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Carbon Emissions and Urbanization in ASEAN-5 Countries

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ABSTRACT

The population in the world reached 7.5 billion in 2019. The population living in the urban area is one of the drivers of carbon emissions due to the higher electricity and fossil fuel consumption. This study aims to estimate the relationship between urbanization and three factors: GDP, trade openness, and coal consumption on carbon dioxide emissions in ASEAN-5 countries, Indonesia, Malaysia, Thailand, Philippines, and Vietnam, from 1990 to 2020. The data was generated from British Petroleum and World Bank. This current study employs a Fixed-Effect estimation model to estimate the data. The result revealed a positive relationship between urban population as a proxy of urbanization, GDP, trade openness, and coal consumption. Policies should highlight using low-carbon technologies and renewable energy to reduce carbon emissions.

Introduction

The world's population growth increased by 3 billion from 1960 to 1999. The world's population reached 7.5 billion in 2019, as reported by World Bank. The increasing population has a positive and negative impact. The higher demand for energy, especially fossil fuel, due to economic activities is one of the negative impacts. The fossil fuel combustion in the production activities will lead to higher carbon dioxide concentration.

The United Nations data reveal that 56.2% population living in an urban area in 2020. While in Asia, 51.1% population lives in urban areas. Several studies stated that urbanization contributes to environmental degradation. Research by Fikriyah & Sunariya (2022) found that built-up density has a correlation with land surface temperature. Furthermore, Khoshnevis Yazdi & Dariani (2019) stated that the population is living in urban area cause two-thirds of greenhouse gas, which contain carbon dioxide emission (CO_2) in it. Research by Anwar et al. (2020) revealed that the percentage of urban population as a proxy of urbanization has a positive relationship

with carbon dioxide emission in Far East Asia countries which are China, Japan, South Korea, Malaysia, Singapore, Philippines, Thailand, Hong Kong, and Macau. The study confirms the previous findings stating that increasing urbanization will lead to higher carbon dioxide emissions using the Fixed-Effect estimation model. The world bank data also revealed that urbanization contributes to 70% of total greenhouse gases emission by consuming two-thirds of the total energy (Anwar et al., 2020). On the other hand, Huo et al. (2020) research revealed that urban population and building floor space affect carbon emissions negatively. The study utilizes panel data of China's 30 provinces from 2000 to 2015. The findings, in line with research by M. Chen et al. (2022), stated that there is a negative indirect effect of population and land urbanization on carbon emissions in China.

Economics activities empirically increase carbon emissions through fossil fuel combustion to produce goods and services (Huang et al., 2018; Khan et al., 2020). Many studies use GDP (Gross Domestic Product (GDP) as a proxy for economic activity (Charfeddine & Barkat, 2020; Collis & Brynjolfsson, 2019). Following the previous study, this current study also utilizes GDP as a proxy for economic activities. A study by Zhang & Zhang (2018) revealed a positive relationship between GDP and carbon emissions in China from 1982 to 2016. The findings, in line with research by Mansoor & Sultana (2018), stated that in the short run, GDP affects carbon emission positively, and an increase in GDP will drive carbon emission. However, in the long run, the study found that GDP affects carbon emissions negatively, where an increase in GDP will decrease carbon emissions. The study assumes that low-carbon technology development will lower carbon emissions. Another study by Mehmood et al. (2021) showed that GDP affects the environment negatively in India, which will increase carbon dioxide emissions. However, the interaction between institutional quality and GDP will lower carbon dioxide emissions significantly.

Another factor affecting carbon dioxide emissions is trade openness. According to World Bank, trade openness is the ratio of the number of exports and imports of goods and services with other countries measured as a share of Gross Domestic Product (GDP). Ansari et al. (2020) found a positive relationship between trade openness and carbon dioxide emissions in Canada and Saudi Arabia by using Autoautoregressive Distributed-Lag (ARDL). More open trade activities (export and import) will lead to higher carbon dioxide emissions.

British Petroleum reported in 2020 that the carbon dioxide emission in the Asia Pacific is the highest among other areas such as Africa, the Middle East, and Europe. It is because most of the countries in the Asia Pacific are developing and least-developed countries. The countries are still using fossil fuels, considered dirty energy production factors. In Asia, fossil fuel is still utilized by certain countries such as Indonesia, Malaysia, Thailand, the Philippines, and Vietnam ((Sandu et al., 2019). Due to the limitation of the previous study, this current research aims to fill the gap.

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Along with urban population as a proxy of urbanization, this study estimates the effect of GDP, trade openness, and coal consumption on carbon emissions in ASEAN-5 countries, Indonesia, Malaysia, Thailand, Philippines, and Vietnam, from 1990 to 2020. This current study also provides the cross-section effect map of each country to show which country best fits in with the model.

Method

This study used secondary data from British Petroleum and World Bank from 1990 to 2020. This study used STATA as statistical software to estimate the data. This study utilizes one dependent variable and three independent variables. Table 1 shows the variable specifications of this study.

Table 1 Variable Specification

No	Dependent Variable	Variable Specification	Source
1.	lncarbon	Carbon dioxide emission from oil, gas, and coal combustion (million tonnes)	British Petroleum
	Independent Variables	**Variable Specification**	**Source**
2.	urban_pop	The number of people living in urban area (%)	World Bank
3.	lngdp_cons	GDP at purchaser's price (constant 2015 in US $)	World Bank
4.	trade	Sum of exports and imports of goods and services (% of GDP)	World Bank
5.	lncoal	Coal consumption in the form of solid commercial fuels only, i.e., bituminous coal and anthracite (hard coal), lignite and brown (sub-bituminous) coal, and other commercial solid fuels, including coal consumed in transformation processes (exajoules)	British Petroleum

This current study employed the panel regression method. There are three models of panel regression methods that consist of Common-Effect, Fixed-Effect, and Random Effects. Generally, some studies have to choose between Fixed-Effect and Random-Effect due to the Common-Effect limitation. Model estimation:

$$lncarbon_{it} = \beta_0 + \beta_1 urbanpop_{it} + \beta_2 lngdp\_cons_{it} + \beta_3 trade_{it} + \beta_4 lncoal_{it} + \varepsilon_{it} \quad 1$$

Where lncarbon are the carbon dioxide emission from oil, gas, and coal combustion (million tonnes); urbanpop are the number of people living in urban area using percentage; lngdp_cons are GDP at purchaser's price; trade are sum of exports and imports of goods and services percentage to the GDP; lncoal are Coal consumption in the form of solid commercial fuels only; β_1, β_2, β_3, β_4 are the coefficient; β_0 constanta and i express the number of cross-section and t the number of time series.

Result and Discussion

The estimation is conducted by using the Fixed-Effect and Random-Effect models. As shown in Table 3, the results are different between Random-Effect and Fixed-Effect estimation. The GDP

and trade openness affect carbon emission positively at 1%, with a significance value of 0.000 for both variables. Meanwhile, the urban population affects carbon emission negatively at a 5% level in the Random-Effet model and positively significant at 1% in the Fixed-Effect model. Furthermore, coal consumption affects carbon emission positively, significant at a 10% level in the Random-Effect model and significant at 1% in the Fixed-Effect model.

Table 2. Result of Panel Data

Variables	FE	RE
urban_pop	0.006	-0.002
	(0.004)**	(0.035)**
lngdp_cons	0.574	1.090
	(0.000)***	(0.000)***
trade	0.004	0.005
	(0.000)***	(0.000)***
lncoal	0.179	0.049
	(0.000)***	(0.063)**
_cons	-10.662	-23.879
	(0.000)**	(0.000)**
Number of Observation	155	155
R^2 within	0.96	0.95

*** = significance at 1% level ; ** = significance at 5% level ; *= significance at 10% level

Source: Data estimation result, 2022

Hausman test is a statistical test developed by Hausman in 1978 to choose between Fixed-Effect and Random-Effect. Table 4 shows the estimation result. The probability value is 0.000, which means that Fixed-Effect is preferred. The Fixed-Effect model has advantages such as limited biases compared to the OLS model (Collischon & Eberl, 2020).

Table 3. Hausman Test

Chi square statistic (chi2)	Prob
303.85	0.000

Source: Data estimation result, 2022

Further, this study also conducted a classical assumption test of multicollinearity and heteroscedasticity. Table 5 shows the classical assumption test.

Table 4. Classical Assumption Test

Multicollinearity		Heteroscedasticity	
Mean VIF	2.96	Prob	0.000

Source: Data estimation result, 2022

The result shows that the mean VIF value as multicollinearity measurement is 2.96. It means that there is no multicollinearity problem in the model. Furthermore, the significance value of the heteroscedasticity test is 0.000, which means there is a heteroscedasticity problem. STATA provides a "robust" command to deal with the heteroscedasticity problem. Table 5 shows the Fixed-Effect estimation result after applying the "robust" command.

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The estimation shows that urban population, GDP, trade openness, and coal consumption positively affect carbon emissions. However, the significance level is different. The urban population affects carbon emission positively but is insignificant, with a significance level of 0.602. The 1% increase in the urban population will lead to a higher carbon emission of 0.006%. This is in line with previous studies such as Anwar et al. (2020), Huo et al. (2020), Khoshnevis Yazdi & Dariani (2019), and Chen et al. (2022). The increasing urban population will drive higher demand for energy to support their activities. Unfortunately, fossil fuels such as oil and coal are still broadly used in Indonesia, Malaysia, Thailand, the Philippines, and Vietnam. At the same time, fossil fuel combustion is one of the main drivers of carbon emissions.

Table 5. Fixed-Effect Estimation Result

Variables	**FE**
urban_pop	0.006
	(0.602)
lngdp_cons	0.574
	(0.010)**
trade	0.004
	(0.012)**
lncoal	0.179
	(0.071)*
cons	-10.662
	(0.029)**
Number of Observation	155
R^2 within	0.96

*** = significance at 1% level ; ** = significance at 5% level ; *= significance at 10% level
Source: Data estimation result, 2022

Gross Domestic Product (GDP) affects carbon emission positively significance at a 5% level with a significance value of 0.010. A 1% increase in GDP will increase carbon emissions by 0.574%. GDP is generated from the goods and services value added. At the same time, the goods and services production process requires energy in the form of fossil fuel. Fossil fuel combustion generates carbon dioxide emissions. The result was confirmed by Zhang & Zhang (2018), which stated a positive relationship between GDP and carbon emissions in China. Research by Gillani & Sultana (2020) also aligns with the result that an increase in GDP will boost carbon emissions in ASEAN countries from 1970 to 2019.

The result also showed that trade openness affects carbon emissions at 5%, with a significance level of 0.012. A 1% increase in trade openness will boost carbon emissions by 0.004%. Mahmood et al. (2019) confirmed this result, which stated that the increasing trade openness drives the dirt industry with high pollution levels. A study by Ansari et al. (2020) also confirmed a positive relationship between trade openness and carbon dioxide emissions in the long run which means the increase in trade openness will lead to higher carbon dioxide emissions. It aligns with the condition that most ASEAN countries are still emerging markets. The emerging

market tends to import cheaper goods and services due to the lower per capita income. While low, price goods tend to result in a higher carbon footprint.

Coal consumption as the proxy of energy use affects carbon emission positively, significant at the 10% level, with a significance value of 0.071. The 1% increase in coal consumption will drive carbon emissions by 0.179%. This result is in line with research by Pata (2018), which revealed that the increase in coal consumption would lead to higher carbon dioxide emissions in Turkey from 1971 to 2014 in the long run. Anees et al. (2018) showed that non-renewable energy, such as coal, is one of the main contributors to carbon dioxide emissions. This is in line with the fact that coal has the highest carbon emission (CO_2) per unit of energy of all fossil fuels at about 25 kg C/GJ (Steen, 2004). Coal combustion produces the largest carbon emission (Paraschiv & Paraschiv, 2020).

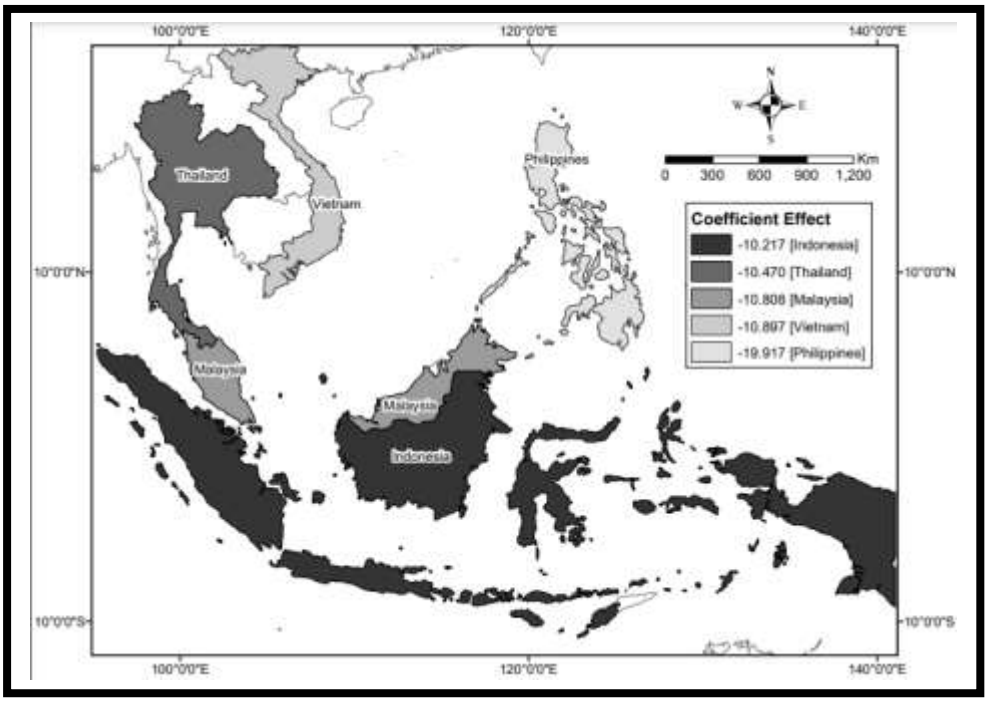

Fig 1. Cross Section Effect map

This current study also provides the Geographic Information System (GIS) in Figure 1 to show which country best fits the model using cross-section effect calculation. The higher the cross-section affect value, the more fit the estimation model is. Some previous studies utilize GIS to show the captured socio-economic research findings and econometrics modeling, such as Kurniawan (2009); Saputra et al. (2017); Rowden & Aly (2018), and Al Faizah et al. (2020). The result showed that the model is fit in with Indonesia with a cross-section effect value of -10.217, followed by Thailand, Malaysia, Vietnam, and the Philippines with cross-section effect values of -10.470, -10.808, -10.897, -19.917, respectively.

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The result showed that the estimation model fit the most in Indonesia, followed by Thailand, Malaysia, Vietnam, and the Philippines. Urban population, GDP, trade openness, and coal consumption positively affect Indonesia's carbon emissions, even at different levels. The estimation result confirmed that the Environmental Kuznets Curve (EKC) exists in countries in ASEAN. The EKC explains that economic growth increase pollution that leads to environmental degradation. However, this condition will experience a turning point where economic growth will lower pollution, such as carbon dioxide emissions. The estimation result is in line with Pratama et al. (2021), which revealed that Indonesia is a country that has an EKC pattern followed by Thailand, Malaysia, and the Philippines. Furthermore, Indonesia is also reported as a country with the largest tropical forest containing carbon stock that will be released as carbon dioxide (CO2) when the organic material decomposes caused by land use (Jaya et al., 2017).

Conclusion

A study about carbon emission as one of the green gas house gasses is often conducted. Many studies do research carbon emissions from multiple disciplines. This study estimates the effect of urban population as a proxy of urbanization, GDP and trade openness for economic activities, and coal consumption as a proxy of energy use on carbon emission in Indonesia, Malaysia, Thailand, Philippines, and Vietnam from 1990 to 2020.

This current study revealed that the Fixed- Effect model is preferred based on the Hausman Test result. The estimation showed a positive relationship between independent variables, which are urban population, GDP, trade openness, and coal consumption, and the dependent variable, carbon dioxide emission, with different significance levels. The urban population affects carbon emissions positively but not significantly, with a significance level of 0.602. It implies that the higher urban population will lead to high carbon dioxide emissions. Gross Domestic Product (GDP) affects carbon emission positively significance at a 5% level with a significance value of 0.010. It implies that the increasing GDP will boost carbon dioxide emissions. Trade openness affects carbon emission positively, significant at 5%, with a significance level of 0.012. The increasing trade openness drives the dirt industry with high pollution levels. Coal consumption as the proxy of energy use affects carbon emission positively, significant at the 10% level, with a significance value of 0.071. It means that the increase in coal consumption will lead to higher carbon dioxide emissions.

This current study suggests policymakers construct policies such as applying low-carbon technologies and renewable energy. Indonesia already applies policies to reduce carbon emissions, such as lower tax incentives for electric cars than conventional cars. It is because

electric cars are considered more eco-friendly. Furthermore, policymakers can use renewable energy, such as hydroelectricity, to replace fossil fuels to supply electric power.

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