Internationally recognized quality certification, human capital and process innovation: the moderating role of informal competition

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Abstract

Purpose – This study aims to investigate whether internationally recognized quality certification and human capital affect process innovation in the Association of Southeast Asian Nations (ASEAN). Most prior research examines large economies such as China or European countries, while a few studies have been done in the ASEAN context. Moreover, this study also investigates the moderating role of informal competition in the international quality certification – process innovation and human capital – process innovation relationships.

Design/methodology/approach – The analysis is performed using data from the Enterprise Surveys conducted by the World Bank with over 4,400 observations in manufacturing industry sectors in ASEAN countries. The empirical investigation uses multilevel mixed-effects logit regression as well as the propensity score matching technique to partly account for the selection bias problem.

Findings – The results reveal that internationally recognized quality certification and human capital are positively associated with process innovation. Specifically, internationally recognized quality certification increases the predicted probability of process innovation by approximately 4.2% points, while employee training significantly boosts this probability by approximately 7.5% points, holding all other variables constant. Furthermore, informal competition positively moderates both the international quality certification – process innovation and human capital – process innovation relationships.

Originality/value – This study provides a comprehensive picture of the moderating mechanism of how informal competition moderates the international quality certification – process innovation nexus based on informality cost and bounded rationality perspectives, which has not been investigated in previous studies. Therefore, this paper contributes as probably the first attempt to investigate the moderating effect of informal competition on the international quality certification – process innovation relationship in the ASEAN context. Moreover, to the best of the authors' knowledge, there has been no empirical research that investigated the moderating impact of informal competition on the human capital and process innovation relationship. Hence, this study fills this research gap based on bounded rationality theory mechanism.

Keywords ASEAN, Human capital, Internationally recognized quality certification, Informal competition, Process innovation

Paper type Research paper

JEL classification – E26, J24, O31

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1. Introduction

Innovation is considered one of the most important activities of firms to create differentiation and distinguish themselves from competitors in the global market (Cui *et al.*, 2016). In the context of globalization, firms need to enhance innovation because of the competitive pressure from foreign markets and increasing customers' needs. Among different types of innovation, process innovation is considered an important contributor that influences the whole business performance (Terziovski and Guerrero, 2014).

Within the range of drivers of firms' process innovation, two important factors are internationally recognized quality certification (Goedhuys and Sleuwaegen, 2016) and human capital (Amarakoon *et al.*, 2018; Sun *et al.*, 2020; van Uden *et al.*, 2017). Through these factors, firms can gain more new external knowledge, which can help them upgrade and update various dimensions of their business (Goedhuys and Sleuwaegen, 2016; Wu and Wu, 2019).

A considerable portion of the extant literature regarding innovation concentrates on developed economies, particularly those in Europe, the USA, and China, which possess well-established institutions, strong regulatory enforcement, abundant resources, extensive R&D investments and advanced technological infrastructure to nurture domestic innovation (Cui *et al.*, 2016). In contrast to developed economies, the Association of Southeast Asian Nations (ASEAN) region has a unique setting characterized by high informal competition, fragmented markets and lagging technological development (Nguyen, 2022). These factors make innovation performance within ASEAN countries remain largely unexamined, which motivates this study.

In addition, firms in developing countries such as those in ASEAN need to cope with the high pressure of informal competition because of the lack of strict laws and regulations (Dwibedy, 2022). Consequently, it becomes a motive for formal firms to attain a competitive advantage through such factors as technology, human capital, operation and quality standards (Bu and Cuervo-Cazurra, 2020). Given this trend, this study aims to investigate the effects of international quality certification and human capital on firm process innovation and the moderating effects of informal competition on the international quality certification – process innovation relationship and the human capital – process innovation relationship.

The paper makes three main contributions to innovation literature. First, prior studies on the role of international quality certification and human capital in process innovation mainly focus on developed and large countries such as China, Korea, France, Australia and Spain (Amarakoon *et al.*, 2018; Terziovski and Guerrero, 2014). However, to the best of our knowledge, the impact of international quality certification on process innovation has not been investigated in the ASEAN context. Therefore, this study aims to address this research gap.

Second, most previous studies focus on the direct impact of informal competition on firm innovation (Abbas *et al.*, 2022; Bu and Cuervo-Cazurra, 2020). However, there is a lack of research examining the moderating role of informal competition in the relationship between international quality certification and process innovation. Hence, this paper aims to provide a comprehensive picture of the moderating mechanism of how informal competition moderates this relationship based on informality cost and bounded rationality perspectives. In this way, this study seeks to bridge the gap in the literature by offering a new perspective on how external competitive pressures (i.e. informal competition) influence innovation strategies. Therefore, this paper contributes as probably the first attempt to investigate the moderating effect of informal competition on the international quality certification – process innovation relationship in the ASEAN context.

Third, human capital is the major driver of firms' innovation, which has been extensively investigated by previous literature (Kucharcikova *et al.*, 2024; Sun *et al.*, 2020; Vinding, 2006).

However, the role of human capital in innovation has not been widely researched in the context of informal competition. To our best knowledge, there has been no empirical research that investigated the moderating impact of informal competition on the human capital and process innovation relationship. Hence, this study tries to fill this gap. Indeed, based on bounded rationality theory, informal competitors force formal firms to strategically respond by investing in human capital to foster innovation, which subsequently enhances its impact on process innovation (McGuirk *et al.*, 2015; Miocevic *et al.*, 2022). Hence, informal competition necessitates more demand for knowledge and expertise, pushing formal firms to enhance human capital to compete with informal competitors via innovation.

The remainder of the study is structured as follows. The next section will examine the theoretical framework and establish hypotheses. In Section 3, we present the data and empirical methods. Section 4 contains a detailed analysis and discussions of empirical findings. Section 5 concludes by summarizing the results and providing practical implications. Finally, Section 6 discusses limitations and future studies.

2. Literature review

2.1 Internationally recognized quality certification and process innovation

Process innovation focuses on advancements in internal production processes and is usually driven by production standards (Utterback and Abernathy, 1975). Several studies pointed out that firms need to promote and develop production processes to support new product development (Abernathy and Townsend, 1975; Griffin, 1997). Process innovation is essential to help firms reduce operational costs while enhancing production efficiency through the adoption of improvements. In the meantime, an internationally recognized quality certification is an official recognition awarded to an organization that meets established international quality standards. These certifications show the commitment of an organization to consistent quality, customer satisfaction, safety and continuous improvement (Moses *et al.*, 2025). Some popular internationally recognized quality certifications include International Organization for Standardization (ISO) 9001 (quality management systems), ISO 14001 (environmental management) and Hazard analysis and critical control points (HACCP) (food safety) (Hu *et al.*, 2023; Yang, Liu, and Luo *et al.*, 2023).

Several studies have revealed a positive effect of external quality certification on the overall process innovation of firms, particularly in the context of technological applications (Cui *et al.*, 2016; Terziovski and Guerrero, 2014).

Firms participating globally must contend with information asymmetry, which can undermine credibility among buyers. International quality certifications thus serve an instrumental signaling function regarding the attainment of quality standards, helping companies overcome distrust (Chen *et al.*, 2024; Ren *et al.*, 2022; Wu and Wu, 2019). For example, ISO 9001 delineates essential requirements for establishing quality management systems. Meanwhile, ISO 9004 guides organizations in achieving sustained success through a quality management approach (ISO, 2009). These certifications thus enhance credibility and continuous improvement. Accordingly, this study delineates salient mechanisms through which international quality certifications may spur process innovation.

First, due to the competitive market pressure, firms need to respond to environmental changes by innovating to differentiate themselves. In this context, international quality certification is considered a vital factor leading to innovation adoption and can help the firm gain a “first mover advantage” (Ren *et al.*, 2022; Terziovski and Guerrero, 2014). For example, ISO 9000 is associated with enhancing organizational knowledge, addressing aspects such as organizational efficiency and the quality of manufacturing processes. By meeting international standards, firms can improve their manufacturing process, which is important for process innovation (Li *et al.*, 2018; Terziovski and Guerrero, 2014; Ullah, 2022).

Second, international quality standards are vital for enhancing management practices and driving transformative changes in the firm. This may ultimately lead to better process innovation (Escrig-Tena *et al.*, 2018). Specifically, these certifications contribute to developing robust and reliable processes across all departments. They also promote an analytical approach that views activities and resources as interconnected components. When quality follows a series of quality management practices, it can create a philosophy of continuous improvement in the organization (Escrig-Tena *et al.*, 2018).

According to the above discussion, we expect that certified ASEAN firms can learn new knowledge from international quality standards, which contributes positively to process innovation. Therefore, we hypothesize:

H1. Internationally recognized quality certification is positively associated with process innovation.

2.2 Human capital and process innovation

Human capital plays an important role in firms' performance and innovation (Fonseca *et al.*, 2019; Gallié and Legros, 2012). Schultz (1961) emphasized investing in human capital as a vital aspect of economic development. He defined human capital as "activities that influence future monetary and psychic income by increasing resources in people" (Becker, 1964). The absorptive capacity gained by human capital enables employees to internalize new external knowledge to foster innovation (Gallié and Legros, 2012; Kucharcikova *et al.*, 2024). In addition, firms can use external knowledge sources to identify innovative opportunities, which can then be translated into new product development initiatives or state-of-the-art quality management processes.

Becker (1964) pointed out the differences between general human capital and specific human capital. General human capital encompasses educational attainment and professional experience and is not specifically tied to a particular occupation (Becker, 1964). Individuals with higher levels of education may exhibit an enhanced capacity to both identify and critically evaluate novel external knowledge. Moreover, the number of years of working experience is an important indicator of general human capital and contributes to the development of tacit knowledge gained through accumulated experience (Luo *et al.*, 2023; Vinding, 2006). In addition, experienced managers make more innovative decisions and investments regarding the strategic direction, production process and technology because they have undergone different contexts and situations in business (Saleh *et al.*, 2024; Su and Wang, 2024).

On the other hand, specific human capital refers to skills and knowledge acquired through industry-specific experience. Specific human capital is not easily transferable to different contexts. Specific human capital focuses on human resource practices and how to enhance employees' unique knowledge. Formal training is considered a valuable method for firms to improve and update employees' knowledge in specific fields (Cui and Diwu, 2024; van Uden *et al.*, 2017). This training equips employees with this specialized knowledge, as many skills are acquired through on-the-job training rather than general education. Moreover, knowledge acquired solely through education can become outdated more rapidly in a constantly changing environment (Ma *et al.*, 2019).

Previous research also shows that small firms with both employees and managers possessing innovation-oriented human capital are more likely to engage in product and process innovations (McGuirk *et al.*, 2015; Sierra-Morán *et al.*, 2024). Moreover, firms commonly use task-related training to disseminate knowledge to their workforce. This helps orienting employees' activities and facilitating the reception, decoding, and assimilation of knowledge (Ma *et al.*, 2019). Through task-related training, employees can gain more updated knowledge and skills (Ma *et al.*, 2019), which has a positive impact on process innovation (Bornay-Barrachina *et al.*, 2023).

Based on the above arguments, we suggest that human capital can improve process innovation by enhancing general and specific human capital, and the following hypothesis is formulated:

H2. Human capital is positively associated with process innovation.

2.3 The moderating role of informal competition

Informal businesses refer to unregistered economic activities that are not regulated by the government, not taxed and often not officially recorded in national statistics (Bu and Cuervo-Cazurra, 2020). Several factors drive firms to operate informally, including the high costs and extensive time required for government registration (Abbas *et al.*, 2022; Xie *et al.*, 2023). Additionally, new market entrants face many regulatory hurdles before legally operating. Consequently, some firms test the market informally before committing resources to registration.

To gain a comprehensive understanding of the moderating impact of informal competition, this study uses the informality cost and bounded rationality perspectives. The informality cost perspective proposes that informal firms suffer from informality costs, leading to changes in their behavior. Informality creates a struggle for firms through informality costs; particularly, costs will increase due to a lack of legal status (Bu and Cuervo-Cazurra, 2020; Miocevic *et al.*, 2022). In particular, they have difficulties in developing and sustaining formal contractual connections both internally and externally.

Informal enterprises may save operating and management expenses by depending on family networks to conduct business activities because family members can support and work for little or no pay. Moreover, informal firms can save cost because they do not need to pay legal fees or taxes. Generally, informal enterprises compete by replicating the product offerings of formal firms at a lower cost (Qi *et al.*, 2020). However, they cannot innovate, which gives formal organizations a competitive edge through their innovative practices. Therefore, lower costs are considered the only competitive advantage that enables informal companies to compete with formal ones. Formal companies, therefore, need to create differentiation to address the challenges posed by informal competitors. Specifically, under the pressure of informal competition, they will focus on firms' innovation to build greater credibility with stakeholders and enhance business performance (Abbas *et al.*, 2022; Bu and Cuervo-Cazurra, 2020; Dwibedy, 2022).

On the other hand, bounded rationality refers to the decision-making process in organizations when employees' mental processing capacities are insufficient to handle the complexity of the operating environment. In addition, bounded rationality reveals that individuals do not always engage in thorough information collection and processing to determine the ideal alternatives (Miocevic *et al.*, 2022). This perspective is rooted in decision-making process and the identification of an alternative when a company faces multiple strategic options. Indeed, the business environment grows more complex because of the dynamic competition between formal and informal firms. Hence, decision-makers should find solutions such as investing in innovation, enhancing human capital or changing strategy when faced with bounded rationality (Simon, 1957).

International quality certifications are considered appealing tools to attract highly educated employees who do not want to work for informal firms due to their illegal status. In fact, informal enterprises usually lack the capacity to offer employee benefits such as health-care insurance or social security (Bu and Cuervo-Cazurra, 2020). This can deter highly skilled employees from joining their workforce. As a result, employees may choose to work for formal companies to receive long-term contracts as well as long-term incentives, which cannot be provided by informal ones (Bu and Cuervo-Cazurra, 2020). Therefore, to cope with informal competition, formal companies adopt more international standards to create an appeal toward external potential employees, leading to innovation. Moreover, international quality certifications create barriers for informal firms in recruiting human resources, which allows formal firms to attract more talented employees (Bu and Cuervo-Cazurra, 2020).

Furthermore, international quality certification increases the credibility of formal firms that enables them to gain more advantages than informal ones in external partner relationships. Specifically, external partners struggle to access reliable information on informal enterprises due to the lack of official records (Bu and Cuervo-Cazurra, 2020). Therefore, it is hard for external suppliers and distributors to establish long-term contracts with informal firms. Formal firms, on the other hand, can leverage the challenges external partners encounter with informal firms to seize collaborative opportunities. Indeed, a formal firm with ISO certifications gains a competitive advantage over informal ones by earning greater trust through standards validated by third-party organizations (Wu and Wu, 2019). Thus, competition from informal firms incentivizes formal firms to enhance innovation through international quality certifications (Qi *et al.*, 2020).

Following the bounded rationality perspective, formal firms need to gain more information and knowledge through international quality certifications to make informed business decisions and perform innovation to compete with informal companies. Internationally recognized quality certification is one of the best methods that help young formal firms achieve standardization in the international market and enhance process and organizational innovation (Escrig-Tena *et al.*, 2018; Hamdoun *et al.*, 2018). Moreover, international certifications are evidence of business and market standards (Wu and Wu, 2019), which is credible information for external partners.

Based on the above discussion, the increase of informal competition may strengthen the relationship between internationally recognized quality certification and process innovation, so we hypothesize as follows:

H3. Informal competition positively moderates the internationally recognized quality certification – process innovation relationship.

Informal firms usually lack highly educated employees, a valuable asset, to compete in the market (Fonseca *et al.*, 2019). Due to informality costs, informal firms are often reluctant to invest in human capital and struggle attract highly educated employees (Bu and Cuervo-Cazurra, 2020). This is an opportunity for formal firms to increase human capital. Using the legal status, they can hire highly educated employees as well as organize firm-specific training, which can help firms upgrade and improve the production process (Dostie, 2017). Several studies reveal that investment in human resources enhances firms' innovation and competitive advantages (Amarakoon *et al.*, 2018; Gallié and Legros, 2012). Recruiting highly educated employees can save operation costs and increase production volume through process innovation (Lager, 2002), which can create a competitive advantage for formal firms in the context of informal competition.

Informal firms have disadvantages in convincing external partners because they have limited resources and lack formal structures. Due to informality costs, informal firms usually use less experienced and poorly trained employees (Miocevic *et al.*, 2022). In contrast, formal firms have more opportunities to recruit qualified staff and enhance the knowledge and skills of human capital. For example, formal firms invest in human capital through firm-specific, industry-specific and customer-specific training that enhances employees' and managers' knowledge and skills (Børing, 2017; Dostie, 2017). They can take advantage of this knowledge to promote and upgrade business performance through product and process innovation (Mendi and Costamagna, 2017).

From the bounded rationality perspective, the increased prevalence of informal competitors will prompt firms to strategically react by innovation (Miocevic *et al.*, 2022). Several studies reveal that human capital generated through firm-specific training, level of education and experience significantly affects innovation activities (Dostie, 2017; Gallié and Legros, 2012; McGuirk *et al.*, 2015). Informal competition is also considered the motive for formal firms to innovate, which helps them achieve business goals (Miocevic *et al.*, 2022). Therefore, we argue that the intensity of informal competition influences the need for knowledge and experience to perform firms' innovation. Faced with the pressure of informal competition, firms need to enhance the knowledge and skills of employees and workers who directly operate companies and face informal competition. Hence, the intensity of informal competition is considered a mechanism by which firms invest in human capital to leverage innovation.

Taking into consideration that the growth of informal competition can enhance the positive effect of human capital on process innovation, we hypothesize as follows:

H4. Informal competition positively moderates the human capital – process innovation relationship.

According to the above discussion, Figure 1 outlines the research framework with four hypothesized relationships in this study. Particularly, we expect that internationally recognized quality certification and human capital are positively associated with process innovation. Moreover, we expect that the increase in informal competition can enhance the positive effect of international quality certification and human capital on process innovation.

3. Data and research methods

3.1 Data

The data used in this study is derived from the World Bank's Enterprise Survey (ES), a firm-level survey containing responses from more than 207,000 private firms in 158 economies (World Bank, 2024a). The ES data has been extensively used in research investigating

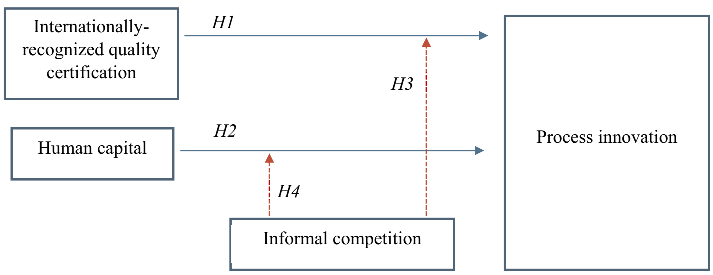

Figure 1. Research framework
Source: Authors' own work

innovation at the firm level in developing countries (Jitsutthiphakorn, 2021). The ES enables the investigation of many issues related to firm-level innovation by providing detailed data on different aspects of firm characteristics (Nguyen-Van and Chang, 2020).

The current study uses the most recent ES data available for nine ASEAN economies. In particular, firm-level data for Cambodia, Indonesia, the Philippines, Singapore and Vietnam were extracted from the 2023 ES survey wave, while data for Malaysian firms was sourced from the 2019 survey. Laotian firm data was obtained from the 2018 ES survey, whereas data for Myanmar and Thailand stemmed from the 2016 survey wave. After excluding outliers, the sample comprised 4,016 observations in manufacturing industries across the ASEAN economies. We exclude firms in the service sector in your study because manufacturing and service firms innovate differently (Pires *et al.*, 2008). Including both sectors can create noise and too generalized results.

3.2 Model specification

To test the four proposed hypotheses, this research uses the following regression equation:

$$\begin{aligned} Process\ innovation_i = {} & \beta_0 + \beta_1 Internationally\ recognized\ quality\ certification_i \\ & + \beta_2 Employee\ training_i + \beta_3 Informal\ competition_i \\ & + \beta_4 Internationally\ recognized\ quality\ certification \\ & \times Informal\ competition_i + \beta_5 Employee\ training \\ & \times Informal\ competition_i + \beta_6 Control_i + \varepsilon_i \end{aligned} \tag{1}$$

3.2.1 Dependent variable. Process innovation: Using the ES data, a binary indicator for process innovation was constructed, assigned a value of "1" if the firm introduced any of the following within the past three years: new or notably upgraded manufacturing methods for products or services, new or significantly enhanced logistics, distribution or delivery approaches for inputs, outputs or services or new or markedly improved ancillary activities related to operations, maintenance, purchasing, accounting or computing systems. The process innovation variable takes a value of "0" if the firm did not implement innovations across those process domains (Nguyen-Van and Chang, 2020).

3.2.2 Independent variables and moderator. Internationally recognized quality certification: This variable is a binary indicator denoting whether a firm possessed internationally recognized quality certification. Specifically, this dummy variable takes a value of 1 if the firm reported holding international certification and 0 otherwise. Respondents ambiguously indicating certification status as "still in process" or "don't know" were omitted from the final analytical sample (Nguyen, 2022).

Employee training: This binary indicator denotes whether the firm offered formal training programs to permanent full-time employees during the preceding fiscal year. Specifically, this variable takes a value of 1 if formal training was provided or 0 if not (Mansour *et al.*, 2024; Sun *et al.*, 2020).

Informal competition: This variable captures the extent of informal rivalry reported by the firm. It was constructed from the survey question "To what degree are practices of competitors in the informal sector an obstacle to the current operations of this establishment?", with responses coded as 0 = "No obstacle," 1 = "Minor obstacle," 2 = "Moderate obstacle," 3 = "Major obstacle" and 4 = "Very Severe Obstacle." Higher values thus indicate a greater perceived competitive threat from informal sector market participants (Abbas *et al.*, 2022; Dwibedy, 2022).

3.2.3 Control variables. R&D: R&D serves as a binary indicator variable, coded as 1 to denote firms that engaged in formal research and development activities during the sample period, and 0 for those that did not (Doan and Chang, 2022). R&D investments frequently result in technological innovations and progress. Such advancing technologies can either be integrated into extant systems to enhance productivity, reduce expenses and diminish ecological impacts or provide the foundations for novel processes that are more effective, economically viable and sustainable from an environmental standpoint (Audretsch and Belitski, 2020; Saleh *et al.*, 2025).

Firm age: In this analysis, firm age was operationalized as the natural log of the number of years since the firm was founded. Older firms may have better process innovation performance because they have a longer operation history which helps them accumulate more industry knowledge and experience (Dwibedy, 2022; Saleh and Maigoshi, 2024).

Firm size: In the present analysis, firm size was operationalized as the natural log of the total number of employees at the company. This continuous variable thus captures the scale of human capital resources available across sampled establishments. Large firms tend to possess more expansive financial and human capital resources. This facilitates investments in R&D and technology adoption that are important for process innovation (Li *et al.*, 2023; Saleh and Mansour, 2024).

3.3 Empirical methods

Logistic and probit regression models are among the most widely applied statistical techniques when estimating binary outcome variables (Wooldridge, 2010). Nevertheless, these methods do not account for the multilevel structure of this current study's data set. Indeed, individual firm-level observations (level 1) are nested within industries (level 2) and country-level data (level 3). Therefore, a multilevel mixed-effects logit model (MLM) is a better method for this analysis, as it can accommodate such a multilevel nature. A MLM is particularly appropriate for data exhibiting a nested structure (e.g. firms within industries and industries within countries) because it accounts for variability at each level of analysis. It allows the modeling of hierarchical dependencies in the data while allowing the inclusion of random effects because fixed-effects models cannot effectively handle in this context (McCoach, 2019). The MLM is compared with the conventional binary logistic model using a likelihood ratio test. A statistically significant test statistic indicates the MLM's advantage in fitting the data. The estimation is based on the "melogit" command in Stata to implement the multilevel logit specification (StataCorp, 2019).

Moreover, this research performed a robustness test regarding the potential selection bias problem. The concern revolves around the prospect that innovative firms might engage in self-selection, meaning they are self-selective in conducting internationally recognized quality certification and employee training activities. Failure to address and account for this selection bias issue may undermines the validity, reliability and generalizability of the results (Rosenbaum and Rubin, 1983; Wooldridge, 2010).

To mitigate this selection bias problem, we used PSM – a technique that attempts to pair treatment and comparison units with similar observable features (Rosenbaum and Rubin, 1983). Propensity score matching facilitates the selection of a comparable control group which exhibits statistical equivalence to the treatment group across observed covariates. By equating groups on propensity scores estimated from measured characteristics, PSM allows for conditioning on these similarities during estimation. Thus, differences that emerge between matched samples can be more readily attributed to the treatment effect rather than selection biases, enabling examination of the causal impact of treatment status on process innovation (Ayllón and Radicic, 2019).

Propensity scores were estimated in Stata 16 using the "teffects psmatch" command, which implements nearest neighbor matching algorithms to pair each treated unit with a single untreated unit exhibiting the closest propensity score (StataCorp, 2019). In this investigation, the control group comprised enterprises possessing internationally recognized quality certification and engaging in employee training activities, while the treatment group consisted of enterprises lacking such activities. Furthermore, the control group encompassed enterprises devoid of quality certification/employee training, encountering no hindrances from the informal sector or the combination of these two conditions. In contrast, the treatment group comprised enterprises performing quality certification/employee training and confronting competition from the informal sector.

To facilitate analysis, the informal sector competition variable was dichotomized into a dummy predictor named "Informal_competition_dummy." Specifically, this indicator variable took on a value of 0 if firms selected "no obstacle" in response to the inquiry "To what degree are practices of competitors in the informal sector an obstacle to the current operations of this establishment?". Conversely, Informal_competition_dummy was coded as 1 if establishments chose options spanning from "a minor obstacle" to "a very severe obstacle" for that same survey question.

Consistent with the recommendation of Caliendo and Kopeinig (2008), this study's covariate selection adhered to the principle of including only variables that concurrently influence both the participation decision and the outcome variable. Accordingly, the logit models incorporated the following covariates: *R&D*, *firm age* (natural log), *firm size* (natural log), industry fixed effects and country fixed effects. Subsequently, the procedure proceeded to estimate the average treatment effect on the treated (ATT).

4. Findings and discussions

4.1 Descriptive statistics

Table 1 presents the descriptive statistics for the key variables under analysis, based on a total sample of 4,016 observations. The data reveals that process innovation was implemented by nearly 10% of the sampled firms. Moreover, approximately 23% of the entities under consideration possessed an internationally acknowledged quality certification. The data also reveals that roughly 25% of surveyed firms provided formal training to employees. The informal competitive intensity exhibited an average value of 0.900, falling marginally below the "a minor obstacle (1)" level.

Table 2 displays the correlations between the independent and control variables used in the study. Multicollinearity does not pose a concern for our investigation, as evidenced by all independent and control variable correlations falling below the 0.5 threshold (Dormann *et al.*, 2013).

4.2 Empirical results

Table 3 delineates the results from a multilevel mixed-effects logistic regression analysis spanning three models to evaluate the postulated hypotheses. Model 1 tests the direct effect relationships between our two key independent variables – internationally recognized quality certification and human capital (captured through employee training) – on the likelihood of process innovation adoption. Model 2 uses an interaction term to inspect the moderating impact of informal competition on the relationship between internationally recognized quality certification and process innovation. Finally, Model 3 tests whether informal competition moderates the nexus between human capital and process innovation.

Table 1. Descriptive statistics

Variable	Obs.	Mean	SD	Min.	Max.
Process innovation	4,016	0.097		0	1
Internationally recognized quality certification	4,016	0.226		0	1
Employee training	4,016	0.254		0	1
Informal competition	4,016	0.900	1.072	0	4
R&D	4,016	0.067		0	1
Firm age (ln)	4,016	2.726	0.698	0	4.248
Firm size (ln)	4,016	3.569	1.533	0	9.393

Source(s): Authors' own work

Table 2. Correlation matrix

Variable	1	2	3	4	5	6
1. Internationally recognized quality certification	1					
2. Employee training	0.354***	1				
3. Informal competition	−0.127***	−0.089***	1			
4. R&D	0.222***	0.275***	0.029*	1		
5. Firm age (ln)	0.153***	0.137***	0.009	0.078***	1	
6. Firm size (ln)	0.495***	0.339***	−0.064***	0.194***	0.124***	1

Note(s): ***$p < 0.01$, *$p < 0.1$
Source(s): Authors' own work

Table 3. Multilevel MLM estimation results

Variable	Model 1	Model 2	Model 3
Internationally recognized quality certification	0.459*** (0.160)	0.309 (0.194)	
Employee training	0.785*** (0.142)		0.513*** (0.183)
Informal competition	0.367*** (0.054)	0.294*** (0.060)	0.236*** (0.067)
Internationally recognized quality certification x Informal competition		0.246** (0.119)	
Employee training x Informal competition			0.276*** (0.105)
R&D	1.664*** (0.166)	1.872*** (0.163)	1.743*** (0.166)
Firm age (ln)	0.220** (0.090)	0.221** (0.090)	0.254*** (0.091)
Firm size (ln)	−0.008 (0.050)	0.058 (0.048)	0.058 (0.046)
Constant	−3.867*** (0.443)	−3.808*** (0.456)	−3.947*** (0.439)
Country (var(_con)	0.914 (0.535)	1.031 (0.598)	0.888 (0.522)
Country > industry (var(_con)	0.117 (0.085)	0.113 (0.082)	0.116 (0.083)
Wald test χ^2	241.83	226.1	243.14
Prob > χ^2	0.0000	0.0000	0.0000
LR test versus logit model	χ^2 = 128.35 Prob > χ^2 = 0.0000	χ^2 = 147.35 Prob > χ^2 = 0.0000	χ^2 = 124.94 Prob > χ^2 = 0.0000
N	4,016	4,016	4,016

Note(s): Standard errors in parenthesis; ***$p < 0.01$, **$p < 0.05$
Source(s): Authors' own work

The likelihood ratio test yields evidence upholding the utilization of multilevel mixed-effects logistic regression over traditional binomial logistic regression, as evidenced by *p*-values under 0.01 across all three estimated models.

Regarding the first relationship, the results show a statistically significant positive relationship between internationally recognized quality certification and a firm's propensity to pursue process innovation. This provides empirical evidence to support *H1* strongly. The result is in line with previous studies (e.g. Ziegler, 2015; Terziovski and Guerrero, 2014). The finding aligns with theoretical frameworks positing that adopting internationally recognized certifications can help firms enhance their processes and facilitate changes across various organizational dimensions, which are essential elements for process innovation (Li *et al.*, 2018; Terziovski and Guerrero, 2014). Moreover, obtaining internationally recognized certifications means adjusting several dimensions of organizations, particularly processes, which ultimately leads to process innovation (Escrig-Tena *et al.*, 2018; Hazarika and Zhang, 2019).

Furthermore, Table 4 shows the marginal effect of internationally recognized quality certification on process innovation. We can find that both margins are statistically significant, indicating that internationally recognized quality certification status affects the predicted probability of process innovation. In particular, when the firm has no internationally recognized quality certification, the average predicted probability of process innovation is approximately 10.9%, keeping all other variables constant. In the meantime, when the firm adopts internationally recognized quality certification, the average predicted probability of process innovation is approximately 15.1%, keeping all other variables constant. This means that having internal quality control increases the predicted probability of process innovation by approximately 4.2% points, holding all other variables constant. This suggests that obtaining an internationally recognized quality certification is associated with a higher likelihood of process innovation.

Second, as can be seen from Table 3, the results reveal a statistically significant positive relationship between human capital (proxied by *Employee training*) and the probability of pursuing process innovation adoption, with a *p*-value substantiating *H2* on this direct linkage at the 1% significance level. This finding confirms theoretical frameworks arguing that training helps enhance the staff's knowledge and skills related to market demands, product design and production processes, which contributes significantly to process innovation (McGuirk *et al.*, 2015; van Uden *et al.*, 2017). Moreover, task-related training can also increase employees' motivation to innovate their work, including process innovation (Børing, 2017; Dostie, 2017).

In addition, Table 4 also shows the marginal effect of employee training on process innovation. The marginal effects of two cases of employee training are statistically

Table 4. Marginal effects

Variable	Status	Dy/dx
Internationally recognized quality certification	No	0.109*** (0.029)
	Yes	0.151*** (0.038)
Employee training	No	0.098*** (0.027)
	Yes	0.173*** (0.042)
N	4,016	

Note(s): Standard errors in parenthesis; ***$p < 0.01$
Source(s): Authors' own work

significant, which indicates that employee training status affects the predicted probability of process innovation. Specifically, the predicted probability of process innovation increases from 9.8% to 17.3% (an increase in the probability of process innovation by approximately 7.5% points, keeping all other variables constant) when the firm provides employee training ("Yes") compared to when there is no training ("No"). This suggests that employee training is associated with a higher likelihood of process innovation. These results provide clear evidence that employee training positively affects the likelihood of process innovation in our data set.

Third, the coefficient for *Internationally recognized quality certification* x *Informal competition* is positive and significant, which indicates that informal competition positively moderates the internationally recognized quality certification – process innovation relationship. This provides strong support for *H3*. The result validates the informality cost and bounded rationality perspectives about the positive moderating impact of informal competition on the relationship between internationally recognized quality certification and process innovation. In particular, international quality certification is a competitive advantage for formal firms to collaborate with external partners under the pressure of informal ones (Wu and Wu, 2019). Generally, certified firms may create a positive image and trust in cooperating with external stakeholders, and they gain a huge advantage in coping with the growth of informal competition. In addition, quality certifications also require a highly educated workforce that enhances process innovation (Bu and Cuervo-Cazurra, 2020). Hence, the achievement of international quality certification increases the competitive level of human capital and quality standards that lead to process innovation (Escrig-Tena *et al.*, 2018; Hamdoun *et al.*, 2018).

Based on the bounded rationality perspective, young firms face challenges toward insufficient knowledge to operate in the international market (Miocevic *et al.*, 2022); therefore, quality certifications not only provide a new and right orientation for them to match international standards but also build a credible image in the eyes of external stakeholders. Therefore, informal competitors will become a driver to increase process innovation through a desire for international quality certifications (Qi *et al.*, 2020).

Finally, the coefficient for *Employee training* x *Informal competition* exhibits positive and statistically significant values in Model 3. This offers robust empirical to support *H4*, which indicates that informal competition positively moderates the human capital – process innovation nexus. The observed outcome provides evidence to support the arguments that recruiting highly educated employees creates a competitive advantage for formal firms in the context of informal competition (Bu and Cuervo-Cazurra, 2020). In fact, informal enterprises may exhibit less willingness to invest in human capital due to informality costs (Bu and Cuervo-Cazurra, 2020). Formal firms can coordinate firm-specific training and hire highly educated personnel by using their legal status (Dostie, 2017), which enables them to assist businesses in upgrading and enhancing their production processes (Amarakoon *et al.*, 2018; Gallié and Legros, 2012). In addition, to compete with informal firms, formal firms may increase human capital to convince external stakeholders through personal channels (Bu and Cuervo-Cazurra, 2020; Mendi and Costamagna, 2017). Therefore, the intensity of informal competition becomes a motive for formal firms to invest in human capital through firm-specific training and recruitment activities, which helps foster process innovation.

4.3 Robustness checks

We used PSM to evaluate the robustness of the primary findings. PSM was used to mitigate the possible selection bias issue. The PSM results presented in Table 5 confirm the results previously shown in Table 3 regarding the positive impacts of internationally recognized

Table 5. PSM estimation results

Variable	ATT
	Process innovation
Internationally recognized quality certification	0.087*** (0.017)
Employee training	0.110*** (0.019)
Internationally recognized quality certification x Informal competition_dummny	0.099*** (0.026)
Employee training x Informal competition_dummny	0.167*** (0.027)

Note(s): Standard errors in parenthesis. ***$p < 0.01$
Source(s): Authors' own work

quality certification, employee training on process innovation and the positive moderating role of informal competition.

4.4 Additional analyses

We performed several additional analyses to examine whether the impacts of internationally recognized quality certification, employee training and the moderating role of informal competition are driven by specific firm size categories and groups of economies (following income classification). First, we explore whether the results are different between small and medium-sized enterprises (SMEs) and large firms. Following the "Enterprise surveys sampling methodology" of the World Bank, firms are classified into SMEs and large enterprises based on the number of employees working for this firm. In particular, SMEs include small firms (5–19 employees) and medium-sized firms (20–99 employees) and large firms have more than 100 employees (World Bank, 2022).

Table 6 presents the results from a multilevel MLM comparing SMEs to large firms. Internationally recognized quality certification has positive effects on process innovation for both SMEs and large firms. Moreover, the implementation of employee training programs is associated with more likelihood of process innovation across firms of varying sizes, including SMEs and large firms.

The interaction effect between internationally recognized quality certification and informal competition does not demonstrate statistical significance for SMEs. Conversely, for large firms, informal competition has a positive moderating impact on the internationally recognized quality certification – process innovation nexus. Additionally, the positive and significant moderating effect of informal competition on the employee training – process innovation relationship is observable solely within SMEs. Therefore, it is important to acknowledge the heterogeneity that exists across different firm size categories regarding the moderating effects of informal competition.

Second, we examined the effects of internationally recognized quality certification, employee training and the moderating impact of informal competition in lower middle-income economies compared with their counterparts in upper middle-income and high-income countries. This classification is supported by the World Bank system that stratifies countries based on gross national income (GNI) per capita. In particular, the lower middle-income category (GNI per capita from $1,136 to $4,465) includes Vietnam, Myanmar, Cambodia, the Philippines and Lao PDR. The upper middle-income and high-income category comprises Indonesia, Thailand and Malaysia (GNI per capita between $4,466 and $13,845), as well as Singapore (GNI per capita higher than $13,846) (World Bank, 2024b).

The results in Table 7 indicate that in lower middle-income economies, internationally recognized quality certification does not affect process innovation. In contrast, for upper

Table 6. Multilevel MLM estimation results (SMEs versus large firms)

Variable	SMEs Model 4	Model 5	Model 6	Large firms Model 7	Model 8	Model 9
Internationally recognized quality certification	0.378* (0.220)	0.450* (0.263)		0.770*** (0.249)	0.273 (0.318)	
Employee training	0.765*** (0.173)		0.440* (0.230)	1.025*** (0.257)		0.936*** (0.347)
Informal competition	0.322*** (0.063)	0.316*** (0.067)	0.211*** (0.075)	0.492*** (0.105)	0.179 (0.142)	0.352** (0.152)
Internationally recognized quality certification x Informal competition		−0.009 (0.187)			0.479** (0.192)	
Employee training x Informal competition			0.306** (0.132)			0.102 (0.196)
R&D	1.881*** (0.233)	2.042*** (0.229)	1.943*** (0.233)	1.475*** (0.236)	1.743*** (0.234)	1.592*** (0.234)
Firm age (ln)	0.297*** (0.106)	0.290*** (0.105)	0.323*** (0.107)	−0.006 (0.181)	−0.009 (0.184)	0.059 (0.180)
Firm size (ln)	0.150 (0.093)	0.216** (0.091)	0.198** (0.091)	−0.017 (0.122)	0.013 (0.122)	0.013 (0.120)
Constant	−4.417*** (0.491)	−4.411*** (0.492)	−4.470*** (0.491)	−3.649*** (0.930)	−2.911*** (0.947)	−3.439*** (0.918)
Country (var(_con))	0.707 (0.424)	0.737 (0.440)	0.695 (0.418)	0.830 (0.620)	1.316 (0.901)	0.653 (0.503)
Country > industry (var(_con))	0.148 (0.104)	0.139 (0.100)	0.146 (0.103)	1.20e-37 (2.14e-20)	3.71e-33 (2.38e-17)	7.66e-35 (2.10e-18)
Wald test χ^2	146.26	132.96	149.64	93.79	91.33	91.42
Prob > χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LR test versus logit model	χ^2 = 89.06 Prob > χ^2 = 0.0000	χ^2 = 94.85 Prob > χ^2 = 0.0000	χ^2 = 87.24 Prob > χ^2 = 0.0000	χ^2 = 17.67 Prob > χ^2 = 0.0000	χ^2 = 31.62 Prob > χ^2 = 0.0000	χ^2 = 15.85 Prob > χ^2 = 0.0000
N	2,916	2,916	2,916	1,100	1,100	1,100

Note(s): Standard errors in parenthesis; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Source(s): Authors' own work

Table 7. Multilevel MLM estimation results (lower middle-income economies versus upper middle-income and high-income economies)

	Lower middle-income economies			Upper middle-income and high-income economies		
Variable	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15
Internationally recognized quality certification	0.117 (0.255)	−0.225 (0.347)		0.721*** (0.215)	0.587** (0.252)	
Employee training	0.830*** (0.216)		0.732** (0.298)	0.747*** (0.192)		0.354 (0.237)
Informal competition	0.282*** (0.072)	0.226*** (0.077)	0.256*** (0.084)	0.474*** (0.080)	0.367*** (0.095)	0.188* (0.110)
Internationally recognized quality certification x Informal competition		0.296 (0.192)			0.271* (0.161)	
Employee training x Informal competition			0.074 (0.155)			0.484*** (0.153)
R&D	1.382*** (0.266)	1.626*** (0.260)	1.401*** (0.263)	1.840*** (0.213)	2.024*** (0.211)	1.944*** (0.215)
Firm age (ln)	0.400*** (0.128)	0.402*** (0.129)	0.405*** (0.128)	0.035 (0.130)	0.030 (0.129)	0.091 (0.133)
Firm size (ln)	−0.018 (0.068)	0.055 (0.065)	−0.005 (0.065)	0.004 (0.073)	0.064 (0.070)	0.132** (0.066)
Constant	−4.123*** (0.697)	−4.144*** (0.702)	−4.131*** (0.694)	−3.609*** (0.542)	−3.438*** (0.571)	−3.721*** (0.539)
Country (var(_con)	1.410 (1.143)	1.448 (1.185)	1.396 (1.134)	0.461 (0.361)	0.593 (0.452)	0.445 (0.350)
Country > industry (var(_con)	0.100 (0.128)	0.126 (0.133)	0.102 (0.127)	0.085 (0.098)	0.076 (0.091)	0.080 (0.094)
Wald test χ^2	85.79	76.02	85.9	165.5	161.21	169.79
Prob > χ^2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LR test versus logit model	χ^2 = 55.75 Prob > χ^2 = 0.0000	χ^2 = 51.31 Prob > χ^2 = 0.0000	χ^2 = 54.95 Prob > χ^2 = 0.0000	χ^2 = 42.01 Prob > χ^2 = 0.0000	χ^2 = 66.27 Prob > χ^2 = 0.0000	χ^2 = 41.57 Prob > χ^2 = 0.0000
N	1,564	1,564	1,564	2,452	2,452	2,452

Note(s): Standard errors in parenthesis; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$
Source(s): Authors' own work

middle-income and high-income economies, this certification has a positive and significant effect. However, employee training has a statistically significant positive effect in both lower middle-income economies and upper middle-income and high-income economies.

The moderating effects of informal competition on the relationships between internationally recognized quality certification and process innovation, as well as between employee training and process innovation, are found to be positive and statistically significant exclusively within the context of upper middle-income and high-income economies. This indicates that the results found in the main estimation (Table 3) are primarily driven by specific income groups, namely, upper middle-income and high-income economies. Hence, the heterogeneity present between income groups should be acknowledged.

5. Conclusions and implications

This study investigates the role of internationally recognized quality certification and human capital in process innovation in ASEAN economies. It also examines the moderating effects of informal competition on the international quality certification – process innovation and human capital – process innovation relationships. The results reveal that internationally recognized quality certification and human capital have a positive impact on process innovation. Furthermore, informal competition positively moderates the effects of both internationally recognized quality certification and human capital on process innovation.

The results from this study offer some managerial implications for managers and policymakers in ASEAN countries to enhance process innovation. First, managers of companies operating in ASEAN should pursue globally recognized quality certifications such as ISO 9001, ISO 9004 and ISO 14000. These certifications give access to international best practices and process standards that may be used to improve the effectiveness and efficiency of operations, which can contribute to process innovation. ASEAN countries' policymakers should also develop policies that would encourage the adoption of international quality certifications by firms such as tax incentives, grants and investment in national quality infrastructure (e.g. standards organizations and accreditation agencies).

Second, the management team should also invest more in staff training and skill development programs. These programs can encompass a broad range of themes, from the innovation process to strategies in problem-solving, new technologies and best practices in manufacturing. Enhanced competencies can help employees identify process inefficiencies, propose ideas for improvement and realize their innovative ideas. Regular training might also foster a culture of continuous learning and innovation.

Third, managers of ASEAN manufacturing companies should consider informal competition as a chance to accelerate their efforts at process innovation. Managers should specifically exploit informal rivalry as a rationale for increasing spending on internationally recognized quality certifications and staff training initiatives. This also creates legitimacy for formal ones.

6. Limitations and future studies

This research has some limitations that can be considered for further studies. First, the current analysis uses cross-sectional survey data from the World Bank Enterprise Surveys. As a result, it is impossible to examine long-term patterns or causal relationships. Hence, future studies should collect more data to form panel data to have a comprehensive understanding of the dynamics of the research topic.

Second, the study covered a large sample of manufacturing enterprises from ASEAN countries. However, the current study does not take into account service sectors, which is a limitation. Indeed, the distinct characteristics of service industries may lead to different dynamics in the relationships we have examined. Process innovation in service sectors might differ due to their unique operational processes and customer interactions. Therefore, studies in the future could extend this investigation to service sectors to have a better understanding of drivers of process innovation in the ASEAN region.

Third, the measure of informal competition is based on the firms' subjective evaluation about the competitors in the informal sector based on survey responses from "no obstacle" to "very severe obstacle." This subjectivity could lead to a mismatch between reported perceptions and the actual competitive threat posed by the informal firms, leading to bias in the results. Similarly, the measure of human capital as a binary variable (i.e. whether or not firms have provided formal training for employees) may oversimplify the nature of human capital. Hence, in future research, more objective measures of informal competition should be collected (e.g. the number of unregistered businesses, market share of informal firms) although obtaining this kind of data may be harder in developing economies like ASEAN. Additionally, prospective research could examine more comprehensive human capital measures such as educational attainment of employees or training hours to better capture its impact on process innovation.

Finally, regarding the research methods, while the PSM technique can partly account for the selection bias problem, it cannot address the endogeneity issue. Hence, future study could use the instrumental variable method to take into account the potential endogeneity concern. Endogeneity arises when explanatory variables, such as quality certification or training, are correlated with the error term in the model, which may occur due to omitted variable bias, measurement error or simultaneity (Roberts and Whited, 2013). For example, unobserved factors such as management quality or innovation culture of the firm, might affect both the adoption of certification or training measures and the likelihood of process innovation, and it may introduce a bias in estimates. This methodological improvement may improve the credibility of estimation results on drivers of process innovation in the ASEAN context.

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