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Technology Transfer in ASEAN Countries: Some Evidence from Buyer-Provided Training Network Data*

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Abstract: *Technology transfers are important channels for firms in developing countries to get access to new technology and initiate innovation. This paper examines the geographical pattern of technology transfers in the form of buyer-provided training in domestic and international production networks. Our unique buyer-supplier network data in four countries in Southeast Asia allow us to directly observe the buyer-supplier relationship as well as the existence of inter-firm provision of training for product/process innovation in order to investigate the geographical structure of knowledge acquisition, dissemination, and aggregation among local and non-local firms. The empirical analysis finds the following: (i) the probability of having training provided by the main buyer presents a U-shaped quadratic pattern with respect to the geographical distance between the respondent firms and the main buyers. The geographical proximity to the main buyer seems to be particularly important for local firms. (ii) The training provision is likely for both local and non-local firms when the main buyer is a multinational located in the same country. (iii) The probability of having training from the main buyer is high when the main buyer conducts R&D. (iv) Both local and non-local firms that have training provided by their main buyers are likely to provide training to their main suppliers. (v) In the case of non-local firms, product innovation with production partners is more likely when they have upstream/downstream training. However, such links seem to be weaker in the case of local firms.*

***Keywords*:** buyer-provided training; FDI spillovers; backward linkages; Southeast Asia
***JEL Classification*:** M5, O31, O32, R12.

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1. Introduction

Innovation is important for not only advanced countries but also developing countries. Although the common belief would be a complete vacuum of innovation activities in developing countries, careful micro-level observation proves that firms in developing countries also conduct process innovation and sometimes even product innovation though the depth and width of innovation may be at a primitive stage. The issue in developing countries is how such innovation can become pervasive among a large number of local firms and the quality of innovation can be upgraded in order to lead continuous productivity enhancement and sustained economic growth.

ASEAN (The Association of South-East Asian Nations) Member States have traced a unique growth trajectory. In contrast to the pattern of industrialization in Japan, Taiwan, and South Korea in the 1950s to 1980s where the development of indigenous firms and industries was at the center, ASEAN have aggressively utilized the mechanics of production networks extended by multinationals and have jump-started their industrialization processes. These countries have further proceeded to the formation of industrial agglomeration in parallel with the fragmentation of production where both "international" production networks and "domestic" vertical links of production have developed hand in hand. This new development strategy has proved to be successful in accelerating industrialization. As for the development of international production networks in ASEAN and East Asia, see Ando and Kimura (2005). The concept of two-dimensional fragmentation of production proposed by Kimura and Ando (2005) is also useful for understanding the parallel development of fragmentation and agglomeration.

Innovation should be explored in the particular context for ASEAN and other developing countries that utilize the mechanics of production networks. Table 1 presents some basic statistics of ASEAN and other Asian countries. Four countries in our study, Thailand, Indonesia, the Philippines, and Viet Nam, belong to the upper or lower middle income level ranging from US$1,755 to US$5,480 per capita, and average years of schooling in these countries indicate their steady bottom-ups of education. However, we have to note that R&D expenses are very small even though the ratios of manufacturing value added to GDP show extensive industrialization. This is because their industrialization has heavily depended on production networks by multinationals and local research capability has not been developed much. Inward FDI (foreign direct investment) stocks to GDP ratios are indeed high, particularly in Thailand (48 percent) and Viet Nam (48 percent). In the catching-up process, countries do not have to explore absolutely new technology and scientific knowledge. Instead, they must utilize the advantage of latecomers and effectively capture technology transfers or spillovers in order to expand and upgrade innovation. Given the current low local capability of absorbing and disseminating technologies, the issue is whether international and domestic production networks can be vehicles for technology transfers from developed to developing economies and from multinationals to local firms.

Table 1: Comparisons of Technology-level between East Asia and ASEAN countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	GDP per capita (US$)	Average years of schooling	R&D expenses	Mfg value added	Royalty receipts	Royalty payments	Inward FDI stock
			(% of GDP)	(% of GDP)	(% of GDP)	(% of GDP)	(% of GDP)
Year	2012	2010	2009	2010	2012	2012	2013
Singapore	51709.45	10.63	2.20%	21.63%	0.57%	5.75%	283.20%
Japan	46720.36	11.52	3.36%	19.65%	0.54%	0.33%	3.50%
South Korea	22590.16	11.89	3.56%	30.29%	0.28%	0.69%	13.70%
Malaysia	10432.06	9.75	1.01%	24.52%	0.04%	0.50%	46.30%
China	6091.01	7.12	1.70%	32.46%	0.02%	0.24%	10.40%
Thailand	5479.76	7.30	0.25%	35.62%	0.07%	0.99%	47.90%
Indonesia	3556.79	7.26	0.08%	24.80%	0.01%	0.21%	26.50%
The Philippines	2587.02	8.18	0.11%	21.44%	0.00%	0.20%	12.00%
Viet Nam	1755.21	7.45		17.95%	N.A.	N.A.	47.90%
India	1489.23	5.39	0.82%	14.87%	0.02%	0.21%	12.10%
Lao PDR	1417.08			7.47%	N.A.	N.A.	27.80%
Cambodia	944.41	4.10		15.62%	0.03%	0.08%	60.00%

Notes: (1) GDP per capita is gross domestic product divided by midyear population. Data are in current U.S. dollars. R&D expenses (% of GDP) are expenditures for R&D activities divided by GDP. Mfg value added (% of GDP) is the net output of manufacturing sector after adding up all outputs and subtracting intermediate. Royalty receipts (% of GDP) and payments (% of GDP) are charges for the use of intellectual property. These are not applicable (N.A.) for Viet Nam and Lao PDR. Inward FDI stock (% of GDP) is stock of inward foreign direct investment divided by GDP.

Sources: World Bank national accounts data 2014 for GDP per capita. Barro-Lee Educational Attainment Dataset for average years of schooling. Science, Technology, and Innovation Dataset of UNESCO for R&D expenses (% of GDP). World Bank national accounts data

2014 for Mfg value added (% of GDP). World Development Indicators 2013, World Bank for royalty receipts (% of GDP) and royalty payments (% of GDP). World Investment Report, UNCTAD 2014 for inward FDI stock (% of GDP).

Technology transfers can be achieved based on the technological capacity of local firms and their effort of knowledge acquirement. Knowledge may be acquired through a variety of channels; it would be done through learning itself, the introduction of foreign technology possibly by importing new capital goods or capturing unintentional technology spillover, interactions with foreign affiliates established by incoming FDI, learning from export, and others. In international and domestic production networks, we often observe buyer-provided training, which may be one of the important channels for intentional technology transfers in order to accelerate process innovation as well as possibly product innovation. In this paper, we would like to investigate how extensively buyer-provided training for process/product innovation is conducted, what would be the relationship with incoming FDI and export by looking at geographical structure of such training, and how far such knowledge acquiring effort would be spread through production networks.

There is a long list of previous studies on knowledge diffusion among enterprises. Keller (2004, 2012) provides excellent overviews of technology transfers across countries. These surveys present economic theories and empirical evidences on multiple ways of costly inter-firm learning through FDI, exporting, and importing. Among several channels of technology transfers, vertical linkages have been specifically tested in a series of recent empirical papers as a knowledge transmission mechanism between upstream and downstream firms, in the context of developing and emerging economies. For example, Aitken and Harrison (1999) show positive impacts of foreign equity participation on plant productivity of small enterprises by using Venezuelan plant-level data. They also find that foreign investment negatively affects the productivity of domestic plants through enhancing competition. They conclude that a net gain from FDI is quite small if we take into account the two offsetting effects. On the other hand, Javorcik (2004) and Blalock and Gertler (2008) find backward linkage impacts from multinational enterprise (MNE) customers on local suppliers' productivity growth by using the share of MNEs in downstream sectors as an explanatory variable. Blalock and Gertler claim the existence of sizable technology transfers from downstream MNEs to upstream firms, based on empirical estimates of the relationship between the share of MNEs in downstream firms and productivity growth in upstream firms. One of the shortfalls of the past literature, however, is to depend only on indirect evidences of technology transfers, rather than pinpointing what sort of technological information is transferred from whom to whom. Another shortage of the past literature is to lay too much emphasis on North-South technology transfer. South-South FDIs and trades among East Asian developing economies are emerging technology transfer channels in ASEAN and East Asia. Machikita and Ueki (2013) investigate technology transfer from China and Japan to Viet Nam.

To fill these gaps, we collected unique buyer-supplier linked data in four Southeast Asian countries to investigate the geographical structure of technology transfers, particularly in the form of buyer-provided training, in domestic and international production networks. One of the novelties in our study is to directly observe links of technology transfers. Previous representative studies such as Javorcik (2004) and Blalock and Gertler (2008) have depended on vertical linkage information based on input-output tables in order to postulate possible horizontal and vertical linkages, not directly capturing actual links. An important exception is Gorodnichenko, *et al.* (2010) who utilize information on direct linkages between domestic and foreign firms to identify several channels of globalization impacts. In the setting limited to agriculture, Conley and Udry (2010) provide a framework and evidence on what sort of neighbors affects productivity growth for pineapple farmers in Ghana. We believe that direct observation of technology transfers in the form of training reveals the nature of vertical linkages among firms including multinationals and local firms located nearby and abroad.

Another unique feature of our study is to focus on buyer-provided training as a particular channel of vertical technology transfers. One attribute of training is to enhance human capital at the individual level, and the literature seems to be interested in the implication of labor turnovers in the globalizing environment.[1] However, in this

[1] Gershenberg (1987) claims that managerial knowledge rarely flows from multinationals to domestic firms in Kenya. Gorg and Strobl (2005) find that enterprise owners who used to work for multinationals move to more productive firms than those who worked only for domestic firms by using the survey from Ghana. Markusen and Trofimenko (2009) show that foreign experts can transfer the knowledge to domestic workers in Colombia. Balsvik (2011) presents that workers with MNE experience have a more sizable contribution to the productivity of their plants than workers without MNE experience in the case of Norwegian manufacturing sector. Poole (2013) documents wage spillovers within a firm through hiring well-trained workers from multinationals

study, training is interpreted as an effort for facilitating and upgrading vertical links in production networks. Not all firms are automatically qualified as participants in production networks. There is a strict qualifying selection, and after that, buyers may have an incentive to provide supplementary training for suppliers in order to teach how to introduce new products, improve production processes, and ultimately make production networks work well.[2] When downstream production partners have global market access and advanced knowledge, they may set out to share their technical knowledge of new products and production processes with their upstream suppliers. Such learning may be linked further along the production networks; i.e., information recipients could become information senders.

The major findings are summarized as follows: first, the probability of having buyer-provided training shows a U-shaped quadratic pattern with respect to the geographical distance between the respondent firms and the main buyers. In other words, the probability is high when the distance is either short or long. It is particularly important for local firms to locate nearby the main buyer to have buyer-provided training not across borders. Second, training provision is likely for both local and non-local firms when the main buyer is a multinational located in the same country. Non-local firms also tend to have training when the main buyer is located in ASEAN, East Asia, or the rest of the world. Foreign buyers play an important role for buyer-provided training to non-local exporters in ASEAN, while such spillovers through exporting do not work for local firms. Third, the probability of having training from the main buyer is high when the main buyer conducts R&D while the capital tie with the main buyer does not seem to enhance the probability.[3] These results imply that training provision is expected to spur by main buyers who have high technological levels. Fourth, both

located in Brazil, but the extent of wage spillovers is limited to higher-skilled domestic workers, not lower-skilled workers. Stoyanov and Zubanov (2012) find that Danish firms hiring workers from more productive firms can experience productivity gains and these gains increase with skill-level of new workers.

[2] As Antras and Rossi-Hansberg (2009) summarizes, Jones and Kierzkowski (1990) provide a theoretical framework on observed fragmentation of production, explaining a tradeoff between gains from fragmentation, when the economic advantages of cross-border production are utilized, and the costs of disintegration from cross-border production.

[3] This finding on the capital relationship between buyers and suppliers seems to be different from the implication of Atalay, *et al.*, (2014) which emphasized the importance of intangible inputs. They concluded that the prime motivation for owning multi-plants is to make more efficient transfers of knowledge of production and information on markets.

local and non-local firms that have training provided by their main buyers are likely to provide training to their main suppliers. An information recipient from the downstream buyer is likely to be an information sender to its upstream supplier along the production chain; this suggests that production networks within and across borders seem to work as a chain of technology transfers. Finally, in the case of non-local firms, product innovation with production partners is more likely when they are information recipients/senders in terms of training. This suggests a tight link of innovation with technology acquisition, knowledge dissemination, and information aggregation for non-local firms, but such links seem to be weak for local firms.[4] The scope of this study is limited in the sense that it concentrates on one particular form of technology transfers, i.e., buyer-provided training. However, we believe that it is worthwhile analyzing the geographical structure of technology transfers in domestic and international production networks with direct observation.

The remaining parts of this paper are organized as follows: section 2 introduces our dataset on firms' self-reported main buyers and main suppliers. It provides the evidence for technology transfers in the form of buyer-provided training in the global value chain network. Section 3 presents the geographical formation of buyer-provided training in a global supply chain. We also demonstrate technology transfers from downstream to upstream firms. Section 4 provides the evidence of product innovation that is correlated with incoming and outgoing technology transfers. Section 5 concludes the paper.

[4] Our findings are partially supported by qualitative case studies on how buyer-supplier trade relationships solve the problem associated with transfers of tacit knowledge, particularly through buyers' provision of technical assistance to their suppliers. An example is found in the transport equipment industry including automobiles and motorcycles in Viet Nam. Viet Nam Manufacturing and Export Processing Co., Ltd. (hereafter VMEP), a motorcycle manufacturer, occasionally assigns technical officers to provide technical assistance for its suppliers. In its close collaborative relationship with Chiu Yi Viet Nam (hereafter CYV), VMEP usually appoints technical staffs in order to enable CYV to enhance product quality as well as supporting the development of new products and designs. Meanwhile, CYV appoints technical staffs to examine process errors on the spot or take part in meetings about quality enhancement as well as submitting a proposal to VMEP on improving technology and product styles (Truong Chi Binh, 2010). A number of case studies have also revealed that the transportation equipment sector is dominated by MNE assemblers who provide their suppliers technical assistance in return for high quality control on the supplier side. We can say that being a part of MNEs' production network is just like attending a "training school" for its suppliers (Intarakumnerd, 2010).

2. The Firm’s Self-reported Buyer and Supplier Data

2.1. The Survey

This paper employs the questionnaire survey data that we collected from firm managers and correspondences. The sample population is restricted to manufacturing firms operating in main industrial districts in four ASEAN countries—the JA-BODETABEK area in Indonesia that comprises Jakarta, Bogor, Depok, Tangerang, and Bekasi; the CALABARZON area in the Philippines that consists of Cavite, Laguna, Batangas, Rizal, and Quezon; the Greater Bangkok area in Thailand; and the Hanoi and Ho Chi Minh City areas in Viet Nam.

Our questionnaire starts by asking a respondent establishment on its basic characteristics such as the year of establishment, capital structure (100 percent locally owned, hereafter “local"), 100 percent foreign owned (MNE), or joint venture (JV)), and size (in terms of employees and assets). Then it tries to quantify achievements in product and process improvements and sources of technologies and information used by the establishment to conduct innovative activities. It also asks questions regarding a main buyer and supplier for the respondent establishment which include the attributes of its main buyer (supplier), collaborative relationships between the respondent and its main buyer (supplier), the distance between them, and the country where the main buyer (supplier) locates.

The survey began in November 2012 and was completed in January 2013. Responses were collected by mail, phone interviews, and face-to-face interviews. 979 establishments agreed to participate in the survey: 157 in Indonesia (16 percent of the total), 218 in the Philippines (22 percent), 284 in Thailand (29 percent), and 320 in Viet Nam (33 percent). The original survey shows that 55 percent of the responded establishments are 100 percent locally owned, and 53 percent of them are SMEs hiring less than 200 employees.

2.2. Characteristics of the Respondent Firms

From the 979 raw observations, we can use 807 restricted observations for this paper as summarized in Table 2. The decrease in the number of observations is caused mainly by missing values for the respondents in Thailand. Consequently about 19.3

percent of the respondents locate in Indonesia, 26.5 percent in the Philippines, 15.1 percent in Thailand, and 39.0 percent in Viet Nam. However, this decrease does not make a significant difference in the importance of local firms and SMEs between the raw and restricted datasets. By the capital structure, 52.4 percent of the 807 respondents are local firms. Multinational enterprises and joint ventures are 36.2 percent and 11.4 percent of the 807 respondents, respectively.

As shown in Table 2, the main manufacturing activity of the respondents is concentrated in machinery (23.4 percent of the sample), chemical products (17.8 percent), automobiles and other transport equipment (11.3 percent), textiles (11.9 percent), and metal products (11.9 percent), and the industrial composition of the dataset for each country is not widely different from that of official statistics in each country (Machikita and Ueki, 2015). The average age of the respondents is 17.2 years. They mainly produce parts and components (33.1 percent) or assemble final goods (48.6 percent). 36.8 percent of them are OEM (original equipment manufacturer).

With respect to the establishment size, the respondents choose one of the following eleven categories: 1-19 persons, 20-49, 50-99, 100-199, 200-299, 300-399, 400-499, 500-999, 1,000-1,499, 1,500-1,999, and 2,000 and more. The variable for the number of employees is defined as the median value of each category, of which the mean is 397.5 as shown in Table 2.

The questionnaire asks the respondents whether they conduct R&D and have achieved process improvements. We use R&D as indicators for absorptive capability (Cohen and Levinthal, 1990). Table 2 shows 51.9 percent of the respondents conduct R&D. It also introduces an indicator for innovative capability that is defined as the standardized sum of 12 dummy variables for process improvements, which have a mean of zero and a standard deviation of one, as defined by Machikita and Ueki (2015) which applies the methods by Ichniowski, *et al.* (1997) and Bloom and van Reenen (2007) to manufacturing firms in Southeast Asia.

Table 2: Summary Statistics for Local and Non-local Firms

	Whole Mean	N=807 Std. Dev.	Local Mean	N=423 Std. Dev.	Non-local Mean	N=384 Std. Dev.
Main buyer characteristics						
Main buyer gave training						
Gave training to main supplier	0.374	0.484	0.272	0.445	0.487	0.5
Develop a new product with	0.297	0.457	0.201	0.401	0.404	0.491
production partners Design a	0.26	0.439	0.189	0.392	0.339	0.474
new product with main buyer	0.379	0.485	0.305	0.461	0.461	0.499
Distance to main buyer (km)	557.897	803.159	341.625	605.065	796.133	919.539
Domestic local buyer	0.405	0.491	0.61	0.488	0.18	0.384
Domestic MNE buyer	0.195	0.396	0.111	0.315	0.286	0.453
Domestic JV buyer	0.135	0.342	0.132	0.339	0.138	0.345
Foreign buyer in ASEAN	0.048	0.215	0.028	0.166	0.07	0.256
Foreign buyer in East Asia	0.128	0.334	0.038	0.191	0.227	0.419
Foreign buyer in EU or US	0.062	0.241	0.043	0.202	0.083	0.277
Foreign buyer in ROW	0.012	0.111	0.014	0.118	0.01	0.102
Capital tie with main buyer	0.229	0.421	0.189	0.392	0.273	0.446
Number of employees of main	497.638	381.408	400.936	364.574	604.162	371.462
Main buyer is doing R&D	0.441	0.497	0.392	0.489	0.495	0.501
Main supplier characteristics						
Distance to main supplier (km)	728.538	853.154	479.793	689.07	1002.546	930.044
Domestic local supplier	0.322	0.468	0.511	0.5	0.115	0.319
Domestic MNE supplier	0.107	0.309	0.104	0.306	0.109	0.313
Domestic JV supplier	0.141	0.349	0.142	0.349	0.141	0.348
Foreign supplier in ASEAN	0.067	0.25	0.035	0.185	0.102	0.302
Foreign supplier in East Asia	0.289	0.453	0.149	0.356	0.443	0.497
Foreign supplier in EU or US	0.043	0.204	0.028	0.166	0.06	0.238
Foreign supplier in ROW	0.019	0.135	0.012	0.108	0.026	0.159
Capital tie with main supplier	0.218	0.413	0.196	0.398	0.242	0.429
Number of employees of main	364.921	312.930	311.575	302.938	423.685	313.617
Main supplier is doing R&D	0.315	0.465	0.305	0.461	0.326	0.469
Respondent firm characteristics						
Capability (z-score)	0	1	-0.025	1.01	0.027	0.99
Doing R&D	0.519	0.5	0.515	0.5	0.523	0.5
OEM	0.368	0.483	0.364	0.482	0.372	0.484
Firm age	17.232	14.287	20.489	16.444	13.643	10.345
Number of employees	397.497	524.739	302.896	471.684	501.706	559.952
Local	0.524	0.500	1	0	0	0
Multinational enterprises	0.362	0.481	0	0	0.76	0.427
Joint ventures	0.114	0.318	0	0	0.24	0.427
Parts and components	0.332	0.471	0.203	0.403	0.474	0.5
Final goods production	0.486	0.5	0.608	0.489	0.352	0.478
Indonesia	0.193	0.395	0.251	0.434	0.130	0.337
The Philippines	0.265	0.442	0.236	0.425	0.297	0.457
Thailand	0.151	0.358	0.232	0.422	0.063	0.242
Viet Nam	0.390	0.488	0.281	0.450	0.510	0.501
Food	0.097	0.296	0.137	0.344	0.052	0.222
Textile	0.119	0.324	0.139	0.347	0.096	0.295
Paper	0.048	0.215	0.069	0.253	0.026	0.159
Chemical	0.178	0.383	0.177	0.382	0.18	0.384
Metal	0.119	0.324	0.128	0.334	0.109	0.313
Machinery	0.234	0.424	0.163	0.370	0.313	0.464
Auto	0.113	0.316	0.05	0.217	0.182	0.387

Note: Local is 100 percent local capital firms. Non-local is 100 percent foreign capital firms (i.e., multinational enterprises) and joint venture firms.

Source: ERIA Establishment Survey 2012.

2.3. Characteristics of a Firm's Main Buyer and Supplier

Table 2 also reports summary statistics for a number of variables regarding the main buyer and the main supplier. There are two types of variables for the distance between the respondent and its main buyer or supplier. One is the distance expressed in kilometers. The questionnaire asks a respondent to indicate the distance to its main buyer (supplier) by choosing one of the following eleven categories: 0-10 kilometers, 11-25, 26-50, 51-100, 101-200, 201-300, 301-400, 401-500, 501-1,000, 1,001-2,000, and more than 2,000. The variable for the distance to the main buyer or supplier is defined as the median value of each category. Table 2 indicates the means of the distance to the main buyer and supplier are 557.9 and 728.5 kilometers respectively. This variable for kilometer distance is log-transformed and squared for the regression analyses in the following sections.

The other variables for the distance are dummy variables defined by the location where the main buyer or supplier resides. We categorized its location into the following five regions: domestic, ASEAN, East Asia (China, Japan, Korea, and Taiwan), EU or US, and the rest of the world (ROW). If the main buyer or supplier is domestic, in other words, located in the same country as the respondent, the main buyer/supplier is further categorized according to its capital structure (local, MNE, JV). Table 2 indicates that many respondents have their main buyers or suppliers domestically, particularly when respondents are local. However, a considerable number of the respondents have their main buyers or suppliers in East Asia while a non-negligible portion has them in ASEAN. EU and the US are still important for ASEAN as buyers, in other words, as export destinations.

There are other attributes of the main buyer or supplier reported in Table 2 that may affect technology transfers between the respondent and its main buyer or supplier. 22.9 percent and 21.8 percent of the respondents have capital ties with their main buyers and suppliers respectively. 44.1 percent and 31.5 percent have main buyers and suppliers who conduct R&D. The means of the number of employees for the main buyers and suppliers are 497.6 and 364.9 respectively. These variables for the number of employees are defined in the same way as the size of the respondents; the survey requested the respondent to indicate the number of employees hired by its main buyer (supplier) by choosing one of the following five categories: 99 or less employees, 100-

199, 200-299, 300-999, and 1,000 and more.

2.4. Main Dependent Variables

Main dependent variables in our regression analyses are dummy variables for technology transfers through the provision of training by a downstream firm to its upstream supplier. Although the questionnaire does not specify the detailed contents of "training," it certainly intends to help the counterparts introduce new intermediate products, economize production processes, and make production networks work well. The unique data on the buyer-supplier relationship allow us to develop two variables related to such technical assistance. One is the training provided for the respondent by its main buyer: the dummy variable is coded 1 if the buyer provides training to the respondent, otherwise 0. The other variable is on the training provided by the respondent for its main supplier: the dummy variable is coded 1 if the respondent provides training to its main supplier, otherwise 0. Table 2 presents 37.4 percent and 29.7 percent of the respondents are provided training by their main buyers and provide training to their main supplier respectively. We regress these dummy variables for training provision on the distance variables and other independent and control variables.

This paper further asks whether the training would link to the formation of collaborative buyer-supplier relationships in order to realize innovations. There are two dummy variables for the collaboration for product development. One is the dummy variable that equals 1 if the respondent has introduced a new product in cooperation with other firms. The other dummy variable is codified 1 if the respondent designs a new product with its main supplier, otherwise 0. As shown in Table 2, 26.0 percent of the respondents have introduced a new product in cooperation with other firms, whereas 38.0 percent of them design a new product with their main suppliers.

3. Regression Results for Buyer-provided Training

This section presents empirical results on buyer-provided (sponsored) technology transfers to suppliers in the form of training provision. First, we check whether buyer-provided (sponsored) technology transfers within a chain are penalized by physical distance between the suppliers and the buyers. Then we investigate whether FDI in developing economies plays an important role for technology transfers through buyer-provided training to local suppliers, in comparison with other possible technology transfer/spillover channels such as spillovers from local buyers and spillovers through exporting. We will see how international exposure of suppliers (i.e., having incoming FDI and exporting) affects technology transfers. Second, we test whether suppliers who receive buyer-provided training also provide training to their upstream suppliers. This is the test that checks how far information recipients can also be information senders in the backward linkage.

3.1. Incoming Technology Transfers shaped by Geography, FDI, and Exports

Our testable hypotheses are (1) the incidence of buyer-provided training to suppliers is negatively correlated with geographic distance between buyers (information senders) and suppliers (information recipients), and (2) the incidence of buyer-provided training to suppliers is positively correlated with having MNE buyers and exporting products to ASEAN buyers. To derive the empirical results, this paper estimates a simple model of technology transfers on buyer-seller networks as follows:

$$
\begin{aligned}
&Pr(Buyer\ gave\ training = 1)_i \\
&\qquad = \alpha + \beta_1 log(Distance\ to\ buyer)_i + \beta_2 \log(Distance\ to\ buyer)^2{}_i \\
&\qquad + \beta_B (Buyer's\ covariates)_i + \beta_X (covariates)_i + \varepsilon_i \qquad (1)
\end{aligned}
$$

where dependent variable$(Buyer\ gave\ training)_i$ signifies a binary variable which is equal to one if firm i's main buyer gave training to respondents, otherwise zero. $(Distance\ to\ buyer)_i$ denotes a distance between main buyer and respondent firms measured in kilometers. $(Buyer's\ covariates)_i$ is capturing the main buyer's characteristics explaining outgoing technology transfers to upstream supplier firms, which include a dummy variable capturing capital ties between main buyers and respondents, main buyers' employment size, and a dummy variable capturing main buyers' R&D activities. $(covariates)_i$ consists of a vector of firm-level observable characteristics capturing firm i's capability score of process improvements, R&D activity, MNE dummy, JV dummy, firm age, firm size, OEM dummy, parts and components producer dummy, final goods producer dummies, and industry dummies as well as country dummies. ε_i is an unobserved error.

Then we move on to estimating the following equation of technology transfers in a buyer-seller network:

$$Pr(Buyer\ gave\ training = 1)_i = \alpha + \gamma_1(Domestic\ MNE\ buyer)_i + \gamma_2(Foreign\ buyer)_i + \gamma_B(Buyer's\ covariates)_i + \gamma_X(covariates)_i + \epsilon_i \quad (2)$$

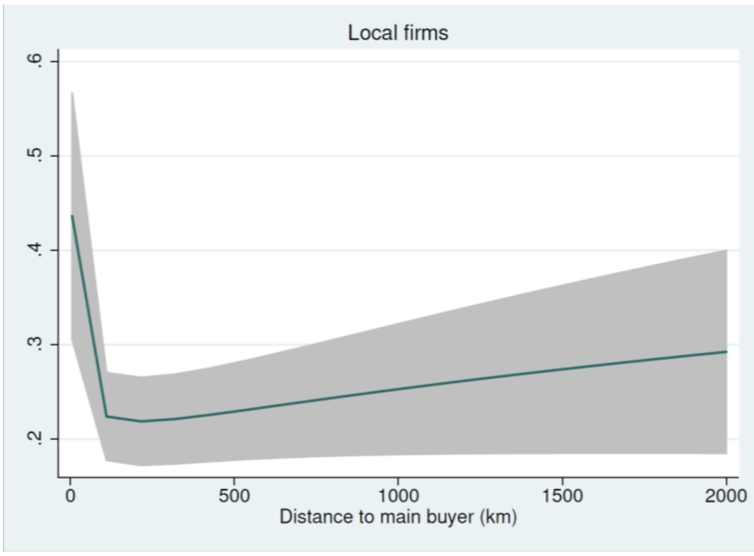
where $(Domestic\ MNE\ buyer)_i$ is a binary variable which is equal to one if firm i's main buyer is an MNE in each country, otherwise zero, $(Foreign\ buyer)_i$ is also a dummy variable which is equal to one if firm i's main buyer is in foreign countries, otherwise zero, and ϵ_i is an unobserved error. As we mentioned before, our hypothesis is that the incidence of incoming technology transfers from buyers is driven not only by geographic distance but also by multinational buyers in the same country through FDI and buyers abroad as export destination.

We provide a first look at the average adjusted prediction (AAP) computed from the first model. Although the AAPs are computed for the log-transformed distances, we plot them against the distance corresponding to each of the log-transformed distance. We present the figures for local and non-local firms separately to visualize different distance effects. Then we show the marginal impacts of geographic distance to the main buyer as well as the firm nationality and location of the main buyer estimated from the first and second models.

Let us start graphing AAP for local firms. Figures 1 plots the average adjusted prediction of the distance between firm i and firm i's main buyer on the probability that local firm *i* receives buyer-provided training with 95 percent confidence intervals. It shows that the probability of having technology transfer through buyer-provided training to local firms in ASEAN follows a U-shaped quadratic pattern with respect to the physical distance to the main buyer. The average probability of receiving buyer-provided training for local firms starts from a bit lower than 0.45. The bottom of the U-shaped curve is around 200-250km to the main buyer where the probability of receiving buyer-provided training is 0.22. Then the upward sloping portion of the quadratic curve continues to 2,000km distance to the main buyer where the average probability of receiving buyer-provided training reaches close to 0.30.

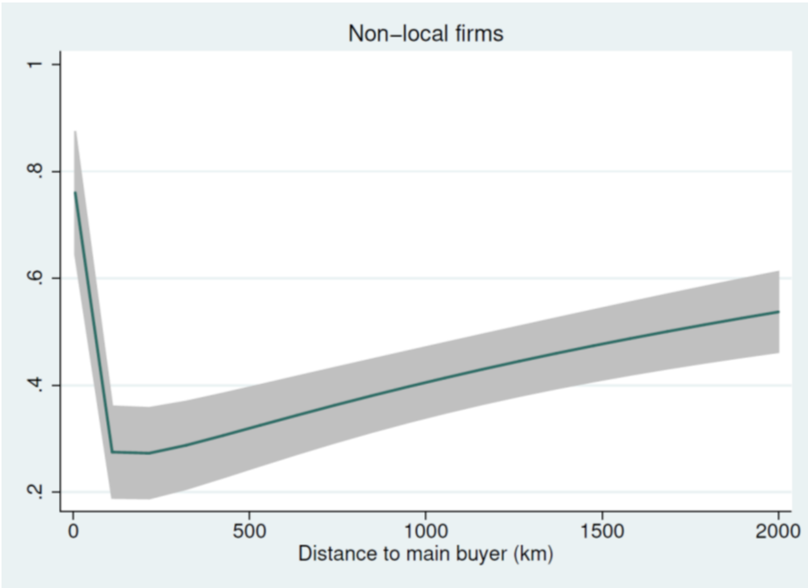
How about the cases of non-local firms, i.e., multinational enterprises or joint ventures? Figure 2 also plots the average adjusted prediction of distance to main buyer on the probability that non-local firms *i* receives buyer-provided training. It clearly shows that technology transfer through buyer-provided training to non-local firms in ASEAN also present a U-shaped quadratic pattern with respect to the distance to the main buyer. The average probability of receiving buyer-provided training by non-local firms starts from the level of more than 0.75. The bottom of the U-shaped curve is again in around 200-250km distance to the main buyer where the probability of receiving buyer-provided training is 0.30. The upward sloping portion of the U-shaped curve for non-local firms follows a higher trajectory than local firms depicted in Figure 1, continuing to 2000km distance to the main buyer where the average probability of receiving buyer-provided training is close to 0.50. In sum, the comparison between Figures 1 and 2 provides the following intuitive findings: (1) Non-local firms are more likely to receive buyer-provided training than local firms; (2) Local firms receives training mainly from buyers located nearby in the same industrial agglomeration, and the role of foreign buyers are limited; (3) On the other hand, non-local firms are more likely to receive training from both buyers nearby and buyers abroad.

Figure 1: Plotting Average adjusted Prediction of Distance (km) to Main Buyer on the receiving Probability of buyer-provided training for Local Firms with 95 percent Confidence Intervals



Source: ERIA Establishment Survey 2012.

Figure 2: Plotting average adjusted prediction of distance (km) to main buyer on the receiving probability of buyer-provided training for non-local firms with 95 percent confidence intervals



Source: ERIA Establishment Survey 2012.

Regression results in Table 3 clearly indicate the pattern of backward linkages of technology transfers from downstream buyers to upstream suppliers. First, Columns 1 to 3 of Table 3 show that a U-shaped quadratic pattern with respect to the distance between firm *i* and firm *i*'s main buyer exists on the decision of buyer-provided training to firm *i*. The quadratic pattern is significant for the whole sample (Column 1), the local sample (Column 2), and the non-local sample (Column 3). Embodied knowledge spillovers through training provided by downstream buyers are bimodal in terms of geographical distance.

Second, the capital tie-up between firm *i* and *i*'s main buyer does not show any positive impact on incoming technology transfers from the buyer to firm *i* (Columns 1 to 3). In addition, non-local supplier *i* is more likely to experience buyer-provided training if the firm size of the main buyer is larger (Column 3), and both local and non-local firm *i* are more likely to have buyer-provided training if the main buyer conducts R&D (Columns 1 to 3).

Third, Columns 4 to 6 of Table 3 intend to identify technological transfers from buyers to suppliers in a production chain through FDI or exports. The reference group is local buyers. The positive coefficient of domestic MNE buyer dummy with a 1 percent statistical significance indicates that the probability of buyer-provided training to suppliers is high if the main buyer is MNE established by incoming FDI, compared with the situation that the main buyer is a local firm. This is true no matter whether firm *i* is a local or non-local supplier (Columns 5 and 6). This is a solid evidence of technological transfers through FDI to local suppliers (Columns 5) as well as technological transfers among non-local suppliers in each country. We cannot find clear results for the case that the main buyer is a joint venture.

Fourth, Columns 4 to 6 of Table 3 also seek the evidence of technology transfers from foreign buyers. We cannot find clear-cut results that foreign buyers would provide training to local suppliers (Column 5). In particular, foreign buyers are less likely to provide training to suppliers than local buyers in each country if foreign buyers are located in ASEAN or EU or US. On the contrary, foreign buyers located in any other ASEAN countries, East Asia, or the rest of the world seem more likely to provide training for non-local supplier *i* than local buyers (Column 6).

In summary, buyer-supplier network data and Table 3 demonstrate the following concrete evidences on technology transfers from buyers to suppliers: (1) the probability of technology transfers in the form of buyer-provided training for suppliers presents a U-shaped pattern with respect to the geographical distance between the buyer and the supplier; in particular, local buyers heavily rely on training provision in a short distance, (2) there exist technology transfers from downstream affiliates of multinationals located in the country to local suppliers while technology transfers from export-destination firms abroad to local suppliers seem to be weak, and (3) there are also significant technology transfers from downstream affiliates of multinationals located in the country to non-local suppliers, and technology transfers from export destination firms seem to work only for non-local suppliers in developing economies.

Table 3: Impacts of the Distance from Main Buyers on Incoming Technology Transfers (training) from buyers

	(1)	(2)	(3)	(4)	(5)	(6)
Respondent firms in ASEAN	Whole	Local	Non-local	Whole	Local	Non-local
Distance to buyer						
Log of distance to main buyer (km)	-0.335***	-0.174***	-0.528***			
	(0.056)	(0.064)	(0.103)			
Square of log of distance to main	0.033***	0.016**	0.052***			
	(0.006)	(0.007)	(0.010)			
Domestic vs. foreign buyer						
Domestic MNE buyer				0.319***	0.233**	0.447***
				(0.058)	(0.105)	(0.075)
Domestic JV buyer				-0.020	-0.047	0.119
				(0.059)	(0.057)	(0.111)
Foreign buyer in ASEAN				0.301***	-0.167**	0.531***
				(0.093)	(0.074)	(0.053)
Foreign buyer in East Asia				0.065	0.208	0.233**
				(0.070)	(0.166)	(0.097)
Foreign buyer in EU or US				-0.116	-0.166***	0.039
				(0.074)	(0.053)	(0.142)
Foreign buyer in rest of the world				0.005	-0.056	0.420***
				(0.194)	(0.157)	(0.109)
Buyer characteristics						
Capital tie with main buyer	-0.096**	-0.074	-0.095	-0.115**	-0.056	-0.147**
	(0.046)	(0.062)	(0.067)	(0.045)	(0.064)	(0.065)
Log of firm size of main buyer	0.075***	0.027	0.141***	0.064***	0.031	0.099**
	(0.023)	(0.025)	(0.039)	(0.023)	(0.025)	(0.039)
Main buyer is doing R&D	0.145***	0.126**	0.131**	0.186***	0.145***	0.253***
	(0.040)	(0.049)	(0.063)	(0.040)	(0.051)	(0.061)
N	807	423	384	807	423	384

Note: All dependent variables are binary variables indicating whether the main buyer gave training to the respondent firm in each country in ASEAN. The reference group is domestic local buyers. Other control variables are a capability score of process improvements, R&D activity, MNE dummy, JV dummy, firm age, firm size, OEM dummy, parts and components producer dummy, final goods producer dummies, industry controls (seven manufacturing industry with reference industry), and country controls.

Source: ERIA Establishment Survey 2012.

3.2. Impacts of Incoming Buyer-provided Technology Transfers on Outgoing Technology Transfers to Suppliers

Let us turn to investigate outgoing technology transfers from suppliers to suppliers' main suppliers. Our hypothesis here is that supplier firm *i* in Indonesia, the Philippines, Thailand, or Viet Nam is likely to provide training to its upstream supplier if firm *i* has been provided training by its down-stream buyer. The test result uncovers the supplier's chain behavior of diffusing knowledge from downstream to upstream in a production chain. To derive empirical estimates of the relationship between incoming and outgoing technology transfers, we estimate the following equation on the buyer-supplier network:

$$Pr(Give\ training\ to\ supplier = 1)_i = \alpha + \mu_1(Buyer\ give\ training\ )_i + \mu_S(Supplier's\ covariates)_i + \mu_B(Buyer's\ covariates)_i + \mu_X covariates)_i + u_i \qquad (3)$$

where variable $(Give\ training\ to\ supplier)_i$ is a dummy variable which is equal to one if supplier firm i provides training to its upstream supplier, otherwise zero, and $(Buyer\ gave\ training)_i$ signifies a dummy variable which is equal to one if firm i's main buyer provides training to firm i, otherwise zero. $(Supplier's\ covariates)_i$ captures main supplier's characteristics which includes the distance between firm *i* and its main supplier, a set of dummy variables of the main supplier's types (domestic or foreign supplier), a dummy variable capturing a capital tie-up between the main supplier and firm *i*, the main supplier's employment size, and a dummy variable for the main supplier's R&D activities. $(Buyer's\ covariates)_i$ is also for the main buyer's characteristics that explain technology transfers to firm *i*, including a dummy variable capturing a capital tie between the main buyer and firm *i*, the main buyer's employment size, and a dummy variable for the main buyer's R&D activities. $(covariates)_i$ is a vector of firm-level observable characteristics which consist of firm i's capability score of process improvements, R&D activity, MNE dummy, JV dummy, firm age, firm size, OEM dummy, parts and components producer dummy, final goods producer dummies, and industry dummies as well as country dummies. u_i is an unobserved error.

Table 4 presents the backward knowledge diffusion of three parties from downstream buyers and the respondents to their suppliers in a production chain through buyer-provided training. Columns 1 of Table 4 shows impacts of incoming technology transfer from firm *i*'s main buyer to firm *i* on outgoing technology transfers from firm *i* to firm *i*'s main supplier, after controlling the distance to the main supplier and the main buyer in the quadratic form. There are significant impacts of receiving buyer-provided training on providing training to the upstream supplier. Columns 2 and 3 of Table 4 present that impacts of incoming technology transfers on outgoing technology transfers are statistically significant for both local and non-local respondents.

The Columns 4 to 6 of Table 4 control the detailed relationship among firm i, firm *i*'s main buyer, and firm *i*'s main supplier. These results confirm the baseline results of Columns 1 to 3, which go with the geographic distances (km) among these three parties; impacts of receiving training from the downstream buyer on providing training to the upstream supplier are again statistically significant at 1 percent for the whole, local, and non-local respondents. Local firms also become information senders by providing training to their supplier if they are recipients of buyer-provided training. It is particularly true for non-local firms. Furthermore, non-local firms are more likely to provide training to their supplier if they have an MNE buyer in each country. In addition, non-local firms are more likely to provide training to their suppliers if they buy intermediate goods from the JV suppliers in each country or they import intermediate products from the foreign suppliers in ASEAN.

In summary, Table 4 finds a solid evidence of backward technology transfers through buyer-provided training where a firm in a production chain is not only an information recipient from its downstream buyer but also an information sender to its upstream supplier. Local firms are also likely to provide training to their suppliers when they receive training from their buyers.

Table 4: Impacts of Incoming Technology Transfers on Outgoing Technology Transfers

	(1)	(2)	(3)	(4)	(5)	(6)
Respondent firms in ASEAN	Whole	Local	Non-local	Whole	Local	Non-local
Incoming technology from buyer						
Main buyer gave training	0.368**	0.313**	0.435***	0.360***	0.328***	0.428***
	(0.040)	(0.058)	(0.061)	(0.041)	(0.059)	(0.065)
Distances to main supplier						
Log of distance to main supplier	-0.018	-0.026	0.023			
	(0.054)	(0.052)	(0.095)			
Square of distance to main supplier	0.001	0.004	-0.004			
	(0.006)	(0.005)	(0.010)			
Distances to main buyer						
Log of distance to main buyer	-0.034	-0.041	-0.031			
	(0.055)	(0.053)	(0.100)			
Square of distance to main buyer	0.001	0.003	0.001			
	(0.006)	(0.005)	(0.010)			
Domestic vs. foreign supplier						
Domestic MNE supplier				0.082	0.070	0.071
				(0.075)	(0.084)	(0.128)
Domestic JV supplier				0.190***	0.117*	0.251**
				(0.068)	(0.071)	(0.114)
Foreign supplier in ASEAN				0.279**	0.208	0.373***
				(0.109)	(0.191)	(0.123)
Foreign supplier in East Asia				0.078	0.111	0.068
				(0.054)	(0.071)	(0.095)
Foreign supplier in EU or US				0.144	0.285*	0.193
				(0.123)	(0.173)	(0.174)
Foreign supplier in rest of the				0.005	-	0.231
				(0.163)	(0.019)	(0.203)
Domestic vs. foreign buyer						
Domestic MNE buyer				0.179***	0.117	0.320***
				(0.061)	(0.077)	(0.095)
Domestic JV buyer				-0.046	-0.007	-0.088
				(0.054)	(0.048)	(0.110)
Foreign buyer in ASEAN				0.099	0.014	0.185
				(0.084)	(0.103)	(0.130)
Foreign buyer in East Asia				-0.037	-	0.073
				(0.057)	(0.029)	(0.112)
Foreign buyer in EU or US				-0.029	0.010	0.015
				(0.080)	(0.087)	(0.157)
Foreign buyer in rest of the world				-0.132		0.314
				(0.082)		(0.240)
Buyer and supplier characteristics						
Capital tie with main buyer	-0.005	0.044	-0.055	-0.015	0.041	-0.089
	(0.049)	(0.063)	(0.078)	(0.049)	(0.061)	(0.079)
Log of firm size of main buyer	-0.054**	-0.014	-0.110**	-	-0.025	-0.141***
	(0.024)	(0.022)	(0.045)	(0.024)	(0.021)	(0.047)
Main buyer is doing R&D	0.135**	0.089**	0.207***	0.158***	0.110**	0.271***
	(0.040)	(0.045)	(0.064)	(0.038)	(0.046)	(0.063)
Capital tie with main supplier	0.264**	0.273**	0.297***	0.277***	0.264***	0.336***
	(0.061)	(0.089)	(0.083)	(0.062)	(0.090)	(0.090)
Log of firm size of main supplier	0.038	-0.005	0.079*	0.037	0.001	0.083*
	(0.026)	(0.025)	(0.047)	(0.025)	(0.024)	(0.047)
Main supplier is doing R&D	0.009	-0.003	-0.024	-0.029	-0.011	-0.081
	(0.042)	(0.045)	(0.074)	(0.039)	(0.039)	(0.071)
N	807	423	384	807	417	384

Note: All dependent variables are binary variables indicating whether the respondent firm in each country in ASEAN gave training to its main supplier. Reference group is domestic local buyer and local supplier. Other control variables are a capability score of process improvements, R&D activity, MNE dummy, JV dummy, firm age, firm size, OEM dummy, parts and components producer dummy, final goods producer dummies, industry controls (seven manufacturing industry with reference industry), and country controls.
Source: ERIA Establishment Survey 2012.

4. Technology Transfer-driven Product Innovation

The next question is whether incoming and outgoing technology transfers encourage product innovation in developing economies. We believe that such investigation is important in order to start thinking of a broader question on the causes and consequences of knowledge acquisition, dissemination, and knowledge aggregation (Levitt, *et al.*, 2013) in buyer-supplier networks. We estimate the following equation:

$$\begin{aligned} Pr(Product\ innovation = 1)_i \\ &= \alpha + \delta_1(Buyer\ give\ training\ )_i + \delta_2(Give\ training\ to\ supplier)_i \\ &+ \delta_B(Buyer\ give\ training)_i * (Give\ training\ to\ supplier)_i + \delta_X(covariates)_i \\ &+ v_i \qquad (4) \end{aligned}$$

where dependent variable $(product\ innovation)_i$ is equal to one if firm *i* develops a new product with production partners, either its main buyer or supplier (for panel A of Table 5), or firm *i* designs a new product with its main buyer (for panel B of Table 5), otherwise zero. $(Buyer\ gave\ training)_i$ is a dummy variable which is equal to one if firm i's main buyer provides training to firm i, otherwise zero. $(Give\ training\ to\ supplier)_i$ is a dummy variable which is equal to one if supplier firm i's provides training to its upstream supplier, otherwise zero. The cross-term of $(Give\ training\ to\ supplier)_i$ and $(Buyer\ gave\ training)_i$ represents possible information aggregation by acquiring information through buyer-provided training and disseminating information through providing training to the supplier. $(covariates)_i$ is a vector of firm-level observable characteristics capturing firm i's capability score of process improvements, R&D activity, MNE dummy, JV dummy, firm age, firm size, OEM dummy, parts and components producer dummy, final goods producer dummies, and industry controls as well as country controls, and v_i is an unobserved error.

Panel A of Table 5 checks impacts of information aggregation within a firm through incoming and outgoing technology transfers on developing a new product with production partners. Before introducing incoming and outgoing technology transfers, Column 1 of Panel A of Table 5 works with a simple question on how product development with production partners works with geography. It shows that the distance to the main buyer does not affect a decision of developing a new product with production partners. It also indicates that the probability of developing a new product with production partners has a U-shaped quadratic pattern with respect to the distance to the main supplier.

Let us move on to the impacts of information aggregation on product development. Column 2 of Panel A shows that the cross-term of “main buyer gave training" and “gave training to supplier" has positively correlated with developing a new product with production partners for the whole samples. Although the coefficients for “main buyer gave training" and “gave training to supplier" present negative signs, the individual effects turn out to be positive after summing up the coefficient for the cross-term. We can thus see for the whole samples that the in-formation aggregation through “main buyer gave training" and “gave training to supplier" works strongly on the probability of developing a new product with production partners. However, Column 3 finds that this is not true for local firms. There is no significant impact of the cross-term between incoming and outgoing technology transfers on product development for local samples. Column 4 of Panel A of Table 5 confirms that the effect of information aggregation comes only from the non-local firms.

Table 5: The Impacts of Incoming and Outgoing Technology Transfers on Product Innovation

Panel A. Dependent var.: Develop a new product with production partners	(1)	(2)	(3)	(4)
	Whole	Whole	Local	Non-local
Incoming and outgoing technologies				
Main buyer gave training		-0.064	-0.101**	0.002
		(0.045)	(0.042)	(0.078)
Gave training to supplier		-0.126**	-0.024	-0.229***
		(0.053)	(0.058)	(0.086)
Main buyer gave training*Gave training to supplier		0.315***	0.102	0.424***
		(0.094)	(0.124)	(0.117)
Distances to buyer and supplier				
Log of distance to main buyer (km)	0.022	0.045	-0.036	0.180**
	(0.053)	(0.054)	(0.063)	(0.086)
Square of distance to main buyer	-0.003	-0.005	0.001	-0.018**
	(0.005)	(0.005)	(0.006)	(0.009)
Log of distance to main supplier (km)	-0.208***	-0.200***	-0.153***	-0.241***
	(0.051)	(0.051)	(0.056)	(0.083)
Square of distance to main supplier	0.019***	0.019***	0.015***	0.022**
	(0.005)	(0.005)	(0.006)	(0.008)
N	807	807	423	384

Panel B. Dependent var.: Develop a new product with main buyer	(5)	(6)	(7)	(8)
	Whole	Whole	Local	Non-local
Incoming and outgoing technologies				
Main buyer gave training		-0.005	0.011	-0.032
		(0.055)	(0.069)	(0.095)
Gave training to supplier		0.243***	0.092	0.449***
		(0.070)	(0.096)	(0.099)
Main buyer gave training*Gave training to supplier		0.255***	0.292*	0.180
		(0.098)	(0.152)	(0.139)
Distances to buyer and supplier				
Log of distance to main buyer (km)	-0.226***	-0.150**	-0.044	-0.449***

	(0.063)	(0.064)	(0.086)	(0.115)
Square of distance to main buyer	0.022***	0.016**	0.008	0.044***
	(0.006)	(0.006)	(0.008)	(0.011)
Log of distance to main supplier (km)	-0.296***	-0.275***	-0.268***	-0.371***
	(0.062)	(0.062)	(0.078)	(0.121)
Square of distance to main supplier	0.026***	0.024***	0.024***	0.034***
	(0.006)	(0.006)	(0.008)	(0.012)
Relationship with buyer and supplier				
Capital tie with main buyer		-0.095*	-0.040	-0.081
		(0.055)	(0.088)	(0.078)
Capital tie with main supplier		-0.177***	-0.170**	-0.267***
		(0.051)	(0.070)	(0.075)
N	807	807	423	384

Note: Other control variables are a capability score of process improvements, R&D activity, MNE dummy, JV dummy, firm age, firm size, OEM dummy, parts and components producer dummy, final goods producer dummies, industry controls (seven manufacturing industry with reference industry), and country controls.
Source: ERIA Establishment Survey 2012.

Panel B of Table 5 also presents the impacts of incoming and outgoing technology transfers on designing a new product though we here focus on the innovative collaboration with the main buyer. Column 1 of Panel B of Table 5 shows that product development with the main buyer is also influenced by the geographic distance. Different from Column 1 of Panel A of Table 5, the probability of designing a new product with the main buyer presents a U-shaped quadratic pattern with respect to the distance to the main buyer, in addition to the distance to the main supplier.

We now look at impacts of information aggregation in the collaboration with the main buyer. In the case of the whole samples (Column 6 of Panel B), the cross-term of incoming and outgoing technology transfers shows positive association with product innovation with the main buyer. Compared with Panel A, however, we can see that information aggregation through “main buyer gave training" and “gave training to supplier" seems to encourage local firms to develop a new product with the main buyer (Column 7). On the other hand, non-local firms that gave training to the main supplier tend to develop a new product with the main supplier (Column 8). In sum, Panel B of Table 5 implies two things: (1) the probability of developing a new product with the main buyer presents a U-shaped quadratic pattern with respect to the distance to the main buyer and the main supplier; (2) information aggregation-driven product innovation seems to be effective for local firms.

5. Conclusion

This paper examines the pattern of technology transfers for product/process innovation in the form of buyer-provided training among local and non-local firms connected by domestic and international production networks. The buyer-supplier network data in Southeast Asia compiled by an ERIA research project provides a new opportunity to directly observe the supplier-buyer relationship as well as the existence of inter-firm provision of training as a form of technology transfers and investigate the geographical structure of knowledge aggregation among local and non-local firms. The data also contributes to find direct evidences for technology transfers through FDI that establishes affiliates in the host country and exports, the destination of which works as buyers.

Our empirical analysis based on the buyer-supplier network data provides the following findings: first, the probability of having training provided by the main buyer presents a U-shaped quadratic pattern with respect to the geographical distance between the respondent firms and the main buyers; i.e., the probability is high when the distance is either short or long. In the case of local firms, the geographical proximity to the main buyer seems to be particularly important in order to have training provided by the main buyer. Second, the training provision is especially likely for both local and non-local firms when the main buyer is a multinational located in the same country; it suggests that incoming FDI enhances technology transfers in domestic production networks. Non-local firms also tend to have training when the main buyer is located in ASEAN, East Asia, or the rest of the world, while such links do not work for local firms; exports in international production networks do not seem to work as a channel of technology transfers for local firms. Third, the probability of having training from the main buyer is high when the main buyer conducts R&D while the capital tie with the main buyer does not seem to enhance the probability. Fourth, both local and non-local firms that have training provided by their main buyers are likely to provide training to their main suppliers; i.e., production networks seem to work as a chain of technology transfers as well. Fifth, in the case of non-local firms, product innovation with production partners is more likely when they have upstream/downstream training; this suggests the link of innovation with technology acquisition, dissemination, and information aggregation. However, such links seem to be weaker in the case of local firms; upstream/ downstream training enhances product innovation working with the main buyers only at a weak statistical significance with large standard errors.

This paper has a limited scope but suggests a number of directions for further research. First, one strong message of this paper is the importance of direct observation of technology transfers. Although this paper concentrates on one particular form of technology transfer, i.e., buyer-provided training, in general we can think of various kinds of technology transfers or spillovers through a number of channels, some of which are certainly observable through hard-working micro data collection. We should explore this direction of research while certainly taking resource constraints into consideration. Second, production networks can also work as channels of technology transfers, and the link between local firms in developing countries and multinationals must be explored further. Such studies are particularly applicable for developing countries like Southeast Asian countries in which production networks designed and operated mainly by multinationals have led industrialization. Third, geography matters for technology transfers. The importance of geographical proximity for technology transfers, particularly for local firms, suggests that proper designing of industrial agglomeration is crucial in developing countries. A number of Southeast Asian countries have aggressively utilized the mechanics of production networks and are now coming into the development stage of formulating industrial agglomeration that should effectively pick up positive agglomeration effects while avoiding congestion. In this context, the geographical structure of production networks, technology transfers, and upgrading innovation must continuously be investigated not only for academics but also for policy makers.

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