Analyzing the Long-term Effects of Tourism, FDI, GDP per Capita, and Trade on CO_2 Emission in ASEAN: A DOLS Approach

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Abstract

Global climate change is a critical challenge, especially in the ASEAN region. Increasing CO_2 emissions that trigger the greenhouse effect are putting pressure to balance economic growth with environmental sustainability. The influx of international tourists also contributes to energy consumption and transportation, which has a direct impact on CO_2 emissions, despite supporting the economy. This study analyzes the impact of Gross Domestic Product per capita, international tourism, trade openness, and foreign direct investment (FDI) on CO_2 emission in five ASEAN countries, namely Indonesia, Malaysia, Thailand, Singapore, and Viet Nam period 2000-2019. This study used Panel Dynamic Ordinary Least Square (DOLS) for the analysis method. The estimation results indicate a positive correlation between international tourism on CO_2 emissions in 5 ASEAN Countries. Then, the negative correlation between GDP, trade openness and CO_2. However, the long runs correlation between FDI and CO_2 emissions is insignificant.

Keywords: CO_2 emission, international tourism, GDP, trade, ASEAN

A. INTRODUCTION

Global climate change has become a serious concern for governments around the world, including in the ASEAN region. Human-induced climate change has resulted in a variety of weather and climate extremes globally (Setiawan & Aisyah, 2024). The issue has become a major focus by policy authorities, civil society organizations and scientists as global awareness of environmental issues increases. The increase in CO_2 emissions fuels the presence of greenhouse gases that are widely recognized as the main cause of global warming. This presents a challenge to balance economic growth with environmental sustainability. In recent times, several studies have suggested that tourism and foreign direct investment actively contribute to CO_2 emissions (Rahaman et al., 2022); (F. Muhammad & Khan, 2021) in addition to its role as a supporting aspect of economic development in creating employment opportunities (Wan & Brahmasrene, 2013).

Figure 1. shows that over the past two decades, the contribution of CO_2 emissions in five ASEAN countries, namely Indonesia, Malaysia, Thailand, Vietnam and Singapore, has continued to increase, although the increase in Singapore is not as drastic as in other countries. CO2 emissions

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in all countries have continued to increase dramatically since 2017 until now. From these five countries, the total CO2 emissions generated in 2019 reached 1,511,519.3 kt (kilotons) with

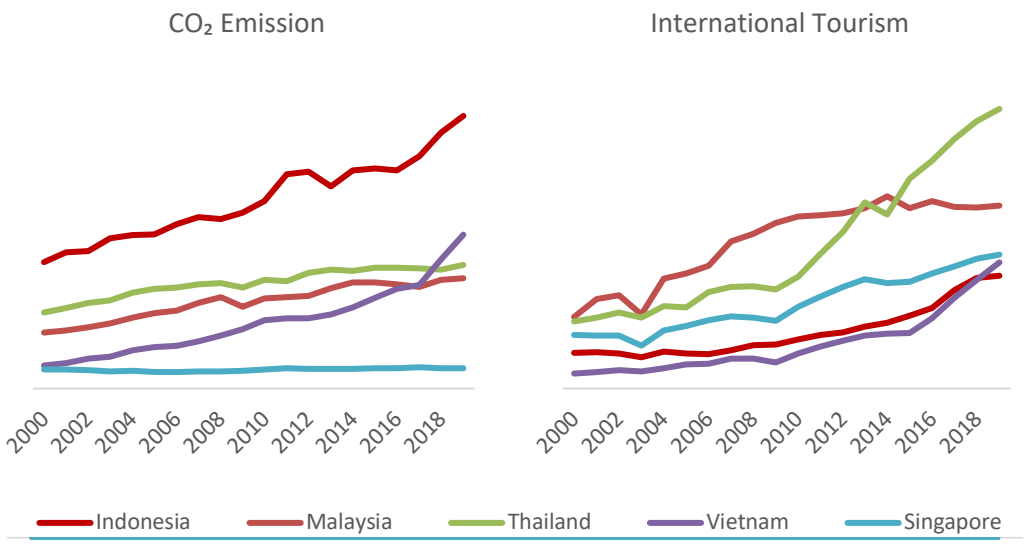

Figure 1. Trends in CO_2 emissions and International Travelers in 5 ASEAN Countries
Source: World Bank

119.249.000 international tourists. In addition, the development of tourist visits also continues to increase every year in line with the increase in CO2 emissions. However, it is undeniable that the development of the tourism sector has contributed greatly to increasing the country's annual income to improve the country's economic conditions and improve the welfare of the community. On the other hand, the transportation sector as a key supporter of tourism is responsible for CO2 emissions due to the arrival and departure activities of tourists, which impose costs on local residents in the form of environmental quality degradation (Liu et al., 2019).

In the case of developing and developed countries, it has been validated that tourism increases CO2 (Paramati et al., 2017). The study by Turan (2014) confirmed tourism in Singapore has an adverse effect on CO2 emissions and there is a long-term relationship. The findings of Azam, et al (2018) on the relationship between tourism and CO2 emissions of Malaysia, Thailand, and Singapore show significant results. Tourism in Malaysia has positive and statistically significant results, while in Singapore the estimation results show negative and significant, then in Thailand tourism and environmental pollution have a significant inverse relationship.

Foreign direct investment (FDI) is a key driver of industrialization in ASEAN, bringing capital and technology that are essential to the region's economic growth. Countries such as Indonesia, Malaysia, and Vietnam are actively attracting FDI to strengthen their manufacturing, infrastructure, and technology sectors, and there are even certain incentives. The large market share means ASEAN has the potential to become a major destination for FDI (Fiannurizki, 2024). While FDI can play a role in creating jobs and increasing production capacity, it can also exacerbate CO_2 emission levels, especially if investment is directed towards energy-intensive industrial sectors. On the other hand, FDI oriented towards technology and renewable energy sectors can contribute to reducing emissions through the transfer of environmentally friendly technologies. The study by Omri & Bel (2020)observed that foreign direct investment reduces carbon dioxide emissions in developing countries. In the case of Bangladesh, foreign direct investment (FDI) is estimated to be significant and negative at the 5% confidence level, indicating that this variable

reduces CO_2 emissions (Rahaman et al., 2022). However, Abban et al. (2020) and Shahbaz et al. (2015) found bidirectional causality between FDI and carbon dioxide emissions, and FDI contributes to increased environmental degradation.

Trade openness indicates a country's level of economic integration with the global market, which encourages increased economic activity through exports and imports. ASEAN is one of the regions with a high degree of trade openness, driven by economic cooperation and free trade agreements. Countries in ASEAN rely heavily on international trade, with a very high trade-to-GDP ratio. On the other hand, intensive trade activities can also increase energy consumption and CO_2 emissions. With the expansion of markets, trade intensity will be greater and encourage the use of fossil fuels, as well as massive exploitation of natural resources, which will eventually lead to increased pollution, but the abundance of knowledge and competition due to trade openness can trigger the adoption of more environmentally friendly and efficient technologies, especially for developed countries (Grossman et al., 1991). Paramati et al. (2017) study highlights that trade openness and tourism reduce CO2. Another study by Huang et al (2019) trade openness was able to reduce emission levels in China and research with similar results by Managi et al. (2009) was also conducted for OECD and non-OECD countries.

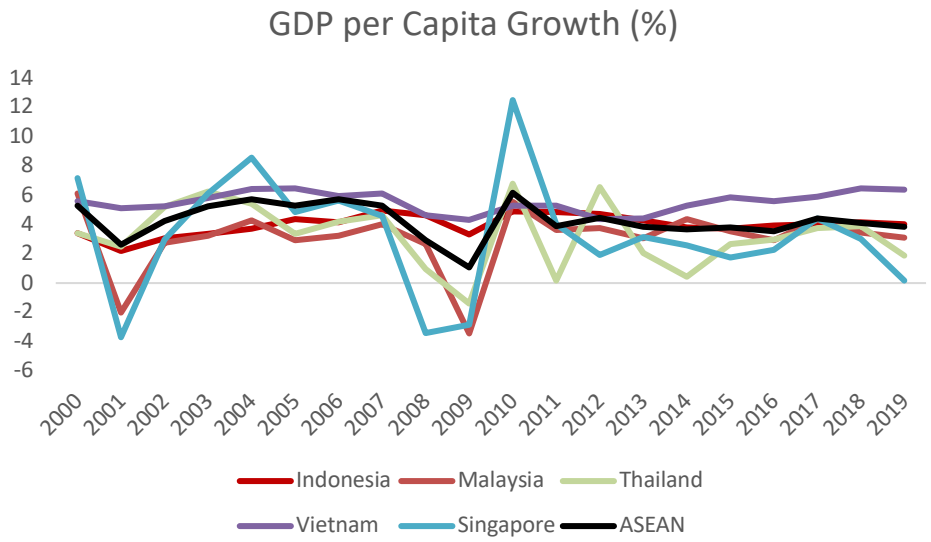

Figure 2. GDP per Capita Growth (%) Trend in 5 ASEAN Countries
Source: World Bank

GDP per capita growth in ASEAN during 2000-2019 fluctuated. Graph 2. shows that in 2019, there were 3 countries whose growth was below the average of the ASEAN region, namely Singapore, Thailand and Malaysia. While Indonesia has a value that is almost the same as the ASEAN average, and Vietnam occupies the highest position. The peak of the increase in GDP per capita in the ASEAN region in 2010 where all countries experienced a significant increase, even Singapore was able to reach the highest point of 12.5%. ASEAN's growing GDP per capita drives energy consumption and infrastructure, potentially increasing CO_2 emissions. Countries such as Singapore and Malaysia that have a higher GDP per capita than other ASEAN countries can start adopting environmentally friendly technologies as a measure to reduce CO_2 emissions, while developing countries such as Indonesia Thailand and Vietnam that are still experiencing an increase in GDP are generally still dependent on fossil fuels.

Previous studies have examined the existence of an inverted U-shaped relationship between CO2 emissions and GDP, known as the Environmental Kuznets Curve (EKC) hypothesis which implies that as GDP increases, CO2 emissions will continue to increase until reaching a certain threshold level of GDP and then further increases in GDP CO2 emissions will tend to decrease (Grossman et al., 1991). The studies of Zaman et al. (2016) have shown the emissions caused by tourism and their studies support the EKC hypothesis for both developing and developed economies. Another study in Bangladesh also proved the relationship between GDP and CO2 emissions is inverted U-shaped (Rahaman et al., 2022). The use of DOLS and FMOLS estimators estimated that there is a clear and substantial U-shaped correlation between the square of GDP and CO2 emissions, where GDP has a significant and positive influence on CO2 emissions in the long run (Munir et al., 2024). However, in some cases, the EKC hypothesis is only valid for high-income countries, while for lower-middle income countries in Asia the EKC hypothesis is invalid. This means that CO2 emissions per unit of GDP in high-income countries are lower than in upper-middle-income countries (Handoyo et al., 2022).

This research aims to examine the impact of economic determinants—Gross Domestic Product (GDP) per capita, international tourism, trade liberalization, and foreign direct investment (FDI)—on CO_2 emissions in five ASEAN nations (Indonesia, Malaysia, Thailand, Singapore, and Vietnam) from 2000 to 2019. Using the Dynamic Ordinary Least Squares (DOLS) Panel methodology, this investigation delineates the contribution of each determinant to carbon emissions and offers insights pertinent to sustainable development strategies. Although numerous studies have been undertaken regarding the nexus between economic advancement and CO_2 emissions, there exists a dearth of detailed research specifically addressing ASEAN member states. This study enriches the literature by scrutinizing these variables within the context of the region's foremost economies.

B. RESEARCH METHOD

This study uses annual data from 2000 to 2019, concentrating on five ASEAN countries: Indonesia, Malaysia, Thailand, Singapore, and Viet Nam. The analysis examines Foreign Direct Investment (FDI), Gross Domestic Product per capita (GDP per capita), international tourism, and trade openness as independent variables. Carbon dioxide emissions (CO2 emissions) are analyzed as the dependent variable.

Table 1 Variables and data sources

Variables	Measurement units	Data source
CO2 emissions	Kilotons (Kton)	World Bank
GDP per capita	Current US$	World Bank
Foreign Direct Investment	% GDP	World Bank
International Tourism	People	World Bank
Trade Openness	% GDP	World Bank

In this paper, an econometric model is cited to(Merlin & Chen, 2021). Our study's econometric model is shown in Equation (1).

$$CE = f(GDP, FDI, INTOUR, TRADE) \quad (1)$$

CO2 emissions, denoted as CE, are featured in equation (1). To facilitate time series analysis, we transform the equation into logarithmic form, with GDP, FDI, INTOUR, TRADE representing gross domestic product, foreign direct investment, International Tourism, Trade Openness respectively.

$$LogCEit = \beta 0 + \beta 1\ logGDPit + \beta 2\ FDIit + \beta 3\ LogINTOURit + \beta 4\ TRADEit + \varepsilon_i \quad (2)$$

The symbol for the natural logarithm is Log, and the symbol for the coefficient value is β. The time series, spanning the years 2000–2019. A stochastic error of ε_i is present. The estimating method used in this study was Panel Dynamic Ordinary Least Square (DOLS). The DOLS technique was created by (Stock & Watson, 1993).

Here is the study's approach. First, the stationarity of the study's data was evaluated using a unit root test. To determine whether the variables showed a long-term association, a cointegration test was overseen in the following phase. Ultimately, Panel DOLS was used to probe the impact of several parameters on carbon emissions in the third step of the investigation (Setyadharma et al., 2024).

C. FINDINGS AND DISCUSSION

This study use the Dynamic Ordinary Least Square approach, and before running this regression panel data, the best model for panel data must be checked. There are three main types of regression in panel data analysis: Common Effect Model, Fixed Effect Model, and Random Effect Model. To determine the most suitable model for the study, statistical tests were employed. The Chow Test, Lagrange-Multiplier Test, and Hausman Test were used to select the optimal model for panel data regression (Budiono & Purba, 2023).

Table 2. Model Testing

Test	Value	Criteria	Result
Chow Test	0.0000	Prob < 0.05	Fixed Effect Model
Hausman Test	0.0000	Prob < 0.05	Fixed Effect Model
Lagrange Multiplier Test	0.1197	Prob > 0.05	Common Effect Model

Source**:** Researcher, processed (2024).

Table 2 shows that the Chow test probability value 0.0000 which is less than 0.05, indicates that the null hypothesis (Ho) is rejected, and the alternative hypothesis (Ha) is accepted, leading to the selection of the Fixed Effects Model. The Hausman test probability value is 0.0000 which is less than 0.05. Thus, Ho is rejected and Ha is accepted, so the Fixed Effects Model was chosen. The Lagrange multiplier test probability value is 0.1197, which is more than 0.05. As a result, Ho is accepted, and Ha is rejected. So, the Common Effect Model was selected. Based on these results, the Fixed Effects Model is determined to be the most suitable model.

Table 3. Classic Assumption Test

Test	Score	Result
Multicollonierity Test	< 0.8	There was no multicollonierity
Normality Test	< 0.05	Abnormally distributed
Heteroscedasticity Test	> 0.05	There was no heteroscedasticity

Source: Researcher, processed (2024).

Result on table 2 show the classical assumption test which are multicollonierity test, normality test, and heteroscedasticity test. The multicollonierity test result with variable correlation are less that 0.8 indicates that there is no multicollonierity. The normality test yields a

Jarque Bera probability 0.0000 less than 0.05 indicating that the research data is abnormally distributed. Referring to the assumption of the central limit theorem which states that for large samples, especially more than 30 (n>30), the sample distribution has been considered normal (Simanjuntak et al., 2024). The heteroscedasticity test reveals that each variable has a value greater tha 0.05, so there is no heteroscedasticity.

Table 4. Unit Root Test

Variable	The ADF Test	
	Level	1st Difference
$LogCO_2$	0.0000	0.0000
FDI	0.0000	0.0000
LogGDP	0.9384	0.0000
LogINTOUR	0.0000	0.0000
TRADE	0.7913	0.0000

Source: Researcher, processed (2024).

Panel unit root tests conducted to determine whether the variables were stationary at the same level. This research adopted Fisher-ADF and PP test in conducting a panel unit root tests and the result are shown in able 4. The result test confirmed that variablses were stationary at levels except LogGDP and Trade. Furthermore, all the variables were stationer at the first difference. It can be concluded that variables are first differenced stationary. These empirical findings not only revealed the non-stationary properties of the variables but also provided a strong basis for conducting panel cointegration analysis.

Table 5. KAO Residual Cointegration Test

ADF	**t-Statistic**	**Prob.**
	-4.028610	0.0000
Residual variance	0.255232	
HAC variance	0.144806	

Source: Researcher, processed (2024)

An approach known as cointegration is used to assess the long-term impact of non-stationary correlation between variables. In order to verify reliability, this study uses two cointegration tests: panel cointegration tests, which were created by Pedroni (2004) and Kao (1999) to examine the cointegration connection. Table 5 shows the Kao cointegration test. A long-run panel cointegration relationship between the observable variables is shown by the rejection of the hypothesis null that there is no cointegration between the variables with probability 0.0000.

Table 6. Pedroni Cointegration Test

Alternative hypothesis: common AR coefs. (within-dimension)

			Weighted	
	Statistic	**Prob.**	**Statistic**	**Prob.**
Panel v-Statistic	-2.248273	0.9877	-2.491113	0.9936
Panel rho-Statistic	0.643780	0.7401	0.626665	0.7346
Panel PP-Statistic	-16.87598	0.0000	-12.36856	0.0000

Panel ADF-Statistic	-4.538381	0.0000	-4.809975	0.0000
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	**Prob.**		
Group rho-Statistic	1.295958	0.9025		
Group PP-Statistic	-13.74582	0.0000		
Group ADF-Statistic	-1.831675	0.0335		

Source: Researcher, processed (2024)

The findings of Pedroni's panel cointegration tests are shown in two sections in Table 6. The Ha results in the assumption that the coefficients of the lagged autoregressive residuals across individual units are the same in the first portion, but this assumption is relaxed in the second. The Panel PP-Statistic and Panel ADF-Statistic (including their weighted versions) reject the H_0 at the 5% significance level, and the Group PP-Statistic and Group ADF-Statistic in the second section accept the H_a at the 5% significance level. In general, Pedroni's statistics clearly show that the variables cointegrate over long run.

Table 7. Panel DOLS Estimation Result

Variable	**Coefficient**	**t-Statistic**	**Prob.**
LGDP	-0.407459	-2.810456	0.0064
LINTOUR	0.983222	14.53559	0.0000
TRADE	-0.003019	-2.046838	0.0444
FDI	0.000342	0.015119	0.9880
R-squared	0.763021	Mean dependent var	11.94140
Adjusted R-squared	0.686254	S.D. dependent var	0.852314
S.E. of regression	0.477407	Sum squared resid	16.18215
Long-run variance	0.209803		

Source: Researcher, processed (2024)

In panel DOLS long-run estimation, the coefficients for GDP per capita, trade openness, and international tourism are all statistically significant at the 5 percent significance level. Consistent with the results of Thi et al. (2023) and Khan & Ahmad (2021), there is a robust and statistically significant long-run relationship among GDP per capita, international tourism, trade openness and CO_2 emissions in the term of DOLS calculations. According to the DOLS model, the findings show that international tourism is statistically significant with positive effect on CO_2 emissions at 5% level, implying that a 1% rise in international tourism is linked to a 0.983222 percent rise in CO_2 emissions. Our results are in line with those of Muhammad et al. (2021) and Thi et al. (2023), who also show that an increase in international tourism in a decline in environmental quality. In table 7, GDP per capita and trade openess were statistically significant with negative effect on CO_2 emissions at 5% level, implying a 1% rise in GDP per capita and trade openness is linked to a 0,407459% and 0,003019% decrease in CO2 emissions, respectively. While, FDI has no significant effect on CO_2 emissions.

Additionally, based on the R-squared 0.763021 and adjusted R-squared values 0.686254, it can be concluded that the independent factor together can explain the variation occurs in the dependent variables 68,62 percent and the other 31,38 percent explained by variables not included in this study. All the panel DOLS long-run estimation results for the Indonesia, Malaysia, Thailand,

Vietnam and Singapore countries suggest that, the variables of GDP per capita, international tourism, and trade openness have an effect on CO2, with the exception of FDI.

D. CONCLUSION

This study employs panel data series from five ASEAN countries (Indonesia, Malaysia, Thailand, Singapore, and Viet Nam) spanning 2000 to 2019. In this study, the Dynamic Ordinary Least Square (DOLS) model results show that international tourism, GDP per capita, and trade openness exhibit a significant long-term impact on CO_2 emissions, while Foreign direct investment (FDI) shows no significant long-term impact on emissions.

The results verify the connection between international tourism, GDP per capita, and trade openness with CO_2 emissions. The positive correlation between international tourism and CO_2 emissions indicates that increased tourism drives higher energy consumption and transportation demand, leading to greater emissions. Conversely, GDP per capita and trade openness have a negative relationship with CO_2 emissions, suggesting that higher levels of welfare and open trade contribute to emissions reductions, possibly due to increased efficiency or improved environmental standards.

The findings highlight the importance of balancing economic activities with sustainable environmental practices, particularly as tourism grows and economic policies shape the region's emissions profile. For policymakers, this calls for strategies that support both economic growth and environmental protection. Encouraging policies that promote sustainable tourism, lower emissions from transportation, and facilitate greener trade practices are crucial. Additionally, adopting green technologies, investing in sustainable infrastructure, and supporting initiatives that reduce reliance on carbon-intensive energy sources are effective strategies for mitigating CO_2 emissions.

In conclusion, addressing CO_2 emissions in the ASEAN region requires coordinated action from governments, businesses, and international organizations. Policymakers must adopt strategies that support both economic development and environmental sustainability, ensuring that future growth does not come at the cost of the environment. By focusing on sustainable tourism, green technologies, and trade policies that promote cleaner industries, ASEAN countries can achieve a more sustainable and prosperous future, contributing to global efforts to combat climate change.

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