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Role of ICT in the Innovation Process Based on Firm-Level Evidence from Four ASEAN Economies: An SEM Approach

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Abstract

Although the East Asian economies have been developing in the 21st century, innovation is indispensable for their further economic development. In order to achieve successful innovation, firms have to elevate their capability including technology, human resources, business organization, ICT use and so on by collaborating with outside organizations such as MNCs (Multi-national companies), universities, public organizations. The outside organizations are termed as external linkages. Based on authors' survey data of four ASEAN economies such as Vietnam, Indonesia, the Philippines, and Thailand from 2012 to 2013, this paper examines how factors such as organizational learning, ICT use, and technology enhance product and process innovation. These factors are used as latent variables in analysis and consist of the following variables: (i) technology such as capital goods, (ii) organizational learning including QC, cross-functional teams, (iii) ICT use such as B2B, B2C, EDI, SCM, ERP, CAD/CAM, groupware, SNS etc., and (iv) external linkages, such as MNCs, local and public organizations, and universities. This study employs SEM (Structural equation modeling) in order to analyze the causal relationships not only among the above four latent variables but also between these and innovation. The six hypotheses were postulated as follows: H1. External linkages enhance organizational learning; H2. External linkages improve capital goods; H3. External linkage improves ICT use; H4.

Organizational learning improves capital goods; H5. Organizational learning improves ICT use; and H6. Organizational learning, ICT use, and capital goods enhance innovation. Estimation results on product innovation demonstrate that organization learning, technology (capital goods), and ICT use enhance product innovation. On the other hand, organization learning promotes technology (capital goods) and ICT use, which promotes process innovation. Accordingly, this study clarifies that ICT use, technology and innovation capability enhance product and process innovation.

Key words: ICT use, innovation, internal capability, external linkages, SEM (Structural equation modeling)

1. Introduction

The East Asian Economies are required to transform from being the global production base into knowledge based economies. For this goal, firms there have to achieve innovation by enhancing their innovation capability. The innovation process has been analyzing intensively and the factors promoting innovation have been obtained such as R&D, technology, managerial organization, human factors, and ICT use, to create innovation (Tidd, Bessant, and Pavitt, 2001; Christensen and Kaufman, 2009; Idota et al, 2013). Since most new information is obtained from outside the firms (Chesbrough, 2006a, 2006b), the collaboration with outside organizations such as MNCs (Multi-national corporations), universities, public research organizations, other local firms, and so on is indispensable for local firms in developing economies (Cohen and Levinthal, 1990; Zahra and George, 2002). This paper aims to examines the relationship between the factors and innovation, namely how ICTs such as B2B, B2C, EDI (Electronic Data Interchange), SCM, ERP (Enterprise Resource Planning), CAD/CAM, groupware, SNS etc., technology such as the ability of manufacturing capital goods and organizational learning such as QC, cross functional team, enhance product innovation and process innovation by sharing information and collaborating with outside

organizations.

The structure of the paper is as follows. Following an introduction, the summary of previous studies is presented. The hypotheses and methodology of the analysis are presented in Section 3. The survey data is summarized in Section 4. This paper employs SEM (Structural equation modeling). SEM and latent variables used in the analysis are explained in Section 5. The results of the estimations and discussion are presented in Section 6. Brief conclusions are shown in Section 7.

2. Literature view

There are many factors behind the promotion of innovation in an economy, as the endogenous economic growth theory emphasizes, i.e. capital, labor and technology. In reality, it is difficult to raise these factors and promote economic development across the entire economy, but it is more difficult to improve the power of innovation within individual firms. This paper attempts to identify the factors behind innovation in individual firms. Such power is referred to as the innovation capability, which is defined as the ability to continuously transform knowledge and ideas into new products, processes, and systems for the benefit of the firm and its stakeholders (Lawson and Samson, 2001). Innovation capability consists of various factors, which are listed as audit tools, for measuring innovation capability, and related factors are categorized into groups; Mariano and Pilar (2005), for example, categorize them as follows: (1) Communication with the external environment; (2) Level of know-how and experience within the organization; (3) Diversity and overlap in the knowledge structure; and (4) Strategic positioning. The causality among these categories is one of the major research questions in this area, to identify the causes and results (Lawson and Samson, 2001; Perdomo-Ortiz et al., 2009). In order to demonstrate causality, different methodologies such as regression analysis, covariance structure analysis, and the structural equation

modeling were employed. This paper terms it as internal innovation capability, or internal capability, for short, which is defined as an integrated ability of a firm to create innovation consisting of all resources, core competence, or competitiveness. In more detail, internal capability includes the technological level such as the number of patents, production facilities, and R&D facilities, human resources such as the number of engineers with higher degrees or skills, the level of craftsmanship, work ethics, and the organizational nature, such as the communication between workers and top management, the speed of decision-making, and leadership by the top management. In what follows, this study also groups these factors into several categories. Traditionally, on the other hand, a part of internal capability was focused on and referred to as “absorptive capability” by Cohen and Levinthal (1990), Zahra and George (2002) and Christensen and Kaufman (2009), for example. Christensen and Kaufman define it as a firm’s ability to reorganize the value of new external knowledge, and assimilate this for commercial benefit. They also recognize the innovation process is a learning process consisting of four dimensions; acquisition, assimilation, transformation, and exploitation. Acquisition is the process to identify the relevant information from the total amount of information. Assimilation is the ability to process and analyze the information obtained. Transformation is the ability to modify and adopt new knowledge and combine this with knowledge already existing inside the firm. Exploitation is the ability to transform this knowledge into innovation or competitive advantage. Thus the absorptive capability determines the competitive advantage of a firm (Barney, 1991).

Another source of innovation is to make use of factors outside a firm and utilize them to promote internal capability. New information related to innovation is fundamentally obtained from outside the firm, and the literature mentioned above is analyzing this more or less. The collaboration with entities outside the firm such as other firms, universities, and local research institutions for the innovation process came

to be the center of the research and was analyzed in the framework of “open innovation” (Chesbrough, 2003, 2006a, 2006b). The concept of the open innovation process is developed in accordance with the growth of the assembly and processing industries, which handle numerous parts and components, such as the automotive or electronics industries. New information for innovation is conveyed via the supply chain. In addition, the success of the university-firm collaboration such as in Silicon Valley or Route 128 in the early 1990s inspired open innovation. The clustering effect, namely firms finding locations closer to universities, influences open innovation. The open innovation system becomes mandatory for a region or a firm to establish a strategy for innovation. There are two strategies for obtaining information; one is through transactions with other firms, from suppliers and customers, while another is collaboration with research institutions (Kagami, Giovannetti, and Tsuji, 2007). And Information and knowledge are transferred from outside the firms and shared in the firms by using ICT.

The above literature focuses on how innovation capability is formed and contributes to the final outcome of innovation. The arguments are not limited to the innovation process in the developed economies, but are also applicable to developing economies. Firms in the developing economies have their own problems; a weak basis for internal capability, particularly due to a lack of technology, human resources, and knowledge infrastructure. The strategy of firms or governments in the less developed economies is different from those in the developed economies. Among literature on the innovation process or internal capability related to the less developed economies, Ernest (2002) emphasizes blending diverse international and domestic sources of knowledge and making use of international linkages. Kesidoua and Szirmai (2008) also specifies two types of knowledge spillover in the Uruguay software industry; local and international, and they came to the conclusion that the latter is more important than the former. Pietrobelli and Rabellotti (2011) shows international knowledge spillover via

the global value chain, which enhances innovation in the less developed economies. Srholec (2011) takes social factors such as human capital or skill formation in the innovation process into consideration. Chen and Puttitanun (2005) examines the relationship between innovation and intellectual property rights.

In addition, ICT are indispensable for Innovation. ICT contribute to firms in the following processes: (i) improving the efficiency of management and communication inside the firm; (ii) enabling networking and collaboration among business entities and organizations by reducing the time required for communication and overcoming geographical constraints; and (iii) creating new markets for business, such as e-commerce. As a result, ICT has become one of the essential bases for promoting innovation activities (Dogson et al., 2006; Lee & Xia, 2006; Idota et al., 2010, 2011, 2012a, 2012b, 2013a, 2013b, 2014).

It is reported that even the simple use of social media such as SNSs (Social Networking Services), twitters, and logs among employees promotes innovation (Idota et al., 2011). In addition to ICT use inside the firm, ICT is also used for supporting collaboration with entities outside the firm. In particular, cooperation with other firms, universities, and local research institutions has been an important factor for innovation (Chesbrough, 2003, 2006a, 2006b). In the open innovation process, a strategy for sharing information and resources with other firms, from suppliers to customers, for example, is required. The use of ICT is therefore indispensable for the promotion of open innovation, since ICT can connect firms and expedite the sharing of information related to innovation (Tsuji and Miyahara, 2010, 2011; Idota et al., 2010, 2012a, 2013b).

Based on the above discussions, ICT has the following two functions: (1) ICT promotes the efficiency of firms by sharing information among employees and employers, and activates communication, which leads to the enhancement of knowledge

management activities for innovation inside the firm; and (2) ICT enables firms to share, exchange, and communicate with agents outside the firm, which connects it more tightly with other firms or universities, consultants, or research institutes. Thus firms can absorb technology, know-how, and information from outside. This study refers to the former as “ICT use inside the firm” and to the latter as “ICT use outside the firm.” Taking the two ICT uses into consideration, ICT influences the promotion of innovation through the following two channels: (i) enhancing internal innovation capability; and (ii) supporting internal capabilities leading to innovation. In this study, examples of the former consist of ERP (Enterprise Resource Planning) packages, groupware, CAD/CAM and Intra-SNSs. The latter consist of B2B E-commerce, B2C E-commerce, EDI (Electronic Data Interchange), SCM (Supply Chain Management) and Public SNSs.

Based on the above literature, this paper examines how ICT use, organizational learning, and capital goods enhance product as well as process innovation. This paper attempts to identify internal capability, which includes the technological level such as capital goods, organizational learning such as quality control, and cross functional team, and ICT use. In addition to these, this paper emphasizes agents outside the firm, which promote internal capability, that is, the transaction and knowledge channels (Tsuji and Miyahara, 2010, 2011). The former transfers information from agents via transactions or supply chains (Pietrobelli and Rabellotti, 2011). The latter includes MNCs, universities, regional research institutions, and business organizations, which can transfer technology and other information to local firms. The domestic effort by individual firms and external factors, when assimilated, enhances internal capability so that the companies can create their own new products, services, technologies, and ideas.

3. Hypotheses and Methodology: SEM (Structural equation model)

3.1 Hypotheses

This paper focuses on the firms in four ASEAN economies, such as Vietnam, Indonesia, the Philippines, and Thailand. These countries have been making use them for their export and growth strategies. In authors' previous papers, the innovation process in these economies has been analyzed (Idota et al, 2013b). In other words, the same factors are analyzed that were identified as important in our previous studies that also enhance product development as well as process innovation. These are summarized as R&D capability, organization culture or managerial organization including QC, cross-functional teams, and human resources. The following five hypotheses were postulated to be examined in this study:

- (H1) External linkages enhance organizational learning
- (H2) External linkages improve capital goods
- (H3) External linkages improve ICT use
- (H4) Organizational learning improves capital goods
- (H5) Organizational learning improves ICT use
- (H6) Organizational learning, ICT use, and capital goods enhance innovation

The relationships among the above variables are summarized in Figure 1.

3.2 Methodology

This study employs SEM (Structural equation modeling) or CSA (Covariance structural analysis), which enables a study of the relationship among various variables that are related to each other. SEM is said to be a mixture of factor analysis and regression analysis; the former constructs latent variables from observed variables by using factor analysis, while the latter examines the causal relationship between latent variables by regression analysis. Thus, SEM analysis can be used even for cases in which the variables are endogenous and the usual Least Squares cannot be applied. The idea of

SEM was proposed as CSA by Bock (1960) initially and developed by Bock and Bargmann (1966) in order to solve issues related to multivariate analysis. Later Bagozzi (1980) and Bollenn (1989) termed this as SEM.

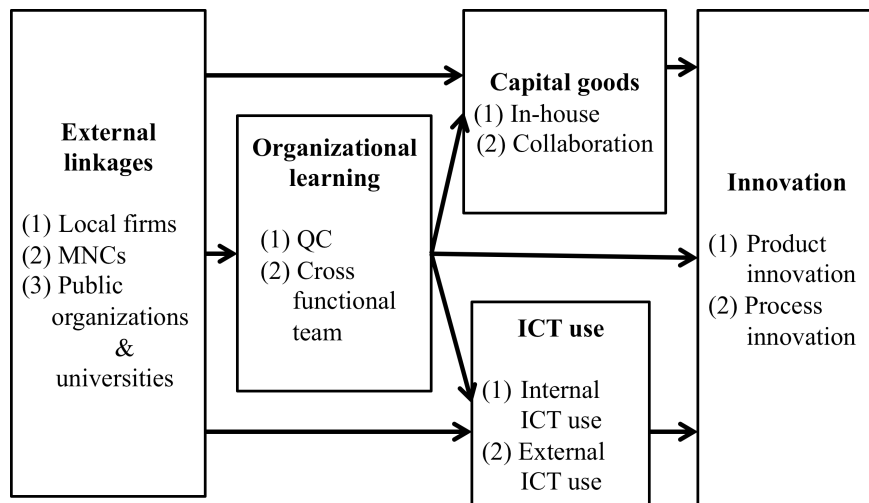


Figure 1: Causal relationships

The merits of SEM are summarized as follows: regression analysis, which enables the causal relationship between variables, can handle only the observed variables, that is, endogenous variables, which are referred to as “latent variables” in SEM. Factor analysis can construct latent variables, which are common nature behind observed variables, but it cannot analyze their causal relationship. SEM can solve the issues related to factor and regression analysis and integrate these two methods. In other words, SEM introduces latent variables which are not observable, and by fixing the causal relationship between latent and observed variables, statistically examines the social as well as natural phenomena.

4. Summary of Data and Innovation

4.1 Surveys conducted

This study is based on mail surveys and phone interviews conducted with firms in four

ASEAN economies, such as Vietnam, Indonesia, the Philippines, and Thailand from 2012 to 2013, which amount to 1,132 in the Hanoi area and 1,000 in the Ho Chi Minh City area, Vietnam, 239 in the Batangas and other areas in the Philippines, 437 in the Jabodetbek area, Indonesia, and 878 in Greater Bangkok, Thailand. The surveys were conducted from November 2012 to January 2013. The total number of valid responses from these areas was 998 (26.36%).

4.2 Characteristics of the respondent firms

(1) Industries

Regarding the category of industries questioned and the distribution of firms responded, for Vietnam, industries consist of “other electronics and components” (17.2%), “plastic and rubber products” (14.1%), and “machinery, equipment and tools” (10.6%), while in Indonesia, “food, beverages and tobacco” (16.3%) is the largest. The Philippines has “metal products” (18.2%), “apparel and leather” (11.2%), and “other electronics & components” (11.2%), and Thailand has “other business activities” (26.4%), “automobiles and auto parts” (13.8%), and “other electronics & components” (9.1%).

(2) Year of establishment

63.9% of Vietnamese, 25.0% of Indonesian, 29.4% of Filipino, and 24.4% of Thai firms replied that they started operating between 2001 and 2010. Those that started between 1991 and 2000 included 44.8% Filipino, 24.4% Thai, 21.6% Vietnamese, and 34.6% Indonesian firms. Concerning Thai firms, 32.05% replied that their establishment dated from between 1981 and 1990 and that they had more years of operation compared to firms in other countries that were established less than 20 years ago. These results depend on when economic growth started in each economy.

(3) Ownership

Most firms are 100% locally owned in all the countries: Vietnam (37.9%), Indonesia (67.3%), the Philippines (48.3%), and Thailand (71.8%). The second biggest category is

100% foreign-owned (MNC): Vietnam (58.9%), Indonesia (20.2%), and the Philippines (28.7%). In Thailand, however, joint ventures (local and foreign-owned) amounted to 16.4%, the second-largest type.

(4) Firm size

The size distribution of firms in terms of total assets and that 20.0% of responding firms have assets from USD1million to USD4.9 million. However, the largest category in the Philippines is from USD100,000 to USD499,999 (22.7%) and for Thailand, it is either from USD1 million to USD4.9 million (23.5%) or from USD10 million and above (32.5%). On the other hand, the size distribution of firms in terms of full-time employees and that almost half of the firms have 20 to 199 employees, except the Vietnamese firms. In Vietnam, the largest category is from 200 to 299 employees (20.7%), that is, the firms in Vietnam that replied belong to the category of larger firms. In the Philippines, about 50% of firms have less than 100 employees and the same can be said of Thai firms, where the number is about 44%.

4.4 Data related to internal capability

(1) Capital goods

In what follows, the responses to questions related to internal capability are presented, and are important for empirical analysis. Let us begin with “capital goods”, which are proxies for the level of technology in firms. Achievements in capital goods/product methods in the last 2 years (2011-12) are indicated. “In-house modification of existing capital goods” ranks highest in Vietnam, the Philippines, and Thailand. Indonesia has a high percentage of “in-house modification of existing capital goods” (59.6%) and “increased degree of automation of the production process” (60.6%). “In-house modification of existing capital goods,” “increased degree of automation of the production process,” “in-house design of capital goods,” and “collaboration with capital

goods producers to customize standard machines” are also high in all the economies, while “co-development of new capital goods with universities/public research institutes” is low.

(2) QC

Regarding questions about QC and delivery management, “Adopted 3S or 5S (*Seiri, Seiton, Seisou, Seiketsu, Shitsuke*),” “operate a QC circle” and “adopted just-in-time delivery” are the largest items in all the economies. “Operate a QC circle” is large in Indonesia (90.4%) and the Philippines (74.8%). In particular, the Indonesia has most replies regarding “adopted just-in-time delivery (93.3%).” This data shows that just-in-time delivery and QC activity have already become standardized systems in these countries.

(3) Cross-functional teams

The cross-functional teams as managerial organizations stimulates innovation. A “manufacturing department” is found in Vietnam (34.8%), the Philippines (38.5%), and Indonesia (31.7%). A “sales & marketing department” exists in Indonesia (34.6%), the Philippines (42.0%), and Thailand (27.2%). A “development department” is found in Vietnam (19.7%) and Indonesia (30.8%). A “research department” is found in Vietnam (36.1%), while a “quality control department” is in Vietnam (25.7%), Indonesia (40.4%), and the Philippines (44.1%).

(4) ICT use

Table 1 shows that “B2B e-commerce” and “CAD/CAM” are used widely in all the countries. In Vietnam (65.8%) and the Philippines (30.1%), “B2B e-commerce” shows a high usage. In Indonesia, “EDI” (44.2%) is the most used. In Thailand, “SCM” (33.3%) and “(ERP)” (27.6%) use is relatively high.

4.5 External linkages

In the pooled data of the four economies, “final consumer” (57.0%), “local customer (100% local capital)” (48.9%), “local supplier (100% local capital)” (40.2%), and “competitor” (38.0%) are ranked in order of importance. For Vietnam, the order is “local customer (100% local capital)” (52.4%), “MNC/JV customer located in country” (51.4%), “local supplier (100% local capital)” (44.8%), and “final customer” (43.3%). Indonesia has “final consumer” (71.2%) and “local customer (100% local capital)” (51.9%) as very important sources. The order for the Philippines is “final consumer” (65.0%), “local customer (100% local capital)” (58.0%), “local supplier (100% local capital)” (48.3%), and “buyer or trading company” (42.7%). In Thailand, the order is “final consumer” (64.2%), “competitor” (49.2%).

Table 1. ICT use

	Vietnam		Indonesia		Philippines		Thailand		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
B2B e-commerce	210	65.8	19	18.3	43	30.1	64	25.3	336	41.0
B2C e-commerce	163	51.1	14	13.5	18	12.6	56	22.1	251	30.6
Electronic Data Interchange (EDI)	167	52.4	46	44.2	24	16.8	37	4.6	274	33.5
Supply Chain Management (SCM)	82	25.7	31	29.8	22	15.4	84	33.2	219	26.7
Enterprise Resources Planning (ERP)	154	48.3	22	21.2	31	21.7	69	27.3	276	33.7
Groupware	82	25.7	12	11.5	12	8.4	7	2.8	113	13.8
CAD/CAM	154	48.3	22	21.2	57	39.9	63	24.9	296	36.1
Intra-Social Networking Services (SNS)	43	13.5	14	13.5	14	9.8	29	11.5	100	12.2
Public SNS	62	19.4	3	2.9	6	4.2	7	2.8	78	9.3

Note: *multiple answers.

Source: Authors.

4.6 Product innovation

(1) General efforts

In this section, the situation of innovation in each economy is presented and used as the explained variables in the analysis in this study. Let us begin with product innovation. Table 2 asks about general trials for creating new products and shows the number of trials conducted concerning product innovation over the last two years (2011-12). Vietnam (63.0%) conducted the largest number, followed by Thailand (61.0%),

Indonesia (58.7%), and the Philippines (51.7%).

(2) Redesigning packaging and appearance

This category of innovation contains the lowest novelty level such as changing packaging and appearance. Table 2 shows that 32.6% of firms achieved this type of innovation in all industries. Vietnam is ranked top (35.7%), followed by Thailand (38.2%) and the Philippines (35.0%), but Indonesia remains at 6.7%.

(3) Improvement type of innovation

This innovation is categorized for new products, or significantly improving existing products, and Table 2 shows that more than half of the firms in all industries attempted and 36.6% of them achieved innovation. Vietnam (48.3%), Thailand (35.4%), and the Philippines (32.2%) show the best achievement performance, while Indonesia has the lowest level at 9.6%.

(4) New products based on existing technology

The development of new products based on the firms' existing technology has been attempted by slightly less than half the firms in all industries and in all these economies, and the average success rate is 26.8%. Among these economies, Thailand achieved the best (32.2%) and second is the Philippines (30.8%). Vietnam (24.8%) and Indonesia (14.4%) follow.

(5) New products based on new technology

This innovation has the highest category using new technology. Table 2 shows that in all industries and all economies, about 40% of firms attempted this type of innovation but that only 15.5% of them achieved innovation. Thailand is ranked best in the success rate (23.6%), followed by the Philippines (22.4%) and Indonesia (11.5%). Vietnam is the lowest (7.5%).

The distribution of the above four categories of product innovation is shown in Figure 2 for all industries. From this figure, the number of innovations is decreasing

generally from Type I to Type IV.

Table 2. Product innovation

		Vietnam		Indonesia		Philippines		Thailand		Total	
		Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Tried to introduce a new product in last 2 years	Yes	201	63	61	58.7	74	51.7	155	61.3	491	60
	No	118	37	43	41.3	69	48.3	98	38.7	328	40
	Total	319	100	104	100	143	100	253	100	819	100
Redesigning packaging or significantly changing appearance design	Achieved	114	35.7	7	6.7	50	35	96	37.9	267	32.6
	Tried	36	11.3	37	35.6	13	9.1	53	20.9	139	17
	Not tried yet	169	53	60	57.7	80	55.9	104	41.1	413	50.4
	Total	319	100	104	100	143	100	253	100	819	100
Introduced a new product, significantly improving existing products	Achieved	154	48.3	10	9.6	46	32.2	89	35.2	299	36.5
	Tried	25	7.8	39	37.5	21	14.7	62	24.5	147	17.9
	Not tried yet	140	43.9	55	52.9	76	53.1	102	40.3	373	45.5
	Total	319	100	104	100	143	100	253	100	819	100
Development of a totally new product based on the “existing” technologies	Achieved	79	24.8	15	14.4	44	30.8	82	32.5	220	26.9
	Tried	30	9.4	34	32.7	17	11.9	64	25.4	145	17.7
	Not tried yet	210	65.8	55	52.9	82	57.3	106	42.1	453	55.4
	Total	319	100	104	100	143	100	252	100	818	100
New product based on new technologies	Achieved	24	7.5	12	11.5	32	22.4	58	23.3	126	15.5
	Tried	70	21.9	25	24	19	13.3	75	30.1	189	23.2
	Not tried yet	225	70.5	67	64.4	92	64.3	116	46.6	500	61.3
	Total	319	100	104	100	143	100	249	100	815	100

Source: Authors.

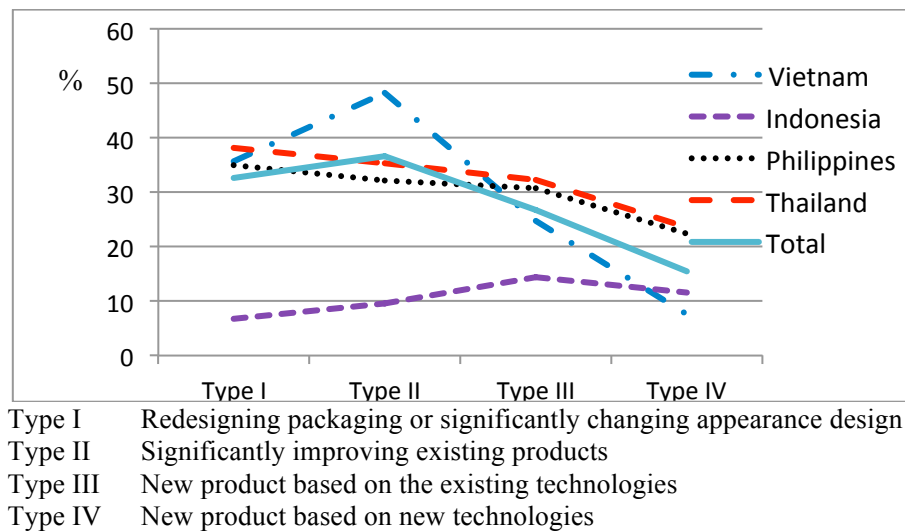


Figure 2: Product innovation

4.7 Process innovation

The status of process innovation is shown in Table 3. Process innovation in this study is primarily related to cost saving, reducing input, promoting product quality, and upgrading from subcontracting to own manufacturing. The most successful innovation is found in categories such as “decreased production of defective products,” “reduced delivery delays,” and “reduced variation in product quality.”

Table 3. Process innovation

	Vietnam		Indonesia		Philippines		Thailand		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Decreased production of defective products	252	79.0	93	89.4	108	75.5	190	77.9	643	79.4
Reduced raw materials and energy usage	269	84.3	52	50.0	72	50.3	147	60.5	540	66.7
Reduced labor input (man-hour)	203	63.6	40	38.5	70	49.0	89	36.5	402	49.6
Secured a new source of intermediate goods	152	47.6	60	57.7	83	58.0	142	59.9	437	54.4
Substituted subcontract of intermediate goods for self-manufacture	191	59.9	37	35.6	46	32.2	103	43.5	377	46.9
Reduced delivery delay	207	64.9	96	92.3	123	86.0	209	85.7	635	78.4
Reduced prices of your main products	139	43.6	27	26.0	68	47.6	106	43.4	340	42.0
Reduced variation in product quality.	249	78.1	48	46.2	76	53.1	200	82.0	573	70.7

Note: *multiple answers.

Source: Authors.

5. SEM and latent variables

5.1 Internal capability

Internal capability, which plays an essential role for creating innovation, was assumed to consist of the following factors: (1) Capital goods, (2) Organization learning, and (3) ICT use. In what follows, let us explain how these are constructed one by one.

(1) Capital goods

This variable is based on the following questions, which aimed to ask about the standard of equipment:

E. Capital goods (Key machinery, Equipment, Molds, Jigs, etc. for your main products)

Q25. Has your establishment achieved the following in the last 2 years (2011 and 2012)?

Q25.1. In-house modification of existing capital goods

- Q25.2. In-house design of capital goods
- Q25.3. Collaboration with capital goods producers to customize standard machines
- Q25.4. Co-development of new capital goods with capital goods producers
- Q25.5. Co-development of new capital goods with universities or public research institutions
- Q25.6. Introduction of new software for production methods
- Q25.7. Increased degree of automation in the production process

Capital goods consist of two composite variables, such as in-house arrangements and development by collaboration with agents outside the firm, depending upon whether they can develop capital goods themselves. The former consists of questions Q25. 1, Q25.2, Q25.6 and Q25.7, while the latter Q25.3, Q25.4 and Q25.5. The values of these two variables are determined by the number of Yes answers and thus the former has a value from 0 to 4, while the latter from 0 to 3.

(2) Organization learning

This latent variable is constructed by questions related to QC and cross-functional teams. These two questions indicate whether and how much knowledge management or learning process has been established in the firm. The former is based on Q22 and the latter on Q21. The score of the two variables is determined by the number of Yes answers to each question.

Q22. Quality Control (QC) and delivery management

- Q22.2.** Does your establishment operate a QC circle?
- Q22.3.** Does your establishment have a system/practice to disseminate successful experiences of a QC circle group across your establishment?
- Q22.4.** Does your establishment have a system/practice to learn from successful experiences of a QC circle group of your customers/suppliers?
- Q22.5.** Does your establishment have a system/practice to share successful experiences of a QC circle group of your establishment with your customers/suppliers?

Q21. Cross-functional teams for introduction of new products: Which departments / who are involved in the cross-functional teams that your establishment organizes to introduce a new product?

- Market Research
- Research

Development
Sales & Marketing

Again QC and Cross-functional teams have five points from 0 to 4. Organization learning thus consists of these two observed variables.

(3) ICT use

This latent variable consists of internal use of ICT and external use of ICT, and the former relates to ICT use inside the firm, while the latter relates to collaboration with agents outside the firm. The related questions are in Q30 as shown below.

F. Information technology and management

Q30. Has your established introduced the following IT systems?

Internal ICT use

Enterprise Resources Planning (ERP)
Groupware
Computer Aided Design (CAD)/ Computer Aided Manufacturing (CAM)
Intra-Social Networking Services (SNS)

External ICT use

Business-to-Business Electronic commerce (B2B E-commerce)
Business to Consumer (B2C) E-commerce
Supply Chain Management (SCM)
Public SNS

The variables of internal and external use of ICT have five points from 0 to 4. ICT use is thus based on these two variables.

5.2 External linkages

The questions related to external linkages are shown in Q23 consisting of the following organizations:

D: External Sources of new technology and information for upgrading and innovation

Q23. Which external source is the most important for upgrading/innovation?

Q23.1. Final consumer

Q23.2. Competitor

- Q23.3.** Buyer or trading company
Q23.4. Consultant
Q23.5. Local customer (100% local capital)
Q23.6. Local supplier
Q23.7. MNC (100% non-local capital)/Joint Venture (JV) customer located in your country
Q23.8. MNC/JV supplier located in your country
Q23.9. MNC/JV customer located in a foreign country
Q23.10. MNC/JV supplier located in a foreign country
Q23.11. Public organizations (government, public agency, public financial institution)
Q23.12. Local business organizations
Q23.13. University or Public Research Institute

Firms were asked to reply according to the Likert Four scale such as “0. Not practicing,” “1. Not important,” “2. Not very important,” “3. Somewhat important,” and “4. Very important.” The maximum likelihood and Promax rotation were employed to identify the factors. The result of the factor analysis is shown in Table 4. The following three factors were identified and they are called (1) Local firms; (2) MNCs; and (3) Public organizations & universities.

Table 4. Result of Factor analysis

	Common factors		
	Local firms	MNCs	Public organizations and universities
Q23.5. Local customer (100% local capital)	0.775	-0.064	-0.082
Q23.6. Local supplier	0.481	0.064	0.034
Q23.2. Competitor	0.471	-0.004	0.151
Q23.1. Final consumer	0.451	0.027	0.139
Q23.9. MNC/JV customer located in a foreign country	-0.165	0.867	0.072
Q23.10. MNC/JV supplier located in a foreign country	-0.126	0.821	0.115
Q23.8. MNC/JV supplier located in Vietnam	0.088	0.765	-0.003
Q23.7. MNC (100% non-local capital)/Joint Venture (JV) customer located in your country	0.258	0.747	-0.205
Q23.13. University or Public Research Institute	-0.043	-0.066	0.833
Q23.12. Local business organization	0.228	0.019	0.605
Q23.11. Public organization (government, public agency, public financial institution)	0.057	0.079	0.558
Factor Correlation Matrix			
1	0.185	1	0.408

2	1	0.185	0.366
3	0.366	0.408	1

6. Results of the estimations

6.1 Path diagram

Since the factor analysis discussed in the previous section shows the correlation among the latent variables, in the following detailed path diagram the arrows move in both directions (Figure 3) and a simplified diagram is shown in Figure 4.

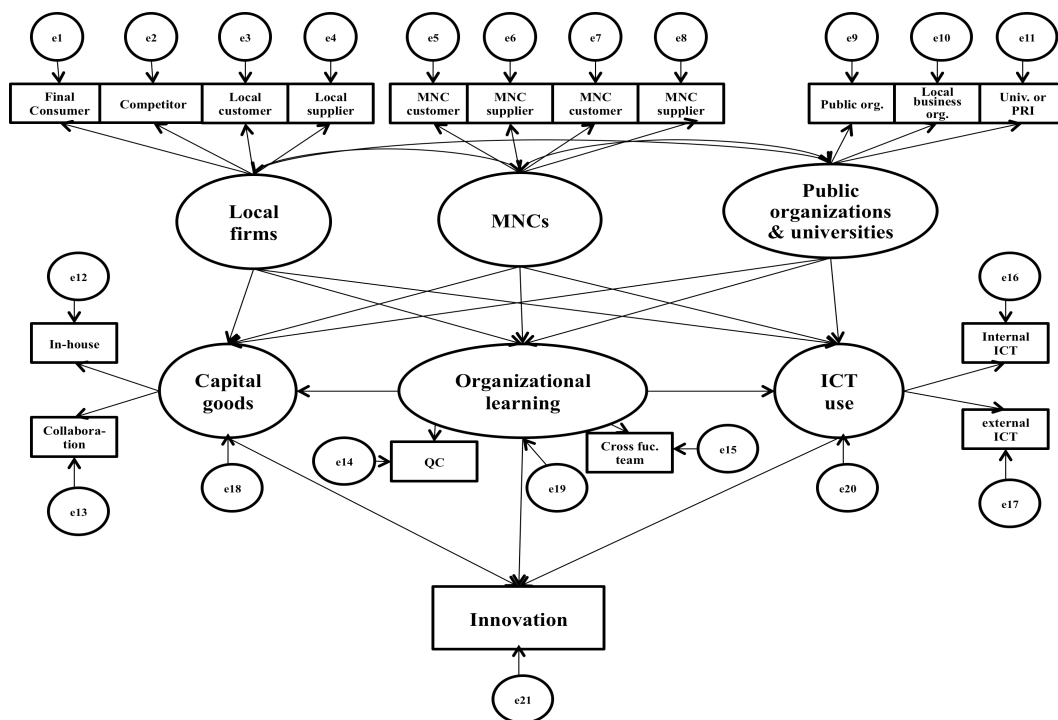


Figure 3: Detailed path diagram

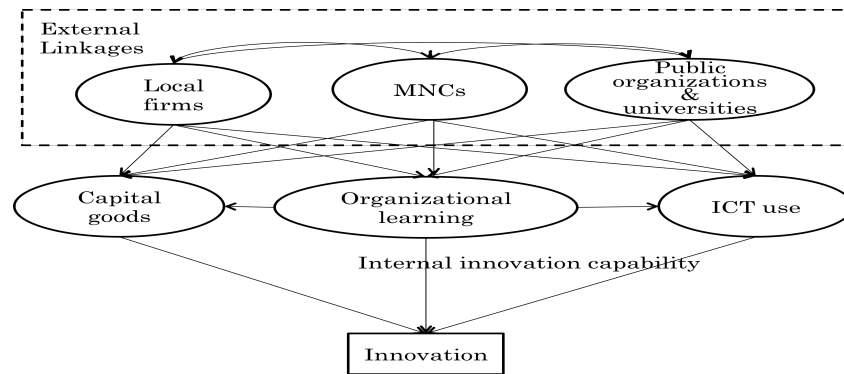


Figure 4: Simplified path diagram

6.2 Fitness of the model

Tables 5 and 6 indicate the fitness of the two SEM models for product and process innovation. GFI (Goodness of Fit Index) and AGFI (Adjusted Goodness of Fit Index) take the values between 0 and 1, which indicate the criteria of the explanatory power of the model. If $GFI \geq AGFI$ and both indices are 0.9 or more, the model can be judged as a good fit. The CFI (Comparative Fit Index) evaluates the model in terms of goodness-of-fit, which indicates how much the model has improved in comparison with the independent model estimated under the assumption that there is no correlation among the observed variables. It takes the values from 0 to 1, and the model is judged as being a good fit if the CFI is 0.9 or more. Moreover, the RMSEA (Root Mean Square Error of Approximation) is an index that expresses the divergence between the estimated and actual distribution of the model expressed in terms of the amount of degree of freedom. The model can be judged as a good fit if it is 0.05 or less. The values of these indices for product innovation show values such as GFI (0.945 \geq 0.9), AGFI (0.911 \geq 0.9), CFI (0.941 \geq 0.9), RMSEA (0.032 \leq 0.05). The values of these indices for process innovation have values such as GFI (0.950 \geq 0.9), AGFI (0.915 \geq 0.9), CFI (0.946 \geq 0.9), RMSEA (0.031 \leq 0.05). Thus these tests do show that the goodness-of-fit of the two models is high.

Table 5. Fitness of model (Product innovation)

χ^2 value	Degree of freedom	p value	GFI	AGFI	CFI	RMSEA	AIC
882.063	318	0	0.944	0.909	0.939	0.033	1272.063

Table 6. Fitness of model (Process innovation)

χ^2 value	Degree of freedom	p value	GFI	AGFI	CFI	RMSEA	AIC
811.905	303	0	0.949	0.913	0.946	0.032	1231.905

Table 7. Result of SEM: product innovation

From	To	Standardizing Coefficient	SE	Test statistic	<i>p</i> value
Local firms	Final consumer	0.680			
Local firms	Competitor	0.719	0.077	12.844	0.000***
Local firms	Local customer (100% local capital)	0.505	0.078	11.06	0.000***
Local firms	Local supplier	0.472	0.065	10.284	0.000***
MNCs	MNC (100% non-local capital)/Joint Venture (JV) customer located in your country	0.633			
MNCs	MNC/JV supplier located in your country	0.710	0.044	23.157	0.000***
MNCs	MNC/JV customer located in a foreign country	0.887	0.07	19.712	0.000***
MNCs	MNC/JV supplier located in a foreign country	0.869	0.065	19.564	0.000***
Public organizations & universities	Public organization (government, public agency, public financial institution)	0.679			
Public organizations & universities	Local business organization	0.753	0.063	16.265	0.000***
Public organizations & universities	University or Public Research Institute	0.727	0.068	16.196	0.000***
Capital goods	In-house	0.851			
Capital goods	Collaboration	0.754	0.045	13.557	0.000***
Organizational learning	Quality Control	0.459			
Organizational learning	Cross-functional team	0.554	0.097	7.104	0.000***
ICT use	Internal ICT use	0.578			
ICT use	External ICT use	0.531	0.116	8.454	0.000***
Public organizations & universities	Organizational learning	0.113	0.075	1.293	0.196
MNCs	Organizational learning	0.172	0.057	2.545	0.011**
Local firms	Organizational learning	0.083	0.079	1.065	0.287
Public organizations & universities	ICT use	-0.163	0.06	-1.807	0.071*
MNCs	ICT use	0.224	0.048	3.066	0.002***
Local firms	ICT use	0.033	0.064	0.402	0.688
Public organizations & universities	Capital goods	0.096	0.092	1.462	0.144
MNCs	Capital goods	-0.005	0.072	-0.098	0.922
Local firms	Capital goods	-0.018	0.098	-0.293	0.769
Organizational learning	Capital goods	0.525	0.137	6.203	0.000***
Organizational learning	ICT use	0.592	0.092	4.992	0.000***
Capital goods	Product innovation	0.213	0.067	4.062	0.000***
ICT use	Product innovation	0.152	0.144	2.797	0.005***
Organizational learning	Product innovation	0.266	0.154	3.542	0.000***

Note 1: ***, ** and * indicate levels of significance of 1%, 5%, and 10%, respectively.

Note 2: *P* value of “from local firms to final consumer,” “from MNCs to MNC (100% non-local capital)/Joint Venture (JV) customer located in your country,” “from public organizations & universities to public organization (government, public agency, public financial institution),” “from capital goods to in-house,” “from organizational learning to quality control,” and “from ICT use to internal ICT use” cannot be calculated, since these path coefficients are fixed to 1.

Source: authors

6.3 Result of product innovation

We conducted SEM regarding product and process innovation. Firstly, the results for product innovation are presented. The result is summarized in Table 7, and the following results were obtained: (i) MNCs promote Organization learning and ICT use; (ii) Organization learning enhances Capital goods as well as ICT use; (iii) Organization learning, Capital goods, and ICT use enhance product innovation. The path diagram is shown in Figures 5.

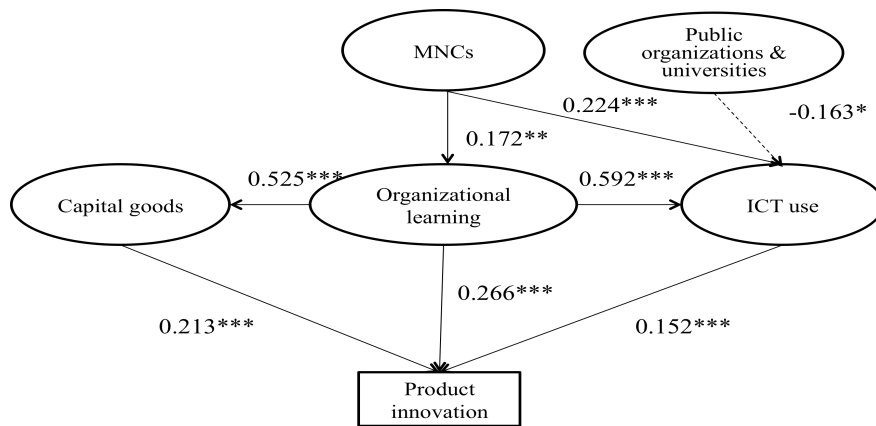


Figure 5. Result of SEM: Product innovation

6.4 Result of process innovation

Secondly, the results for process innovation are summarized. They are summarized in Table 8, and the following results obtained: (i) MNCs promote ICT use; (ii) Public organizations and universities enhance organization learning and Capital goods, but they provide a negative effect for ICT use; (iii) Organization learning promotes Capital goods and ICT use; and (iv) Capital goods and ICT use promote process innovation. The path diagram is shown in Figure 6, respectively.

Table 8. Result of SEM: Process innovation

From	To	Standardizing Coefficient	SE	Test statistic	p value
Local firms	Final consumer	0.678			
Local firms	Competitor	0.723	0.078	12.766	0.000***
Local firms	Local customer (100% local capital)	0.503	0.078	11.027	0.000***
Local firms	Local supplier	0.467	0.066	10.2	0.000***
MNCs	MNC (100% non-local capital)/Joint Venture (JV) customer located in your country	0.633			
MNCs	MNC/JV supplier located in your country	0.708	0.044	23.205	0.000***
MNCs	MNC/JV customer located in a foreign country	0.883	0.069	19.758	0.000***
MNCs	MNC/JV supplier located in a foreign country	0.877	0.065	19.728	0.000***
Public organizations & universities	Public organization (government, public agency, public financial institution)	0.685			
Public organizations & universities	Local business organization	0.745	0.061	16.538	0.000***
Public organizations & universities	University or public research institute	0.745	0.068	16.572	0.000***
Capital goods	In-house	0.792			
Capital goods	Collaboration	0.813	0.055	12.922	0.000***
Organizational learning	Quality Control	0.564			
Organizational learning	Cross-functional team	0.46	0.074	6.341	0.000***
ICT use	Internal ICT use	0.585			
ICT use	External ICT use	0.543	0.123	8.019	0.000***
Public organizations & universities	Organizational learning	0.164	0.091	1.896	0.058*
MNCs	Organizational learning	0.096	0.069	1.447	0.148
Local firms	Organizational learning	0.106	0.096	1.368	0.171
Public organizations & universities	ICT use	-0.229	0.06	-2.547	0.011**
MNCs	ICT use	0.314	0.048	4.335	0.000***
Local firms	ICT use	0.025	0.064	0.313	0.754
Public organizations & universities	Capital goods	0.071	0.084	1.095	0.273
MNCs	Capital goods	0.054	0.066	1.042	0.297
Local firms	Capital goods	-0.023	0.091	-0.382	0.702
Organizational learning	Capital goods	0.53	0.115	5.667	0.000***
Organizational learning	ICT use	0.525	0.074	4.537	0.000***
Capital goods	Process innovation	0.185	0.044	3.445	0.000***
ICT use	Process innovation	0.292	0.087	5.298	0.000***
Organizational learning	Process innovation	-0.018	0.062	-0.296	0.768

Note 1: ***, ** and * indicate levels of significance of 1%, 5%, and 10%, respectively.

Note 2: P value of “from local firms to final consumer,” “from MNCs to MNC (100% non-local capital)/Joint Venture (JV) customer located in your country,” “from public organizations & universities to public organization (government, public agency, public financial institution),” “from capital goods to in-house,” “from organizational learning to quality control,” and “from ICT use to internal ICT use” cannot be calculated, since these path coefficients are fixed to 1.

Source: author

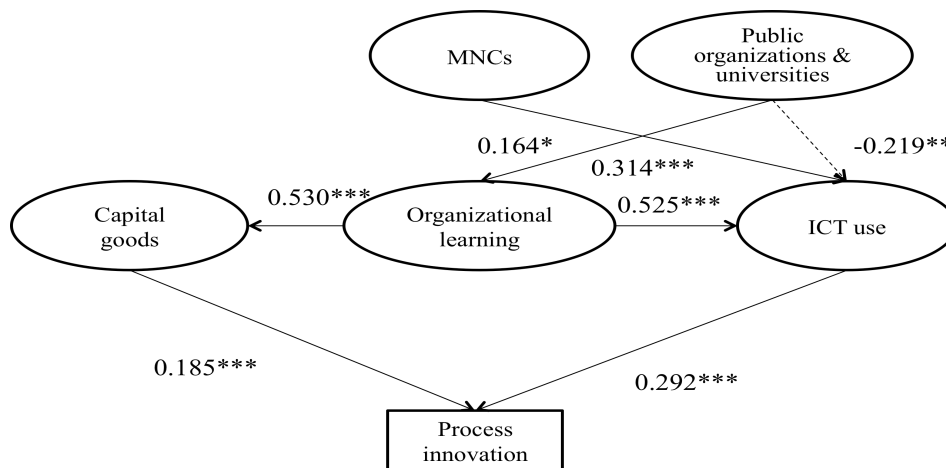


Figure 6. Result of SEM: Process innovation

6.5 Discussions on the results of the pass analysis

Product innovation can be explained by all latent variables except the path from “MNCs” to “capital goods.” Most significant levels are smaller than 5%. The hypotheses postulated in this study have been demonstrated. Regarding process innovation, the path from “organizational learning” to process innovation becomes not significant, while the latent variable of “public organizations & universities” affects “organizational learning” significantly, but the path from “public organizations & universities” to ICT use is negatively significant, although this does not coincide with the reality. In addition, the path from “MNCs” to “organizational learning” becomes not significant, which does not fit reality either. From these findings, further analyses are required to improve the estimation results.

7. Conclusions

This study examines innovation activity in four economies in ASEAN based on mail/phone surveys. In order to examine their potential, basic research on their internal innovation capability, external linkages to promote innovation, or how they are integrated into the global supply chain constructed by MNCs, for example, is required. For this purposes, a rigorous statistical method such as SEM should be employed to

obtain the correct results. We postulate the theory that external linkages promote internal capability and then finally enhance innovation. The results obtained indicate that MNCs affect organization learning, which enhances capital goods and ICT use, and then all these three factors that construct internal capability can also promote product innovation.

The limitations in this study are the same as the limitations of SEM, that is, SEM is a good tool to examine a hypothesis, but it is not necessarily good at finding the reasons for issues or establishing a policy to solve them. Thus we need to combine various research methods by further analysis.

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