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Innovation in Linked and Non-linked Firms: Effects of Variety of Linkages in East Asia*

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Abstract: This paper proposes a new mechanism linking innovation and network in developing economies to detect explicit production and information linkages and investigates the testable implications of these linkages using survey data gathered from manufacturing firms in Indonesia, Thailand, the Philippines, and Vietnam. In-house R&D activities, internal resources, and linkages with local firms and foreign firms play a role in reducing the costs of product and process innovation and search costs for finding new suppliers and customers. We found that firms with more varieties of information linkages achieve more types of innovations. Complementarities between internal and external sources of knowledge are also found.

Keywords: innovation, linkages, sources of knowledge, dissimilarity, complementarities

JEL classifications: O31, O32, O33

1. Introduction

This paper proposes a new mechanism linking innovations and networking activities in developing economies to identify explicit internal and external information sources. It also investigates the empirical implications of this new mechanism using survey data gathered from manufacturing firms in four countries in East Asia: 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 to precisely capture the knowledge transmission mechanism in inter-firm communication.

There is a lack of quantitative evidence that rigorously identifies the effects on several types of innovation of different varieties of internal and

external knowledge sources except for Cassiman and Veugelers (2002, 2006), Vega Jurad *et al*. (2008), and Frenz and Ietto-Gilles (2009). This paper is closely related to the theoretical concept employed by Frenz and Ietto-Gillies (2009) in their research. They tried to estimate the impact of different sources of knowledge on innovation performance using UK CIS dataset. In addition, as our first empirical test, this paper tries to estimate the benefits of diversity within each source of knowledge on innovation performance. Our second test is to examine complementarities between the degree of own knowledge creation (R&D activities) and internal and external sources on innovations. Diversity impacts of linkages have not been fully examined in the field of innovation performance in developing economies. Since we need to quantify the contribution of searching for internal sources and networking with external sources on innovation, this paper collects detailed information about varieties of linkages and varieties of innovation. This field survey-based information provides findings that are lacking in previous studies.

To examine the complementarities between the degree of own knowledge creation and internal and external sources on innovations, we need to identify the extent of companies' investment in R&D as the proxy of knowledge creation, 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 or other information sources. 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. R&D activities and the variety of linkages on innovations. Estimating the empirical elasticity of each linkage would enable us to detect the exact channels of several types of innovations.

This paper will investigate the role of production networks on industrial upgrading by documenting the spatial architecture of upstream and downstream firms in developing economies and examining the network effects of innovations. Local network externalities are a mechanism for understanding the relationship between production networks and innovation. At the cross-country level, 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. In household or farmer's level, Conley and Udry (2009) studied the role of communication networks in determining the importance of learning from others.

The next section shows our framework and concept. Data will be described in Section 3. Empirical results are examined in Section 4. The discussions and conclusion are shown in Sections 5.

2. Variety of Linkage Effects on Innovation Performance

Manufacturing industries in East Asia are primarily involved in exporting and importing, and receive benefits from agglomeration economies within each country. Since they face not only domestic competitions but also international competitions, the firms adopt new technologies, acquire new organizational forms to adapt to situations of market changes, create new markets, find new inputs for improving product quality and cost efficiency, and introduce new products. They utilize the external environment and local/international markets to upgrade themselves.

We test what happens to firms' innovations when firms successfully attract or hold many types of production or information linkages. In particular, we ask (1) why firms with many types of internal and external sources achieve different types of innovations; (2) why different types of internal and external sources complement each other to achieve innovations.

2.1 The Benefit of Diversity within Same Types of Sources

Table 1 provides a summary of the main characteristics of the different types of knowledge sources which are examined in this paper. First, we have five types of internal and external sources: (1) internal resources; (2) linkages with local firms; (3) linkages with multinational enterprises (MNEs hereafter); (4) linkages with public organizations; (5) linkages with universities (see Rajah, 2009). These internal and external sources are characterized by different varieties of sources within each type of source. Internal resources are divided into nine sources, for example, R&D department, recruitment of personnel retired from MNEs and large firms, and reverse engineering and so on. The varieties of internal resources are quite dissimilar and heterogeneous. Linkages of local and MNEs also share these tendencies. Since linkages with public organizations have six different varieties of sources, public organizations usually provide some public information services: technical assistance and research and business consortium. Linkages with public organizations would be more similar than linkages with local firms or linkages with MNEs. Linkages with universities provide technical cooperation and also provide more similar information services than internal resources and external linkages with firms.

One reason for the success of firms with many varieties of linkages is that each variety of linkage provides unique information about upgrading business processes and changes in the market. We assume that these linkages do not cancel out each other's contributions. If a combination of linkages is not costly, the combination of two different sources of knowledge is valuable for innovations. In fact, Saxenian (1996, 2006) shows that Indian or Chinese technicians coming back from Silicon Valley combine their resources

Table 1: Types of Sources and Their Characteristics

Types of sources	Varieties of sources within each type	Similarities within types
Source 1:		
Internal resources	(1) Own R&D department (2) Own Sales department or sales agent (3) Own production or manufacturing department (4) Technological agreement with the headquarters or affiliated firm (5) Recruitment of mid-class personnel (6) Recruitment of personnel retired from MNCs and large firms (7) Technical information obtainable from patents (8) Introduction of "foreign-made" equipment and software (9) Reverse engineering	Dissimilar
Source 2:		
Linkages with local firms	(1) Joint venture established by your firm with other local firms (2) Local supplier or customer (100% local capital) (3) Local competitor (4) Local firm in the different business (5) Licensing technologies from other local firms (6) Local consultant hired by your firm	Dissimilar
Source 3:		
Linkages with MNEs	(1) Joint venture established by your firm with other multinationals (2) Multinational supplier or customer (3) Multinational competitor	Dissimilar

Table 1: (continued)

Types of sources	Varieties of sources within each type	Similarities within types
	(4) Foreign-owned firm in the different busines (5) Licensing technologies from other MNCs (6) International consultant hired by your firm	
Source 4: Linkages with public organization	(1) Technical assistance financed/provided by government/ public agency (2) Technical assistance financed/provided by local business organization (3) Research consortium organized with the support of government (4) Research consortium organized with the support of local business organization (5) Business consortium organized with the support of government (6) Business consortium organized with the support of local business organization	Similar
Source 5: Linkages with universities	(1) Technical cooperation with local university or R&D institute (2) Technical cooperation with foreign university or R&D institute (3) Academic society and academic journal	Similar

Source: ERIA Establishment Survey 2008.

with local knowledge to create new businesses. Berliant and Fujita (2008) formalize in full detail that knowledge creation needs appropriate diversity of knowledge between two persons.

2.2 Accuracy Arising from Interactions

Product, production process, and organizational innovations are, by nature, a process of trial and error. One of the reasons why many varieties of linkages within each type of sources are beneficial to innovations is that the number of varieties of external sources and internal resources are interpreted using instruments that help produce more accurate information compared to trial and error. If firms have many varieties of production linkages with local firms or MNEs, the number and diversity of linkages would insure accuracy when firms invest in innovations trials. If firms do not already have an instrument for internal trial and error, they can learn about other firms' trials and errors only through external linkages. On the other hand, firms with sufficient internal resources or with R&D activities could acquire this information by themselves. It is also true that firms with R&D activities could learn from several types of external resources than firms without R&D activities. That is, information accuracy increases when firms successfully attract external resources into their own internal resources including R&D activities.

There is some literature 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) developed the Bayesian framework of learning by doing and learning from others in village and estimate the neighbourhood impacts of introducing HYV which is a risky project in the initial stage. Conley and Udry (2009) collected more detail information in neighbourhood communication network. They find significant impacts of local interaction in terms of updating farmer's belief in input control. In the setting of labor mobility across regions, previous research shows the flow of knowledge being embedded in local labor mobility. Almeida and Kogut (1999) find localized knowledge to be restricted to certain regions coupled with the occurrence of a large variation of localization across regions. In addition, they find that local transfer of knowledge is stimulated by inter-firm mobility of engineers, technicians and other professional and technical personnel (see Rasiah, 1994, 1995). Similarly, Song *et al*. (2003) shows the occurrence of inter-firm knowledge transfer that emanates from hired engineers, who possess technological expertise distant from that of the hiring firm. They conclude that learning-by-hiring can be useful when hired engineers are used for exploring technologically distant knowledge. These two researches suggest that engineers are expected to bring fresh ideas to a firm, though the flow of knowledge seems to be geographically embedded.

2.3 The Role of Linkages with Multinational Enterprises

We should not forget about the presence of MNEs in developing economies, especially in East Asia. Since Japanese MNEs have led the formation of production networks in the region, the relationship between production networks and innovation intensity and its type should vary according to the degree of firms' capital tie-up with MNEs. In Indonesia and Thailand, Ramstetter and Sjoholm (2006) try to answer the following three empirical questions: (1) why multinationals pay higher wages than local firms and whether the entry of multinationals raise wages for domestic workers; (2) why multinationals have higher productivity and whether multinationals affect the productivity of domestic enterprises; (3) whether multinationals have a greater tendency to export than local firms. If these are true, transaction linkages with MNEs provide positive pecuniary and technological externalities especially for local firms.

2.4 Hypothesis

In summary, linkages with local and foreign firms may help to reduce the cost of finding new suppliers and customers. Firms with more information linkages are more likely to introduce new goods and technologies in new markets as well as finding a new supplier. Then the varieties of linkages stimulate not only product innovations, process innovations but also the new input and market creation. In line with the above three previous literatures, we examine the effects of varieties of internal and external sources on innovation performance through the following hypotheses:

Hypothesis 1

The varieties of internal and external sources increase the benefits from combinations of varieties within each type of source, leading to higher innovation performance.

Hypothesis 2

In-house research and development activities and the different types of internal and external sources complement each other, leading to higher innovation performance.

Hypothesis 3

The different types of external sources (linkages with local firms and linkages with MNEs) complement each other, leading to higher innovation performance.

3. Data

This section presents the survey data, sampling, and summary statistics of dependent and independent variables. The data used are sourced by the authors from an original survey of manufacturers in Southeast Asia. In contrast to the standard administrative data, our dataset covers variables that relates to different types of product and process innovations including other unique variables closely associated with management practices inside the firm as well as management practices that support network of firms to external linkages.

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. For statistical purposes respondents with missing observations are excluded from the estimated sample. Number of observations is 578 firms.

3.2 Dependent Variables

We classified innovations into the following five categories based on the Schumpeterian view: (1) product innovation (introduction of new goods); (2) production process innovations, including adoption of new technology; (3) organizational innovations to improve product quality and cost efficiency; and (4) procurement innovations, that is, securing new suppliers to produce existing products for efficiency or obtaining new products; (5) market creating innovations securing new customers to sell existing lineup or new products. Table 2a shows summary statistics of the number of types of innovations. The variety of product innovations for each firm is the sum of the types of innovations within product innovations. The sample average of variety of product innovations for the pooled dataset is 0.671. Production process and organizational innovations (1.752) are more popular than product innovations (1.469) among firms. Procurement innovations (2.549) are less popular than market creating innovations (2.742). As shown in Table 2a, there is a large cross-sectional dispersion of innovations within a type. The detailed characteristics of each type of innovations are shown in Table 2b.

Table 2a: Summary Statistics of the Number of Types of Innovations

	Mean	Std. Dev.	Min	Max
Number of Types of Product Innovations	0.671	0.870	0	3
Number of Types of Production Process Innovations	1.752	1.220	0	3
Number of Types of Organizational Innovations	1.469	1.198	0	3
Number of Types of Procurement Innovations	2.549	2.061	0	7
Number of Types of Market Creating Innovations	2.742	2.128	0	7

Source: ERIA Establishment Survey 2008.

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

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

Source: ERIA Establishment Survey 2008.

Table 2c: Summary Statistics of Market-based Innovations

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

Source: ERIA Establishment Survey 2008.

Table 2b decomposes product, production process, and organizational innovations into three varieties respectively. While approximately 45 per cent of the firms, on average, are able to do product innovations in general, it appears that more firms find 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 2c decomposes procurement and market creating innovations into seven varieties respectively. 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 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.

3.3 Independent Variables Explaining Innovation Performance

The independent variables are presented in Table 3. The main independent variables are types of sources and its variety of sources within each type of sources as depicted in Table 1. Table 3 shows R&D activities, number of types of internal resources (nine different varieties of internal resources), number of types of linkages with local firms (six different varieties of linkages), number of types of linkages with MNEs (six different varieties of linkages),

Table 3: Summary Statistics and Correlations of Independent Variables (Sources and Controls)

	Mean	Std. Dev.	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) R&D activities (1 if yes, 0 otherwise)	0.221	0.416	0	1	1								
(2) Number of types of internal resources	4.051	3.203	0	9	0.2726*	1							
(3) Number of types of linkages with local firms	1.881	2.251	0	6	0.1858*	0.7887*	1						
(4) Number of types of linkages with MNEs	1.878	2.282	0	6	0.1403*	0.7584*	0.7457*	1					
(5) Number of types of linkages with public organizations	1.509	2.383	0	6	0.1768*	0.6494*	0.7894*	0.5804*	1				
(6) Number of types of linkages with universities	0.663	1.175	0	3	0.1838*	0.6406*	0.7777*	0.6135*	0.8740*	1			
(7) Multinational enterprises	0.251	0.434	0	1	-0.1621*	0.0026	-0.1117*	0.0695	-0.2406*	-0.2070*	1		
(8) Age	14.202	12.392	1	80	0.2370*	-0.0112	-0.0002	-0.056	0.1072*	0.1037	-0.2990*	1	
(9) Full-time employees	293.879	456.483	10	2000	0.1950*	0.0607	-0.0596	0.0426	-0.0644	-0.0351	0.1462*	0.2112*	1

Note: Correlations with asterisk ($p < 0.01$).
Source: ERIA Establishment Survey 2008.

number of types of linkages with public organizations (six different varieties of linkages), number of types of linkages with universities (three different varieties of linkages).

We count the number of *varieties* of linkages. If the firm has a linkage to a local or foreign customer or supplier, we count that as *one* type of local or foreign production linkage. In addition, if the firm has a linkage to local or foreign university, we also count that as another type of local or foreign intellectual linkage. This means that such a firm has two types of linkages.

R&D activities are done by 22 per cent of firms. The detailed variety of linkages is also quite different across types of linkages. The sample average (standard deviation) of the number of sources is 4.05 (3.20) types of internal resources. Firms holding linkages with local firms only have 1.88 types of linkages on average while firms holding linkages with MNEs have an average of 1.89 types of linkages. Public linkages are 1.50 types on average. As in Table 3, these suggest that firms usually have less than two types of production and public linkages though standard deviations are quite large. On average, firms holding linkages with universities only have 0.66 types of linkages.

The most striking evidence of technical transfer is that production-related linkages are more cultivated than intellectual linkages. For example, collaboration in the form of joint ventures established by a sample firm with other local firms and collaboration with a local supplier or customer were done by 32 per cent and 41 per cent of the firms, respectively. On the other hand, 27 per cent of the firms accepted technical assistance, financed or provided by a government or public agency while 23 per cent engaged in technical cooperation projects with a local university. Technology transfer between firms is prevalent, and University-Industry Linkages (hereafter, UIL) do not play a key role in technology transfer in East Asia.

Furthermore, many firms also rely on internal sources for information on upgrading and innovation. Thirty-four per cent of the surveyed firms depend on their own R&D departments as a source of information and R&D initiatives while 38 per cent utilize their own sales departments and sales agents as information sources. Fifty-one per cent of the surveyed firms use technological agreements with headquarters or affiliated firms; 62 per cent look to their own production and manufacturing departments when undertaking upgrades.

3.4 Other Control Variables

Table 3 also presents the summary statistics of the control variables. "Multinational Enterprises" is a dummy variable equal to one for a firm that is wholly funded by foreign capital. Multinationals can access global technology frontiers and belong to international markets. This is not only a proxy of

financial advantages for innovations but also a proxy of technology advantages compared with local firms. Age and employment size are also attributes of innovations. Aged firms have a history of established production linkages and accumulated innovations. There is also a difference in the types of innovations and innovation investments that large and small/medium firms make. Cross-country differences can be attributed to the fundamental differences in the causes and consequences of innovations in response to market conditions.

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 whole 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 per cent are local firms; 13 per cent, joint-venture firms; and 25 per cent, MNEs.

4. Results

This section presents the average correlations between the several types of innovations and external linkages based on our econometric model to detect effective production and information linkages. First, we document the baseline results between the impacts of different types of linkages on different varieties of innovations. Second, we examine complementarities between R&D and linkages in terms of achieving product innovations. Third, we also emphasize complementarities between two types of external sources in terms of procurement innovations (securing new supplier).

4.1 The Varieties of Innovations within each Type

To what extent are firms able to do innovations with and without linkages? In this section, we answer this question in order to present the effects of diversity of linkages on innovations performance. Innovation performance is measured in two ways: (1) how different varieties of innovation are achieved simultaneously within each type of innovations; and (2) how each variety of innovation is achieved. In order to answer the first empirical question, we have two assumptions. This paper assumes that firms which own many types of linkages have potentially several directions of knowledge sources. This also could be information sources of choice of innovation activities. We set estimated equation to explain the firm's achievement of several types of innovation as in the following ordered logit model:

$$Logit\ \ (y_{ic}) = \alpha R_{ic} + \beta VARIETY\_LINK_{ic} + \gamma x_{ic} + u_{ic}$$

where y means the number of types of innovation performance for each firm i located in each country; the variable R signifies whether each firm

achieves the R&D activities or not, the variable *VARIETY_LINK* signifies the number of types of linkages, i.e. production linkages with local customers or suppliers, linkages with MNCs or Joint Ventures linkages with public supports, and linkages with academics; *x* is other controls, i.e. age, size, status of exporting goods to foreign countries, status of importing intermediate goods from foreign countries, and country dummy variables. Error term follows logistic distribution and this is shown by *u*. We estimate this ordered logit model to simply regress the dependent variable (the number of types of innovation performance) to independent variables and controls. We focus on the estimated coefficient of *VARIETY_LINK* as the degree of innovation management technology across firms which transform several different types of linkages into different kinds of innovation achievement.

Table 4 presents the baseline results of the impacts of different types of linkages on different varieties of innovations within each type. The dependent variable is the number of varieties of innovations within each type, i.e. the sum of varieties within product innovations, the sum of varieties within production process innovations, the sum of varieties within organizational innovations, the sum of varieties within procurement innovations, and the sum of varieties within market creating innovations.

Column (1) of Table 4 shows that the coefficient for the R&D activities is 0.804 with standard error of 0.223 for product innovations; it is statistically significant at the 1 per cent level. In other words, R&D activities raise the number of varieties within product innovations through introducing new products to new markets or introducing new products using new technologies. The effects of R&D activities are quite pervasive and significant in explaining other types of innovations: production process innovations, organizational innovations, procurement innovations, and market creating innovations as shown in column (2) to (5).

The coefficient for the number of types of internal resources is 0.180 with standard error of 0.063 in explaining the number of varieties of product innovations; it is statistically significant at the 1 per cent level. Firms with more varieties of internal resources could implement significantly more new products than firms with fewer varieties of internal resources, even after controlling for firm and country characteristics. However, the impacts of internal resources disappear in explaining innovations in production processes, organizational level, procurement, and market creation.

The impacts of linkages with local firms and impacts of linkages with MNEs have different directions compared to the results of internal resources. As shown in column (4), the coefficient for the varieties of linkages with local firms is 0.168 with standard error of 0.068 in explaining procurement innovations; it is statistically significant at the 5 per cent level. As shown in column (5), the coefficient for the number of types of linkages with local firms

Table 4: Number of Linkages and Number of Innovations by Function

Ordered Logit Model	(1)	(2)	(3)	(4)	(5)
Dependent variables: Number of varieties of innovations within each type	Type: Product Innovations	Type: Process Innovations	Type: Organizational Innovations	Type: Procurement Innovations	Type: Market Creating Innovations
R&D activities	0.804**	0.920**	1.231**	0.705**	0.599*
	[0.223]	[0.224]	[0.218]	[0.249]	[0.243]
Number of varieties of internal resources	0.180**	0.005	0.053	0.021	0.059
	[0.063]	[0.054]	[0.054]	[0.055]	[0.048]
Number of varieties of linkages with local firms	-0.009	-0.043	0.082	0.168*	0.139+
	[0.083]	[0.072]	[0.103]	[0.068]	[0.072]
Number of varieties of linkages with MNEs	-0.163*	0.043	0.093	0.063	0.100+
	[0.067]	[0.069]	[0.071]	[0.057]	[0.055]
Number of varieties of linkages with public organizations	0.100	0.075	0.017	-0.011	-0.030
	[0.086]	[0.079]	[0.092]	[0.071]	[0.078]
Number of varieties of linkages with universities	-0.096	-0.118	-0.136	-0.006	0.050
	[0.178]	[0.160]	[0.187]	[0.111]	[0.124]
Multinational enterprises	-0.422+	-0.645**	1.550**	1.160**	0.580*
	[0.248]	[0.235]	[0.236]	[0.223]	[0.227]
Age	0.003	0.009	-0.004	0.004	0.008
	[0.008]	[0.007]	[0.007]	[0.008]	[0.007]

Table 4: (continued)

Ordered Logit Model	(1)	(2)	(3)	(4)	(5)
Dependent variables: Number of varieties of innovations within each type	Type: Product Innovations	Type: Process Innovations	Type: Organizational Innovations	Type: Procurement Innovations	Type: Market Creating Innovations
Full-time employees	0.001**	0.001**	0.001**	0.000*	0.000+
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Indonesia	-0.335	-0.497+	-1.963**	-0.773**	-1.373**
	[0.308]	[0.286]	[0.322]	[0.264]	[0.272]
Philippines	0.496	-0.090	-1.059**	-0.189	-1.360**
	[0.334]	[0.324]	[0.334]	[0.278]	[0.285]
Vietnam	-0.567	-1.320**	-1.324**	0.947*	0.237
	[0.440]	[0.383]	[0.422]	[0.377]	[0.353]
Observations	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: ERIA Establishment Survey 2008.

is 0.139 with standard error of 0.072 in explaining procurement innovations; it is statistically significant at the 10 per cent level. These suggest that the varieties of linkages with local firms raise procurement and market creating innovations.

The coefficient for the number of varieties of linkages with MNEs is -0.163 with standard error of 0.067 in explaining product innovations; it is statistically significant at the 5 per cent level. The coefficient for the number of varieties of linkages with MNEs is 0.10 with standard error of 0.055 in explaining market creating innovations; it is statistically significant at the 10 per cent level. Firms which hold linkages with MNEs have lower probability to produce new products. But such firms have higher probability to find new market.

On the other hand, the impact of varieties of linkages with public organizations and universities is not significant. The effects of being an MNE suggest that MNEs in East Asia do not devote their resource and capacity to product and production process innovations while MNEs achieve organizational innovations, procurement innovations, and market creating innovations.

Cross-country differences in the variety of innovations are apparent: firms in Indonesia and the Philippines innovate less than those in Thailand. This sample also reflects the difference between less developed countries in East Asia like Indonesia and the Philippines and more developed countries like Thailand. There is also significant difference between Vietnam and Thailand except for procurement innovations. Firms in Vietnam achieve more procurement innovations compared to Thailand.

4.2 Complementarities between R&D and Linkages: Production Process Innovations

To what extent are firms with R&D able to do innovations when they have varieties of internal-external sources? We test this question here to focus on inside the production process innovations: introducing new machines. Table 5 reports the interaction terms of R&D and several types of internal-external sources as well as the effects of R&D and several types of internal-external sources. We use the Probit model to estimate the marginal impacts of complementarities between R&D and linkages on investment in new machines. First of all, the marginal impacts of R&D activities and each type of internal and external sources are not significant by themselves in the face of introducing new machines. Several specifications do not strongly suggest their own impacts.

Column (1) of Table 5 suggests that the coefficient for interaction terms between R&D activities and number of varieties of internal resources is 0.056 with standard error of 0.017; it is statistically significant at the 1 per cent level. Column (2) of Table 5 suggests that the coefficient for interaction terms

Table 5: Number of Varieties of Linkages Explains Introducing New Machines

Probit Model (Marginal Effects)	(1)	(2)	(3)	(4)	(5)
Dependent variables: Probability of Introducing New Machines					
R&D activities	-0.113	0.013	0.065	0.048	0.090
	[0.103]	[0.083]	[0.076]	[0.078]	[0.074]
Number of varieties of internal resources	-0.021	-0.006	-0.011	-0.006	-0.008
	[0.016]	[0.016]	[0.016]	[0.016]	[0.016]
Number of varieties of linkages with local firms	-0.023	-0.041^{+}	-0.022	-0.028	-0.024
	[0.021]	[0.023]	[0.021]	[0.021]	[0.021]
Number of varieties of linkages with MNEs	-0.018	-0.016	-0.029	-0.015	-0.016
	[0.018]	[0.018]	[0.019]	[0.018]	[0.018]
Number of varieties of linkages with public organizations	0.011	0.008	0.011	-0.003	0.010
	[0.021]	[0.022]	[0.022]	[0.022]	[0.022]
Number of varieties of linkages with universities	0.033	0.033	0.031	0.032	0.015
	[0.042]	[0.042]	[0.042]	[0.042]	[0.044]
R&D activities x Number of varieties of internal resources	0.056**				
	[0.017]				
R&D activities x Number of varieties of linkages with local firms		0.064**			
		[0.023]			
R&D activities x Number of varieties of linkages with MNEs			0.049*		
			[0.023]		
R&D activities x Number of varieties of linkages with public organizations				0.058**	
				[0.022]	
R&D activities x Number of varieties of linkages with universities					0.085^{+}
					[0.044]
Multinational Enterprises	-0.181**	-0.183**	-0.175**	-0.190**	-0.182**
	[0.060]	[0.059]	[0.060]	[0.059]	[0.059]
Age	0.000	0.000	-0.001	0.000	0.000
	[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]
Indonesia	-0.133	-0.134	-0.137^{+}	-0.117	-0.120
	[0.082]	[0.083]	[0.082]	[0.082]	[0.082]
Philippines	-0.078	-0.071	-0.080	-0.062	-0.067
	[0.091]	[0.092]	[0.091]	[0.092]	[0.091]
Vietnam	-0.041	-0.057	-0.047	-0.055	-0.053
	[0.114]	[0.113]	[0.113]	[0.113]	[0.113]
Observations	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: ERIA Establishment Survey 2008.

between R&D activities and number of varieties of linkages with local firms is 0.064 with standard error of 0.023; it is also statistically significant at the 1 per cent level. Column (3) of Table 5 suggests that the coefficient for interaction terms between R&D activities and number of varieties of linkages with MNEs is 0.049 with standard error of 0.023; it is statistically significant at the 5 per cent level. Column (4) of Table 5 suggests that the coefficient for interaction terms between R&D activities and number of varieties of linkages with public organizations is 0.058 with standard error of 0.022; it is also statistically significant at the 1 per cent level. Finally, Column (5) of Table 5 suggests that the coefficient for interaction terms between R&D activities and number of varieties of linkages with universities is 0.085 with standard error of 0.044; it is statistically significant at the 10 per cent level. These results show the apparent evidence of complementarities between R&D activities and internal and external sources.

4.3 Complementarities between Two Types of External Sources: Evidence from Procurement Innovations

Finally, we test the following question: what is the impact on innovations when they have linkages with MNEs. We test this question here to focus on the procurement innovations: introducing new machines. Table 6 reports the interaction terms of linkages with local firms and linkages with MNEs as well as the effects of linkages with local firms and linkages with MNEs. We also use the Probit model to estimate the marginal impacts of complementarities between the above two types of linkages on finding new suppliers. Column (1) to (4) shows the results of finding new suppliers domestically while column (5) to (7) shows the results of international procurement.

First of all, the interaction terms are not significant in the columns (1) to (4) which present the results of finding new supplier domestically. These results do not show the apparent evidence of complementarities between two types of external sources. In column (5), the interaction term (number of varieties of linkages with local firms and number of varieties of linkages with MNEs) is significant in explaining new supplier in other ASEAN countries. In column (7), the interaction term is also significant in explaining new suppliers in other foreign countries (EU or US). These results show the evidence of complementarities between two types of external sources.

5. Summary and Discussion

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 within and across regions foster arm's length

Table 6: Number of Varieties of Linkages Explains Securing New Supplier

Probit Model (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Probability of Securing New Supplier	New Local Supplier in Near Area	New Local Supplier Outside Area	New MNEs or JVs Supplier in Near Area	New MNEs or JVs Supplier Outside Area	New Supplier in Other ASEAN	New Supplier in East Asia	New Supplier in Other Foreign Countries
R&D activities	0.051	0.041	0.077^{+}	0.087^{+}	0.088	0.125^{+}	0.110^{+}
	[0.057]	[0.060]	[0.046]	[0.046]	[0.061]	[0.066]	[0.061]
Number of varieties of internal resources	-0.003	0.034*	-0.001	0.003	-0.006	-0.003	0.012
	[0.015]	[0.016]	[0.010]	[0.010]	[0.016]	[0.017]	[0.015]
Number of varieties of linkages with local firms	0.072**	0.037^{+}	-0.028	0.009	0.025	0.023	-0.030
	[0.024]	[0.022]	[0.017]	[0.018]	[0.025]	[0.026]	[0.024]
Number of varieties of linkages with MNEs	-0.036	-0.040	0.010	0.000	-0.031	0.029	-0.051^{+}
	[0.028]	[0.032]	[0.019]	[0.018]	[0.027]	[0.033]	[0.029]
Number of varieties of linkages with public organizations	-0.020	-0.049*	0.026^{+}	0.002	0.030	0.000	0.048*
	[0.021]	[0.022]	[0.015]	[0.015]	[0.026]	[0.027]	[0.022]
Number of varieties of linkages with universities	-0.012	-0.035	0.000	-0.006	-0.045	0.001	-0.023
	[0.039]	[0.042]	[0.032]	[0.029]	[0.048]	[0.046]	[0.042]
Number of varieties of linkages with local firms x Number of varieties of linkages with MNEs	-0.002	0.009	0.005	0.004	0.013*	0.003	0.016**
	[0.006]	[0.006]	[0.004]	[0.004]	[0.006]	[0.007]	[0.006]
Multinational Enterprises	0.102^{+}	-0.130*	0.012	0.053	0.325**	0.498**	0.328**
	[0.057]	[0.061]	[0.041]	[0.044]	[0.057]	[0.053]	[0.057]

Table 6: (continued)

Probit Model (Marginal Effects)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables: Probability of Securing New Supplier	New Local Supplier in Near Area	New Local Supplier Outside Area	New MNEs or JVs Supplier in Near Area	New MNEs or JVs Supplier Outside Area	New Supplier in Other ASEAN	New Supplier in East Asia	New Supplier in Other Foreign Countries
Age	-0.003^{+}	0.000	0.000	0.003*	0.002	0.003	0.002
	[0.002]	[0.002]	[0.001]	[0.001]	[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]
Indonesia	-0.159^{+}	-0.313**	-0.051	-0.071	-0.134^{+}	-0.107	-0.059
	[0.082]	[0.076]	[0.050]	[0.045]	[0.074]	[0.080]	[0.082]
Philippines	-0.321**	-0.092	-0.028	0.046	0.144	0.112	0.189^{+}
	[0.084]	[0.090]	[0.060]	[0.064]	[0.097]	[0.101]	[0.107]
Vietnam	0.203*	0.127	0.158	0.037	0.398**	0.233^{+}	0.460**
	[0.098]	[0.121]	[0.111]	[0.088]	[0.127]	[0.132]	[0.138]
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: ERIA Establishment Survey 2008.

contract. Since both inter-firm supplier customer relationships and intra-firm upstream and downstream processes face higher transportation costs, firms with capital tie-up to their main trading partners tend to co-locate near one another. This co-location also fosters frequent information exchanges between firms.

The findings here can be summarized as follows: in-house R&D activities raise the number of varieties within product innovations. The effects of R&D activities are pervasive and significant for production process innovations, organizational innovations, procurement innovations, and market creating innovations. Second, firms with more varieties of internal resources could implement significantly more new products than firms with fewer varieties of internal resources. Third, the varieties of linkages with local firms raise procurement and market creating innovations. Fourth, firms holding linkages with MNEs have fewer propensities to produce new products while such firms have many propensities to find new markets. Fifth, the impact of varieties of linkages with public organizations and universities is not significant. This would be due to similarity of sources within public linkages or university linkages. The benefits from diversity will not work well for these linkages. Sixth, there are evidences of complementarities between R&D activities and internal and external sources. Finally, complementarities between linkages with local firms and linkages with MNEs do not work for procurement innovations in terms of domestic market. On the other hand, complementarities between linkages with local firms and linkages with MNEs work well for procurement innovations in terms of an international market. Linkages with MNEs play an important role for providing knowledge on international procurement.

What is the policy implication based on this network-based theory of innovation? Policy resources should be allocated to the reduction of obstacles to do research and development activities and to establish internal and external sources. Since information exchanges on different sources happen at the local and international levels, (1) innovation impacts of research and development activities is also stimulated at the local and international level and (2) business matching within and across regions could stimulate the upgrading of firms and industries through intra-regional or international knowledge exchanges at the different stages of innovations.

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