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Foreign Direct Investment, Skilled Labour, and Technical Efficiency: Perspective from Indonesia's Foods and Beverages Exports

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Abstract

In this study, we examined the roles of foreign direct investment (FDI), skilled labour, and technical efficiency in determining the exports of the food and beverage industries in Indonesia. To address this issue, we utilised data from industry micro firms for the period 2010-2015. We applied the maximum likelihood estimation (MLE) technique to the logistic model and the stochastic frontier analysis (SFA). Findings revealed that the food and beverage industries are operating below the possible technical efficiency (TE). However, foreign direct investment, skilled labour, technical efficiency, and industrial concentration assert a significant positive effect on the probability of firms' exports. In the food and beverages sector and the beverages industry, firm size promotes exports; however, in the food industry, firm size has the opposite effect, reducing exports. The imported raw materials have an insignificant effect on the firms' probability of exporting. Interestingly, findings on the mediating roles of technical efficiency and industrial concentration, as well as technical efficiency and firm size, revealed an increasing influence on the probability of exporting. Skilled labour and firm size only positively promote exports in the foods and beverages sector and the food industry, but not in the beverages

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industry. These findings are novel and present an important pathway for policy-making related to the food and beverage industry, potentially shaping future strategies and initiatives in the Indonesian food and beverage sector.

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Introduction

Exporting is a key indicator of firm performance, particularly for firms engaged in foreign markets and competition (Lestari *et al*., 2024). Exporting offers firms an avenue for growth and access to foreign markets, which stimulates dynamism in an economy (Edwards *et al*., 2017). Business firms are attempting to enhance their competitive position by entering foreign markets through exports, a trend that is not exclusive to the Indonesian food and beverage (F&B) industries, nor to similar ones. To maintain a competitive position, product and service quality must be improved, and this will pave the way for further innovation (Rehman, 2017). In this study, we aim to address the issues of exporting in Indonesia's food and beverage sector. This is because, at the global level, the demand for food has increased significantly, and Indonesia has played a crucial role in meeting this global demand. This is because Indonesia is a key player in the food and beverage sector, as it is one of the world's largest suppliers of food and beverages. The food and beverage sector is a key component of the Indonesian economy. The industries in the sector continued to be a source of value addition, employment generation, and expanding economic activities. An analysis of the F&B sector is important as these food items tend to experience a rapid increase in consumption over supply. This trend has also been accompanied by an expanding global conflict and population growth, which mostly hamper food distribution (Rozi *et al*., 2023). The F&B sector is growing rapidly in Indonesia and contributes heavily to the growth of manufacturing and other sectors (Tamin *et al*., 2024; Yasin, 2021). The sector is the second-largest contributor to the Indonesian economy (Bui *et al*., 2022). Indonesia can play a crucial role in the global food and beverage supply chain by exporting and contributing to the mitigation of impending global food insecurity.

Export is key to the growth, expansion, and survival of firms in the food and beverage industry. It has resulted in increased competitiveness and productivity for many years. Various factors determine the engagement of firms within the industry in international markets. Therefore, understanding and assessing the factors influencing exports in the F&B sector will be of immense significance. Indonesia is a relatively large, open market economy that makes a significant contribution to global exports. Considering the role

of exporting in Indonesian food and beverage firms and the economy as a whole, it is essential to examine this issue.

The state of Indonesia's exports experienced an average annual growth of 13% from 2010 to 2019, with the highest export recorded in 2011, valued at $ 203.5 billion (USD). Meanwhile, the lowest export value was recorded in 2016, at $ 144.49 billion. This is based on the Indonesian Foreign Trade Statistics, as per the 2018-2019 ISIC code, published by the Indonesian Statistics Bureau. Increased exports are associated with improved performance in the food and beverage industries. In Indonesia, the gross manufacturing value-added contribution of the F&B industries is 23.15% with a strong linkage with upstream and downstream sectors (Tamin *et al*., 2024).

Empirically, two theories explain the reason why firms that export have higher productivity than firms that do not export. The first theory is the self-selection condition, which applies only to firms with high productivity and those that engage in exporting (Gupta *et al*., 2018; Rachbini, 2017; Serti & Tomasi, 2008). Engaging in the international market and exporting is restricted by barriers or additional costs, such as marketing and transportation costs (Niringiye & Tuyiragize, 2007; Rachbini, 2017). The second theory is learning by exporting (LBE), where firms that export will become more productive and efficient. This occurs because business firms that engage in exporting gain knowledge, such as new technologies and information from foreign buyers.

Additionally, firms are motivated to improve product quality and continue innovating to fulfil foreign consumer tastes and increase competitiveness (Lemi & Wright, 2020). The validation of these theories remains unclear and is still debated to date. However, the theory of self-selection has been recognised more than the theory of LBE, and some researchers have reported biased findings (Granér & Isaksson, 2009; Thomas & Narayanan, 2012).

The existence of foreign investment is also a factor that affects the company's decision to export. Foreign direct investment (*FDI*) through spillover can carry information, knowledge, and new technology, as well as access to international market networks (marketing) that can benefit the firm (Niringiye & Tuyiragize, 2007). The role of *FDI* in influencing a firm's decision to export has been shown to have a significant and positive impact on export (Fu, 2011; Hoekstra, 2013; Wignaraja, 2008a, 2008b). Furthermore, the existence of skilled labour can accelerate the absorption of new technology, as well as the development of business strategies and company management capabilities that can increase competitiveness (Wignaraja, 2008a). The role of skilled labour has proven to have a significant and positive influence on exports (Díaz-Mora *et al*., 2015; Wignaraja, 2008a).

From Indonesia's perspective, studies that explain the factors influencing exports are limited, with very few exceptions, such as Handoyo *et al.* (2023b)

who examined trade margins of rubber exporters and Saputra (2014), who examined the presence of self-selection theory where technical efficiency (*TE*) affects firms' exports in 6 Indonesian industrial sectors. However, in this study, we aim to investigate the influence of *FDI*, skilled labour, and *TE* on the export of the F&B sector. We utilised firms' level micro data and appropriate econometric techniques and assessed the role of these factors in determining exports of the F&B industries. To date, there is no existing study that specifically focuses on the export of food and beverage firms. This signifies a gap in existing studies, which our present study intends to bridge.

Additionally, the present study contributes to existing works by further investigating the mediating influence of *TE* and skilled labour among other variables on the export of F&B firms. Our empirical strategies indicate that, regardless of the control variables incorporated into our formulated models, *FDI*, skilled labour, and *TE* positively influence the probability of firms' exports in the F&B sector and specifically in each of the industries operating within the sector. However, firms' size and industrial concentration also influence the probability of firms' exports. Interestingly, findings on the mediating roles of *TE* and industrial concentration, as well as *TE* and firm size, and skilled labour and firm size, reveal an increasing impact on firms' exports. Although our results are specific to Indonesia, the findings will serve as a guide for policy-making in the food and beverage industries of other economies.

The remaining components of this work are organised into the following four segments: Part One presents a review of the literature and theoretical underpinnings, Part Two discusses the research methods, Part Three presents the findings, and lastly, the study provides a conclusion.

1. Literature and Theoretical Basis

There exist two hypotheses that explain why firms that engage in exports are more inclined to be productive and efficient compared to non-exporting firms. These prepositions are self-selection, which posits that companies that have high productivity can penetrate the international market (export more). This is due to additional costs, such as transportation, marketing, and network-building expenses abroad, as well as costs incurred to employ skilled labour to manage networks abroad or develop product innovations for export. It has been well-documented that firms engaging in exports record more success than their counterparts (or non-exporting firms) due to increased competitiveness and productivity (Harris & Li, 2008; Imbriani *et al.*, 2014). The second premise, known as "learning-by-exporting" or "learning-by-doing", posits that the knowledge acquired from foreign buyers

and competitors helps the potential firm to improve and effectively handle the advent of new competitors after entering the market. In addition, companies that engage in international sales face greater exposure to competition in comparison to domestic enterprises. Consequently, they must enhance their performance at a faster pace and strive for flawless execution to outperform their local counterparts. (Haidar, 2012; Bernard & Jensen, 1999; Bernard & Wagner, 1997). By entering foreign markets, firms tend to gain greater knowledge through innovation and the adoption of new productive techniques (De Loecker, 2013). Although many studies have established evidence of self-selection, Aggrey *et al.* (2010) observed the non-existence of self-selection in the case of East African firms' export decisions.

Export is influenced by many factors, as reported by many other recent studies (Handoyo *et al.*, 2022a; Handoyo *et al.*, 2023a; Handoyo *et al.*, 2023b; Handoyo *et al.*, 2024a; Handoyo *et al.*, 2024b; Handoyo *et al.*, 2024c; Ibrahim *et al.*, 2024), among many others. In addition, existing studies explained that skilled labour, firm size, foreign investment, raw materials imports, industrial concentration, and technical efficiency affect firms' exports. For instance, exporting firms tend to recruit skilled labour, offer higher remuneration, and are more technologically inclined than their counterparts (Trofimenko, 2008). In Máté's (2015) study, an industry is deemed highly skilled if it possesses a proportion of skilled labour that exceeds the average by 20%. An industry is considered medium-skilled if its skill requirement is 5% higher than the average across industries. If, however, none of the mentioned characteristics exist, the industry is considered low-skill. The relationship between skilled employment and exports has been well-documented by numerous studies. In the case of the Chilean manufacturing industry, Balat *et al.* (2016) report that companies that use skilled labour tend to export more to developed countries. Lundberg & Wiker (1997) discovered that highly educated workers tend to specialise in exports that require advanced skills and meet international standards. Coxhead & Li (2008) revealed that Indonesia, as a labour-abundant economy, could have seen greater benefits from skill-intensive exports if it had managed to attract more *FDI* and highly trained labour. Cieślik *et al.* (2015) and Cieślik *et al.* (2018) report that skilled labour employment promotes export performance in Baltic and Central European firms as well as MENA countries. Contrary to these studies, Fakih & Ghazalian (2013) revealed a decreasing impact of skilled labour on the probability of firms' export in the MENA sample.

Firm size does affect exports, because large firms have the wherewithal to expand their market beyond the domestic market. Large firms enjoyed a lower cost advantage due to their economies of scale (Roth *et al.*, 2014). Expanding into the international market requires efficient operations by the participating firm, and there is a high tendency for the firm to increase its

exports as it grows in size (Arnold & Hussinger, 2005). Firm size is therefore a crucial determinant of efficiency and productivity, which stimulates export performance (Handoyo *et al*., 2022b). Studies on the factors influencing exports have confirmed a positive and significant relationship between firm size and exports. For instance, Handoyo *et al*. (2024b) and Saputra (2014) have documented evidence of an increase in export performance due to an increase in firm size. In studies by Cieślik *et al*. (2015) and Cieślik *et al*. (2018), as well as Fakih & Ghazalian (2013), the probability of exporting increases with firm size in Baltic and Central European manufacturing firms, as well as in the MENA region. Contrarily, Iyer (2010) observed that an increase in firm size reduces agricultural exports in New Zealand.

The impact of Foreign Direct Investment (FDI) on exports is a topic of significant interest and has been the subject of numerous studies. It has been reported that foreign companies often outperform domestic companies (Din *et al*., 2009). *FDI* can impact a country's export composition in two distinct ways (Harding & Javorcik, 2012). Firstly, multinational corporations possess superior productive capabilities and technology, enabling them to produce more sophisticated goods than the host country. Secondly, foreign firms possess a significant advantage in terms of knowledge and technology over local firms. According to a study by Head & Ries (2003), foreign firms are more likely to engage in exports, with firm size being a key factor. However, there is a link between firm productivity, market size, and factor incomes in host countries, emphasising the need for careful consideration. In Turkey, for instance, foreign-owned companies contributed a greater percentage to the economy's exports, and a long-run causal link exists between *FDI* and exports (Temiz & Gokmen, 2011). Foreign capital increases the probability of exporting to foreign markets, as noted by Cieślik *et al*. (2015, 2018) and Fakih & Ghazalian (2013). Findings from studies by Prasanna (2017) and Sahoo & Dash (2014) revealed that the inflow of *FDI* into the Indian economy is crucial in promoting the export sector, highlighting the significant role of foreign investment in international trade.

Industrial concentration is an important factor influencing export performance (Handoyo *et al*., 2021). Industrial concentration has proven records of promoting export resilience (Zaclicever, 2016). This suggests that the greater the concentration of industry, the higher the probability of surviving in international competition. However, firms can import raw materials/input to meet foreign demand for their products. Importing can enhance the quality of exports (Xu & Mao, 2018). By importing inputs, the company can leverage the latest technology to enhance the quality of its existing products (Castellani & Fassio, 2019). Sourcing raw materials from foreign markets can pave the way for higher productivity and quality, which in turn leads to increased exports (Edwards *et al*., 2017). Business enterprises

that simultaneously engage in export and import activities experience greater capital intensity, productivity, and employment gains than those involved in either export or import alone (Edwards *et al.*, 2017). A study by Halpern *et al.* (2015) found that high productivity gains and quality output result from mixed sources that utilise both domestic and foreign inputs. Studies on the link between exports and raw materials imports include Xu & Mao (2018), who, in the case of China, scrutinised and examined the relationship between export quality and intermediate imports. They report that increased import is closely linked to high-quality exports. Edwards *et al.* (2017) examined the link between manufacturing exports and imports of intermediate inputs, observing that imports of intermediate inputs from developed countries promote exports in South Africa. This corroborates with Grazzi *et al.*'s (2017) finding.

In the case of Indonesia, Saputra's (2014) empirical strategies revealed that technical efficiency influenced export intensity in six sub-manufacturing sectors. While examining the effect of allocative efficiency (*AE*) and *TE* on exports for Slovenian firms, Pušnik's (2010) study revealed that export orientation is high in more efficient firms, and the role of *TE* in promoting exports is more pronounced than that of *AE*. As reported by Náglová & *Šimpachová* Pechrová (2021), foreign companies were found to be more efficient than local firms in the Czech Republic's food and beverage sector, and firm size also influences technical efficiency. The impact of F&B exports on *TE* in Iran has been investigated by Kazerooni *et al.* (2013), who employed SFA and dynamic panel modelling to data covering the period 2000-2009. The strategies unravelled that exports and research and development (R&D) spending positively and significantly influence the *TE* of F&B exports, while human capital in terms of skill reduces *TE*.

Using data from the Halal F&B industry in five countries (Indonesia, Pakistan, South Africa, Malaysia, and Singapore), Rusmita *et al.* (2023) analysed the effect of technical efficiency on firms' value. The panel estimation strategy reveals that, except in the case of Pakistan, technical efficiency has a significant impact on firm value in all countries. At the same time, stock market performance is crucial for firms' technical efficiency. Over the period from 2009 to 2019, Hamidi *et al.* (2022) analysed the technical efficiency of Indonesian and Malaysian palm oil exports to 59 major importing countries. Their principal findings are that there exist inefficient exports of the world's palm oil, although the two countries dominate different markets with high export potential in the same markets. During the study period, Indonesia proved to be more efficient than Malaysia. Therefore, the two countries need to harmonise their policies related to palm oil to tap their existing export potential in partner countries fully. A study by Setiawan *et al.* (2012) examined the relationship between technical efficiency and industrial

concentration in the Indonesian food and beverage industry. Their findings suggest that the industry is less efficient with high industrial concentration, and a one-way Granger causality exists, with concentration negatively affecting technical efficiency.

A study by Rifin (2017) examined the influence of firm size, location, imported inputs, and foreign capital on exporting in Indonesia's food processing sector. Findings indicate that location, imported inputs, and foreign capital affect processed food exports in Indonesia. The dynamics and competitiveness of Indonesian food industry exports, along with their determinants, have been analysed by Wardani *et al.* (2018). Their strategy, based on revealed comparative advantage, indicates strong competitiveness in Indonesia's Regional Comprehensive Economic Partnership (RCEP) countries, as recorded by the food industry. Likewise, the dynamics of the food industry indicate a rising trend, driven by GDP and population growth in importing countries, as well as factors such as distance, trade openness, tariffs, and export prices, influencing food exports to RCEP countries. In the case of Indonesia's palm oil exports, Teguh *et al.* (2024) report that exports are influenced not only by product comparative advantage but also by export prices, previous market demand, and an increase in the downstream industry. Sugiharti *et al.* (2020) revealed that Indonesia's food exports have a more price elastic supply, implying that price volatility could mainly affect food exports, with improved logistics enhancing exports. Based on firm-level data (2008-2015), Solow's residual growth accounting and fixed effect (FE) model, Yasin's (2021) study shows that the F&B industry exhibits an increasing total factor productivity (TFP).

Additionally, firm size, market concentration, and absorptive capacity increase the TFP of F&B-producing firms. The intensity of imported raw materials reduces the growth of TFP, although firms that import raw materials perform more than non-importing firms. Similarly, Widodo & Firmansyah (2017) demonstrate that the F&B industry experienced greater TFP and productivity growth than any other industry in Indonesia over the period 2000-2009. Furthermore, the main drivers of F&B's TFP growth are *TE*, scale efficiency, and technical progress. The Indonesian food and beverage industry experienced a steady decline in productivity due to a low level of innovation, as reported by Setiawan *et al.* (2022). Only after the commencement of Indonesian competitive law has innovation had a positive influence on dynamic productivity growth.

Between 2001 and 2021, Abdullahi *et al.* (2024) employed the gravity model of trade. They found that the economic size of China, African population growth, and trade costs promote agricultural food exports between China and 48 African countries. Similarly, in the case of Nigeria's bilateral agricultural food exports to European Union (EU) countries, Abdullahi *et*

al. (2021a) report that Nigeria and EU's GDP and transport cost increases agricultural food exports from Nigeria to EU member states, while their per capita income, exchange rate, and EU new membership negatively affect export to EU. Using the gravity model of trade, fixed effect (FE), ordinary least square (OLS) estimate, Poisson Pseudo Maximum Likelihood (PPML), and Heckman models Abdullahi *et al.* (2021b) show that Nigeria's agricultural exports to its 70 major trading partners are positively affected by its GDP and importer partners' GDP, importers population, ECOWAS and EU memberships, and contiguity. Exchange rate, distance, Nigeria's population, and landlocked status negatively affect agricultural food exports. Nzewi (2017) established a link between Nigeria's processed food exports and global demand for processed food during the period from 1995 to 2004.

In another study, Aktas *et al*. (2023) employed the gravity model to examine the determinants of Turkey's exports of dried fruit and dried fruit products from 2005 to 2021. Their empirical strategy, based on the PPML estimator, indicates that Turkey's GDP, the GDP of importing countries, EU membership, trade agreements with importing countries, and temperature change all increase the production of dried fruits and dried fruit products. The transport cost, as measured by distance, reduces exports. Shariar *et al.* (2019) employed the gravity model, PPML, and Heckman models to examine the factors influencing Chinese food meat exports to its 31 trading partners over the period 1970-2016. The study shows that exchange rate, GDP, land mass, common language, common border, 'Belt and Road' initiative, and WTO membership influence food meat export. In the Kea *et al*. (2019) study, the dynamic gravity model, PPML, generalised least squares (GLS), and the Heckman models were employed to analyse the factors influencing Cambodian rice exports. Findings indicate that agricultural land reform, exchange rates, and historical ties have a positive impact on rice exports to China, ASEAN, and EU countries. On the contrary, factors such as economic recession and macroeconomic issues can reduce exports to trading partners. A study by Kumar *et al*. (2024) analysed the opportunities and determinants of the Indian rice trade with its selected trading partners using the Heckman selection model. The study results indicate that WTO membership, historical trade ties, and economic factors influence rice trade. At the same time, the population, per capita income, and higher GDP of trading partners promote the prospect of rice trade.

Meanwhile, exchange rate volatility and differences in income levels reduce trade. Additionally, transport costs, as well as logistical complexities, affect trade decisions. Rehman (2017) analysed the relationship between exporting, productivity, and innovation in 29 Eastern/Central Eurasian economies. Findings indicate that innovation and R&D tend to promote exports. Due to managerial skills and innovation, foreign enterprises are more productive than their domestic counterparts.

2. Data and Methodology

2.1. *Sample and Variables*

During the analysis of this study, we employed panel data comprising a sample of F&B firms in Indonesia. The utilised data are secondary, obtained from the Central Statistics Agency of the Indonesian Industry Group (CSAIIG), which conducted a survey covering the period 2010-2015. The data from CSAIIG is particularly valuable due to its comprehensive coverage of the F&B industry in Indonesia during the specified period. The data comprises a panel of 2491 F&B business firms. Our sample period only covered 2010-2015 because the survey from which the data was obtained only covered this period, and there is no extension to this data coverage. Every survey conducted by the Central Statistics Agency comes with different data classifications, and there is no identification code for each firm in the food and beverage industry. The variable's operational definitions, measurement, and theoretical a priori are also explained and reported in Table 1.

Table 1 - Variable Measurement, A Priori Expectation, and Data Source

Variable	Measurement	A priori	Data source
Y	Output is measured as the firm's level of output in a thousand Rupiah		CSAIIG
K	The capital stock is measured in thousand Rupiah	+	CSAIIG
L	Labour is measured by the number of workers employed by a given firm	+	CSAIIG
M	Imported raw materials measured in thousands of rupiah amount	+	CSAIIG
E	Energy consumption measured in thousand Rupiah amount	+	CSAIIG
Export	Export measure as a dummy with one if a given firm exports and zero otherwise		CSAIIG
FDI	Foreign investment is measured as a dummy variable with a value of one if the firm receives foreign investment worth 10% or more, and zero otherwise	+	CSAIIG
Skill	Skilled labour is measured by human resource intensity, represented as a dummy variable with a value of 1 if the ratio of non-production workers to productive workers is 30% or more, and zero otherwise	+	CSAIIG
Eff	Technical efficiency is measured by an efficiency score, which lies between 0 and 1	+	Authors' estimate (see Section 2.2)
Size	Firm size is measured by the ratio of the firm's output to the total industry output in thousands of Rupiah	+	CSAIIG
HHI	Herfindahl-Hirschman-Index measures the industrial concentration	+	CSAIIG

The output is measured in thousand Rupiah. The capital stock comprises the land, buildings, vehicles, and other assets, and is expressed in thousands of Rupiah. The labour (*L*) variable is measured based on the number of workers employed by firms, including both production and non-production workers. The amount of energy comprises gasoline, diesel, and electric energy used by the company, expressed in thousand Rupiah. The imported raw material is the total of all raw materials used to produce output and is measured in thousands of Rupiah. The *export* variable is represented as a dummy variable, equal to 1 if a given firm exports and zero if it does not. The *FDI* is measured using a benchmark, namely, companies that receive foreign capital worth 10% or more. This is done following a study by Krugman *et al*. (2012). In this case, we also used a dummy variable for *FDI*, assigning a value of 1 if the firm receives *FDI* of 10% or more and 0 otherwise. Technical efficiency measures a company's ability to produce the highest possible output with a given combination of inputs. The technical efficiency variable, which lies between 0 and 1, is estimated using SFA (Aigner *et al*., 1977), as detailed in Section 2.2. The size of the company is calculated as the ratio of the firm's output level to the total output of the industry:

$$Size_{it} = \frac{Q_{it}}{Q_{jt}} \tag{1}$$

In Equation (1), Q_{it} is the output level of firm *i* at time *t*, and Q_{jt} is the total output of industry to *j* which the firm belongs. *t* represents the time. The industrial concentration in the F&B processing sector is measured using (i.e. the Herfindahl-Hirschman-Index), which is expressed as:

$$HHI_{it} = \left(\frac{Q_{it}}{Q_{jt}}\right)^2 \tag{2}$$

The skilled labour is calculated using the human resource intensity, i.e. the ratio of non-production workers to productive workers. A dummy variable is used, taking the value of 1 if human resource intensity is greater than or equal to 30% and zero otherwise (Sugiharti *et al*., 2019).

2.2. *Stochastic frontier model*

The theoretical model upon which the analytical models in this study were formulated is the production function. The production theory is centered around the transformation of inputs into outputs. The mechanism connecting

resource transformation is known as the production function, which expresses the technical link between the inputs needed and the corresponding final outputs that can be obtained. The production function determines the highest possible output that can be manufactured with a given amount of resource quantities, which may include machinery, skill, and knowledge (Sari, 2019). The relationship between input and output or production function can be modelled as:

$$Q = f(K, L, X \ldots\ldots) \tag{3}$$

In Equation (3), Q is the output level, which is a function of K (representing capital) and L (representing labour), and X is the vector of other inputs. A firm in an industry may face constant returns to scale, increasing returns to scale, and decreasing returns to scale. In most cases, when factors are held constant, doubling the unit of capital and labour can lead to a proportionate increase in output, especially for small and medium-scale industries (Wulan *et al.*, 2018). An important concept related to production theory that is of interest to this study is technical efficiency (*TE*), which refers to a company's ability to obtain the maximum possible output for a given combination of inputs. Technical efficiency can be examined from various perspectives. According to Coelli *et al.* (2005), there are two types of technical efficiencies: output-oriented and input-oriented. The output-oriented technical efficiency measures "by how much can output quantities be proportionally expanded without altering the input quantities used?" (Coelli *et al.*, 2005, p. 137). The input-oriented technical efficiency measures "by how much can input quantities be proportionally reduced without changing the output quantities produced?" (Coelli *et al.*, 2005, p. 137). Technical efficiency is only one aspect of general efficiency, which can enhance a firm's performance and competitive position (Kumbhakar & Lovell, 2000; Kumbhakar & Lovell, 2015). In this study, we consider the output-oriented *TE*, which is defined as the ratio between the actual and the highest possible amount of output. Therefore, *TE* takes a value between 0 and 1, where a value of 1 indicates the firm is fully technically efficient. For example, a value of 0.82 indicates that the firm is producing 82% of its maximum possible output.

In this study, the firms' level of technical efficiency is estimated using the technique of stochastic frontier analysis (SFA), as proposed by Aigner *et al.* (1977). SFA assumes the following model:

$$\ln y_{it}^{*} = f(x_{it}, \beta) + v_{it} \qquad v_{it} \sim_{i.i.d.} N(0, \sigma_v^2) \tag{4}$$

$$\ln y_{it} = \ln y_{it}^{*} - u_{it} \qquad u_{it} \sim_{i.i.d.} N^{+}(0, \sigma_u^2) \tag{5}$$

In Equations (4) and (5), i denotes the specific firm, t denotes the time (which in our case is 2010-2015), y_{it} is the actual amount of output, y^*_{it} is the highest possible amount of output, x_{it} is the vector of the input variables, f is the deterministic part of the production function characterised by the unknown parameter vector β, and random variables v_{it} and u_{it} represent the deviation from the production frontier due to exogenous factors and inefficiency. The v_{it} are assumed to be independent and normally distributed with zero mean and constant variance σ_v^2. In contrast, the u_{it} are assumed to be independent of each other and the v_{it}, and follow a half-normal distribution with zero mean and constant variance σ_u^2 (Martey *et al.*, 2019). Since u_{it} the are non-negative, the observed output y_{it} always falls below the maximum possible output y^*_{it}, therefore $y_{it} < y^*_{it}$ for a technically inefficient firm. According to Equation (5), the output-oriented technical efficiency for a given firm i at time t depends only on u_{it}, and is given by the following formula:

$$TE_{it} = \frac{y_{it}}{y_{it}^*} = \exp(-u_{it}) \tag{6}$$

The ratio $\gamma = \frac{\sigma_u^2}{\sigma^2}$, where $\sigma^2 = \sigma_v^2 + \sigma_v^2$, is the proportion of deviations from the production frontier attributable to inefficiency, whereas the remaining proportion is due to exogenous factors.

Compared to other techniques for estimating technical efficiency, such as data envelopment analysis (DEA), SFA has the advantage of distinguishing inefficiency from deviations due to exogenous factors (Bonfiglio *et al.*, 2020). This is because the production frontier is stochastic due to the presence of the random term v_{it} (Afrin *et al.*, 2017; Martey *et al.*, 2019). In this study, we specify f as a translog production function, leading to the following model:

$$\begin{aligned}\ln y_{it} = \delta_0 + \delta_1 lnK_{it} + \delta_2 lnL_{it} + \delta_3 lnM_{it} + \delta_4 lnE_{it} + \tfrac{1}{2}\delta_5 (lnK_{it})^2 + \tfrac{1}{2}\delta_6 (lnL_{it})^2 + \tfrac{1}{2}\delta_7 (lnM_{it})^2 + \\ \tfrac{1}{2}\delta_8 (lnE_{it})^2 + \delta_9 (lnK_{it})(lnL_{it}) + \delta_{10}(lnK_{it})(lnM_{it}) + \delta_{11}(lnK_{it})(lnE_{it}) + \delta_{12}(lnL_{it})(lnM_{it}) + \\ {}_{it})(lnE_{it}) + \delta_{14}(lnM_{it})(lnE_{it}) + \delta_{15} t + \delta_{16} t^2 + \delta_{17}(lnK_{it})(t) + \delta_{18}(lnL_{it})(t) + \delta_{19}(lnM_{it})(t) + \\ \delta_{20}(lnE_{it})(t) + v_{it} - u_{it}\end{aligned} \tag{7}$$

In Equation (7), K represent the value of capital in a given firm, L is labour as measured by workers employed by the firm, M represents the material imports, E is energy consumption, and δ_0, δ_1, δ_2, …, are unknown parameters to be estimated.

2.3. *Logit Model*

However, to analyse the factors that influence exports in the F&B industry, the study used the following logit model, as expressed in Equations (8) – (14). Equation (8) is the baseline model upon which all the remaining models would be compared to determine the robustness of the effect of the variables of interest on firms' exports.

$$L_{it} = ln\left(\frac{Pr_{it}}{1-Pr_{it}}\right) = \eta_1 + \eta_2 FDI_{it} + \beta\eta_3 Skill_{it} + \eta_4 Eff_{it} + u_{it} \quad (8)$$

$$L_{it} = ln\left(\frac{Pr_{it}}{1-Pr_{it}}\right) = \eta_1 + \eta_2 FDI_{it} + \beta\eta_3 Skill_{it} + \eta_4 Eff_{it} + \eta_5 Size_{it} + u_{it} \quad (9)$$

$$L_{it} = ln\left(\frac{Pr_{it}}{1-Pr_{it}}\right) = \eta_1 + \eta_2 FDI_{it} + \beta\eta_3 Skill_{it} + \eta_4 Eff_{it} + \eta_5 HHI_{it} + u_{it} \quad (10)$$

$$L_{it} = ln\left(\frac{Pr_{it}}{1-Pr_{it}}\right) = \eta_1 + \eta_2 FDI_{it} + \beta\eta_3 Skill_{it} + \eta_4 Eff_{it} + \eta_5 Import_{it} + u_{it} \quad (11)$$

$$L_{it} = ln\left(\frac{Pr_{it}}{1-Pr_{it}}\right) = \eta_1 + \eta_2 FDI_{it} + \beta\eta_3 Skill_{it} + \eta_4 Eff_{it} + \eta_5 (Eff \times HHI)_{it} \quad (12)$$

$$L_{it} = ln\left(\frac{Pr_{it}}{1-Pr_{it}}\right) = \eta_1 + \eta_2 FDI_{it} + \beta\eta_3 Skill_{it} + \eta_4 Eff_{it} + \eta_5 (Eff \times Size)_{it} \quad (13)$$

$$L_{it} = ln\left(\frac{Pr_{it}}{1-Pr_{it}}\right) = \eta_1 + \eta_2 FDI_{it} + \beta\eta_3 Skill_{it} + \eta_4 Eff_{it} + \eta_5 (Skill \times Size)_{it} \quad (14)$$

Where, in Models (8) – (14), P_{it} is the probability that firm *i* exports to a foreign market at time *t*. Therefore, L_{it} is the logit of the same event. The *FDI* represent the foreign investment, *Skill* is a measure of skilled labour, and *Eff* represent technical efficiency. In addition to the variables of interest, we also control for other vital factors, such as firm size (*Size*), imported raw materials (*Import*), and export concentration (*HHI*), as measured by the Herfindahl-Hirschmann Index (*HHI*). This index is best known as a measure of product or export concentration (Handoyo *et al.*, 2021). We estimate the indirect effect of firms' technical efficiency *Eff* (), export concentration (*HHI*), firm size (*Size*), and skilled labour (*Skill*). This is as demonstrated in Models 12 – 14 by interacting (*Eff* × *Size*), (*Skill* × *Size*), and (*Eff* × *HH*). The η_1, η_2, η_3… are the model parameters to be estimated. At the same time, *u* is the classical white noise or error term. As mentioned earlier, to estimate technical efficiency, we applied the production function with the *SFA* approach. A logarithmic transcendental production function model (trans log) is estimated using the MLE (i.e. the maximum likelihood method) on the logistic model. We applied the trans-log production function model because it is considered more flexible, which can reduce the risk of errors in model specifications (Sari *et al.*, 2016). Since we have a categorical or binary explanatory variable, the use of logistic regression has become necessary in this study. The use of the logit model is necessitated by the fact that we are faced with binary

or categorical dependent variables, which assume either 0 or 1. The export variable is derived from the survey conducted by the Central Statistics Agency of the Indonesian Industry Group (CSAIIG). In the survey, business firms that participate in exporting are assigned a value of 1, and those that do not participate are assigned a value of 0. Therefore, the logit model is the most suitable technique for handling this type of dependent variable. In addition, the software program used for this estimate is Frontier 4.1 (Coelli, 1996).

3. Results and discussion

Table 2 presents the data description, including the average value, maximum and minimum values, as well as the standard deviation, for the following variables: export variable (the proportion of goods produced for export), skilled labour (the proportion of skilled workers in the workforce), technical efficiency (the ratio of actual output to maximum potential output), company size (measured by revenue or number of employees), imported raw materials (the proportion of raw materials imported), industrial concentration (the degree of market power held by a few firms), and ***FDI*** (foreign direct investment). From the descriptive statistics, in terms of variability, as measured by the standard deviations, which are low in our case, there are no high variations among the sample firms. This implies that the firms under study exhibit similar characteristics, which will help in reducing cross-sectional heterogeneity in our empirical analysis.

Table 2 - Variable Statistical Description

Variable	Mean	Std.Dev	Min	Max
lnY	15.47	1.97	10.03	23.80
lnK	13.86	2.04	4.33	26.35
lnL	3.92	1.02	2.99	9.54
lnM	14.78	2.18	5.12	23.49
lnE	11.87	1.98	4.32	20.14
Export	0.076	0.27	0	1
FDI	0.04	0.19	0	1
Skill	0.25	0.44	0	1
Eff	0.61	0.19	0.26	1
Size	0.04	0.26	9.2E-1	9.50
HHI	0.07	1.71	9.7E-1	90.16
Import	0.07	0.25	0	1

Source: Authors' processed data.

Tables 3, 4, and 5 present the estimated results of the translog production function, obtained using the MLE method with Frontier 4.1 software. The production function uses 20 independent variables. In the case of the food industry, 15 of these variables are found to be significant (mostly at a level of less than 1%). For the beverages industry, we observed that of these 20 variables, only 11 variables assert a significant influence on output, mainly at a1%. level of significance. An estimate of the combined food and beverage industries reveals that 18 of these variables have been found to have a significant effect on the industry's output at a high level of significance (mostly at a p-value of less than 0.01). In the foods and beverages industry, variables *K*, *L*, and *E* have a positive and significant effect on output, while variable *M* shows a negative influence on output.

Furthermore, variables K^2, L^2, M^2, and M^2 show a positive and significant influence on output. This implies that an increase in input is associated with an increase in output, a finding that has significant implications for the industry. The presence of interaction terms is intended to reveal an interaction link between inputs and to determine whether there is a substitution or complementary nexus. Almost all the interaction terms show a significant effect except for *L* and *E*. The interaction variables *K* and *L* yield positive results, indicating a complementary effect between variables *L* and *L*. The interaction variables *K* and *M*, *K* and *E*, *L* and *M*, and *M* and *E* show negative and significant results, indicating a substitution effect. The variables that interact with time (*t*) show positive and significant results, indicating technological progress over time, as seen in the interaction variables *K* and *t*, and *L* and *t*.

In contrast, *M* and *t* have a negative and significant effect, implying that technological lapse occurs. While *E* and *t* do not have a significant effect on output. A small sigma square indicates that inefficiency is usually distributed, while the gamma value indicates the ratio between inefficiency and random error. A gamma value of 0.58 means that 58% of the residual comes from inefficiency in production, and the rest (42%) comes from random error. The estimates for the two different industries revealed almost identical patterns to those of the combined industries. This demonstrates the inseparable nature of Indonesia's food and beverage sector. The estimated value of γ for the food industry is 0.5376. This shows that 53.8% of the deviation from the production frontier is due to inefficiency, while 46.2% is due to exogenous factors. Moreover, the estimated value of γ for the beverages and combined F&B industries is 0.4046 and 0.585, respectively. This indicates that 40.46% and 58.5% of the deviation from the production frontier is due to inefficiency, while the remaining 59.54% and 41.5% are due to exogenous factors, respectively.

Table 3 - Results of maximum likelihood estimation (MLE): Trans log model for the food Industry

Production Function: The Dependent Variable is Output (Y)			
Variable	**Coefficient**	**Standard error**	**t-ratio**
δ_0	4.3497***	1.0503	4.1412
lnK	0.1788**	0.0844	2.1180
lnL	0.5411***	0.2477	2.1842
lnM	0.5081***	0.1211	4.1946
lnE	–0.0569	0.1210	–0.4705
$(lnK)^2$	0.0041	0.0028	1.4585
$(lnL)^2$	0.0077	0.0243	0.3178
$(lnM)^2$	0.0631***	0.0039	16.1347
$(lnE)^2$	0.0450***	0.0048	9.4784
(lnK)(lnL)	0.0292**	0.0136	2.1418
(lnK)(lnM)	–0.0415***	0.0077	–5.3629
(lnK)(lnE)	0.0242***	0.0077	3.1526
(lnL)(lnM)	–0.0497***	0.0170	–2.9179
(lnL)(lnE)	–0.0037	0.0160	–0.2309
(lnM)(lnE)	–0.0831***	0.0082	–10.1295
T	0.1255	0.0901	1.3938
t^2	–0.0128***	0.0054	–2.3471
(lnK)(t)	0.0022	0.0049	0.4426
(lnL)(t)	0.0208*	0.0110	1.8832
(lnM)(t)	–0.0098	0.0061	–1.6104
(lnE)(t)	0.0048	0.0055	0.8742
σ^2	0.4265***	0.0516	8.2610
γ	0.5376***	0.0372	14.4548

Source: Authors' processed data.

Notes: The significance levels are; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 4 - Results of maximum likelihood estimation (MLE): Trans log model for the Beverages Industry

Production Function: The Dependent Variable is Output (Y)			
Variable	**Coefficient**	**Standard error**	**t-ratio**
δ_0	4.1807*	2.2675	1.8437
lnK	–0.1128	0.2617	–0.4309
lnL	1.7504***	0.6018	2.9088
lnM	–0.0281	0.1963	–0.1431
lnE	0.5496***	0.2380	2.3093
$(lnK)^2$	0.0067	0.0076	0.8818
$(lnL)^2$	0.0463	0.0415	1.1148
$(lnM)^2$	0.0614***	0.0059	10.4923
$(lnE)^2$	0.0294***	0.0062	4.7191
(lnK)(lnL)	–0.0021	0.0300	–0.0704
(lnK)(lnM)	0.0172	0.0150	1.1444
(lnK)(lnE)	–0.0271*	0.0165	–1.6422
(lnL)(lnM)	–0.1795***	0.0295	–6.0798
(lnL)(lnE)	0.0811***	0.0281	2.8841
(lnM)(lnE)	–0.0658***	0.0095	–6.9676
T	0.0489	0.1903	0.2573
t^2	–0.0266***	0.0095	–2.7936
(lnK)(t)	0.0126	0.0109	1.1581
(lnL)(t)	0.0084	0.0223	0.3786
(lnM)(t)	–0.0003	0.0121	–0.0286
(lnE)(t)	–0.0019	0.0110	–0.1750
σ^2	0.2750***	0.0619	4.4439
γ	0.4046***	0.1278	3.1672

Source: Authors' processed data.

Notes: The significance levels are; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 5 - Results of maximum likelihood estimation (MLE): Trans log model for F&B Industries

Production Function: The Dependent Variable is Output (Y)			
Variable	**Coefficient**	**Standard error**	**t-ratio**
δ_0	4.055***	0.2030	19.977
lnK	0.179***	0.0196	9.1430
lnL	0.880***	0.0484	18.196
lnM	–0.114***	0.0201	–5.662
lnE	0.456***	0.0228	20.024
$(lnK)^2$	0.005***	0.0008	5.7475
$(lnL)^2$	0.018***	0.0054	3.3647
$(lnM)^2$	0.073***	0.0007	107.685
$(lnE)^2$	0.034***	0.0013	26.140
(lnK)(lnL)	0.015***	0.0031	4.887
(lnK)(lnM)	–0.019***	0.0015	–12.322
(lnK)(lnE)	–0.004**	0.0018	–2.190
(lnL)(lnM)	–0.068***	0.0033	–20.357
(lnL)(lnE)	–0.001	0.0041	–0.316
(lnM)(lnE)	–0.070***	0.0017	–40.390
T	0.124***	0.0220	5.656
t^2	–0.004*	0.0025	–1.486
(lnK)(t)	0.006***	0.0017	3.713
(lnL)(t)	0.006**	0.0036	1.795
(lnM)(t)	–0.011***	0.0017	–6.397
(lnE)(t)	0.001	0.0020	0.479
σ^2	0.149***	0.0050	29.716
γ	0.585***	0.0108	54.105

Source: Authors' processed data.

Notes: The significance levels are; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

The firms' annual technical efficiencies, as measured by SFA, are presented in Figures 1, 2, and 3 over the study period (2010-2015). Technical efficiency in the combined sample of F&B processing industries decreased by 4 to 6 per cent annually, as demonstrated in Figure 3. On a scale of 0 to 1, the industry average technical efficiency is 0.576, with the highest value

of 0.6161 recorded in 2010 and the lowest value of 0.5258 recorded in 2015. This value is far from the frontier value of 1, implying that the use of inputs in production is not optimal. An estimate of technical efficiency that falls below the average estimate indicates technical inefficiency. The estimate of technical efficiency in the food industry followed the same pattern as in the combined foods and beverages sector. This is because, in this industry, the efficiency has been declining over the years, with an average efficiency level of 0.4355. The highest efficiency recorded in this industry was 0.4734 in 2010, and the lowest was 0.3975 in 2015. Unlike in the combined food and beverage (F&B) sector, technical efficiency has been increasing over the years in the beverages industry. In this industry, the average efficiency level was 0.4753, with a high value of 0.5315 and a low value of 0.4184.

Figure 1 - The food industry's average technical efficiency

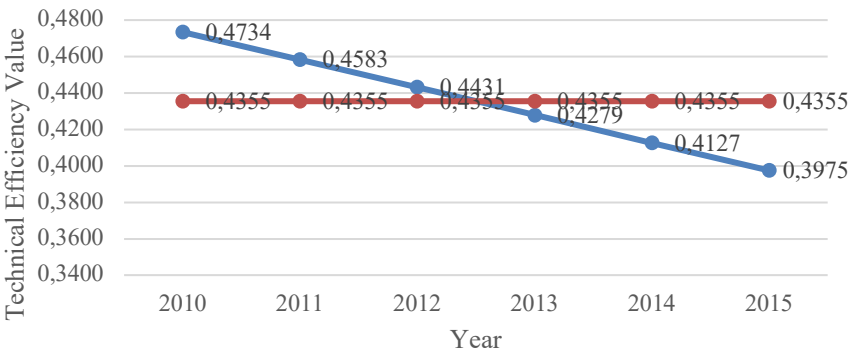


Figure 2 - The Beverages industry's average technical efficiency

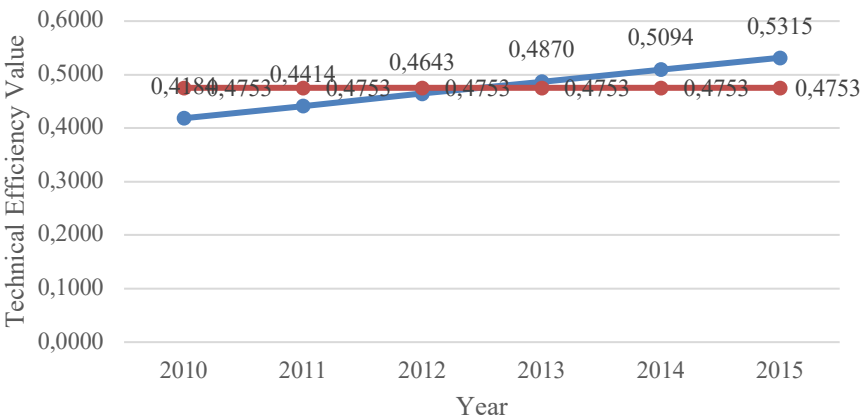
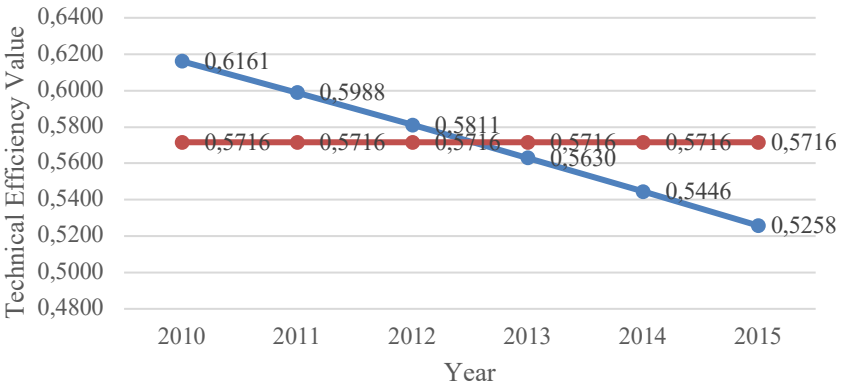


Figure 3 - The food and beverage industries' average technical efficiency



The result from our baseline model, as presented in Column 1 of Table 6, indicates *FDI* that has a positive and significant influence on firms' exports. This signifies the role of *FDI* in stimulating export performance, implying that business firms with *FDI* (i.e., foreign ownership or foreign capital) can export more compared to companies that do not have foreign investment as capital. These results support the work of Amornkitvikai & Harvie (2018), which examined manufacturing firms in Thailand. They observed that *FDI* can increase export activities and raise the intensity of both small, medium, and large business firms. In Columns 2-7, despite controlling for firm Size, industry concentration, imported raw materials, and interaction terms, foreign ownership still maintains a positive and increasing effect on exports. This result remains robustly observed in all estimates despite controlling for different firms' characteristics. The skilled labour employed asserts a significantly increasing impact on the probability of exporting and export performance in the F&B industries. That is, companies that employ skilled workers have a higher tendency and probability of exporting more food and beverages (F&B) to global markets. These findings are consistent with Cieślik *et al.* (2015), Cieślik *et al.* (2018), and Wignaraja (2008a), who examined Baltic and Central European manufacturing firms, companies in the MENA region, and Chinese electronics manufacturers. Their research demonstrates that firms employing skilled labour are more likely to increase exports, as skilled workers enhance technology absorption and contribute to the design and implementation of strategic business plans. In the case of technical efficiency, we observed that firms' *TE* have an increasing influence on the probability of exporting by firms and export performance. This implies that an increase in a firm's *TE* will be accompanied by higher chances of exporting and an improvement in export performance. This

finding supports the self-selection theory, which posits that only companies with high productivity and efficiency can successfully export to foreign markets. However, the findings are consistent with studies by Cieślik *et al.* (2015), Cieślik *et al.* (2018), and Pušnik (2010), who examined the influence of allocative and technical efficiencies on the exports of Baltic, Central European, MENA, and Slovenian manufacturing firms.

Table 6 - The Results from the Maximum Likelihood (ML) on the Logistic Model for F&B Industries

	1	**2**	**3**	**4**	**5**	**6**	**7**
Constant	–4.244*** (0.201)	–4.280*** (0.202)	–4.270*** (0.202)	–4.290*** (0.202)	–4.266*** (0.203	–4.223*** (0.203	–4.257*** (0.202)
FDI	1.866*** (0.118)	1.917*** (0.116)	1.910*** (0.117)	1.878*** (0.121)	1.910*** (0.117)	1.869*** (0.118)	1.890*** (0117)
Skill	0.181*** (0.086)	0.211** (0.085)	0.203** (0.085)	0.200** (0.086)	0.203** (0.085)	0.185** (0.086)	0.177**1 (0.087)
Eff	2.401*** (0.312)	2.468*** (0.310)	2.451*** (0.311)	2.472*** (0.311)	2.445*** (0.311)	2.374*** (0.313)	2.434*** (0.311)
Size		0.322*** (0.094)					
HHI			0.024* (0.013)				
Import				0.158 (0.134)			
Eff × *HHI*					0.033* (0.018)		
Eff × *Size*						0.410*** (0.134)	
Skill × *Size*							0.250*** (0.098)
n	9964	9964	9964	9964	9964	9964	9964
Pseudo R^2	0.069	0.68	0.067	0.067	0.067	0.068	0.067
LR Chi^2 *(4)*	369.57	364.54	361.04	359.47	361.24	367.82	364.17

Source: Authors' processed data.

Notes: The significance levels are; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors (SE) were in parentheses.

Based on our estimate, the variable *Size* which measures firm Size, also affects the probability of firms' exports. This implies that as firms increase in size, there is an increasing tendency for them to export more food and beverage products to foreign markets. The estimated parameter of this

variable, *Size*, appeared to be significant and positive, implying that the higher the company's size, the higher its export performance. Large firms are more inclined to export due to their economies of scale in production and the use of modern technologies. This conclusion aligns with Cieślik *et al.* (2015), Imbriani *et al.* (2014), Rehman (2017), and Sebolao *et al.* (2019), who found that firm *Size* affects the firm's decision to export and its export intensity. The effect of *Size* on the probability of exporting is triggered by cost, especially the sunk cost, which occurs as firms start engaging in export activities. However, small-sized firms cannot bear the sunk costs associated with participating in the international market. This implies that small-sized firms faced an obstacle to penetrating foreign markets. While our results support some studies, they also contradict Van Beveren & Vandenbussche's (2010) finding. The export concentration, as measured by the *HHI*, asserts a significantly increasing influence on the intensity of the firm's export. These results validate the "Nationale Champion Rationale" theory, which posits that a high concentration of industries in the domestic market can necessitate a company to achieve a high magnitude of economies of scale, thereby increasing competitiveness in foreign markets. This finding supports Zaclicever's (2016) study, which reports that the greater the export concentration of the industry, the greater the tendency of the firm to continue exporting in Uruguay. In the case of raw material imports, although the coefficient is positive, there is no statistically significant evidence of an impact on exports. This shows that, irrespective of whether a firm imports raw materials or not, it will not affect the tendency to export more or less to international markets. In furtherance of this, since the effect of imported raw materials remains neutral, the firm can resort to using locally sourced raw materials whose quality is superior to foreign ones, thereby increasing its export share in the international market. This finding is contrary to Xu & Mao's (2018) finding, which observed an increasing influence of material imports on export quality.

We tested and examined the secondary or indirect influence on export through the use of the interaction effect. These include the indirect impact of *TE* and export concentration (*Eff* × *HHI*), and *Size* (*Eff* × *Size*), and *Skill* and *Size* (*Size* × *Skill*), all of which show positive and significant effects on export. The findings indicate that firms that are highly and technically efficient, and have industrial concentration, tend to export more F&B products to foreign markets. This signifies the indirect effect of industry efficiency and concentration on exports. We observed that the indirect influence of *TE* is much lower than the direct influence on firms' exports. For the export concentration or industrial concentration, its indirect effect via technical efficiency is significantly larger than the direct effect. This, thus, underlines the role of technical efficiency in influencing F&B exports. The indirect effect of firm *TE* and firm *Size* revealed a statistically increasing

impact on exports. The result, therefore, indicates that larger companies with high industrial concentration tend to export more food and beverages (F&B) to foreign markets. The indirect effect of *Size* and efficiency only exceeds the direct effect of *Size* but not that of efficiency. The same increasing influence on export has been observed for *Skill* and *Size* interaction terms. That is, larger firms that employ highly skilled labour tend to export more than those firms that rely on semi-skilled and unskilled labour. The interaction between the company's technical efficiency and its size has a significantly increasing influence. The estimated coefficient in this regard is greater than the coefficient for company size. This signifies that companies with high technical efficiency and larger *Size* are more inclined to export than firms with smaller only.

Table 7 - The Results from the Maximum Likelihood (ML) on the Logistic Model for the Food Industry

	1	**2**	**3**	**4**	**5**	**6**	**7**
Constant	–1.56 (1.50)	–1.05 (1.55)	–1.57 (1.50)	–1.12 (1.53)	–8.40*** (2.53)	–1.64 ((1.51)	–0.51 (1.54)
FDI	0.82*** (0.32)	0.84*** (0.32)	0.89 (0.60)	0.73** (0.32)	0.69** (0.33)	0.79** (0.32)	0.72** (0.33)
Skill	0.70** (0.27)	0.74*** (0.28)	0.69** (0.28)	0.69** (0.28)	0.66** (0.28)	0.84** (0.38)	0.77*** (0.28)
Eff	3.53*** (1.23)	3.53*** (1.23)	3.49*** (1.24)	3.64*** (1.28)	3.43*** (1.24)	3.54*** (1.27)	3.92*** (1.32)
Size		–2.08*** (0.31)					
HHI			1.07** (0.42)				
Import				0.10 (0.69)			
Eff × *HHI*					0.033* (0.018)		
Eff × *Size*						2.11*** (0.53)	
Skill × *Size*							4.97*** (1.91)
n	5336	5336	5336	5336	5336	5336	5336
Pseudo R^2	0.1923	0.1946	0.1924	0.1981	0.2307	0.1929	0.2253
LR Chi^2 *(4)*	87.08	88.11	87.1	89.69	104.46	87.35	102.01

Source: Authors' processed data.

Notes: The significance levels are; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Standard errors (SE) were in parentheses.

Table 8 - The Results from the Maximum Likelihood (ML) on the Logistic Model for the Beverages Industry

	1	**2**	**3**	**4**	**5**	**6**	**7**
Constant	–1.71 (1.75)	–2.10 (1.76)	–1.68 (1.75)	–2.21 (1.85)	–0.84 (2.95)	–1.99 (1.77)	–0.89 (1.78)
FDI	1.64*** (0.39)	1.64*** (0.39)	1.51*** (0.58)	1.53*** (0.40)	1.64*** (0.39)	1.55*** (0.39)	1.68*** (0.40)
Skill	0.81** (0.40)	0.81** (0.40)	0.81** (0.40)	0.83** (0.41)	0.79** (0.40)	0.79* (0.41)	1.36*** (0.46)
Eff	6.26*** (1.34)	4.24** (2.12)	6.28*** (1.35)	6.49*** (1.36)	6.22*** (1.35)	6.20*** (1.32)	6.54*** (1.35)
Size		2.63*** (0.37)					
HHI			0.22 (0.74)				
Import				0.24 (0.65)			
Eff × HHI					0.033* (0.018)		
Eff × Size						10.94*** (2.73)	
Skill × Size							–2.7 (2.34)
n	4628	4628	4628	4628	4628	4628	4628
Pseudo R²	0.4283	0.4312	0.4285	0.4564	0.4286	0.4308	0.4439
LR Chi² (4)	201.25	202.58	201.34	214.42	201.39	202.42	208.55

Source: Authors' processed data.

Notes: The significance levels are; * p < 0.1, ** p < 0.05, *** p <0.01. Standard errors (SE) were in parentheses.

Comparable results for the disaggregated food and beverage sector are reported in Tables 7 and 8. Similar to the estimates obtained in the case of the F&B sector, in both the food and beverage industries, *FDI*, *Skill*, and *Eff* have a statistically significant influence on the probability of exporting to foreign markets. This highlights the significant role of *FDI* in enhancing the competitiveness of Indonesia's food and beverage industries. The effect of these variables of interest remained robust in all estimates of Tables 7 and 8 despite controlling for *Size*, *HHI*, *Import*, and interaction terms. While the firm size asserts a positive influence on export in the F&B sector and the beverages industry, it asserts an adverse effect in the case of the foods industry, as reported in Column 2 of Table 7, i.e. only in the food industry does an increase in firm size reduce the firm's competitive position. We

established strong evidence that export concentration increases the probability of exporting, but not in the case of the beverages industry. The use of foreign raw materials neither promotes nor decreases exports, based on the statistically insignificant coefficient of *Import* in both estimates.

In the analysis of the F&B sector, which encompasses both the food and beverage industries, we observed that firms that are highly technically efficient and have high export concentration have a better chance of exporting foods and beverages to foreign markets. Moreover, firms that are highly technically efficient and larger tend to export more than their counterparts.

Table 9 - The Results from the Maximum Likelihood (ML) on the Logistic Model for F&B Industries (Dummy Variable of Food Industry)

	1	**2**	**3**	**4**	**5**	**6**	**7**
Constant	–4.356*** (0.232)	–4.364*** (0.232)	–4.350*** (0.232)	–4.342*** (0.232)	–4.366*** (0.232)	–4.353*** (0.232)	–4.357*** (0.232)
FDI	2.434*** (0.122)	2.431*** (0.124)	2.438*** (0.122)	2.436*** (0.122)	2.467*** (0.120)	2.469*** (0.124)	2.470*** (0.126)
Skill	0.205*** (0.063)	0.223*** (0.063)	0.232*** (0.062)	0.256*** (0.062)	0.250*** (0.061)	0.225*** (0.062)	0.197*** (0.062)
Eff	2.651*** (0.368)	2.782*** (0.366)	2.673*** (0.368)	2.423*** (0.368)	2.445*** (0.368)	2.498*** (0.370)	2.465*** (0.368)
Dummy	0.875*** (0.069)	0.867*** (0.069)	0.883*** (0.068)	0.876*** (0.068)	0.875*** (0.068)	0.876*** (0.069)	0.875*** (0.069)
Size		0.486*** (0.082)					
HHI			0.022* (0.012)				
Import				0.168 (0.146)			
Eff × *HHI*					0.043* (0.024)		
Eff × *Size*						0.520*** (0.121)	
Skill × *Size*							0.287*** (0.088)
n	9964	9964	9964	9964	9964	9964	9964
Pseudo R^2	0.074	0.074	0.074	0.075	0.078	0.076	0.076
LR Chi^2 *(4)*	713.50	715.89	718.43	710.80	719.25	712.25	714.60

Source: Authors' processed data.

Notes: The significance levels are; * p < 0.1, ** p < 0.05, *** p <0.01. Standard errors (SE) were in parentheses.

Only in the case of the beverages industry (i.e. Table 8), larger firms that employ highly skilled labour do not export more beverages to foreign markets.

To check the robustness of our estimate, we included a dummy variable for the food = 1 and beverage = 0 in the model of the F&B sector. Since the included dummy is for the food industry, the result for the dummy reported in Table 9 measures the extent to which the food industry enhances export performance in the F&B sector. Therefore, the parameters of the dummy variable for Models 1-7 are not significantly different in terms of size and magnitude. This implies that, regardless of the independent variables used, the average increase in exports for the beverages industry compared to the food industry is not significantly different.

Conclusion

This study examines the role of foreign direct investment, skilled labour, and technical efficiency, along with other key factors, in determining the export performance of the food and beverage sector in Indonesia. Unlike previous studies, this study utilised micro-level data from 2,491 firms, derived from a survey of the food and beverage industries, which has been rarely employed in existing studies analysing the food and beverage sector. The study has not only focused on the direct influence of these factors but also on their mediating role in determining export performance. This also signifies the unique aspect and significant contribution of this study. Studies that focused on technical efficiency mostly applied data envelopment analysis (DEA), which is less robust in estimating efficiency scores. In our case, we applied SFA, which is more robust for estimating efficiency, while the maximum likelihood estimation (MLE) technique and logistic model were used for the analysis. Our empirical strategies revealed an interesting finding about the F&B sector and its export determinants. The results show a relatively low level of technical efficiency in the F&B sector and the food and beverage industries. Although the beverages industry has shown improved efficiency, the analysed firms (in the F&B sector and food industry) not only recorded low technical efficiency but also exhibited a downward trend, with no improvement in their efficiency scores. Despite the low and declining efficiency, firms' efficiency has remained the primary factor influencing exports to foreign markets. This implies that technical efficiency contributes to increasing the probability of exporting more than any other variable incorporated.

However, *FDI* has proven to have a significant and increasing influence on firm exports across both sectors and industries. This indicates that enterprises

that accommodate *FDI* are more likely to experience increasing exports. Firms that employ highly skilled labour stand a better chance of exporting more to foreign markets. Except in the food industry, as firms increase in size, the tendency to export also tends to increase. Export concentration is closely linked to increasing the probability of exporting in the food and beverage (F&B) sector, specifically in the food industry, but not in the case of the beverages industry. Imported raw materials show an increasing impact, although it is not statistically significant and has no influence on the probability of exporting. Findings from the interaction of efficiency and export concentration revealed that firms with high levels of efficiency and concentrated export stand a better chance of exporting more than firms with low efficiency and export concentration. This applies to all analyses of the F&B sector, as well as to the food and beverage industries. Larger and more efficient enterprises tend to have a higher probability of exporting and penetrating foreign markets than larger and less efficient firms, as well as smaller and less efficient firms. Larger firms that employ highly skilled labour possess a greater tendency to export than smaller firms that employ skilled labour. This is only valid for the analysis of the F&B sector and the food industry, but not for the beverages industry.

These findings carry significant policy implications. The role of foreign capital in the food and beverage industries is crucial and should be a cornerstone of strategies aimed at boosting exports. This necessitates a more open policy on FDI. Enhancing FDI inflow into the food and beverage industries can be achieved by improving infrastructure quality and streamlining bureaucratic processes that hinder *FDI*. Given the positive impact of skilled labour on the industries' exports, there is a clear need to enhance access to formal education, a prerequisite for skill development. This can be achieved through substantial investment in education and the promotion of skill acquisition. The need for a concerted effort to improve the technical efficiency of the food and beverage sector, given its significant impact on export performance, is clear. This can be achieved by identifying the optimal input combination that produces high output at the lowest possible cost. Since imported raw materials do not significantly impact exports, the policy effort should be focused on promoting the use of local raw materials. The role of firm size must be taken into consideration in government policy for licensing new companies. Due to increased exports resulting from larger firm size, smaller firms should be encouraged to merge and form larger corporations to compete globally. However, to promote exports, F&B firms must simultaneously consider increasing technical efficiency and export concentration, as well as technical efficiency and firm size, and skilled labour employment and firm size.

It is essential to acknowledge that this study has its limitations. Some of these limitations are related to data, data coverage, and the study's context. Our sample period only covered 2010-2015 due to the survey's limited coverage, and there is no extension to this data coverage. The data is classified into different categories, and there is no unique identification code for each firm in the F&B sector, which limits the use of updated data for further research. The research focused solely on the F&B industry, yielding findings that are specific to the F&B industry and cannot be applied to other industries. Therefore, future research should extend the scope of this study by considering other industries to provide a comparative analysis of how the analysed factors affect the export performance of different industries in Indonesia and beyond.

Additionally, the study only considered a few determinants of F&B exports, as identified in the literature, which were not comprehensive. Therefore, future work should consider incorporating other factors influencing F&B exports. These limitations underscore the need for further research and the potential for new contributions to this field.

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