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The Impacts of Face-to-face and Frequent Interactions on Innovation: 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 and investigates 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 innovations than firms that did not. Just-in-time relationship is effective for dealing with process innovation. We found that such strong complementarities 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: Innovation; Linkages; Exchanges of engineer; Just-in-time; Status Quo

JEL Classification: O31, O32, R12

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1. Introduction

This paper proposes a new mechanism linking innovations (product and process innovation) and networks in developing economies to identify 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 sampling cities belong to 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. There is also a lack of quantitative evidence that rigorously identifies the effects on product innovation of production-related knowledge based on process innovation or creation of new markets.

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. 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 on 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, particular, Romer (1986, 1990) emphasizes the importance of innovation in economic growth. But the inside mechanism is as almost 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. Conley and Udry (2009) studied the role of communication networks in determining the importance of learning from others. 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. Secondly, 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 sections 5.

2. Knowledge Exchanges and Innovation Performance

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.

2.1. The Value of Knowledge Diversity

One reason for the success of firms with different types of linkages is that each type of linkage provides unique information about opportunities for upgrading business processes, and about changes in the market. The linkages variable is composed of two different types of linkages: production and intellectual linkages. The former refers to linkages with several production partners that are located within or between areas of concentration. The empirical results also imply that two extremely different types of linkages complement product and process innovations. These linkages do not cancel out each other's contributions. Cassiman and Veugelers (2002, 2006), Vega Jurad *et al.* (2008), Frenz and Ietto-Gilles (2009), and Machikita and Ueki (2010) 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. Jovanovic and Rob (1989) and Keely (2003) provide some microeconomic explanations of knowledge exchanges over time. Most recently, Berliant and Fujita (2008) formalize in detail that knowledge creation needs appropriate diversity of knowledge between two persons.

2.2. Accuracy Arising from Face-to-face and Frequent Interactions

Product and process innovations are, by nature, a process of trial and error. One of the reasons why many types of linkages and face-to-face or frequent communications are beneficial to innovations is that the number of types of linkages is interpreted using instruments that help produce more accurate information compared to trial and error. If firms have many types of production linkages or have face-to-face and frequent information exchanges, the number and diversity of linkages would insure accuracy when firms invest in innovation. There is some literature focus on information accuracy from local interactions across different fields. In the setting of agricultural innovation, for example HYV (high-yield varieties), Foster and Rosenzweig (1995) develops the Bayesian framework of learning by doing and learning from others in a village, and estimates the neighborhood impacts of introducing HYV (which is a risky project in the initial stages). They show the significant impacts of neighborhood experience in updating information about optimal input volume. In the setting of labor mobility, Almeida and Kogut (1999) and Song *et al.* (2003) empirically show that there is a large level of labor mobility through new hiring across firms *within* a region, and that engineers cite patents to other engineers located *within* the same region. These behaviors within a cluster stimulate the acquisition of accurate information from local interactions. On the other hand, Berliant and Fujita (2008) emphasized the dynamic implications of knowledge creation based on face-to-face and frequent communications over time.

2.3. Berliant and Fujita in the Setting of Upstream-downstream Linkages

We derive the organizational (upstream and downstream relationship) implications of Berliant and Fujita (2008) here. Berliant and Fujita (2008) 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 to communicate 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 insure 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

3.1. 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.

3.2. 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, approximately 60 percent are local firms; 13 percent, joint-venture firms; and 25 percent, MNEs.

Firm function is classified into one of five categories here. 46 percent of the firms process raw materials. 28 percent produce components and parts while 71 percent produce final goods. A total of 24 percent procure raw materials while 43 percent carry out marketing activities.

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

3.3. Dependent Variables

Tables 2a and 2b present our main interests: 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 percent of the sample firms, on average, are able to make product innovations in general, it appears that more firms find it difficult to achieve certain kinds of product innovations. Only 9 percent said they were able to introduce new goods to new markets, while only 11 percent of 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 percent 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 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

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 percent for securing a new supplier and 65 percent for securing a new customer) than the probability of securing a new supplier or customer outside the metropolitan area (56 percent for securing a new supplier and 58 percent 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 percent for securing a new supplier and 27 percent for securing a new customer). Sample firms also found it difficult to buy inputs from, or sell products to, MNEs. Only 17 percent of the firms successfully secured new multinational suppliers within a metropolitan area while only 16 percent 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 percent of the firms successfully secured new multinational customers within an agglomeration area, while 21 percent did so outside.

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

3.4. 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. 45 percent of firms adopt the JIT system with their main customer. 34 percent of firms accept engineers from their main customer, while 21.5 percent of firms dispatch engineers to their main customer. On the other hand, 36 percent of firms adopt the JIT system with their main supplier, 27 percent of firms accept engineers from their main supplier, and 17 percent of firms dispatch engineers to their main supplier.

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

3.5. 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 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 forge 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; (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 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

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 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

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.

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

With Customer	With 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

4. The Impacts 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 introduction of new products. The dependent variable is equal to one if each firm introduces new products 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, age, firm size, and country dummy variables. We separately estimate the impacts of flows of engineers on product innovation by goods characteristics, that is, customized- and standard-goods production. As reported in Table 7, the coefficient for accepting engineers from suppliers is .329 with a standard error of .105, and it is statistically significant at the 1 percent level. Thus, firms that accept engineers from main suppliers are likely to experience a significantly higher probability of product innovation than firms that do not accept engineers from main suppliers. This effect holds true if the main customers and suppliers produce standard goods. Overall, product innovation is positively related to accepting engineers from main suppliers and dispatching engineers to main customers.

Table 8 presents the innovation impacts of dispatching engineers to main customers and suppliers. The dependent variable is product innovation. This is equal to one if each firm introduces new varieties and is zero if otherwise. 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 Table 8, the coefficient for dispatching engineers to main customers is .153 with a standard error of .080 if the main customer produces customized goods. The coefficient for dispatching engineers to main suppliers is .248 with a standard error of .100 if the main supplier produces standard goods. These results suggest that the acceptance of engineers from the main supplier and the dispatching of engineers to the main partners are positively important for product innovation.

Table 7. Engineer Acceptance from Customers/Suppliers and Introduction of New Good

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Introduction of New Good (Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
Accept Engineers from Customer	-0.039	-0.024	-0.017	0.024	-0.076
	[0.067]	[0.085]	[0.115]	[0.097]	[0.098]
Accept Engineers from Supplier	0.104	0.059	**0.329****	-0.038	**0.343****
	[0.069]	[0.083]	**[0.105]**	[0.090]	**[0.081]**
Multinational Enterprises	-0.179**	-0.234**	-0.041	-0.162*	-0.077
	[0.059]	[0.069]	[0.110]	[0.077]	[0.103]
Age	0.001	0.003	-0.004	0.002	-0.001
	[0.002]	[0.002]	[0.003]	[0.003]	[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]
Indonesia	-0.213**	-0.174*	-0.348**	-0.230**	-0.217*
	[0.059]	[0.075]	[0.099]	[0.075]	[0.095]
Philippines	-0.068	-0.103	-0.053	-0.133	-0.093
	[0.062]	[0.085]	[0.091]	[0.089]	[0.083]
Vietnam	-0.249**	-0.253**	0.334*	-0.320**	0.217+
	[0.070]	[0.087]	[0.149]	[0.089]	[0.132]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Table 8. Engineer Dispatch to Customers/Suppliers and Introduction of New Good

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Introduction of New Good (Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
Dispatch Engineers to Customer	**0.122+**	**0.153+**	0.054	0.116	0.078
	[0.067]	**[0.080]**	[0.133]	[0.093]	[0.106]
Dispatch Engineers to Supplier	0.124	0.124	0.104	0.046	**0.248***
	[0.077]	[0.098]	[0.132]	[0.108]	**[0.100]**
Multinational Enterprises	-0.158**	-0.224**	0.020	-0.170*	-0.044
	[0.056]	[0.065]	[0.103]	[0.070]	[0.101]
Age	0.001	0.003	-0.003	0.002	-0.001
	[0.002]	[0.002]	[0.003]	[0.003]	[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]
Indonesia	-0.223**	-0.191*	-0.321**	-0.234**	-0.204*
	[0.059]	[0.076]	[0.101]	[0.075]	[0.095]
Philippines	-0.107+	-0.158+	-0.047	-0.153+	-0.097
	[0.063]	[0.083]	[0.091]	[0.088]	[0.082]
Vietnam	-0.265**	-0.278**	0.303+	-0.321**	0.178
	[0.064]	[0.080]	[0.162]	[0.082]	[0.141]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Let us move to process innovations. Table 9 presents the impact of accepting engineers from the supplier on improving existing machines. The coefficient for accepting engineers from the supplier is -.140 with a standard error of .081 if the main customer produces customized goods. The coefficient for accepting engineers from the supplier is .173 with a standard error of .080 if the main customer produces standard goods. The coefficient for accepting engineers from the supplier is -.242 with a standard error of .094 if the main supplier produces customized goods. The coefficient for accepting engineers from the supplier is .191 with a standard error of .053 if the main supplier produces standard goods. These results indicate that, if the main partners produce customized goods, it is not easy to improve existing machines for firms that accept engineers from suppliers. On the other hand, if the main partners produce standard goods, accepting engineers from main suppliers stimulates the improvement of existing machines.

Table 10 reports the result of dispatching engineers to the main partners on improving existing machines. The coefficient for dispatching engineers to the customer is .139 with a standard error of .074 if the main customer produces customized goods. The coefficient for dispatching engineers to the customer is .174 with a standard error of .089 if the main supplier produces customized goods. The coefficient for dispatching engineers to the supplier is .157 with a standard error of .060 if the main supplier produces standard goods. Thus, firms that dispatch engineers to customers and suppliers could experience a significantly higher probability of internal process innovation, involving the improvement of existing machines. In summary, process innovation leading to improved internal production efficiency is negatively related to accepting engineers from suppliers if production linkages are used to produce customized goods. On the other hand, process innovation is positively related to accepting engineers from suppliers if production linkages are used to produce standard goods. Process innovation is also positively related to dispatching engineers to customers if production linkages are used to produce customized goods.

Table 11 presents the effect of accepting engineers from suppliers for firms that are working on getting ISO certification. The first column indicates that the coefficient for accepting engineers from the main supplier is .250 with a standard error of .060. Thus, firms that accept engineers from the main supplier have a significantly higher probability of becoming ISO certified. This is true if the main customer and supplier produce customized and standard goods, respectively. Table 12 reports the effect of dispatching engineers to the main customer. The coefficient for dispatching engineers to customers is .193 with a standard error of .067, indicating that firms that dispatch engineers to customers have a significantly increased probability of getting ISO certified, which is considered as a process innovation directed towards the external market.

Making investments to deal with disequilibria is another kind of process innovation. The dependent variable is equal to one if a firm invests in internal activities that will help it adjust to changes in the market. As reported in Table 13, the coefficient for accepting engineers from the supplier is .332 with a standard error of .053. Thus, firms that accept engineers from suppliers are more likely to make investments that will enable them to adjust to changes in the market. Table 14 shows that the coefficient for dispatching engineers to the customer is .218 with a standard error of .059 while the coefficient for dispatching engineers to the supplier is .150 with a standard error of .073. The impacts on process innovation of the practice of dispatching engineers is higher for firms that dispatch engineers to customers than for firms that dispatch engineers to suppliers in the face of market disequilibria or market turbulence. In summary, 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.

Table 9. Engineer Acceptance from Customers/Suppliers and Improved Existing Machines

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Improved Existing Machines (Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
Accept Engineers from Customer	0.050	0.082	-0.023	0.116	0.004
	[0.062]	[0.083]	[0.100]	[0.101]	[0.074]
Accept Engineers from Supplier	-0.059	**-0.140+**	**0.173***	**-0.242***	**0.191****
	[0.065]	**[0.081]**	**[0.080]**	**[0.094]**	**[0.053]**
Multinational Enterprises	-0.219**	-0.277**	-0.089	-0.198*	-0.146
	[0.061]	[0.074]	[0.113]	[0.085]	[0.106]
Age	0.003	0.004	0.000	0.006+	-0.001
	[0.002]	[0.003]	[0.003]	[0.003]	[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]
Indonesia	-0.053	-0.114	-0.073	0.046	-0.190+
	[0.067]	[0.094]	[0.104]	[0.093]	[0.097]
Philippines	-0.056	-0.115	-0.030	-0.031	-0.126+
	[0.064]	[0.104]	[0.080]	[0.109]	[0.068]
Vietnam	-0.293**	-0.351**	0.048	-0.263*	-0.063
	[0.082]	[0.103]	[0.159]	[0.113]	[0.136]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Table 10. Engineer Dispatch to Customers/Suppliers and Improved Existing Machines

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Improved Existing Machines (Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
Accept Engineers to Customer	**0.118+**	**0.139+**	0.020	**0.173+**	0.027
	[0.060]	**[0.074]**	[0.121]	**[0.089]**	[0.076]
Accept Engineers to Supplier	**0.115+**	0.106	0.136	0.048	**0.157****
	[0.065]	[0.087]	[0.099]	[0.112]	**[0.060]**
Multinational Enterprises	-0.237**	-0.316**	-0.061	-0.278**	-0.114
	[0.058]	[0.068]	[0.110]	[0.074]	[0.103]
Age	0.002	0.003	0.001	0.005	-0.001
	[0.002]	[0.003]	[0.003]	[0.003]	[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]
Indonesia	-0.062	-0.118	-0.060	0.054	-0.183+
	[0.067]	[0.095]	[0.101]	[0.092]	[0.095]
Philippines	-0.089	-0.152	-0.041	-0.036	-0.125+
	[0.064]	[0.104]	[0.081]	[0.107]	[0.069]
Vietnam	-0.298**	-0.348**	0.004	-0.227*	-0.086
	[0.077]	[0.096]	[0.180]	[0.101]	[0.152]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Table 11. Engineer Acceptance from Customers/Suppliers and Adopted ISO

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Adopted ISO (Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
Accept Engineers from Customer	0.069	0.057	0.131	0.023	0.138
	[0.065]	[0.084]	[0.112]	[0.092]	[0.095]
Accept Engineers from Supplier	**0.250****	**0.249****	**0.261***	**0.279****	**0.196+**
	[0.060]	**[0.073]**	**[0.111]**	**[0.077]**	**[0.101]**
Multinational Enterprises	0.240**	0.247**	0.242*	0.242**	0.269**
	[0.058]	[0.071]	[0.111]	[0.079]	[0.094]
Age	-0.001	-0.002	-0.002	-0.002	-0.002
	[0.002]	[0.003]	[0.003]	[0.003]	[0.003]
Full-time Employees	0.000**	0.000**	0.001**	0.000**	0.000**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Indonesia	-0.361**	-0413**	-0.344**	-0.355**	-0.364**
	[0.061]	[0.078]	[0.103]	[0.090]	[0.079]
Philippines	-0.331**	-0.476**	-0.199*	-0.408**	-0.297**
	[0.062]	[0.079]	[0.094]	[0.098]	[0.081]
Vietnam	-0.270**	-0.361**	0.002	-0.279*	-0.208
	[0.078]	[0.097]	[0.230]	[0.109]	[0.133]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Table 12. Engineer Dispatch to Customers/Suppliers and Adopted ISO

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Adopted ISO (Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
Accept Engineers to Customer	**0.193****	**0.190***	**0.226+**	**0.198***	**0.197+**
	[0.067]	**[0.079]**	**[0.124]**	**[0.082]**	**[0.109]**
Accept Engineers to Supplier	0.087	0.025	0.178	0.005	**0.207+**
	[0.082]	[0.101]	[0.136]	[0.110]	**[0.116]**
Multinational Enterprises	0.323**	0.342**	0.289**	.0353**	0.291**
	[0.053]	[0.062]	[0.107]	[0.067]	[0.093]
Age	-0.002	-0.003	-0.002	-0.002	-0.001
	[0.002]	[0.002]	[0.004]	[0.003]	[0.003]
Full-time Employees	0.000**	0.000**	0.001**	0.000**	0.000**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Indonesia	-0.362**	-0.422**	-0.324**	-0.367**	-0.356**
	[0.060]	[0.077]	[0.103]	[0.088]	[0.080]
Philippines	-0.350**	-0.490**	-0.224*	-0.446**	-0.310**
	[0.061]	[0.077]	[0.095]	[0.095]	[0.080]
Vietnam	-0.213**	-0.315**	-0.055	-0.246*	-0.254+
	[0.076]	[0.095]	[0.254]	[0.106]	[0.137]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Table 13. Engineer Acceptance from Customers/Suppliers and Adjust Changes in the Market

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Introduced Internal Activities to Adjust Changes in the Market (Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
Accept Engineers from Customer	0.061	0.102	-0.051	0.138	-0.025
	[0.066]	[0.080]	[0.112]	[0.091]	[0.094]
Accept Engineers from Supplier	**0.332****	**0.336****	**0.368****	**0.308****	**0.367****
	[0.053]	**[0.065]**	**[0.084]**	**[0.077]**	**[0.065]**
Multinational Enterprises	0.140*	0.103	0.201+	0.153+	0.147
	[0.062]	[0.078]	[0.114]	[0.082]	[0.102]
Age	-0.001	-0.002	0.003	0.000	-0.002
	[0.002]	[0.003]	[0.003]	[0.003]	[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]
Indonesia	-0.612**	-0.584**	-0.695**	-0.553**	-0.667**
	[0.051]	[0.073]	[0.061]	[0.083]	[0.056]
Philippines	-0.370**	-0.386**	-0.379**	-0.397**	-0.374**
	[0.066]	[0.098]	[0.090]	[0.109]	[0.080]
Vietnam	-0.407**	-0.457**	0.042	-0.400**	-0.346*
	[0.081]	[0.100]	[0.249]	[0.111]	[0.135]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Table 14. Engineer Dispatch to Customers/Suppliers and Adjust Changes in the Market

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Introduced Internal Activities to Adjust Changes in the Market (Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
Accept Engineers to Customer	**0.218****	**0.228****	0.113	**0.215****	**0.236****
	[0.059]	**[0.067]**	[0.125]	**[0.079]**	**[0.089]**
Accept Engineers to Supplier	**0.150***	0.096	**0.282****	0.117	**0.198+**
	[0.073]	[0.093]	**[0.104]**	[0.103]	**[0.103]**
Multinational Enterprises	0.255**	0.256**	0.252*	0.305**	0.175+
	[0.053]	[0.063]	[0.105]	[0.065]	[0.099]
Age	-0.001	-0.003	0.004	-0.001	-0.002
	[0.002]	[0.003]	[0.003]	[0.003]	[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]
Indonesia	-0.613**	-0.595**	-0.681**	-0.560**	-0.658**
	[0.050]	[0.071]	[0.062]	[0.081]	[0.056]
Philippines	-0.399**	-0.406**	-0.408**	-0.449**	-0.385**
	[0.066]	[0.098]	[0.089]	[0.106]	[0.080]
Vietnam	-0.343**	-0.382**	-0.107	-0.312**	-0.423**
	[0.083]	[0.103]	[0.283]	[0.113]	[0.129]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Finally, the formation of a JIT system is also a proxy of information exchanges through production linkages. Table 15 reports the impacts of forming a JIT system with the main customer and supplier, on introducing new products to new markets, which is a type of product innovation, or some combinations of product innovations and market-creating innovations. 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. Column 1 of Table 15 shows that the coefficient for a JIT system with the customer is -0.090 with a standard error of .038. Colum 3 of Table 15 shows that the coefficient for a JIT system with the customer is -0.191 with a standard error of .051 if the customer produces a standard product. Colum 5 of Table 15 shows that the coefficient for a JIT system with the customer is -0.243 with a standard error of .053 if the supplier produces a standard product. These results indicate that JIT with customer does not stimulate the introduction of new goods to new markets. On the other hand, Colum 5 of Table 15 shows that the coefficient for a JIT system with the supplier is 0.141 with a standard error of .069 if the supplier produces a standard product. This result indicates that JIT with supplier stimulates the introduction of new goods to new markets.

Table 16 reports the impact of forming a JIT system with the main customer and supplier on earning ISO certification, which is a type of process innovation towards the external market. 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. Table 17 shows that the coefficient for a JIT system with the customer is .245 with a standard error of .100 if the customer produces a standard product. The coefficient for a JIT system with the supplier is .225 with a standard error of .098 if the supplier produces a customized product. These results indicate that firms that form a JIT system with a customer have a significantly higher probability of getting ISO certified than firms that do not have a JIT system with their main customer.

Table 17 presents the impact of forming a JIT system with a customer on a firm's ability to adjust to changes in the market. The empirical question here is whether a JIT system provides information flows relevant to market changes or market turbulence. The coefficient for a JIT system with the customer is .206 with a standard error of .102 if the customer produces a standard product, 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. 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.

Table 15. JIT with Customers/Suppliers and Introduction of New Good to New Market

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Introduction of New Good to New Market(Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
JIT with Customer	**-0.090***	-0.037	**-0.191****	0.009	**-0.243****
	[0.038]	[0.048]	**[0.051]**	[0.048]	**[0.053]**
JIT with Supplier	0.041	0.060	0.005	0.005	**0.141***
	[0.045]	[0.059]	[0.056]	[0.049]	**[0.069]**
Multinational Enterprises	-0.031	-0.039	-0.003	-0.041	0.001
	[0.031]	[0.034]	[0.058]	[0.031]	[0.053]
Age	0.001	0.001	0.000	0.001	0.000
	[0.001]	[0.001]	[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]
Indonesia	0.030	0.026	0.044	0.100	-0.048
	[0.040]	[0.045]	[0.087]	[0.068]	[0.042]
Philippines	0.002	0.014	-0.018	0.057	-0.050
	[0.032]	[0.046]	[0.051]	[0.069]	[0.043]
Vietnam	-0.073*	-0.031		0.021	-0.086**
	[0.029]	[0.044]		[0.060]	[0.025]
Observations	587	376	203	325	262

Note: Dependent variable equals to 1 if introduction of new good to new market (Yes); 0 otherwise. Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Table 16. JIT with Customers/Suppliers and Adopted ISO

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Adopted ISO (Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
JIT with Customer	**0.122+**	0.106	**0.245***	**0.225***	0.071
	[0.068]	[0.095]	**[0.100]**	**[0.098]**	[0.092]
JIT with Supplier	-0.041	0.027	**-0.204+**	-0.015	-0.054
	[0.071]	[0.092]	**[0.113]**	[0.100]	[0.099]
Multinational Enterprises	0.310**	0.331**	0.252*	0.350**	0.278**
	[0.053]	[0.063]	[0.104]	[0.068]	[0.089]
Age	-0.002	-0.002	-0.002	-0.002	-0.001
	[0.002]	[0.002]	[0.003]	[0.003]	[0.003]
Full-time Employees	0.000**	0.000**	0.001**	0.000**	0.000**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Indonesia	-0.375**	-0.464**	-0.301*	-0.466**	-0.344**
	[0.063]	[0.077]	[0.118]	[0.092]	[0.084]
Philippines	-0.322**	-0.483**	-0.153	-0.493**	-0.241**
	[0.063]	[0.079]	[0.100]	[0.092]	[0.082]
Vietnam	-0.149+	-0.265**	0.174	-0.196+	-0.116
	[0.079]	[0.097]	[0.202]	[0.108]	[0.152]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

Table 17. JIT with Customers/Suppliers and Adjust Changes in the Market

Probit (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Introduced Internal Activities to Adjust Changes in the Market(Yes/No)	All	Customer makes Customized Product	Customer makes Standard Product	Supplier makes Customized Product	Supplier makes Standard Product
JIT with Customer	**0.117+**	0.085	**0.206***	0.147	0.114
	[0.066]	[0.090]	**[0.102]**	[0.099]	[0.090]
JIT with Supplier	-0.042	0.030	-0.178	0.014	**-0.089**
	[0.067]	[0.087]	[0.111]	[0.098]	**[0.095]**
Multinational Enterprises	0.240**	0.235**	0.238*	0.295**	0.180*
	[0.052]	[0.064]	[0.100]	[0.065]	[0.091]
Age	-0.001	-0.003	0.003	0.000	-0.002
	[0.002]	[0.003]	[0.003]	[0.003]	[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]
Indonesia	-0.606**	-0.608**	-0.661**	-0.603**	-0.637**
	[0.053]	[0.072]	[0.070]	[0.085]	[0.060]
Philippines	-0.361**	-0.378**	-0.347**	-0.457**	0.325**
	[0.067]	[0.099]	[0.095]	[0.106]	[0.083]
Vietnam	-0.269**	-0.314**	0.147	-0.257*	-0.276+
	[0.085]	[0.103]	[0.202]	[0.113]	[0.155]
Observations	587	376	211	325	262

Note: Robust standard errors in brackets. + significant at 10%; * significant at 5%; ** significant at 1%. Reference country is Thailand.

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. 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.

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.

Secondly, 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) insuring 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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