Comparative Analysis of Formal and Informal R&D for Innovation in Firms in ASEAN Countries

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Abstract

Many ASEAN SMEs successfully achieve innovation without owning specific R&D facilities. Firms that do not own specified in-house departments or sections to conduct R&D are defined as non-R&D firms. The aim of this study is to identify factors promoting innovation in the framework of R&D activity based on surveys on firms in five ASEAN countries including Indonesia, Laos, Thailand, the Philippines, and Vietnam. The method of analysis is to divide sample firms into two categories, namely "the R&D group" and "non-R&D group." The analysis attempts to identify which of the internal capabilities, consisting of technology, human factors and organization factors, promote innovation. In addition, top management leadership is postulated as an important factor in small SMEs based on the field surveys. The results of the estimation procedure indicate that the two groups pursue product innovation differently. The R&D group promotes innovation by (i) cross-functional teams of production, engineering, manufacturing, and sales & marketing for innovation of all types and (ii) IT use, while non-R&D group by (iii) HRD program for workers, (iv) Group award for suggestions or QC, and (v) ISO9000 series. These differences are due to their innovation or knowledge environment such as types of products and production methods, seeds of innovation, learning process, and so on.

Keywords: R&D; MNCs; leadership; internal capability; learning process; QC; cross-functional team; HRD.

JEL classification: O32, O31, O19

1. INTRODUCTION

For further economic development in ASEAN economies, transformation from simple production bases, known by terms such as the “factory of the world,” to “knowledge economies” is mandatory. In addition to so-called national innovation initiatives for this transformation, sector specific or firm specific policy is also required for industry or firms to upgrade their production and management. Particularly, the transformation of SMEs in these regions is an urgent prerequisite for overall macroeconomic development. In this regard, in order to postulate the basic behavior of firms toward innovation, the innovation process and internal capability for innovation inside the firm must be clarified. The innovation process was defined and studied by Cohen and Levinthal (1990), Zahra and George (2002) and Christensen and Kaufman (2009), for example. They also recognize the innovation process as a learning process consisting of four dimensions; acquisition, assimilation, transformation, and exploitation. Firms must elevate their abilities in all four dimensions to promote innovation, which is referred to as internal capability for innovation including an integrated ability of a firm to create innovation which consists of all resources, core competence, or competitiveness, as noted by Mariano and Pilar (2005), Lawson and Samson (2001), and Perdomo-Ortiza, Benitob, Galendeb (2009). In more detail, internal capability includes the technological level, such as the number of patents; production facilities; human resources, such as the number of engineers with higher degrees or skills; the level of craftsmanship and work ethics; and organizational aspects, such as communication between workers and top management, speed of decision-making, and top management leadership.

R&D is thought to be the back side of the coin, and the above innovation process can be viewed from R&D. Similarly to the above four sub-processes, the R&D process can be decomposed into the following sub-processes, for example: (i) Idea generation; (ii) Screening Business Analysis; (iii) Development; (iv) Testing; (v) Commercialization (Booz, Allen and Hamilton, 1982). In this R&D process, the internal innovation capability of firms plays essential role to achieve innovation. R&D is one of the riskiest among businesses (Booz, Allen and Hamilton, 1982; Crawford, 1987; Cooper, 2001; Nadia, 2011). This nature of R&D motivates numerous text books and handbooks to be published for firms including Crawford (1987, 1997), Smith and Reinertsen (1998), Cooper (2001), and Kahn (2013). Similarly various papers analyze

R&D from the view of autonomy (Argyres and Silverman, 2004; Lerner and Wulf, 2007), managing R&D team (Leven and Cross; Colquitt and Rodell; 2011), leadership (Hirst and Mann, 2004; Berson and Linton, 2005; Zheng et al., 2010; Wong and Tong, 2012), reward and incentive scheme (Lerner and Wulf, 2007) and so on. On the other hand, there also various studies of innovation through non-R&D, hidden innovation, or informal R&D, which characterize the different pattern or mode of innovation and R&D. The difference between tow is well summarized by Jensen et al. (2008) as the science, technology and innovation (STI) mode and the Doing, Using, and Interacting (DUI) mode. The former is dominated by scientific and technical knowledge which is related to formal process of R&D, whereas the latter is characterized as informal process of learning and experienced-based skills and know-how (Thomä, 2017). The two notions are not dichotomous, but rather ambiguous. Even in high-technology firms, which are perfect example of STI, conduct non-R&D (Barge-Gil et al., 2011; Hervas-Oliver et al., 2015).

This paper examines the innovation and R&D processes of SMEs in the ASEAN countries which are less STI-type because of the current level of technology and size of firms in terms of employees and assets, that is, they are too small to own specific sections or units for R&D. Our field research more than ten years found that they conduct R&D as well as non-R&D there are two kinds of R&D. Accordingly the research questions of the paper are whether there are differences in performances and conducting innovation between two types of R&D. In so doing, this paper examines using rigorous statistical analysis whether and how SMEs with informal R&D and which are located in the regions achieve innovation.

This paper consists of the following sections: The next section identifies the nature of R&D and non-R&D in ASEAN firms based on the surveys of firms. A summary of the data obtained by research teams in five countries is provided in Section 3. Methodology and models to be estimated are discussed in Section 4. The estimation results and their implications are presented in Section 5. Brief conclusions and directions for further research are provided in the final section.

2. NATURE OF R&D AND NON-R&D IN ASEAN FIRMS

2.1 Factors promoting innovation under non-R&D

(1) Top management

The leadership of the SME owner plays an essential role in the whole innovation process, this being particularly seen in ventures. The owners are generally engineers with knowledge, skills, ideas, and experience, and at the same time they are capable of managing all aspects of a firm, including marketing, HRD, and so on. They can directly and independently invent new products and discover new production processes. In addition to engineering ability, they also have passion and high motivation toward innovation, and are more interested in creating something new, which is product innovation, rather than making improvements. Since the firms are not large enough to employ college graduates, various types of on-the-job training are inevitable. The owners also take the initiative to implement HRD. It was in this context that the generation of current top management was surveyed.

(2) Size of firms

The size of firms in terms of the number of employees and capital is an important factor. Although this concept is primitive, it is crucial for these firms when establishing an R&D unit. R&D is not a simple process but is related to other learning practices such as QC or cross-functional teams. These practices require a certain number of employees.

(3) Types of products and production methods

Types of products and production methods, namely, whether the products are final products or parts determine the direction of innovation and R&D. Parts are also categorized as complete or simple parts, and physical parts or materials, and these are also important. In the case of final products or complete parts, it is essential for firms to carry out R&D to create new products, and more resources and funds are required for R&D. However, as most SMEs are engaged in the manufacture of simple parts or material manufacturing, there are fewer chances to create something new, but more opportunities for improvement; process innovation rather than product innovation.

(4) Seeds of innovation

The type of product thus determines the type of innovation, and this can be discussed from the viewpoint of the sources of innovation or R&D methods. In the case of firms

producing final products, searching and finding seeds of innovation is carried out under their own responsibility, and the R&D process can be termed “autonomous.” In contrast, when the products are simple parts or materials, seeds of innovation come basically from the buyers of their products. Typical examples are as follows: (a) model changes in the final product, (b) claims from customers, and (c) improvement of product quality. At the time of a model change in the customer’s final product, SMEs which supply materials or parts are required to change their products, which, in a sense, is their innovation. That is, innovation initiated in one firm is transmitted to other firms via the supply chain. Due to customer claims regarding quality, SMEs as parts suppliers are required to improve their manufacturing process, which also implies process innovation. Thus this type of informal R&D tends to create mainly process innovation, and accordingly innovation of this kind can be termed “non-autonomous.”

(5) Risk

If firms can afford to bear various kinds of risks, they will be capable of conducting R&D for a new product. On the other hand, R&D for process innovation is less risky, since it can be achieved by reducing the failure rate in production, or savings in materials, labor, energy, and so on. Another way to reduce costs is speedup at the manufacturing site. Reductions in the failure rate, for example, can be achieved through simple efforts made by workers as well as top management by means of 5S, QC, and by training that entails very little cost.

2.2 R&D structure

R&D does not simply create something new in terms of technology or engineering, but is related to various aspects of manufacturing and also has related sections or functions attached to it, such as production technology, manufacturing technology, quality assurance, design, and so on. These sections are well organized so as to conduct R&D in a coherent manner.

On the other hand, SMEs which do not own an R&D section, but each engineer is trained to fulfil customer needs. Since the firm manufactures simple parts such as gears, all kinds of requests regarding gears are made to them, and they are required to satisfy customer needs by cultivating their skills and technologies. Although do not own an

R&D center, each craftsman plays this role and other workers are assigned to roles that perform the same functions as sections similar to the R&D centers. In this sense, whether the R&D is formal or informal, a certain number of related functions is required to conduct R&D. The role of ISO9000 series is important, since some of SMEs (nearly 50% of our sample) obtained ISO9001, which are the basis of their standardized structure and functions of R&D.

2.3 R&D Execution

R&D practice is different from R&D and non-R&D groups. The first step is to find ideas or a seed for innovation. A R&D group discovers these seeds by themselves or by collaborating with business partners, mainly MNCs (Multi-national corporations). Once they find a research theme, they conduct R&D either on their own or by collaborating with business partners. Most of the seeds of innovation come from buyers or suppliers in the form of either claims for better products or changes in the models or specs of final products.

Some SEMs have been invited to joint research consortia organized by MNCs and university laboratories. The reason why small SMEs are invited to participate in high-tech projects is that they have superior technology in specific parts. Without these parts, the final products would never be realized. Superior technology in a niche area is a source of further enhancement and widening of technology for these firms. Enhancing and maintaining their own high technology level attracts innovation seeds.

ISO9001 postulates a standardized process on how to conduct R&D once an idea has been found. One nature of SMEs lies in the speed of decision-making. This is another reason why they become partners of MNCs.

2.4 HRD

HRD takes different forms in SMEs according to the technology, product, size of the firm, and other factors. The similarity in HRD is that OJT is the main practice. New employees are assigned to specific sections and receive OJT to achieve required skills from senior colleagues. Even smaller SMEs have their skill-raising process. Workers are required to achieve certain skills; failure to do so will mean that they are not promoted to higher positions. They also have skill assessment system, which evaluates

employee ability on a scale. After passing this, employees can be registered as trainee designers and participate in design as assistants, for example. One example of more intensive OJT is observed as follows. Since most of their new employees are graduates of regular high schools, not technical high school, they are trained thoroughly on a man-to-man basis and are required to master CAD/CAM as the first step. Then the employees are required to master each machine in order, and their performance with each machine is marked up on a skill map. A glance at this map makes it apparent who is able to operate a particular machine and perform a particular function. These skills are reflected in the employees' salaries, providing them with an incentive to work seriously.

2.5 Research questions

Based on the above discussions on the ways of conducting R&D activities, the research questions of this paper are summarized as follows:

RQ I: The informal and formal R&D groups have different innovation processes

RQ II: What are the factors of production innovation for the formal and informal R&D Groups: Are there any difference between them?

3. SUMMARY OF DATA AND ESTIMATION MODEL

In this section, the sources of data, the procedure of estimation, and the construction of variables are presented.

3.1. Surveys conducted

This study is based on mail surveys and phone interviews conducted with firms in four ASEAN economies, such as Vietnam, Indonesia, Laos, the Philippines, and Thailand from 2013 to 2014, amounting to 152 in the Hanoi area and 161 in the Ho Chi Minh City area, Vietnam; 200 in the Batangas and other areas in the Philippines; 181 in the Jabodetbek area, Indonesia; and 160 in Greater Bangkok, Thailand. The surveys were conducted from November 2013 to January 2014. The total number of valid responses from these areas was 1,061.

As explained earlier, this study categorizes R&D activities into two types, R&D

and non-R&D R&D; accordingly the firms were also divided into these two groups. The firms that replied no to both of the questions asked about whether they have an R&D budget (**Q19.1.** What is the ratio between R&D expenditure and sales at present?) and specific personnel who are engaged in only R&D activities (**Q19.3.** Does your establishment develop personnel in charge of R&D at present?). The rationale of this lies in (i) the difficulty of making questions to ask SEMs' R&D and (ii) the ambiguity of the definition of R&D and non-R&D. As stated in Introduction, Regarding (i), questions have to be simple enough for CEO or person who is in charge of R&D or innovation to understand and reply properly. Due to (ii), the concept of non-R&D activity may not be able to separate from those of R&D. Thus questions to identify the type of R&D are limited only above two. Thomä (2017) and Lee and Walsh (2016) utilize official data of the EU and US, respectively. The former categorizes R&D expenditures into R&D and non-R&D, whereas the latter employs the questions such that "the creative process that led to their invention and one about the type of unit to which they belonged at the time of the invention (p. 350)." Although our definition seems to be rough, it is convenient for the questionnaire survey; the accurate but complicated questions are hardly understood by a person who is asked to reply. Since the areas and firms which this study targets are less developing countries and SMEs, simplified definitions are practically useful.

The number of firms analyzed in this study sample was 608 in the formal R&D group, 441 in the Informal R&D group, and 1,049 in total, as shown in Table 2. 58.0% of the respondent firms belong to the formal R&D group. Vietnam had the largest number of firms in the formal R&D group, which amounts to 83.7% of the total, and Indonesia had 61.9%. The percentage of the Philippines is the lowest at 37.3%. These figures imply that the number of firms with informal R&D was larger than that with formal R&D.

Table 2: Types of R&D Group by countries

Type of R&D	Vietnam		Indonesia		Thailand		Philippines		Laos		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
R&D	262	83.7	112	61.9	83	53.5	72	37.3	79	38.2	608	58.0
Non-R&D	51	16.3	69	38.1	72	46.5	121	62.7	128	61.8	441	42.0
Total	313	100.0	181	100.0	155	100.0	193	100.0	207	100.0	1049	100.0

Source: ERIA Establishment Survey

Regarding the size of the firms, 50 % of formal R&D firms have smaller than 200 employees, while that of informal R&D has smaller than 50 employees. In terms of assets, two thirds of Formal R&D are larger than 1 milloin-5 million USD, whereas two thirds of Formal R&D own less than those amount. The informal R&D firms have much smaller than the formal group.

3.2. Construction of variables: Outcome variables

3.2.1 Product innovation

The construction of variables related to product innovation is based on the following four categories of innovation:

(1) Product innovation Type I: Introduction of a new product, redesigning packaging or significantly changing the appearance design of your existing products (Nascia and Perani, 2002)

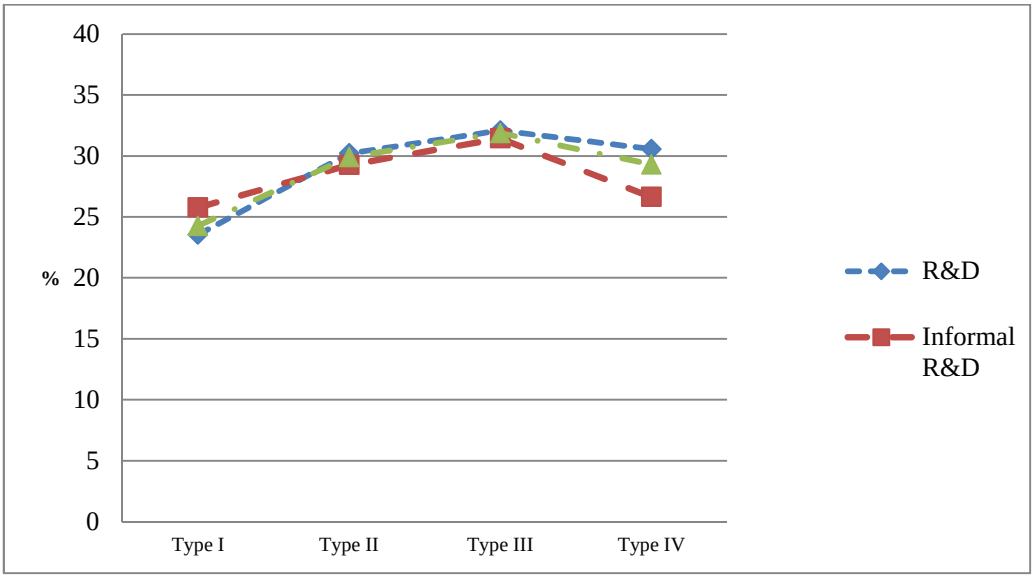
(2) Product innovation Type II: Introduction of a new product, significantly improving your existing products with respect to their capabilities, user friendliness, components, subsystems, etc.

(3) Product innovation Type III: Development of a totally new product based on the "existing" technologies at your establishment

(4) Product innovation Type IV: Development of a totally new product based on "new" technologies at your establishment

These are based on "**Q13**. Have you tried to introduce a new product in the last two years (2013-2014)?" This categorization is based on the OECD Oslo Manual. For each category, the respondents were asked whether they had (i) achieved, (ii) attempted, or (iii) not attempted the innovation. If respondents had achieved the innovation, two points are given; if they had attempted the innovation, one point is given; and those who had not yet attempted the innovation are indicated by zero. Figure 1 shows the

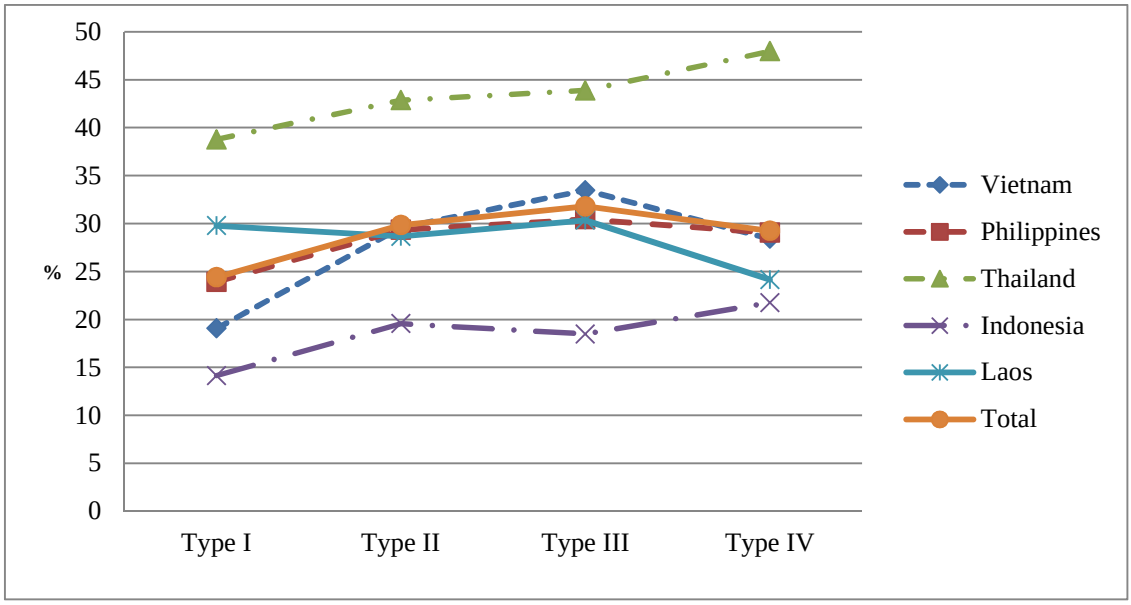
distributions of product innovation by two groups for whole regions, while Figure 2 indicates product innovation by countries without making difference between two groups. The vertical axis of both figures indicates the percent of forms responded to (i) achieved. As shown in Figure 1, in the pooled data, no difference is found in the three groups of firms, but innovation by countries shows that Thailand has the largest percentages of the four types, whereas Indonesia shows the smallest in all types. The other three countries have almost similar figures, except for Type I (Figure 2).



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

Source: ERIA Establishment Survey

Figure 1: Product Innovation: Whole Regions



Source: ERIA Establishment Survey

Figure 2: Product Innovation by countries

3.3. Selection of explanatory variables

This paper employs probit model and the explanatory variables used in the estimation are discussed. All variables play important roles in the promotion of innovation. The most of the previous papers were concerned with the specific research question and did not cover the all related variables which might affect R&D. The authors' previous study which employed SEM (Structural equation modelling) used the categories of explanatory variables such as Cross functional team, QC, Human factors such working experience's for MNCs, and so on (Tsuji et al. 2016). This paper also basically follows those variables.

3.3.1. ISO9000

ISO9000series cover wide activities related to quality management, training, R&D structure and implementation, and so on. The technological level of a firm can be indexed by the number of patents obtained, the amount of R&D investment made, or the quality of equipment used in the manufacturing process. This study focuses only on the ISO9000 series and ISO14000 series, since the number of explanatory variables is large and there are other variables which we wish to highlight in this paper. In the actual estimation, only ISO9000 were employed, since variables related to technology are not

significant. This will be discussed in more detail in what follows.

3.3.2. Human factors:

In the previous papers, human factors are discussed from the various aspects which include labor mobility (Kesidoua and Szirmai, 2008), spillovers (Görg and Strobl, 2005; Balsvik 2011; Poole, 2013) or leadership of R&D team (Sarin and McDermott 2003; Wong and Tong, 2012) in the high-tech industries. The questions related to human factors in this paper confine to those related manager classes and aim obtain the abilities of employees, but these are not in general observable. The questions thus asked subjects to focus on their career backgrounds, or current positions. The variables employed for estimation are based on the following questions:

Q30.1. Does your establishment have a factory manager?

3.3.3. Organizational factors

Since innovation or R&D are conducted with various teams, groups, or units, conflicts among them are easily occurred, and to avoid such conflicts managerial arrangements or organizations are required for conducting R&D coherently. Daniel (1961) and Rockart (1979), for example, asserted that related organizations need to clarify factors that are critical to the success of the R&D process, since failure to achieve coherency would result in organizational failure. The questions related to organizational factors in this paper thus aim to obtain information on whether firms as a whole are systematically and coherently conducting R&D or innovation activities. This factor contains activities which are summarized as follows:

- **Top management leadership:**

This is an important factor particularly for the informal R&D group, as already mentioned. Innovation in SMEs is mainly led by the owners of firms, particularly SMEs with top-down type. The top management leadership contains ability to establish D&R strategy, to encourage related teams or personnel, to avoid conflicts among related groups, to evaluate their performance, etc. Greenleaf (1977) referred their ability to avoid conflicts and coordination failure to as *Servant Leadership*. Since the top management leadership is unobservable, it is obtained from the following questions,

which are also related to top management backgrounds, such as education or past experience:

Q29.8. Does the top manager have experience of working for MNCs?

- **Cross-functional team:**

This is an organizational arrangement for the exchange, dissimulation and sharing of different views or opinions from different sections of a firm that are related to innovation and which become a basis for creating new ideas. The heterogeneity of ideas or thought tends to create something new through communication. The role of cross-functional teams has been recognized not only in the context of innovation but also solving problems in general. Besides previous studies discussed the conditions on which cross-functional teams work. There were empirical studies; Blindenbach-Driessen, (2015) demonstrated the positive relationship between the cross-functional team and innovation by saying that the existence of cross-functional team is not sufficient for successful innovation. Hirunyawipada, Beyerlein, and Blankson, (2010) identified the conditions for teams to works such as task cohesion, interpersonal cohesion, and transformational leadership and the qualification of team members such as common knowledge, functional expertise, and their positions in the network. Again, this factor is unobservable, and the following question is used as a proxy:

Q21.5. Production Engineering, **Q21.6.** Manufacturing, and **Q21.11.** Sales & Marketing

From the survey data, the percentages of firms which practice following three cross-functional teams are as follows:

	Non-R&D	R&D
Research	2.7	26.0
Development	6.3	38.8
Sales & marketing	25.4	40.3

The above questions investigate whether the firm has this characteristic. In the estimation, “No team” and “Cross-functional team (production engineers, manufacturing, and sales & marketing)” are used, and the latter consists of personnel who are “production engineers, manufacturing, and sales & marketing.” The role of

marketing section was emphasized by De Luca and Atuahene-Gima (2007) which obtained the conclusion such that market knowledge and cross-functional collaboration are two fundamental resources for successful product innovation. They identified the mechanisms which combine these two.

- **QC (Quality Control):**

Although QC does not directly contribute to innovation, new ideas related to innovation, particularly related to process innovation, can be obtained through small group activities. Since the improvement of product quality is a part of process innovation, the outcome of QC is equal to innovation itself. The questions used for this factor are as follows:

Q22.2. Does your establishment operate a QC circle?

Q22.7. Group rewards for suggestions or QC

From the data, actual practices are as follows:

	Non-R&D (%)	R&D (%)
QC	53.7	73.4
Group rewards for QC	42.5	56.5

- **Learning Process:**

This role of the learning process is to share the success experiences among related personnel engaged in R&D activities, and consists of the following questions.

Q.33. HRD program for blue-collar workers, such as cross-training or job rotation

- **IT Use:**

IT use is now popular and necessary among SMEs in these areas, and it is important to examine whether or not IT promotes R&D activities, since IT supports employees in dissimulating their experiences and sharing them with others (Idota et al, 2015a; 2015b; 2015c; Idota et al. 2015). IT use was asked in **Q28.2.** Has your establishment introduced the following IT systems?, which consists of the following two IT use.

Internal use of IT:

This variable consists of the number of items of questions which are true to the firm:

5. Enterprise Resources Planning (ERP), 6. Customer Relationship Management (CRM), 7. CAD/CAM, 8. Groupware, 9. Intra-Social Networking Services (SNS)

External use of IT

This variable consists of the number of items of questions which are true to the firm:

1. Business-to-Business e-commerce (B2B), 2. Business to Consumer e-commerce, 3. Electronic Data Interchange (EDI), 4. Supply Chain Management (SCM), 10. Public SNS

IT all

The variable "IT all" includes all of the internal and external uses of IT. In estimation, we use IT all as a variable.

The summary statistics of the above variables are shown in Table 3.

4. RESULT OF ESTIMATION

By using the questions explained previously, probit analysis is employed to identify factors promoting innovation. The results are presented through two models, product and process innovation, in what follows. For the sake of simple and clear discussion, summaries of the estimation results shown in Table 4 are utilized and detailed estimation results are shown in the Appendix (Table A1).

First, ordered probit estimation on product innovation is conducted for *each* type of innovation to identify factors to achieve particular type innovation, and second estimation is conducted through *four* type innovations which aim to identify factors which elevate firms to higher degree of innovation. For both estimation, explained variables are relies such as 2 for "achieved," 1 for "attempted," and 0 for "not attempted." The rationale of this methodology lies in the category of innovation. We assume that up-grading innovation from Type I to Type II, from Type II to Type III, and so on are so drastic changes for local firms in ASEAN countries that ordered probit analysis might not capture essential factors for innovation. Actually the estimation in this way did not bring reasonable results. Thus up-grading from "not attempted" to "attempted," or from "attempted" to "achieved" seems not difficult for SEMs and can capture the desired results. Accordingly, this method is adopted.

Table 4 Estimation result of product innovation

	Type I		Type II		Type III		Type IV	
VARIABLES	Non-R&D	R&D	Non-R&D	R&D	Non-R&D	R&D	Non-R&D	R&D
ISO9000	**		**			**	*	
Factory manager								-**
CEO has experiences working for MNCs or JVs								
CFT (Engineering Manufacturing Sale & Marketing)		***		***		***		***
QC					*	*	**	**
Statistical QC						**		
group rewards for suggestion or QC	***		**		*			
HRD program for blue-collar workers such as cross-training or job routation	**		**		***		***	
IT all	**	***		***		***		***
Observations	383	568	383	568	383	568	383	568
Pseudo R-squared	0.0907	0.0797	0.0703	0.0652	0.0936	0.0703	0.113	0.104
Log likelihood	-305.3	-525.5	-316.6	-561.2	-292.5	-570.8	-251.6	-510.7

4.1 Estimation result for each type of innovation

- **Common factors of two groups**

The results of the first estimation are summarized in Table 4 (for detailed estimation results, see Table A1 in Appendix) in which firm characteristics are omitted for simplicity. The significant variables are different according to the types of innovation and groups, and accordingly it is difficult to obtain clear and unifies explanation. But it can be said that the R&D and non-R&D groups have different innovation patterns, since all significant variables are not necessarily the same to the both groups except:

(i) "**Q22.2.** Does your establishment operate a QC circle?" for Type III and IV

(ii) "IT all" for Type I.

Both groups commonly enhance innovation by practicing QC for higher innovation. But the difference is not measure matter. Thus, the first conclusion obtained from the estimation is that the R&D and non-R&D groups almost operate under different processes for product innovation, which answered to **RQ I** for product innovation.

- **R&D group**

Next, let us focus on the R&D group in more detail. This group has the following significant variables:

(i) Cross-functional team consisting of "Production Engineering, Manufacturing, and Sales & Marketing" for innovation for all types.

(ii) IT all for all Types

From these observations, the factors such as Cross-functional team and IT all are the same variables that were identified to promote innovation obtained in the authors' previous studies (Idota, et al. 2015; Machikita, et al., 2016; Tsuji et al., 2016, for example), implying that the previous studies seemed to be focused on firms conducting formal R&D activities. Moreover, since there are no significant variables related to top management, innovation in this group is mainly enhanced by employee participation, which seems to be different from the conclusion obtained in our previous studies. As discussed in the previous sections, R&D group consists of larger SMEs and has active QC and R&D (improvement activities more precisely) by cross-functional teams with different sections. These results seem to coincide with the results of in-depth interviews.

- **Non-R&D group**

What then are the results for the non-group? The only common factor in this group for different types of innovation is

(i) ISO9000 for Types I, II, and IV
(ii) Group award for suggestions or QC for Types I, II, and, III
(iii) HRD program for workers for all Types
(iv) IT all for Type I.

HRD is the most important factors for this group since HRD is positive significant for all types. This is different from the R&D group. This group achieves innovation by skills and know-how of workers as seen from the in-depth interviews. Group award for suggestions is significant for Types I, II, and, III, which provide incentives suggestions or QC practice. ISO9000 series also contribute innovation for all types except IV. Since ISO9000series cover wide activities related to quality management, training and education, and R&D structure and implementation, further study will require identifying exact factors.

4.2 Comparison with results of field surveys

Let us compare the above results with what we learned from field surveys. Form our past studies, we do not stress on STI type of innovation for ASEAN SMEs. They mainly obtain new information on innovation from MNCs, and they mainly produce parts and components for MNCs. In case of manufacturing final products, SMEs supply to the

local markets. Thus in the same innovation type, firms in two R&D groups are not so different and therefore factors of innovation identified are either cross-functional teams or HRD, which belongs to the category of DUI (Jensen et al. 2007). Even if their innovation is of DUI type, there must be some reasons of the difference, and which comes from innovation or knowledge environment (Thomä, 2017); types of products, for example, simple parts and material, or compete parts and final products. Innovation for the former requires skills of workers accumulated by the learning process at the work place or job shop. In case of the latter, products are a bit complicated because of the number of parts or higher quality. In addition, customers' requests for quality or prices tend to higher. Not only coping with these but also SMEs have to engage in marketing for selling their products. Accordingly, the number of employees increases who participates in these activities. The success of these activities depends on the coordinators or supporting sections who manage these activities. In this sense, firms in the R&D group in ASEAN countries are a bit advanced than those of the non-R&D group.

5. DISCUSSION

The estimation results identify factors of innovation of R&D and non-R&D groups, which are less discussed in the literature thus far. Here let us compare with the results of other studies.

The merit of this paper is to analyze R&D and innovation of firms in ASEAN economies. Previous empirical studies employed large public data of the EU and US, whereas this paper uses own data each country teams collected. US data such as "NSF's Business R&D and Innovation Survey (BRDIS) 2011, shows out of all US firms, only 5% conduct R&D. Furthermore, out of all US product innovating firms, about 72% are non-R&D innovators. At the same time, R&D-active firms do have a higher probability of generating a product innovation than non-R&D-active firms (58% vs. 7%) (NSF, 2014)" (Lee and Walsh, 2017, p. 345.) The data of this study shows the ratio between R&D and non-R&D is 52% vs. 48% (Table 2), but the performance in terms of product innovation seems not large (Figure 1)

Table 3 Summary Statistics

	Variable	Obs	Mean	Std. Dev.	Min	Max
R&D/non-R&D	non-R&D	951	0.40	0.49	0	1
	Dependent Variables					
Product innovation	Type I: Introduced a new product, redesigning packaging or significantly changing appear	951	0.98	0.92	0	2
	Type II: Introduced a new product, significantly improving your existing products	951	0.93	0.89	0	2
	Type III: Development of a totally new product based on the existing technologies	951	0.77	0.86	0	2
	Type IV: Development of a totally new product based on new technologies	951	0.55	0.78	0	2
	Indedendent Variables					
Technology factor	ISO9000	951	0.43	0.50	0	1
Human factor	Appointing factory manager	951	0.69	0.46	0	1
Leadership of top management	CEO has experiences working for MNCs	951	0.41	0.49	0	1
Cross-functional team	Cross functional team (Engineering, Manufacturing, Sale & Marketing)	951	0.93	0.97	0	3
Quality control	Practicing QC	951	0.65	0.48	0	1
	Statistical QC	951	0.54	0.50	0	1
	Group rewards for suggestion or QC	951	0.50	0.50	0	1
Learning process	HRD program for blue-collar workers such as cross-training or job rotation	951	0.59	0.49	0	1
IT	IT all	951	1.99	1.90	0	10
	Control Variables					
Firm characteristics	Ln (operation years)	951	4.68	0.11	4.50	5.35
	Total Assets	951	7.26	2.26	1	10
	100% locally owned	951	0.67	0.47	0	1
	Food	951	0.11	0.31	0	1
	Wear	951	0.15	0.36	0	1
	Wood & Paper	951	0.11	0.31	0	1
	Chemical & plastic	951	0.17	0.37	0	1
	Iron & Metal	951	0.12	0.32	0	1
	Parts & Machine	951	0.21	0.40	0	1
	Other industries	951	0.66	0.48	0	1
Country dummy	Philippines dummy	951	0.18	0.38	0	1
	Indonesia dummy	951	0.19	0.39	0	1
	Laos dummy	951	0.22	0.41	0	1
	Thailand dummy	951	0.09	0.29	0	1
	Vietnam dummy	951	0.32	0.47	0	1

Another merit of this research is to make out the questionnaire by our own interests. As a result, the concrete factors such as cross-functional teams and HRD are obtained. Thomä (2017) used data from the 2011 survey wave of the Mannheim Innovation Panel (MIP), which covers 2008–2010. He emphasizes vocational education and training (VET) in Germany as an innovative factor in the DUI mode of learning. The higher ability of German workers is based on vocational education and training (VET) in Germany. In ASEAN economies, such workers and engineers are severely shortage, and thus firms have to nurture them by HRD.

6. CONCLUSION

The objectives of this study are to examine whether two groups of ASEAN local firms have different R&D activities for achieving innovation. The firms are categorized into two groups depending on whether or not they own specific R&D sections or units. The underlying hypotheses are that the R&D group is characterized by the same process as obtained by previous studies, namely innovations are promoted by technology, human factors, and organizational arrangements. On the other hand, the non-R&D group has a different innovation process due to shortages in human resources, investment funds, or a low level of technology. Based on field research, these firms conduct innovation through the leadership of owners who dominate the firm in terms of technology, ideas, experience, and so on. In addition to this, a cross-functional team of employees discussing, dissimulating, and sharing their ideas, experiences and skills among the members is another factor promoting innovation. Since the firm size is small, top management can participate in the team and the joint effort of employer and employees in the whole firm promotes innovation.

To examine the above hypotheses, this study employs a procedures; one is a model using the same variables for both groups. This examines whether the two groups have the same innovation process or not. The results of the first estimation procedure indicate that the two groups pursue product innovation differently. The formal R&D group promotes innovation by (i) cross-functional teams consisting of marketing personnel as well as technological and manufacturing engineers, (ii) QC, (iii) a learning process such as HRD and worker training. These factors coincide with those obtained in previous studies. The informal R&D group, on the other hand, does not yield clear results. An

estimation model only applicable to this group is therefore employed. As a result, top management leadership, such as their experience and study abroad, is identified. Accordingly, the RQs related to product innovation are partly demonstrated.

Although the roles of top management in the innovation process were recognized, they were not particularly emphasized by the previous studies. The study of connectivity conducted last year identified these roles in the context of the information transmission channel, that is, the route of information flow between MNCs and top management who used to work at MNCs. On the other hand, the role of top management in the innovation process in small SMEs is extracted for the first time in this study. The cross-functional team, training of workers, and QC practices were found to be three major factors prompting innovation in the previous studies. These are also confirmed by this study.

This paper successfully identifies concrete factors promoting innovation for R&D and non-R&D groups in ASEAN economies, which has been less analyzed in comparison with the EU and US. The limitations of this study that are required to be solved in further studies are as follows: (i) the number of samples, (ii) the estimation method; (iii) concrete channels as to how factors affect innovation; and (iv) external linkages. (i) The number of samples related to the non-R&D group is too small to conduct statistical analysis. Further efforts on the survey method for focusing on small SMEs are required. (ii) The estimation method also requires improvement. The estimation method in this study aims rather to find factors which make a difference in the innovation process, but more suitable methods are required to test the hypotheses. (iii) The identification of how different factors affect innovation is also important; for example, how a cross-functional team dissimulating ideas and experiences affects innovation is not solved yet. Can the group reward system, for example, stimulate cross-functional activities? This can be examined by the cross term of two variables. What kind of organizational arrangements can elevate employee ability for innovation is a similar kind of problem that needs to be analyzed. This study focuses on the internal innovation process and is less concerned with (iv) external linkages, which played important role in the previous studies. The introduction of external linkages into the model may yield different results, though the analysis would become much more difficult and complex.

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Appendix 1: Estimation result of product innovation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Type I		**Type II**		**Type III**		**Type IV**	
VARIABLES	Non-R&D	R&D	Non-R&D	R&D	Non-R&D	R&D	Non-R&D	R&D
ISO9000	0.370**	-0.0450	0.437**	-0.0318	0.249	0.271**	0.355*	0.0427
	(0.182)	(0.123)	(0.178)	(0.118)	(0.181)	(0.116)	(0.190)	(0.121)
Factory manager	0.0659	-0.0172	0.168	0.00981	0.0438	-0.0666	0.0260	-0.280**
	(0.164)	(0.129)	(0.162)	(0.125)	(0.167)	(0.125)	(0.181)	(0.133)
CEO has experiences working for MNCs or JVs	-0.119	-0.0175	-0.0174	-0.0832	0.198	0.0231	0.244	0.107
	(0.164)	(0.116)	(0.160)	(0.112)	(0.163)	(0.111)	(0.172)	(0.115)
Cross functional team (Engineering Manufacturing Sale & Marketing)	0.0137	0.275***	0.00394	0.285***	-0.0445	0.195***	0.0367	0.159***
	(0.0910)	(0.0593)	(0.0897)	(0.0570)	(0.0927)	(0.0565)	(0.0957)	(0.0590)
QC	-0.0485	0.0147	0.171	-0.0756	0.315*	0.246*	0.440**	0.294**
	(0.163)	(0.130)	(0.161)	(0.127)	(0.167)	(0.127)	(0.181)	(0.136)
Statistical QC	-0.270	0.195	-0.245	0.118	-0.178	0.259**	-0.206	0.0530
	(0.181)	(0.136)	(0.178)	(0.131)	(0.183)	(0.129)	(0.199)	(0.135)
Group rewards for suggestion or QC	0.549***	0.0711	0.353**	0.165	0.300*	-0.0128	0.284	0.127
	(0.176)	(0.127)	(0.172)	(0.123)	(0.176)	(0.122)	(0.188)	(0.126)
HRD program for blue-collar workers such as cross-training or job routation	0.313**	-0.0838	0.331**	-0.0244	0.413***	-0.0340	0.614***	0.106
	(0.153)	(0.118)	(0.150)	(0.114)	(0.155)	(0.113)	(0.169)	(0.119)
IT all	0.110**	0.104***	0.0433	0.120***	0.0439	0.0810***	-0.0426	0.0762***
	(0.0500)	(0.0284)	(0.0496)	(0.0280)	(0.0510)	(0.0274)	(0.0540)	(0.0276)
Observations	383	568	383	568	383	568	383	568
Pseudo R-squared	0.0907	0.0797	0.0703	0.0652	0.0936	0.0703	0.113	0.104
Log likelihood	-305.3	-525.5	-316.6	-561.2	-292.5	-570.8	-251.6	-510.7
Standard errors in parentheses								
*** p<0.01, ** p<0.05, * p<0.1								