.002]
Full-time Employees	0.000**	0.000	0.000**	0.000**	0.000**	0.000**	0.000**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Food	0.179*	0.041	0.132*	-0.061	-0.047	-0.107	0.028
	[0.077]	[0.048]	[0.058]	[0.115]	[0.079]	[0.067]	[0.076]
Apparel	-0.006	0.013	0.036	-0.006	-0.253**	-0.131*	-0.161*
	[0.073]	[0.041]	[0.064]	[0.117]	[0.078]	[0.063]	[0.082]
Wood and coal	0.090	0.086	0.136^{+}	-0.170	-0.048	0.010	0.080
	[0.108]	[0.076]	[0.072]	[0.163]	[0.109]	[0.104]	[0.087]
Chemical	0.029	-0.026	0.168**	0.018	0.183*	0.089	0.104
	[0.083]	[0.040]	[0.053]	[0.126]	[0.075]	[0.083]	[0.078]

Table 8: (continued)

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Product and Process Innovation (Yes/No)	Introduction of New Good	Introduction of New Good to New Market	Improved Existing Machines	Introduced New Know-How on Production Methods	Adopted ISO	Introduced ICT to Reorganize Business Process	Introduced Internal Activities to Respond to Changes in the Market
Iron, non ferrous, and metals	-0.173*	-0.002	0.173**	0.000	0.149*	0.054	0.063
	[0.077]	[0.046]	[0.056]	[0.125]	[0.076]	[0.080]	[0.080]
Machinery	0.242*	-0.031	0.127	-0.143	0.136	0.089	0.072
	[0.109]	[0.054]	[0.078]	[0.210]	[0.107]	[0.109]	[0.109]
Electronics, computers, and precision	0.137	0.195*	0.206**	-0.113	0.153^{+}	0.144	0.077
	[0.088]	[0.093]	[0.052]	[0.156]	[0.089]	[0.089]	[0.087]
Auto and transportation	0.014	-0.004	0.165**	0.021	0.165^{+}	0.109	0.082
	[0.104]	[0.053]	[0.061]	[0.152]	[0.088]	[0.090]	[0.086]
Indonesia	-0.229**	0.007	-0.013	-0.345**	-0.299**	-0.384**	-0.596**
	[0.061]	[0.033]	[0.067]	[0.099]	[0.066]	[0.036]	[0.054]
Philippines	-0.121^{+}	-0.017	-0.091	-0.123	-0.333**	-0.389**	-0.388**
	[0.065]	[0.030]	[0.066]	[0.083]	[0.063]	[0.043]	[0.066]
Vietnam	-0.280**	-0.048^{+}	-0.305**	-0.116	-0.251**	-0.332**	-0.366**
	[0.065]	[0.029]	[0.080]	[0.173]	[0.078]	[0.041]	[0.082]
Observations	587	587	587	587	587	587	587

Notes: Robust standard errors in brackets. $^{+}$ significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

Table 9: The Relationship between Just-in-Time and Product/Process Innovation

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Product and Process Innovation (Yes/No)	Introduction of New Good	Introduction of New Good to New Market	Improved Existing Machines	Introduced New Know-How on Production Methods	Adopted ISO	Introduced ICT to Reorganize Business Process	Introduced Internal Activities to Respond to Changes in the Market
Just-in-Time with Customer	-0.026 [0.067]	**-0.088**** [**0.033**]	0.021 [0.063]	0.078 [0.068]	0.093 [0.071]	0.055 [0.062]	0.102 [0.066]
Just-in-Time with Supplier	-0.035 [0.069]	0.050 [0.039]	-0.087 [0.065]	-0.060 [0.071]	-0.015 [0.073]	-0.031 [0.062]	-0.021 [0.067]
Multinational Enterprises	-0.177** [0.059]	-0.062* [0.025]	-0.278** [0.060]	-0.122^{+} [0.064]	0.284** [0.056]	0.177** [0.060]	0.224** [0.055]
Age	0.001 [0.002]	0.001 [0.001]	0.002 [0.002]	0.004* [0.002]	-0.002 [0.002]	0.003^{+} [0.002]	-0.001 [0.002]
Full-time Employees	0.000** [0.000]	0.000 [0.000]	0.000** [0.000]	0.000** [0.000]	0.000** [0.000]	0.000** [0.000]	0.000** [0.000]
Food	0.133^{+} [0.077]	0.034 [0.045]	0.107^{+} [0.062]	-0.009 [0.081]	-0.075 [0.078]	-0.127* [0.064]	-0.020 [0.076]
Apparel	-0.044 [0.072]	0.011 [0.039]	0.014 [0.065]	-0.066 [0.077]	-0.278** [0.075]	-0.149* [0.060]	-0.206** [0.079]
Wood and coal	0.094 [0.106]	0.097 [0.080]	0.133^{+} [0.074]	-0.064 [0.106]	-0.026 [0.109]	0.007 [0.103]	0.106 [0.088]
Chemical	0.034 [0.084]	-0.027 [0.038]	0.172** [0.054]	0.096 [0.083]	0.184* [0.075]	0.088 [0.083]	0.113 [0.076]

Table 9: (continued)

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Product and Process Innovation (Yes/No)	Introduction of New Good	Introduction of New Good to New Market	Improved Existing Machines	Introduced New Know-How on Production Methods	Adopted ISO	Introduced ICT to Reorganize Business Process	Introduced Internal Activities to Respond to Changes in the Market
Iron, non ferrous, and metals	-0.150^{+}	0.013	0.181^{**}	-0.009	0.144^{+}	0.050	0.067
	[0.078]	[0.050]	[0.055]	[0.088]	[0.076]	[0.081]	[0.078]
Machinery	0.282^{**}	-0.031	0.167^{*}	0.207^{*}	0.168	0.125	0.134
	[0.100]	[0.048]	[0.068]	[0.096]	[0.104]	[0.110]	[0.099]
Electronics, computers, and precision	0.152^{+}	0.191^{*}	0.214^{**}	0.059	0.170^{+}	0.144	0.101
	[0.087]	[0.091]	[0.052]	[0.091]	[0.088]	[0.090]	[0.085]
Auto and transportation	0.031	-0.001	0.170^{**}	-0.031	0.160^{+}	0.113	0.073
	[0.101]	[0.053]	[0.062]	[0.100]	[0.086]	[0.089]	[0.086]
Indonesia	-0.178^{**}	0.026	0.040	-0.262^{**}	-0.314^{**}	-0.379^{**}	-0.595^{**}
	[0.069]	[0.038]	[0.069]	[0.075]	[0.071]	[0.039]	[0.056]
Philippines	-0.061	0.001	-0.039	-0.131^{+}	-0.311^{**}	-0.370^{**}	-0.357^{**}
	[0.066]	[0.031]	[0.066]	[0.071]	[0.065]	[0.044]	[0.067]
Vietnam	-0.274^{**}	-0.057^{*}	-0.300^{**}	-0.504^{**}	-0.208^{**}	-0.324^{**}	-0.317^{**}
	[0.066]	[0.026]	[0.081]	[0.060]	[0.079]	[0.043]	[0.084]
Observations	587	587	587	587	587	587	587

Notes: Robust standard errors in brackets. $^{+}$ significant at 10%; * significant at 5%; ** significant at 1%.
Reference country is Thailand.

Source: Economic Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

Table 10: The Relationship between Just-in-Time and Product/Process Innovation for Non-R&D Firms

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Product and Process Innovation (Yes/No)	Introduction of New Good	Introduction of New Good to New Market	Improved Existing Machines	Introduced New Know-How on Production Methods	Adopted ISO	Introduced ICT to Reorganize Business Process	Introduced Internal Activities to Respond to Changes in the Market
Just-in-Time with Customer	-0.044	-0.037	0.056	0.075	**0.161***	0.089	**0.182***
	[0.073]	[0.028]	[0.076]	[0.077]	[**0.081**]	[0.064]	[**0.079**]
Just-in-Time with Supplier	-0.041	-0.003	-0.118	-0.041	-0.010	0.000	-0.062
	[0.074]	[0.029]	[0.079]	[0.078]	[0.082]	[0.062]	[0.078]
Multinational Enterprises	-0.135*	-0.058*	-0.280**	-0.079	0.349**	0.212**	0.313**
	[0.064]	[0.024]	[0.068]	[0.070]	[0.062]	[0.062]	[0.064]
Age	0.000	0.001	0.001	0.003	-0.003	0.001	-0.002
	[0.002]	[0.001]	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]
Full-time Employees	0.000**	0.000*	0.000**	0.000**	0.000**	0.000	0.000**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Food	-0.065	0.091^{+}	0.113	-0.214**	-0.269**	-0.309**	-0.550**
	[0.079]	[0.055]	[0.084]	[0.082]	[0.084]	[0.043]	[0.063]
Apparel	-0.046	0.034	0.004	-0.104	-0.266**	-0.308**	-0.399**
	[0.075]	[0.040]	[0.084]	[0.082]	[0.079]	[0.047]	[0.076]
Wood and coal	-0.275**	-0.028	-0.290**	-0.459**	-0.151	-0.263**	-0.279**
	[0.069]	[0.034]	[0.093]	[0.066]	[0.095]	[0.047]	[0.094]
Chemical	0.066	0.093	0.047	-0.027	-0.188*	-0.199**	-0.104
	[0.094]	[0.070]	[0.091]	[0.097]	[0.094]	[0.051]	[0.099]

Table 10: (continued)

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Product and Process Innovation (Yes/No)	Introduction of New Good	Introduction of New Good to New Market	Improved Existing Machines	Introduced New Know-How on Production Methods	Adopted ISO	Introduced ICT to Reorganize Business Process	Introduced Internal Activities to Respond to Changes in the Market
Iron, non ferrous, and metals	-0.032	0.040	0.028	-0.050	-0.245^{**}	-0.104^{+}	-0.172^{+}
	[0.076]	[0.049]	[0.079]	[0.082]	[0.078]	[0.059]	[0.088]
Machinery	0.090	0.066	0.129	-0.062	-0.058	-0.019	0.173^{+}
	[0.115]	[0.078]	[0.103]	[0.112]	[0.121]	[0.104]	[0.102]
Electronics, computers, and precision	0.072	0.035	0.151^{+}	0.031	0.185^{*}	0.112	0.217^{*}
	[0.100]	[0.066]	[0.080]	[0.101]	[0.093]	[0.091]	[0.087]
Auto and transportation	-0.063	0.031	0.208^{**}	0.016	0.120	0.040	0.103
	[0.088]	[0.059]	[0.074]	[0.097]	[0.090]	[0.078]	[0.091]
Indonesia	0.300^{*}		0.155	0.071	0.128	0.214^{+}	0.181
	[0.127]		[0.100]	[0.129]	[0.128]	[0.129]	[0.121]
Philippines	0.207^{*}	0.286^{*}	0.265^{**}	0.064	0.210^{*}	0.158^{+}	0.184^{+}
	[0.097]	[0.113]	[0.069]	[0.100]	[0.098]	[0.090]	[0.094]
Vietnam	0.142	0.050	0.189^{*}	0.029	0.226^{*}	0.184^{+}	0.130
	[0.108]	[0.081]	[0.083]	[0.104]	[0.093]	[0.098]	[0.094]
Observations	459	439	459	459	459	459	459

Notes: Robust standard errors in brackets. $^{+}$ significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Source: Research Institute in ASEAN and East Asia (ERIA) Establishment Survey 2008.

in column (7) of Table 10, the coefficient for JIT system with customer has positive impacts on investment in market disequilibria. The coefficient for a JIT system with the customer is 0.182 with a standard error of 0.079, indicating that the firm that forms a JIT system with a customer has a higher probability of investing in internal activities that will help it adjust to changes in the market. These results indicate that JIT with customer stimulates the process innovation for firms which have not been carrying out in-house R&D activities. Such firms also dominate our estimated sample. Overall, a process innovation that helps a firm adjust to changes in the market environment, for example, ISO certification or market turbulence, is positively related to operation of a JIT system with a customer.

5. Conclusion

In East Asia, a complex production network has been constructed utilizing wage disparity and lower transportation costs across countries in the region. Lower transportation costs between regions foster the fragmentation of production processes over borders. In particular, the intermediate process is more complex, skill intensive, and higher paid while the final process is easier to build, unskilled-labour intensive, and lower paid. On the other hand, since both inter-firm supplier-customer relationships and intra-firm upstream and downstream processes face higher transportation costs, firms with capital tie-ups to their main trading partners tend to co-locate near one another.

From the viewpoint of spatial economy, it is unclear whether geographic proximity between firms tends to spur knowledge transfer between upstream and downstream processes within a concentrated area. On the one hand, co-location stimulates frequent communication between firms. On the other hand, the exchanges of engineers (dispatching of workers to partners and accepting of workers from partners) between firms was shown to be more frequent for firms located in remote areas than nearer their main trading partners. Empirical work was needed to provide a solution. To detect the origin and destination of knowledge flows between upstream and downstream processes, we collected information on exchanges of engineers and implementation of the JIT system to estimate the strength of ties.

The empirical results suggest that firms with face-to-face communication at the engineer level and with frequent interaction with production partners are able to innovate successfully, particularly in the areas of organizational change directed towards external markets, and market-based process innovations like the creation of new markets and securing new sources of input. In particular, however, JIT does not stimulate the introduction of new goods to new markets, while it is effective for ISO certification and response to market turbulences. In summary, this result suggests that JIT is effective for dealing with disequilibria. But such strong complementarities as JIT lead to attitudes that encourage maintaining the status quo.

We offer the following three hypotheses as a possible explanation for these results: (1) different types of external sources (like engineers from customer or supplier) and combinations of external sources and internal resources provide the value of knowledge diversity; (2) different types of external sources provide the opportunity to obtain accurate information about other firms' trials and errors, for firms without their own R&D department or sufficient internal resources; (3) face-to-face communication and frequent interaction with production partners provide a chance to acquire deep and correct information about changes in the market and market turbulence. As a result, the findings in this paper are related to Hortacsu and Syverson (2009) who suggest the importance of intangible inputs like managerial oversight within the firm to show vertical ownership is not usually used to facilitate transfers of goods along the production chain. They conclude that the central motivation of owning production chains is that they allow more efficient transfers of knowledge of production and information of markets. The findings of this paper can extend to the concept of "adaptive organization" *a la* Dessein and Santos (2006) which theoretically analyzes 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 market information and use it in production and vice versa. Therefore, since managerial abilities have centralized local information, these abilities play a key role as a technology of product and process innovations within the firm.

We raise here several remaining issues, most importantly, the actual direction of information flows. We are not able to separate learning activities from teaching. If engineers were transporting their professional knowledge about production process, then accepting engineers from partners seems to provide learning activities for respondent firms while dispatching engineers to partners seems to provide teaching activities for the firms. If firms were absorbing their professional knowledge through partners, then accepting engineers from partners seems to provide teaching activities for respondent firms while dispatching engineers to partners seems to provide learning activities for the firms. To identify which flows are learning or teaching is difficult without more direct information about the "teachers" and "students".

Finally, we derive two policy suggestions based on these empirical results. First, policy resources should target firms that have a few production and intellectual linkages, particularly small- and medium-sized firms in East Asia. Linked firms receive benefits from partners while providing important information about market changes to their other partners, especially their supplier. It is also important to devote policy resources to the implementation of JIT systems. If there are some obstacles to implementing a JIT system that will help firms upgrade, public assistance can be tapped to create such a network. Economies of network based on production linkages could create such externality.

Second, policy resources should be allocated to the reduction of obstacles to exchanges of engineers in East Asia. Since exchanges of engineers happen at the local and international levels, (1) ensuring free exchanges of engineers or simplifying immigration procedures and (2) creating common certification of engineers' skills in East Asia could stimulate the upgrading of firms and industries through face-to-face communication at the different stages of product and process innovation.

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