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Detecting Effective Knowledge Sources in Product Innovation: Evidence from Local Firms and MNCs/JVs in Southeast Asia[#]

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Abstract: This paper examines the effects of internal and external sources of knowledge on the introduction of new products based on new technologies or information at firms which responded to a questionnaire survey conducted in four Southeast Asian countries. The results confirm that local firms make full use of locally available sources of new technology or information to achieve product innovation. On the other hand, foreign-owned firms depend mainly on internal R&D capacities and also possibly upon cooperation with local universities. These findings highlight the fact that local firms complement their lack of internal resources for product innovation with external knowledge sources. Foreign-owned firms utilize their international production networks to concentrate their resources on innovative activities.

Keywords: Innovation; Linkages; Exchanges of engineer; Just-in-time; Status Quo

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1. Introduction

Technological upgrading is gaining importance in industrial policy in East and Southeast Asian countries which face stiff competition in the international market. The governments of semi-developed countries in the region have introduced policies for fostering research and development (R&D) in the private sector. But private firms are not necessarily active in R&D. This is because sustained efforts and investments are needed in order to develop innovation capabilities. These constitute a heavy burden for individual firms without sufficient financial and human resources.

A cost-effective alternative is to develop mechanisms for collective learning where firms can share information and resources necessary for innovation. Fostering linkages among firms is representative in industrial development policies. From this view point, investment and trade promotions are measures to promote knowledge spillover. Governments also provide private firms either directly or indirectly through business organizations with assistance for capacity building and collective learning. Additionally, governments promote scientific and technological research at universities and commercialization of research results by fostering university-industry linkages (e.g., Brimble and Doner ,2007; Hershberg *et al*., 2007).

Empirical literature has focused on sources of knowledge and the differences in their impacts on innovation performance (e.g., Frenz, and Ietto-Gillies 2009). Most of the firm-level analyses are cases from Europe, using the Community Innovation Survey (CIS). The CIS is the harmonized survey approach based on the Oslo Manual developed by the Organisation for Economic Co-operation and Development (OECD). Some countries have conducted similar surveys to the CIS. Therefore, CIS-based

analyses allow for international comparison. The literature shows stylized facts that firms' efforts at innovation or their accomplishments are positively correlated with various types of linkages [1] and the degree of innovativeness also has a positive correlation with various sources of knowledge.[2]

On the other hand, since the formation and maintenance of various knowledge sources are costly, firms compare the costs and benefits of deploying internal knowledge resources with outsourcing knowledge from external sources. Utilizing external resources will be advantageous when agglomeration economies are exerted as spatial economics suggests.[3] Geographic proximity to customers and suppliers, sharing the same labor pool, and knowledge spillovers allow firms located in cities to gain access to external resources more cost effectively. Forman, *et al.*,(2008) examines the trade-off between employing internal resources and purchased external resources in process innovation through investments in advanced Internet technology. They conclude that agglomeration is less important for IT-capable firms.[4] External sources have fewer advantages for firms with better internal resources. It can be said that resources available in cities act as partial substitutes for internal resources.

Based on the framework of Forman, *et al.*,(2008), this paper focuses on the choice of knowledge sources in the phase of product innovation based on technologies new to firms with different levels of innovation capability. We examine whether less capable

[1] See Fagerberg, *et al.* (2009) for recent example.
[2] See Amara and Landry (2005), Simonen (2005), Nieto and Santamaría (2007), Vega-Jurado, *et al.* (2008).
[3] Fujita and Thisse (1996, 2002) provide the microeconomic foundation of Marshall's theories of agglomerations and apply these to several different settings in urban and regional economies. Ellison, *et al.* (forthcoming) provides the evidence that all three of Marshall's theories of agglomerations are supported, with production linkages being particularly important.
[4] This result is in contrast to empirical studies which find complementarities between internal and external resources; Cassiman and Veugelers (2006) whose definition of external knowledge acquisition is not restricted by location.

local firms depend on agglomeration economies to save costs in creating knowledge by themselves and whether foreign-owned firms are more dependent on internal resources and close business partners in the international market, while avoiding obstacles to technology transfer to less capable local firms in their strategy related to the international division of labor. The differences in knowledge sources between these two types of firms will be made clearer by placing research focus on the new technology-based product innovations since they are one of the most radical kinds of innovation. Firms will be exposed to the greatest uncertainty and financial risk, thus necessitate diversified and innovative ideas as well as new technologies when they dedicate themselves to developing completely new products based on these new technologies.

We use the firm-level survey data from four Southeast Asian countries. There are two main reasons why the case of Southeast Asian countries is useful. First, agglomeration has been a major driving force behind industrial development in Southeast Asia. Most manufacturing activities are concentrated in industrial districts around capitals and other big cities. Second, foreign-owned firms have played a leading role in establishing production networks in this region.

Our estimation results suggest that local firms make full use of locally available sources of new technologies or information to achieve product innovation. The benefit of agglomeration economies is important for local firms. This indicates that external resources available in major cities in Southeast Asia are partial substitutes for internal resources for local firms. The empirical results also suggest that foreign-owned firms depend mainly on internal R&D capacities and possibly cooperation with local universities. The benefit of agglomeration economies is less significant for foreign-

owned firms engaged in new product development. This finding makes sense if the quality of external resources available in cities in developing countries falls short of quality standards specified by foreign-owned firms.[5]

The objective of this paper is to identify knowledge sources that promote product innovation based on technologies newly-available to a firm. This paper empirically examines the effects of different sources of knowledge (information or new technologies) on product innovation, using an original dataset developed by survey questionnaires in four Southeast countries. The rest of this paper is organized as follows: Section 2 explains the hypothesis and methodology. Section 3 describes the data and descriptive statistics. Section 4 reports estimation results. Section 5 develops discussions about implications derived from the estimation results. Section 6 presents the conclusion.

2. Framework

The hypotheses and methodology used in this paper follow stylized facts that a firm's internal and external sources of knowledge contribute to achievements in product innovation. Knowledge can be transferred via linkages within a firm and between firms. Such knowledge transfer facilitates individual efforts and collaboration among the firms for innovation, thus enhancing the probability of product innovation.

[5] These results are in line with previous studies. Lee (2009) reports firms in clusters are less likely to invest in R&D than non-clustered firms. Kugler and Verhoogen (2008) supports their quality-complementarity hypothesis; the hypothesis that input quality and plant productivity are complementary in generating output quality. This result suggests foreign-owned firms need to utilize internal resources if the quality of input from external sources is unsatisfactory.

These benefits of utilizing various information sources for innovative activities will be more essential for local firms than for multinational enterprises (MNCs) or joint ventures (JVs). Local firms in Southeast Asia and other developing countries, being under severe financial, human, or technological capital constraints, have weaker R&D capabilities and have fewer available internal sources of new technologies and information than MNCs in general. Therefore, local firms will be encouraged to explore wide-ranging partnerships with technologically-capable entities such as their suppliers or customers, local business organizations, governmental agencies, and local universities.

Foreign-owned firms, or MNCs/JVs, established in developing countries can take advantage of such external sources. But many of them will have difficulties in developing links with local collaborators that have sufficient technological capabilities or unique knowledge to be their equal partners. There is a significant difference in technological competence between MNCs/JVs and indigenous firms in Southeast Asia. Thus, MNCs explore practical ways to optimize their international division of labor. They outsource less innovative activities to less capable local partner firms. On the other hand MNCs/JVs tend to create relatively close collaboration with their headquarters, affiliates, suppliers or customers established jointly with local partners or other MNCs. Among local entities, top local research universities and institutes will have greater potential to become research partners of MCNs/JVs.

Based on these observations, this paper firstly examines the following baseline hypothesis:

(1) *Different knowledge sources among firms with equivalent degree of innovativeness.*

Firms will have different knowledge sources effective for product innovation, which are internally and externally available to them, according to their capabilities and resource allocation strategies. It can be said that firms may achieve product innovation with approximately the same frequency, using different sources of information and new technologies.

To investigate the first, baseline hypothesis carefully, this paper goes into detail on the difference in knowledge sources between local firms and MNCs/JVs. They may have different internally available resources and business partners. The baseline hypothesis allows for the following three additional hypotheses to be derived.

(2) *Open partnership policy of local firms*

Local firms need to complement their incomplete internal resources available for product innovation with external knowledge sources. Therefore, they tend to create more open partnerships than MNC/JVs.

(3) *Selective partnership policy of MNCs*

MNCs/JVs seek partners with top level research or information-gathering capabilities in host countries. Outsourcing non-value-adding processes to local partners enables MNC/JVs to concentrate their resources on their internal R&D and other innovative activities.

(4) *Local firms having diversified knowledge sources*

The variety of knowledge sources is more relevant to product innovation by local firms than MNCs/JVs. This hypothesis is derived from the second and third hypotheses.

To examine these hypotheses and detect effective knowledge sources for local firms and MNCs/JVs in Southeast Asia, the following binary probit Product Innovation model is estimated:

$$\text{Probit}(PI_i) = \alpha + \beta\, Linkage_{ij} + \gamma\, x_i + u_i.$$

The dependent variable *PI* indicates the product innovation. This variable is coded 1 if the firm (i) introduced a new product based on "new technologies to the firm" between 2006 and 2008. If no such new products were introduced it is coded 0. The independent variables are *Linkage*, other control variables *x* and error term *u*. Details of the independent variables are as described below.

The variable *Linkage* is the firm (i)'s internal or external knowledge source (j). The variable *Linkage* takes 1 if the firm obtains information or new technologies through the linkage. In the estimation, eight types of linkages are introduced. Among them, the internal linkages are the following four types of knowledge sources: (1) *R&D department*; (2) *sales department*; (3) *production department*; and (4) *technological agreement* with the headquarters or an affiliated firm. The rest of the four types are classified as external sources that include the following: (5) *local supplier or customer*; (6) *foreign-owned supplier or customer*; (7) technical assistance from a *local business organization*; and (8) technical cooperation with a *local university or R&D institute*. Additionally, these internal and external sources are aggregated into the following variables: *Internal, External* and *Variety* of linkages to measure the variety of each source that the firm utilizes. The aggregated variables *Internal* and *External* are integral numbers between 0 and 4, and *Variety* ranges between 0 and 8. Among these aggregated variables, only *Variety* is introduced into the empirical model to make a

comparison with the estimation result in Machikita and Ueki (2010) which confirmed that firms with more varieties of linkages achieve more types of innovation.

The variables *x* is other control variables. Among these, *Local* is a dummy variable that takes 1 if the firm (i) is wholly owned by local capital or else 0. The variable *Employees* is the number of full-time employees that is rated on a scale of 10 to 2,000. The firms which responded to the survey were asked to confirm the number of full-time employees by selecting one of the 11 choices. *Employees* is defined as the median value of each choice. For example, if the respondent chose "1-19 persons," *Employees* takes 10. The dummy variable *Other electronics* is defined to consider characteristics of the electronics sector excluding computers and their parts. Finally the remaining control variables are country dummy variables for Indonesia, the Philippines and Vietnam. The reference country is Thailand.

3. Data

The dataset used in this paper was created from the ERIA 2008 Survey on Production and Logistics Networks (SPLN) for manufacturing firms in four Southeast Asian countries; Indonesia, the Philippines, Thailand, and Vietnam (Kitti, 2009). The objective of the survey was to collect firm-level data on production and logistics networks with the focus on pinpointing sources of knowledge transfer facilitated by economic integration in Asia. The sample population is restricted to the selected manufacturing districts 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).

An original questionnaire was developed solely for the survey by reference to the Oslo Manual. The questionnaire was distributed in December 2008 and January 2009. A total of 605 firms agreed to participate in the survey: 150 firms in Indonesia (24.8% of the whole sample); 204 firms in the Philippines (33.7%); 113 firms in Thailand (18.7%); and 138 firms in Vietnam (22.8%). By national origin of the firms, 373 firms (61.7%) are local, thus the remainder are MNCs or JVs. If the firms are categorized by the number of full-time employees, then small and medium-sized enterprises (SMEs) that employ less than 200 personnel account for 66.1% of the whole sample (400 firms). For the following analyses, 602 observations are used.

The firms which participated in the survey were asked if they introduced new products or services to the market in the period between 2006 and 2008. Then the questionnaire categorizes product innovation into three types. The first type is the introduction of a new product into a market new to the respondents, or market-oriented product innovation ("New market" in Table 1). The second is the introduction of a new product based on a technology new to the respondents, or new technology-based product innovation ("New technology"). The third is incremental product innovation ("Incremental") that is neither market-oriented nor technology-oriented product innovation. As shown in Table 1 which summarizes the responses to these questions, the responding firms are innovative. Some 45.5% of the respondents (274 firms) introduced a new product. But there are differences in the degree of innovativeness. Most of the product innovations (39.7%) are categorized as incremental product innovation. Some 9.6% (58 firms) of them introduced a new product into a new market,

whereas 11.8% (71 firms) of them introduced a new product based on a technology new to the respondent.

Table 1. Product Innovation Achieved by the Respondent

	Whole sample		Local firm		MNC & JV		Differences in Means	
Innovativeness	Freq.	Percent	Freq.	Percent (1)	Freq.	Percent (2)	| t-Statistic |	
Product innovation	274	45.5	179	48.4	95	41.0	1.783	**
Incremental	239	39.7	156	42.2	83	35.8	1.559	*
New market	58	9.6	43	11.6	15	6.5	2.091	**
New technology	71	11.8	44	11.9	27	11.6	0.094	
Total	602	100.0	370	100.0	232	100.0		

Note: ** and * indicate the null hypothesis H_0:(1)=(2) tested against the alternative hypothesis H_a:(1)>(2) is significant at the 5% and 10% level respectively.

Source: ERIA 2008 SPLN.

Table 2 presents the sources of information or technologies used by the respondents to implement innovative activities. Internal departments are the main sources. In particular, 61.6% of the respondents depend on their production department, followed by technological agreement with their headquarters or affiliated firms (51.2%) and sales department (44.5%). R&D department is not as forthcoming as other internal sources, although 33.7% of the firms recognize it as a knowledge source. Among the external sources, linkages with foreign-owned firms are the main sources (44.9%) and those with local firms (41.0%) are almost equally important. On the other hand, technical assistance from a local business organization (30.1%) and cooperation with a local university (23.1%) are not especially significant, even though their importance is emphasized in the recent discussion on industrial policy.

There are differences in the probability of product innovation between local and foreign owned firms (MNCs or JVs). It is noteworthy that more local firms introduced a new product than foreign-owned firms (Table 1). An exception is the introduction of new products based on new technologies. Almost the same proportion (12%) of local and foreign-owned firms introduced such products.

There are also differences in the sources of knowledge between the two groups. Among the internal sources, 39.5% and 50.0% of the local firms obtain information from their own R&D and sales departments, respectively (Table 2). These percentages for local firms are higher than those for foreign-owned firms. On the other hand, foreign-owned firms are more dependent on knowledge obtainable from technological agreement with their headquarters and affiliated firms than are local firms.

Among the external sources, there is not a significant difference between local and foreign-owned firms in the utilization of the linkages with local suppliers or customers. About 40% of both local and foreign-owned firms acquire knowledge from this source (Table 2). There is a substantial difference in the linkages with foreign-owned suppliers or customers. Some 55.2% of foreign-owned firms use the knowledge transferred from this linkage for their innovative activities, whereas 38.4% of local firms use it. In contrast, assistance from and cooperation with local entities are considerably more important for local firms.

Table 2. Summary Statistics

Variable	Whole sample Mean	Std. Dev.	Local firm Mean (1)	Std. Dev.	MNC & JV Mean (2)	Std. Dev.	Differences in Means | t-Statistic |	
Dependent variable (0/1)								
Product innovation based on new technologies	0.118	0.323	0.119	0.324	0.116	0.321	0.094	
Internal source (0/1)								
R&D department	0.337	0.473	0.395	0.489	0.246	0.431	3.800	***
Sales department	0.445	0.497	0.500	0.501	0.358	0.480	3.446	***
Production department	0.616	0.487	0.603	0.490	0.638	0.482	0.864	
Technological agreement	0.512	0.500	0.465	0.499	0.586	0.494	2.914	[***]
External source (0/1)								
Local supplier / customer	0.410	0.492	0.416	0.494	0.401	0.491	0.372	
Foreign-owned supplier/ customer	0.449	0.498	0.384	0.487	0.552	0.498	4.081	[***]
Local business organization	0.301	0.459	0.349	0.477	0.224	0.418	3.266	***
Local university/ R&D institute	0.231	0.422	0.268	0.443	0.172	0.379	2.708	***
Internal (min=0, max=4)	1.910	1.601	1.962	1.669	1.828	1.487	1.004	
External (min=0, max=4)	1.390	1.459	1.416	1.507	1.349	1.381	0.549	
Variety (min=0, max=8)	3.301	2.816	3.378	2.926	3.177	2.632	0.855	
Other control variables								
Local (0/1)	0.615	0.487						
Employees (min=10, max=2000)	293.9	456.5	200.8	377.9	442.3	527.3		
Other electronics (0/1)	0.090	0.286	0.024	0.154	0.194	0.396		
Indonesia (0/1)	0.248	0.432	0.335	0.473	0.108	0.311		
Philippines (0/1)	0.339	0.474	0.278	0.449	0.435	0.497		
Vietnam (0/1)	0.229	0.421	0.151	0.359	0.353	0.479		
Observations	602		370		232			

Note: *** indicates the null hypothesis H_0: (1)=(2) tested against the alternative hypothesis H_a: (1)>(2) is significant at the 1% level. [***] indicates the same null hypothesis tested against Ha: (1)<(2) is significant at the 1% level.

Source: ERIA 2008 SPLN.

Finally, statistically significant differences between local and foreign-owned firms are not found in the average numbers of internal and external sources and the variety shown in Table 2. This finding encourages detailed analyses on the knowledge sources promoting product innovation based on new technologies.

4. Results

This section provides estimation results of the binary probit models of product innovation on knowledge sources specified in the second section to examine the hypotheses proposed in the same section. These regressions are estimated by firstly using the whole sample as baseline estimations and then dividing it into local and foreign-owned firms in order to identify differences between them in knowledge sources that affect product innovation. When the model is estimated, the eight types of knowledge sources are introduced into the model alternately to avoid multicollinearity problems.

As Tables 1 and 2 suggest, there are differences in the linkages that local and foreign-owned firms utilize as the sources of knowledge whereas there is no significant difference between the two groups in the percentage of the introduction of new products based on new technologies. Regressions using the dataset with such unique features create a distinction in effective sources to radical product innovation between local firms and MNCs/JVs.

The main estimation results are as follows: The results of the estimations using the sample restricted to local firms show that a local firm's internal and external knowledge sources contribute to product innovation. Knowledge can be transferred via linkages within the firm as well as between firms. External knowledge complements internally available knowledge to encourage the firm to be innovative. Therefore, firms lacking the necessary resources for innovation, typically indigenous firms in developing countries, may take advantage of creating open partnerships with diversified external entities. In contrast, MNCs/JVs concentrate their investments in more knowledge-

creating processes and cooperate with their internal departments, close business partners or top research universities/institutes in host countries, while contracting out non-value-adding processes to local partners. These estimation results are discussed in detail below.

4.1. Baseline Results

Table 3 reports the results of regressions using the whole sample. As shown in the column (1), the coefficient on *R&D department* is 0.563 and statistically significant at the 1% level. The coefficients on *sales department*, *production department* and *technological agreement* in columns (2) to (4) are positively significant at the 10%, 5% and 10% levels respectively. Contrary to the internal sources, only the coefficient on *local university or R&D institute* in column (8) is significant at the 5% level among the external sources, whereas all of the coefficients on the four external sources are positive.

All of these eight sources are included in column (9), where the coefficients on *R&D department* and *local university or R&D institute* are positively significant at the 1% and 5% levels respectively. The coefficients on these two sources are relatively robust. In addition, the marginal effects of *R&D department* and *local university or R&D institute* on the probability of technology-oriented product innovations are larger than other sources. These results suggest the importance of R&D capacities for adopting new technologies into new products, whether such capacities are internally or externally developed.

Column (10) in Table 3 examines the effect of the *variety* of linkage on product innovation. The estimation result shows that the coefficient on the variable is 0.075 and significant at the 5% level. Thus, variety of knowledge sources is important for firms to

develop technologically novel products. This result provides new evidence on the findings of Machikita and Ueki (2010), which emphasizes the importance of the diversity of knowledge sources to achieve more diversified innovation, using the ERIA 2008 SPLN dataset.[6]

Table 3 also presents the marginal effects of other control variables. The coefficients on the dummy variable for *local* firms are positive but only significant at the 10% level for column (8). Such insignificant coefficients on local firms can be expected from Table 1. The coefficients on *employees* are positive and robustly significant at the 1% level, implying that there is a higher probability for larger firms to introduce new products than smaller firms. The coefficients on *other electronics* are positively significant, thus the firms in this sector have a greater propensity to develop new products using new technologies than those in other sectors. The coefficients on the country dummy variable for *Indonesia* and *Vietnam* that are statistically significant are negative in several columns. There are no significant coefficients for the *Philippines*. Thus there is little difference in the probability of product innovation between the Philippines and Thailand but a greater difference between Indonesia/Vietnam and Thailand.

[6] Machikita and Ueki (2010) takes into account more types of linkages including the eight types of linkages used for the estimations in this paper. They verify that firms with more varieties of linkages achieve a greater variety of innovation. They also find complementarities between internal and external sources of knowledge in terms of production and marketing process innovation.

Table 3. Baseline Result of the Product Innovation Model (Whole Sample)

Dependent variable: Probability of introducing a new product based on new technologies to the respondent										
Probit model (Marginal effect)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Internal source (0/1)										
R&D department	0.563***								0.635***	
	(0.173)								(0.225)	
Sales department		0.272*							-0.230	
		(0.160)							(0.224)	
Production department			0.406**						0.194	
			(0.176)						(0.263)	
Technological agreement				0.342*					-0.001	
				(0.193)					(0.272)	
External source (0/1)										
Local supplier/customer					0.078				-0.167	
					(0.168)				(0.210)	
Foreign-owned supplier/customer						0.032			-0.399	
						(0.193)			(0.253)	
Local business organization							0.249		-0.026	
							(0.178)		(0.235)	
Local university/R&D institute								0.474**	0.590**	
								(0.218)	(0.299)	
Variety of linkages										0.075**
										(0.033)
Other control variables										
Local	0.225	0.234	0.239	0.265	0.256	0.258	0.261	0.282*	0.256	0.251
	(0.168)	(0.168)	(0.166)	(0.168)	(0.167)	(0.168)	(0.168)	(0.171)	(0.174)	(0.168)
Employees	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Other electronics	0.449*	0.436*	0.427*	0.379*	0.423*	0.426*	0.413*	0.434*	0.496**	0.405*
	(0.233)	(0.229)	(0.230)	(0.229)	(0.227)	(0.227)	(0.231)	(0.230)	(0.239)	(0.231)
Indonesia	-0.263	-0.427*	-0.387*	-0.353	-0.501**	-0.512**	-0.439*	-0.342	-0.248	-0.289
	(0.231)	(0.222)	(0.223)	(0.236)	(0.222)	(0.233)	(0.229)	(0.240)	(0.262)	(0.253)
Philippines	0.229	0.054	0.109	0.118	-0.063	-0.095	0.067	0.217	0.309	0.266
	(0.223)	(0.217)	(0.216)	(0.237)	(0.224)	(0.221)	(0.235)	(0.262)	(0.281)	(0.270)
Vietnam	-0.067	-0.308	-0.491**	-0.491**	-0.442*	-0.461**	-0.289	-0.083	0.388	-0.282
	(0.264)	(0.245)	(0.229)	(0.227)	(0.230)	(0.232)	(0.251)	(0.304)	(0.422)	(0.251)
Constant	-1.784***	-1.543***	-1.674***	-1.611***	-1.383***	-1.347***	-1.532***	-1.707***	-1.897***	-1.801***
	(0.261)	(0.255)	(0.275)	(0.284)	(0.267)	(0.265)	(0.267)	(0.305)	(0.337)	(0.329)
Observations	602	602	602	602	602	602	602	602	602	602
Pseudo R2	0.088	0.068	0.074	0.069	0.062	0.062	0.066	0.074	0.104	0.075

Note: *** p<0.01, ** p<0.05, * p<0.1, Robust standard errors in parentheses. Thailand is the reference country.

Source: ERIA 2008 SPLN.

4.2. Local Firm

The regression results in Table 4 are based on the sub-dataset composed of the local firms. The coefficients on the four internal sources are statistically significant as in Table 3 for the whole sample. The coefficient on *production department* is larger than

that on *R&D department*. The marginal effect of this internal source on local firms is greater than the whole sample case. These findings imply that effective usages of internally existing technologies and information related to production processes are important for local firms with weaker R&D capacities than MNCs/ JVs to develop technologically innovative new products.

From the results for the whole sample, it can be seen that the impact of the external sources is very different. The coefficient on *local supplier or customer* in column (5) is positively significant at the 5% level. Therefore, the inter-firm linkage among local firms is essential not only for procurement of inputs or distribution of products but also for collaboration on product innovation. As many innovation policies postulate, the coefficients on *local business organization* and *local university or R&D institute* in columns (7) and (8) are positively significant at the 1% level. On the other hand, the coefficient on foreign-owned suppliers or customers in column (6) is not statistically significant. This finding does not support the transfer of knowledge from foreign-owned firms that foreign direct investment promotion policies predict, even though nearly 40% of the local firms are linked to MNCs or JVs.

All of the eight sources are included in column (9). The coefficient on *production department* is 0.516 and significant at the 10% level. This implies that local firms utilize incremental (probably process) innovations to develop new products. The coefficient on *local university or R&D institute* is 0.674 and again significant at the 10% level. Thus, local firms combine internal knowledge obtained from daily learning-by-producing with external scientific knowledge generated from laboratory work to introduce new-technology-based products into the market.

Table 4. Result of the Product Innovation Model for Local Firms

Dependent variable: Probability of introducing a new product based on new technologies to the local respondent										
Probit model (Marginal effect)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Internal source (0/1)										
R&D department	0.544**								0.384	
	(0.214)								(0.281)	
Sales department		0.388*							-0.318	
		(0.208)							(0.265)	
Production department			0.650***						0.516*	
			(0.241)						(0.310)	
Technological agreement				0.538**					-0.037	
				(0.244)					(0.357)	
External source (0/1)										
Local supplier/customer					0.456**				0.146	
					(0.205)				(0.257)	
Foreign-owned supplier/customer						0.290			-0.212	
						(0.250)			(0.317)	
Local business organization							0.555***		0.100	
							(0.214)		(0.304)	
Local university/R&D institute								0.869***	0.674*	
								(0.306)	(0.366)	
Variety of linkages										0.144***
										(0.047)
Other control variables										
Employees	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Other electronics	0.924**	0.939**	0.844*	0.826*	1.026**	0.915**	0.966**	1.006**	0.929**	0.861**
	(0.452)	(0.442)	(0.438)	(0.428)	(0.427)	(0.414)	(0.446)	(0.435)	(0.466)	(0.439)
Indonesia	-0.103	-0.248	-0.165	-0.096	-0.226	-0.245	-0.206	-0.010	0.124	0.107
	(0.271)	(0.257)	(0.260)	(0.266)	(0.258)	(0.286)	(0.260)	(0.289)	(0.349)	(0.316)
Philippines	0.243	0.129	0.232	0.296	0.219	0.078	0.329	0.569	0.778*	0.669*
	(0.281)	(0.270)	(0.271)	(0.298)	(0.275)	(0.285)	(0.283)	(0.365)	(0.405)	(0.368)
Vietnam	0.245	0.133	-0.136	-0.148	-0.034	-0.179	0.270	0.598	0.627	0.253
	(0.309)	(0.302)	(0.276)	(0.276)	(0.279)	(0.281)	(0.299)	(0.396)	(0.487)	(0.317)
Constant	-1.712***	-1.577***	-1.826***	-1.693***	-1.607***	-1.431***	-1.702***	-1.946***	-2.352***	-2.205***
	(0.260)	(0.256)	(0.289)	(0.273)	(0.248)	(0.261)	(0.245)	(0.336)	(0.425)	(0.386)
Observations	370	370	370	370	370	370	370	370	370	370
Pseudo R2	0.102	0.090	0.106	0.094	0.094	0.082	0.098	0.116	0.140	0.119

Note: *** p<0.01, ** p<0.05, * p<0.1, Robust standard errors in parentheses. Thailand is the reference country.

Source: ERIA 2008 SPLN.

Column (10) in Table 4 examines the effect of the *variety* of linkage on product innovation. The estimation result shows that the coefficient for local firms is 0.144 and

significant at the 1% level. Thus, the variety of knowledge sources is important for local firms in order to develop technologically new products.

Among other control variables, the coefficients on *employees* are positively significant at the 1% level in column (1) to (10). Thus larger firms tend to introduce new products based on new technologies in the case of local firms. This may reflect the realization that investments related to new product developments represent a heavy burden for smaller local firms. The coefficients on *other electronics* are positively significant as in Table 3. The coefficients on the country dummy variables for the *Philippines* are positive but significant only in columns (9) and (10). The coefficients on *Indonesia* and *Vietnam* are not significant. Therefore, there is no significant difference in the probability of product upgrading between local firms in these four countries.

4.3. MNC/JV

Table 5 presents results of the regressions estimated using the sub-dataset composed of the foreign-owned firms. The results are quite different from those for the local firms. Among the internal sources, only the coefficient on *R&D department* is positively significant at the 10% level. Among the external sources in columns (5) to (8) only the coefficient on *local supplier or customer* is significant at the 10% level. But the coefficient is negative (-0.592), indicating that MNCs/JVs using information from their local partners are not positive about pursuing technology-based product innovation.

As shown in column (9), if the eight sources are included in the estimation, the coefficient on *R&D department* is 0.944 and significant at the 5% level. *Local university or R&D institute* is also positive (1.032) and significant at the 10% level.

These results indicate that foreign-owned firms make use of institutions with R&D capacities including their own R&D facilities to develop new products. On the other hand, the coefficient on *local supplier or customer* is significant at the 5% level, although it is negative (-0.775). Although the percentage of foreign-owned firms linked to local firms are almost the same as local firms (Table 2), local business partners of MNCs/JVs do not have sufficient capacity to become collaborators in the upgrading of product technologies necessary for product innovation.

At first glance, the negative coefficients on local partners are contrary to the standard prediction of knowledge spillover effects. However, this finding can be interpreted as MNCs/JVs being linked with local partners with the expectation that their local partners can provide them with information and ideas necessary for incremental innovations, in particular production process improvement, in addition to ample cheap labor to decrease production costs. This enables MNCs/JVs to concentrate their limited human and capital resources in R&D and optimize their international division of labor.

Column (10) in Table 5 includes the variable *variety* of linkage. The coefficient on this variable is negative and not statistically significant. This finding is in contrast to the result for local firms in Table 4 and different from Machikita and Ueki (2010). This evidence indicates that less innovation-capable firms, for example local firms, will be beneficiaries of the variety of linkages or agglomeration.

Table 5. Result of the Product Innovation Model for MNC/JV

Dependent variable: Probability of introducing a new product based on new technologies to the MNC/JV respondent										
Probit model (Marginal effect)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Internal source (0/1)										
R&D department	0.518*								0.944**	
	(0.303)								(0.439)	
Sales department		0.105							0.140	
		(0.273)							(0.422)	
Production department			0.074						-0.446	
			(0.282)						(0.494)	
Technological agreement				0.099					0.108	
				(0.296)					(0.401)	
External source (0/1)										
Local supplier/customer					-0.592*				-0.775**	
					(0.347)				(0.363)	
Foreign-owned supplier/customer						-0.325			-0.567	
						(0.316)			(0.415)	
Local business organization							-0.366		-0.608	
							(0.410)		(0.601)	
Local university/R&D institute								-0.020	1.032*	
								(0.340)	(0.565)	
Variety of linkages										-0.009
										(0.052)
Other control variables										
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)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Other electronics	0.395	0.365	0.366	0.352	0.436	0.374	0.384	0.360	0.586**	0.362
	(0.276)	(0.273)	(0.272)	(0.276)	(0.279)	(0.273)	(0.274)	(0.272)	(0.290)	(0.273)
Indonesia	-0.743*	-0.822*	-0.837*	-0.819*	-0.939**	-0.891**	-1.037**	-0.863*	-0.990*	-0.878*
	(0.450)	(0.451)	(0.448)	(0.473)	(0.454)	(0.436)	(0.472)	(0.462)	(0.528)	(0.466)
Philippines	-0.095	-0.321	-0.348	-0.333	-0.716*	-0.531	-0.648	-0.404	-0.430	-0.434
	(0.378)	(0.381)	(0.375)	(0.383)	(0.389)	(0.361)	(0.467)	(0.402)	(0.530)	(0.434)
Vietnam	-0.949*	-1.266***	-1.331***	-1.340***	-1.424***	-1.180***	-1.579***	-1.334***	-0.183	-1.337***
	(0.529)	(0.475)	(0.435)	(0.434)	(0.431)	(0.445)	(0.530)	(0.516)	(0.777)	(0.456)
Constant	-1.199***	-0.866**	-0.841**	-0.853**	-0.412	-0.602*	-0.480	-0.765*	-0.785	-0.726
	(0.399)	(0.384)	(0.396)	(0.387)	(0.375)	(0.356)	(0.451)	(0.402)	(0.555)	(0.452)
Observations	232	232	232	232	232	232	232	232	232	232
Pseudo R2	0.131	0.112	0.111	0.112	0.134	0.118	0.118	0.111	0.195	0.111

Note: *** p<0.01, ** p<0.05, * p<0.1, Robust standard errors in parentheses. Thailand is the reference country.

Source: ERIA 2008 SPLN.

The estimated coefficients on the other control variables are different from those in Tables 3 and 4. The coefficients on *employees* are not statistically significant. This signifies that the size of a firm is unrelated to the innovativeness of the firms investing in developing countries from abroad. The coefficient on *other electronics* is positive but significant only in column (9). The country dummy variables have negative coefficients, suggesting foreign-owned firms in Thailand make more effort in product innovation introducing new technologies than those in the other three countries. This evidence is statistically supported for Indonesia and Vietnam.

4.4. Verification of the Hypotheses

Table 3 for the baseline results using the whole sample shows internal knowledge sources mainly contribute to product innovation, while external knowledge sources other than local universities/R&D institutes are not relevant in explaining product innovation (columns (1) to (8) in Table 3). The estimation introduced all variables for internal and external knowledge sources which illustrates the importance of internal and external R&D capabilities in the technology-based product innovation (column (9)). The estimation in column (10) of Table 3 verifies the importance of a variety of knowledge sources for product innovation. These results provide benchmarks for the hypotheses.

In Table 4 for the estimation results using the data for local firms, all internal and external sources other than foreign-owned suppliers/customers have positive impacts on product innovation (columns (1) to (8)). This is supportive of the first and second hypotheses. The positive coefficient on the variety of linkages in column (10) of Table 4 coincides with the expectation that can be derived from the second hypothesis. The

characteristics of local firms are revealed when the eight knowledge sources are included in the estimation (column (9) in Table 4). In addition to external R&D institutions, production departments act as extensively important and significant knowledge sources for local firms. They bind knowledge obtained through daily production processes to scientific findings from research in external R&D institutions to introduce new technologies into new products. In this sense, this evidence does support the second hypothesis to some extent.

The estimation results for MNCs/JVs in Table 5 are different from those for local firms, reflecting differences between the two groups in innovation capabilities and optimal structures of international division of labor. The coefficients in columns (1) to (8) show that only R&D departments exert a positive effect on the innovation. The variety of linkages does not have a significant impact on it (column (10)). The main difference in the estimations using whole sample and local firm data is the negative effect of the linkages to local suppliers or customers. The estimation including all knowledge sources provides positively significant coefficients on *local university/R&D institutes*, maintaining a positive effect of *R&D department* and a negative effect of *local supplier or customer* (column (9)). This evidence fully supports the second, third and fourth hypotheses if the findings for local firms are taken into consideration.

5. Discussion

This paper investigates the effects of linkages on the introduction of new products based on new technologies to the respondent firms. The type of innovation this paper

focuses on requires firms to develop or absorb relatively advanced technologies. But even if a technology is new to a firm, it is not necessarily new to other firms. As the sample includes local SMEs, it would be better to say that the product innovation emphasized in this paper requires relatively higher firm-level learning capacity and enterprising spirit.

The local firms and foreign-owned firms in the sample do not show a significant disparity in product innovation capability measured by their product innovation records. There is no difference between local and foreign-owned firms in the percentage of firms who achieved product innovation by introducing new technologies into new products. The dataset shows only about 12% of the respondent firms introduced new products based on the technologies new to them.

On the other hand, empirical results verified the differences in the knowledge sources between types of firms. As the first hypothesis suggested, there is a significant d*ifference in knowledge sources between local and foreign firms even though they realize product innovations with approximately the same frequency*. Namely, local firms have an o*pen partnership policy*. They tend to make full use of locally available sources. In contrast, *foreign-owned firms have a selective partnership policy*. Top level research institutes/universities in host countries can be their collaborators. As a result, *local firms have more diversified knowledge sources* than foreign-owned firms.

Columns (10) in Tables 3, 4 and 5, which indicate the impacts of varieties of linkages on the introduction of new technologies into new products, suggest important implications helpful when considering innovation performance of local firms. Tables 3 and 5 verify their positive impacts for the whole sample and local firms in particular. In contrast, Table 4 presents the negative but statistically insignificant impact of variety of

linkage for foreign-owned firms. The findings from this paper indicate that less innovation-capable firms, for example local firms, are beneficiaries of the variety of linkages, or agglomeration. This result for local firms is in line with the case of Spanish firms examined by Nieto and Santamaría (2007) which shows collaborative networks comprising different types of partners have a significant impact on the degree of novelty in product innovation.

In contrast, foreign-owned firms are much more dependent on their own R&D capacities. This finding corresponds with the case of the UK examined by Frenz and Ietto-Gillies (2009) showing that the international spread of intra-firm networks has a positive impact on firm-level innovation performance. On the other hand, among local sources, only local universities or R&D institutes possess the required competency to collaborate with foreign-owned firms according to the estimations shown above. This finding supports Frenz and Ietto-Gillies (2009) that points out external collaboration is less successful than international internal networks but contrasts with Nieto and Santamaría (2007) which concludes that the impact of cooperation with research organizations on the degree of novelty is not as significant as cooperation with suppliers and customers. These estimation results partially reflect MNCs' current international division of labor inasmuch as their affiliates in developing countries are responsible mainly for the production of existing products developed by their headquarters or R&D systems in the home countries, based on the established partnerships among MNCs. In other words, MNCs have difficulties in finding local firms capable of providing technologies or information they lack. But cooperation with local firms in production and incremental improvements allow MNCs to concentrate their resources into R&D and other innovative activities.

The other important finding is the absence of interdependence in the area of product development based on new technologies between foreign-owned and local firms. The empirical results in columns (1) to (8) of Tables 3, 4 and 5 show that, among the eight sources investigated in this paper, only foreign-owned suppliers or customers can not be recognized as knowledge sources important for local firms. Weak linkages between them are suggested by Machikita *et al*. (2008). But about 40% of the foreign-owned firms in this paper consider local firms as a source of information or technologies. The same percentage of local firms obtains these technologies from foreign-owned firms (Table 2). Thus the reason for the absence of interdependence may be the mismatch in the information or technologies for new product developments that MNCs can provide to local firms and vice versa. Further investigations on this matter are needed, in particular if there are institutional obstacles that hinder technology transfer from MNCs to local firms or knowledge sharing among them.

Empirical evidence derived from the control variables other than the eight knowledge sources also has important implications. The dataset used in this paper is composed of the four Southeast Asian countries with heterogeneous characteristics of industrial structures and development stages. However, the difference in the probability of product innovation using new technologies is not detected between local and foreign-owned firms. This finding supports the policy of encouraging local firms to develop new products based on new knowledge. The difference in the probability between countries disappears when the regressions are estimated using the dataset limited to local firms. This finding justifies the policy of developing linkages irrespective of industrial development stages. The number of employees makes little difference for foreign-owned firms but is significant for local firms. This evidence signifies the gap in

R&D capacities between large local firms and SMEs and the heavy burden on local SMEs of investments in R&D, testing facilities and production processes for new products. Thus more generous assistance is needed for smaller indigenous firms in developing countries.

6. Conclusion

This paper investigates four main hypotheses, considering the heterogeneous effects of eight different knowledge sources on the radical product innovation achieved by firms with different innovation capabilities: (1) firms with different internal resources for innovative activities have different sources of knowledge for product innovation; (2) local firms have an open partnership policy to overcome their limited resources usable for innovative activities; (3) MNCs/JVs collaborate mainly with top research institutes/universities in host countries under their selective partnership policy; and (4) the knowledge sources of local firms are more diversified than MNCs/JVs. This paper examines these hypotheses, using original firm-level data collected in four Southeastern Asian countries.

The empirical results verify the hypotheses. The baseline results based on the whole sample show that internal knowledge sources mainly contribute to product innovation, while among external sources only local universities/R&D institutes are relevant in explaining product innovation. The estimation also verifies the importance of variety of knowledge sources for product innovation.

For local firms, all internal and external sources other than foreign-owned

suppliers/customers have positive impacts on their product innovation. Thus, the variety of linkages is also significantly related to product innovation. One of the characteristics of local firms is the importance of their production department. They combine knowledge obtained through the daily production process with scientific findings from research in external R&D institutions to develop new products.

The knowledge sources for MNCs/JVs are different from those for local firms, reflecting differences between the two groups in innovation capabilities and optimal structures of international division of labor. Only R&D departments and local university/R&D institutes demonstrate a positive effect on their product innovation. MNCs/JVs do not have any significant effect of the variety of linkages on their product innovation and do have negative effects on the linkages with local suppliers or customers. If the estimation results for local firms are taken into account, complementary relationships in the product development between local firms and MNCs/JVs are not verified. These conclusions are different from previous studies. Therefore further investigation is needed in the future.

In summary, local firms have an open partnership policy. They take advantage of benefits of agglomeration, making full use of locally-available knowledge to complement resources they lack. In contrast, MNC/JVs have a closed partnership policy. They take advantage of international production networks to optimize their resource usages in order to enhance competitiveness. In their system of international division of labor, local firms linked with them provide MNCs with knowledge helpful for incremental improvements, in addition to the cheap labor-intensive processes necessary for reducing production costs. This allows MNCs/JVs to concentrate their efforts on more value-adding knowledge-creating activities.

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