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The Role of Foreign Direct Investment on Ecological Footprint of the ASEAN-5 Nations

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Abstract

This study investigates the effect of foreign direct investment (FDI) on ecological footprint in 5 ASEAN countries: Indonesia, Malaysia, the Philippines, Singapore, and Thailand. We implement the autoregressive distributed lag (ARDL) model to acquire the outcomes of short-run and long-run coefficients using annual data during 1980 to 2018. Furthermore, Toda-Yamamoto Granger causality test is employed to assure the robustness of our study. The empirical findings reveal that positive effects of FDI on ecological footprint are detected in Indonesia and Malaysia, while Thailand has negative connection between FDI and the ecological footprint. However, there is no significant impact of FDI on ecological footprint in the Philippines and Singapore. In addition, the results from control variables indicate that GDP per capita shows positive impact on ecological footprint in Indonesia, whereas, it has a negative effect in Malaysia, Singapore and Thailand. The exports have no impact on ecological footprint in all 5 ASEAN countries. Nonetheless, energy consumption exhibit positive association with ecological footprint for all 5 ASEAN members.

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Key Words: Foreign direct investment, Ecological footprint, ASEAN, ARDL model, Causality test

Ⅰ. Introduction

Foreign direct investment (FDI) is an essential factor for the processes of economic development of the developing countries primarily. It contributes to important economic activities. It increases job opportunities and employments in the host country (Tomoharaac et al. 2011). Consequently, it boosts up economic growth and therefore reduces the poverty (Acharyya 2009; Fowowe et al. 2014). Hence, many developing countries put the efforts to attract more FDI. The Southeast Asian countries are no exception. According to ASEAN Investment Report (2021), the ASEAN (Association of Southeast Asian Nations) members became the largest destination of foreign direct investment (FDI) among the developing nations. They received inflows of FDI by 182 billion USD, which occupied 11.90 percent of total inward FDI in the world in 2019.

The FDI generally creates significant impacts in many dimensions in the host countries, not only economic development effect, but also the environmental effects. Currently, the global warming and climate change turn into the main issues among the world societies. The environmental degradations which are caused by the increases in emissions of greenhouse gases (GHGs) are the biggest challenges for the global environmental sustainabilities.

The association between FDI and environmental degradations is inconclusive in both empirical and theoretical viewpoints. While the pollution haven hypothesis illustrates that FDI worsens environmental quality, the pollution halo hypothesis predicts that FDI improves the environment. Most of the previous studies on the connection between FDI and environment use carbon dioxide (CO_2) emissions to represent the environmental pollution, since it has the biggest share in the GHGs and it is easy to obtain the data. However, the CO_2 emissions could be a weak indicator to address environmental degradations in some certain cases such as the stocks of resources, for instance, oil, soil, mining, and forests (Ulucak et al. 2018). This is one of the limitations of the existing researches. Hence, the comprehensive indicator for environmental degradations is needed (Solarin et al. 2018). The ecological footprint is one of a suitable comprehensive indicators as it measures the consumptions of six classifications of resources and generate wastes, including carbon footprint, built-up land, forest, cropland, pasture and fisheries (Global Footprint Network 2022).

Given that the ASEAN is the significant destination of FDI and the association between FDI and environment is an important global issue, this research assesses the effect of FDI on ecological footprint in 5 major ASEAN members: Indonesia, Malaysia, the Philippines, Singapore, and Thailand. Only 5 out of 10 ASEAN countries are employed in our research, due to the data unavailability. While inward FDI data of Vietnam is available from 1990, the data is not available for Brunei, Cambodia, Laos and Myanmar during 1980-2018. Besides, the data of energy consumption is not available for Cambodia, Laos and Myanmar either. The autoregressive distributed lag (ARDL) model is adopted as research methodology using annual data during 1980 to 2018. Furthermore, Toda-Yamamoto Granger causality test is conducted to assure the robustness of our study. The remaining sections are arranged as follows. Section Ⅱ illustrates the current situation of FDI and ecological footprint in the 5 ASEAN countries, while a literature review is described in section Ⅲ. Section Ⅳ explains the theoretical framework and research methodology. Section Ⅴ elaborates the empirical outcomes, and research conclusion and policy recommendation are drawn in section Ⅵ.

Ⅱ. Ecological footprint and foreign direct investment in ASEAN-5 countries

1. Ecological footprint

The ecological footprint is defined as the impact of human activities, which is measured in terms of the biologically productive land to sustain the use of natural resources in order to provide everything that people need from the nature. Generally, it includes not only the production of goods for consumption, but also the absorbtion of the generated wastes. Hence, the ecological footprint tracks the usage of six groups of productive areas including built-up land, cropland, fishing grounds, forest land, grazing land and carbon footprint. The carbon footprint, generally, is measured as the forest land needed to absorb emissions of the carbon dioxide (Global

Footprint Network 2022). The high value of the ecological footprint threatens the sustainability of natural resources and the welfare of human being. Currently, the carbon footprint accounts for 60 percent of the ecological footprint worldwide. The unit of ecological footprint is global hectare (gha). According to the Global Footprint Network (2022), the average per capita ecological footprint of the world is 2.8 gha, whereas the average per capita available biocapacity is just 1.6 gha. Therefore, the related policy makers need to have optimal policies to manage natural resources and environments.

<Table 1> Components of ecological footprint (EF), 1980-2018 (%)

Country	Total EF	Built-up Land	Carbon footprint	Cropland	Fishing Grounds	Forest land	Grazing Land
Indonesia	100	3.85	33.18	29.25	11.23	20.76	1.73
Malaysia	100	1.98	49.56	19.75	10.11	15.27	3.33
Philippines	100	4.14	33.56	29.88	19.01	10.68	2.72
Singapore	100	0.34	76.22	9.32	3.21	7.35	3.57
Thailand	100	2.93	53.73	20.04	9.65	12.57	1.08

Source: Author's compilations from Global Footprint Network (2022).

The statistics in <Table 1> show the components of ecological footprint of ASEAN-5 countries. Carbon footprint is the largest component of the ecological footprint, following by cropland, in all five countries. While the forest land ranks the third position for Indonesia, Malaysia, Singapore, and Thailand, it is fishing grounds for the case of the Philippines.

2. Foreign direct investment and ecological footprint

The statistics of FDI in ASEAN-5 are presented in <Table 2>. Generally, ASEAN is the major destination of FDI. Especially, it accounts for 162.27, 34.20 and 23.10 percent of GDP in Singapore, Malaysia and Thailand during 1980 to 2018 respectively. Not only the share of GDP, the growth rate of FDI is also remarkably high, 14.92 percent for Singapore and 8.94 percent for Malaysia respectively.

<Table 2> FDI and ecological footprint (1980-2018)

	FDI stock (% of GDP)	FDI growth (%)	EF per capita (gha)	EF growth (%)
Indonesia	13.769	10.269	1.355	2.689
Malaysia	34.197	8.942	3.323	3.942
Philippines	11.509	10.977	1.169	2.795
Singapore	162.274	14.916	5.860	3.637
Thailand	23.095	14.346	1.806	3.177

Note: EF = Ecological footprint; gha = Global hectare.
Source: Author's compilations from UNCTAD (2022) and Global Footprint Network (2022).

Moreover, the ecological footprint per capita is significantly high, especially, in Malaysia (3.32 gha) and Singapore (5.86 gha). These numbers are much higher than the world's average ecological footprint per capita (2.70 gha) in 2019 (Global Footprint Network, 2022). Although the ecological footprint per capita of Indonesia (1.36 gha), the Philippines (1.17 gha) and Thailand (1.81 gha) is lower than the world by average, it is increasing over time. The growth rate of the ecological footprint of Indonesia, the Philippines and Thailand is 2.69, 2.80 and 3.18 percent during 1980 to 2018 respectively.

Ⅲ. Literature review

1. General literature review

This section reviews the effect of FDI as well as the three important control variables (GDP per capita, exports, energy consumption) on ecological footprint.

First, FDI and ecological footprint: the effect of FDI on ecological footprint is generally explained based on two competing theories, the pollution haven hypothesis versus the pollution halo hypothesis. The pollution haven hypothesis (Chowdhury et al. 2020) advocates that the developing countries ease their environmental policies to induce the multinational firms to invest in industrial and manufacturing sectors in their countries. This creates environmental pollution. Therefore, FDI stimulates ecological footprint in the host countries. The findings of existing works support the prediction of the pollution haven hypothesis, including the case of the South Asian countries (Sabir et al. 2019), OPEC countries (Fakher 2019), Turkey (Udemba 2020b) and Malaysia (Mehraaein et al. 2021). On the contrary, the pollution halo hypothesis (Usman et al. 2021) argues that FDI mitigates the degradation of environment. This is because the multinational companies in developed countries transfer their green technology through FDI to the host countries. Consequently, FDI reduces ecological footprint in the host countries. This argument is supported by the empirical findings in the United States (Zafar et al. 2019), the coastal Mediterranean countries (Nathaniel et al. 2020), China (Khan et al. 2020) and Uruguay (Ergun et al. 2020).

Second, GDP per capita and ecological footprint: studies on GDP per capita and ecological footprint are explained as the followings. The economic activities are generally driven by economic growth. These raise the demand for natural resources, and therefore result in higher pollution of the environment. The empirical works which support this concept include the cases of the certain Belt and Road Initiative countries (Liu et al. 2018; Baloch et al. 2019) and 117 selected countries from developing and developed countries (Doytch 2020). However, increase in GDP per capita represents higher level of national income. This increases demand for higher environment quality. Consequently, the pollution-free technology is developed and it will reduce the ecological footprint. The empirical works which support this hypothesis are found in Turkey (Udemba 2020b) and South Asia (Murshed et al. 2022).

Third, exports and ecological footprint: generally, the environmental policies are lax in developing countries. This makes the export-oriented goods of the host countries are mainly inefficient-productivity and energy-intensive polluted products (Rafique et al. 2022). This hypothesis is supported by Chen and Chang (2016) which studied the case of selected 99 middle-income and high-income countries. Therefore, the exports encourage the growth of ecological footprint. Conversely, export-oriented commodities from the host countries can also be energy-efficient products with green technologies. Accordingly, exports lower ecological footprint. These evidences were found in Mexico, Indonesia, Nigeria, and Turkey (Dogan et al. 2019) and the G7 countries (Ahmed et al. 2020).

Fourth, energy consumption and ecological footprint: given the cheap price of fossil fuels, the world's majority of energy consumption usually comes from fossil fuels. This generally increases the pollutions (Solarin et al. 2018). The empirical findings in Uruguay (Ergun et al. 2020), India (Udemba 2020a) and the United Arab Emirates (Udemba 2021a) all support this argument.

Besides, it is worth mentioning that Merican et al. (2007) studied the impact of FDI on pollution in ASEAN countries. The pollution in their work is measured through carbon dioxide emission. Our work is different from them in that we measure the effect of FDI on ecological footprint, which is more comprehensive, because the ecological footprint not only includes carbon footprint, but also built-up land, forest land, cropland, and pasture and fisheries.

With regard to Williams et al. (2022), they study the determinant of FDI using nonlinear autoregressive distributed lag (NARDL) method. In their work, bio capacity is treated as determinant of FDI. In contrast, we treat FDI as a determinant of ecological footprint, using linear autoregressive distributed lag (ARDL) technique.

2. Literature review on the ASEAN-5

Certain works investigated the issues of ecological footprint in the

ASEAN countries. While Zeraibi et al. (2021) examined the effects of technological innovation as well as economic growth on ecological footprint in the ASEAN-5 countries, Ahmed et al. (2019) investigated the consequence of globalization on ecological footprint in Malaysia. In addition, Nathaniel (2020) assessed the effect of urbanization and economic growth in Indonesia and Khoi et al. (2021) focused on the role of tourism development on ecological footprint in Singapore. While Hussain et al. (2021) tested the impact of globalization on ecological footprint in Thailand, Muoneke et al. (2022) investigated the impacts of agriculture and globalization in the Philippines. None of these works scrutinizes the effect of FDI on ecological footprint. The only research which observed the impact of FDI was Mehraaein et al. (2021), which employed the ARDL model using the annual data between 1971 and 2014. Their empirical results suggested the positive effect of FDI on ecological footprint in Malaysia.

The above literature review reveals that the effect of FDI on ecological footprint is inconclusive. Moreover, the research for the ASEAN countries is insufficient, only one existing is found (Mehraaein et al. 2021) which focused on Malaysia. To fill this research gap, our research examines the effect of FDI on ecological footprint in the ASEAN countries. However, due to the data unavailability, only 5 ASEAN member states are included in our research: Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The ARDL model is applied in our study using the data from 1980 to 2018. Furthermore, the Toda-Yamamoto Granger causality test is also performed in our work to observe the causal relations among studied variables, which was not conducted in

Mehraaein et al. 2021).

Ⅳ. Research methodology

1. Model specification

The IPAT model stipulates that the environmental impacts (I) are associated with P (population), A (affluence), and T (technology). It was primarily proposed by Ehrlich et al. (1971). Subsequently, a deterministic version is reformulated into a stochastic framework to explore the stochastic impacts (STRIPAT) model (Dietz et al. 1994; York et al. 2003). A standard form of STRIPAT model is specified as follows.

$$I_t = aP_t^b A_t^c T_t^d e_t \tag{1}$$

where I measures the degradation of environment, P stands for population, A represents the affluence, and T is technology. The b, c and d are the estimating parameters and e is an error term.

Accordingly, the STRIPAT model is adopted as a research framework in our study. The environmental degradation (I) is proxied by ecological footprint. Following Xiao et al. (2020), the population (P) is proxied by energy consumption in our research, as the increase in population raises the demand for consumption of energy. The energy sectors including oil, gas and coal are still relatively cheap and available to all people. Hence, the energy consumption induces the environmental degradation in general (Ergun et al. 2020).

The affluence (A) is represented by GDP per capita. Generally, increase in GDP per capita stimulates economic activities, subsequently, raises the demand for natural resources utilizations, which induces environmental pollutions (Doytch 2020).

Technology (T) can be determined by various factors, upon the studied contexts (Bello et al. 2018). By following Solarin et al. (2018) and Solarin et al. (2021), technology is a function of FDI and exports in our work.

The effect of FDI on ecological footprint is uncertain. It can have either positive or negative effect on ecological footprint, according to the argument from the pollution haven hypothesis (Chowdhury et al. 2020) and the pollution halo hypothesis (Zafar et al. 2019) respectively.

Based on the above literature review, the effect of export on ecological footprint is also inconclusive. It depends on the characteristics of export-oriented goods, whether they are inefficient-productivity and energy-intensive polluted products (Rafique et al. 2022) or energy-efficient products with green technologies (Dogan et al. 2019; Ahmed et al. 2020).

On the basis of STRIPAT model, equation (1) can be rewritten as equation (2) below.

$$EF = f\ (FDI,\ GDP,\ \mathrm{EXP}ORT,\ ENC) \tag{2}$$

The logarithmic form of (2) is presented as equation (3)

$$\ln EF_t = \beta_0 + \beta_1 \ln FDI_t + \beta_2 \ln GDP_t + \beta_3 \ln EXPORT_t + \beta_4 \ln ENC_t + \epsilon_t \tag{3}$$

while the ln expresses natural logarithm, the variable EF, FDI, GDP, EXPORT, and ENC are ecological footprint, foreign direct investment, GDP per capita and energy consumption, respectively. The ε is disturbance term. For simplicity, let the lowercase represents the logarithmic form (ef_t = $\ln EF_t$). Accordingly, equation (4) is obtained as follow.

$$ef_t = \beta_0 + \beta_1 fdi_t + \beta_2 gdp_t + \beta_3 \text{exp}ort_t + \beta_4 enc_t + \epsilon_t \tag{4}$$

According to the above theoretical discussion, the expected signs of β_1 and β_3 are uncertain, while the signs of β_2 and β_4 are expected to be positive.

2. Empirical model

The autoregressive distributed lag (ARDL) model (Pesaran et al. 2001) is adopted to implement the empirical works in our study. Accordingly, the equation (4) will be transformed as the followings.

(1) The autoregressive distributed lag (ARDL) model

The ARDL model generally possesses four main advantages. First, a small number of observations can give reliable estimation results using the ARDL model (Toda 1994). Second, The coefficients of short-run and long-run can be produced with this technique. Third, the bounds test of this approach can check cointegration properties and perform empirical estimation simultaneously. Fourth, it is appliable regardless the order of integration, I(d), of studied variables. It can be either I(0) variable or I(1) variable, or combination of them. Hence, the ARDL model is an appropriate technique for our study, as the numbers of samples are limited (1980 to 2018), as well as our studied variables are combinations of I(0) and I(1) variables (according to the unit root test in <Table 2>). Consequently, the error correction form (ECM) for the ARDL model can be described as belows.

$$\Delta ef_t = \alpha + \sum_{i=1}^{a}\beta_i \Delta ef_{t-1} + \sum_{i=1}^{b}\gamma_i \Delta fdi_{t-1} + \sum_{i=1}^{c}\delta_i \Delta gdp_{t-1} + \sum_{i=1}^{d}\eta_t \Delta \mathrm{export}_{t-1} + \sum_{i=1}^{e}\zeta_i \Delta enc_{t-1} + \lambda ef_{t-1} + \theta fdi_{t-1} + \mu gdp_{t-1} + \pi \mathrm{export}_{t-1} + \psi enc_{t-1} + \epsilon_{t-1} \quad (5)$$

where $\lambda, \theta, \mu, \pi$ and ψ are the long-run parameters. The Δ is the first difference term. In addition, the parameter a, b, c, d and e are optimal lag lengths. They are specified based on the Akaike information criterion (AIC). In order to check the existence of long-term relationships among the studied variables, the equation (5) is used. To apply the bounds test to examinate the cointergration properties, the null hypothesis (H0: $\lambda = \theta = \mu = \pi = \psi = 0$) illustrates the non-existence of the cointegration, whereas an alternative hypothesis (H1: $\lambda \neq 0$, or $\theta \neq 0$, or $\mu \neq 0$, or $\pi \neq 0$, or $\psi \neq 0$) demonstrates the existence of cointegration properties.

(2) Long-run and short-run coefficients

Equation (5) can provide the long-run coefficients by assigning the first differences, which imply short term, to be zero ($\Delta ef = \Delta fdi = \Delta gdp = \Delta \mathrm{export} = \Delta enc = 0$). Accordingly, the long-run coefficients can be acquired from equation (6).

$$ref_{t-1} = \Omega_0 + \Omega_1 fdi_{t-1} + \Omega_2 gdp_{t-1} + \Omega_3 \mathrm{export}_{t-1} + \Omega_4 enc_{t-1} + \nu_t \tag{6}$$

where $\Omega_0 = -\alpha/\lambda$, $\Omega_1 =-\theta/\lambda$, $\Omega_2 =-\mu/\lambda$, $\Omega_3 =-\pi/\lambda$, $\Omega_4 =-\psi/\lambda$ and ν_t is an error term. Equation (6) is presented with error correction form (ECM) as (7).

$$\Delta ef_t = \alpha + \sum_{i=1}^{a} \beta_i \Delta ef_{t-1} + \sum_{i=1}^{b} \gamma_i \Delta fdi_{t-1} + \sum_{i=1}^{c} \delta_i \Delta gdp_{t-1} + \sum_{i=1}^{d} \eta_t \Delta \mathrm{export}_{t-1} + \sum_{i=1}^{e} \zeta_i \Delta enc_{t-1} + \phi ECM_{t-1} + \epsilon_t \tag{7}$$

where the ECM_{t-1} is an error correction term. The β_i, γ_i, δ_i, η_i, ζ_i are the short-term coefficients and ϕ is the speed of adjustment, returning toward long-run equilibrium. As a result, the negative value of ϕ is necessary.

(3) Toda-Yamamoto Granger causality test

The Toda-Yamamoto approach (Toda et al. 1995) for Granger causality tests are performed to check the robustness of our work, as presented in equation (8) to (12) below.

$$\begin{aligned} ef_t = \alpha_0 + \sum_{i=1}^{k}\alpha_{1i}ef_{t-i} + \sum_{j=k+1}^{dmax}\alpha_{2j}ef_{t-j} + \sum_{i=1}^{k}\beta_{1i}fdi_{t-i} + \sum_{j=k+1}^{dmax}\beta_{2j}fdi_{t-j} \\ + \sum_{i=1}^{k}\gamma_{1i}gdp_{t-i} + \sum_{j=k+1}^{dmax}\gamma_{2j}gdp_{t-j} + \sum_{i=1}^{k}\delta_{1i}\mathrm{export}_{t-i} + \sum_{j=k+1}^{dmax}\delta_{2j}\mathrm{export}_{t-j} \\ + \sum_{i=1}^{k}o_{1i}enc_{t-i} + \sum_{j=k+1}^{dmax}o_{2j}enc_{t-j} + u_{1t} \end{aligned} \tag{8}$$

$$\begin{aligned} fdi_t = \theta_0 + \sum_{i=1}^{k}\theta_{1i}fdi_{t-i} + \sum_{j=k+1}^{dmax}\theta_{2j}fdi_{t-j} + \sum_{i=1}^{k}\iota_{1i}ef_{t-i} + \sum_{j=k+1}^{dmax}\iota_{2j}ef_{t-j} \\ + \sum_{i=1}^{k}\kappa_{1i}gdp_{t-i} + \sum_{j=k+1}^{dmax}\kappa_{2j}gdp_{t-j} + \sum_{i=1}^{k}\lambda_{1i}\mathrm{export}_{t-i} + \sum_{j=k+1}^{dmax}\lambda_{2j}\mathrm{export}_{t-j} \\ + \sum_{i=1}^{k}\mu_{1i}enc_{t-i} + \sum_{j=k+1}^{dmax}\mu_{2j}enc_{t-j} + u_{2t} \end{aligned} \tag{9}$$

$$\begin{aligned} gdp_t = \pi_0 + \sum_{i=1}^{k}\pi_{i1}gdp_{t-i} + \sum_{j=k+1}^{dmax}\pi_{2j}gdp_{t-j} + \sum_{i=1}^{k}\rho_{1i}ef_{t-i} + \sum_{j=k+1}^{dmax}\rho_{2j}ef_{t-j} \\ + \sum_{i=1}^{k}\sigma_{1i}fdi_{t-i} + \sum_{j=k+1}^{dmax}\sigma_{2j}fdi_{t-j} + \sum_{i=1}^{k}\tau_{1i}\mathrm{export}_{t-i} + \sum_{j=k+1}^{dmax}\tau_{2j}\mathrm{export}_{t-j} \\ + \sum_{i=1}^{k}\nu_{1i}enc_{t-i} + \sum_{j=k+1}^{dmax}\nu_{2j}enc_{t-j} + u_{3t} \end{aligned} \tag{10}$$

$$\begin{aligned} \mathrm{export}_t = \varphi_0 + \sum_{i=1}^{k}\varphi_{1i}\mathrm{export}_{t-i} + \sum_{j=k+1}^{dmax}\varphi_{2j}\mathrm{export}_{t-j} + \sum_{i=1}^{k}\omega_{1i}ef_{t-i} + \sum_{j=k+1}^{dmax}\omega_{2j}ef_{t-j} \\ + \sum_{i=1}^{k}\vartheta_{1i}fdi_{t-i} + \sum_{j=k+1}^{dmax}\vartheta_{2j}fdi_{t-j} + \sum_{i=1}^{k}\varpi_{1i}gdp_{t-i} + \sum_{j=k+1}^{dmax}\varpi_{2j}gdp_{t-j} \\ + \sum_{i=1}^{k}\Gamma_{1i}enc_{t-i} + \sum_{j=k+1}^{dmax}\Gamma_{2j}enc_{t-j} + u_{4t} \end{aligned} \tag{11}$$

$$
\begin{aligned}
enc_t = \Theta_0 + \sum_{i=1}^{k}\Theta_{1i} enc_{t-i} + \sum_{j=k+1}^{dmax}\Theta_{2j} enc_{t-j} + \sum_{i=1}^{k} H_{1i} ef_{t-i} + \sum_{j=k+1}^{dmax} H_{2j} ef_{t-j} \\
+ \sum_{i=1}^{k} I_{1i} fdi_{t-i} + \sum_{j=k+1}^{dmax} I_{2j} fdi_{t-1} + \sum_{i=1}^{k} K_{1i} gdp_{t-i} + \sum_{j=k+1}^{dmax} K_{2j} gdp_{t-j} \\
+ \sum_{i=1}^{k} \Lambda_{1i} \mathrm{export}_{t-i} + \sum_{j=k+1}^{dmax} \Lambda_{2j} \mathrm{export}_{t-j} + u_{5t}
\end{aligned} \tag{12}
$$

As per equation (8), the Granger causalities from fdi_t, gdp_t, export_t and enc_t to ef_t imply that $\beta_{1i} \neq 0$ or $\gamma_{1i} \neq 0$ or $\delta_{1i} \neq 0$ or $o_{1i} \neq 0$, respectively. The same concept is applied to equation (9) to (12).

3. Data and source

We utilize the annual time series data with periods of 1980-2018 for 5 ASEAN nations: Indonesia, Malaysia, the Philippines, Singapore, and Thailand, due to the data unavailability. The ecological footprint (ef, global hectares) is per capita ecological footprint. It is obtained from the Global Footprint Network. The foreign direct investment, fdi, is stock of FDI, as percent of GDP. The FDI data (million USD) comes from the United Nations Conference on Trade and Development (UNCTAD). The data of GDP (million USD) is from the World Development Indicators (WDI). The GDP per capita (gdp, USD) is obtained from the World Development Indicators, WDI). For export, export, it is in percent of GDP. It is also extracted from the World Development Indicators (WDI). The energy consumption (enc) is per capita energy consumption

(Gigajoule). It comes from the bp Statistical Review of World Energy.

V. Empirical results

1. Descriptive data

The following <Table 3> describes the data using in our work. The mean value indicates that the ecological footprint is quite high in Malaysia. The data of FDI is significantly high for Singapore. Generally, the values of kurtosis are approximately 2 and lower, indicating the normal distribution of data (George 2011). The skewness lies between -3 to +3, which is value (Brown 2006). In addition, the p-value of the Jarque-Bera, generally greater than 0.05, indicating that the data are consistent with having skewness and excess kurtosis zero, implying a normal distribution of studied variables.

<Table 3> Descriptive data

	Indonesia					Malaysia				
Statistics	ef	fdi	gdp	export	enc	ef	fdi	gdp	export	enc
Mean	0.295	2.497	7.026	3.204	5.251	1.173	2.336	8.377	4.278	4.362
Median	0.291	2.343	6.816	3.186	6.313	1.276	2.377	8.335	4.257	4.464
Maximum	0.569	3.277	8.267	3.966	6.461	1.490	2.950	9.339	4.672	4.922
Minimum	0.087	1.696	6.092	2.742	1.987	0.676	1.637	7.455	3.804	3.504
Stand. Dev.	0.136	0.532	0.764	0.242	1.832	0.245	0.452	0.638	0.250	0.474
Skewness	0.268	0.150	0.484	0.733	-1.113	-0.747	-0.305	0.113	-0.274	-0.448
Kurtosis	2.027	1.549	1.742	4.311	2.257	2.149	1.664	1.686	2.150	1.774
Jarque-Bera	2.003	3.566	4.098	6.285	8.945	4.804	3.508	2.888	1.661	3.745
Probability	0.367	0.168	1.742	0.043	0.011	0.091	0.173	0.236	0.436	0.154
Observations	39	39	39	39	39	39	39	39	39	39

	Philippines					Singapore				
Statistics	ef	fdi	gdp	export	enc	ef	fdi	gdp	export	enc
Mean	0.153	2.334	6.909	3.090	2.516	1.737	4.848	9.960	4.468	5.923
Median	0.162	2.520	6.908	2.994	2.560	1.839	4.746	10.075	4.505	5.981
Maximum	0.384	3.180	7.692	3.818	2.909	2.106	6.057	11.108	5.186	6.444
Minimum	-0.009	1.246	6.284	2.466	2.168	1.249	3.806	8.503	3.927	5.115
Stand. Dev.	0.087	0.487	0.376	0.402	0.181	0.261	0.710	0.723	0.301	0.410
Skewness	0.211	-0.274	0.328	0.518	0.008	-0.728	0.171	-0.334	0.202	-0.622
Kurtosis	2.850	2.310	2.408	1.990	2.691	2.092	1.588	1.197	2.767	2.163
Jarque-Bera	0.325	1.261	1.271	3.403	0.156	4.780	3.432	2.629	0.354	3.652
Probability	0.850	0.532	0.530	0.182	0.925	0.092	0.180	0.269	0.838	0.161
Observations	39	39	39	39	39	39	39	39	39	39

	Thailand				
Statistics	ef	fdi	gdp	export	enc
Mean	0.545	1.532	9.014	3.629	3.581
Median	0.682	1.813	9.061	3.870	3.738
Maximum	0.946	2.950	9.754	4.111	4.377
Minimum	0.133	-0.526	8.162	2.767	2.402
Stand. Dev.	0.320	1.113	0.514	0.437	0.662
Skewness	-0.765	-0.389	-0.175	-0.523	-0.566
Kurtosis	2.153	1.855	1.803	1.760	1.927
Jarque-Bera	4.968	3.113	2.527	4.276	3.953
Probability	0.083	0.211	0.283	0.118	0.139
Observations	39	39	39	39	39

2. The unit root test

We employ the augmented Dickey-Fuller (ADF) tests with intercept and trend to check for the degree of cointegration of variables. The test results are in <Table 4> below.

<Table 4> The unit root test results

	Indonesia					Malaysia				
Vari.	Level form		1st diff. form		Coin.	Level form		1st diff. form		Coin.
	t-stat	Prob.	t-stat	Prob.		t-stat	Prob.	t-stat	Prob.	
ef	-13.626	0.000			I(0)	-2.325	0.411	-7.879	0.000	I(1)
fdi	-3.432	0.063			I(0)	-1.912	0.629	-5.584	0.000	I(1)
gdp	-2.152	0.502	-6.088	0.000	I(1)	-2.392	0.378	-5.173	0.001	I(1)

export	-1.713	0.726	-5.255	0.001	I(1)	-0.578	0.975	-5.257	0.001	I(1)
enc	-3.028	0.142	-6.092	0.000	I(1)	0.100	0.996	-3.606	0.044	I(1)
Philippines						Singapore				
Vari.	Level form		1st diff. form		Coin.	Level form		1st diff. form		Coin.
	t-stat	Prob.	t-stat	Prob.		t-stati	Prob.	t-stat	Prob.	
ef	-2.636	0.268	-5.293	0.001	I(1)	-1.365	0.855	-5.527	0.000	I(1)
fdi	-5.293	0.001			I(0)	-2.545	0.306	-7.896	0.000	I(1)
gdp	-1.558	0.791	-4.782	0.002	I(1)	-2.254	0.447	-3.868	0.024	I(1)
export	-0.624	0.972	-4.950	0.002	I(1)	-1.591	0.778	-4.945	0.002	I(1)
enc	-1.564	0.789	-4.666	0.003	I(1)	-1.443	0.832	-4.355	0.007	I(1)
Thailand										
Vari.	Level form		1st diff. form		Coin.					
	t-stat	Prob.	t-stat	Prob.						
ef	-1.461	0.825	-6.586	0.000	I(1)					
fdi	-1.926	0.621	-6.728	0.000	I(1)					
gdp	-2.755	0.222	-3.348	0.074	I(1)					
export	-0.564	0.976	-5.784	0.000	I(1)					
enc	0.011	0.995	-4.330	0.008	I(1)					

Note: Vari. = Variable; Coin.= Cointegration order; 1st diff. = First difference

The results in <Table 4> indicate that all studied variables are I(0) and I(I) variables. Since I(2) variable does not exist in our estimations. Therefore, the ARDL model is applicable for our research.

3. Cointegration test

To test the long-run relationships of the studied variables, the bounds test is performed. The null hypothesis is H0: $\lambda = \theta = \mu = \pi = \psi = 0$, while an alternative hypothesis is H1: $\lambda \neq 0$, or $\theta \neq 0$, or $\mu \neq 0$, or $\pi \neq 0$, or $\psi \neq 0$. There are two critical values (lower and upper critical values) for the bounds test. The null hypothesis is rejected when the calculated F-statistic is bigger than upper critical value. This suggests the presence of cointegration among the studied variables. Nonetheless, when the calculated F-statistic is less than lower critical value, cointegration does not exist. For the purpose of conducting the bounds test and implementing the ARDL model, the lag length is defined. Because of small samples, we follow Baek (2013) and Bahmani-Oskooee et al. (2017) in that the maximum lag is set at 4, then the Akaike's information criterion applied to obtain the optimum lag length. The outcomes of the bounds tests are reported in <Table 5>.

<Table 5> The bounds test results

Indonesia				Malaysia		
Calculated F-stat	10.96			5.49		
Critical F-stat	Lower bound	Upper bound	Significance level	Lower bound	Upper bound	Significance level
	2.20	3.09	10%	1.90	3.01	10%
	2.56	3.49	5%	2.26	3.48	5%
	3.29	4.37	1%	3.07	4.44	1%
Philippines				Singapore		
Calculated F-stat	5.23			7.35		
Critical F-stat	Lower bound	Upper bound	Significance level	Lower bound	Upper bound	Significance level
	2.20	3.09	10%	2.20	3.09	10%
	2.56	3.49	5%	2.56	3.49	5%
	3.29	4.37	1%	3.29	4.37	1%
Thailand						
Calculated F-stat	6.94					
Critical F-stat	Lower bound	Upper bound	Significance level			
	1.90	3.01	10%			
	2.26	3.48	5%			
	3.07	4.44	1%			

According to <Table 5>, the calculated F-statistic of Indonesia, Malaysia, the Philippines, Singapore, and Thailand is 10.96, 5.49, 5.23, 7.35 and 6.94, respectively. They are all significant at 1 percent significance level. These indicate that there are long-run relationships among studied variables in all 5 ASEAN nations.

4. Long-run and short-run coefficients

<Table 6> shows the outcomes from long-run estimations. For FDI, it indicates that 1 percent rise in FDI induces the ecological footprint by 0.06 percent in Indonesia and 0.34 percent in Malaysia. The result of Malaysia is consistent with the finding of Mehraaein et al. (2021) in that FDI raises ecological footprint by 0.06 percent. For Malaysia, the coefficient of our study (0.34) shows the positive sign as the finding from Mehraaein et al. (2021). However, the value of coefficient is 0.07 in the study of Mehraaein et al. (2021). The difference in coefficient's size can come from the different studied period. While Mehraaein et al. (2021) used the data during 1971 to 2014, our data is between 1980 and 2018.

Our findings for the case of Indonesia and Malaysia support the pollution haven hypothesis. The multinational companies go to manufacturing and industrial sectors in he host countries and create environmental pollutions. The positive effects of FDI on ecological footprint are also discovered by Xu et al. (2022). They claimed that FDI increases by 1 percent will raise ecological footprint by 0.01 percent in China, during 1990 to 2017. The similar findings are also reported by Chowdhury et al. (2020) and Xue et al. (2021) for the case of 92 selected countries and the South Asian economies, respectively.

In contrary, the negative consequence of FDI on ecological footprint is found for Thailand. One percent rise in FDI lowers ecological footprint by 0.09 percent. This finding is consistent with the prediction of pollution halo hypothesis. The multinational enterprises transfer their green technology to the host country which helps to prevent environmental degradation. The similar results, which support the argument of the pollution halo hypothesis, are found in the United States during the period of 1970-2015 (Zafar et al. 2019), the coastal Mediterranean countries (Nathaniel et al. 2020) and the 93 selected countries (Usman et al. 2021), respectively.

The FDI shows insignificant impact on ecological footprint in the Philippines and Singapore. The low value of FDI explains the its insignificant effect for the Philippines. The statistics in <Table 2> indicate that FDI, as percent of GDP, shows the lowest number (11.51 percent), compared to the other 4 ASEAN countries. As per Singapore, most of FDI is mainly channelled to financial and service sectors (Udemba 2021a) relative to energy-intensive polluted manufacturing sectors. As a result, there is a small change for FDI to induce the ecological footprint. The insignificant impact of FDI on ecological footprint are also found by Solarin et al. (2018) in the 20 selected developed and developing countries during 1982 to 2013 and Bulut (2020) in the case of Turkey for the period 1970 to 2016.

<Table 6> Long-run estimates

	Indonesia	Malaysia	Philippines	Singapore	Thailand
fdi	0.061*** (3.266)	0.338* (1.979)	-0.040 (-0.908)	-0.223 (-0.763)	-0.094* (-1.791)
gdp	0.121*** (8.247)	-0.201* (-1.948)	-0.281 (-1.694)	-0.763*** (-3.084)	-0.235*** (-5.975)
export	0.022 (0.585)	-0.573 (-1.648)	0.007 (0.129)	0.222 (0.601)	-0.090 (-1.144)
enc	0.013** (2.695)	0.959** (2.265)	0.942** (2.652)	2.189*** (5.316)	0.860*** (7.241)

Note: t-statistics are presented in parentheses.
The significance level is expressed as *** (1 %), ** (5 %), * (10 %).

With regard to the effect of the other control variables on ecological footprint, the results are present as the followings. For the GDP per capita, a 1 percent rise in GDP per capita increases ecological footprint by 0.12 percent in Indonesia. This finding suggests that economic growth stimulates economic activities, which results in higher demand for utilization of natural resources. This leads to environmental degradation (Doytch 2020). Our finding is in line with Liu et al. (2018) and Baloch et al. (2019) which found the positive association between GDP per capita and ecological footprint in 44 studied countries and the 59 Belt and Road Initiative countries, respectively.

Nevertheless, the negative effects of GDP per capita on ecological footprint are also discovered. One percent increase in GDP per capita diminishes ecological footprint by 0.28, 0.76 and 0.23 percent in Malaysia, Singapore and Thailand respectively. The GDP per capita has no impact on ecological footprint in the Philippines. This is because the improvement in income raises the demand for higher quality of environment which leads to the green technical advancements, and therefore reduces and prevents the degradation of environment (Khan et al. 2020). Our findings are consistent with Udemba (2021b) and Solarin et al. (2021) which discovered the negative linkage between GDP per capita and ecological footprint in Pakistan and Nigeria respectively.

As per the role of energy consumption, it exhibits the positive effect on ecological footprint in all 5 ASEAN countries. One percent increase in energy consumption stimulates ecological footprint by 0.01, 0.96, 0.94, 2.19 and 0.86 percent in Indonesia, Malaysia, the Philippines, Singapore and Thailand, respectively. The findings imply that most of the consumption of energy comes from fossil fuels, which contribute to the pollution of environment significantly (Destek et al. 2019; Ergun et al. 2020). Our outcomes are similar to the results of Majeed et al. (2019) and Khan et al. (2019) in the case of 131 selected countries (1971-2017) and the Belt and Road Initiatives countries (1990-2016) respectively.

Regarding the role of exports, our findings exhibit that exports play no role on ecological footprint in all 5 ASEAN countries. This is because the exports are mixed between energy-intensive polluted products and energy-efficient products with green technologies.

<Table 7> Short-run estimates

	Indonesia	Malaysia	Philippines	Singapore	Thailand
$\triangle ef_{t-1}$		-0.438*** (-3.108)	0.506*** (3.656)	0.135 (1.156)	
$\triangle ef_{t-2}$			0.524*** (4.313)	-0.155 (-1.472)	

$\triangle ef_{t-3}$			0.329** (2.606)		
$\triangle fdi$	-0.026 (-1.676)	0.023 (0.305)		0.060 (0.577)	-0.063 (-1.404)
$\triangle fdi_{t-1}$		-0.112 (-1.551)		0.629*** (5.079)	
$\triangle fdi_{t-2}$				0.646*** (4.127)	
$\triangle gdp$		0.439*** (5.446)	0.114 (1.177)	0.759*** (4.230)	0.416* (2.042)
$\triangle gdp_{t-1}$		0.335** (2.752)		0.526** (2.818)	
$\triangle gdp_{t-2}$				1.587*** (5.896)	
$\triangle \text{export}$	0.098*** (3.853)	0.343** (2.396)	-0.149*** (-3.242)	0.040 (0.479)	-0.353*** (-3.554)
$\triangle \text{export}_{t-1}$	-0.023 (-0.965)	0.288** (2.120)	-0.092* (-1.820)	-0.250** (-3.013)	0.073 (0.839)
$\triangle \text{export}_{t-2}$	-0.068*** (-2.863)	0.332** (2.552)		-0.441*** (-5.545)	0.096 (1.189)
$\triangle \text{export}_{t-3}$				-0.163** (-2.309)	
$\triangle enc$		0.912*** (4,317)	0.379** (2.649)	0.763*** (4.533)	0.347 (1.575)
$\triangle enc_{t-1}$		0.343 (1.670)	-0.201 (-1.649)	-1.926*** (-6.741)	0.686*** (3.161)
$\triangle enc_{t-2}$		0.851*** (4.650)		-1.591*** (-4.844)	
$\triangle enc_{t-3}$				-1.335*** (-4.988)	
$\triangle ECM_{t-1}$	-0.605*** (-8.855)	-0.315*** (-5.740)	-0.982*** (-6.234)	-0.803*** (-7.819)	-0.773*** (-6.365)

Note: t-statistics are presented in parentheses.
The significance level is expressed as *** (1 %), ** (5 %), * (10 %).

The empirical outcomes of short-run coefficients are illustrated in <Table 7>. Generally, despite the values between short-run coefficients and long-run coefficients are not exactly the same, the results of short-run are consistent with long-run outcomes. the coefficients of the ECM are all negative and less than one at 1 percent level of significance. These indicate that the short-run deviations move back toward the long-run equilibrium in all 5 ASEAN countries.

5. The Toda-Yamamoto Granger causality test

The modified Wald test (MWALD) was employed for the test of causality by Toda et al. (1995). According to Wolde-Rufael (2004), Zapata et al. (1997) and Ghosh et al. (2014), the MWALD can be applied regardless of the degree of cointegration of the studied variables. Therefore, it minimizes the risk happening from misidentifying the order of the series integration (Mavrotas et al. 2001). Therefore, this method is fit with our dataset. This approach applies vector autoregressive model, VAR (k). We use the Akaike information criterion to pick the optimal VAR lag length (k). Hence, k, which is the order of the VAR system, is added by the maximum order of integration (d_{max}). Accordingly, the system of VAR ($k+d_{max}$) is estimated. The chi-square (λ^2) is used as the test statistics. The outcomes of Toda-Yamamoto Granger causality test, based on equation (8) to (12), are presented in <Table 8>.

<Table 8> Toda-Yamamoto Granger causality test

Variable	Indonesia	Malaysia	Philippines	Singapore	Thailand
	Wald Stat.	Wald Stat.	Wald Stat.	Wald Stat.	Wald Stat.
fdi → ef	16.468***U (0.006)	3.542*B (0.60)	1.927 (0.749)	5.506 (0.138)	6.349*B (0.096)
gdp → ef	13.889**U (0.016)	0.000 (0.986)	8.294*B (0.081)	14.571***U (0.002)	3.592 (0.309)
export → ef	11.575**U (0.041)	1.540 (0.215)	9.242*U (0.055)	5.922 (0.116)	10.925**U (0.012)
enc → ef	15.054**U (0.010)	0.639 (0.424)	11.032**B (0.026)	6.267*B (0.099)	19.114***U (0.000)
ef → fdi	2.432 (0.787)	7.093***B (0.008)	2.509 (0.643)	5.660 (0.129)	8.236**B (0.041)
gdp → fdi	2.206 (0.820)	0.388 (0.533)	14.055***U (0.007)	7.543*B (0.057)	10.329**B (0.016)
export → fdi	5.805 (0.326)	0.400 (0.527)	6.609 (0.158)	0.472 (0.925)	6.954*B (0.073)
enc → fdi	2.053 (0.842)	0.331 (0.565)	5.484 (0.241)	4.641 (0.200)	4.263 (0.234)
ef → gdp	6.209 (0.286)	0.000 (0.989)	16.482***B (0.002)	1.649 (0.648)	9.988**U (0.019)
fdi → gdp	5.575 (0.350)	0.055 (0.815)	7.079 (0.132)	7.701*B (0.053)	40.135***B (0.000)
export → gdp	5.204 (0.392)	0.257 (0.612)	10.655**U (0.031)	3.513 (0.319)	13.924***U (0.003)
enc → gdp	2.405 (0.791)	1.086 (0.297)	12.886**B (0.012)	6.520*B (0.089)	2.167 (0.538)
ef → export	1.491 (0.914)	0.094 (0.760)	1.211 (0.876)	1.868 (0.600)	3.359 (0.340)
fdi → export	2.739 (0.740)	0.011 (0.916)	3.402 (0.493)	9.891**U (0.020)	6.999*B (0.072)
gdp → export	2.979 (0.703)	4.528**U (0.033)	2.299 (0.681)	8.773**U (0.033)	1.865 (0.601)
enc → export	3.191 (0.671)	1.482 (0.223)	2.199 (0.699)	11.481***B (0.009)	1.866 (0.601)

ef→enc	2.642 (0.755)	0.342 (0.559)	8.719*B (0.069)	7.874**B (0.049)	4.915 (0.178)
fdi→enc	6.207 (0.287)	0.402 (0.526)	5.099 (0.277)	4.713 (0.194)	12.065***U (0.007)
gdp→enc	4.965 (0.420)	0.162 (0.687)	20.098***B (0.001)	7.045*B (0.071)	5.166 (0.160)
export→enc	11.0512**U (0.050)	2.025 (0.155)	7.022 (0.135)	7.605*B (0.055)	6.371*U (0.095)

Notes: p-values value are in parentheses.
"U" = Unidirectional; "B"=Bidirectional
The level of significance is expressed as *** (1 %), ** (5 %), * (10 %).

According to <Table 8>, the unidirectional causality runs from FDI to ecological footprint in Indonesia. The bidirectional causality between FDI to ecological footprint is found in Malaysia and Thailand. There is no casual relationship between ecological footprint and FDI in the Philippines and Singapore. Generally, the findings from the Toda-Yamamoto Granger causality tests support the results from the ARDL model estimations in <Table 6>.

For the GDP per capita, there is a unidirectional causality runs from GDP per capita to ecological footprint in Indonesia and Singapore, whereby the bidirectional causality is discovered in the Philippines. Likewise, there is a unidirectional causality, running from energy consumption toward ecological footprint, in Indonesia and Thailand, and the bidirectional causality is discovered in the Philippines and Singapore.

Although the ARDL model estimations do not detect the effect of exports on ecological footprint, the Toda-Yamamoto Granger causality tests show the unidirectional causality running from export to ecological footprint in Indonesia, the Philippines and Thailand.

6. Diagnostic tests of the ARDL model

In order to assure the validity of our estimating ARDL model, several diagnostic tests are performed. Based on <Table 9>, The consequences from Jarque-Bera tests are all insignificant, indicating that the error terms in our models have normal distributions. The Breusch-Godfrey serial correlation LM tests reveal that the LM statistics are not significant in all countries. These suggest that there is no autocorrelation problem in our empirical model of all 5 ASEAN countries. Regarding the Ramsey's RESET tests, the Chi-square statistics are insignificant, meaning that all of our empirical models are correctly specified. The R^2 shows satisfy goodness of fit in all 5 ASEAN countries.

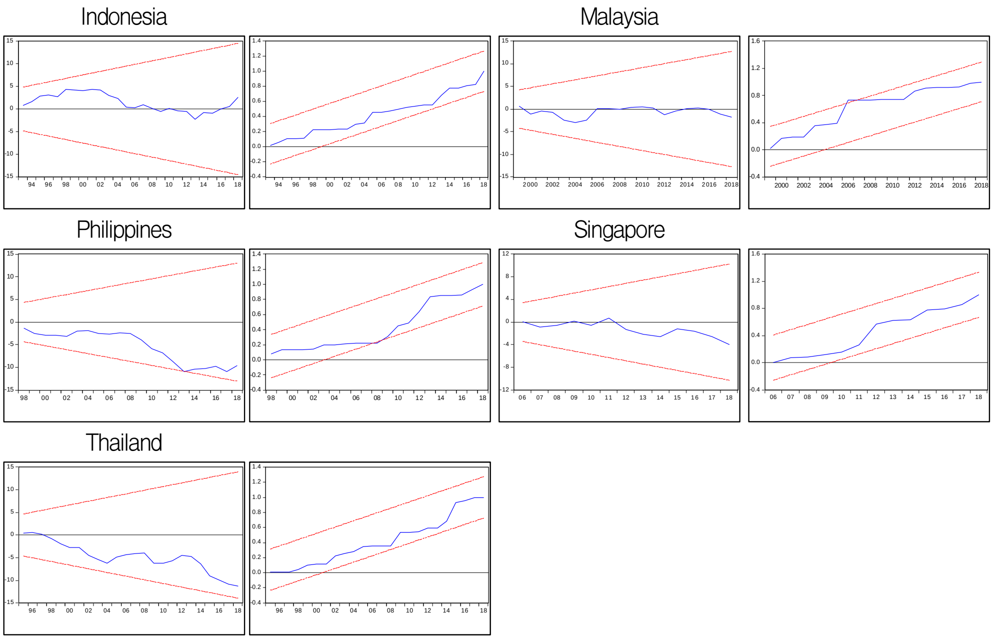
<Table 9> Diagnostic tests

	Indonesia	Malaysia	Philippines	Singapore	Thailand
R^2	0.986	0.975	0.931	0.982	0.986
Jarque-Bera	0.035 (0.983)	1.834 (0.340)	1.493 (0.474)	0.053 (0.974)	2.295 (0.317)
LM	0.446 (0.504)	0.008 (0.928)	0.614 (0.434)	0.302 (0.582)	0.100 (0.757)
RESET	0.445 (0.5110)	0.112 (0.741)	0.979 (0.334)	0.981 (0.341)	0.138 (0.713)

Note: P-values are in parentheses.

Moreover, <Figure 1> illustrates the cumulative sum of recursive residuals (CUSUM) as well as the cumulative sum of the square of recursive residual or CUSUM of squares. The figures show that the model structure is stable in all 5 ASEAN countries, at 5 percent level of significance.

<Figure 1> CUSUM and CUSUM of squares



7. Discussion of empirical finding

The empirical findings indicate that FDI increases ecological footprint in Indonesia and Malaysia, whereas it lowers ecological footprint in Thailand. There is no significant relationship between FDI and ecological footprint in Singapore and the Philippines. The explanation on the association between FDI and ecological footprint may rest on two perspectives: structure of FDI in certain industries and environmental policy of the host country.

The statistics in <Table 10> show the allocation of FDI across the industry in each host country.

<Table 10> FDI by industry (%)

Industry	Indonesia	Malaysia	Philippines	Singapore	Thailand
Agriculture, forestry and fishing	2.42	2.26	0.19		0.07
Mining and quarrying	13.75	6.84	0.19		0.08
Manufacturing	44.78	43.74	33.89	12.00	43.55
Electricity, gas, steam and air conditioning supply	10.85		20.43		0.06
Water supply; sewerage, waste management			0.03		
Construction	0.29	0.95	3.69		0.07
Wholesale and retail trade		7.26	0.26	14.84	6.94
Transportation and storage	11.99		2.64	2.04	0.24
Accommodation and food service activities	1.54		0.06	1.13	0.11
Information and communication		7.56	5.18	1.75	
Financial and insurance activities		22.22	17.84	55.53	20.37
Real estate activities	7.23		9.77	12.72	18.64
Professional, scientific and technical activities			1.39		
Administrative and support service activities			1.56		
Education			0.10		
Human health and social work activities			0.67		
Arts, entertainment and recreation			2.11		
Other service activities	7.15	9.17	0.00		9.87
Total	100	100	100	100	100

Note: Period of data : Indonesia (2021), Malaysia (2008-2019), Philippines (2017-2012), Singapore (2020), Thailand (2010-2021)

Source: Ministry Of Investment/BKPM of Indonesia, Department of Statistics Malaysia Official Portal, Bangko Sentral ng Pilipinas (BSP), A Singapore Government Agency, Bank of Thailand

The positive effect of FDI on ecological footprint of Indonesia can be explained through the allocation of FDI. The majority of FDI are distributed to polluting industries, such as manufacturing (44.78%), mining and quarrying (13.75%), and electricity, gas, steam and air conditioning supply (10.85%). Only these three sectors account for 69.38 percent of total FDI inflows of Indonesia. Since Indonesia is a resource-rich country, 22 percent of inward FDI only goes to iron and steel manufacturing sector. Moreover, the Environmental Performance Index, EPI (Wolf et al. 2022) indicates that Indonesia holds the lowest scores (28.20, out of 100), among ASEAN-5 countries. The low EPI scores imply that the environmental issue is not managed seriously by the authorities of Indonesia. Likewise, the positive consequence of FDI on ecological footprint of Malaysia can be described through the structure of FDI. Most of the FDI in Malaysia is allocated to manufacturing sector (43.74%). The FDI of manufacturing and mining and quarrying industry (6.84%) already hold 50.58 percent of inward FDI of Malaysia. This suggests that majority of FDI go to polluting industries. Consequently, FDI raises ecological footprint in Malaysia.

In contrary, FDI lowers ecological footprint in Thailand. Although 43.55 percent of FDI goes to manufacturing sectors, FDI is concentrated in cleaner and less emitting sectors such as manufacture of computer and optical products, for 7.97 percent (OECD, 2021). In addition, the EPI index of Thailand is fairly high (38.10), which makes Thailand the second best after Singapore (50.90), among ASEAN-5 countries. This implies that the authorities of Thailand manage well to control the environmental issues. From <Table 11>, Thailand planned to reduce 20% of GHG emissions by 2030 from the BAU level, and achieve at least 50% renewable electricity generation from new power generation capacity by 2050.

<Table 11> Environmental Policy

Country	Policy Target	Plan	Year
Indonesia	*Decrease 29% of GHG emissions from BAU by 2030	Presidential Regulation No. 61 of 2011 on the National Action Plan on Greenhouse Gas Emission Reduction	2016-
	*Decrease 41% of carbon emissions by 2030.	Indonesia Emas 2045 (Golden Indonesia 2045) Program	2022-
Malaysia	*Decrease 45% of GHG emissions intensity per unit of GDP by 2030 compared to 2005.	Intended Nationally Determined Contribution of the Government of Malaysia	2016-
	*No longer establish new coal-fired power plants by 2050.	12th Malaysia Plan	2021-
Philippines	*Decrease around 70% of the GHG (CO2) emissions coming from energy, transport, waste, forestry and industry sectors by 2030 under BAU.	Intended Nationally Determined Contributions	2016-
	*Decrease 75% of GHG emissions by 2030.	Commitment to the Paris Agreement on Climate Change	2021-
Singapore	*Decrease 50% of the GHG emissions to 33 Mt CO2e by 2050 *Achieve net-zero GHG emissions at the half of the century.	Singapore's Long-Term Low-Emissions Development Strategy	2020-
	*Achieve peak emissions at 65 MtCO2e by 2030.	Singapore's Long-Term Low-Emissions Development Strategy	2020-
	*Decrease 36% of emissions intensity from the levels of 2005 by 2030	Singapore's Intended Nationally Determined Contributions and Accompanying Information	2016-

Thailand	*Decrease 20% of GHG emissions by 2030 from the BAU level.	Thailand's Intended Nationally Determined Contribution	2016-
	*Decrease no less than 25% of energy intensity from BAU by 2030.	Climate Change Master Plan	2015-
	*Achieve at least 50% renewable electricity generation from new power generation capacity by 2050.	Thailand National Energy Plan	2022-

Notes: GHG = Greenhouse gas; CO2e= Carbon dioxide equivalents;
BAU = Business-as-usual; GW = Gigawatts

The insignificant impacts of FDI on ecological footprint are found in the case of Singapore and the Philippines. For Singapore, the structures of FDI exhibit that the majority of FDI is distributed to services sectors, such as financial and insurance activities (55.53%) and wholesale and retail trade (14.84%). As a result, FDI inflows do not have connection with ecological footprint. As per the Philippines, even though most of FDI is distributed to the polluting industries including manufacturing sector (33.89%) and electricity, gas, steam and air conditioning supply (20.43%), the empirical findings show that inward FDI does not have effect on ecological footprint. This can be explained through the small volume of FDI inflows to the Philippines, i.e. the volume of FDI is too small to affect the level of ecological footprint. The statistics from UNCTADstat database suggest that the inward FDI, in percentage of total world, is 0.18 percent for the Philippines during 2003-2021. This is the smallest value among ASEAN-5 countries: Singapore (3.43%), Thailand (0.67%), Indonesia (0.62%), and Malaysia (0.46%). The small volume of FDI inflows is caused by high restriction on FDI of the Philippines.

The OECD foreign direct investment regulatory restrictiveness index (FDI Index) exhibits that the Philippines ranked the third for the most restrictive country (behind Libya and Palestine), out of the 84 countries, in 2020 with the score 0.374 (full score is 1). The OECD FDI index measures FDI restriction in four dimensions: foreign equity limitations, approval mechanisms, employment of foreigners, and other operational restrictions.

With regard to the ASEAN environmental policy, as a single group, the current cooperation on environmental issues are based on the ASEAN Socio-Cultural Community (ASCC) Vision 2025. The ASCC addresses the quality of life of people through certain activities including environmental cooperation for sustainable development among the member states. The ASCC proposes four major cooperation areas including (i) conservation and sustainable management of biodiversity and natural resources, (ii) sustainable climate, (iii) sustainable consumption and production, (iv) environmental sustainable cities (ASEAN Secretariat 2016). The first two ares are connected to the issues of ecological footprint and FDI. According to our empirical findings, the positive effects of FDI on ecological footprint in Indonesia and Malaysia imply that Indonesia and Malaysia need to implement appropriate environmental policy in order to mitigate the consequences from FDI on ecological footprint. Considering the ASEAN as a single organization, although the carbon neutrality is a common destination of the member states, each country just follows its own map, depends on the individual conditions. For instance, <Table 11> exhibits that while Malaysia agrees to decrease 45 percent of GHG emissions intensity per unit of GDP by 2030, Indonesia determines to decrease it by 29 percent. However, the ASEAN way of non-interference turns to be an obstacle on regional cooperation regarding an environmental issues (Aggarwal et al. 2010). In this context, ASEAN needs to find the concrete way on the cooperation to alleviate the impact of FDI on ecological footprint within its political space (Nguyen 2016).

Ⅵ. Conclusion

The research examines the role of FDI on ecological footprint in 5 ASEAN countries. The control variables (GDP per capita, exports and energy consumption) are included in the estimations. The ARDL model is employed using the data from 1980 to 2018. The long-run coefficients from the ARDL model indicate that FDI raises the ecological footprint in Indonesia and Malaysia. These findings are consistent with the prediction of the pollution haven hypothesis. Nonetheless, the FDI reduce ecological footprint in Thailand. This consequence is in line with the pollution halo hypothesis. Besides, FDI displays insignificant effect on ecological footprint in the Philippines and Singapore. The outcomes from Toda-Yamamoto causality tests are in line with the long-run results from the ARDL model.

Regarding the others control variables, while GDP per capita accelerates ecological footprint in Indonesia, it discourages ecological footprint in Malaysia, Singapore and Thailand. In addition, the exports show insignificant effect on ecological footprint in all 5 ASEAN nations. Lastly, energy consumption promotes ecological footprint in all of 5 ASEAN countries.

Our empirical findings provide important policy implications to the ASEAN countries. Indonesia and Malaysia receive FDI to boost economic development in exchange with environmental degradations. Accordingly, the authorities of Indonesia and Malaysia should implement appropriate policy to maintain the environmental quality such as encouraging multinational companies to increase green technology implementation in the production procedures. For the Philippines, Singapore and Thailand although FDI does not generate significant ecological footprint, the authorities should keep maintaining the policy to ensure environmental-friendly atmosphere.

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<국문요약>

아세안 5개국의 생태발자국에 대한 외국인 직접투자의 역할

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본 연구는 아세안 5개국의 생태발자국에 대한 외국인 직접투자(FDI)의 영향을 조사한다. 인도네시아, 말레이시아, 필리핀, 싱가포르, 태국. 1980년부터 2018년까지의 연간 데이터를 사용하여 단기 및 장기 계수의 결과를 얻기 위해 자기 회귀 분산 지연(ARDL) 모델을 구현한다. 또한, Toda-Yamamoto Granger 인과관계 테스트는 우리 연구의 견고성을 보장하기 위해 사용된다. 경험적 연구 결과에서는 FDI가 인도네시아와 말레이시아 생태발자국에 미치는 긍정적인 영향을 끼친 반면에, 태국은 FDI와 생태발자국 사이에 부정적인 연관성이 있음을 보여준다. 그러나 필리핀과 싱가포르에서는 FDI가 생태발자국에 미치는 영향은 크지 않다. 또한 제어 변수의 결과는 1인당 GDP가 인도네시아의 생태발자국에 긍정적인 영향을 미치는 반면 말레이시아, 싱가포르, 태국에서는 부정적인 영향을 미친다는 것을 나타낸다. 이 수출은 아세안 5개국 모두에서 생태발자국에 영향을 미치지 않는다. 그럼에도 불구하고 에너지 소비는 5개 ASEAN 회원국 모두에게 생태학적 발자국과 긍정적인 연관성을 보여준다.

주제어: 해외직접투자, 생태발자국, ASEAN, ARDL모델, 인과성검사