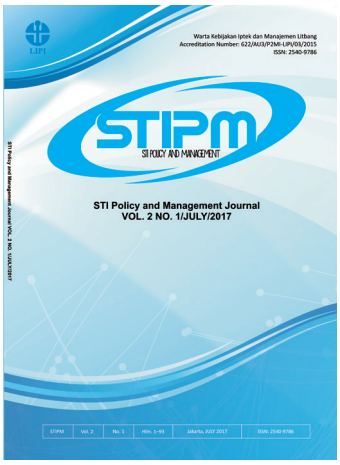

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Innovation Process of Natural Resource–based Firms in Four ASEAN Economies: A SEM Approach

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JOURNAL OF SCIENCE, TECHNOLOGY AND INNOVATION POLICY AND MANAGEMENT (STIPM JOURNAL), Volume 02, Number 01, July 2017

FOREWORD by EDITOR-in-CHIEF

We are very pleased to inform readers that *Journal of Science, Technology and Innovation Policy and Management* (STIPM Journal) Vol. 2, No. 1, July 2017 is now ready for public reading.

The STIPM Journal is an online research journal managed by the Center for Science and Technology Development Studies at the Indonesian Institute of Sciences (PAPPIPTEK-LIPI). As a peer-reviewed journal, the STIPM Journal provides free access to research thoughts, innovation, and original discoveries mostly aimed at scholars.

In this edition, the STIPM Journal contains six articles dealing with science, technology and innovation policy and management written by scholars from Japan, Australia, and Indonesia.

The first article is entitled "Innovation Process of Natural Resource-based Firms in Four ASEAN Economies: A SEM Approach" by Masatsugu Tsuji, Hiroki Idota, Yasushi Ueki, and Teruyuki Bunno. Using a structural equation model (SEM), this paper discusses the innovation process in natural resource-based industries in Vietnam, Indonesia, the Philippines, and Thailand in comparison to other assembling and processing industries by focusing how factors affect product as well as process innovation.

The second article is written by Noel Taylor-Moore, entitled "The Innovative Policy Options for Coastal Fisheries Economic Development: A Case of Kwandang Bay Coastal Ecosystem". This article uses a policy innovation framework in the context of STI inputs and a multi-level perspective (MLP), selects a potential site in which a fisheries economic development hub would be implemented, and performs a SWOT analysis of the selected site as a hub.

Erman Aminullah, Trina Fizzanty, Karlina Sari, Rizka Rahmaida, and Qinan M. B. Soesanto present the third article, "Interactive Learning for Upgrading and Growth: Case of Indonesian Fishery Firms." This article discusses an interactive learning model for upgrading and growth in Indonesian fishery firms using the case of fish processing and aquaculture (shrimp). The model suggests that the dynamics of upgrading and growth through interactive learning will be able to continue in a stable manner as constraints from limiting elements are eased through: combating illegal fishing; encouraging interaction with universities; shifting to higher added-value products; increasing institutional support for global trading; preventing shrimp diseases; and providing infrastructure, business facilities, and regulation information.

The fourth article, entitled "Developing the Marine and Fisheries Industry in Pangandaran using a Bioecoregion-based Technopark Framework", is written by Atikah Nurhayati and Agus H. Purnomo. This article discusses how to establish a marine and fisheries technopark in Pangandaran. By using gap and SWOT analysis, it was found that particular recommendations for improvement should be made,

the existing bioecoregional environment and development variables in Pangandaran would support the development of a marine and fisheries technopark.

The fifth article, entitled "Development of National Technology Audit Policy", is presented by Subiyanto. This article discusses the concept of a national technology auditing policy, particularly with regard to infrastructure requirements, and with emphasis on technical regulation effectiveness and implementation tool readiness. This article discusses setting a policy agenda by discussing the governance aspect of national technology auditing.

The final article is written by Anugerah Yuka Asmara and Toshio Mitsufuji with the title "Photovoltaic Development from the New Order Era to the Reform Era in Indonesia: From a Technological Innovation System Perspective". This article discusses the phenomena of PV development between the New Order era and the Reform era using a technological innovation system (TIS) approach. This paper concludes that PV projects and technology could not be developed en masse without intervention from the government in both the New Order era and the Reform era.

We also would like to thank the authors, editors, and reviewers who have worked very hard for this edition. We hope that all the articles featured in this edition proves useful to the reader.

Jakarta, 16 July 2017

Editor-in-Chief

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Innovation Process of Natural Resource–based Firms in Four ASEAN Economies: A SEM Approach

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ABSTRACT

This paper focuses on natural resource-based firms in four ASEAN economies: Vietnam, Indonesia, the Philippines, and Thailand. These countries have relative advantages in natural resource-based industries, since they are affluent in resources and have been making use of them in their export and growth strategies. In this study, the innovation process in natural resource-based industries in these countries are examined in comparison with other assembling and processing industries by focusing factors that enhance product as well as process innovation. Those are summarized as i) technology; ii) organizational learning; including quality control (QC) and cross-functional teams; iii) information, communications technology (ICT) use; and iv) external linkages, such as MNCs, universities, local and public organizations, and universities. This study employs structural equation model (SEM) in order to analyze the causal relationships not only among above four latent variables. but also between these and innovations.

I. INTRODUCTION

East Asian economies need to transform from being the production base of the world into knowledge-based economies. To achieve this goal, firms there have to achieve innovation by enhancing their innovation capability. The innovation process has been analyzed extensively, identifying factors promoting innovation such as R&D, technology, managerial organization, human factors, and ICT use to create innovation (Tidd, Bessant, & Pavitt, 2001; Christensen & Kaufman, 2009; Idota, Ueki, Shigeno, Bunno, & Tsuji, 2016). Since most of new information is

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obtained outside the firm (Chesbrough, 2006a), collaborations with outside organizations, such as multinational corporations (MNCs), universities, public research organizations, other local firms, and so on are indispensable for local firms in developing economies.

In previous papers (Tsuji, Akematsu, & Ueki, 2011a; Tsuji, Minetaki, & Akematsu, 2011b; Tsuji, Akematsu, Ueki, & Idota, 2012; Tsuji, Idota, Ueki, Bunno, & Shigeno, 2016), the innovation process of ASEAN four economies has been extensively analyzed focusing on the following research questions: i) contents of internal capability; ii) how internal capability promotes innovation; iii) external linkages from which local firms obtain new information; and iv) how external linkages enhance internal capability and innovation of local firms. The main findings of these studies, which are related to the relationship between internal capability and external linkages, are summarized as follows i) external linkages promotes internal capability, but affects innovation less directly; ii) the transmission channels of information from external linkages to internal capability consist of transaction and research channels; and iii) local firms obtain more information related to innovation via the transaction than the research channels (Tsuji et al., 2011a, 2011b, 2012, 2016). It should be noted that these findings are observed mainly in the processing industries, including the automotive or electronic industries, because MNCs have been establishing factories and local headquarters in those countries and the relationship between MNCs and local firms in technology transfer or knowledge transfer in the broader sense attracted the writers' interest. In this study, on the other hand, the natural resource-based industries such as rubber, iron, food, wood, paper and non-ferrous metals are selected as targets. Although promotion of high-tech manufacturing has attracted people's interests, primary commodities and natural resource-based products are still important as exports for many ASEAN countries. Little attention has been paid to the natural resource-based industries for identifying relationships between MNCs and local firms in the context of entrepreneurship, technology, and network.

Accordingly, this study aims to answer: i) how the innovation process in the natural resource-based industries differs from those of automotive and electronics; ii) whether knowledge is being transferred from leading MNCs to local firms through production networks; iii) how technologies, including management practices, achieve product and process development in the natural resource–based industries.

II. BACKGROUND LITERATURE

In this section, some relevant literature related to innovation process was looked into to provide a background to the study. Innovation capability consists of various factors, which are listed as audit tools for measuring innovation capability, while related factors are categorized into groups. Mariano and Pilar (2005, pp. 1141–1157), for example, categorize those factors as follows: i) communication with the external environment; ii) level of know-how and experience within the organization; iii) diversity and overlaps in the knowledge structure; and iv) strategic positioning. The causality among these categories is one of the major research questions in this area, identifying which are causes and which are effects (Lawson & Samson, 2001; Perdomo-Ortiza, Benitob & Galendeb, 2009). In order to demonstrate causality, different methodologies, such as regression analysis, covariance structure analysis, and structural equation model, are employed. This paper defines internal innovation capability, or internal capability for short, as an integrated ability of a firm to create innovation that consists of all resources, core competence, or competitiveness. In a more detailed fashion, internal capability includes the technological level, such as the number of patents; production and R&D facilities; human resources, such as the number of engineers with higher degrees or skills; the level of craftsmanship; work ethics; and organizational nature, such as communication between workers and top management, speed of decision-making, and leadership of 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) and Zahra and George (2002). It is defined as a firm's ability to reorganize the value of new external knowledge, assimilate to commercial ends. They also recognize that the innovation process is a learning process which consists of four dimensions: acquisition, assimilation, transformation, and exploitation (Zahra and George, 2002). Therefore, absorptive capability determines the competitive advantage of a firm (Barney, 1991).

Another source of innovation is to make use of factors outside the firm and utilize them to promote internal capability. New information related to innovation is fundamentally obtained outside the firm, and the literature mentioned above is more or less analyzing this phenomenon. Collaboration with entities outside the firm such as other firms, universities, and local research institutions in the innovation process came to be the center of research and was analyzed in the framework of "open innovation" (Chesbrough, 2003, 2006a, 2006b). The concept of open innovation process is developed in accordance with the growth of the assembling and processing industry, which deals with numerous parts and components such as the automotive or electronics industries. There are two strategies for obtaining information–one is through transactions with other firms, from suppliers to customers, while the other is through collaboration with research institutions (Kagami, Giovannetti & Tsuji, 2007).

The above literature focuses on how innovation capability is formed and how it contributes to final outcomes of innovation. The arguments are not limited only to the innovation process in the developed economies, but are also applicable to the developing economies. Firms in developing economies have their own problems: weak basis for internal capability particularly due to lack of technology, human resources and knowledge infrastructure. Strategies used by firms or governments in developing economies are different from those in developed economies. In the literature on the innovation process or internal capability relating to developing economies, Ernest (2002) emphasizes blending diverse international and domestic sources of knowledge and making use of international linkages. Kesidoua and Szirmai (2008) also specify two types of knowledge spillover in the Uruguay software industry, i.e. local and international; 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 enhances innovation in developing economies.

Based on the above literature, this paper attempts to identify internal capability, which includes technological level, human resources, and organizational culture nature such as communication between workers and top management, speed of decision-making, and leadership of top management. In addition to this, this paper emphasizes agents outside the firm which promote internal capability, that is, transaction and knowledge channels (Tsuji & Miyahara, 2010, 2011). The former is to transfer information from agents via transactions or supply chain (Pietrobelli & 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 of individual firms and external factors, when assimilated, enhance internal capability so that companies can create their own new products, services, technologies, and ideas.

III. HYPOTHESES AND METHODOLOGY: STRUCTURAL EQUATION MODEL (SEM)

A. Hypotheses

This paper focuses on the natural resource-based firms in four ASEAN economies: Vietnam, Indonesia, the Philippines, and Thailand. These countries have relative advantages in the natural resource-based industries, since they are affluent in resources and have been making use of them for their export and growth strategies. In previous studies, the innovation process in these economies was analyzed; in this study, particularly, the innovation process in the natural resource-based industries in these countries is examined. In other words, the factors analyzed were those extracted as important in the writers' previous studies, including in enhancing product as well

as process innovation. These factors are summarized as R&D capability, organization culture or managerial organization including quality control (QC), cross functional team, and human resources. The following five hypotheses were postulated to be examined in this study based on the writers' previous studies:

- (H1) External linkage promotes innovation
- (H2) External linkage enhances organizational learning
- (H3) External linkage improves capital goods
- (H4) External linkage improves ICT use
- (H5) Organizational learning improves capital goods
- (H6) Organizational learning improves ICT use
- (H7) Organizational learning promotes innovation
- (H8) Capital goods promote innovation
- (H9) ICT use promotes innovation

These hypotheses are examined in the natural resource-based industries in comparison with the processing industries, which were the focus of many previous studies. The relationships among the above variables are summarized in Fig. 1.

B. Methodology

This study employs structural equation model (SEM) or covariance structural analysis (CSA) which enables an examination 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. SEM analysis thus can be used even for cases in which variables are endogenous and usual least squares cannot be applied. The idea of SEM was proposed as CSA by Bock (1960) at the beginning and developed by Bock and Bargmann (1966) in order to solve issues related to multivariate analysis. Later, Bagozzi (1980) and Bollenn (1989) termed it SEM.

The merits of SEM are summarized as follows: regression analysis, which enables the causal relationship between variables, can handle only observed variables, that is, endogenous variables which are referred to as "latent variable" 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 these issues, which are related to factor and regression analysis, and integrate these two methods. In other words, SEM introduces latent variables, which are not observable, and thus by fixing the causal relationship between latent and observed variables, it statistically examines social as well as natural phenomena.

IV. SUMMARY OF DATA AND INNOVATION

A. Surveys conducted

This study is based on mail surveys and phone interviews conducted on firms in four ASEAN economies: Vietnam, Indonesia, the Philippines,

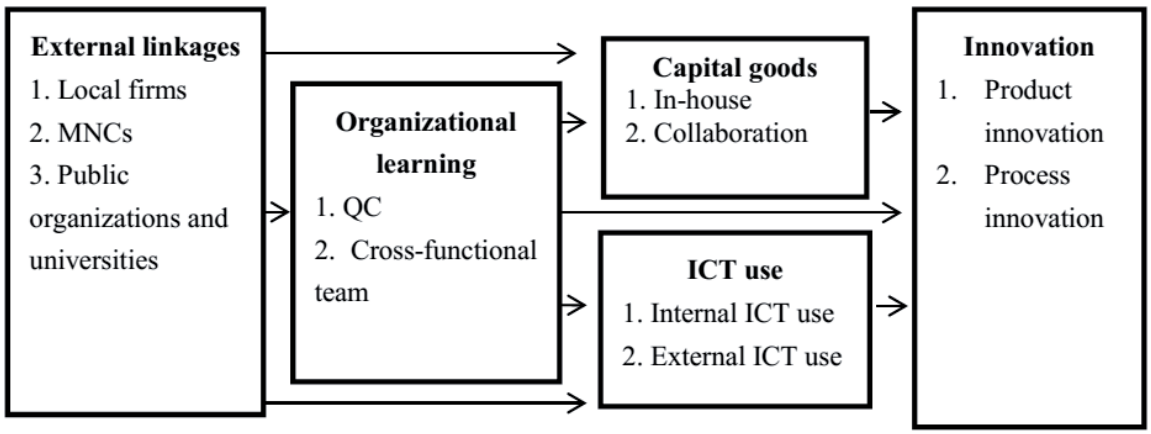


Figure 1. Causal relationships

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

B. Definition of natural resource-based industries

From the questions in this survey, the natural resource-based industries consist of: i) food, beverages, and tobacco; ii) wood and wood products; and iii) paper, paper products, and printing, while other industries are categorized as "others" and mainly consist of processing industries. Usually, industries such as rubber products, iron, metals, non-ferrous metals and so on are considered natural resource-based, but in this survey, the questions relating to these industries asked about processed products and thus these are categorized as "others (processing)". The number of sample firms analyzed in this study was 105, which are natural resource-based, 714 in other industries, and 819 in total as shown in Table 1.

12.9% of total respondent (firms) belongs to the natural resource-based industries. Indonesia has the largest number of firms in the natural resource-based industries, amounting to 20.2%, while Thailand has 15%. The percentage of Vietnam is the lowest at 9.1%, since Vietnam was the last of these economies to accept foreign direct investment (FDI) and its industries are concentrated in "others", including electronics and components; machinery, equipment and tools; and plastic and rubber products, as Table 1 shows.

C. Product innovation

1. General attempt

The situation of innovation in each economy is presented and used to explain variables in the analysis. The number of trials in the creation of new products, or product innovation, conducted from 2011–2012 in each economy are as follows: Vietnam conducted the largest number (63.0%), followed by Thailand (61.0%), Indonesia (58.7%), and the Philippines (51.7%). 57.1% of the natural resource-based industries actually tried product innovation, while 60.3% of other industries attempted it. In the former industry category, Indonesia showed the largest percentage at 71.4%, followed by Thailand (56.8%), Vietnam (55.2%), and the Philippines (44.4%). Excluding the Philippines, in each economy, more than half of the respondents attempted product innovation in the natural resource-based industries.

2. Redesigning packaging and appearance

This category of innovation has the least novelty, such as changing packaging and appearance. Responses show 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 the Philippines stays at 6.7%. The natural resource-based industries show better achievement in comparison with the other industries; that is, the former has 35.2%, while the latter 32.2%. In particular, Thailand (48.6%), Vietnam (41.4%) and the Philippines (33.3%) have more than one-third, but Indonesia has the lowest at 4.8%.

Table 1.
Types of industries by countries

Type of Industry	Vietnam		Indonesia		Philippines		Thailand		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Natural-resource-based industry	29	9.1	21	20.2	18	12.6	37	15.0	105	12.9
Others	290	90.9	83	79.8	125	87.4	216	85.4	714	87.2
All industries	319	100.0	104	100.0	143	100.0	246	100.0	819	100.0

Source: Authors

3. Improvement type of innovation

This innovation is categorized as a new product which significantly improves existing products, and the result of survey shows that more than half of firms in all industries attempted it; 36.6% of them achieved innovation. Vietnam (48.3%), Thailand (35.4%), and the Philippines (32.2%) show the better performance in achievement, while Indonesia stays on a low level at 9.6%. In the natural resource-based industries, the success rate is 34.3%, which is smaller than that of the other industries (36.9%). Among the economies, Thailand shows the highest success rate at 48.6%, followed by Vietnam (37.9%) and the Philippines (33.3%); Indonesia, on the other hand, has the lowest rate (4.8%).

4. New product based on the existing technologies

The development of new products based on existing technologies owned by firms has been attempted by slightly less than half of firms in all industries and in all economies; the average success rate is 26.8%. Among the economies, Thailand achieved the best (32.2%), the second being the Philippines (30.8%), followed by Vietnam (24.8%) and Indonesia (14.4%). Looking at data by industry category, there is no big difference between the natural resource-based and the other industries. Thailand has a better success rate in the former than the latter by about 10%, while Vietnam and the Philippines have the opposite, the difference being about 5%. There is no difference in Indonesia's case.

5. New product based on new technologies

This innovation is of the highest category, as it uses new technologies. In all industries and all economies, about 40% of firms attempted this type of innovation and only 15.5% of them achieved innovation. By economy, Thailand is ranked best in success rate (23.6%), followed by the Philippines (22.4%) and Indonesia (11.5%). Vietnam is ranked the lowest (7.5%). Natural resource-based industries have the same success rate as all industries. Among the economies, Thailand has the highest success rate (32.4%) as well as highest attempt rate (about 50%), and the Philippines shows the second highest rate (16.7%). The actual number of success is quite small: Thailand shows 12, the Philippines 3, Indonesia 1, and Vietnam 0. It should be noted that about 40% of firms attempted this type of innovation, but it did not necessarily lead to a better outcome.

The distribution of the above four categories of product innovation are shown in Fig. 2 for all industries and Fig. 3 for the natural resource-based industries. From these figures, the types of innovation are labeled from Type I to Type IV.

D. Process innovation

Process innovation in this study is primarily related to saving costs, reducing input, promoting product quality, and upgrading from subcontracting to own manufacturing. The most successful innovation is found in decreased production of defective products, reduced delivery delays, and reduced variation in product quality. These are similar in all industries and the natural resource-based industries, and more than 70% of firms responded with positive replies. The details of process innovation except the results are omitted here.

V. SEM AND LATENT VARIABLES

A. Internal capability

Internal capability which plays essential role for creating innovation was assumed to consist of the following factors in our previous reports: 1) technology, 2) managerial organization, and 3) human factor. In this study, however, due to the methodology of SEM, 1) capital goods, 2) organization learning and 3) ICT use were selected. In what follows, explaination on how these were constructed one by one.

1. Capital goods

This variable is based on the following questions which aim to ask about the level of their equipment:

E. Capital goods (key machineries, equipment, mold, 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

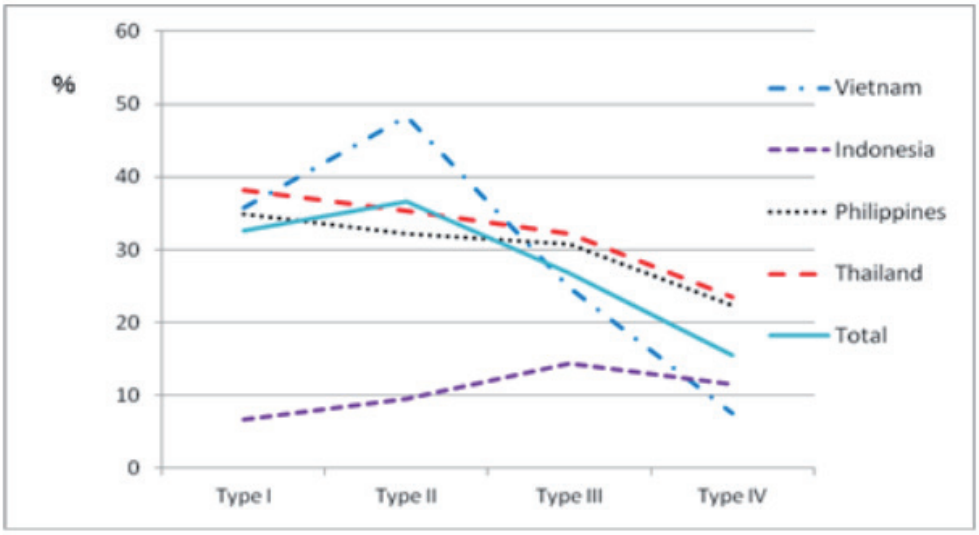
Q25.4. Co-development of new capital goods with capital goods producers

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 of production process

Capital goods consist of two composite variables, such as in-house arrangement and development by collaboration with agents outside the firm, depending on whether they can develop their capital goods by themselves. The former consists of questions Q25. 1, Q25.2, Q25.6 and



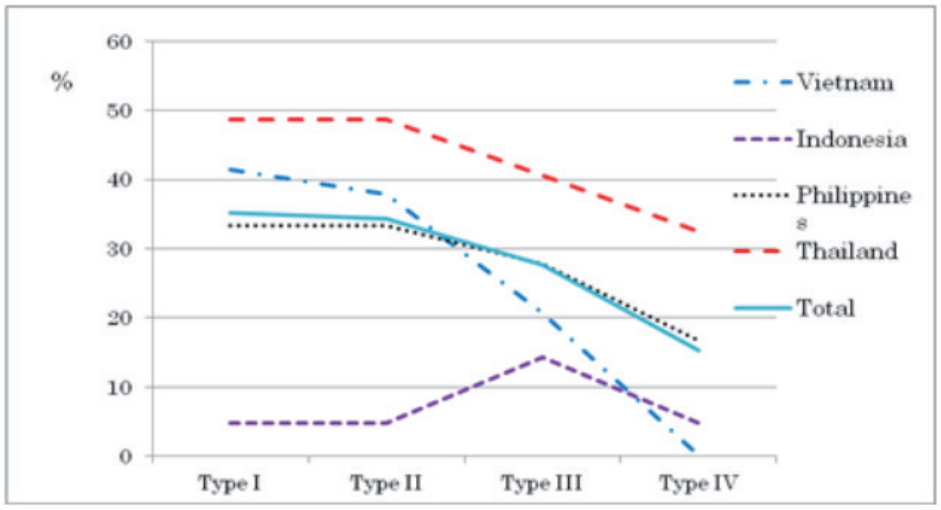
Type I Redesigning packaging or significantly changing appearance design

Type II Significantly improving existing products

Type III New product based on the existing technologies

Type IV New product based on new technologies

Figure 2. Product Innovation (All Industries)



Type I Redesigning packaging or significantly changing appearance design

Type II Significantly improving existing products

Type III New product based on the existing technologies

Type IV New product based on new technologies

Figure 3. Product Innovation (Natural Resource–Based Industry)

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' responses and thus the former variable has values 0 to 4, while the latter has 0 to 3.

2. Organization learning

This latent variable is constructed by questions related to QC and cross-functional team. These two questions indicate whether and how much knowledge management or learning process is established in the firm. The former is based on Q22 and the latter on Q21. The scores of two variables are determined by the number of 'yes' responses 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 customer/supplier?

Q22.5. Does your establishment have a system/practice to share successful experiences of a QC circle group of your establishment with your customer/supplier?

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

Market Research
Research
Development
Sales & Marketing

Again, the questions regarding QC and cross-functional teams operate on a five-point scale 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. The former relates to ICT use inside the firm, while the latter relates to collaboration with agents outside the firm. The related questions are Q30, which is shown below.

F. Information technology and management

Q30. Has your establishment introduced the following ICT 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 values, i.e. 0 to 4. ICT use is thus based on these two variables.

B. External linkages

The questions related to external linkages are shown in Q23 which consists of the following organizations:
D: External Sources of new technologies and information for Upgrading and Innovation

Q23. How important is the external source 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 organization (government, public agency, public financial institution)
Q23.12. Local business organization
Q23.13. University or Public Research Institute

Firms are asked to reply with Likert four-point scale, with the values of 0 = not practicing, 1 = not important, 2 = not very important, 3 =

Table 2.
Result of Factor Analysis

	Common factors		
	Local company	MNCs	University
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
Cronbach's α	0.872	0.676	0.745

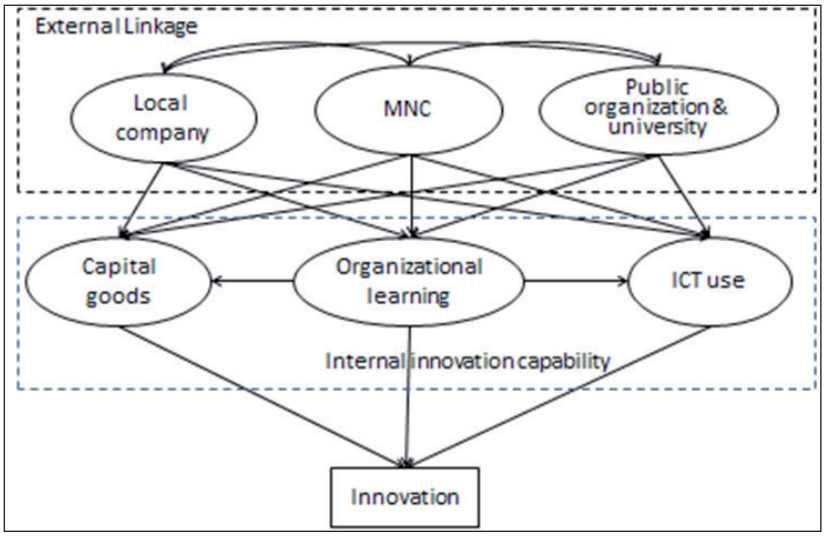


Figure 4. Path diagram

somewhat important, and 4 = very important. The maximum likelihood and Promax rotation are employed to induce factors. The results of factor analysis are shown in Table 2. Three factors are identified as 1) local firm; 2) MNCs; and 3) university[1].

[1] Cronbach's α is 0.676, which is rather low. In case of Explanatory Factor Analysis (EFA), it is acceptable if it is larger than 0.6 (Bagozzi, 1994), although it is generally required to be larger than 0.7.

VI. RESULTS OF ESTIMATIONS

A. Path diagram

Since the factor analysis discussed in the previous section shows correlation among the latent variables, in the following detailed path diagram, arrows go in both directions (Fig. 4).

B. Fitness of model

Table 3 indicates the fitness of SEM model of product. Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) take values between 0 and 1, which indicate criteria of the

explanatory power of the model. If GFI >= AGFI and the index is 0.9 or more, the model can be judged as proper. Comparative Fit Index (CFI) evaluates the model in terms of goodness-of-fit, which indicates how much the model is improved in comparison with the independent model estimated under the assumption that there is no correlation among the observed variables. It takes the value from 0 to 1, and the model is judged as being good fit if CFI is 0.9 or more. Moreover, Root Mean Square Error of Approximation (RMSEA) is an index that expresses the divergence between the estimated and actual distribution of the model expressed in terms of the amount a degree of freedom. The model can be judged as having good fitness if its RMSEA is 0.05 or less. The values of those indices of product innovation take the values such as follows: GFI (0.945 >= 0.9), AGFI (0.911 >= 0.9), CFI (0.941 >= 0.9), and RMSEA (0.032 <= 0.05). Furthermore, the values of those indices of process innovation take the values as follows: GFI (0.950 >= 0.9), AGFI (0.915 >= 0.9), CFI (0.946 >= 0.9), and RMSEA (0.031 <= 0.05). Therefore, these tests can show that the goodness-of-fit of the model is high.

C. Result of product innovation

We conducted SEM on the categories of all industries and natural resource-based industries regarding product and process innovations. First, the results on product innovation are presented and the path diagrams of all industries and the natural resource-based industries are indicated in Figs. 5 and 6 respectively. In all industries, the following results are obtained: i) MNCs promote organizational learning (H2) and ICT use (H4); ii) organizational learning enhances capital goods (H5) as well as ICT use (H6); iii) organizational learning, capital goods, and ICT use enhance product innovation (H7, H8, H9). Meanwhile in the natural resource-based industries, only path from MNCs via organization learning to product innovation is significant. Accordingly, H1 is demonstrated.

D. Result of process innovation

The path diagrams of all industries and the natural resource-based industries are depicted in Figs. 7 and 8, respectively. The results on process innovation in all industries are summarized as

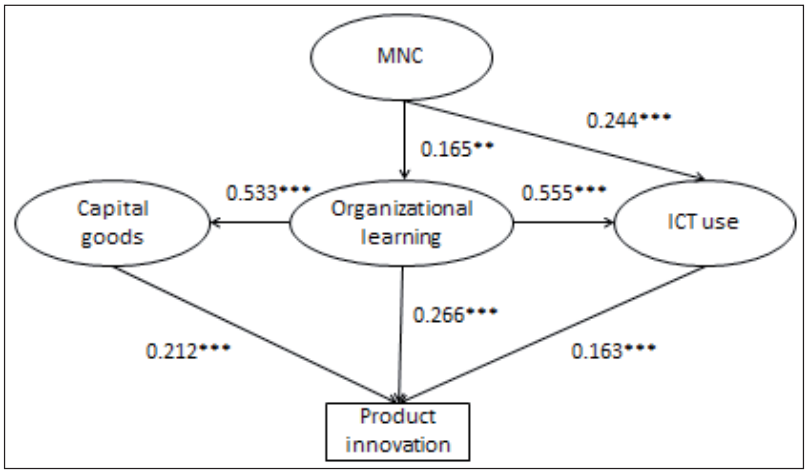


Figure 5. Result of SEM (product innovation: all industries)

Table 3.
Fitness of model (Product innovation)

χ^2 value	Degree of freedom	p value	GFI	AGFI	CFI	RMSEA	AIC
860.102	318	0	0.945	0.911	0.941	0.032	1250.102

Table 4.
Fitness of model (Process innovation)

χ^2 value	Degree of freedom	p value	GFI	AGFI	CFI	RMSEA	AIC
788.59	303	0	0.95	0.915	0.946	0.031	1208.59

follows: i) MNCs promote ICT use (H4); ii) public organizations and universities enhance organizational learning (H2), although they have a negative effect on ICT use; iii) organizational learning promotes capital goods (H5) and ICT use which promotes process innovation (H8), t H1 is verified. Regarding the natural resource-based industries, only path from MNCs via ICT use significantly affects process innovation. Accordingly, H1 is weakly demonstrated.

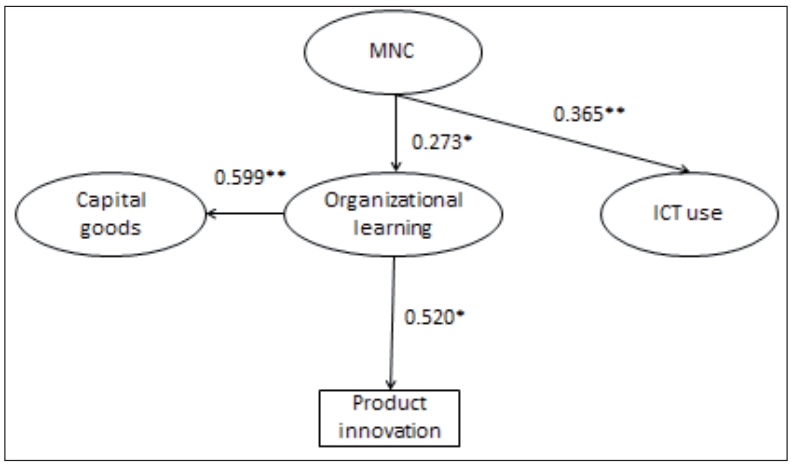


Figure 6. Result of SEM (product innovation: natural resource–based industries)

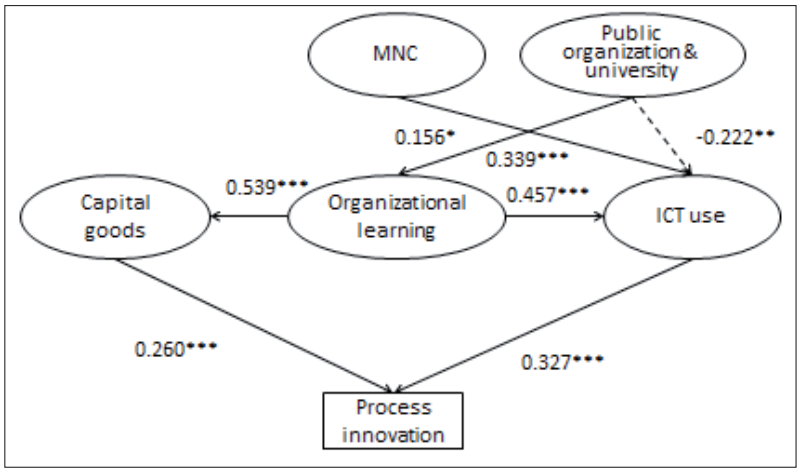


Figure 7. Result of SEM (process innovation: all industries)

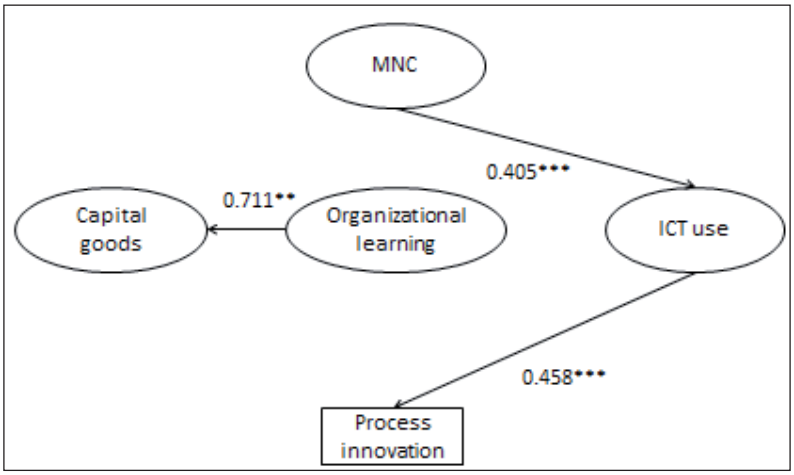


Figure 8. Result of SEM (process innovation: natural resource–based industries)

E. Summary of results

Here the results of SEM of two models and those of our prevous studies (Tsuji et al., 2011a, 2011b, 2012, 2016) are summarized. Regarding product innovation, for all industires which is similar to other industores than resource-based industries, MNCs are siginificant to inovation vis organizational learning and ICT use. This results are similar to the those of previous studies, which did not contain capital goods as a variables, whereas for resource-based industries, MNCs is significant only via organizational learning. Therefore, the connectivity to MNCs holds in this inovation, but in case of procres innovation, the connectivity has smaller effect than the previous studies.

The results of process innovation are different. For all indsutries, MNCs has significant path via ICT use to process innovation, while public institutions and universities has significant path to organizational learning. However, it does not have direct path to innovation, only indirectly from capital goods. In the previous studies, MNCs generally has siginificant pathes to both of organizational lerning and ICT use. On the other hand, for natural recource-based industries, the significant path to innovation is via ICT use, implying that organizational learning is not significant. This seems not consistent with the reality, different from what we learned from the various filed research. Accordingly, the connctivity to MNCs in case of product innovation is partially obtained. The difference in results obtained from our field surveys might be due to the number of samples of the resource-based industries. To clarify this requires further analysis.

VII. CONCLUSIONS

This study examines the innovation activity of natural resource-based industries in comparison with other industries in four ASEAN economies, using mail/phone/face-to-face surveys. The natural resource-based industries, which have a long tradition, are indigenous to their economies and thus, in this sense, they have relative advantages. Although their shares in the national economies are small, they have the potential to become export industries by expanding the boundary of their activities. In order to examine their possibility, basic research on their internal innovation capability, external linkages to promote innovation or on how they are integrated in the global supply chain constructed by MNCs, for example, is required. For this purpose, the rigorous statistical method of SEM is employed to obtain accurate results. By using results from our previous studies on innovation in these regions, we postulate the hypothesis that external linkages promote internal capability and then finally enhance innovation. The results obtained show that MNCs affect organization learning, which enhance capital goods and ICT use, and then all three factors, which construct internal capability and promote product innovation. These results are consistent with our previous studies; for the natural resource-based industries, however, these conclusions do not apply. The reason is clear: the number of their samples is small and cannot yield clear and contracted results. Observation on the data, however, shows that the natural resource-based industries have similar characteristics to other industries. The diffusion of QC or *kaizen* reached these industries in a timely manner; this is due to transactions or collaborations with MNCs, which are one of their main customers.

Therefore, policy implications particularly based on the analysis of this paper are difficult, since the results of SEM do not show good comparison with those of our previous papers which analyzed typical manufacturing industries such as automobile and electronics. However, some industries, like woods, furniture, garment, food, rubber so on, considered as natural-based industries were included in the previous studies, and accordingly policy recommendations obtained in previous papers such as Tsuji et al., (2010, 2011a, 2011b, 2012, 2016) can be applied. Since the main buyers of the above industries are foreign whole sellers, trading companies, and MNCs, the strengthening connectivity to those foreign firms can be applicable. Among all, what local firms, as well as governments, have to implement are to enhance quality of product and procurement. These are essential and mandatory. The factors to achieve these are i) capital goods such as new production machine, ii) organization learning such as QC, and cross functional team, and iii) and ICT use. Other factors which are essential

but not analyzed here include human resource development (HRD) such as basic training of workers in the production line. 5S, for example, implying sorting, setting-in-order, shining, standardizing, and sustaining the discipline, is a basis for promoting quality of product. The natural resource-based industries which were not analyzed in the writers' previous studies and this paper include oil and gas. These industries are in general protected by policy from the forging competitors, which tends to become obstacles for promoting productivity and competitiveness. The deregulation is another policy recommendation. A Thai oil company has been entering the markets in the neighboring countries and expanding its business and this is a good example.

The limitation of this study is the same as the limitation of SEM; that is, SEM is a good tool to examine hypothesis, but it is not necessarily good at finding reasons of issues or inducing policy to solve such issues. Therefore, various research methods need to be combined for further analysis.

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