The Impact of Foreign Direct Investment on Manufacturing Company Innovation Opportunities in ASEAN: A CDM Model Analysis

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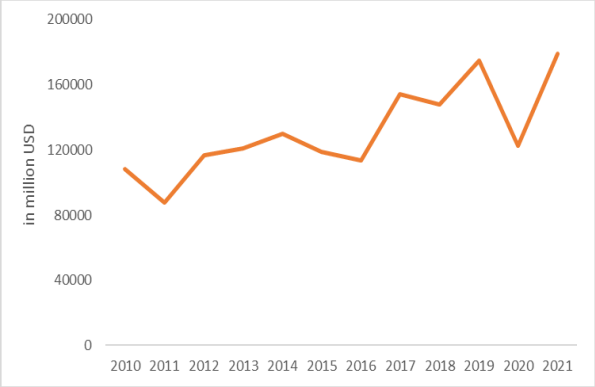
Abstract
ASEAN is known as a region that has several comparative advantages that can attract and encourage increased FDI. As the 2023 ASEAN Chairmanship, Indonesia raised the theme "ASEAN Matters: Epicentrum of Growth". However, there are two fundamental problems, FDI restrictions in the telecommunications sector and low R&D activity, which have implications for low innovative activity and lead to deindustrialization in ASEAN. Thus, to answer this problem, this study will analyze the effect of FDI on innovation opportunities for manufacturing companies using the CDM model approach. The Heckman Selection Model and Probit methods found that the presence of FDI reduces R&D spending. The results of R&D spending have a positive and significant relationship to manufacturing company innovation opportunities. In addition, it was found that innovation in ASEAN was not from R&D activities but from foreign R&D that had been carried out in their home countries.
Keywords*: Foreign Direct Investment, R&D, Innovation, CDM Model.*
JEL*: A11, A13*

A. INTRODUCTION

"One Vision, One Identity, One Community" is the motto of the Association of Southeast Asian Nations (ASEAN). ASEAN, dominated by developing countries, indeed possesses an allure in the form of comparative advantages in terms of economic aspects and resources (natural and human). However, ASEAN, dominated by developing countries, has limitations in terms of capital and technology. Therefore, all ASEAN member states have agreed to implement the principles of open and soft regionalism to expand economic cooperation with other countries, ultimately achieving economic convergence in Southeast Asia (Verico, 2017). The term "open" means that ASEAN member states are given the freedom to collaborate with non-member countries. On the other hand, "soft regionalism," adopted by ASEAN, also implies the absence of discrimination, making it closer to multilateralism. As a result, cooperation with ASEAN is easier compared to other regions.

Based on the regionalism principles mentioned above, ASEAN cannot implement its region's Customs Union (CU) strategy (Verico, 2017). Therefore, ASEAN introduced a significant initiative known as the ASEAN Economic Community (AEC). Implementing AEC has increased Foreign Direct Investment (FDI) inflows into ASEAN (see Figure 1). The entire inflow of foreign investment is divided into three components: equity, reinvested earnings, and other debt-related capital (Srivastava, 2003). The increased FDI into ASEAN primarily flows into the manufacturing sector.

In line with the growth of FDI, Indonesia, as the host country for the ASEAN Chairmanship in 2023, has chosen the theme "ASEAN Matters: Epicentrum of Growth." Indonesia has highlighted three priority issues in the economic field, namely recovery and rebuilding, digital economy, and sustainable development. These priorities are implemented in the 16 Priority Economic Deliverables (PED) for the year 2023 (Kemenko, 2023).



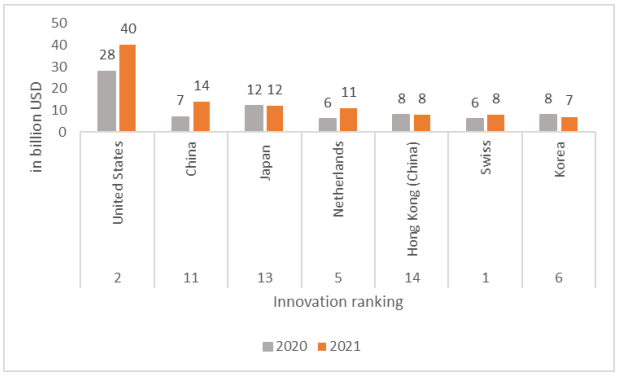
Source: ASEAN Secretariat, 2022

Figure 1. FDI in ASEAN (2010-2021)

However, to address these three priority issues, ASEAN faces two fundamental challenges that may hinder the achievement of these objectives. First, there are FDI restrictions imposed by ASEAN member countries in the telecommunications sector. Second, there is a low level of R&D activity among ASEAN member countries. World Bank (2021) reports that the average R&D expenditure in ASEAN is only 0.84%. Meanwhile, Indonesia is only 0.14%. This makes the level of innovation in ASEAN low. (WIPO, 2022).

All the issues mentioned above have resulted in ASEAN member countries being ranked low in innovation. According to WIPO (2022), innovation is influenced by various factors, ranging from business sophistication, market conditions, availability of infrastructure, levels of human capital and research activities to the quality of institutions in the country.

However, considering the significant amount of FDI in ASEAN, ideally, FDI should serve as an external source of financing for middle-income developing countries to fund research and innovation activities for companies. Moreover, FDI in ASEAN sourced from advanced and innovative countries (see Figure 2) should be a booster for company innovation. The existence of a gap between advanced and developing countries in the innovation process can create channels for promoting innovation through technology and knowledge transfer to companies (Liu, 2008).



Source: ASEAN Secretariat, 2022

Figure 2. Seven Largest Investors in ASEAN and Innovation Rankings (2020-2021)

The low innovation score has significant implications for reduced productivity, especially among manufacturing companies (WIPO, 2022). The decline in productivity has had an impact on the decline in manufacturing value added from 2001 to 2017. In 2021, the manufacturing contribution to GDP, which initially ranged from 25-30% in each country, but in 2017, this contribution had dropped notably, with Indonesia experiencing a 10% decline, Malaysia 8%, and the Philippines 5%.

Consistent with this research, Verico (2017) mentioned Indonesia's early experience of deindustrialization, showing that the manufacturing sector is no longer the backbone of economic growth in Indonesia. Over the past 15 years, Indonesia's economy has become dependent on the service sector, which has limited capacity to absorb the workforce. As a result, if this trend continues, it could pose a threat in the form of difficulty escaping the middle-income trap.

Therefore, this research aims to empirically investigate the relationship between the inflow of FDI into ASEAN countries and the innovation opportunities through R&D in manufacturing companies. With a CDM model approach, the author formulates three research

questions: (1) Does the presence of FDI increase the likelihood of R&D activities in manufacturing companies in ASEAN countries? (2) Does the presence of FDI increase R&D expenditures in manufacturing companies in ASEAN countries? (3) How does FDI influence the likelihood of innovation outputs through R&D in manufacturing companies in ASEAN countries? By answering these questions, this research is expected to uncover the impact of FDI on R&D and innovation in manufacturing companies in ASEAN.

B. LITERATURE REVIEW

The Theory of Foreign Direct Investment (FDI)

The Organisation for Economic Co-operation and Development (OECD) defines Foreign Direct Investment (FDI) as a cross-border investment activity between countries with a long-term duration and significant influence of the investing company on the economy of the host country. Additionally, the International Monetary Fund (IMF) also explains that for an investment to be classified as FDI, the foreign ownership stake in a domestic company should be at least 10%. If the ownership stake is less than 10%, it is considered a portfolio investment.

According to the Bank for International Settlements (BIS) in 2003, FDI can be conducted by both individuals and foreign companies, and it can take various forms, such as associations, subsidiaries, or branches. In a partnership, the foreign company is required to have ownership ranging from 10% to 50%. A subsidiary is formed when the foreign company holds more than 50% ownership, whereas a branch signifies that the company established in another country is fully owned by the parent company.

Definition of Research and Development

The Frascati (2015) defines R&D as a creative and systematic activity conducted to enhance the stock of knowledge. These R&D activities can be directed towards specific or general objectives but always aim to discover something new based on original concepts (and their interpretations) or hypotheses. Furthermore, the knowledge generated through R&D can be freely transferred or traded in the market. In addition, for an activity to be considered as R&D, it must meet five core criteria: novelty, creativity, uncertainty, systematicity, and transferability and/or reproducibility.

The Smiling Curve Theory

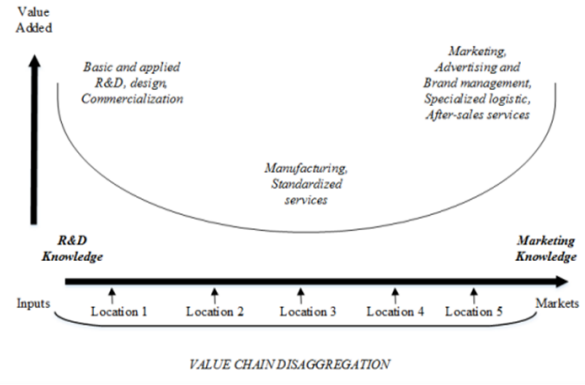
The smiling curve theory explains that a country's ability to capture increased value-added depends on the governance of the value chain. This means that if a country is used as a basis for research and development (R&D), the value-added by manufacturing companies in that country will be higher compared to a country that is only used as a production or manufacturing base (Fu, 2018).

Relations Foreign Direct Investment and Research and Development

The foreign need to adjust the design of their products (product characteristics, and production processes) to match the market conditions (demand) and regulations in the host country. Therefore, R&D activities are necessary as an effort to maintain their existence in the increasingly competitive host country market. Based on Athukorala and Kohpaiboon (2010)R&D activities in the host country also benefits for foreign by providing easy access to local technology, local researchers, and gaining technology spillover benefits in the operating location.

According to Jongwanich and Kohpaiboon (2011), foreign investors play a significant role in driving research activities in the host country. This is because foreign companies generally possess assets such as knowledge, technology, better management quality, and skilled workforce. Van Nguyen (2019) provides a detailed explanation of

four main factors that contribute to foreign ownership stimulating R&D activities in the host country, especially in developing countries.



Source: Shih (1992)

Figure 3. Smilling Curve Theory

Firstly, foreign owners can provide financial resources and technology for R&D activities. Secondly, foreign ownership in manufacturing companies in the host country can give foreign parties a stake in managing the activities of their local partner companies. Thirdly, the presence of foreign investors in companies can provide good managerial knowledge and relational resources to local partners, which can drive innovative activities. Fourthly, companies with a majority of foreign ownership tend to focus on expanding into new and international markets.

Several literatures (Athukorala and Kohpaibon, 2010) also explains the process of conducting R&D activities in the host country Based on the findings of the study, local firms affiliated with foreign will collaborate to establish production activities, where the technological base will be provided by the foreign parent company. Typically, foreign will spend a significant amount of money to acquire new equipment for R&D activities to produce product or process innovations. Subsequently, once the host country's firm has gained various knowledge from the foreign company, along with high potential demand in the market, the firm will engage in R&D activities. Moreover, the R&D process will be expedited if it is supported by regulations that encourage R&D.

Absorptive Capacity in R&D: Linking FDI and Innovation

Based on several literatures, R&D is generally considered as an input to innovation (Ganotakis and Love, 2010; Karamanos, 2015; Love and Roper, 1999) and plays two crucial roles, namely (i) enhancing innovation, and (ii) improving the firm's ability to assimilate and exploit existing knowledge or "absorptive capacity" (Cohen and Levinthal, 1990; Griffith et al, 2004). R&D directly contributes to innovation by creating new technologies or specialized knowledge that can be used for innovation in different ways (Ganotakis and Love, 2010).

Cohen and Levinthal (1990) define absorptive capacity as "the ability of a firm to recognize the value of new information, assimilate it, and apply it for commercial purposes." Therefore, R&D investment is crucial for firm innovation by leveraging absorptive capacity (Cohen and Levinthal, 1990). Firms with high absorptive capacity can more easily absorb knowledge, enabling them to generate new ideas and products (Cohen and Levinthal, 1990). Consequently, they can utilize knowledge from foreign partners to support their innovation efforts (Tsai, 2001). Specifically, foreign investors can transfer advanced technology to subsidiaries. The more absorptive capacity a firm possesses, the more knowledge and resources it can gain from foreign partners, facilitating its innovation activities (Chen et al., 2016; Tsai, 2001).

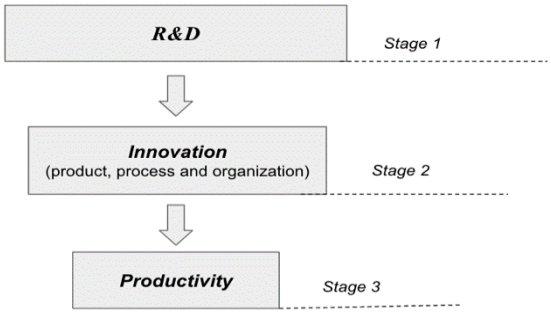
Indeed, if a firm's level of absorptive capacity is limited, the company will likely lack the adequate ability to acquire or create knowledge through interactions with foreign investors. As a result, the firm may be unable to effectively transfer foreign knowledge into the development of new products (Chen et al., 2016).

***Knowledge Production Function* CDM (Crepon, Duguet dan Mairesse) Model Theory**

Crepon, Duguet, and Mairesse (1998) are the developers of the Knowledge Production Function theory for firms. Their research titled "Research, Innovation, and Productivity" comprehensively explores the innovation behavior of firms through an analytical framework known as the CDM model (Lööf, 2009). This model refines the standard knowledge production function approach of Griliches (1979) by analyzing various stages of the innovation process rather than directly estimating the relationship between R&D expenditure and productivity.

The productivity approach by Griliches (1979), used in Harhoff's study (1998), indicates that R&D is a crucial determinant of productivity growth in German manufacturing firms and provides strong evidence of a positive relationship between R&D and productivity. However, Crepon et al. (1998) with their CDM model found empirical evidence that it is not the input of innovation (R&D) that enhances productivity, but rather the output of innovation. This is because companies investing in R&D aim to develop innovative processes and products, which can contribute to productivity and other economic performance.

It is important to note that there are four equations in the framework of the CDM model, with two for R&D, innovation, and production. These four equations connect the decision-making process for R&D with R&D expenditure and its determinants. Next, the innovation equation links R&D expenditure (innovation input) to innovation output. Finally, the productivity equation connects innovation output to firm productivity (refer to Figure 4). All of these equations require different econometric calculations to obtain unbiased analytical results.



Source: Crepon et al, 1998

Figure 4. CDM Model Basic Framework

Innovation Cycle Theory

Schoen et al (2005) describes several stages in the innovation cycle. According to their explanation, the innovation cycle there are three steps that have different results and goals.

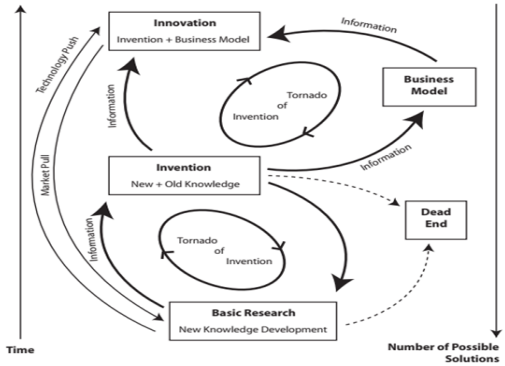
1. **Basic research**: This stage that produces new knowledge.
2. **Invention:** a novelty or creation based on human intelligence, but the concept of invention does not require commercial success in its application.
3. **Innovation:** which includes the renewal of the results of human thought accompanied by success in its application, such as technical, commercial and economic success.

Previous Research Results

The empirical literature discusses the influence of Foreign Direct Investment (FDI) on R&D activities and innovation in companies. In the study conducted by Sasidharan and Kathuari (2011), it was found that FDI, through the inflow of investment from foreign companies into India, has resulted in encouraging high-tech manufacturing companies in India to engage in R&D activities and import technology to compete with other companies.

Another finding (Jongwanich and Kohpaiboon, 2011) also states that globalization, represented by affiliating with foreign companies (foreign-owned), engaging in exports, and participating in global production networks, has

led manufacturing companies in Thailand to become more active in R&D activities. Additionally, indirect spillovers, such as competition in the market, also contribute to driving R&D investments for companies.



Source: Schoen et al, 2005

Figure 5. Innovation Cycle

Further research (Erdal and Gocer, 2015) conducted in developing countries in Asia found that the inflow of FDI from developed countries is a key determinant of high economic growth rates achieved by developing countries, particularly China and India. When multinational companies invest in R&D in the host country, it can accelerate the development of high technology in the host country. After generating new technology, products, and production processes, multinational companies will then increase the number of patents in the host country.

In addition, Guo et al. (2021) revealed in their research that R&D activities can enhance the absorptive capacity of manufacturing firms in China. Using the GMM methodology, they found that the high absorptive capacity resulting from extensive R&D activities can serve as a means to absorb foreign knowledge, which in turn drives innovation in Chinese firms. Moreover, the study also discovered that human capital is another factor that can influence the increase in absorptive capacity for companies. Thus, the research elucidates that when companies have high spending on R&D and possess substantial human capital, it strengthens the relationship between FDI and the innovation process of manufacturing firms in China.

In his comprehensive study, Erick (2018) examined the influence of FDI and spillover effects on innovation in manufacturing firms in Kenya. Using the CDM model approach, Erick investigated the impact of FDI in the form of foreign ownership on R&D activities in firms as input for innovation to produce output in product and process innovation. The analysis revealed a positive and significant relationship between FDI in the form of foreign ownership and R&D activities in manufacturing firms in Kenya. Furthermore, the conducted R&D activities were accompanied by forward and horizontal spillover effects from FDI, which were found to stimulate the creation of output in product and process innovation in Kenyan firms. Erick also found that export activities and obtaining international quality certifications empirically influenced the likelihood of innovation in manufacturing firms in Kenya.

In their latest research, Vujanovic et al. (2022) employed the CDM model approach to analyze the types of innovation resulting from FDI spillover effects in a European emerging economy, namely Serbia. The study revealed that in emerging economies, the process of innovation is mostly driven by imitation rather than the generation of new knowledge. Additionally, local firms benefited from foreign counterparts in the early stages of the innovation process. The stronger FDI effects were observed in companies that pursued innovation through knowledge use rather than knowledge generation.

C. RESEARCH METHODS

Data

This research used data sourced from the World Bank Enterprise Survey (WBES). For this study, the author utilized the latest WBES data, which is from the year 2015, for the ASEAN

countries, including Indonesia, Malaysia, the Philippines, Myanmar, and Vietnam. The data used is in the form of a cross-section and only includes samples from manufacturing companies in those countries.

Model and Methodology

The model used in this study refers to and modifies previous research conducted by Duch Brown et al. (2018) based on the analytical approach of the Crepon, Duguet, and Mairesse (CDM) model from 1998. This model consists of three iterative steps with four consecutive equations. In the first step (a two-step innovation decision procedure), it is referred to as the Heckman equation model. The second step estimates innovation output (knowledge production function) using probit regression estimation. The third step assesses whether innovation output influences or enhances productivity (Heckman, 1998; Crépon et al., 1998). However, in this study, the third step (productivity) is not measured. The following is the model used:

$$D_i = \begin{cases} 1 \text{ if } \delta Z_i + \varphi_i + \varepsilon_{1i} > 0 \\ 0 \text{ if } \delta Z_i + \varphi_i + \varepsilon_{1i} < 0 \end{cases} \quad (1)$$

In equation (1) above, D_i is a dichotomous observable variable that takes a value of 1 if the company decides to engage in R&D activities and 0 if it does not. Next, Z_i represents the explanatory variable, φ_i captures unobserved firm heterogeneity, and ε_{1i} is the error term. Thus, the details of equation 1 in this study are as follows:

$$Pr\,(R\&D\ Decision_i = 1) = \beta_0 + \beta_1 ForeignOwned_i + \beta_2 LogSizeFirm_i + \beta_3 LogAgeFirm_i + \beta_4 Cooperation_i + \beta_5 Training_i + \beta_6 PurchaseEq_i + \beta_7 Tax\ rate_i + \beta_8 ICT\ Sector_i + \varphi_i + \varepsilon_{1i} \quad (1)$$

Furthermore, equation (2) below represents the Heckman selection model. Equation (2) models the amount of spending on Research and Development (R&D) activities. Equation (2) is based on whether the company engages in R&D activities or not, as described in equation (1). Thus, equation (2) takes the following form:

$$R\&D_i = \begin{cases} \beta X_i + \alpha_i + \varepsilon_{2i} \; if \; D_i = 1 \\ 0 \; if \; D_i = 0 \end{cases} \quad (2)$$

Based on equation (2) above, X_i represents all determinants that influence R&D intensity, which is measured as the ratio of R&D spending to total sales. α_i captures unobserved firm heterogeneity, and ε_{2i} is the error term. Thus, the details of equation (2) in this study are as follows:

$$LogR\&D\ Intensity_i = \beta_0 + \beta_1 ForeignOwned_i + \beta_2 LogSizeFirm_i + \beta_3 LogAgeFirm_i + \beta_4 Cooperation_i + \beta_5 Tax\ Rate_i + \alpha_i + \varepsilon_{2i} \quad (2)$$

In the second stage or the third equation of the CDM model (the knowledge or innovation production function), the probit model approach will be used as an analytical tool to link innovation inputs (R&D Intensity) and other explanatory variables with innovation output. Product and process innovations are the most important innovations that can quickly drive productivity. Therefore, this study will measure the impact of FDI on one form of innovation, namely product innovation. The following is the third equation in this study:

$$INN_i = \gamma \widehat{R\&D_i} + \omega W_i + \theta_i + \mu_i \quad (3)$$

In equation 3 above, INN_i is a binary innovation variable, where it takes the value of 1 if firm (i) introduces an innovation and 0 if the firm does not undertake any innovation. The notation $\widehat{R\&D_i}$ represents the predicted R&D intensity estimated from equation (2) and is used to address potential endogeneity issues. On the other hand, W_i is an explanatory variable that describes other determinants of innovation. Then, θ_i is a notation used to capture unobservable firm characteristics that differ from

the variables included in W_i. Finally, μ_i represents the error term. Thus, the details of equation 3 in this study are as follows:

$$Pr\,(Innovation_i = 1) = \beta_0 + \beta_1 \widehat{R\&D_i} + \beta_2 LogSizeFirm_i + \beta_3 LogAgeFirm_i + \beta_4 Training_i + \beta_5 Export_i + \beta_6\, Competition_i + \beta_7 FinanceObs_i + \theta_i + \mu_i \quad (3)$$

Based on all the explanations of the models used in this study, it can be summarized that in the first stage, equation (1) models the R&D decision-making process, while equation (2) describes the spending on R&D activities based on the decisions taken from equation (1). Both equations are modelled as Heckman selection equations and analysed using Heckman regression. Then, in the second stage, the predicted values of R&D Intensity obtained from the first stage will be used to estimate their influence on innovation using a probit model. However, equation productivity in the CDM model above will not be analysed in this study because the research only measures the influence of FDI on product innovation in manufacturing companies.

Variable Operationalization

In this study, there are three types of variables used: dependent variables, independent variables, and control variables. Below are the definitions and the variables that will be used by the author.

Table 1. Types of Variables

Variable	Type of Variables
R&D Activity	Binary variable 1: Company conducts R&D. 0: Not conducts R&D.
R&D Intensity (log)	Continuous variable that explains the total expenditure of a company on research and development (R&D) activities in the last fiscal year (in logarithm).
Innovation	Binary variable: 1: Company conducts innovation. 0: Not conducts innovation.
Foreign Owned	Binary variable: 1: There is foreign ownership (minimum 10%). 0: Not foreign ownership.
Size Firm (log)	Number of employees employed by the manufacturing company.
Age Firm (log)	The difference in years between the company's establishment date and the year of conducting this survey (in logarithm).
Cooperation	Binary variable 1: Company conducts cooperation with other for R&D. 0: Company not cooperation.
Training	Binary variable 1: Company give training employees. 0: Company does not give training.
Purchase Equipment	Binary variable: 1: Company has purchased new equipment, machinery, or other capital goods within the last year. 0: Company does not purchase within the last year.

Variable	Type of Variables
Tax Rate	Binary variable: 1: Perception company to applied tax rates, both high and moderate, in the country. 0: Perception company to applied low tax rate.
ICT Sector	Binary variable: 1: Company in ICT sector. 0: Not ICT sector.
Export	Binary variable: 1: Company conducts export. 0: Not export.
Competition	Binary variable: 1: Perception company if the company faces competition ranging from moderate to intense. 0: Perception company if the company faces low levels of competition.
Finance Obstacle	Binary variable: 1: Perception company if the company experiences financial access constraints ranging from moderate to severe. 0: Perception company if the company experiences low financial constraints.

Source: Authors, 2023.

From the table of variable definitions above, here is a summary of the variables that will be used in each stage according to the CDM model.

D. RESULTS AND DISCUSSION

In this section, the author will explain the descriptive statistical analysis of various variables used in the model

Table 2. Variable Operationalization

Stage 1		Stage 2	
No.	**Variable Dependent**	**No.**	**Variable Dependent**
1	R&D Activity	1	Innovation
2	R&D Intensity (log)		
No.	**Variable Independent**	**No.**	**Variable Independent**
1	Foreign Owned	1	R&D Intensity (log)
No.	**Variable Control**	**No.**	**Variable Control**
1	Size Firm (log)	1	Size Firm (log)
2	Age Firm (log)	2	Age Firm (log)
3	Cooperation	3	Training
4	Training	4	Export
5	Purchase Equipment	5	Competition
6	Tax Rate	6	Finance Obstacle
7	ICT Sector		

Source: Authors, 2023.

Table 3 shows the list of variables used in this study. Each variable has a total of 997 observations from manufacturing companies in various sectors across 5 ASEAN countries. However, in the R&D Expenditure variable, there are only 268 observations. This is because not all manufacturing companies disclose their R&D spending. From the R&D Expenditure variable, it can also be observed that the average R&D spending of the observed manufacturing companies in this study is 17,738 US dollars, with the highest value being 230,440 US dollars.

Table 3. Descriptive statistics

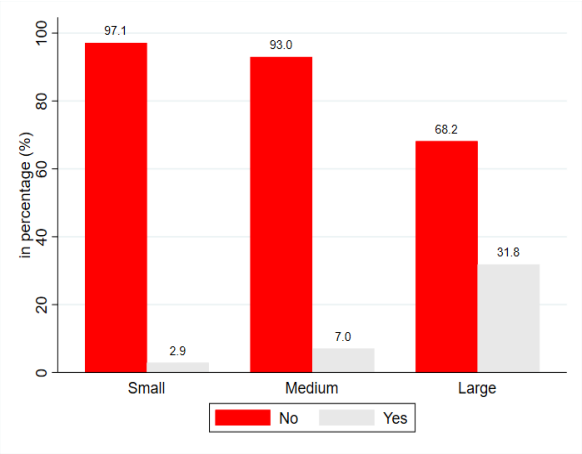
Variabel	Obs	Mean	Std. dev	Min	Max
R&D Activity*	977	0.292	0.454	0	1
R&D Expenditure (USD)	268	17,738	39,758	0	230,441
Innovation*	997	0.724	0.447	0	1
Foreign Owned	997	0.142	0.350	0	1
Size Firm (person)	977	209	672.15	1	9000
Age Firm (years)	997	20	14.27	1	118
Cooperation	997	0.429	0.495	0	1
Training	997	0.324	0.468	0	1
Purchase Equip	977	0.555	0.497	0	1
Tax Rate	997	0.314	0.464	0	1
Export	997	0.273	0.445	0	1
Financial Obstacle	997	0.315	0.464	0	1
Competition	997	0.340	0.474	0	1
ICT Sector	997	0.116	0.321	0	1

Source: Authors, 2023.

Then, to obtain information about the characteristics of manufacturing companies that are more appealing to foreign investors for investment, the author uses the variables "Size Firm" and "Age Firm" as proxies.

Based on the aspect of Size Firm, the above cross-tabulation (see figure 6) results show that only 139 companies have foreign ownership (FDI).

Out of the total, it was found that FDI is predominantly present in large companies (with more than 99 employees) with a total of 107 companies or 31.8%. Meanwhile, medium-sized companies (with 20 to 99 employees) and small companies (with 1 to 19 employees) accounted for only 23 companies (or 7%) and 9 companies (or 2.9%), respectively. In other words, it is evident that FDI is more dominant in large companies. This is because large companies have better and more efficient governance and are more likely to expand. As a result, foreign investors are more interested in investing (Shi et al., 2020).



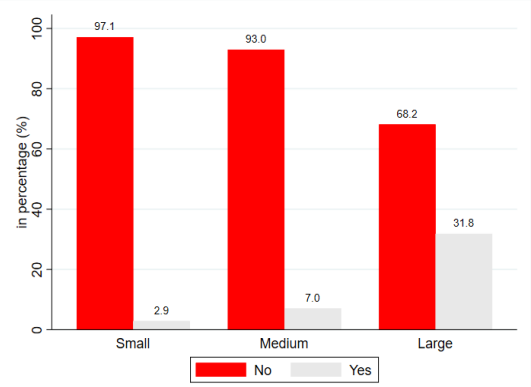
Source: Authors, 2023.

Figure 6. Cross Tabulation FDI and Size Firm

Moving on to the aspect of company age (see figure 7), out of a total of 139 companies with foreign ownership (FDI), it was found that FDI is more prevalent in older companies (more than 15 years old). From the table below, it can be observed that there are 88 old companies that have foreign ownership. On the other hand, the mature category (5 to 15 years old) only consists of 46 companies with foreign ownership (FDI). Finally, there are only 5 young companies (1 to 5 years old) with foreign ownership.

In other words, from each group of old, medium, and young companies, it can be observed that FDI in companies older than 15 years tends to be more attractive to investors,

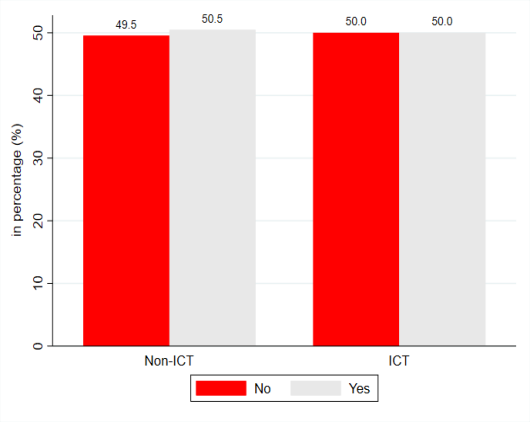
accounting for approximately 16%. Meanwhile, it constitutes only 13% for medium-sized companies and 7% for young companies. According to Liu and Zou (2008), foreign investors are more interested in investing in older companies because they have demonstrated good sustainability capabilities in the market competition. Additionally, older companies possess more experience and competent business strategies due to their longer establishment in the industry.



Source: Authors, 2023.

Figure 7. Cross Tabulation FDI dan Age Firm

Based on the cross-tabulation results between companies with foreign ownership (FDI) and those conducting R&D activities (see figure 8), it is evident that the majority is still dominated by non-ICT manufacturing companies. The low number of ICT companies indicates that the ICT manufacturing sector has not developed well in the five countries (Indonesia, Malaysia, Philippines, Myanmar, and Vietnam). Ibrahim (2023) mentioned that the number of ICT manufacturing companies in Indonesia is only around 1.24%. ICT companies were found to be concentrated in West Java and the Riau Islands. The ICT sector also includes semiconductor manufacturing plants, electronic tube, and connector manufacturing plants. Additionally, the low R&D expenditure in the ICT sector is due to FDI primarily taking the form of subsidiaries in that sector (ASEAN Secretariat, 2022).



Source: Authors, 2023

Figure 8. R&D Activities by Industry Sector with Foreign Ownership

Stage 1 Heckman Regression

In this study, the authors divided the analysis into two stages. First, the stage to examine various factors influencing the decision to engage in R&D. Then, for companies that have decided on R&D, the consistency of various factors affecting the company's decision to incur R&D investment costs will be tested. This is in line with previous research conducted by Erick (2018) on manufacturing companies in Kenya. The process of R&D activities usually gives rise to issues of selection bias and endogeneity. Selection bias arises because not all companies engage in innovation (incurring R&D costs). Additionally, endogeneity issues arise due to the correlation between independent variables and the error term in the model.

Based on the potential issues mentioned above, the author decides to use the Heckman selection model in the first stage. There are two equations in the first stage, namely the equation for the decision to engage in R&D activities and the equation for R&D expenditure (R&D Intensity). According to Heckman (1979), there are three assumptions that must be met to apply the Heckit model.

First, the standard error of the selection model (equation 1) must be correlated with the standard error of the outcome model (R&D

Intensity). In this section, there is a hypothesis, where H0: there is no correlation in standard error between the selection model (probit) and the outcome model (OLS). Meanwhile, H1: there is a correlation in standard error between the selection model (probit) and the outcome model (OLS).

From these assumptions, a covariate resulting from the regression of the selection model (probit) called the inverse Mills ratio will be used. The value of the inverse Mills ratio can be represented by the symbol lambda or lnsigma. Subsequently, this covariate in the form of the inverse Mills ratio will be tested in the outcome regression using OLS. If the result is not significant, then H0 is accepted, indicating that there is no selection bias problem in the model. Thus, the Heckit model cannot be used, and only the OLS model can be applied, and vice versa.

The second assumption that needs to be met is that the inverse Mills ratio used must be able to resolve the selection bias problem by creating two independent equations. The final assumption is that all covariates included in the model must be appropriate. Table 4 below is the estimation table from the Heckit regression (stage 1 of the CDM model).

Based on Table 4 above, the Heckman assumptions can be addressed. From the table, it is evident that the first assumption is met. This is because the rho test with the athrho coefficient, which measures the correlation between the error terms, is 0.337 and statistically significant at the 5% level (P>|z|=0.034). Therefore, the hypothesis of no correlation in standard error between the selection model (probit) and the outcome model (OLS) is rejected (H0 rejected). Due to the presence of this selection bias, the Heckit method is suitable for use in this research model. Furthermore, the second assumption is also satisfied. The Wald LR test for the independence coefficient is 3.69 and significant at the 10% level ($\chi2=0.054$), indicating that the selection bias has been corrected. Finally, the assumption of measuring the suitability of covariates in the model is also fulfilled. This is evident from the overall Wald test result, which is 23.88 and significant at $\chi2=0.000$. This implies that the covariates used in the model are appropriate, and the results can be trusted for interpretation.

In the above Heckit method, there are 2 equations. First, the equation describes various factors influencing the decision to engage in R&D activities. In the first equation, there are internal factors such as firm size (size firm), firm age (age firm), job training (training), the purchase of new equipment (PurchaseEq), and the company's sector. On the other hand, external factors include the presence of foreign ownership (FDI), collaboration with other parties for R&D (Cooperation), and the application of tax rates in the country.

From the above Heckit regression, it is found that Foreign Direct Investment (FDI) in the form of foreign ownership (independent variable) does not significantly influence the likelihood of R&D decision. However, the variables Size Firm, Training, and Cooperation can significantly increase the likelihood of a firm's decision to engage in R&D activities at a significance level of 1%. Additionally, PurchaseEq can significantly increase the likelihood of a firm's decision to engage in R&D activities at a significance level of 10%. Finally, the variables Age Firm, Tax Rate, and ICT sector do not significantly influence the likelihood of a firm's decision to engage in R&D activities.

In the second equation, this research measures the consistency of R&D activities (outcome) through the level of R&D Intensity. Several factors are measured until the company incurs R&D expenses. Just like previous research conducted by Duch Brown et al (2018) and Erick (2018), Foreign Owned is used as an independent variable in the first stage of this study. Size firm,

age firm, cooperation, and tax rate are some of the variables that can influence the magnitude of R&D expenditure in manufacturing companies. From the results of the regression, it is found that the presence of Foreign Owned (FDI), cooperation, and tax rate can significantly affect the magnitude of R&D Intensity at the 1% and 5% levels. However, the variables Size firm and Age firm do not significantly influence R&D Intensity in manufacturing companies.

Stage 2 probit regression estimation

In the second stage, Probit analysis is chosen as the method to be used. Following the CDM model's theoretical framework, R&D Intensity will be used as a moderator to measure the impact of FDI on a company's innovation. In the second stage, the predicted R&D Intensity values are used as the independent variable. The use of predicted R&D Intensity is intended to avoid endogeneity problems and to achieve simultaneity as consistent with the CDM model's theory.

Table 5 presents the marginal effects from the probit regression results. It shows the marginal effect values and the level of significance for each variable operationalized in this stage. Since this model uses probit, the interpretation will be based on the marginal effect values generated. Therefore, if there is a one-unit change in any of the variables, it will alter the likelihood of manufacturing companies engaging in innovation activities according to the magnitude of their respective marginal effect coefficients.

From the results of the chi-square probabilities in all the models above, it is evident that the results are significant at the 1% level of significance (α=1%). The chi-square probabilities (probit) represent global tests for the research in ASEAN.

model. Therefore, based on the obtained results, it indicates that all the variables operationalized in the model, when considered together, have a significant impact on the dependent variable, which is the innovation variable.

Based on the above regression results, it is evident that a 1% increase in R&D Intensity can significantly increase the likelihood of innovation in manufacturing companies at a 1% significance level. Similarly, for other variables like age firm and size firm, a 1% increase in these variables can also significantly increase the likelihood of innovation in manufacturing companies at a 1% significance level. Furthermore, the presence of training, export, competition, and financial obstacles also significantly influence the likelihood of innovation in manufacturing companies at a 1% significance level. These results suggest that these factors play a crucial role in encouraging and facilitating innovation within manufacturing firms.

Discussion

In this section, the author will discuss the interpretation of all the numbers (estimation results) from the above models.

Mismatch of FDI and R&D Flows

Based on the findings from the Heckman selection model above, the presence of Foreign Direct Investment (FDI) in the form of foreign ownership does not have a significant influence on the likelihood of making R&D decisions for manufacturing companies (failing to reject H0). Moreover, foreign ownership has a negative and statistically significant relationship (rejecting H0) with R&D Intensity for manufacturing companies. In other words, the presence of FDI in manufacturing companies can decrease R&D Intensity by 1.17% for manufacturing companies

Table 4. Heckman regression estimation results (Stage 1)

	Stage 1 (*R&D Equation*)	
	(Eq.1)	**(Eq.2)**
Variabel	**R&D Activity (*dummy*)**	**R&D Intensity (*log*)**
Foreign Owned	0.223	-1.167***
	(0.145)	(0.444)
Size Firm (log)	0.291***	-0.221
	(0.0845)	(0.319)
Age Firm (log)	0.118	0.252
	(0.157)	(0.608)
Cooperation	-0.558***	-1.401***
	(0.107)	(0.442)
Training	0.852***	
	(0.102)	
Purchase Equip	0.257**	
	(0.108)	
Tax Rate	-0.0290	-0.865**
	(0.105)	(0.371)
ICT Sector	-0.109	
	(0.160)	
Constant	-1.625***	-3.720***
	(0.240)	(1.125)
Total Observation	919	
Selected	227	
Non-Selected	692	
/Athrho	0.337** (0.178)	
/lnSigma	0.994*** (0.061)	
Wald Chi2 (Prob > chi2)	23.88***	
LR test of independent equations	(rho = 0): chi2 (1) = 3.69	Prob > chi2 = 0.054

Note: *** p < 0.01; ** p < 0.05; * p < 0.1; standard error (...)

Source: Authors, 2023

The findings are consistent with previous research conducted by Shi et al (2020) in China. Manufacturing companies with foreign ownership can reduce R&D expenditure (invest less in R&D) compared to domestic companies (without foreign ownership) in China. According to their study, foreign investors in developing countries tend to focus on seeking profits from the size of the market rather than developing knowledge (R&D) in that country. The results of their study align with the current situation happening in Indonesia. Foreign companies entering Indonesia mainly focus on sales in the Indonesian market and not on developing R&D. This is evident from the portion of R&D expenditure by private entities, which only accounts for approximately 20% of the total R&D spending.

When reflecting on the per capita income levels of the five countries classified as low and middle-income countries, Gugler (2010) suggests that there is a positive relationship between income levels and the standard of living in a region and the innovation activities of companies. This means that in regions with high income levels and living standards, companies operating there

Table 5. Probit Regression Estimation Results (Stage 2)

Variable	**Stage 2 (*Innovation)***			
	(1)	(2)	(3)	(4)
Predict R&D Intensity	0.196***	0.201***	0.197***	0.192***
	(0. 013)	(0.012)	(0.011)	(0.010)
Age Firm (log)		0.175***	0.138***	0.131***
		(0.033)	(0.032)	(0.031)
Size Firm (log)		0.185***	0.075***	0.084***
		(0.018)	(0.020)	(0.019)
Training			0.275***	0.267***
			(0.030)	(0.029)
Export			0.142***	0.143***
			(0.034)	(0.033)
Competition				0. 096***
				(0.024)
Finance Obstacle				-0.085***
				(-0.023)
Industry FE	**YES**	**YES**	**YES**	**YES**
Constant	4.063***	2.679***	3.492***	3.646***
Prob > Chi2	0.0000	0.0000	0.0000	0.0000
Pseudo R2	0.1444	0.2747	0.3679	0.3965
Total Observation	977	977	977	977

Note: *** p < 0.01; ** p < 0.05; * p < 0.1; standard error (...)

Source: Authors, 2023

will compete through innovation, producing new and different goods using the most advanced production processes. This condition can be observed from the success of Singapore, which is one of the ASEAN member countries with high per capita income and ranks highly as an innovative country in the world.

Indeed, the lack of interest in R&D investment by foreign entities and the focus of the ASEAN market solely as a profit-seeking market can be attributed to the demand conditions within the ASEAN countries, which tend to prioritize price over the quality of goods produced. As a result, companies need to prioritize cost efficiency and allocate R&D budgets according to consumer preferences and priorities (Safarzyńska, 2010). Consequently, the characteristics of the society will become one of the factors shaping the quality of supply and demand for goods in the ASEAN market.

Indeed, ASEAN has been predominantly used as a region for production bases rather than R&D centers. This is evident from the continuous growth of FDI in the form of greenfield investments (establishment of new production units). According to the ASEAN Secretariat's report (2022), foreign investment in the form of greenfield projects has increased by 12%, particularly in the manufacturing sector. As a result, this situation illustrates the ASEAN countries' position as manufacturing hubs (fabrication) in the smiling curve theory, leading to relatively low value-added gains.

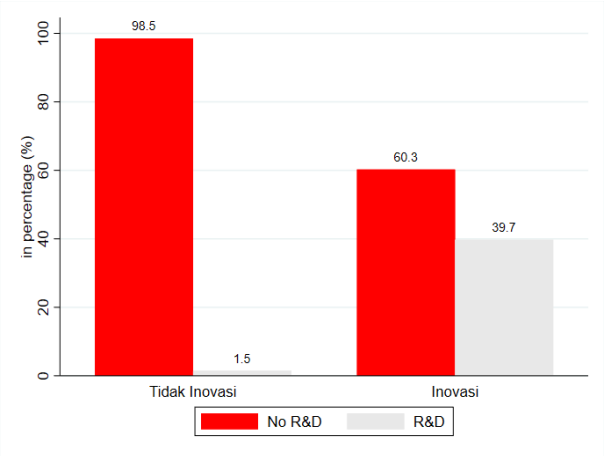
Another reason for the low investment in R&D in ASEAN is because the industrial characteristics in the region tend to be oriented

towards labor-intensive rather than capital-intensive production. Based on the findings of the study by Setyari et al. (2016) in five ASEAN countries (Indonesia, Malaysia, Singapore, Thailand, and the Philippines), it was found that only Singapore has effectively utilized capital-intensive approaches as an engine of economic growth. From the results of the study, it was also found that Indonesia has the lowest level of capital intensity among these countries. In other words, industries in Indonesia are still predominantly characterized by their reliance on labor as the primary factor of production.

One other ASEAN country that still relies on labor-intensive industries in its economy is Vietnam. The implementation of low labor wage regulations has made Vietnam an attractive destination for foreign investments to establish production factories. Moreover, during the escalating trade war between the US and China, many reports and analyses indicate that Vietnam has been the biggest beneficiary, as Chinese-based companies diversified or shifted their production operations to Vietnam (Ha and Puch, 2019).

The condition in ASEAN where it is primarily used as a manufacturing base in Global Value Chains (GVCs) by foreign entities will lead to innovation characteristics that stem from imitation (knowledge use) rather than from R&D outcomes (knowledge creations). This phenomenon is not limited to ASEAN but also occurs in developing countries in Europe, such as Serbia (Vujanović et al., 2022). According to Kravtsova and Radosevic (2012), economic growth in developing countries due to FDI is driven by the adoption and assimilation of existing knowledge, which is manifested through the import of machinery and equipment, rather than through knowledge creation resulting from investments in R&D.

Based on the cross-tabulation analysis between companies that conduct R&D and innovation (see figure 9), it is evident that many manufacturing companies in ASEAN do not engage in R&D. According to the table, there are 692 companies recorded as not conducting R&D, while only 285 companies perform R&D. However, it is noteworthy that even among the companies not conducting R&D, a significant number of them (426 companies or 60.3%) still experience innovation within their organizations over the past three years. From this observation, it becomes apparent that innovation activities in ASEAN are not primarily driven by the outcomes of R&D conducted within the region. Instead, it suggests that ASEAN benefits from the results of R&D activities conducted by foreign entities in their home countries.



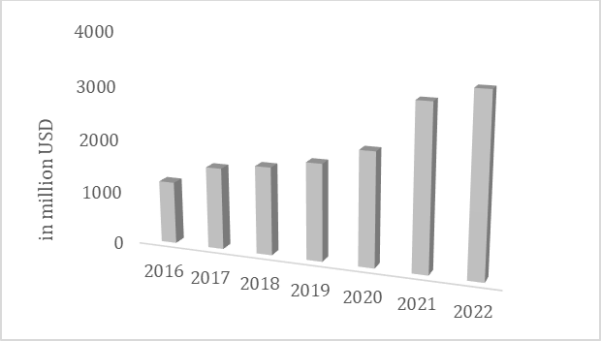
Source: Authors, 2023

Figure 9. R&D Activities and Company Innovation

Based on the findings of Kaneva and Untura (2018), engaging in R&D activities directly has a more significant impact on the per capita GDP growth of a country compared to relying on R&D spillovers from other companies or merely accepting the results of R&D conducted by foreign entities. This is because when a country focuses on conducting R&D and allocates more resources to it, the likelihood of developing new technologies and innovations increases, leading to improvements in productivity. On the other hand, relying solely on R&D spillovers or foreign

R&D results may lead to a lag of time in innovation. Industries that are geographically distant from the centers of R&D activities may experience slower knowledge diffusion, hindering their ability to keep pace with technological advancements and innovate effectively.

Thus, investment in R&D is crucial as a catalyst for industrial revolution and increasing the per capita GDP of a country (Gordon, 2012). Moreover, to generate a surplus value in the Balance of Payment, R&D is needed as a driver of innovation output that impacts the increase in export value, the decrease in imports, and the rise of investments in a country. In fact, this has already happened, as the low R&D spending in the Information and Communication Technology (ICT) sector in Indonesia has led to Bank Indonesia (2023) consistently reporting a deficit in the current account for ICT services, such as software, telecommunications, programming, and others, over the past 7 years (see figure 10). Certainly, if R&D remains low, this deficit will continue to grow, parallel to the dynamic development of the digital economy as an engine of growth in the modern era.



Source: Bank Indonesia, 2023

Figure 10. Growth of Current Account Deficit in ICT Services Sector in Indonesia (2016-2022)

Furthermore, from the internal factor's perspective (company characteristics), Size Firm has a positive and significant relationship with the decision to conduct R&D. This means that an increase in Size Firm by 1% leads to a higher likelihood of engaging in R&D activities. However, Size Firm does not have a significant influence on R&D Intensity within the company. According to Duch Brown et al. (2018), larger-sized firms have a higher likelihood of making R&D decisions compared to smaller companies. This is because larger firms possess sufficient resources to support R&D.

However, based on their findings in the TIK manufacturing companies in Spain, Duch Brown et al. (2018) stated that small companies are not significantly less capable of allocating funds for R&D to support their competitiveness. Therefore, the size of the company does not significantly influence R&D expenditure. Furthermore, the age of the firm (company age) was found to be insignificant, indicating that the age of the company does not determine its investment in R&D. In other words, both young and old companies strive for R&D (Erick, 2018).

Examining other internal factors, the provision of training and the purchase of new equipment have a positive and significant impact. This means that when companies conduct training and invest in purchasing new equipment, it increases the likelihood of engaging in R&D activities in manufacturing companies. Based on studies by Shi et al. (2020) in manufacturing companies in China and Erick (2018) in Kenya, training and purchase of equipment are essential internal factors to support R&D. These aspects are useful for enriching the capabilities of workers and the company's capital. According to the R&D process, companies usually undertake R&D when both training and equipment purchase are deemed sufficient to support the R&D process. The goal is to avoid potential risks such as R&D failure.

Moving on to external factors, namely cooperation and tax rates, it appears that both have a negative and significant relationship. This means that when companies engage in cooperation with other parties and face high tax

rates, it can reduce the likelihood of engaging in R&D activities and decrease R&D expenditures by 0.87% and 1.41%, respectively, in manufacturing companies. Consistent with findings in other studies in developing countries, it is found that increased cooperation in R&D is vulnerable to the risk of leaking R&D results. Since developing countries generally have low intellectual property protection, if R&D results leak to unintended parties, it can lead to losses for the company. Intellectual property, such as patents, is a crucial component in protecting the outcomes of R&D.

As evidenced by the study conducted by Elschner (2011) on manufacturing companies in the European Union, the implementation of excessively high taxes can decrease the interest of companies in investing in R&D. However, after the EU government implemented tax reduction incentives, the amount of R&D expenditures in the country increased significantly. Therefore, the high tax rates in ASEAN countries (Indonesia, Malaysia, the Philippines, Myanmar, and Vietnam) have been shown to reduce the interest of manufacturing companies in investing in R&D. Consequently, considering the conditions of all five countries, the ICT sector, which should have the potential to influence R&D intensity due to the rapid dynamics of changes in that sector, does not significantly affect R&D decisions. This is mainly due to the lack of supportive R&D regulations in ASEAN.

One example of the lack of government support can be seen from the departure of PT Fairchild Semiconductor Indonesia in July 1986 from Indonesia to Malaysia. The closure of the company occurred due to the government's automatic rejection of automation in the production process, as it was perceived to potentially increase unemployment in Indonesia. Coupled with regulations that did not support a conducive foreign investment climate (such as high tax rates), Indonesia eventually became less attractive to investors as a base for production and innovation. Unfortunately, this trend continued until 2019. The World Bank reported that out of 33 foreign companies that left China, none relocated to Indonesia. The majority of these companies, 23 of them, moved to Vietnam. Meanwhile, 10 companies moved to Malaysia, Thailand, and Cambodia.

R&D Intensity as a Driver of Innovation in Manufacturing Companies

Furthermore, according to previous research conducted by Duch Brown et al (2018), company characteristics such as size firm and age firm are also considered as determining factors for the likelihood of innovation output in companies. Based on the findings, age firm has a positive and significant impact. This means that a 1% increase in age firm will increase the likelihood of innovation by 0.130 or 13% in manufacturing companies. This aligns with the findings of Ayalew et al. (2019) in manufacturing companies across several African countries. According to their study, experience helps older companies generate additional innovations compared to younger companies.

The variable size firm was also found to have a positive and significant relationship. This means that a 1% increase in size firm will increase the likelihood of innovation by 0.083 or 8% in manufacturing companies. These findings are consistent with Schumpeter's theory, which explains that large companies are the best innovators because they have strong capital derived from substantial profits to fund R&D and produce innovative outputs. This theory is supported by previous empirical studies conducted by Ayalew (2019), Abdu and Jibir (2018), and Danso (2020), stating that larger companies benefit from economies of scale and have better capabilities in managing risks during the innovation process.

Another factor that influences the likelihood of innovation in companies is the

provision of training. Based on the regression results, it was found that training has a positive and significant relationship. This means that when manufacturing companies provide training to their employees, it can increase the likelihood of innovation by 0.266 or 26%. According to studies measuring the impact of training on company innovation conducted by Abdu and Jibir (2018) in Nigerian manufacturing companies and Gallié and Legros (2012) in French manufacturing companies, it was noted that high human capital resulting from training enhances the company's absorptive capacity from external sources to generate innovation.

Furthermore, from the regression results, it was found that export activities also have a positive and significant impact on the likelihood of innovation in companies. This means that when manufacturing companies engage in export activities, it can increase the likelihood of innovation by 0.143 or 14%. These findings are consistent with the study conducted by Edeh and Acedo (2021) in manufacturing companies in Nigeria. According to their study, export activities can stimulate innovation as companies need to adapt to the preferences of customers in other countries. Additionally, there are various product standards that need to be met to enter foreign markets, thereby motivating manufacturing companies to innovate.

Lastly, the study also measured obstacles that could influence the likelihood of innovation in companies, such as the level of competition and financial obstacles. The results showed that competition has a positive and significant relationship with the likelihood of innovation in companies. This means that the presence of competition in the markets of the five ASEAN countries can increase the likelihood of innovation in manufacturing companies by 0.096 or 9%. On the other hand, financial obstacles have a negative and significant relationship. This means that the presence of financial obstacles can decrease the likelihood of innovation in manufacturing companies by 0.085 or 8%.

From previous research by Ayalew et al. (2019) and Duch Brown (2018), both in developing markets (African countries) and developed countries (Spain), competition has been found to drive innovation opportunities. This is because the relationship between competition and innovation takes the form of an inverted-U. This means there is an assumption that companies currently lagging behind the technology leader in the same sector need to catch up by engaging in innovation activities to become innovative leaders in that sector. On the other hand, the challenge of financial obstacles, when companies face financing limitations, can reduce the likelihood of innovation in those manufacturing companies. This is because innovation requires substantial funding.

E. CONCLUSION

This research aims to empirically analyze the influence of FDI on innovation in manufacturing companies in ASEAN. Based on all the tests above, the authors draw three important main findings. First, FDI, proxied by the presence of foreign ownership in manufacturing companies in the five ASEAN member countries, has an insignificant relationship with the decision to conduct R&D. Second, the presence of foreign ownership (FDI) has a negative and significant relationship with the level of R&D intensity. Third, the results from R&D expenditures in these five countries indeed show a positive and significant relationship with the likelihood of innovation for manufacturing companies in ASEAN.

Thus, based on the potential above and the findings of this research, it is evident that ASEAN cannot rely solely on foreign entities to drive innovation. Therefore, the author recommends several policies that need to be implemented at the ASEAN level, national level, and company level. At the ASEAN level, it is advisable for ASEAN

member countries to promptly design the establishment of an ASEAN digital single market. This aims to integrate and enhance digital economic growth in ASEAN. At the national level, it is recommended to implement low tax regulations and a business climate that encourages exports. Lastly, at the company level, it is essential to provide ample training and invest in advanced technology equipment for manufacturing.

Nevertheless, from all the aforementioned findings, there are four limitations in this study. First, this study not deeply analyzing by comparing the performance of foreign ownership (FDI) and domestic companies (non-FDI) towards innovation in manufacturing companies. Therefore, it is expected that the subsequent research can analyze it to observe the magnitude of the influence from FDI.

Second, the innovation outputs utilized in this study employ production innovation data, thus not enabling a comparison of the influence of R&D intensity on various other forms of innovation (process and organizational innovation) within manufacturing companies in ASEAN. It is hoped that future research can analyze the effect of FDI on various forms of innovation.

Third, the data in this research employs a cross-sectional approach, thereby unable to capture changes or patterns in R&D intensity over a longer time span due to the presence of FDI in each manufacturing company. Therefore, it is expected that future research can incorporate observations with a longer time frame.

Lastly, from the findings of this research, which indicate that innovation in ASEAN is not generated from R&D activities, but rather that ASEAN only receives the outcomes of R&D from foreign entities conducted in their home countries. Therefore, the author suggests that future research could directly measure the impact of FDI on innovation activities in ASEAN or can also measure the level of spatial dependence between ASEAN and developed countries. This is to further develop the CDM model in the context of developing countries.

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