Roles of Top Management Characteristics, Human Resource Management, and Customer Relationships in Innovations in Southeast Asia

Machikita, Tomohiro (2); Ueki, Yasushi (1)
Machikita, Tomohiro (2); Ueki, Yasushi (1)

Abstract
This study explores non-R&D determinants of innovations. Following findings from innovation literature, this study focuses on customer relationships, human resource management (HRM), and top management characteristics as possible determinants of innovations. For empirical analyses, this study conducts a questionnaire survey in Lao PDR, Thailand, and Vietnam in the beginning of 2017. The results of the questionnaire survey and regression analyses present that customer relationships are significantly correlated with product innovations, whereas HRM practices have significant associations with process innovations. Top management contributes to product innovations only by developing mentoring relationships with their engineers. However, top management may make a significant contribution to innovations, by playing a key role in creating customer relationships to promote knowledge transfer.

Keywords: Top management, human resource management, customer relationship, innovation, ASEAN

JEL classification: O32

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1. INTRODUCTION

Innovation literature considers absorptive capacity as a fundamental enabler of innovations (Cohen & Levinthal, 1990; Zahra & George, 2002). Absorptive capacity is the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends. Absorptive capacity is one of the consequences of R&D investment (Cohen & Levinthal, 1990).

Since the seminal study by Cohen and Levinthal (1990), empirical studies use R&D investment and related measurements as absorptive capacity indicators. However, Cohen and Levinthal (1990) also claims that firms can develop absorptive capacity through non-R&D activities including personnel technical training and manufacturing operations. Recent innovation studies devote increased attentions to non-R&D activities as determinants of innovations (e.g., Hervas-Oliver, Garrigos, & Gil-Pechuan, 2011; Lee & Walsh, 2016). As most of the firms except large ones do not have sufficient resources to make investments in R&D, studies on non-R&D innovations will bring practical implications for policy makers and business operators.

This study explores non-R&D factors that affect product and process innovations. The focus of this study is placed on the following three factors. The first is customer relationships, especially face-to-face interactions with customers. Firms can supplement internal knowledge with external knowledge to realize innovations as open innovation literature suggest. Customer relationships are main channels to acquire new knowledge useful for develop novel and quality goods and services.

The second is human resource management (HRM) designed especially for engineers. Appropriate HRM enable firms to develop coordination mechanisms for knowledge exchange that enhance absorptive capacity of the firms. The relationship between HRM and innovations has been recognized since Cohen and Levinthal (1990), the innovation literature and HRM literature have not been integrated satisfactorily. This study will provide evidence that may contribute to better understanding of the role of HRM in innovation.

The third is top management characteristics. Top management characteristics are associated with top managements' consciousness that guide their strategic decisions or actions related to absorptive capacity building and innovations. Innovation empirical studies identify CEO characteristics and other manager related variables as internal determinants of innovations (Becheikh, Landry, & Amara, 2006). Top management is likely to take a leading role in firms that lack human resources. However, top management characteristics can affect innovation directly and indirectly through other moderators. It will be necessary to carefully investigate the impacts of top management characteristics on innovations.

The results of the questionnaire survey and regression analyses present that customer relationships are important factors for product innovations, whereas HRM practices have significant impacts on process innovations. Top management can contribute to product innovations in the more direct manner by developing mentoring relationships with their engineers. Rather than directly contributing to product or process innovations, top management may play a gatekeeper role that link the firms with their customers to promote knowledge transfer (Allen & Cohen, 1969; Allen, 1977).

This paper has the following structure: Section 2 presents the theoretical background on R&D and non-R&D causal conditions for innovation. Section 3 explains the method that includes the data and main variables. Sections 4 to 6 provide the results of the survey and regressions. Finally, Section 7 summarizes the results and draws policy implications.

2. THEORETICAL BACKGROUND AND RESEARCH QUESTIONS

2.1. Customer Relationships

The decomposition of absorptive capacity by Zahra and George (2002) into potential capacity (i.e., a firm's capability to recognize, value, and acquire external knowledge) and realized capacity (i.e., a firm's capability to transform, exploit, and leverage the knowledge that has been absorbed) help differentiating conditions for the former from those for the latter and linking two capacities with innovations. Zahra and George (2002) illustrate exposures to external knowledge sources and experiences gained from interactions with customers and learning by doing will influence the development of absorptive capacity, whereas internal and external triggers are necessary for stimulating firms to seek and learn from external knowledge and experiences. Fosfuri and Tribó

(2008) adopt the theoretical framework proposed by Zahra and George (2002) to find that external knowledge acquisition, R&D cooperation, and experience with knowledge search are antecedents of a firm's potential absorptive capacity.

Other empirical studies on non-R&D determinants of innovations also present the importance of links with external knowledge sources, especially with customers (Rothwell, 1992). Slater and Narver (1995) claim that market orientation is necessary for the creation of a learning organization that continuously acquire, process, and disseminate throughout the organization new knowledge based on experience and experimentation and information from external sources including customers. Hervas-Oliver, Garrigos, and Gil-Pechuan (2011) show that marketing can affect product and process innovations.

Although these literature show interests in the role of customer and other external knowledge sources in absorptive capacity building and innovations, studies of innovation quality go into the details of cooperative relationships with customers, suppliers, and other organizations. Innovation literature does not necessarily recognize knowledge flows as a one-way inward flow, but emphasize interactive knowledge exchanges and collaboration as well as characteristics of exchanged knowledge that may create novel knowledge and innovations (Nieto & Santamaría, 2007; Tödtling, Lehner, & Kaufmann, 2009; West & Bogers, 2014).

Our empirical studies of innovations in Southeast Asia present significant relationships between external knowledge sources and innovations (Machikita & Ueki, 2012; Tsuji, Idota, Ueki, Shigeno, & Bunno, 2016). Among various methods of knowledge transfer and exchanges, face-to-face interactions are effective to transfer tacit knowledge (Machikita & Ueki, 2015; Norasingh, Machikita, & Ueki, 2015; Kimura, Machikita, & Ueki, 2016). Therefore, this study focuses on different types of face-to-face interactions among engineers from different companies and their impacts on innovations.

Therefore, this study empirically investigate the following research question.

RQ1. Customer relationships are positively associated with innovations.

2.2. Human Resource Management

The definitions of absorptive capacity suggest that availability of external knowledge is not sufficient to enable firms and organizational units inside the firms to use it for innovation. Firms need to develop mechanisms for enhancing potential and realized capacity.

Organizational mechanisms associated with coordination capabilities enhance knowledge exchange within and across units. Job rotation is one of the organizational mechanisms widely implemented by firms that influence potential and realized absorptive capacity. Rotation of employees with different knowledge to a unit will enable the unit to acquire, assimilate, transform, and exploit knowledge new to the unit. The rotated employees will also bring new contacts to external knowledge into the unit, which increase absorptive capacity of the unit (Jansen, Van Den Bosch, & Volberda, 2005). Job rotation within a unit will have the most effect of knowledge sharing within the unit on absorptive capacity of the unit whereas the effects of rotation across units reach a wider range of the units within the firm. Thus, job rotation within a unit and across units may have different influence to absorptive capacity at the unit and firm level.

The absorptive capacity and related innovation literature lead to the investigations on HRM as a determinant of absorptive capacity. HRM literature is also aware of its relationship with innovation studies as Sheehan, Garavan, and Carbery (2013) point out the relationship between human resource development and innovation. However, according to De Leede and Looise (2005), innovation literature used to see HRM as a toolkit of specific practices that contribute to specific innovation activities or stages, whereas HRM literature take a more integrated look at the roles of HRM that contribute to both the creation of an innovative organization and specific innovation stages, activities, or projects. This comparative view is consistent to the argument that HRM or HRD to build trust and cooperation at the organizational level (Sheehan, et al., 2013).

Related to such discussion is the study by Khoja and Maranville (2010) based on the resource-based view that organizational culture fostering absorptive capacity is a firm specific resources leading to competitive advantages. Their study postulates that organizational culture is associated with absorptive capacity on the assumption that HRM practices will nurture organizational culture that promote the creation and sharing of knowledge within the organization.

HRM is relevant to a wide range of organizational unit from individual to group, and to the firm. As Hervas-Oliver, Garrigos, and Gil-Pechuan (2011) pay attention to the recruitment of tertiary degree employees, HRM also involve a variety of managerial practices that may affect innovations, such as recruitment, staffing, individual development and careers, team work, leadership, reward, communication and participation (De Leede & Looise, 2005; Sheehan, et al, 2013).

Based on these theoretical backgrounds and the empirical literature review, this study focus on rotational programs designed for engineers. By focusing on different levels of rotational programs including rotation within a unit, between units, and across the firm and career path program, this study attempts to discuss whether or not and in what way HRM practices will affect both the creation of an innovative organization and specific innovation projects.

RQ2. Human resource management practices are positively associated with innovations.

2.3. Top Management

Top management is one of the human resources, although HRM discussed above targets engineers and other employees. Top management may influence absorptive capacity, innovation, and firm performance by taking the initiatives in particular actions and decision makings.

Studies on top management and firm performance focus on top management characteristics and top management teams as determinants of firm performance, although particular characteristics of top management teams are associated with the firm performance. Top management literature supposes that particular characteristics of top management or top management team are related to top managements' consciousness that guide their strategic decisions or actions (Tihanyi, Ellstrand, Daily, & Dalton, 2000). Top management characteristics that may affect firm performance include education, organizational tenure, international experience, functional background, and team heterogeneity (Papadakis & Bourantas, 1998; Tihanyi, et al., 2000; Herrmann & Datta, 2005). With respect to team heterogeneity, top management team power inequality may result in a better firm performance when it leads to effective decision makings. It may be negatively correlated with firm performance when team power inequality creates lower quality, less creative strategic choices and hurts group cohesion (Smith, Houghton, Hood, & Ryman, 2006).

A concern about the studies on top management characteristics is the probable presence of the “black box” that may link top management characteristics with firm performance. Top management may influence absorptive capacity, innovation, and firm performance indirectly through “black box” (Tihanyi, et al., 2000). Thus, if this study does not find robust positive relationships between top management characteristics and innovations, further investigations may be needed to explore variables that mediate the relationships.

RQ3. Top management characteristics are positively associated with innovations.

3. METHOD

3.1. Data

This research project constructed a dataset by conducting questionnaire survey projects in Lao PDR, Thailand, and Vietnam in cooperation with local research institutes. The survey sites are selected mainly from major industrial districts in each country. The survey targets various types of establishments mainly in the manufacturing industries, which contain both locally- and foreign-owned and from small to large. The research project members developed a questionnaire in English. Local research institutes translate it into local languages, distributed it to firms, and collected responses from them during the period of December 2016 to March 2017.

The survey in Lao PDR geographically covers Vientiane municipality and two provinces of Champasak and Savannakhet that attract manufacturing industries in special economic zones (SEZ) developed in the border areas with Thailand. The Lao study team started the survey project in the middle of January 2017 and completed it by 10 March 2017. The Lao team distributed 290 set of the questionnaire door-to-door and made follow-up telephone calls to encourage firms to return the questionnaire. As a result, the Lao team collected 170 responses, achieving a 58.6% response rate.

The survey in Thailand focused on establishments located mainly in and around Bangkok. The Thai study team distributed 1,000 sets of the questionnaire directly to firms and collected 209 responses, which is equivalent to 20.9% response rate, during the period of December 2016 to February 2017. The survey project in Thailand took a two-step approach. The first is e-mail/mail survey of the firms located in Bangkok metropolitan area. By this approach, the team collect 57 responses (25 responses by e-mail and 32 by post), even though they distributed 1,000 sets of questionnaires. The second is phone calling and walking in interviews with the firms located in Bangkok metropolitan area, and industrial zones including Map Ta Phut Industrial Estate in Rayong and Amata Nakorn Industrial Estate in Chonburi. The team prepared another 400 sets of the questionnaire and collected 152 responses.

The survey in Vietnam targets establishments operating in and around the two major metropolitan regions, namely the greater Hanoi and greater Ho Chi Minh City regions. The Vietnamese study team selected 1,000 establishments in the regions and conducted a pilot survey with the participation of 20 firms. Then, the Vietnamese team sent out the questionnaire to the target firms and collected 154 valid responses (i.e., 15.4% response rate), which contain 82 responses from the greater Hanoi region and 72 from the greater Ho Chi Min City region. The Vietnamese team sent and collect the questionnaires in February 2017.

Thus, the dataset constructed by this study contains 533 observations in total. The observations for Thailand constitute of 39.2% of the entire observations, whereas those for Lao PDR and Vietnam comprise 31.9% and 28.9% of the total.

[Table 1 about here]

3.2. Main Variables

This dataset enables to investigate whether factors related to top management, HRM, and customer relationship may affect innovations. These factors are measures with the answers to the questions of the survey as shown in the Appendix table that list the variables used for this study.

The binary variables for top management are related to backgrounds of the top management including whether the top management used to be an engineer (variable name is *Engineer*), have experiences working for MNCs or joint ventures (JVs) (*Worked for MNCs*), is the main mentor for engineers in innovative activities (*Engineer's mentor*), and is the founder or from founder's family (*From founder's family*).

The binary variables for HRM are defined to identify the importance of engineers' capabilities and within- and between-organization networks that engineers can develop through their own working experiences. Firms can design rotational program and other personnel systems to give engineers various experiences and develop human assets necessary for innovative activities. This study asked to the establishments whether they have a program for their engineers to rotate within a department (*W/in a department*) or between departments (*B/w departments*), and to temporarily transfer to other establishments (*Secondment*). The survey also asked whether the establishments have a career path program to develop leaders of innovative activities (*Career path*).

Customer relationships for this study mean face-to-face interactive relationships among engineers that the respondent establishments have with their customers. This study introduces four binary variables defined based on the questions regarding whether the main customer dispatch personnel to the respondent establishment (*Customer dispatch*), whether the establishment provides training to the main customer (*Training to customer*), whether the establishment receives training from the main customer (*Training from customer*), and whether the establishment designs a new product or service with the main customer (*Co-design with customer*).

Innovation is categorized into product and process innovation. The indicator for product innovation consists of the following four types of product innovation during the period of 2015 to 2016: (1) a new product, redesigning packaging or significantly changing appearance design of the existing products of the respondent (*Redesign*); (2) a new product, significantly improving the existing products of the respondent, with respect to its capabilities, user friendliness, components, subsystems, etc. (*Improve*); (3) a totally new product based on the existing technologies for the respondent (*Existing_tech*); (4) a totally new product based on new technologies for the respondent (*New_tech*). Each of these product innovation types is measured on a 3 point Likert scale (i.e., 0 = Not tried yet, 1 = Tried, 2 = Achieved). Following the method of Bloom and Van Reenen (2007) and Machikita and Ueki (2015), this study simply sums up these four measures to derive the composite indicator for product innovation (*Sum_product*). Thus, the variable for product innovation ranges from 0 to 8.

The indicator for process innovation is calculated by using the same method for product innovation. This study can use the following 11 variables for process improvement during the period of 2015 to 2016: (1) reduced defects during production; (2) reduced labor input; (3) reduced lead time to introduce a new product; (4) reduced unscheduled line stop; (5) reduced worker's injuries; (6) reduced plant accidents; (7) reduced delivery delay; (8) reduced dispersion in product quality; (9) reduced time to changeover; (10) reduced claims from customers; (11) reduced plant maintenance costs. Each of these variables is measured on a 4 point Likert scale (0 = No, 1 = Little, 2 = Somewhat, 3 = Much). These 11 variables are aggregated into the composite indicator for process innovation (*Sum_process*). Thus the indicator for process innovation can range from 0 to 33.

Other variables that are important but not described in detail in the following sections are variables on local, country, and industry dummies that are introduced in the regression models as control variables. The dummy for local is coded 1 if the respondent firms are 100% locally owned, and otherwise 0. The dummy for country is coded according to the country where this study conducted the questionnaire survey.

4. RESULTS OF THE SURVEY

4.1. Characteristics of the Respondents

The questionnaire starts with questions about firm characteristics. Among the 533 respondent establishments, 67% of them are 100% locally-owned, whereas 20% and 10% are 100% foreign-owned and joint ventures (JVs), respectively. About 3% missing values contain 17 Thai respondents who did not answer the question. By country, local firms account for 52% in Lao PDR, 68% in Thailand, and 81% in Vietnam.

The respondents are mostly small and medium-sized enterprises (SMEs) in terms of the number of the full-time employees. About 62% of them employ less than 200 full-time personnel. The survey in Lao PDR collected more responses from SMEs, which account for 83% of the total number of the responses. SMEs also compose more than half of the respondents in Vietnam (53%) and Thailand (52%). The asset size of the respondents in Lao PDR is also smaller than in Thailand and Vietnam. About 70% of the entire respondents have a capital of US$ 4.9 million or less, whereas the percentages for Lao PDR, Vietnam, and Thailand are 91%, 69%, and 54%, respectively.

R&D activities are also heterogeneous among the respondents and these three countries. Some 53% of the respondents made no expenses on R&D. The figures for Lao PDR and Thailand are 63% and 62%. On the other hand, 29% of the respondents in Vietnam do not make expenses in R&D, whereas 62% of them allocate less than 1% of their total sales to R&D. Compared to R&D expenditure, the respondents devote more personnel to R&D activities. About 46% of the respondents do not have personnel dedicated to R&D activities. Among the three countries, the respondents who do not have R&D personnel account for 62% of those in Lao PDR, 44% in Thailand, and 29% in Vietnam. This figure indicates that the respondents in Vietnam are more active in R&D than in Thailand as a whole. On the other hand, R&D activities in Thailand are taken major roles by larger firms compared to Vietnam. About 7% of the respondents in Thailand have more than 50 R&D personnel, whereas the percentage for Vietnam is 2%.

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4.2. Characteristics of Top Management

The respondent establishments are operated by top managements with various backgrounds that may affect innovative activities. About 32% of the respondents have top management who is or used to be an engineer. The percentage is different among the countries. About 47% of the respondents in Vietnam have top managements with engineering backgrounds, whereas the percentage for Thailand is 22%, the lowest among the three countries.

Although FDI promotion policy expects knowledge transfer from MNCs through the domestic labor movement, less than half of the respondents have top management who worked for MNCs or JVs even though these establishments include the foreign-owned. The three countries have almost same figures, ranging from 45% to 47%.

The survey also presents the role of top managements in fostering engineers in innovative activities. Some 64% of the respondents have a top management who is a main mentor for engineers involved in innovative activities. The percentage is high for Lao PDR (75%) and Thailand (70%), compared to the figure for Vietnam (42%).

Ownership of the establishments may affect their risk-taking decisions on R&D investments. The dataset is based on information obtained from many family businesses. About 70% of the respondents have a top management who is a founder or from a founder's family. The figures for Lao PDR (81%) and Thailand (77%) are much higher than for Vietnam (49%).

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4.3. HRM for Capacity Building of Engineers

Skills and knowledge of engineers affect innovative activities. The survey asked the respondents about rotational programs and career path that may help engineers to deepen their own expertise and obtain new skills and knowledge.

Job rotation within a department is adopted by 37% of the respondents. The respondents in Lao PDR (56%) are more likely to adopt an intra-department rotation than in Thailand (33%) and Vietnam (22%).

The adoption rate of a job rotation between departments is 37% for the entire sample, which is the same as the rate for intra-department rotation. However, the percentage for Lao PDR is 43%, which is lower than the country-level figure for intra-department rotation. The adoption rate for Vietnam is 45%, so that the respondents in Vietnam have a higher propensity to introduce inter-department rotation than intra-department rotation. The penetration level for Thailand is 27%, the lowest among the three survey countries.

Like these job rotation programs, 31% of the respondents have a career path program to develop leaders of innovative activities. The adoption rate for Thailand is 36.4%, the highest among the three countries. The figures for Lao PDR and Vietnam are 35.9% and 19.5% respectively.

Firms also have a secondment program to give employees experiences working outside the firms. About 19% of the respondents give their engineers such opportunities. Among the three countries, 32% of the establishments in Thailand transfer their engineers to other establishments including their customers and suppliers. Such secondment program is introduced by 13% and 10% of the respondents in Vietnam and Lao PDR, respectively.

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4.4. Customer Relationships

About 39% of the respondents have face-to-face contacts with personnel from their main customer without regard to objectives of their contacts. More respondents in Vietnam (78%) have such relationships with their customer compared to those in Thailand (35%) and Lao PDR (9%).

If the contacts are limited to training purpose, the number of respondents who contact face-to-face with their main customer is decreased. Twenty percent of the respondents provide training to their main customer. The percentages for Thailand, Lao PDR, and Vietnam are 40%, 10%, and 6%, respectively.

One the other hand, about 29% of the respondents receive training from their main customer. The percentage for Thailand is 39%, the highest among the three countries, followed by Vietnam (30%) and Lao PDR (16%). These indicate that the establishments in Thailand are more likely to have teacher-student relationships with their partner firms.

Although less than 30% of the respondents provide to or receive from their customer technical assistance, 50% of the respondents cooperate with their customers for designing a new product or service. The respondents in Vietnam (65%) have established better links with their customer for this purpose than those in Thailand (49%) and Lao PDR (36%).

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4.5. Product and Process Innovation

As described above, the survey asked the respondents questions regarding the degrees of product and process innovations, which are quantified in the method described above.

The mean value for the introduction of a re-designed product is 1.12, which is followed by a significantly improved product (0.94), a new product based on the existing technology (0.89), and a new product based on new technologies (0.70). The mean value decreases as the product types require higher technologies. The mean value for a new product based on new technologies is the smallest for the three surveyed countries. The mean value of the composite indicator for product innovation (*Sum_product*) is 3.65 for the entire sample and distributed around 3.6 for each country.

The mean values for the 11 variables for process innovation ranges from 1.39 to 1.91. The higher mean values indicate more process improvements. The respondents make considerable achievements in the reductions of delivery delay (1.91), claims from customers (1.87), and dispersion in product quality (1.85). The lower mean values are associated with reductions of lead time to introduce a new product (1.39), labor input (1.41), and unscheduled line stop (1.52). The mean value of the composite indicator for process innovation (*Sum_process*) is 18.25 for the entire sample. The respondents in Lao PDR (19.26) demonstrate greater process improvements than in Thailand (18.45) and Vietnam (16.85).

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[Table 20 about here]

4.6. Mean-Comparison Tests

A mean-comparison test compares the mean values the composite indicator for product/process innovation between two samples grouped according to factors that may affect innovations. This test is useful to explore factors influential to innovative activities before performing regression analyses.

The results of the mean-comparison tests show that the mean values of the composite indicate for product innovation are not statistically different between the two groups divided according to characteristics of top management. Among the variables for rotational programs for engineers, career path and secondment to external organizations make a significant difference in the mean values. All variables for customer relationships except the dispatch of personnel from the main customer to the respondent establishment are statistically significant.

Characteristics of top management do not show substantial influences on the composite indicator for process innovation. All four variables for top management are not statistically significant. On the other hand, all four variables for HRM programs for engineers make significant differences in the mean values of process innovation indicator between groups with and without such programs. As in the case of product innovation, the grouping of the respondents by customer relationships excluding the dispatch of personnel from the main customer, generate statistically different mean values of process innovation.

These results of the mean-comparison tests suggest that product and process innovations are more likely to be dependent on HRM designed for engineers and customer relationships than characteristics of top management.

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5. MAIN RESULTS OF REGRESSIONS

5.1. Regressions of Product Innovation on Top Management Characteristics, HRM, and Customer Relationships

The results of the OLS estimations show that the role of top management as an engineers' mentor, and customer relationships such as provision of training and co-design of a new product have positive and statistically significant impacts on product innovation. None of the coefficients on the variables for rotational programs for engineers are statistically significant, contrary to the expectation from the results of the mean-comparison tests. Among the control variables included in the regressions, the coefficients on the variables for R&D expenditure and asset size are statistically significant at the 1% level.

These results indicate the importance of knowledge sharing with customers and the necessity of investments in R&D and other capital equipment to embark on R&D for product innovation. The significant impact of the provision of training to customers suggests that firms need to have high capabilities enough to teach their customers. The analyses could not verify direct involvements of top management in R&D activities for product innovations. However, top management can play a considerable important role in fostering engineers and encourage them to enhance skills and accomplish product development projects successfully.

[Table 27 about here]

5.2. Regressions of Process Innovation on Top Management Characteristics, HRM, and Customer Relationships

The results of the OLS estimations show positively significant impacts of rotational programs for engineers and customer relationships on process innovations as expected from the results of the mean-comparison tests. The estimated coefficients on rotation programs within a department, career path programs to develop leaders of innovative activities, and secondment to external organizations are positively significant at the 5% level. The coefficient on co-design with customer is significant at the 1% level, whereas those on dispatch of personnel from the main customer, receipt of training from the main customer are significant at the 10% level. On the other hand, no coefficients on the variables related to top management are statistically significant.

Among the control variables included in the regressions, the coefficient on R&D expenditure is statistically significant at the 1% or 5% level as in the case of product innovation. Differently from the result of product innovation, the estimated coefficients on asset size are not significant whereas the coefficients on R&D personnel are all statistically significant at the 5% or 10% level.

These findings indicate the important role of human factors (i.e. engineers and other employees) for process innovations, although R&D investments and customer relationships are necessary. Direct interventions by top management in activities for process innovation look limited in Southeast Asia, although further analyses are indispensable to conclude. The significant coefficients on rotation of engineers within a department and career path program and insignificant coefficient on rotation between departments may suggest the necessity for engineers to cultivate their expertise and related skills. The significant coefficients on secondment to external establishments, dispatch of personnel from the main customer, and receipt of training from the main customer emphasize the impact of knowledge transfer from outside, especially from customers. In addition to these results, the insignificant coefficient on provision of training to the main customer can be interpreted as indicating that firms need to develop capabilities enough to learn from their customers, rather than teaching capabilities, to achieve process innovations.

[Table 28 about here]

6. POSSIBLE ROLES OF TOP MANAGEMENT IN INNOVATION

The regressions did not derive robust relationships between the characteristics of top management and product/process innovations. Do top management characteristics have no impact on innovation?

6.1. Regressions of Customer Relationships on Top Management Characteristics

Previous studies on top management and top management team suggest the possible role of top management characteristics in the formation of customer relationships, which affect product and process innovations. Collins and Clark (2003) present the relationships between top management team social networks and firm performance and between network-building human resource practices and top management team social networks. Tihany, Ellstrand, Daily, and Dalton (2000) and Herrmann and Datta (2005) discuss top management team characteristics and internationalization.

HRM programs for engineers, which this study focuses on, may also have associations with customer relationships. Collins and Smith (2006) examine the association of human resource practices with knowledge exchange and firm performance. Chen and Huang (2009) show the mediating role of knowledge management capacity between human resource practices and innovation performance. Kesting, Mueller, Jørgensen, and Ulhøi (2011) claim that HRM practices can help SMEs to enter into network collaborations that will increase their innovation capability. Machikita, Tsuji, and Ueki (2016) empirically present that Kaizen activities help firms to enter into production networks where downstream customers provide technical assistance to their suppliers. Thus, this study performs regressions of customer relationships on top management characteristics and HRM programs.

The results of the probit estimation show that the dispatch of personnel from the customer is significantly associated with top management characteristics (i.e., engineering backgrounds and working experiences for MNCs) and rotational programs (i.e., rotation within a department and secondment to external organizations). Among the control variables, the significant coefficients on R&D personnel and insignificant ones on R&D expenditure imply face-to-face interactions among engineers from the respondent and its main customer, although the survey did not ask who interact with personnel dispatched by the main customer.

The provision of training to the main customer does not have significant relationships with the variables related to top management characteristics. Instead, this dependent variable is significantly affected by all variables related to the rotational programs at the 1 or 5% level. Additional findings include positive and significant coefficients on R&D expenditure and personnel. All of these results imply that the respondents capable of providing technical assistance to their main customer invest in R&D activities and cultivation of engineers. The HRM programs contribute not only to capacity building of engineers but also to networking among engineers from different establishments.

The receipt of training from the main customer depends on top management who worked for MNCs and rotation within a department. The estimated coefficients on these two variables are significant at the 1% level.

The respondents who co-design a new product or services with their main customer are more likely to have top management who is a founder or from founder’s family, rotation within department, and a career path program to develop leaders of innovative activities.

These estimation results present the effects of top management depend on the types of customer relationships. However, no particular variable for top management characteristics is consistently significant in the probit estimations. Therefore, all this study can indicate is that top management characteristics affect customer relationships, so that further studies are needed to answer the research question. On the other hand, the coefficient on rotation within a department has a significant effect on the four types of customer relationships at the 1% level. This finding suggests the necessity of cultivating skilled engineers with expertise for firms to achieve innovations through cooperation with customers.

6.2. Regressions of HRM on Top Management Characteristics

From a perspective of strategic HRM literature, characteristics of top management may affect strategic decisions that lead to innovation and long-term business goals of the firms. Thus, this study performs regressions of HRM (i.e., job rotation program designed for engineers) on top management characteristics.

The regressions of job rotation on top management characteristics derive the results that the respondents whose top management used to be an engineer or work for MNCs are more likely to introduce job rotation within a department and between departments and a career path program, whereas the respondents whose top management take the role of engineers' mentor are less likely to introduce these job rotation programs and a career path program. Top management who is a founder or from the founder's family is less likely to rotate engineers between departments of the firm.

These results imply that engineering backgrounds help top management to have a long term perspective that supports the development of HRM systems leading to capacity building of engineers. However, when top management exert a strong presence in R&D and engineering activities, or when firms are over-dependent on power and capabilities of talented top management in their strategic decision makings, firms place low priority on the invest in HRM and HRD for engineers.

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7. CONCLUSION

This study explores determinants of product and process innovations. Special attentions are paid to top management characteristics, HRM designed for engineers, and customer relationships as possible factors to promote product and process innovations.

This study found that top management as an engineers' mentor and customer relationships (specifically, provision of training to customers and co-design of a new product with customers) are significantly important factors for product innovations. Process innovations are more dependent on rotational programs for engineers (precisely, rotation within a department, career path programs to develop leaders of innovative activities, and secondment to external organizations) and customer relationships (specifically, co-design of a new product, dispatch of personnel from the main customer, receipt of training from the main customer), whereas the effects of top management characteristics on process innovations are insignificant.

Customer relationships have significant impacts on both product and process innovations. A managerial challenge for top management is to establish closer interactive relationships with their customers. Top managers can develop such relationships by using their engineering knowledge, working experiences for MNCs, and taking the strong leadership backed by a founder or founder's family backgrounds. This finding is consistent with Tsuji et al. (2016) that claim the role of top management as a gatekeeper.

HRM for engineers is a set of practices available for top managers to cultivate engineers indispensable to realize process innovations and deepen cooperative relationships with their customers for product and process innovations. Top managers can contribute to product innovations in the more direct manner by developing mentoring relationships with their engineers.

The regression analyses of this study do not necessarily show robust relationships between innovation and top management characteristics. On the other hand, the results also present the associations of top management characteristics with customer relationships and HRM. These findings imply that top management characteristics do not always have direct impacts on innovations but may affect strategic decisions regarding customer relationship, HRM, and other managerial issues related to company-wide business strategy and long-term business goals.

Public policies tend to emphasize the necessity of increasing R&D investments and personnel. This study illustrates significant coefficients on these variables that support such policy direction. In addition, this study provides novel evidence of the significant effect of HRM on customer relationships and innovations, after controlling for the effects R&D investments and personnel. The findings from this study demand policy supports to HRM practices in tandem with promotions of R&D investments and personnel development.

Further investigations are needed to apply more advanced estimation methods or identify other factors that may affect top management's decisions, including their nationality.

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APPENDIX

List of variables

Variable	Question and scale
Sum_product	The sum of the following four variables for the degree of a product innovation type measured on a 3 point Likert scale (0 = Not tried yet, 1 = Tried, 2 = Achieved).
	Introduction a new product, redesigning packaging or significantly changing appearance design of the existing products of the establishment
	Introduction of a new product, significantly improving the existing products with respect to its capabilities, user friendliness, components, subsystems, etc.
	Development of a totally new product based on the “existing” technologies for the establishment
	Development of a totally new product based on “new” technologies for the establishment
Sum_process	The sum of the following 11 variables for the degree of a process innovation type measured on a 4 point Likert scale (0 = No, 1 = Little, 2 = Somewhat, 3 = Much).
	Reduced defects during a manufacturing process
	Reduced labor input (man-hour)
	Reduced lead time to introduce a new product
	Reduced unscheduled line stop
	Reduced worker’s injuries
	Reduced plant accidents
	Reduced delivery delay
	Reduced dispersion in product quality
	Reduced time to changeover (converting production line)
	Reduced claims from customers
	Reduced plant maintenance costs
Top management	
Engineer	Was or Is the top management an engineer? (0 = No, 1= Yes)
Worked for MNCs	Does the top management have experiences working for MNCs or joint ventures (JVs)? (0 = No, 1= Yes)
Engineers' mentor	Is the top management the main mentor for engineers in innovative activities? (0 = No, 1= Yes)
From founder’s family	Is the top management the founder or from founder’s family? (0 = No, 1= Yes)

Engineer rotation	
W/in a department	Does your establishment have a rotational program for your engineers, in which they rotate through various roles within a department of your establishment? (0 = No, 1= Yes)
B/w departments	Does your establishment have a rotational program for your engineers, in which they rotate through various departments within your establishment? (0 = No, 1= Yes)
Career path	Does your establishment have a career path program for engineers to develop leaders of innovative activities? (0 = No, 1= Yes)
Secondment	Does your establishment have a secondment program (temporal transfer to other establishment) that gives your engineers opportunities to work at other establishments? (0 = No, 1= Yes)
Customer relationship	
Customer dispatch	Does the main customer dispatch personnel to the establishment? (0 = No, 1= Yes)
Training to customer	Does the establishment provide any training to the main customer? (0 = No, 1= Yes)
Training from customer	Does the establishment receive any training from the main customer? (0 = No, 1= Yes)
Co-design with customer	Does the establishment design a new product or service with the main customer? (0 = No, 1= Yes)
R&D expenditure	The ratio between R&D expenditure and sales at present (0 = No Expenditure, 1 = Less than 0.5%, 2 = 0.5–0.99%, 3 = 1% or more)
R&D personnel	The number of personnel who are dedicated to R&D activities (0 = None, 1 = 1–5 persons, 2 = 6–-10, 3 = 11–20, 4 = 21–30, 5 = 31–50, 6 = 51–100, 7 = 101 or more)
Asset	Total Assets (US$) (1 = Less than 10,000, 2 = 10,000–24,999, 3 = 25,000–49,999, 4 = 50,000–74,999, 5 = 75,000–99,999, 6 = 100,000–499,999, 7 = 500,000–999,999, 8 = 1 million–4.9 million, 9 = 5 million –9.9 million, 10 = 10 million or more)

Table: Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
Independent variables					
Sum_product	525	3.65	2.81	0	8
Sum_process	526	18.25	7.15	0	33
Top management					
Engineer	519	0.33	0.47	0	1
Worked for MNCs	526	0.46	0.50	0	1
Engineers' mentor	532	0.64	0.48	0	1
From owner family	527	0.71	0.45	0	1
Engineer rotation					
W/in a department	529	0.38	0.48	0	1
B/w departments	528	0.38	0.49	0	1
Career path	527	0.32	0.47	0	1
Secondment	521	0.20	0.40	0	1
Customer relationship					
Customer dispatch	525	0.40	0.49	0	1
Training to customer	528	0.21	0.41	0	1
Training from customer	527	0.29	0.46	0	1
Co-design with customer	527	0.50	0.50	0	1
Control variables					
R&D expenditure	524	0.84	1.06	0	3
R&D personnel	514	1.19	1.62	0	7
Asset	515	7.11	2.22	1	10
Local	516	0.69	0.46	0	1
Country dummy					
Lao PRD	533	0.32	0.47	0	1
Thailand	533	0.39	0.49	0	1
Vietnam	533	0.29	0.45	0	1

Source: ERIA Survey FY2016.

Tables and Figures

Table 1: The number of respondents

	Lao PDR	Thailand	Vietnam			Total
				Hanoi	Ho Chi Minh	
Obs.	170	209	154	82	72	533
Percent	31.9	39.2	28.9	15.4	13.5	100.0

Source: ERIA Survey FY2016.

Table 2: Capital structure

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
100% locally-owned	88	(51.8)	143	(68.4)	124	(80.5)	355	(66.6)
100% foreign-owned	65	(38.2)	20	(9.6)	21	(13.6)	106	(19.9)
Joint Venture	17	(10.0)	29	(13.9)	9	(5.8)	55	(10.3)
N.A.	0	(0.0)	17	(8.1)	0	(0.0)	17	(3.2)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 3: The number of full-time employees

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
1-19 persons	53	(31.2)	44	(21.1)	3	(1.9)	100	(18.8)
20-49	39	(22.9)	21	(10.0)	19	(12.3)	79	(14.8)
50-99	24	(14.1)	22	(10.5)	29	(18.8)	75	(14.1)
100-199	25	(14.7)	21	(10.0)	31	(20.1)	77	(14.4)
200-299	12	(7.1)	22	(10.5)	19	(12.3)	53	(9.9)
300-399	5	(2.9)	11	(5.3)	10	(6.5)	26	(4.9)
400-499	3	(1.8)	8	(3.8)	12	(7.8)	23	(4.3)
500-999	6	(3.5)	21	(10.0)	15	(9.7)	42	(7.9)
1,000-1,499	0	(0.0)	10	(4.8)	6	(3.9)	16	(3.0)
1,500-1,999	1	(0.6)	6	(2.9)	3	(1.9)	10	(1.9)
2,000 and above	1	(0.6)	20	(9.6)	7	(4.5)	28	(5.3)
N.A.	1	(0.6)	3	(1.4)	0	(0.0)	4	(0.8)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 4: The number of full-time employees

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
Less than 10,000	4	(2.4)	1	(0.5)	0	(0.0)	5	(0.9)
10,000-24,999	11	(6.5)	14	(6.7)	0	(0.0)	25	(4.7)
25,000-49,999	10	(5.9)	9	(4.3)	0	(0.0)	19	(3.6)
50,000-74,999	10	(5.9)	7	(3.3)	2	(1.3)	19	(3.6)
75,000-99,999	5	(2.9)	8	(3.8)	5	(3.2)	18	(3.4)
100,000-499,999	48	(28.2)	30	(14.4)	18	(11.7)	96	(18.0)
500,000-999,999	34	(20.0)	13	(6.2)	30	(19.5)	77	(14.4)
1 million-4.9 mil.	33	(19.4)	30	(14.4)	51	(33.1)	114	(21.4)
5 mil.-9.9 mil.	6	(3.5)	21	(10.0)	34	(22.1)	61	(11.4)
10 million and above	9	(5.3)	58	(27.8)	14	(9.1)	81	(15.2)
N.A.	0	(0.0)	18	(8.6)	0	(0.0)	18	(3.4)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 5: R&D expenditure per sales

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No Expenditure	107	(62.9)	129	(61.7)	45	(29.2)	281	(52.7)
Less than 0.5%	27	(15.9)	23	(11.0)	55	(35.7)	105	(19.7)
0.5-0.99%	16	(9.4)	22	(10.5)	40	(26.0)	78	(14.6)
1% or more	20	(11.8)	26	(12.4)	14	(9.1)	60	(11.3)
N.A.	0	(0.0)	9	(4.3)	0	(0.0)	9	(1.7)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 6: The number of R&D personnel

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
None	106	(62.4)	93	(44.5)	45	(29.2)	244	(45.8)
1-5 persons	58	(34.1)	41	(19.6)	21	(13.6)	120	(22.5)
6-10	6	(3.5)	21	(10.0)	34	(22.1)	61	(11.4)
11-20	0	(0.0)	10	(4.8)	31	(20.1)	41	(7.7)
21-30	0	(0.0)	3	(1.4)	15	(9.7)	18	(3.4)
31-50	0	(0.0)	7	(3.3)	5	(3.2)	12	(2.3)
51-100	0	(0.0)	7	(3.3)	3	(1.9)	10	(1.9)
101 or more	0	(0.0)	8	(3.8)	0	(0.0)	8	(1.5)
N.A.	0	(0.0)	19	(9.1)	0	(0.0)	19	(3.6)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 7: Top management with engineering background

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	116	(68.2)	150	(71.8)	82	(53.2)	348	(65.3)
Yes	54	(31.8)	45	(21.5)	72	(46.8)	171	(32.1)
N.A.	0	(0.0)	14	(6.7)	0	(0.0)	14	(2.6)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 8: Top management with working experiences at MNCs

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	93	(54.7)	108	(51.7)	82	(53.2)	283	(53.1)
Yes	77	(45.3)	94	(45.0)	72	(46.8)	243	(45.6)
N.A.	0	(0.0)	7	(3.3)	0	(0.0)	7	(1.3)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 9: Top management playing a role of mentor for engineers

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	42	(24.7)	61	(29.2)	89	(57.8)	192	(36.0)
Yes	128	(75.3)	147	(70.3)	65	(42.2)	340	(63.8)
N.A.	0	(0.0)	1	(0.5)	0	(0.0)	1	(0.2)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 10: Top management from founder's family

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	32	(18.8)	42	(20.1)	79	(51.3)	153	(28.7)
Founder	84	(49.4)	116	(55.5)	58	(37.7)	258	(48.4)
Founder's family	54	(31.8)	45	(21.5)	17	(11.0)	116	(21.8)
N.A.	0	(0.0)	6	(2.9)	0	(0.0)	6	(1.1)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 11: Rotational program for engineers within a department

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	75	(44.1)	135	(64.6)	120	(77.9)	330	(61.9)
Yes	95	(55.9)	70	(33.5)	34	(22.1)	199	(37.3)
N.A.	0	(0.0)	4	(1.9)	0	(0.0)	4	(0.8)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 12: Rotational program for engineers between departments

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	97	(57.1)	147	(70.3)	85	(55.2)	329	(61.7)
Yes	73	(42.9)	57	(27.3)	69	(44.8)	199	(37.3)
N.A.	0	(0.0)	5	(2.4)	0	(0.0)	5	(0.9)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 13: Career path for engineers to develop leaders of innovative activities

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	109	(64.1)	127	(60.8)	124	(80.5)	360	(67.5)
Yes	61	(35.9)	76	(36.4)	30	(19.5)	167	(31.3)
N.A.	0	(0.0)	6	(2.9)	0	(0.0)	6	(1.1)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 14: Secondment for engineers to work other establishments

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	153	(90.0)	131	(62.7)	134	(87.0)	418	(78.4)
Yes	17	(10.0)	66	(31.6)	20	(13.0)	103	(19.3)
N.A.	0	(0.0)	12	(5.7)	0	(0.0)	12	(2.3)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 15: Customer dispatch personnel

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	154	(90.6)	128	(61.2)	34	(22.1)	316	(59.3)
Yes	16	(9.4)	73	(34.9)	120	(77.9)	209	(39.2)
N.A.	0	(0.0)	8	(3.8)	0	(0.0)	8	(1.5)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 16: Provision of training to customer

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	153	(90.0)	121	(57.9)	145	(94.2)	419	(78.6)
Yes	17	(10.0)	83	(39.7)	9	(5.8)	109	(20.5)
N.A.	0	(0.0)	5	(2.4)	0	(0.0)	5	(0.9)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 17: Receipt of training from customer

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	143	(84.1)	122	(58.4)	108	(70.1)	373	(70.0)
Yes	27	(15.9)	81	(38.8)	46	(29.9)	154	(28.9)
N.A.	0	(0.0)	6	(2.9)	0	(0.0)	6	(1.1)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 18: Co-design of a new product with customer

	Lao PDR		Thailand		Vietnam		Total	
	Obs.	(%)	Obs.	(%)	Obs.	(%)	Obs.	(%)
No	109	(64.1)	100	(47.8)	54	(35.1)	263	(49.3)
Yes	61	(35.9)	103	(49.3)	100	(64.9)	264	(49.5)
N.A.	0	(0.0)	6	(2.9)	0	(0.0)	6	(1.1)
Total	170	(100.0)	209	(100.0)	154	(100.0)	533	(100.0)

Table 19: Mean of the variable for product innovation

	Lao PDR		Thailand		Vietnam		Total	
	Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean	Obs.
Redesign	0.89	170	0.93	203	1.64	154	1.12	527
Improve	0.95	170	0.94	203	0.95	154	0.94	527
Existing_tech	1.01	170	0.95	202	0.68	154	0.89	526
New_tech	0.84	170	0.85	201	0.34	154	0.70	525
Sum_product	3.68	170	3.66	201	3.61	154	3.65	525

Note: The composite indicator for product innovation (*Sum_product*), ranging from 0 to 8, is the sum of four variables for the degree of a product innovation type measured on a 3 point Likert scale (0 = Not tried yet, 1 = Tried, 2 = Achieved).

Table 20: Mean of the variable for process innovation

	Lao PDR		Thailand		Vietnam		Total	
	Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean	Obs.
Reduced defects during production	1.88	170	1.64	205	1.76	154	1.75	529
Reduced labor input	1.52	170	1.39	207	1.32	154	1.41	531
Reduced lead time to introduce a new product	1.18	170	1.41	206	1.60	154	1.39	530
Reduced unscheduled line stop	1.55	170	1.52	204	1.39	154	1.49	528
Reduced worker's injuries	2.12	170	1.78	206	1.28	154	1.74	530
Reduced plant accidents	2.11	170	1.84	205	1.25	154	1.75	529
Reduced delivery delay	2.01	170	1.91	207	1.79	154	1.91	531
Reduced dispersion in product quality	1.93	170	1.86	206	1.76	154	1.85	530
Reduced time to changeover	1.59	170	1.61	204	1.49	154	1.57	528
Reduced claims from customers	1.86	170	1.85	204	1.91	154	1.87	528
Reduced plant maintenance costs	1.51	170	1.66	207	1.30	154	1.51	531
Sum_process	19.26	170	18.45	202	16.85	154	18.25	526

Note: The composite indicator for process innovation (*Sum_process*), ranging from 0 to 33, is the sum of 11 variables for the degree of a process innovation type measured on a 4 point Likert scale (0 = No, 1 = Little, 2 = Somewhat, 3 = Much).

Table 21: Top management characteristics and product innovation

	Engineer		Worked for MNCs		Engineers' mentor		From founder's family	
Group	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
No	344	3.7	280	3.5	188	3.4	153	3.8
Yes	169	3.6	240	3.8	336	3.8	367	3.6
Total	513	3.7	520	3.6	524	3.7	520	3.6
Ha: diff != 0								
Pr(|T| > |t|)	0.59		0.22		0.17		0.34	

Note: The composite indicator for product innovation, ranging from 0 to 8.

Table 22: Engineer rotation and product innovation

	W/in a department		B/w a department		Career path		External secondment	
Group	Obs.	Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
No	325	3.5	324	3.5	356	3.5	415	3.5
Yes	197	3.9	198	3.8	165	4.1	101	4.4
Total	522	3.7	522	3.6	521	3.7	516	3.7
Ha: diff != 0								
Pr(|T| > |t|)	0.19		0.21		0.02		0.00	

Note: the same as in Table

Table 23: Customer relationship and product innovation

	Customer dispatch		Training to customer		Training from customer		Co-design with customer	
Group	Obs.	Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
No	312	3.5	415	3.4	369	3.4	258	3.2
Yes	208	3.8	107	4.5	153	4.2	264	4.1
Total	520	3.6	522	3.6	522	3.6	522	3.6
Ha: diff != 0								
Pr(|T| > |t|)	0.29		0.00		0.01		0.00	

Note: the same as in Table

Table 24: Top management characteristics and process innovation

	Engineer		Worked for MNCs		Engineers' mentor		From founder's family	
	Obs	Mean	Obs	Mean	Obs	Mean	Obs	Mean
No	344	18.0	280	17.7	189	17.9	153	18.5
Yes	170	18.6	241	18.9	336	18.5	368	18.1
Total	514	18.2	521	18.2	525	18.3	521	18.2
Ha: diff != 0								
Pr(|T| > |t|)	0.35		0.06		0.40		0.54	

Note: The composite indicator for process innovation, ranging from 0 to 33.

Table 25: Engineer rotation and process innovation

	W/in a department		B/w a department		Career path		External secondment	
Group	Obs.	Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
No	327	17.1	326	17.7	357	17.3	416	17.7
Yes	196	20.1	197	19.1	165	20.3	100	20.4
Total	523	18.2	523	18.2	522	18.3	516	18.2
Ha: diff != 0								
Pr(|T| > |t|)	0.00		0.04		0.00		0.00	

Note: the same as in Table

Table 26: Customer relationship and process innovation

	Customer dispatch		Training to customer		Training from customer		Co-design with customer	
Group	Obs.	Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
No	312	17.8	415	17.8	370	17.7	261	17.3
Yes	208	18.9	108	20.0	152	19.6	261	19.2
Total	520	18.3	523	18.2	522	18.3	522	18.3
Ha: diff != 0								
Pr(|T| > |t|)	0.11		0.00		0.00		0.00	

Note: the same as in Table

Table 27: Top management characteristics, HRM, customer relationship, and product innovation, OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Top management												
Engineer	-0.44											
	(0.29)											
Worked for MNCs		0.07										
		(0.26)										
Engineers' mentor			0.65**									
			(0.28)									
From founder's family				0.01								
				(0.29)								
Engineer rotation												
W/in a department					-0.14							
					(0.29)							
B/w departments						-0.09						
						(0.28)						
Career path							0.02					
							(0.30)					
Secondment								0.49				
								(0.37)				
Customer relationship												
Customer dispatch									-0.24			
									(0.33)			
Training to customer										0.84**		
										(0.38)		
Training from customer											0.41	
											(0.30)	
Co-design with customer												0.51*
												(0.27)
R&D expenditure	0.39***	0.38***	0.41***	0.38***	0.42***	0.41***	0.40***	0.41***	0.39***	0.37***	0.40***	0.40***
	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.14)	(0.15)	(0.14)	(0.14)	(0.14)
R&D personnel	0.15	0.14	0.12	0.14	0.12	0.10	0.09	0.08	0.11	0.04	0.10	0.08
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Asset	0.20***	0.20***	0.23***	0.21***	0.21***	0.22***	0.21***	0.21***	0.22***	0.22***	0.22***	0.22***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)
Observations	470	476	479	476	479	479	478	473	478	479	479	479
Adjusted R-squared	0.08	0.08	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.09	0.09	0.09

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Local, country, and industry dummies are included.

Table 28: Top management characteristics, HRM, customer relationship, and process innovation, OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Top management												
Engineer	0.22											
	(0.70)											
Worked for MNCs		0.32										
		(0.69)										
Engineers' mentor			0.44									
			(0.69)									
From founder’s family				-0.28								
				(0.74)								
Engineer rotation												
W/in a department					1.79**							
					(0.73)							
B/w departments						0.31						
						(0.67)						
Career path							1.65**					
							(0.75)					
Secondment								2.00**				
								(0.96)				
Customer relationship												
Customer dispatch									1.57*			
									(0.81)			
Training to customer										1.06		
										(0.97)		
Training from customer											1.25*	
											(0.72)	
Co-design with customer												1.76***
												(0.66)
R&D expenditure	0.98***	1.06***	0.94***	1.07***	0.87**	0.91***	0.90**	0.96***	0.96***	0.90**	0.93***	0.91***
	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)	(0.35)	(0.34)	(0.35)	(0.35)	(0.34)
R&D personnel	0.47*	0.46*	0.60**	0.46*	0.48*	0.58**	0.48*	0.48*	0.52**	0.55**	0.55**	0.50**
	(0.24)	(0.24)	(0.25)	(0.24)	(0.25)	(0.25)	(0.25)	(0.26)	(0.24)	(0.25)	(0.25)	(0.24)
Asset	0.28	0.24	0.19	0.24	0.16	0.19	0.13	0.18	0.16	0.18	0.19	0.18
	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)	(0.20)
Observations	470	476	479	476	479	479	478	472	477	479	478	478
Adjusted R-squared	0.07	0.07	0.06	0.07	0.06	0.06	0.07	0.07	0.07	0.06	0.06	0.07

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Local, country, and industry dummies are included.

Table 29: Top management characteristics, HRM, and customer relationship (Customer dispatch personnel), Marginal effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Top management								
Engineer	0.17***							
	(0.06)							
Worked for MNCs		0.13**						
		(0.06)						
Engineers' mentor			0.02					
			(0.06)					
From founder’s family				-0.01				
				(0.06)				
Engineer rotation								
W/in a department					0.18***			
					(0.07)			
B/w departments						0.08		
						(0.06)		
Career path							0.08	
							(0.07)	
Secondment								0.14*
								(0.08)
R&D expenditure	-0.03	-0.03	-0.02	-0.03	-0.03	-0.03	-0.03	-0.02
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
R&D personnel	0.05**	0.04**	0.05**	0.05**	0.04*	0.05**	0.04**	0.05**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Asset	0.05***	0.06***	0.06***	0.06***	0.05***	0.05***	0.05***	0.05***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Observations	468	474	477	474	477	477	476	471
Pseudo R-squared	0.402	0.398	0.383	0.391	0.394	0.386	0.384	0.391

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Local, country, and industry dummies are included.

Table 30: Top management characteristics, HRM, and customer relationship (Provide training to customer), Marginal effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Top management								
Engineer	-0.02							
	(0.03)							
Worked for MNCs		0.05						
		(0.03)						
Engineers' mentor			0.00					
			(0.04)					
From founder's family				-0.03				
				(0.04)				
Engineer rotation								
W/in a department					0.12***			
					(0.04)			
B/w departments						0.08**		
						(0.04)		
Career path							0.11***	
							(0.04)	
Secondment								0.20***
								(0.06)
R&D expenditure	0.05***	0.05***	0.05***	0.05***	0.05***	0.05***	0.05***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
R&D personnel	0.05***	0.05***	0.05***	0.05***	0.04***	0.05***	0.04***	0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Asset	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	451	456	464	456	464	464	463	457
Pseudo R-squared	0.296	0.301	0.308	0.297	0.327	0.315	0.326	0.352

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Local, country, and industry dummies are included.

Table 31: Top management characteristics, HRM, and customer relationship (Training from customer), Marginal effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Top management								
Engineer	0.04							
	(0.05)							
Worked for MNCs		0.16***						
		(0.05)						
Engineers' mentor			0.04					
			(0.05)					
From founder’s family				0.06				
				(0.05)				
Engineer rotation								
W/in a department					0.15***			
					(0.05)			
B/w departments						0.08		
						(0.05)		
Career path							0.06	
							(0.05)	
Secondment								0.09
								(0.06)
R&D expenditure	0.04*	0.04*	0.04*	0.04*	0.04*	0.04	0.04*	0.04*
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
R&D personnel	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Asset	0.02*	0.02	0.02*	0.02*	0.02	0.02	0.02	0.02*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	460	466	469	466	469	469	468	463
Pseudo R-squared	0.140	0.164	0.148	0.144	0.169	0.148	0.150	0.156

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Local, country, and industry dummies are included.

Table 32: Top management characteristics, HRM, and customer relationship (Co-design with customer), Marginal effect

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Top management								
Engineer	0.08							
	(0.06)							
Worked for MNCs		0.01						
		(0.05)						
Engineers' mentor			0.05					
			(0.06)					
From founder’s family				0.23***				
				(0.06)				
Engineer rotation								
W/in a department					0.17***			
					(0.06)			
B/w departments						0.08		
						(0.05)		
Career path							0.14**	
							(0.06)	
Secondment								0.08
								(0.07)
R&D expenditure	0.03	0.04	0.04	0.04	0.03	0.03	0.03	0.05*
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
R&D personnel	0.04*	0.04**	0.05**	0.05**	0.03*	0.04**	0.03	0.04**
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Asset	0.02*	0.02	0.02	0.03**	0.02	0.02	0.02	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Observations	471	477	480	477	480	480	479	474
Pseudo R-squared	0.124	0.125	0.127	0.147	0.139	0.129	0.134	0.135

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Local, country, and industry dummies are included.

Table 33: HRM and top management characteristics, Marginal effect

	(1) W/in a department	(2) B/w departments	(3) Career path	(4) Secondment
Top management				
Engineer	0.27*	0.37**	0.32**	-0.13
	(0.15)	(0.15)	(0.16)	(0.19)
Worked for MNCs	0.41***	0.41***	0.32**	0.16
	(0.14)	(0.14)	(0.15)	(0.18)
Engineers' mentor	-0.27*	-0.28*	-0.30*	-0.25
	(0.15)	(0.15)	(0.16)	(0.18)
From founder's family	0.03	-0.60***	0.24	-0.03
	(0.17)	(0.15)	(0.17)	(0.20)
R&D expenditure	0.08	0.07	0.06	0.07
	(0.07)	(0.07)	(0.07)	(0.09)
R&D personnel	0.17***	0.10*	0.28***	0.16**
	(0.05)	(0.05)	(0.06)	(0.06)
Asset	0.03	0.05	0.08*	0.11**
	(0.04)	(0.04)	(0.04)	(0.06)
Local	0.02	0.39**	0.03	-0.53**
	(0.18)	(0.18)	(0.19)	(0.22)
Observations	471	469	455	426
pseudo-R-squared	0.195	0.169	0.186	0.236

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Local, country, and industry dummies are included.