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## Article

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Research in Globalization

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*Suggested Citation:* Yot Amornkitvikai; Teerawat Charoenrat (2024) : The impact of female chief executive officers, ownership, and globalization on ASEAN manufacturers' technical efficiency performance, Research in Globalization, ISSN 2590-051X, Elsevier, Amsterdam, Vol. 8, pp. 1-10, <https://doi.org/10.1016/j.resglo.2024.100206>

This Version is available at:

<https://hdl.handle.net/10419/331131>

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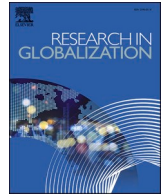
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# The impact of female chief executive officers, ownership, and globalization on ASEAN manufacturers' technical efficiency performance

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## ARTICLE INFO

### Keywords:

female CEOs

Ownership

Globalization

Technical efficiency

Manufacturing

## ABSTRACT

The premature deindustrialization of Association of Southeast Asian Nations (ASEAN) economies has impeded their development by restricting all prospects for growth, including economies of scale, human capital development, and worker productivity. In male-dominated industries, sexism and discrimination may prevent women from attaining leadership positions, especially in manufacturing. This is especially apparent where women are viewed as less technical in ASEAN manufacturing. Therefore, this study employs the beta regression model to examine the impact of female CEOs and those with ownership on the technical efficiency and performance of ASEAN manufacturers. The impact of economic globalization via foreign direct investment (FDI) and exports on technical efficiency is also examined in this study. FDIs are found to enhance ASEAN manufacturers' technical efficiency. This study also found that firms operated by female CEOs are more technically efficient, implying that they prefer stewardship-driven management strategies over agency-driven approaches. Female CEOs with ownership are likely to decrease technical efficiency, confirming the entrenchment hypothesis that their interests are not aligned with shareholders' interests. In addition, skilled labor, ISO certification, IT use, and firm size boost their technical efficiency.

## 1. Introduction

The ASEAN region has been becoming crucial since it was the fifth world's largest economy, accounting for US\$ 3.0 trillion in 2020 (The ASEAN Secretariat, 2021). Despite the ASEAN region's fast economic growth, some economies in ASEAN have been at risk of premature deindustrialization,<sup>1</sup> for example, Thailand, Malaysia, Indonesia, the Philippines, and Singapore (Chuntongvirat, 2020; Grabowski & Self, 2020; Lee, 2020; Ofreneo, 2014; Rasiah, 2020). This phenomenon has impeded their development by restricting all prospects for growth, including economies of scale, human capital development, and worker productivity (Tsukada, 2022). Moreover, manufacturing's share of the total GDP in ASEAN declined from 39.5 % in 2005 to 35.8 % in 2020 (Asian Productivity Organization, 2022; Dieppe, 2021).

Economic openness via internationalization can be critical to alleviating its current deindustrialization (Ghose, 2000). It can help increase the share of Thailand's manufacturing GDP due to more foreign market

opportunities, innovation, workers' skills development, and firm productivity improvement (Jongwanich, 2022). The decision to internationalize can be achieved through a number of potential entry modes such as exporting, foreign patent/franchising/licensing, and foreign direct investment (Blomstermo, Deo Sharma, & Sallis, 2006; Kyriakis & Koboti, 2015). Moreover, FDI could have spillover effects from advanced technology transfers and know-how to enhance the innovation of domestic manufacturing firms (Truong & Dong, 2021). Exporting, which is one of the crucial internationalization strategies, can improve firms' productivity after entering export markets. Exporting firms can gain learning-by-exporting benefits from their information access on best practices of managerial and marketing techniques and advanced technologies from foreign markets (Siba & Gebreyesus, 2017).

Men are likely to dominate male-dominated industries like manufacturing because they are more technically proficient (Jha & Saxena, 2016). This gender discrimination is expected to prohibit women from reaching the highest levels of management. In addition,

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<sup>1</sup> This phenomenon occurs in developing countries whenever the manufacturing sector reaches its peak at a much lower income level and share in employment and output than it did for early industrializers (Felipe, 2018; Tsukada, 2022).

only 24 percent of middle and senior management posts in the private sector are held by women, indicating that the glass ceiling for higher-paying jobs remains unchanged (ASEAN and UN Women, 2021). As a result of sexism and discrimination, women in ASEAN are less likely to obtain managerial positions, especially manufacturing, where women are regarded as less technically savvy.

Nonetheless, women are often more risk-averse, ethical, and observant, which may impact organizational performance (Kramer, Konrad, Erkut, & Hooper, 2006). Consequently, women who are in leadership roles may boost firm performance and decrease risk-taking (Belaounia et al., 2020). While agency theory tackles the conflict between manager and principal objectives, stewardship theory asserts that managers are stewards whose goals are aligned with their principals. Beaufort and Summers (2014) also pointed out that women prefer stewardship-driven management styles that stress collaboration over agency-driven approaches.

Due to these problems, this study contributes significantly to the existing literature by examining how female CEOs and those with ownership affect manufacturers' technical efficiency in ASEAN, including Thailand, Vietnam, Malaysia, Indonesia, and the Philippines. Agency and stewardship theories can be applied to examine the effect of female CEOs on technical efficiency. More specifically, this study aims to examine the existence of the convergence of interests and entrenchment hypotheses for female CEOs and owners in ASEAN manufacturers. The convergence-of-interests hypothesis refers to managers who own stock in their company and share the aligned interest with ordinary shareholders. In contrast, the entrenchment hypothesis refers to the situation in which business executives behave opportunistically, resulting in a lack of managerial discipline and a decrease in firm performance (Iwasaki, Ma, & Mizobata, 2022; Jensen & Meckling, 1976; Shan, 2019).

Unlike other measurements of firm performance, this study uses technical efficiency as a measurement of firm performance by creating a non-parametric piece-wise surface (or frontier) over the data using linear programming techniques (Coelli, Rao, O'Donnell, & Battese, 2005). Conceptually, technical efficiency refers to a company's capacity to generate the greatest possible output from a given set of inputs and technologies. If a company's output lies at the frontier of efficient production, then it is technically efficient. It is not technically efficient, however, if it produces less than this quantity.

To the best of the authors' knowledge, this study is the first to examine whether female CEOs and those with managerial ownership will exploit or maximize other shareholders' benefits for ASEAN manufacturers. In addition, this study aims to analyze the impact of globalization via FDI and exports on technical efficiency.

## 2. Material and method

### 2.1. Material

This study employs the World Bank's enterprise surveys, covering the firm-level data from Thailand (2016), Malaysia (2015), the Philippines (2015), Indonesia (2015), and Vietnam (2015). There are 5,651 manufacturing, retail, and service enterprises for five-country data sets. Nevertheless, this study excludes firms in service and retail industries. Finally, 2,174 samples of manufacturing firms are used in this study. Table 1 shows descriptive statistics for variables used in this study.

### 2.2. Methodology

#### 2.2.1. Measuring technical efficiency

This research measures firm performance by adopting technical efficiency (TE). Technical efficiency (TE) outperforms total factor productivity (TFP) in a cross-sectional study since TFP may result in skewed and inconsistent estimates due to a contemporaneous correlation between inputs and unobserved variables (Amornkitvikai, Harvie, &

Sangkaew, 2023). Technical efficiency is a company's capacity to achieve the greatest output feasible from a given set of inputs and technologies. If a company's output lies along the border of efficient production, it is technically efficient. However, it is not technically efficient if it produces less than this amount (Coelli et al., 2005).

Either a non-parametric technique, such as data envelopment analysis (DEA), or a parametric technique, such as stochastic frontier analysis (SFA), can be used to determine a company's technical efficiency (SFA). This study uses the DEA approach to predict technical efficiency, which does not require functional forms; instead, it uses linear programming to establish a frontier that encompasses all enterprises' data. Therefore, all businesses are measured against the best performers (Coelli et al., 2005, p. 162).

DEA is also a non-parametric performance assessment method, requiring no assumptions about functional forms. In addition, the output-oriented model is appropriate when businesses have fixed input levels and are motivated to maximize output production.<sup>2</sup> Therefore, this study employs VRS<sup>3</sup> linear programming with an output-oriented model, which can be expressed in Equation (1) (Amornkitvikai, Harvie, & Charoenrat, 2014; Coelli et al., 2005):

$$\text{Max}_{\varphi, \lambda} \varphi$$

$$\text{st } -\varphi y_i + Y\lambda \geq 0, i = 1, 2, \dots, n,$$

$$x_i - X\lambda \geq 0,$$

$$\Pi' \lambda \leq 1,$$

$$\lambda \geq 0,$$

(1)

Where:

$\varphi$  is a scalar.  $1 \leq \varphi < \infty$ , and  $\varphi - 1$  is the amount by which the  $i^{\text{th}}$  firm's output rises proportionally ( $y_i$ ), while its inputs remain the same ( $x_i$ );  $\frac{1}{\varphi}$  is the  $i^{\text{th}}$  firm's efficient score;  $x_i$  is the  $i^{\text{th}}$  firm's input vector;  $\lambda$  is constants' vector;  $\Pi' \lambda \leq 1$  defines non-increasing returns to scale.

In this study, one output was measured by the logarithm of total sales per worker of the  $i^{\text{th}}$  firm and two inputs were measured by the logarithm of intermediate costs of the  $i^{\text{th}}$  firm and the logarithm of the average wage of the  $i^{\text{th}}$  firm.<sup>4</sup> The DEAP version 2.1<sup>5</sup> is used to predict the technical efficiency of the  $i^{\text{th}}$  firm, which can be measured by the linear programming of data envelopment analysis (DEA) in Equation (1).

<sup>2</sup> Technical efficiency in output-oriented models is defined as a proportionate increase in output production at constant input levels.

<sup>3</sup> The VRS implies that firms do not operate at the full scale due to imperfect competition, government interference, and financial restrictions (Coelli et al., 2005).

<sup>4</sup> For a robust check using the sensitivity analysis of input-output mix, this study alternatively uses one input as measured by the logarithm of the average wage of the firm and one output as measured by the logarithm of the value-added, which is calculated by the total sales per worker of the firm minus the intermediate costs of the firm. All values of predicted technical efficiency are summarized in Appendix 1. In addition, Spearman's rank correlation is conducted to measure the strengths and monotonic association between the technical efficiency using the logarithm of the average wage of the firm as the input and the logarithm of the value-added as the output and the technical efficiency scores using the logarithm of total sales per worker as the output and two inputs that are the logarithm of intermediate costs and the logarithm of the average wage. The Spearman's rho is 0.9980 (prob > |t| = 0.0000), indicating a significantly strong positive relationship between the ranks in two different estimations of technical efficiency scores. Hence, the technical efficiency scores can be used in this study due to the consistent results found from the different input-output mixes.

<sup>5</sup> DEAP version 2.1 can be publicly downloaded at <https://economics.uq.edu.au/cepa/software>.

**Table 1**  
Variables and descriptive statistics.

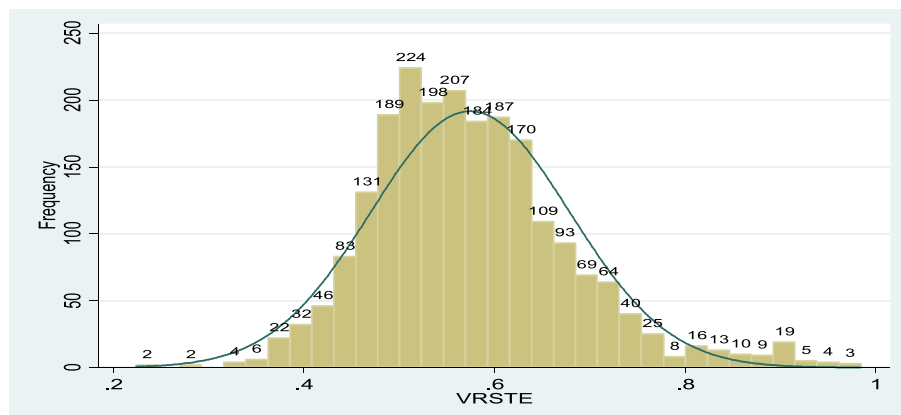
Variable	Definition	N	Yes (Mean)	No (SD)	Min	Max
VRSTE	A firm's technical efficiency, as predicted by DEA (DEAP version 2.1)	2,174	(0.5746578)	(0.1043759)	0.224	0.985
Firm size	The logarithm of a firm's market value	2,174	(0.8189573)	(0.2392124)	0	1
Skilled workers	A firm's skilled workers, as measured by skilled workers to total workers	2,174	(2.493773)	(2.493773)	-2.817607	25.94011
FDI	A dummy for foreign direct investment (FDI): = 1 if a firm has FDI = 0, otherwise	2,174	389	1,785	0	1
Export	A dummy for an exporting firm; = 1 if a firm exports = 0, otherwise	2,174	1,428	746	0	1
Female owners*female CEOs	A dummy for a female who owns and controls the firm; = 1 if a female owns and controls the firm. = 0, otherwise	2,174	542	1,632	0	1
Female owners	A dummy for a female who only owns the firm; = 1 if a female only controls the firm. = 0, otherwise	2,174	1,017	1,157	0	1
Female CEOs	A dummy for a female who only controls the firm; = 1 if a female only controls the firms. = 0, otherwise	2,174	644	1,530	0	1
Website usage	A dummy for a firm that adopts its website; = 1 if a firm adopts its website. = 0, otherwise	2,174	1,649	525	0	1
ISO certification	A dummy for a firm that has ISO certification; = 1 if a firm has an ISO license. = 0, otherwise	2,174	(692)	1,482	0	1
Thailand	A dummy for a firm located in Thailand; = 1 if a firm is located in Thailand. = 0, otherwise	2,174	(386)	1,788	0	1
Vietnam	A dummy for a firm located in Vietnam; = 1 if a firm is located in Vietnam. = 0, otherwise	2,174	333	1,841	0	1
Malaysia	A dummy for a firm located in Malaysia; = 1 if a firm is located in Malaysia. = 0, otherwise	2,174	289	1,885	0	1
Indonesia	A dummy for a firm located in Indonesia; = 1 if a firm is located in Indonesia. = 0, otherwise	2,174	768	1,406	0	1
Philippines	A dummy for a firm located in the Philippines; = 1 if a firm is located in the Philippines. = 0, otherwise	2,174	398	1,776	0	1

Source: Authors' calculation.

The technical efficiency predicted by equation (1) using DEAP version 2.1 is given in Figs. 1 and 2. According to Fig. 1, the predicted technical efficiency (TE) values show superimposed normal distribution, comprising proportions on the opened interval (0, 1). Consequently, the Tobit regression model is subject to identical critiques as the linear regression model (Kieschnick & McCullough, 2003). More specifically, the ordinary least square (OLS) assumptions are no longer valid. The conditional expectation function is likely to be nonlinear since it projects onto a bounded interval. In addition, its variance tends to be

heteroskedastic because it reaches zero as the mean approaches either boundary point (Kieschnick & McCullough, 2003). The Tobit model may not be applicable since the observed boundary values of the [0, 1] range for proportional data are not found in this study.

From Fig. 2, the average TE of ASEAN manufacturers predicted by DEAP version 2.1 is 0.5747. In addition, the Philippines has the highest average TE (0.6164), followed by Vietnam (0.5991), Thailand (0.5796), Indonesia (0.5501), and Malaysia (0.54769).



**Fig. 1.** The technical efficiency of ASEAN manufacturers, predicted by DEA. Source: Authors' estimates.

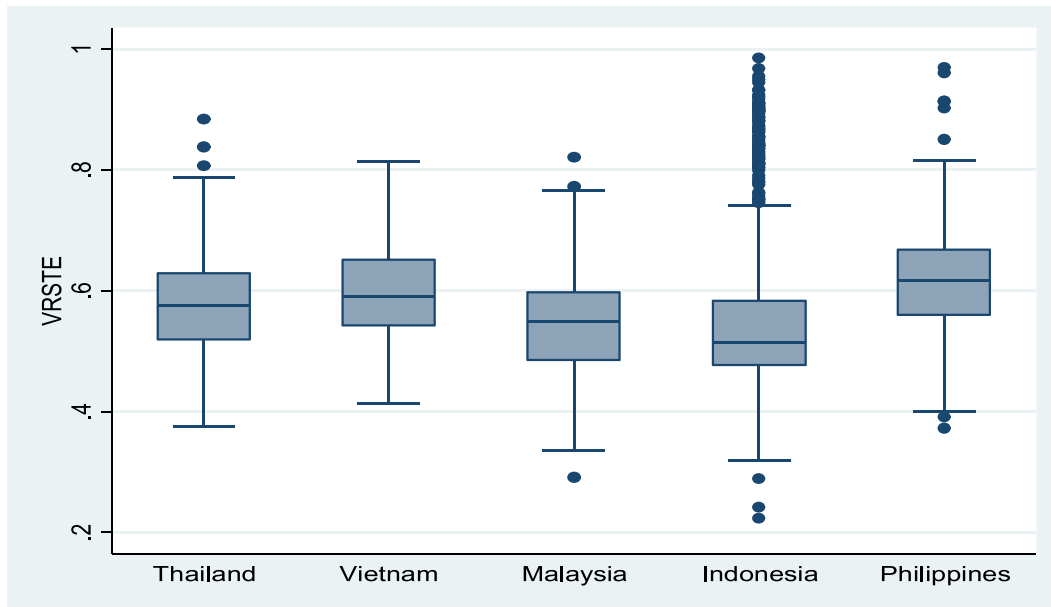


Fig. 2. The technical efficiency of ASEAN manufacturers, classified by countries. Source: Authors' estimates.

### 2.2.2. Econometric model

The linear regression model, particularly the OLS, is widely employed in many studies. However, the OLS is not applicable when the dependent variable is confined to the range (0, 1) since the OLS may provide fit values for the variable of interest that exceed its lower and upper limits (Ferrari & Cribari-Neto, 2004). Due to the predicted technical efficiency, the beta regression model proposed by Kieschnick and McCullough (2003) and Ferrari and Cribari-Neto (2004) is used in this study since the beta regression is appropriate only for a dependent variable that is strictly greater than zero and strictly less than one because the beta distribution has support only on the interval (0, 1). The beta distribution is very flexible for modeling proportions since its density can have quite different shapes depending on the values of the two parameters that index the distribution. The density of a beta-distributed dependent variable  $y$  conditional on covariates  $x$  can be written as follows (Ferrari & Cribari-Neto, 2004):

$$f(y; u_x, \varphi_x) = \frac{\Gamma(\varphi_x)}{\Gamma(u_x \varphi_x) \Gamma((1 - u_x) \varphi_x)} y^{u_x \varphi_x - 1} (1 - y)^{(1 - u_x) \varphi_x - 1}, 0 < y < 1 \quad (2)$$

Where  $0 < u_x < 1$  and  $\varphi_x > 0$ ;  $u_x = E(y|x)$ ;  $u_x$  is linked to the covariates by the link function  $g(u_x) = x\beta$ ;  $\varphi_x$  scales the conditional variance according to  $\text{Var}(y|x) = \frac{u_x(1-u_x)}{1+\varphi_x}$ .

There are several possible choices for the link function  $g(u_x)$ . Hence, this study will employ the logit function ( $g(u_x) = \ln(\mu_x/(1 - \mu_x))$ ), the probit function ( $g(u_x) = \Phi^{-1}(\mu_x)$ ), where  $\Phi(\bullet)$  is the cumulative distribution function of a standard normal random variable, the complementary log-log function ( $g(u_x) = \ln(-\ln(1 - \mu_x))$ ), and the log-log function (Ferrari & Cribari-Neto, 2004).

$$E(y|x) = h(Y\beta + \Psi\beta + \Pi\beta + u) \quad (3)$$

Where;

$y$  is the vector of the technical efficiency, which is predicted by equation (1).

$Y$  is the matrix of the included exogenous variables such as i) FDI, ii) export, iii) skilled workers, iv) female owners\*female CEOs, v) female owners, female CEOs, vi) ISO certification, vii) firm size, viii) website adoption.

$\Psi$  is the matrix of the control variable, such as i) countries and ii) sub-manufacturing sectors.

$\beta$  is the vector of the parameters of explanatory and control variables.

Finally, the Akaike's Information Criteria (AIC) statistic is used to select the most appropriate model fitted to the data. The AIC statistic varies by regression model class and sample size. Moreover, the AIC statistics is the optimal Kullback-Leibler information-based model selection criteria for non-normal and quasi-likelihood regression models (Burnham & Anderson, 2004; Kieschnick & McCullough, 2003). The Bayesian information criterion, often known as BIC statistics, is another method that may be utilized to choose the appropriate model to use in large samples. As a result, the basic strategy for model selection is to seek the model that produces the lowest AIC and BIC values (Cameron & Trivedi, 2005; Smithson & Verkuilen, 2006).

## 3. Theoretical and empirical reviews

### 3.1. Stewardship and agency theories

Given this study's primary objective, the agency and stewardship theories are well-suited for deployment to this research. According to the agency theory proposed by Jensen and Meckling (1976), as utility maximizers, both the agent (manager) and the principal (shareholder) are liable to have conflicts of interest. Due to adverse selection and moral hazards, a lack of managerial effort, an aversion to higher-risk projects, a preference for short-term investments with high returns, and conflicts of interest in increasing earnings retention for shareholders, the separation of ownership and control is likely to induce agency costs (Jensen & Meckling, 1976). As a result, management is unlikely to act in the best interests of shareholders. Managers may use company resources depending on the discrepancy caused by information asymmetry in this manner (Fama & Jensen, 1983).

Although agency theory tackles the divergence of manager-principal interests, stewardship theory contends that managers are stewards whose intentions align with their principals' aims. Consequently, managers as stewards are more inclined to safeguard and increase shareholder wealth through organizational effectiveness as this maximizes their utility function (Buachoom & Amornkitvikai, 2022; Davis, Schoorman, & Donaldson, 1997).

More specifically, the recent literature applies agency theory to examine the principal-agency (type I) and principal-principal (type II) problems (Villalonga & Amit, 2006). For the principal-agency problem (type I), large shareholders may have more incentives to oversee



management, reducing the owner-manager conflict, as suggested by Jensen and Meckling (1976). Managers who own shares in their company share a common interest with other shareholders. Therefore, they optimize the firm's worth, contributing to its success (Iwasaki et al., 2022; Jensen & Meckling, 1976; Shan, 2019). However, according to the principal-principal dilemma (type II), large shareholders may leverage their firm ownership for personal gain at the expense of minor shareholders. In other words, this alludes to the entrenchment concept, which argues that shareholders or the board of directors may find it difficult to exert influence over managers to optimize their earnings due to managers' significant ownership (Shan, 2019). This may induce executives to act opportunistically, resulting in a lack of managerial discipline and diminishing the organization's value (Iwasaki et al., 2022; Jensen & Meckling, 1976; Shan, 2019). This dispute could be resolved by adopting enforceable contracts, independent boards, and external senior management.

Some empirical studies also found that managerial ownership can significantly affect firm performance. For instance, Iwasaki et al. (2022) discovered that managers' ownership positively impacts the performance of their owned enterprises. However, the relationship between corporate ownership and performance is generally weak. This study shows that investors' management discipline in emerging markets needs to be improved in comparison to advanced economies. Shan (2019) found both convergence-of-interest and entrenchment effects, with firm performance improving in the 0–20 percent managerial ownership range and deteriorating when board directors become entrenched in the 20–50 percent ownership range. According to Buachoom, Amornkitvikai, Al Farooque, and Sun (2023), women are more likely to have high moral standards and be aware of a company's advantages to its stakeholders. Their findings confirm the stewardship theory by demonstrating that Thai female directors may mitigate the detrimental impact of family ownership, resulting in increased business value.

According to the human capital model of Polachek (1981), women tend to work less than males. Women are more likely than men to seek work-life balance through flexible hours and part-time jobs (Cortes & Pan, 2018). Men are likely to dominate male-dominated industries like manufacturing because they are more technically proficient (Jha & Saxena, 2016). Defeminization may be related to women's inability to compete in capital-intensive sectors (Lan & Shepherd, 2018). In male-dominated industries, sexism and prejudice may prevent women from attaining leadership positions. The influence of female leadership on business success is particularly intriguing in those Asian nations where women find less support than men in the labor market (Singhathep & Pholphirul, 2017). Singhathep and Pholphirul (2017) discovered that although there are few women in the manufacturing sector, female CEOs of Thai manufacturing firms tend to have a detrimental relationship with short-term financial performance indicators (such as annual sales and profits) and long-term firm development indicators (such as product and process innovations). Several empirical studies also found that female employees have a negative effect on productivity and technical efficiency (Danso-Abbeam, Baiyegunhi, & Ojo, 2020; Islam, Gaddis, Palacios-Lopez, & Amin, 2018; Tsou & Yang, 2019).

Hence, adopting stewardship and agency theories, this study will test whether female CEOs and owners are more likely to act like stewards, which means they are more likely to protect and increase shareholder wealth, leading to higher levels of technical efficiency, or whether they may use their firm ownership for personal gain at the expense of minor shareholders due to the type II principal-principal agency problem. Due to the principal-principal agency dilemma (type II), none of previous research have investigated the influence of female CEOs and female owners on the technical efficiency of ASEAN manufacturing enterprises.

### 3.2. Globalization and internationalization theories

Given the objective of this study, economic globalization via FDI and exports are crucial in promoting technical efficiency. Globalization

refers to the growing interdependence of national economies world-wide. Still, the complexity of globalization stems from integrating its economic, social, and political ramifications (Ghosh, 2021). For example, social globalization is primarily concerned with culture and norms, whereas political globalization involves how a country's political system integrates into the global political level. Furthermore, economic globalization investigates how trade and investment influence nations (Ghosh, 2021). With a rapid globalization, internationalization theories have been explored in the literature to explain the process of internationalization and its impact on the efficiency of enterprises operating in home and host countries. Focusing on international economics, Dunning (1980) proposed the eclectic theory of international production, consisting of three crucial factors for making a firm's decision to internationalize in the host country such as 1) ownership (i.e., human capital intensity in a host country), 2) location (i.e., a host country's ability to produce particular goods, relative wages and relative market shares), and 3) internalization (i.e., the exploitation in a host country's production mechanisms and resources rather than those of the home country).

Based on the Uppsala internationalization model, Johanson and Wiedersheim-Paul (1975) distinguished between four different stages for entry into foreign markets. The successive stages indicate higher levels of international involvement, such as i) having no regular export activities, ii) exporting via independent agents, iii) establishing a sales subsidiary in the foreign (host) country, and iv) having a production or manufacturing unit in the foreign (host) country. In addition, the decision to enter foreign markets is made rationally, based on the analysis of transaction costs. More specifically, it helps a firm in the home country decide whether or not to establish a manufacturing subsidiary in the foreign (host) country (Whitelock, 2002).

As a result, internationalization is likely to cause spillover effects for firms in home and host countries, which directly affect a firm's technical efficiency. In this study, globalization can be proxied by foreign direct investment (FDI) and exports. Based on the eclectic theory of international production proposed by Dunning (1980), foreign direct investment (FDI) will likely transmit spillover effects to the host country, which can boost domestic firms' efficiency (Arif-Ur-Rahman & Inaba, 2021). In addition, FDI is motivated to share their experience with local suppliers in the backward linkages to maximize production control. As a result, FDI may directly influence the firm performance of their foreign subsidiaries via their supply chains (Hwang & Kim, 2021). Several empirical studies have examined the impact of FDI on technical efficiency (Amornkitvikai & Harvie, 2011; Charoenrat & Harvie, 2017; Ghali & Rezgui, 2011; Sur, Nandy, & Zhang, 2018; Wang & Wong, 2016; Yasin, 2021; Zhang, Guo, & Wang, 2014). However, the empirical results from those studies are inconclusive.

According to Wang and Wong (2016), horizontal FDI, which refers to the overseas production of the same goods and services produced in the home market, does not always increase the firm's technical efficiency in Chinese manufacturing enterprises. On the other hand, firms with greater absorptive abilities profit more from horizontal FDI than others. They also discovered that FDI in downstream industries improve technical efficiency, but FDI in upstream sectors do not. Charoenrat and Harvie (2017) found a significant positive association between FDI and technical efficiency for Thai manufacturing SMEs.

Based on the Uppsala internationalization model, exports play an essential role in enhancing the technical efficiency of export-oriented firms (Mengistae & Pattillo, 2004; Mok, Yeung, Han, & Li, 2010). More specifically, exports boost production efficiency through the learning-by-doing experience (Xuan & Chen, 2019). Furthermore, by entering a larger and more competitive market, manufacturers may enhance production processes, technical standards, quality control, and inventory management technology, which improves technical efficiency (Xuan & Chen, 2019). In addition, exporting firms are more likely to have better technical efficiency due to their economies of scale and scope (Mengistae & Pattillo, 2004; Mok et al., 2010). Furthermore,

exporting firms are required to manufacture items that satisfy international standards and the high expectations of foreign clients in terms of product quality and variety, driving them to improve their technical skills and, therefore, their technical efficiency (Mok et al., 2010). Some empirical investigations have shown a strong and positive relationship between exporting and technical efficiency (Amornkitvikai & Harvie, 2011; Charoenrat & Harvie, 2014, 2017; Handoyo et al., 2022; Mok et al., 2010; Ngo, Le, Tran, Nguyen, & Nguyen, 2019; Sur & Nandy, 2018; Yasin, 2022). For instance, Yasin (2022) found that exporting firms are more technically efficient than non-exporting firms in Indonesian manufacturing sectors. Handoyo et al. (2022) revealed that firms that focus on exporting are more efficient than those that solely sell domestically for the textile industry in Indonesia. Similarly, Charoenrat and Harvie (2017) stated that small firms that export are more likely to be technically efficient than those that do not export in Thailand's manufacturing sector. On the other hand, medium-sized firms have no significant impact on their technical efficiency.

As a result, this study adopts Dunning's (1980) eclectic theory of international production, which contends that foreign direct investment (FDI) will probably have spillover effects on ASEAN economies that can increase the productivity of their local firms. According to the Uppsala internationalization model, exports are hypothesized to enhance ASEAN manufacturers' technical efficiency through learning-by-doing experience.

#### 4. Results

The empirical findings, estimated by the beta regression models, are reported in Tables 2 and 3. Table 2 shows the results of the beta regression models obtained by the logit function and the probit function. Table 3 shows the beta regression models obtained by the complementary log-log function and the log-log function. According to AIC and BIC statistics, the beta regression model based on the complementary log-log link function reports the lowest BIC and AIC values (-3771.196 and -3913.304) compared to other link functions. As a result, the beta regression with the complementary log-log link function is the most appropriate model compared to the three other link functions. In addition, robust-standard errors are employed in this study, which can correct the heteroscedasticity. Marginal effects for the beta regression

models are given in Tables 2 and 3.

This study found consistent results among four-link functions, as in Tables 2 and 3. In addition, this study revealed that female CEOs could significantly and positively affect the technical efficiency performance of manufacturing firms in selected ASEAN countries, including Thailand, Vietnam, Malaysia, Indonesia, and the Philippines, at the 1 percent significant level ( $p < 0.01$ ). The marginal effect of female CEOs for the complementary log-log link function is 0.0449, indicating that female CEOs' probability of being technically efficient would be 4.49 percentage points higher than male CEOs.

However, female owners are not found to be significantly associated with their firm's technical efficiency. Interestingly, female CEOs with ownership are likely to reduce a firm's technical efficiency at the 5 percent significance level ( $p < 0.05$ ). The marginal effect of female CEOs with managerial ownership for the complementary log-log link function is -0.0390, indicating that female CEOs' probability of being technically efficient would be 3.90 percentage points less than those without managerial ownership.

In addition, skilled labor is significantly and positively associated with a firm's technical efficiency at the 5 percent significant level ( $p < 0.05$ ). The marginal effect of skilled labor for the complementary log-log link function is 0.0172, indicating that a one-percent increase in skilled labor will increase the probability of being technically efficient by 1.72 percentage points.

Focusing on the impact of globalization on technical efficiency, FDI is found to be significantly and positively associated with technical efficiency at the 10 percent level of significance, but exports are not significantly correlated with technical efficiency. The marginal effect of FDI for the complementary log-log link function is 0.0229, indicating that firms with FDI are more likely to be technically efficient than firms without foreign direct investment by 2.29 percentage points. In this study, the ISO license significantly and positively affects a firm's technical efficiency at a 1 percent significance level.

For the complementary log-log link function, the marginal effect of FDI is 0.0229. This means that firms with FDI are 2.29 percentage points more likely to be technically efficient than firms without FDI. Finally, IT (website) usage and firm size are significantly and positively associated with technical efficiency at the 1 percent significance level. For the complementary log-log link function, the marginal effects of IT usage

**Table 2**

Beta regression models: (1) Logit link function and (2) Probit link function.

Link Function	Beta regression: Logit link function $g(u) = \log(u/(1-u))$ [Logit]				Beta regression: Probit link function $g(u) = \text{invnormal}(u)$ [Probit]			
	Coef.	Robust Std. Err.	dy/dx	Delta-method Std. Err.	Coef.	Robust Std. Err.	dy/dx	Delta-method Std. Err.
Technical Efficiency								
FDI	0.0964***	(0.0316)	0.0233***	(0.0076)	0.0599***	(0.0196)	0.0232***	(0.0076)
Export	-0.0338	(0.0241)	-0.0082	(0.0058)	-0.0211	(0.0150)	-0.0082	(0.0058)
Skilled workers	0.0719**	(0.0337)	0.0173**	(0.0081)	0.0446**	(0.0210)	0.0173**	(0.0082)
Female owners*female CEOs	-0.1601**	(0.0710)	-0.0386**	(0.0171)	-0.0999**	(0.0442)	-0.0388**	(0.0171)
Female owners	-0.0009	(0.0257)	-0.0002	(0.0062)	-0.0003	(0.0160)	-0.0001	(0.0062)
Female CEOs	0.1825***	(0.0665)	0.0440***	(0.0160)	0.1141***	(0.0414)	0.0443***	(0.0160)
ISO certification	0.1558***	(0.0239)	0.0376***	(0.0058)	0.0968***	(0.0149)	0.0375***	(0.0057)
Countries (ref: Thailand)								
Vietnam	0.0667**	(0.0310)	0.0161**	(0.0075)	0.0416**	(0.0193)	0.0161**	(0.0075)
Malaysia	-0.1938***	(0.0304)	-0.0475***	(0.0074)	-0.1207***	(0.0189)	-0.0474***	(0.0074)
Indonesia	0.0564*	(0.0329)	0.0136*	(0.0079)	0.0364*	(0.0206)	0.0141*	(0.0080)
Philippines	0.1376***	(0.0311)	0.0330***	(0.0074)	0.0857***	(0.0193)	0.0331***	(0.0075)
Firm size	0.0281***	(0.0055)	0.0068***	(0.0013)	0.0176***	(0.0035)	0.0068***	(0.0013)
IT usage	0.2174***	(0.0265)	0.0525***	(0.0064)	0.1363***	(0.0165)	0.0529***	(0.0064)
Sectors	Yes		Yes		Yes		Yes	
Constant	-0.3009***	(0.0778)			-0.1888***	(0.0486)		
Number of obs	2174				2174			
Wald chi2(23)	696.72				700.49			
Prob	0.000***				0.000***			
Log pseudolikelihood	1976.4966				1977.2581			
BIC	-3760.885				-3762.408			
AIC	-3902.993				-3895.623			

Remarks: \*, \*\* and \*\*\* indicate that the corresponding null hypothesis is rejected at the 10%, 5%, and 1%, respectively.

**Table 3**

Beta regression models: (3) Complementary log–log link function and (4) Log–log link function.

Link Function	Beta regression: cloglog link function $g(u) = \log(-\log(1-u))$ [Comp. log–log]				Beta regression: loglog link function $g(u) = -\log(-\log(u))$ [Log–log]			
	Coef.	Robust Std. Err.	dy/dx	Delta-method Std. Err.	Coef.	Robust Std. Err.	dy/dx	Delta-method Std. Err.
Technical Efficiency								
FDI	0.0635***	(0.0206)	0.0229***	(0.0074)	0.0750***	(0.0248)	0.0236***	(0.0078)
Export	–0.0233	(0.0162)	–0.0084	(0.0058)	–0.0254	(0.0184)	–0.0080	(0.0058)
Skilled workers	0.0477**	(0.0229)	0.0172**	(0.0083)	0.0549**	(0.0255)	0.0173**	(0.0080)
Female owners*female CEOs	–0.1082**	(0.0465)	–0.0390***	(0.0168)	–0.1217**	(0.0556)	–0.0383**	(0.0175)
Female owners	0.0015	(0.0172)	0.0005	(0.0062)	–0.0027	(0.0198)	–0.0009	(0.0062)
Female CEOs	0.1245***	(0.0436)	0.0449***	(0.0157)	0.1384***	(0.0520)	0.0436***	(0.0164)
ISO certification is	0.1021***	(0.0157)	0.0368***	(0.0057)	0.1218***	(0.0187)	0.0384***	(0.0059)
Counties (ref: Thailand)								
Vietnam	0.0459**	(0.0208)	0.0165**	(0.0075)	0.0499**	(0.0237)	0.0157**	(0.0074)
Malaysia	–0.1318***	(0.0208)	–0.0468***	(0.0074)	–0.1462***	(0.0228)	–0.0478***	(0.0075)
Indonesia	0.0475**	(0.0231)	0.0171**	(0.0083)	0.0353	(0.0243)	0.0111	(0.0076)
Philippines	0.0924***	(0.0207)	0.0334***	(0.0075)	0.1057***	(0.0240)	0.0328***	(0.0074)
Firm size	0.0193***	(0.0039)	0.0070***	(0.0014)	0.0211***	(0.0041)	0.0066***	(0.0013)
IT usage	0.1542***	(0.0186)	0.0556***	(0.0067)	0.1595***	(0.0196)	0.0502***	(0.0061)
Sectors	Yes		Yes		Yes		Yes	
Constant	–0.5793***	(0.0539)			0.1463**	(0.0578)		
Number of obs	2174				2174			
Wald chi2(23)	694.9				705.67			
Prob	0.000***				0.000***			
Log pseudolikelihood	1981.6521				1972.8116			
BIC	–3771.196				–3753.515			
AIC	–3913.304				–3895.623			

Remarks: \*, \*\* and \*\*\* indicate that the corresponding null hypothesis is rejected at the 10 %, 5 %, and 1 %, respectively.

and firm size are 0.0556 and 0.0070, respectively. This indicates that firms adopting IT (website) are more likely to be technically efficient than firms without IT usage by 5.56 percent. Finally, a one-percent increase in a firm's market value (firm size) increases the predicted probability of being technically efficient by 0.70 percentage points.

## 5. Discussions

This study found that female CEOs are likely to increase the technical efficiency performance of ASEAN manufacturers. This favorable evidence implies that women tend to be more conservative, ethical, and observant than males, which can impact an organization's success (Kramer et al., 2006). As a result, having women in leadership roles may improve the performance of an organization while also reducing the amount of risk taken by the company (Belaounia, Tao, & Zhao, 2020). This study also supports the hypothesis that women are more inclined to run their companies using steward-driven management styles, in which the female CEOs function in the role of stewards whose objectives are congruent with those of the company's owners (Beaufort & Summers (2014)). In other words, this evidence is inconsistent with the principal–agency problem that highlights the conflicts of interest between management and stockholders due to the separation of ownership and control (Buachoom & Amornkitvikai, 2022; Jensen & Meckling, 1976). This study's finding is aligned with Gutiérrez-Fernández and Fernández-Torres (2020) that female board representatives improve Spanish-listed enterprises' technical efficiency due to better governance.

Nonetheless, this study discovered those female CEOs with ownership are likely to lower firms' technical efficiency. This finding could support the agency problem (type II) or the entrenchment hypothesis, which contends that executives act opportunistically, resulting in a lack of managerial discipline (Iwasaki et al., 2022; Jensen & Meckling, 1976; Shan, 2019). This could reduce the company's technical efficiency. The finding of this study is also comparable to that of Shan (2019), who demonstrated the existence of the entrenchment hypothesis by showing that a firm's value falls when board directors become entrenched with additional degrees of ownership.

This study confirms that skilled labor can positively affect a firm's technical efficiency. This result suggests that a higher proportion of competent workers might increase a firm's marginal product of labor,

leading to greater technical efficiency. Businesses can maximize their outputs with a smaller workforce by hiring more skilled workers than unskilled ones. This result is consistent with the findings of Pedersen, Scedrova, and Grecu (2022) found that trained labor with hardware investments can increase the technical efficiency of Danish businesses.

Globalization via FDI is critical in enhancing firms' technical efficiency in ASEAN. FDI is incentivized to share their knowledge with local suppliers in the backward linking chain to maximize production control. However, because local suppliers are involved in the supply chain of FDI, their actions may directly impact the firm performance of foreign subsidiaries (Hwang & Kim, 2021). FDI spillover effects may increase the effectiveness of domestic enterprises (Arif-Ur-Rahman & Inaba, 2021). The positive evidence is consistent with Charoenrat and Harvie (2017) that found a significant and positive relationship between FDI and technical efficiency for Thai manufacturing SMEs. Finally, this study suggests that ISO certification and IT usage can enhance their technical efficiency. This study also indicates that ISO 9000 and ISO 9001-certified ASEAN manufacturers will achieve technical efficiency through quality management. This outcome is similar to Kakouris and Sfakianaki (2018) suggested that adopting ISO 9000 delivers benefits associated with internal process enhancements, such as quality awareness and process improvement, productivity, and overall efficiency. This study found that business size boosts technical efficiency. Larger businesses are more likely to profit from economies of scale and scope, cheaper production costs, and increased efficiency and competitiveness (Charoenrat, Harvie, & Amornkitvikai, 2013; Heshmati & Rashidghalam, 2018).

## 6. Conclusion and policy implications

This study confirms the eclectic theory of international production that economic globalization via FDI is likely to increase technical efficiency through the spillover effects of their technology and expertise. Therefore, FDI should be promoted for ASEAN manufacturers since FDI increases input quality through vertical connections, particularly backward links, by transferring knowledge to local input sources. As a result, ASEAN governments may impose and integrate policies such as: 1) specific industrial policies (i.e., promoting specific industries or specific types of FDI that are appropriate to each ASEAN nation's development),



2) sound macroeconomic policies (i.e., policies to reduce corruption) and policies to attract FDI (i.e., building capacity of local suppliers and sound competition policies), and 3) policies to upgrade FDI (i.e., encouraging value-added productions). 4) Policies to strengthen linkages and spillovers to domestic firms (for example, developing linkages between foreign multinationals and local suppliers through linkage programs and R&D).

In a society that values masculinity, men are expected to lead traditionally masculine occupations such as manufacturing due to their superior technical abilities. Whether female executives' management styles will increase or decrease firm performance has been debated, especially in male-dominated industries like manufacturing. In this study, stewardship and agency theories are applied to examine the effect of female CEOs on firms' technical efficiency in ASEAN. This study confirms that female CEOs can enhance manufacturers' technical efficiency in ASEAN. This implies that female CEOs are more likely to choose stewardship-driven management styles that stress collaboration than agency-driven approaches, which improve their firms' technical efficiency. In other words, the separate roles of female CEOs and owners can reduce agency problems. However, this study found that female CEOs with managerial controls (ownership) will likely deteriorate their firms' technical efficiency. This could be due to the principal-principal agency problem (type II), in which female CEOs with management ownership may exploit the benefits of other shareholders by acting opportunistically, resulting in a lack of organizational discipline and weakening their firms' technical efficiency.

As a result, women in leadership positions should be promoted in ASEAN, especially in those male-dominated sectors like manufacturing. As a result, ASEAN manufacturing firms should consider hiring more female CEOs or promoting female employees to leadership positions within their organizations, since female CEOs are more capable of utilizing inputs to maximize their enterprises' technical efficiency than male CEOs. In particular, the government may help to pass new laws, regulations, and initiatives that promote a gender-inclusive viewpoint in male-dominated industries such as manufacturing.

However, the separation of female leaders and their ownership should be considered for ASEAN manufacturing firms, as this can reduce agency costs, leading to higher levels of firms' technical efficiency. In other words, ASEAN manufacturing enterprises should support effective corporate governance, which entails balancing the interests of various stakeholders, such as shareholders, senior executive directors, clients, suppliers, creditors, governments, and communities.

Aside from the responsibilities of female entrepreneurs and ownership affecting technical efficiency, a larger share of skilled labor can improve their enterprises' technical efficiency since competent workers are more likely to create more outputs than those without or with less technical knowledge. ASEAN manufacturing employees should engage in training and upskilling programs as part of skill development measures. Immigration and talent recruiting policies should be devised to ease labor supply deficiencies, cover skill gaps in the near term, and highlight long-term needs. This research demonstrates that ISO certifications and IT usage positively affect their technical efficiency. Likewise, promoting ISO certifications and IT use among ASEAN businesses can increase efficiency. Finally, large organizations also have more technical efficiency; thus, ASEAN manufacturers should focus on expanding their businesses.

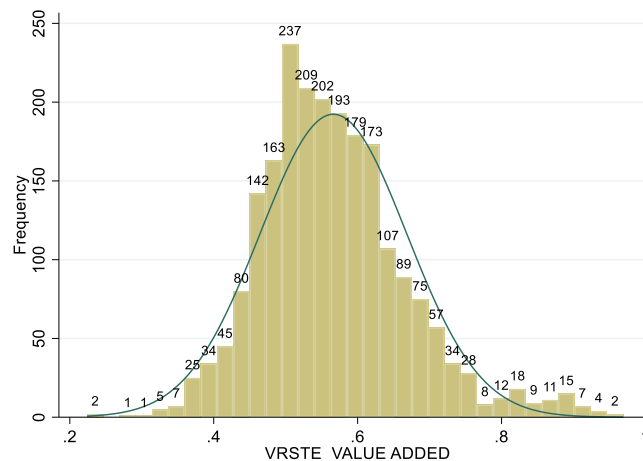
#### Credit authorship contribution statement

**Yot Amornkitvikai:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Supervision, Writing – original draft, Writing – review & editing. **Teerawat Charoenrat:** Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Appendix 1:. Technical efficiency scores predicted by DEA using the value-added output



Source: Authors' estimates.

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