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Innovation, firm productivity, and export survival: firm-level evidence from ASEAN developing countries

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Abstract

This firm-level study investigates the importance of innovation as a determinant of firm productivity and how firm productivity could impact firm export survival. This is the first integration of the innovation approach, productivity approach, and firm survival approach to explore their linkages at the regional level in ASEAN developing countries. Using the panel database from the World Bank Enterprise Survey, which covers six developing countries in ASEAN—the Philippines, Indonesia, Vietnam, Laos, Cambodia, and Myanmar—and also covers six selected industries, we construct four equations: innovation inputs, innovation output, firm productivity, and export survival. The four equations' findings suggest that the technology level of the sector, firm size, and exports are significant factors for R&D expenditure (innovation input). R&D expenditure is a significant driver of a firm's product and process innovation (innovation output). Increasing firm productivity in the six ASEAN developing countries we considered is driven by process innovation rather than product innovation, and productive firms are more likely to survive in the export market.

Keywords: Firm survey, Innovation, Firm productivity, Export survival, ASEAN

JEL Classification: D24, F14, F23, O31

1 Introduction

The ASEAN Economic Community (AEC) was established in 2015. Promoting productivity is one of the AEC blueprint agendas through to 2025 to ensure sustainable and inclusive growth. One of the AEC's strategies is to be a highly competitive economic region in the prospect of efficiency and productivity growth. Meanwhile, the main aim (to be a more competitive economic region) involves promoting innovation, improving the business environment and infrastructure development, and strengthening participation in the global value chain to promote inclusive and sustainable economic growth.

Many governments in ASEAN developing countries are now focusing on promoting productivity. Meanwhile, endogenous growth theory (Romer 1990) stated that innovation and productivity could be absorbed from outside countries through trade channels. However, at the firm level, as noted in Appendix Box 1, the World Bank Enterprise Survey provides panel data quantifying exporting firms' behavior between two timepoints

between 2009 and 2017 in six ASEAN developing countries, revealing that most ASEAN developing countries have fewer large and SME exporting firms. Neither large firms nor SMEs can sustain and exit from the export market, and only a small number of SMEs have successfully expanded to become large firms.

Many previous studies have well established that innovation could lead the firm to have higher productivity. However, the study at firm-level analysis is still limited to a single country, not at a regional level. This firm-level analysis should help the policymaker better understand the firm's behavior and help to tailor the policy to achieve the goal of productivity promotion and inclusive growth. The purpose of this study is to explore the linkages between innovation, firm productivity, and export survival at the firm level of ASEAN developing countries by showing how innovation determines firm productivity and how firm productivity enhances export survival using the World Bank Enterprise Survey data from six developing countries in the ASEAN region. The following research questions will be addressed: (1) How innovation impacts firm productivity? (2) How firm productivity impacts a firm's export survival?

The main finding of our study is that innovation determines firm productivity; understanding this will help firms in the six ASEAN developing countries retain competitiveness to survive in the global market.

This paper is organized as follows. Section 2 discusses the literature review. Section 3 presents the methodology. Section 4 presents the data construction. Section 5 presents the results and discussion. The last section reviews the conclusions, policy implications, and future direction.

2 Literature review

2.1 CDM model concept

This study is connected to the concept of the study by Crépon et al. (1998) to investigate the firm level in France, exploring the linkages between innovation input and productivity, by constructing the structural model that involving three steps; firm's determination on innovation input, how innovation input impact on innovation output, and the relation between innovation output and firm productivity. This structural model has known as the CDM model. This paper's results suggested that firm size, market diversification, and the sector's technology level are the key drivers for firm engagement in innovation input (R&D investment). Innovation output (patent numbers, innovative sales) significantly increases following R&D investment, and finally, innovation output has a high correlation with firm productivity.

Several studies have applied the CDM model to study the relationship between R&D, innovation, and firm productivity and extend to the trade. For example, Halpern and Muraközy (2012) paper adopted the CDM model to study innovation, firm productivity, and exports at the firm level in Hungary. Their first contribution was to find the linkages between innovation, firm productivity, and trade performance of a firm. They found that an innovative firm is more likely to be more productive and export to more countries. They also found that foreign firms weakly determine innovation output. Another study in ASEAN countries was a single country study by Lee (2008) that looked at the relationship between innovation, productivity, and exports at the firm level in Malaysia. He found that the technology level of the sector and exporting impact on the firm impacted

intent to conduct R&D, but not the intensity of the R&D expenditure. Only firm size had an impact on both R&D decisions and the intensity of R&D expenditure. He also found an R&D expenditure impact on process innovation rather than product innovation. Process innovation is a driver of firm productivity, which is influenced by exporting and is related to the decision to conduct R&D.

For this study contributes by extending the CDM structural model to include how Total Factor Productivity (TFP)'s firm impacts the firm's export survival and the methodological contribution by taking into account the possibility of the endogeneity of the TFP's firm.

2.2 Product and process innovation definition

According to the Oslo Manual (OECD 2005), product innovation can be described as introducing new goods and services such as a digital camera that uses new technologies. New goods also include a minor change in the technical specification, such as a new detergent that uses the chemical composition previously only used in the coating production.

Significant improvement in components, materials and incorporate software such as a new introduction in ABS braking or GPS for car navigation is also considered the product innovation. The AIRism, which is highly breathable and quick-drying of clothes, is also an example of the significant improvement by using the new material to improve the product's performance.

Process innovation can be described as the implementation of new or significantly improved production or delivery methods. It also includes significant techniques such as installing automation in production that has an intention to decrease unit cost or improve the quality. Market innovation can be described as implementing a new marketing method such as the product or packaging design. Organizational innovation is also defined as an organization's implementation that intends to increase the firm's performance.

Previous studies have distinguished the innovation output of the process and product innovation. Bernard et al. (2009) explained that the difference between product and process innovation is that product innovation can be described as product-level expertise, while process innovation can be described as a firm-level ability. Moreover, Balwin and Harrigan (2011) added that improved product quality comes from consumer demand for product innovation. Therefore, product innovative firms can export to more markets directly without achieving firm productivity. Another study by Otchia (2020) also distinguished between product innovation and process innovation the interaction term between product and process innovation. His study also connected the innovation approach with the export survival approach by using Stata Extended Regression Models to show that export survival depends on innovation.

The definition of innovation in this study is based on the Oslo Manual using product and process innovation using the World Bank Enterprise Survey (WBES) database that also has distinguished between product and process innovation.

2.3 Relationship between innovation and firm productivity

Most literature has studied a specific sector and country. Reichstein and Salter (2006) studied manufacturing firms in the UK. They found that the impact of the process innovation, defined as new input material, task specification, new equipment that put in the production or service operation, and the process innovation, increased the firm productivity. Atalay et al. (2013) studied the relationship between technological innovation (product and process innovation) and the firm performance in the automobile industry in Turkey. The study found that technological product and process innovation could lead firms to survive and become more efficient and profitable than non-innovative firms.

In the Pakistan study by Saleem et al. (2019), innovation significantly contributes to the TFP, including imported machinery, education, and trade openness contribute to the TFP in Pakistan.

Another study by Hu et al. (2020) found that innovation in products and processes could help the hotel business in Ghana become more expandable and profitable than non-innovative hotel businesses.

Our contribution to the above literature is to provide evidence at the regional level for ASEAN developing countries. To my knowledge, this is the first study of the linkage of the innovation approach, productivity approach, and export survival approach at the regional level in ASEAN developing countries. The second contribution is extending the equation of R&D expenditure with the market share by constructing the ASEAN market share by combining the export market's macro variable from the UN Comtrade with the firm-level data from the World Bank Enterprise Survey. The third contribution is to extend the equation of the innovation output to consider the years of education of workers, according to the study by Vinding (2006) and Na (2021). A higher level of education among employees can support product or process innovation, organizational, marketing, and R&D investments.

3 Methodology

3.1 How does innovation impact firm productivity?

To answer the first research question, this study's framework, as shown in Fig. 1, applied the CDM model by establishing the first three main equations: innovation input, innovation output, and TFP.

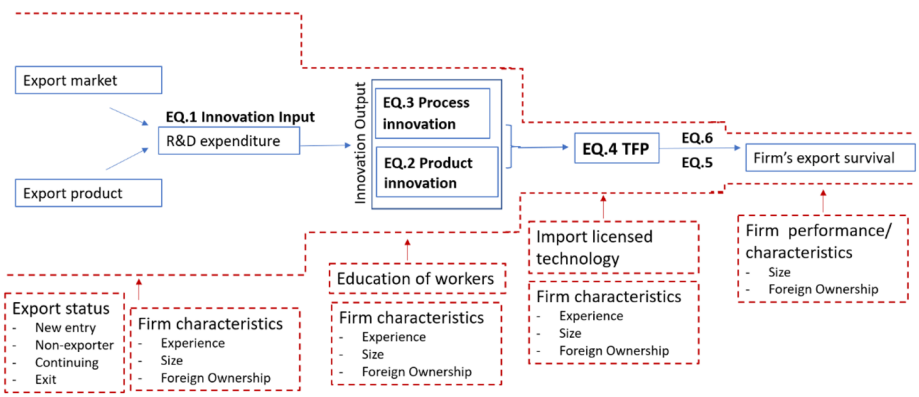


Fig. 1 A framework of the present research (source: author)

In the first equation, the innovation input equation, this study used R&D expenditure as an innovation input, then investigated what factors determine R&D expenditure. Adopting the framework study by Crépon et al. (1998), the independent variables were market concentration and the technology level of the sector, controlling for firm characteristics (firm experience, firm size, foreign-owned firm, and export status).

The R&D expenditure model was modified from Lee (2008), as shown in Eq. 1:

$$\mathrm{rd}_{it}^{*} = \beta_0 + \beta_1 x_{it} + \beta_1 \mathrm{Characteristics}_{it} + \nu_{it}, \tag{1}$$

where rd_{it}^{*} is the binary variable of R&D expenditure of firm i at time t, x_{it} is the explanatory variable of firm i at time t, which are the export market concentration (the Herfindahl–Hirschman index: HHI), medium to the high technology level of the sector (MH). This export market is the (log) ASEAN market share to total export. The details on how to construct the ASEAN market variable are explained in the data construction section. The export status is a binary variable: export = 1, non-exporter = 0. This study also distinguishes the export status into four types: new entry firm = 1, 0 = otherwise, non-exporter = 1, 0 = otherwise, continuing exporting firm = 1, 0 = otherwise, exit firm = 1, 0 = otherwise). $\mathrm{Characteristics}_{it}$ of firm i at time t are (log) employment, (log) age, and (%) foreign ownership, divided by 100, and ν_{it} denotes year survey, sector, and country of the firm to control each dimension's effects and errors.

The second equation is the innovation output equation. This study distinguished product innovation (Eq. 2) and process innovation (Eq. 3) to see R&D's independent impacts on product innovation and process innovation. This equation includes the number of years of workers' education to control the impact of worker education on product and process innovation:

$$\text{Product Innovation}_{it}^{*} = \beta_0 + \beta_1 x_{it} + \beta_1 \mathrm{Characteristics}_{it} + \nu_{it}, \tag{2}$$

$$\text{Process Innovation}_{it}^{*} = \beta_0 + \beta_1 x_{it} + \beta_1 \mathrm{Characteristics}_{it} + \nu_{it}, \tag{3}$$

where $\text{Product Innovation}_{it}^{*}$ is the binary variable of firm i at time t; product innovation = 1 if the firm has product innovation, 0 = if the firm has no product innovation. $\text{Process Innovation}_{it}^{*}$ is the binary variable of firm i at time t; process innovation = 1 if the firm has process innovation, 0 = the firm has no process innovation. The details on constructing the product and process innovation variables are explained in the data construction section. x_{it}, both in Eqs. 2 and 3, is the R&D expenditure (rd_{it}^{*}), years of education of workers, and export status. $\mathrm{Characteristics}_{it}$ and ν_{it} have the same definition as in Eq. 1.

The third equation, the TFP equation to test the relationship between total factor productivity (TFP) and innovation output and how to measure the TFP from the World Bank Enterprise Survey, are explained in the data construction section. This equation also included imported licensed technology, as the imported machine has a significant and positive impact on the innovation (Saleem et al. 2019):

$$\ln \mathrm{TFP}_{it}^{*} = \beta_0 + \beta_1 x_{it} + \beta_2 \mathrm{Characteristics}_{it} + \nu_{it}, \tag{4}$$

where $\ln \text{TFP}^*_{it}$ is the (log) TFP of firm i at time t, and x_{it} is Product Innovation$^*_{it}$, Process Innovation$^*_{it}$ and the interaction term between product and process innovation (product X process). This model also includes the imported licensed technology of firm i at time t, a binary variable.Characteristics$_{it}$ and ν_{it} have the same definition as in Eq. 1.

3.2 How does firm productivity impact firm export survival?

This section contributes to the literature of the CDM model (Crépon et al. 1998) by including how TFP's firm impacts the firm's export survival as represented by Eq. 5 and the methodological contribution by taking into account the possibility of the endogeneity of the TFP's firm. It is represented by Eq. 6, instrumenting the TFP in Eq. 5 with the estimated TFP from Eq. 4:

$$\text{Export Survival}^*_{it} = \beta_0 + \beta_1 \ln \text{TFP}_{it} + \beta_2 \text{Characteristics}_{it} + \nu_{it}, \tag{5}$$

$$\text{Export Survival}^*_{it} = \beta_0 + \beta_1 \text{Estimated TFP}_{it} + \beta_2 \text{Characteristics}_{it} + \nu_{it}, \tag{6}$$

where Export Survival$^*_{it}$ is a binary variable = 1 if the firm exports both in the first and second survey rounds, and = 0 otherwise. $\ln \text{TFP}_{it}$ is the (log) TFP of firm i at time t. Estimated TFP$_{it}$ is the TFP that has to take the firm with have process innovation, import license technology, and high foreign ownership into account [estimated TFP from Eq. 4 model (3)]. Characteristics$_{it}$ is the (log) employment and the (%) foreign ownership, divided by 100 of firm i at time t. ν_{it} has the same definition as in Eq. 1.

4 Data construction

This section provides details of the data construction. Descriptive statistics are shown in Appendix Table 8.

Firm survey data for this study used a unique panel dataset between 2009 and 2017, as shown in the sample description in Appendix Table 7, from the World Bank Enterprise Survey (WBES 2019), covering the top six selected industries: electronic products, non-metallic, and mineral products, rubber and plastic products, food and beverages, chemicals, and textiles and apparel, of six ASEAN developing countries (the Philippines, Indonesia, Vietnam, Laos, Myanmar, and Cambodia), as shown in Table 1. These industries comprise about 60% of exports of all ASEAN countries, and the selected industries represent 52.1% of the total firms in the World Bank Enterprise Survey (WBES).

Total factor productivity (TFP) at the firm level in this study was calculated from the WBES panel database from 2009 to 2017 that provides six countries and six selected export sectors using the OLS method, following the study by Saliola and Seker (2012) and Erick and Mendez (2018) under the assumption of the increasing return to scale and perfect competitive market for the production function:

$$\text{va}_{it} = \beta_0 + \beta_k k_{it} + \beta_l l_{it} + \nu_{it}, \tag{7}$$

$$\text{tfp}_{it} = \text{va}_{it} - \hat{\beta}_k k_{it} + \hat{\beta}_l l_{it}, \tag{8}$$

Table 1 Export values by industry compared to the total number of survey firms from WBES

Sector	% total export value (2017)	Number of survey firms	% of total survey firms
1. Electronic products	26.0	111	3.6
2. Non-metallic and mineral products	10.6	202	6.6
3. Rubber and plastic products	6.0	225	7.4
4. Food and beverages	11.0	355	11.7
5. Chemicals	2.1	197	6.5
6. Textile and apparel	4.0	496	16.3
Selected industries (from 1. to 6.)	59.6	1586	52.1
Other	40.4	1458	47.9
Total	100.0	3044	100

Source: author's calculations using World Bank Enterprise Survey and ASEAN Secretariat

where va_{it} denotes the (log) value-added (sales—intermediate inputs) of firm i at time t. $\hat{\beta}_k, \hat{\beta}_l$ is the parameter for capital and labor, respectively, estimated from Eq. 7. k_{it}, l_{it} denotes the (log) capital and (log) labor, respectively.

Export market The limitation of the study from the WBES is where to export. The destination of export also matters. Exporting to a high-level income country can also be beneficial because those firms can improve production quality. Therefore, this study contributes by mapping firm-level data of WBES with macro variables from UN Comtrade (2020). Appendix Fig. 2 shows how to construct an export market.

The technology level of the sector At the firm-level, in panel form of the WBES, this study grouped export products into the medium–high technology level of the sector based on the classification of the technology level of the sector by the OECD (2011), to test if the technology level of the sector has an impact on firm innovation.

The sector's technology level is classified as follows: medium-to-high technology industries are chemicals and electronic products; medium to low technology industries are non-metallic, mineral products and rubber and plastic products; and low technology industries are food and beverages and textile and apparel.

Innovation The WBES provides the innovation database and distinguishes between product and process innovation. The survey questions on product innovation ask if the firm has had a new or significantly improved product/service over the last 3 years. For process innovation, the survey questions ask if firms have had a new or significantly improved manufacturing product method or servicing, marketing method, logistic and distribution method, and organization method over the last 3 years.

Export firm status The export firm status used for this study can be classified into four categories: (1) new entry firms, which started to export in the second round of the survey; (2) exit firms were already exporters in the first survey round but exited in the second survey round; (3) continuing exporting firms, which exported during both rounds of the survey; and (4) non-exporting firms which never exported during the survey period, as shown in Table 2.

R&D expenditure A dummy variable was obtained from the WBES database. The survey question asked if firms have spent on R&D activities over the last 3 years.

Table 2 Export status in ASEAN developing countries across industries from the WBES

Sector	No. of survey firms	%	Export status (% of total survey firms by sector)			
			New entry	Exit	Continuing exporting	Non-exporter
1. Electronic products	111	3.6	8.1	9.9	4.0	42.3
2. Non-metallic and mineral products	202	6.6	7.4	2.5	11.4	**78.7**
3. Rubber and plastic products	225	7.4	8.0	9.8	16.4	65.8
4. Food and beverages	355	11.7	5.4	8.5	9.0	**77.2**
5. Chemicals	197	6.5	8.6	7.1	15.2	69.0
6. Textile, apparel	496	16.3	**10.3**	**11.1**	**25.4**	53.2
Selected industries (from 1. to 6.)	1586	52.1	8.1	8.6	18.4	64.8
Other sectors	1458	47.9				
Total	3044	100				

Dominant sector of each export status type has shown in bold number

Source: author's calculations using the World Bank Enterprise Survey and ASEAN Secretariat

Imported licensed technology This data variable is a dummy variable obtained from the WBES survey. The question asked whether the firm used licensed technology from a foreign-owned company, excluding software, in that survey year.

5 Results and discussion

5.1 R&D expenditure equation

The R&D expenditure equation applied the logit model with a fixed effect to estimate the factors that determine R&D expenditure, a binary variable. As shown in Table 3, model (1)–(5), the results, shown in the marginal effects, suggest that the medium to the high technology level of the sector (chemicals and electronic products), exporting, and firm size are the key factors predicting whether firms in the six ASEAN developing countries engage in R&D expenditure. This is in line with many previous studies showing that higher technology firms are more likely to spend more on R&D. Meanwhile, exporting firms tend to use technology to enhance their product quality to meet international standards. Therefore, exporting firms tend to spend more on R&D, along with larger firms that can access finance for investing in R&D. Moreover, models (2)–(5), which classified the export status into four categories (new entry firm, non-exporter, continuing exporting firm, exit firm) suggest that firms that can continue exporting are more likely to undertake R&D.

The results also revealed that foreign ownership negatively affects firms' R&D expenditure in the six ASEAN developing countries. This may be because foreign firms conduct R&D in their headquarter country. Most foreign investors are focused on the low cost of production in less developed countries rather than R&D. Additionally, the dominant sector of the firm survey shown in Table 1 is the textile and apparel sector; foreign owners are not likely to invest in R&D in this sector. The results are in agreement with a previous study by Almeida and Fernandes (2006). They studied the firm level in 43 developing countries and found that foreign-owned firms are less likely to invest in R&D.

Table 3 R&D expenditure equation

Variables	Marginal effects on R&D expenditure				
	(1)	(2)	(3)	(4)	(5)
HHI index	0.537 (0.558)	0.463 (0.563)	0.519 (0.556)	0.458 (0.543)	0.399 (0.565)
MH	0.127** (0.0583)	0.125** (0.0591)	0.123** (0.0587)	0.123** (0.0577)	0.123** (0.0594)
ASEAN (log)	−0.0173 (0.0394)	−0.0112 (0.0396)	−0.0149 (0.0393)	−0.0105 (0.0389)	−0.0102 (0.0394)
Export status	0.0570* (0.0337)				
New entry firm		−0.0142 (0.0436)			
Non-exporter firm			−0.0260 (0.0317)		
Continuing exporting firm				0.0747** (0.0350)	
Exit firm					−0.0488 (0.0425)
Employment (log)	0.0652*** (0.00986)	0.0711*** (0.00956)	0.0669*** (0.0104)	0.0644*** (0.00979)	0.0724*** (0.00972)
Age (log)	−0.0146 (0.0258)	−0.0132 (0.0258)	−0.0152 (0.0258)	−0.0199 (0.0257)	−0.0159 (0.0256)
Foreign ownership (%)	−0.101** (0.0462)	−0.0695 (0.0423)	−0.0767* (0.0430)	−0.0879** (0.0428)	−0.0725* (0.0425)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	605	605	605	605	605
Pseudo-R^2	0.269	0.265	0.265	0.273	0.268

Standard errors in parentheses

Source: author's calculations using the World Bank Enterprise Survey

***$p < 0.01$

**$p < 0.05$

*$p < 0.1$

5.2 Product innovation and process innovation equation

Using the logit model with a fixed effect to estimate the product innovation equation (Eq. 2) and process innovation equation, binary variables (Eq. 3), this section will identify how R&D expenditure, the innovation input impacts product and process innovation. As shown in Table 4, the marginal effects suggest that R&D expenditure is a significant driver for product innovation and process innovation. Further, the more years of education the workers have, the firm is more likely to achieve process innovation and product innovation. A firm with more experience is more likely to have more product innovation than process innovation, as this type of firm has more expertise in products due to consumer demand, consistent with the study by Bernard et al. (2009). Larger firms are more likely to have process innovation than product innovation because larger firms require more management of their production line to enhance the overall firm performance, which involves considering the production method, marketing, logistics, and organization structure. Foreign ownership does not affect the innovation output, as it does not impact whether a firm undertakes R&D. The other interesting finding of this study is that export status is one of the

Table 4 Product innovation and process innovation equation

Variables	Marginal effects on product innovation	Marginal effects on process innovation
R&D expenditure	0.166** (0.0703)	0.281*** (0.0486)
Years of education	0.0181* (0.0102)	0.0165* (0.00880)
Employment (log)	0.0211 (0.0143)	0.0448*** (0.0128)
Age (log)	0.0783* (0.0413)	0.0285 (0.0330)
Foreign ownership (%)	− 0.0267 (0.0610)	− 0.0996 (0.0655)
Export status	− 0.0465 (0.0458)	0.0102 (0.0458)
Country fixed effects	Yes	Yes
Sector fixed effects	Yes	Yes
Year fixed effects	Yes	Yes
Observations	617	607
Pseudo-R^2	0.179	0.261

Standard errors in parentheses

Source: author's calculations using the World Bank Enterprise Survey

***$p < 0.01$

**$p < 0.05$

*$p < 0.1$

determinants of R&D (innovation input). However, it is a weak driver for product and process innovation, consistent with a previous study in Malaysia by Lee (2008). This can be explained by the fact that exporting in ASEAN developing countries could help the exporter initiate R&D expenditure. However, it cannot help the exporting firm establish the process and product innovation, especially product innovation, which increases for higher value-added products but remains low for low value-added products. Therefore, exporting does not affect product innovation and process innovation output. From the policy perspective, the government can facilitate or subsidize exporting firms to establish product or process innovation.

5.3 Total factor productivity equation

This section will explore the impact of product and process innovation on firm productivity. Since the TFP is the continuous variable, Eq. 4 applies the OLS with a fixed effect for estimation. As shown in Table 5 for models (1)–(4), the results suggest that process innovation induces firms to have higher firm productivity; meanwhile, product innovation does not show a statistically significant effect on firm productivity. This result is consistent with previous studies in developing countries, suggesting that firm productivity is driven by process innovation rather than product innovation. Product innovation requires more expertise and technology, while process innovation, such as production processing, marketing, logistics, and structure organization, does not require much technology.

In model (4), testing the complementary relationship between process and product innovation and the process innovation interaction term with product innovation, the results also suggest a complementary relationship between product and process innovation. However, it is a weak relationship that is not statistically significant. Models (1)–(4) confirm the hypothesis that firms with imported licensed technology tend

Table 5 Total factor productivity equation

Variables	(log) TFP			
	(1)	(2)	(3)	(4)
Product innovation	0.00665 (0.0162)		−0.00540 (0.0191)	
Process innovation		0.0301* (0.0157)	0.0323* (0.0175)	
Product X process				0.0141 (0.0188)
Imported license technology	0.0713*** (0.0177)	0.0709*** (0.0186)	0.0711*** (0.0186)	0.0734*** (0.0186)
Age (log)	−0.00185 (0.0119)	−0.00406 (0.0134)	−0.00387 (0.0134)	−0.00323 (0.0135)
Employment (log)	−0.0109** (0.00452)	−0.0114** (0.00498)	−0.0114** (0.00498)	−0.0101** (0.00494)
Foreign ownership (%)	0.0466* (0.0248)	0.0579** (0.0270)	0.0577** (0.0271)	0.0561** (0.0271)
Country fixed effects	Yes	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Constant	2.255*** (0.0640)	2.178*** (0.151)	2.247*** (0.0702)	2.246*** (0.0704)
Observations	503	453	452	452
R^2	0.577	0.590	0.589	0.586

Standard errors in parentheses

Source: author's calculations using the World Bank Enterprise Survey

***$p < 0.01$

**$p < 0.05$

*$p < 0.1$

to significantly enhance their firm productivity in the six ASEAN developing countries. Additionally, the higher the number of workers, the lower the TFP. Larger firm size in a labor-intensive industry is more likely to be less productive. As classified by sector (Table 1), this firm database is dominated by the textile sector; therefore, a firm with a high number of workers has less productivity.

An interesting finding of this study reveals that foreign ownership positively impacts firm productivity. Foreign equity does not affect a firm undertaking R&D and innovation, but foreign equity can provide a market channel through higher prices to achieve higher value-added. This result is also consistent with Almeida and Fernandes (2006). Their study at the firm level of 43 developing countries found that foreign-owned firms do not differ in innovation but have higher productivity.

5.4 Firm export survival equation

This section explores the linkages between innovation, firm productivity, and export survival by using the Panel Probit and Stata Extended Regression Model, to estimate Eq. 5 and IV regression (2SLS) with fixed effect in Eq. 6 to address the problem of endogeneity. As shown in Table 6, models (1) using the TFP(log) have confirmed that firms with high TFP are more likely to survive in the export market. Meanwhile, in model (2), I use the resized TFP (log), which means dropping firms that have TFP(log) data but do not have the process innovation data which aim to get close to the sample size of the TFP model in Table 5 that has a much smaller sample size from missing data of process innovation. The result still confirms that even if we address the sample size difference between the TFP model in Table 5 and the model (1) in Table 6, firms with higher TFP are more likely to survive in the export market.

Table 6 Firm export survival

Variables	Export survival = 1, others = 0		
	(1)	(2)	(3)
TFP (log)	0.989** (0.454)		
Resized TFP (log)		1.135* (0.587)	
Estimated TFP (log)			1.301* (0.523)
Employment (log)	0.449*** (0.0513)	0.488*** (0.0710)	
Foreign ownership (%)	1.105*** (0.177)	1.226*** (0.272)	
Country fixed effects	Yes	Yes	Yes
Sector fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Constant	− 5.376*** (1.062)	− 9.362 (562.5)	− 2.763** (1.189)
Observations	836	460	452
Pseudo-R^2	0.327	0.327	–

Standard errors in parentheses

Source: author's calculations using the World Bank Enterprise Survey

***$p < 0.01$

**$p < 0.05$

*$p < 0.1$

Meanwhile, exporting activities can affect TFP because foreign ownership and import licensed technology are usually the exporters. There is the endogeneity issue in the model (2); therefore, model (3) addresses the endogeneity issue by using the estimated TFP estimated from the TFP model in model (3) of Table 5, which already takes into account the effect of exports on the TFP by considering process innovation, product innovation, imported licensed technology, age, employment, and foreign ownership as instrumental variables. The result has confirmed that the estimated TFP is still significant, so the firm that survives in the export market must have a high TFP.

6 Conclusions

Using the WBES panel data for six ASEAN developing countries, this chapter explored the linkages between innovation, firm productivity, and firm export survival. Firstly, I explored how innovation impacts firm productivity. I adopted the CDM structural model by constructing three equations (innovation input, innovation output, and firm productivity), applying the logit with the fixed-effect model to estimate the innovation input and output equation, and applying the OLS fixed-effect model for the estimation of the firm's TFP equation. The R&D expenditure represented the innovation input. The results revealed that the sector's technology level, firm size, and export status determine the firm's engagement in R&D expenditure when controlling for firm characteristics.

The innovation output equation showed that R&D expenditure is a significant driver for product innovation and process innovation. However, the firm productivity equation showed that only process innovation determines whether firms in the six ASEAN developing countries increase productivity.

The second research contributes to the literature of the CDM model (Crépon et al. 1998) by including how TFP's firm impacts the firm's export survival and methodological

contribution by instrumenting the TFP with the estimated TFP from the TFP equation, model (3). The result confirmed that to survive in the export market. Firms should have high productivity.

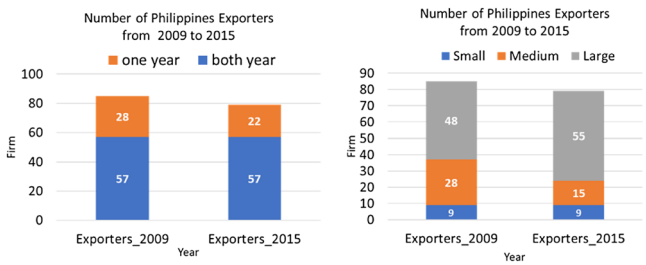
Overall, the findings from the first and second research questions align with the literature that innovation has a significant and positive impact on firm productivity and firm productivity has a significant and positive impact for the firm to survive in the export market.

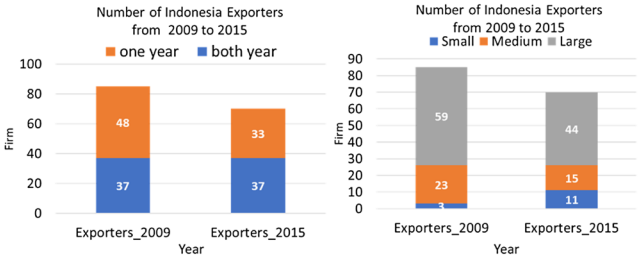
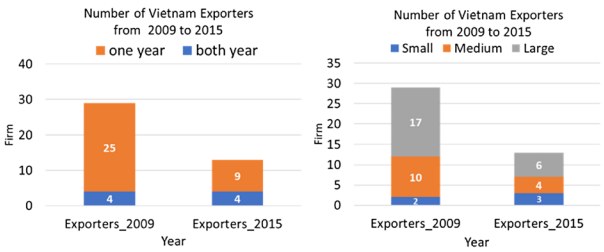
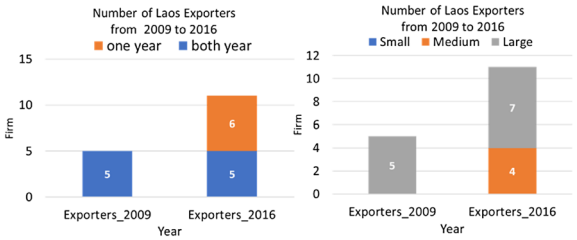
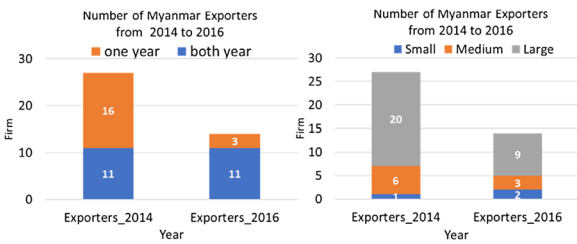
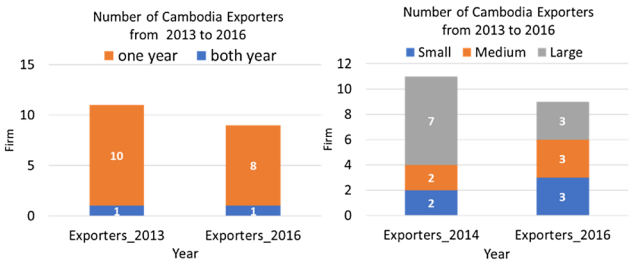
With regard to policy, to promote firms to increase productivity, this study confirmed that promoting the industry to a higher level of technology—for instance, in developing countries in ASEAN promoting industry, such as Thailand has now proposed the Thailand 4.0 strategy will engage more innovation and lead to more investment in R&D to enhance productivity and reinforce its competitiveness. Exporting is also a significant determinant of R&D expenditure. However, the findings suggest that exporting cannot induce the firm to innovate, leading to productivity. Therefore, the government can support current continuing exporting firms to engage in process innovation. For example, through export-supporting programs, a government can help an exporter improve its product quality to increase innovation and knowledge. Alternatively, it can provide a tax incentive for R&D expenditure and the importing of machines. When innovation drives firms to higher productivity levels, it could help firms in the six ASEAN developing countries maintain their competitiveness and survive globally.

This study contributes to the literature by expanding to the ASEAN developing countries. However, with rich data—individual countries in ASEAN could be the future research.

Appendix

Box 1. Export experience of ASEAN developing countries, by World Bank Enterprise Survey's panel data at the two timepoints

Country/year	Panel data: number of exporting firms at two timepoints	Note
Philippines 2009–2015		The total number of exporting firms in 2015 fell because of the exiting of exporting medium firms (− 13 firms) and because of either an expansion of firm size from SME to large or the new entry of large firms (+ 7 firms)

Country/year	Panel data: number of exporting firms at two timepoints	Note
Indonesia 2009–2015		The total number of exporting firms in 2015 decreased because of the exiting of exporting large firms (− 15 firms) and medium-firms (− 8 firms) and the new entry of exporting small firms (+ 8 firms)
Vietnam 2009–2015		The total number of exporting firms fell because of the exiting of exporting large firms (− 11 firms) and medium-firms (− 6 firms) and the new entry of a exporting small firm (+ 1 firm)
Laos 2009–2016		The total number of exporting firms increased because of the new entry of large firms or firms that grew into large firms (+ 2 firms) and the new entry of medium-firm (+ 4 firms)
Myanmar 2014–2016		The total number of exporting firms decreased because of the exiting of exporting large firms (− 11 firms) and medium firms (− 3 firms) and than the new entry of an exporting small firm (+ 1 firm)
Cambodia 2013–2016		Total number of exporting firms decreased because of the exiting of large firms (− 4 firms) and the increase in the number of medium (+ 1 firm) and small (+ 1 firm) firms

Source: author's calculations using the WBES.

See Tables 7, 8

Construction of % export market

Table 7 Sample description

Year	2009	2010	2013	2014	2015	2016	2017	Total
Sector								
Chemicals	86	3	1	5	79	6	2	182
Electronic products	43	0	1	1	43	2	0	90
Food and beverages	107	5	17	39	104	54	5	331
Non-metallic and mineral products	83	5	0	9	74	5	0	176
Rubber and plastic products	91	2	1	5	97	4	1	201
Textile, apparel	197	6	6	35	171	40	13	468
Total	607	21	26	94	568	111	21	1448
Country								
Indonesia	297	16	0	0	313	0	0	626
Cambodia	0	0	26	0	0	26	0	52
Laos	17	0	0	0	0	17	0	34
Myanmar	0	0	0	70	0	49	21	140
Philippines	227	0	0	0	227	0	0	454
Vietnam	66	5	0	24	28	19	0	142
Total	607	21	26	94	568	111	21	1448

Source: WBES

Table 8 Descriptive statistics

Variables	Obs	Mean	Std. Dev	Min	Max
R&D expenditure	807	0.146	0.354	0	1
HHI index	1431	0.104	0.085	0.058	0.442
MH	1448	0.188	0.391	0	1
ASEAN (log)	1256	2.638	0.871	0.531	4.198
Export status	1448	0.260	0.439	0	1
New entry firm	1448	0.079	0.269	0	1
Non-exporter	1448	0.698	0.459	0	1
Continuing exporting firm	1448	0.137	0.344	0	1
Exit firm	1448	0.086	0.281	0	1
Employment (log)	1430	3.955	1.609	0	9.324
Age (log)	1425	2.952	0.549	0	4.771
%Foreign ownership	1444	0.127	0.316	0	1
Process innovation	735	0.369	0.483	0	1
Product innovation	817	0.234	0.423	0	1
Number of education years	942	7.972	3.604	0	24
TFP (log)	838	2.423	0.208	1.389	3.098
Imported licensed technology	1375	0.173	0.378	0	1
Value added (log)	1149	19.920	3.269	11.462	30.560

Source: author's calculations using the WBES

- How to match WBES database with UN Comtrade database as a proxy for the export market destination to capture the change in the export market between two time periods of survey (Fig. 2).

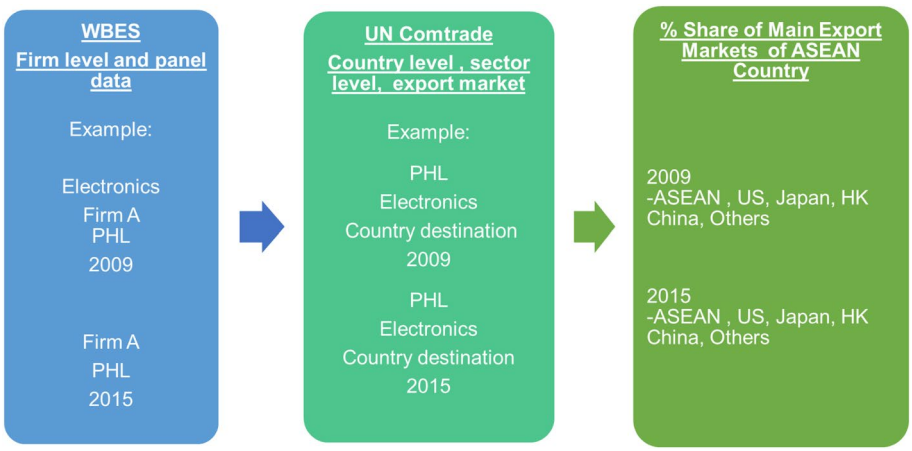


Fig. 2 Data construction of % export market share (source: author)

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Declarations

Competing interests
The author declares no competing interests.

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