

The Effect Of Gdp, Fdi, Number Of Motor Vehicles, Industrial Growth, And Renewable Energy On Co2 In Asean

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ABSTRACT:

This study aims to analyze and determine the effect of GDP, FDI, number of motor vehicle, industrial growth, and renewable energy on carbon dioxide emissions in ASEAN countries. This study uses panel data from 2010 - 2020 using the Random Effect Model (REM). The dependent variable used is the level of carbon dioxide emissions and the independent variables include GDP, FDI, number of motor vehicle, industrial growth, and renewable energy. The results in this study showed that GDP, industrial growth, and number of motor vehicle had a positive and significant effect, while FDI had a positive insignificant effect to the CO2 emissions in ASEAN countries. Renewable energy had a negative and significant effect related to the CO2 emissions.

A. INTRODUCTION

In recent decades carbon dioxide emissions have continued to increase. This caused worldwide attention, especially because air pollution due to CO2 emissions will greatly impact the

environment. Air pollution is one of the negative externalities in the public economy that is a consequence of the production of goods or services. The ever-increasing amount of CO₂ emissions will reduce the quality of life and environmental sustainability. Environment is also considered as a factor influenced by human activities in enhancing the growth and development of a country.

The biggest challenge for developing countries is how to maintain economic growth, while keeping environmental quality at an acceptable level so that it will not harm the environment. A developing region that is focusing on development and growth is ASEAN. ASEAN is a geopolitical and economic organization of countries in the Southeast Asian region. Increasing economic production is one indication of the achievement of the economic development process in ASEAN. Each country produces economic output that is assessed as national income or Gross Domestic Product (GDP).

The relationship between environmental quality and economic growth is explained in the Environmental Kuznets Curve (EKC) which is in the shape of an inverted U. This curve explains the stages that occur in the relationship between economic growth and environmental quality, it can be seen that EKC is divided into three stages, namely, pre-industrial, industrial, post-industrial.

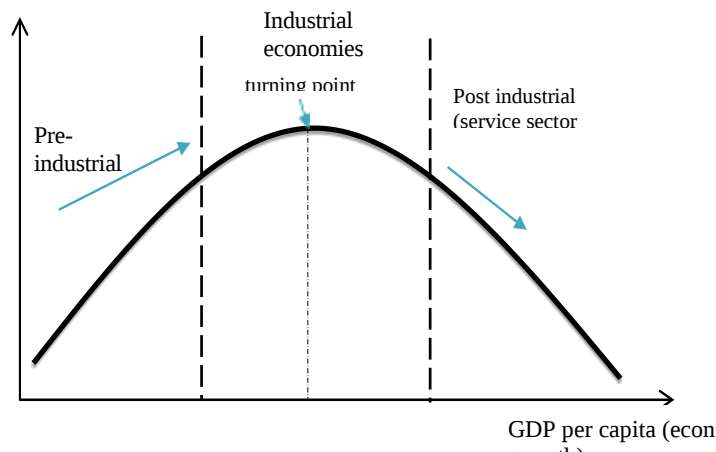


Figure 1. Environmental Kuznets Curve.

This curve explains the transition from agriculture to industry, causing environmental damage to increase because

structural changes lead to mass production, and consumption growth. Then the economic stage focuses on the industrial sector and then decreases with the second change in economic structure from energy-based heavy industry to service-based industry at this stage the high income level, the progress of economic development is dominated by the service economy. At this stage environmental awareness rises, spending on the environment is higher, technological efficiency, and demand for environmentally friendly goods/services increases.

Currently, rapid economic growth accompanied by industrial growth has increased air pollution which can affect global warming and decrease environmental quality. Industry produces a lot of toxic gases, and liquid waste that causes environmental degradation. Industrial processes produce CO₂ emissions which is released into the air, thus causing high amounts of CO₂ emissions in the air.

The rapid economic increase also contributes to air pollution, especially CO₂ emissions with the use of motor vehicles as transportation capital. The transportation sector has contributed greatly in contributing to the amount of CO₂ emissions in the air. The high number of motor vehicles will affect the amount of emissions produced. Countries with heavy traffic will produce a lot of CO₂ emissions.

The influx of foreign investment can also cause changes in the amount of CO₂. The easing of foreign investment entry policies can increase CO₂ emissions (Pao & Tsai, 2011). In developing countries tend to ignore environmental problems through looser or unenforced regulations, this phenomenon is called the pollution heaven hypothesis. However, the impact of FDI can be reversed when low-carbon technologies are introduced and when FDI flows to focus on service industries to reduce carbon dioxide emissions. Foreign companies are believed to be using better management and using advanced technologies conducive to a clean environment in the host country, known as the pollution halo hypothesis.

To expand the economy without compromising environmental quality, the application of renewable energy has been recommended. Where using renewable energy will reduce various impacts, especially the impact on the production of CO₂ emissions. The process of producing renewable energy does not involve as much carbon dioxide emissions as energy from fossil fuels (Kwakwa et al., 2020). In addition, the use of energy from renewable sources does not

cause carbon emissions (Adams et al., 2018) . Renewable energy consumption is still very limited, due to the high price of development and selling prices of renewable energy.

Based on the explanation above, it is necessary to examine the effect of GDP, FDI, Industrial Growth, Number of Motor Vehicles, and Renewable Energy on CO₂ emissions in ASEAN.

B. LITERATURE REVIEW

Sustainable Development

At conferences organized by the United Nations (UN) known as Conference on the Human Environment in Stockholm in 1972, the term "sustainable development economics" was first used. Sustainability is an organizational principle that aims to achieve human development goals. Improving the welfare and prosperity of society is the main goal of development. On the other hand, sustainable development means development of meeting needs. Achieving these goals requires an implementation strategy that includes equity, participation, diversity, integration and a long-term perspective with an ideal approach. In reality, the goal of sustainable development is to ensure that development is equal between current and future generations.

Environmental Kuznets Curve (EKC)

The Environmental Kuznets Curve (EKC) hypothesis is one way to study and analyze the problems of economic growth and environmental degradation in an area. The EKC hypothesis is a theory that seeks to explain the improvement in environmental quality that occurs at an increase in per capita income levels and is related to factors including changing output composition, the introduction of industrial technology, and consumer demand for better environmental quality, resulting in stricter environmental regulations. According to (Panayotou, 1994), the inverted U-shaped EKC is caused by three factors: scale, composition, and technology. Environmental pollution grows along with increasing per capita income due to economies of scale. When the economic structure changes from agrarian to industrial, environmental degradation increases, this is known as the compositional effect. Over time, this economic activity led to a slower decline in environmental quality. Finally, the relationship between income and environmental pollution depends on the

technology of production or the effects of technology, which indicates an increase in production technology in economic activities that is less damaging to the environment.

Carbon Dioxide Emissions

Carbon dioxide is a colorless, odorless and tasteless gas. Emissions are byproducts of burning fossil fuels that can damage the environment. Carbon dioxide compounds themselves, also known as charcoal acid substances, are chemical compounds consisting of one carbon dioxide atom covalently bonded and two oxygen atoms. Deforestation, forest fires, industrial activities, motor vehicles, and households contribute to increased air temperatures, resulting in higher carbon dioxide (CO₂) emissions in the air. Carbon dioxide concentrations are higher in urban areas than in rural areas due to more industrial and transportation activities.

Economic Growth

Economic growth reflects the welfare of the people in the country, economic growth is closely related to the increase in per capita output which is an important target of the government. If a country experiences economic growth, there is also a growth in per capita output related to an increase in the average income of the community in real terms and an increase in people's living standards. Economic growth is also used as an orientation of economic development planning. According to (Samuelson, Paul A., William, 2004) Economic growth describes when a country's ability to produce frontier (PPF) moves right or out, GDP or national output imaginably increases. Several factors can affect economic growth, but increasing the amount of production, improving the quality of human capital, creating new goods through innovation, and utilizing sustainable technologies can be key drivers of economic growth in many countries or regions (Todaro, M.P; Smith, 2012).

Foreign Direct Investment

According to (Suyatno, 2017) Foreign capital that enters the private sector directly or indirectly is called Foreign Direct Investment (FDI). Direct investment is a type of international investment that indicates a desire to gain investment in another country's economy. A direct investment relationship occurs when investors acquire 10 percent or more of common stock granting them voting rights in the company. Foreign

direct investment (FDI) is an important part of globalization and the world economy. Thus, foreign direct investment becomes a means to increase employment, technological development and productivity. And and can spur economic growth at the right time. Foreign capital contributes to the growth of the industry by increasing the overall cost of the economy and creating more job opportunities. Foreign capital brought not only money and machinery, but also engineering skills.

The Pollution Haven Hypothesis explains that industrial relocation that results in pollution from developed to developing countries as well as increased pollution in developing countries is due to strict environmental regulations in developed countries. Companies that receive foreign investment will be leveraged as tools to transfer polluting technology to regions with weak environmental regulations, just as more developed countries will try to transfer their polluting production facilities to developing countries to benefit from weak environmental regulations in developing countries. Thus, FDI will have a negative impact on the environment, especially in developing countries with weaker environmental standards (Kastratović, 2019).

Pollution Halo Hypothesis, in this theory, foreign direct financing by multinational corporations helps recipient countries reduce emissions through advanced technology and high-quality production methods. This will encourage industries to continuously increase their production levels to become more competitive. Thus, foreign investment accelerates industrial growth in the host country (Hergert & Marton, 2017) . (Zafar et al., 2019) finding evidence that FDI brings advanced technology and innovative products in the U.S. that can lower environmental pollution, it aligns with the Pollution Halo Hypothesis.

Industry Growth

Industry according to BPS is a facility or manufacturing unit that operates economically in a particular location with the aim of converting one thing mechanically, chemically, or manually into another thing that has higher value and is marketed to the end consumer. Industrial development along with agricultural development is the main objective of the development program. Indicators of development progress can be seen from the growth rate of a country's industry, especially in developing

countries. As stated by (Suseno, 1990), the main measure of industrial growth is the increase in the value of industry relative to GDP and to various commodities, such as agriculture, mining, industry, buildings, electricity, gas, and drinking water, among others.

Transportation

Transportation is one of the supports in the success of the economy. Transportation has a negative impact, one of which is causing air pollution. Motor vehicles are one part of transportation. Motor Vehicle is any vehicle driven by mechanical equipment in the form of machinery other than vehicles that run on rails, namely motorcycles, passenger cars, bus cars, freight cars, and special vehicles

Renewable Energy

Energy is an ability to do work and is necessary in the process of life. Renewable energy sources or can be referred to as alternative energy are energy sources whose regeneration period requires a fast cycle so that it will be available continuously for a very long time. The main advantage of using renewable energy resources is their availability throughout the year. With a one-time investment, we can draw energy for decades without affecting the environment (Alrikabi, 2014). Renewable energy resources include (Tromly & Pengelly, 2001): solar energy, geothermal energy, water energy, biomass, wind energy, marine energy.

Research Hypothesis

- Hypothesis 1: It is suspected that the GDP variable has a positive effect on carbon dioxide (CO₂) emissions in ASEAN.
- Hypothesis 2: It is suspected that FDI variables have a positive effect on carbon dioxide (CO₂) emissions in ASEAN.
- Hypothesis 3: It is suspected that the variable number of motor vehicles has a positive effect on carbon dioxide (CO₂) emissions in ASEAN.
- Hypothesis 4: It is suspected that industrial growth variables have a positive effect on carbon dioxide (CO₂) emissions in ASEAN.
- Hypothesis 5: It is suspected that renewable energy consumption variables negatively affect carbon dioxide (CO₂) emissions in ASEAN.

Hypothesis 6: It is suspected that GDP, FDI, number of motor vehicles, industrial growth, and renewable energy consumption together affect carbon dioxide (CO₂) emissions in ASEAN.

C. METHODOLOGY

Data Types and Sources

This study used a quantitative descriptive approach. This study examines how the influence of GDP, FDI, industrial growth, the number of motor vehicles, and renewable energy on the amount of CO₂. The data used in this study is secondary data in the form of panel data (a combination of time series and cross section data). The time series data is on an annual basis starting from 2010 to 2020, while the cross-section data consists of nine ASEAN countries, namely Indonesia, Brunei Darussalam, the Philippines, Cambodia, Malaysia, Singapore, Myanmar, Thailand, and Vietnam. The dependent variable used in this study was carbon dioxide (CO₂) emissions. The independent variables used in this study are GDP, FDI, industrial growth, number of motor vehicles, and renewable energy.

Analysis Methods

The analysis method used in this study was panel data regression. To prove the correctness of the hypothesis, data analysis is needed. To determine the effect of one independent variable on the dependent variable, the following formulation can be made:

$$CO2it = \beta_0 + \beta_1 GDPit + \beta_2 FDIit + \beta_3 JKit + \beta_4 INDit + \beta_5 RECit + e$$

Regression model after being transformed into logarithmic equations:

$$CO2it = \beta_0 + \beta_1 LOGGDPit + \beta_2 LOGFDIit + \beta_3 LOGJKit + \beta_4 INDit + \beta_5 RECit + e$$

Information:

CO ₂ it	= Carbon dioxide emissions (million tons)
GDPit	= GDP (billion US\$)
FDIit	= Foreign Direct Investment (billion US\$)

JK_{it} = Number of Motor Vehicles (thousands)

$INDI_{it}$ = Industrial growth (Value added (% of GDP))

REC_{it} = Renewable Energy (% of final energy)

$\beta_1 \beta_2 \beta_3 \beta_4 \beta_5$ = Coefficient

e = Error Term

Classical Assumption Test

When analyzing panel data, mak needs to meet several assumptions, namely: normality test, multicollinearity test, autocorrelation test, and heteroscedasticity test.

RESULTS AND DISCUSSION

Panel Data Model Selection

Table 1 Chow Test

Effect Test	Statistics	d.f	Prob.
Cross-section F	106,219937	(8,85)	0,0000
Cross-section Chi-square	237,366163	8	0,0000

Source: Processed evIEWS data 10, 2023.

Based on the results of the Chow test, it shows a probability value of 0.0000 smaller than the real level (α) 0.05 so that H_0 is rejected so that it can be concluded that the Fixed Effect Model model is more appropriate than the Common Effect Model.

Table 2 Hausman Test

Effect Test	Chi-Sq Statistics	Chi-Sq d.f	Prob.
Cross-section random	5,827128	5	0,3234

Source: Processed evIEWS data 10, 2023.

Based on the results of the hausman test, a probability value (P- value) of 0.3234 is greater than the significance level (α) of 0.05, then H_0 is accepted. This means that the Random Effect Model is the best model that can be used in research.

Table 3 Lagrange Multiplier (LM)

Null (no ran. Effect) Alternative	Cross-section One-sided	Period One-sided	Both
Breusch-Pagan	342,4111 (0,0000)	3,521681 (0,0606)	345,9328 (0,0000)

Source: Processed eviews data 10, 2023.

Based on the results of the lagrange multiplier test, the Breusch-Pagan probability value is 0.0000 or less than 0.05, so H0 is rejected. So, the best model chosen in this study is the Random Effect Model (REM)

Panel Data Model Regression Results**Table 4 Random Effect Model (REM)**

Variable	Coefficient	Std. error	t-Statistic	Prob
C	3,783299	2,384164	1,586845	0,1159
LOGGDP	0,293603	0,116132	2,528180	0,0132
LOGFDI	0,016274	0,037185	0,437642	0,6627
LOGJK	0,389832	0,075304	5,176785	0,0000
IND	0,020948	0,006162	3,399535	0,0010
REC	-0,013687	0,004592	-2,980639	0,0037

Source: Processed eviews data 10, 2023.

$$\text{LOGCO2it} = 3.783299 + 0.293603 \text{ LOGGDPit} + 0.016274 \text{ LOGFDLit} + 0.389832 \text{ LOGJKit} + 0.020948 \text{ INDit} - 0.013687 \text{ RECit}$$

β_0 = Value of 3.783299 means that if all independent variables are considered constant or do not change, carbon dioxide emissions will increase by 3.783299 million tons.

β_1 = Value 0.293603 means that when GDP in ASEAN countries increases by 1 billion US\$, carbon dioxide emissions will increase by 0.293603 million tons assuming other variables remain (ceteris paribus).

β_2 = Value of 0.016274 means that when FDI in ASEAN countries increases by 1 billion US\$, then carbon dioxide emissions will increase by 0.016274 million tons assuming other variables remain (ceteris paribus).

β_3 = Value of 0.389832 means that when the number of motor vehicles in ASEAN countries increases by one thousand, carbon dioxide emissions will increase by

0.389832 million tons assuming other variables are fixed (ceteris paribus).

β_4 = Value 0.020948 means that when industrial growth in ASEAN countries increases by 1 percent, carbon dioxide emissions will increase by 0.020948 million tons assuming other variables remain (ceteris paribus).

β_5 = Value -0.013687 means that when renewable energy consumption in ASEAN countries increases by 1 percent, carbon dioxide emissions will decrease by 0.013687 million tons assuming other variables remain (ceteris paribus).

Classical Assumption Test

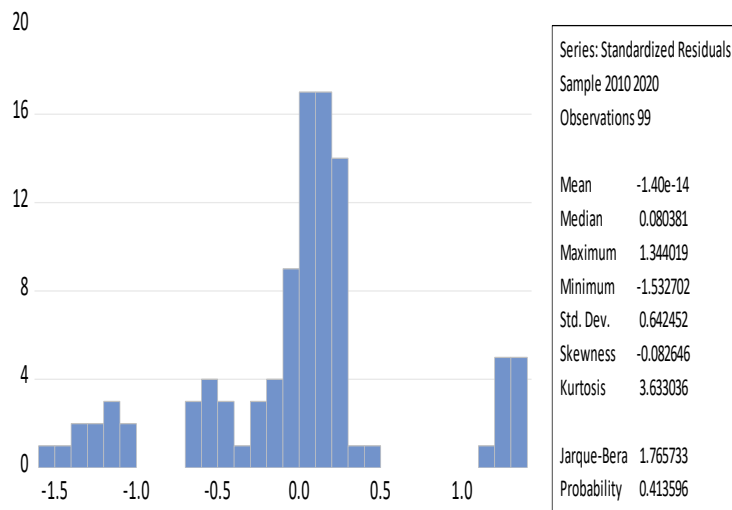


Figure 2. Normality Test.

Based on the test results, the probability value for the Jarque-Bera normality test is $1.765733 > 0.05$ (greater than 0.05), and the value is 0.413596. The normality test using Jarque-Bera data shows that the distribution is normal.

Table 5 Heteroscedasticity Test

Variable	Coefficient	Std. error	t-Statistic	Prob
C	2,122978	1,253703	1,693367	0,0937
LOGGDP	-0,088062	0,065416	-1,346175	0,1815
LOGFDI	-0,013906	0,023597	-0,589319	0,5571
LOGJK	0,051531	0,040203	1,281791	0,2031
IND	-0,002312	0,003493	-0,662001	0,5096
REC	0,001991	0,002402	0,828824	0,4093

Source: Processed eviews data 10, 2023.

From the test results above, it can be concluded that the REM model used in this study is free from heteroscedasticity because the value of each independent variable, namely GDP, FDI, industrial growth, the number of motor vehicles, and renewable energy is greater than $\alpha = (5\%)$.

Table 6 Autocorrelation Test

D count	DW	Du	DI	4-Du	4-dl
Value	1,025706	1,7799	1,5683	2,2201	2,4317

Source: Processed eviws data 10, 2023.

The test results show that the calculated DW is in the region of positive autocorrelation. But the method chosen in this study is REM with cross-section weights, so the method used in the study is the GLS (Generalized Least-square) method. So the output results can be concluded that the GLS method has accommodated the problem of otocorrelation (Gujarati, 2013).

Table 7 Heteroscedasticity Test

	LOGGD P	LOGFDI	LOGJK	IND	REC
LOGGD				-	-
P	1.0000	0.7796	0.6051	0.3329	0.2924
	00	79	04	40	62
LOGFD				-	-
I	0.7796	1.0000	0.3007	0.5510	0.2833
	79	00	10	05	56
LOGJK					-
	0.6051	0.3007	1.0000	0.0939	0.0822
	04	10	00	45	92
IND	-	-			-
	0.3329	0.5510	0.0939	1.0000	0.4012
	40	05	45	00	03
REC	-	-	-	-	
	0.2924	0.2833	0.0822	0.4012	1.0000
	62	56	92	03	00

Source: Processed eviws data 10, 2023.

The results of the multicollinearity test show that there is no variable whose value is greater than 0.80. Thus it can be said that there is no linear relationship between the independent

variables used in this study, or the variables used do not exhibit multicollinearity.

Test the hypothesis

Table 8 t-Statistical Test

Variable	t-stat	t-Table	Probability	Conclusion
LOGGDP	2.528180	1,66123	0.0132	H0 rejected
LOGFDI	0.437642	1,66123	0.6627	H0 accepted
LOGJK	5.176785	1,66123	0.0000	H0 rejected
IND	3.399535	1,66123	0.0010	H0 rejected
REC	-	1,66123	0.0037	H0 rejected
	2.980639			

Source: Processed eviws data 10, 2023.

Based on the results of the t test variables GDP, FDI, and industrial growth the probability value is smaller than (α) 5 percent (0.05), so it can be concluded that all independent variables namely GDP, FDI, industrial growth, number of motor vehicles, and renewable energy have an influence on carbon dioxide emissions in ASEAN countries.

Table 9 f-Statistical Test

f-Table	f-Statistics	Prob.	Conclusion
2,47	55.13944	0,000000	H0 rejected

Source: Processed eviws data 10, 2023.

Based on the results of the f test, it can be concluded that rejecting H0 and can be known the f-Statistics value of 55.13944 > the f-Table value of 2.47 with a probability value of 0.000000 < 0.05, so that statistically the variables GDP, FDI, industrial growth, number of motor vehicles, and renewable energy together have a significant influence on carbon dioxide emissions in ASEAN countries.

Results of the Coefficient of Determination (R²)

The R-Squared value based on the regression findings is 0.747760. With a value of 74.77%, GDP, FDI, industrial growth, the number of motor vehicles, renewable energy, and variable carbon dioxide emissions in ASEAN countries can be explained,

while 25.23% provides different explanations from the panel data regression model with a confidence level of 95 percent.

Discussion of Research Results

The Effect of GDP on Carbon Dioxide (CO₂) Emissions

The regression results show that GDP has a positive and significant effect on CO₂ emissions in ASEAN countries. This means that if GDP in ASEAN countries increases by 1 billion US \$ then CO₂ emissions will increase by 0.293603 million tons assuming other variables remain (*ceteris paribus*). These results are in accordance with studies conducted by ((María A. et al., 2017);(Poudel et al., 2009); (Sinha Babu & Datta, 2013)) which found a positive relationship between GDP and environmental damage as measured by CO₂ emissions levels. Increasing GDP will be followed by an increase in the amount of CO₂ emissions which causes a decrease in environmental quality in ASEAN. This is because the amount of economic activities carried out by a country in production, distribution and consumption that encourages economic growth will produce externality in the form of pollution which will then have an impact on increasing environmental damage. The use of energy in households for heating, cooling, and combustion also causes CO₂ emissions.

The Effect of FDI on Carbon Dioxide (CO₂) Emissions

Regression results show that FDI affects CO₂ emissions positively but not significantly to CO₂ emissions in ASEAN countries. This means that if FDI in ASEAN countries increases by 1 billion US \$ then CO₂ emissions will increase by 0.016274 million tons assuming other variables remain (*ceteris paribus*). The results showed that FDI did not have a significant effect on CO₂ emissions. This can be caused because incoming foreign investment has applied environmentally friendly energy and technology so that it does not produce too much CO₂ emissions, so it does not have a significant impact on environmental pollution. The insignificance of FDI to CO₂ emissions is because the host country has stricter environmental standards, foreign companies choose to be cautious and produce less pollution than local companies, foreign companies may have newer production methods that further suppress air pollution, and foreign companies may want to use less polluting technologies to avoid backlash from

their home countries (Kim & Adilov, 2012). The results obtained are the same as the results of the study (Kizilkaya, 2017) found no significant relationship between foreign direct investment and CO₂ emissions.

The Effect of the Number of Motor Vehicles on Carbon Dioxide (CO₂) Emissions

The regression results show that the number of motor vehicles affects CO₂ emissions positively and significantly to CO₂ emissions in ASEAN countries. This means that if the number of motor vehicles in ASEAN increases by one thousand, CO₂ emissions will increase by 0.389832 million tons assuming other variables remain (*ceteris paribus*). This is because the gas released by motor vehicles produces direct greenhouse gas emissions of carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) from the combustion of various types of fuel. The most significant exhaust emissions from motor vehicles into the atmosphere by mass, are carbon dioxide gas (CO₂), and water vapor (H₂O) resulting from complete fuel combustion which can be achieved by the availability of excess air supply. The results of this study are in line with the research conducted (Walsh et al., 2008) that motor vehicles have a positive influence on the amount of CO₂ emissions.

The Effect of Industrial Growth on Carbon Dioxide (CO₂) Emissions

Regression results show that industrial growth affects CO₂ emissions positively and significantly to CO₂ emissions in ASEAN countries. This means that if industrial growth in ASEAN increases by 1 percent, CO₂ emissions will increase by 0.020948 million tons assuming other variables remain (*ceteris paribus*). Judging from the results of the study (Pangestu, 2017) shows industrial growth has a positive and significant relationship with increased CO₂ emissions, and research results (Monika, 2015) (Monika, 2015) that industrial growth has a positive and significant impact on CO₂. The increase in the industrial sector can make pollution in developing countries even greater (Helda, N. P., Jamal, A., & Dawood, 2018). The growth of the industrial sector will have an impact on increasing the amount of CO₂ emissions and cause an increase in air pollution. In developing countries in the ASEAN region, it is still stuck in a phase of environmental destruction as their pollution levels increase every year. The increasingly massive industrial development in all countries accompanied

by the acceleration of technology has a significant impact on increasing CO₂ emissions. Industries that depend on fossil energy such as coal, oil, and natural gas in the production process or for power generation will produce high CO₂ emissions. Industrial activities dominated by the use of energy, consumption and various other resources can lead to increased environmental degradation through increased CO₂ emissions.

The effect of renewable energy consumption on carbon dioxide (CO₂) emissions

Regression results show that renewable energy consumption affects CO₂ emissions negatively and significantly to CO₂ emissions in ASEAN countries. This means that if renewable energy consumption in ASEAN increases by 1 percent, CO₂ emissions will decrease by 0.013687 million tons assuming other variables remain (*ceteris paribus*). This is because the use of renewable energy sources can reduce dependence on non-renewable energy sources, such as fossil fuels, which can contribute to an increase in CO₂ emissions in the air. Carbon dioxide emissions are a major contributor to climate change and global warming. These gases are produced from the burning of fossil fuels such as coal, oil, and gas, as well as through industrial processes and land use change. Therefore, reducing carbon dioxide emissions is essential to mitigate the effects of climate change (Wang & Wang, 2023). Renewable energy sources are sustainable and produce few greenhouse gases, making them an excellent alternative to fossil fuels. The adoption of renewable energy technologies has grown rapidly in recent years, with solar and wind being two of the fastest-growing sources of electricity in the world. As more countries and companies turn to renewable energy, reductions in carbon dioxide emissions are becoming more achievable (Wei et al., 2023). The results of this study are in accordance with the research (Hoa et al., 2023) that the consumption of renewable energy negatively affects environmental pollution.

D. CONCLUSIONS AND RECOMMENDATION

Conclusion

GDP has a positive and significant effect on the level of CO₂ emissions in ASEAN by 0.293603. This means that an increase in GDP will be followed by an increase in CO₂ emissions.

FDI has a positive insignificant effect on the level of CO₂ emissions in ASEAN by 0.016274. This means that the increase in FDI does not have a significant effect on increasing CO₂ emissions.

The number of motor vehicles has a positive and significant effect on the level of CO₂ emissions in ASEAN of 0.389832. This means that an increase in the number of motor vehicles will be followed by an increase in CO₂ emissions.

Industrial growth has a positive and significant effect on the level of CO₂ emissions in ASEAN of 0.020948. This means that increased industrial growth will be followed by increased CO₂ emissions.

Renewable energy consumption has a negative and significant effect on the level of CO₂ emissions in ASEAN by -0.013687. This means that an increase in renewable energy consumption will be followed by a decrease in CO₂ emissions.

GDP, FDI, industrial growth, number of motor vehicles, and renewable energy together have a significant influence on carbon dioxide emissions in ASEAN countries.

Recommendation

Development based on the green economy in the industrial sector can be carried out if the government is more oriented towards renewable resource power generation.

Research and Development, provides subsidies for Research and Development that produce environmentally friendly technologies such as R&D in the field of technology development and innovation to improve energy efficiency in sectors such as transportation, buildings, and industry to reduce production costs and increase efficiency.

Governments can provide incentives and financial support to encourage the use of renewable energy, such as low taxes or reduced costs of installing solar panels and reducing fossil energy subsidies to make renewables more economically competitive.

Increasing electric vehicles, because electric vehicles do not produce carbon dioxide emissions and can help reduce air pollution and provide public transportation so as to help reduce the number of motor vehicles on the road and carbon dioxide emissions.

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