The Effect of Economic Variables on CO₂ Emissions in 7 Asian Countries

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Abstract

This study aims to determine and analyze the direct and indirect effects of economic variables on carbon dioxide (CO2) emissions in 7 Asian countries during the 2010-2019 period. This research uses a descriptive quantitative approach and path analysis model. The results show that employment in the industry directly has an influence on CO2 emissions, the population has an influence on CO2 emissions, energy consumption has an influence on CO2 emissions, and FDI has an influence on CO2 emissions. Whilindirectly employment in the industry has no effect on CO2 emissions through economic growth, the population has no influence on CO2 emissions through economic growth, energy consumption has no effect on CO2 emissions through economic growth, and FDI has an influence on CO2 emissions through economic growth.

Keywords: *Carbon Dioxide Emissions (CO2), Economic Variables, Material Balance Model, Economic Growth*

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INTRODUCTION

In recent years, climate change and global warming are increasing on earth. Global warming is the process of releasing greenhouse gases (GHG) into the atmosphere which results in an extreme increase in the earth's surface temperature (Riebeek, 2010). Climate change is a global challenge in influencing shared prosperity. The negative impacts of climate change include rising sea surface temperatures, extreme weather

intensity, changes in rainfall patterns, and large waves (Nurhayati et al, 2020). Increasing climate change and global warming will not only have an impact on environmental damage. However, climate change also has an impact on development, is a humanitarian threat, and knows no boundaries.

The issue of climate change attracts the attention of all parties. In overcoming this, international agencies realized it through global actions including the Stockholm Declaration (1972), Rio Earth Summit (1992), Kyoto Protocol (1997), Bali Action Plan (2007), Paris Agreement (2015), climate change summit in Bonn (2017), and the Netherlands CAS Summit (2021).

Environmental scientists who are members of the Intergovernmental Panel on Climate Change (IPCG) say that the main factor for global warming is greenhouse gas emissions. Where in greenhouse gas emissions there are emissions of carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and F gas. Carbon dioxide gas (CO_2) is a greenhouse gas that is one of the main causes of global warming (Ghosh, 2010).
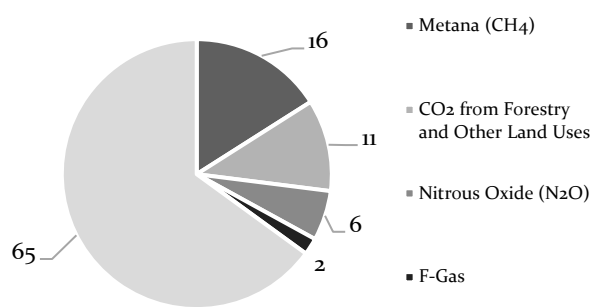

Figure 1. Greenhouse Gas (GHG) Emissions by Gas Type in 2010 (percent)
Source: EPA in IPCC, 2014

CO_2 emissions are the biggest contributor to greenhouse gases (GHG). Where 76 percent of greenhouse gases come from CO_2, which consists of 65 percent CO_2 from fossil fuels and industrial processes and 11 percent CO_2 from forestry and other land uses.

Increased economic growth is needed, especially for developing countries. However, the growth of environmental quality also needs to be considered to prevent global warming maintain human life. The Environmental Kuznet Curve (EKC) describes the relationship between economic growth and environmental degradation. The EKC approach was first introduced by (Grosman and Krueger, 1991).

The inverted U-shaped EKC hypothesis is about the relationship between the environment and economic growth. The early stages of improvement in the economy will cause environmental degradation which results in increased pollution. However, after the economy reaches a certain threshold the trend will reverse, where the economy of a region will continue to increase but there is an improvement in the environment (Kizilkaya, 2017).

The EKC hypothesis claims that the early stages of a country's development process will lead to environmental degradation. However, after reaching a certain level of the economy the process will be reversed, and there will be a process of improvement in the environment. This is in line with research conducted by Kolstad and Krautkraemer (1993) where economic growth causes negative effects on the environment and tends to be cumulative. In addition, the impact will be more visible in the long term. Therefore, the development of environmental quality is very necessary apart from the development of the economic sector (Todaro et al., 2009).

Based on Figure 2, global CO_2 emissions are grouped into eight regions including Africa, Asia, Central America, Middle East Europe, North

America, Oceania, and South America. Based on the data above, the development of CO_2 emissions in the eight regions is different. The Asian region is the region that produces the highest amount of CO_2 emissions among the seven other regions. The development of the number of CO_2 emissions in the Asian region from 1995 to 2019 has an upward trend. In 1995, CO_2 emissions produced by countries in the Asian region were 7.047 MtCO2 and continued to increase until 2019 to 17.588 MtCO2, or an increase of 149 percent from 1995.
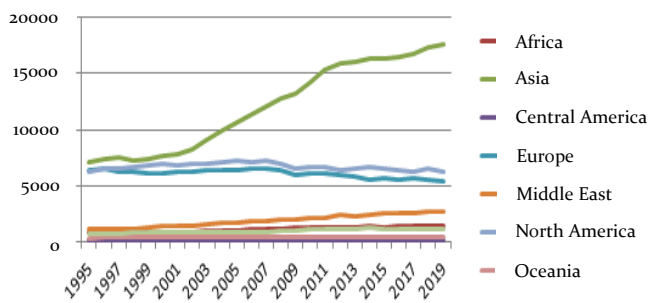

Figure 2. Total CO_2 Emissions by Regions (MtCO2)

Source: Globalcarbonatlas, 2020

The very high amount of CO_2 emissions in the Asian region is caused by the economic sector in Asian countries which is dominated by the industrial sector. It is estimated that the number of emissions in the Asian region will continue to grow, along with a large number of industries in the Asian region. In addition, the very high population in the Asian region has the potential to increase the number of CO_2 emissions produced. This is because industrial processes and other economic activities require a large amount of energy in the production process. The following is data on the development of the number of CO_2 emissions in 7 Asian countries during the 1960-2019 period.

Based on figure 3 shows that China is the country with the largest amount of CO_2 emissions during 1960-2019. In 2019, China's CO_2 emissions were 10.175 MtCO2. Meanwhile, the country with the lowest amount of CO_2 emissions in 1960-2019 was the Philippines. The increase in CO_2 emissions is caused by high emissions from fossil fuels, high growth in the industrial sector, and cement which has a major influence on Greenhouse Gas (GHG) emissions. The use of energy and the establishment of industries that are not environmentally friendly in the long term will increase the number of CO_2 emissions.

Panayotou (1993) states that when the economic structure shifts from the agricultural sector to the industrial sector, this will be followed by environmental degradation. In the Environmental Kuznet Curve (EKC) theory, it is explained that the early stages of economic improvement, will be accompanied by an increase in environmental damage. This happens to a certain extent, where the economy will increase but environmental degradation will gradually improve. This is because there is public awareness of the importance of maintaining environmental sustainability. Liu & Bae (2018) found that industry has a positive and significant effect on CO_2 emissions.

Economic growth is one of the goals to be achieved by a nation. However, in realizing a high level of economic growth, the reality is that environmental quality must be sacrificed. The increase in economic growth is due to an increase in goods and services due to an increase in community demand that must be met. The increase in economic growth in the seven Asian countries is in line with the increase in CO_2 emissions in each of these countries. Based on World Bank data in 2010 China was the country

with the highest economic growth compared to six other countries, namely 10.636 percent, and decreased to 5.95 percent in 2019. Meanwhile, Indonesia was the country with the lowest economic growth in 2010 at 6.24 percent.
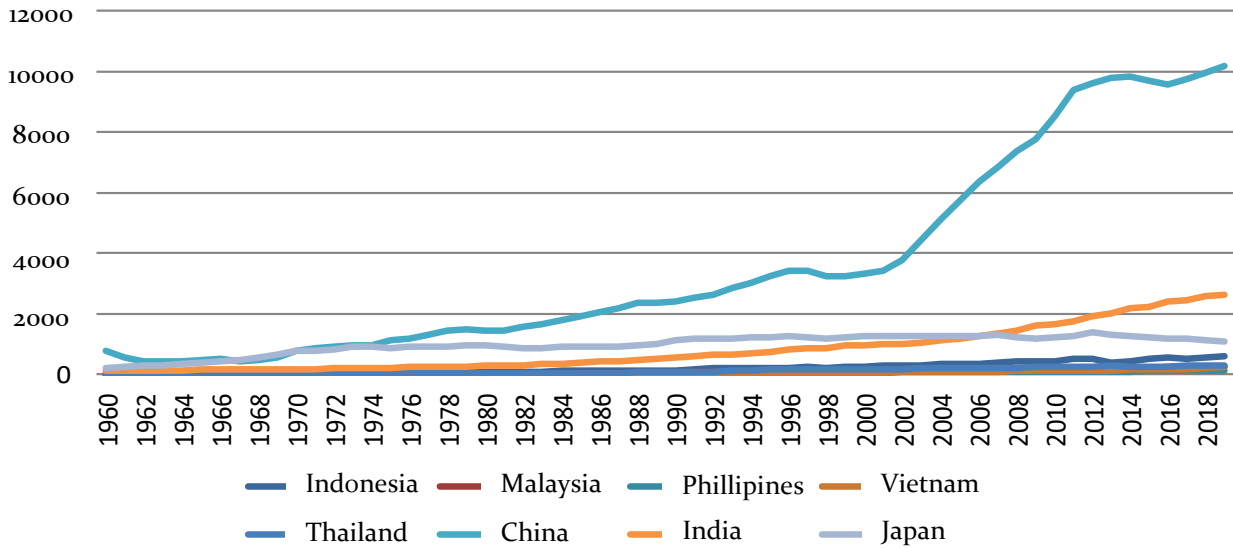

Figure 3. Total CO2 Emissions in 8 Countries in Asia (MtCO2)

The magnitude of economic growth in each of these countries is dominated by the industrial sector. The proportion of China's industry in 2010 to GDP was 46.5 percent and decreased to 38.6 percent in 2019 (World Bank, 2019). Meanwhile, the proportion of Industry in Indonesia's GDP in 2010 was 42.8 percent and decreased to 38.9 percent in 2019 (World Bank, 2019).

The initial stage of a country's economy will focus on how the economy is able to develop rapidly. One way to do this is through economic development through the industrial sector because it is believed to be able to absorb a high workforce. At this stage, the environment has not become the main focus. Based on World Bank data, it is known that China is the country with the highest proportion of workers in the industrial sector to total workers compared to six other countries. This is in line with the number of CO2 emissions produced by China. In 2010 the proportion of workers in the industrial sector to total workers in China was 28.7 percent and decreased to 27.42 percent in 2019.

Meanwhile, the Philippines is a country with the lowest proportion of workers in the industrial sector to total workers compared to six other countries. The number of workers in the Philippine industrial sector in 2010 was 15.72 percent and rose to 19.12 percent in 2019.

Development and population are two things that cannot be separated. This is because development will not occur without a population, while the population will not prosper without development. Hanif and Gago-de-Santos (2017) state that the developing countries have a high rate of population growth while their resources are very limited. This condition can hinder the production of goods and services if accompanied by poor economic performance. The high population growth causes aggregate demand to

increase in the short term, resulting in excess demand. To meet the excess demand, the state will exploit resources excessively. This is exacerbated by unstable economic conditions, causing aggregate supply to fall. In short, a country with a high population growth rate accompanied by poor economic performance will make it difficult for the country to reach the turning point of the Kuznets Theory. In the end, the damage to the environment cannot be suppressed, and CO2 emissions continue to rise.

Asia is one of the most populous regions in the world. A large number of residents will affect the amount of energy consumption. The following is a graph of the population of seven countries on the Asian continent from 2010-2019.

Table 1. Total Population of Seven Asian Countries 2010-2019 (people)

Year	Indonesia	Malaysia	Philipines	Vietnam	Thailand	China	India
2010	241.8	28.2	93.0	88.0	67.2	1,368.8	1,234.3
2011	245.1	28.7	95.6	88.9	67.5	1,376.5	1,259.3
2012	248.5	29.1	97.2	89.8	67.8	1,384.2	1,280.8
2013	251.8	29.5	98.9	90.8	68.1	1,391.9	1,295.6
2014	255.1	29.9	100.5	91.7	68.4	1,399.5	1,295.6
2015	258.4	30.3	102.1	92.7	68.7	1,406.8	1,310.2
2016	261.6	30.7	103.7	93.6	69.0	1,414.0	1,324.5
2017	264.7	31.1	105.8	94.6	69.2	1,421.0	1,338.7
2018	267.7	31.5	106.7	95.5	69.4	1,427.6	1,352.6
2019	270.6	31.9	108.1	96.5	69.6	1,344.8	1,366.4

Source: World Meter, 2020

Based on table 1, it is known that China is the country with the largest population. The total population of China in 2019 was 1,433,783,686 people. Meanwhile, the country with the lowest population is Malaysia with a population of 31,949,777 people in 2019.
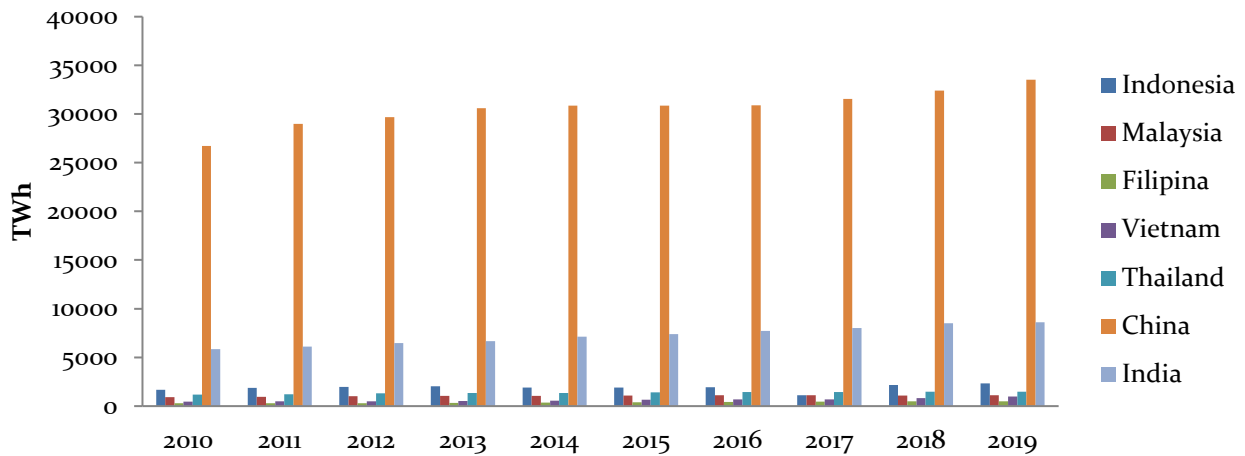

Figure 4. Fossil Energy Consumption in 7 Asian Countries
Source: Our World in Data, 2020

The use of energy consumption is one of the optimal ways to move the economy through the industrial sector as well as a means of accumulating development capital to produce outputs in the economy (Perman & Stern, 2003). In Asian countries, the use of fossil energy still dominates. The use of fossil energy in the long term will increase the number of CO2 emissions in the air and have an impact on environmental degradation.

Based on Figure 4, it is known that China is the country with the highest fossil energy consumption in 2019, which is 33.512 percent. Meanwhile, the country with the lowest consumption of fossil energy compared to the other six countries is the Philippines. The Philippines' fossil energy consumption in 2019 was 497 TWh.

Investment is a component of Gross Domestic Product (GDP), so the addition that occurs in investment will result in an increase in GDP. However, the increase in economic growth and the movement of capital in the world has become a debate on environmental degradation.

Many developing countries still ignore environmental problems with the aim of attracting FDI so that the country's economic growth increases. So that FDI exacerbates environmental problems in developing countries. In the literature of Kizilkaya (2017) this situation is called the Pollution Haven Hypothesis.

In recent times FDI has become a symbol of the trend of international economic integration. In addition, FDI has an important role in efforts to reduce development inequality and encourage global economic development (Randelovic, Mihajlov, and Kerkovic, 2013). It is undeniable that developing countries need FDI to increase their economic growth. Developing countries are the main destination for developed countries to invest.

Shao (2018) proves that FDI has a greater impact on environmental damage to the host country than the country of origin. Investments in manufacturing have an increasing impact on environmental degradation compared to investments in the non-manufacturing sector.
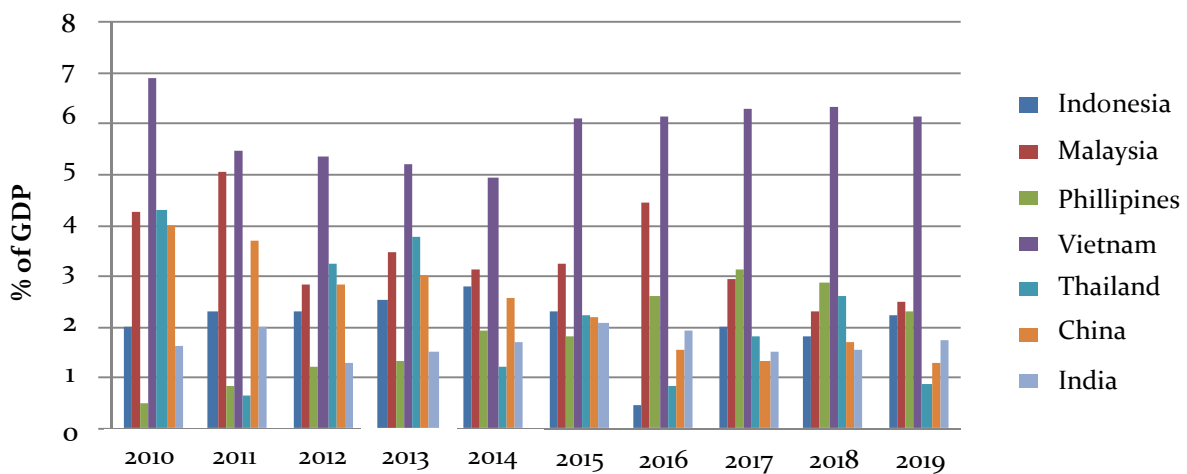

Figure 5. FDI Net Inflow in 7 Asian Countries
Source: World Bank, 2020

FDI net inflow growth in seven Asian countries fluctuated from year to year. Vietnam is the country with the largest FDI net inflow contribution to GDP compared to six other countries in the Asian region. In 2019, FDI net inflow into Vietnam was 6.15 percent. Then the country with the lowest FDI net inflow contribution in 2019 was the Philippines, which was 2.41 percent.

Based on the explanation above, the authors are interested in conducting further research to find out how economic growth, employment in industry, population, energy consumption, and foreign direct investment has a direct and indirect effect on CO2 emissions in 7 Asian countries during the 2010-2019 period.

RESEARCH METHODS

This study uses descriptive and verification methods using a quantitative research approach. Starting from data collection, and processing on the variables used to the explanation stage on the results of the data that has been processed. Descriptive research is research that aims to determine the value of a variable independently, be it one or more variables, but without making comparisons between one variable and another. While the verification method is a method that aims to determine the causal relationship between one variable and another variable.

The data used in this study is panel data (pooled data), which is a combination of data between individuals (cross-section) and time series data (time series). This study uses data from a time period of 10 years between 2010-2019 in seven Asian regions, so the number of observations used is 70 data. The data used in this study are secondary data obtained from the official website of Global Carbon Atlas, World Bank, Our World in Data, World Meter, and Unctadstat.

The method used in this research is a quantitative method. Then the processing of the existing data is carried out so that the results are in accordance with the objectives of the research. In conducting processing, researchers use path analysis (path analysis). Path analysis is an extension of the regression model used to analyze causal relationships that occur in multiple regression, if the independent variable affects the dependent variable not only directly, but also indirectly (Setyaningsih, 2020:149).

The model used in the study can be said to be good if it meets the BLUE (Based, Linear, Unbiased, Estimator) properties, namely when it meets the classical assumptions or avoids problems of normality, multicollinearity, autocorrelation, and heteroscedasticity. However, prior to the classical assumption test, the model was tested using three approaches, namely the common effect, fixed effect, and random effect to determine the best model.

In path analysis, you must go through several tests including hypothesis testing which consists of a partial test (t-test), a joint test (F-test) and the coefficient of determination (R_2,) and a mediation effect test (Sobel test). The Sobel test will produce a standard error of the indirect effect of X on Y_2 through the mediation of Y_1, namely the coefficient ab, with the standard deviation of ab as follows:

$$S_{ab} = \sqrt{b^2 Sb^2 + a^2 Sb^2}$$

$$Z = \frac{ab}{\sqrt{(b^2 SEa^2) + (a^2 SEb^2)}}$$

The calculated Z value is compared with the critical value, which is 1.96. If the calculated Z

value is > 1.96, it indicates that there is a mediating effect of the y_1 variable on testing the relationship between X and Y2. This study uses 4 independent variables, I intervening variable, and 1 dependent variable. The structural equation in the path analysis in this study is formulated in the following equation:

$$GDP\ Growth_{it} = \beta_0 + \beta_1\ EMP_{it} + \beta_2\ POP_{it} + \beta_3\ EC_{it} + \beta_4\ FDI_{it} + \mu_{it}$$

$$CO2_{it} = \beta_0 + \beta_5\ EMP_{it} + \beta_6\ POP_{it} + \beta_7\ EC_{it} + \beta_8\ FDI_{it} + \beta_9\ GDP\ Growth_{it} + \mu_{it}$$

When CO2 is carbon dioxide emissions, GDP Growth is economic growth, EMP is employment in industry, POP is population, EC is energy consumption, FDI is net inflow, β is regression coefficient, i is seven asian countries, t is year-t (2010-2019), μ is error (confounding factors outside the model).

The first equation model uses the combined data and then is estimated using the Random Effect Model (REM) approach. Where this model has the assumption that each individual (cross section data) has a different intercept, but the intercept is assumed to be a random or stochastic (Widarjono, 2013:234). The equation of the random model is as follows:

$$GDP\ Growth_{it} = \beta_0 + \beta_1\ EMP_{it} + \beta_2\ Log^\wedge POP_{it} + \beta_3\ Log^\wedge EC_{it} + \beta_4\ FDI_{it} + \mu_{it}$$

The model in the second equation is estimated using the Fixed Effect Model (FEM) approach. The characteristic of the fixed effect model approach is to capture the difference in the intercept by using the dummy variable technique (Widarjono, 2013). The equation using the fixed effect model is formulated as follows:

$$Log^\wedge CO2_{it} = \beta_0 + \beta_5\ EMP_{it} + \beta_6\ Log^\wedge POP_{it} + \beta_7\ Log^\wedge EC_{it} + \beta_8\ FDI_{it} + \beta_9\ GDP\ Growth_{it} + \mu_{it}$$

This study uses the variable CO2 emissions (CO2) as the dependent variable, namely the variable that is influenced by other variables. CO2 emissions are expressed in one MtCO2 recorded in the Global Carbon Atlas in the period 2010 to 2019. The intervening variable is a variable that influences the relationship between the independent variable and the dependent variable to be indirect (Sugiyono, 2016:66).

This study uses 1 intervening variable, namely economic growth. The unit used in economic growth is percent. Economic growth data is taken from the World Bank website for the period 2010 to 2019. Independent variables or independent variables are variables that influence or cause changes or the emergence of the dependent variable (Sugiyono, 2016:64).

Employment in industry, is a variable that affects CO2 emissions and economic growth. Employment in industry is expressed as one percent of total workers. Employment in industry data is obtained from the World Bank. Population is a variable used to see its effect on CO2 emissions and economic growth. The unit of population is expressed in people. Population data was obtained from World meter from 2010 to 2019.

Energy consumption is a variable used to see the relationship and influence on economic growth and CO2 emissions. Energy consumption is expressed in units of TWh. Energy consumption data is sourced from the Our World in Data website using the years 2010-2019. FDI net inflow is used to see the relationship and influence on CO2 emissions and economic growth. The data used is obtained from Unctadstat and the unit of FDI is percent of GDP.

RESULTS AND DISCUSSION

Based on the results of the tests that have been carried out on the equations of model 1 in and model 2, it can be described in the path analysis diagram as follows:
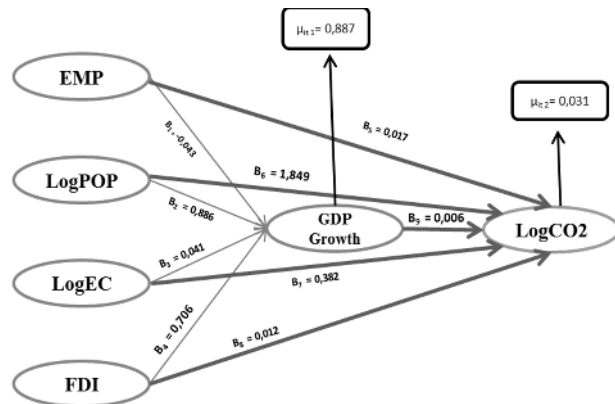

Figure 6. Path Analysis Equation Model
Source : Data Processed, 2022

In figure 6, it is known that the coefficient of determination of each independent variable the dependent variable. Then it can be written in the structural equation as follows:

$$GDP\ Growth_{it} = \beta0 - 0.043EMP + 0.886Log^{\wedge}POP + 0.041Log^{\wedge}EC + 0.706FDI + \mu_{it}$$

$$Log^{\wedge}CO2_{it} = \beta0 + 0.006GDP\_Growth + 0.017EMP + 1.849Log^{\wedge}POP + 0.382Log^{\wedge}EC + 0.012FDI + \mu_{it}$$

From the various tests that have been carried out, it is known the magnitude of the direct effect. Then for the indirect effect, the Sobel test was carried out using the Sobel Test Calculator for the Significance of Mediation application. So that the following results are obtained:

Table 7. Results of Path Analysis of Direct Effect and Indirect Effect

Variable Name	Standard Coefficient	Direct Effect	Indirect Effects
Economic growth	0.0006	5.7860	-
Employement In Industry	0.017	10.2816	-0.3699
Population	1.849	10.1946	1.3043
Energy Consumption	0.382	6.7416	0.0544
Foreign Direct Investment	0.012	6.6927	3.2958

Source: 9.0 Output Results

Based on table 7, it is obtained that the t-count value has a direct effect on each of the variables GDP Growth (5.7860), EMP (10.2816), Log^POP (10.1946), Log^EC (6.7416), and FDI (6.6927) partially has a significant effect on CO₂ emissions. Meanwhile, indirectly, the t-count value of FDI (3.2958) means that it partially has a significant influence on CO₂ emissions through economic growth. while the t value for each variable EMP (-0.3699), Log^POP (1.3043), and Log^EC (0.0544) has no effect on CO₂ emissions

through economic growth in 7 Asian countries. Economic growth on CO₂ emissions according to research by Hanif et al (2019).

This could be due to an increase in production, distribution, and consumption activities. To overcome this increase, high resources are needed. The increase in production, distribution, and consumption activities in an aggregate manner can increase economic growth which in turn increases CO₂ emissions. The increase in industrial sector workers is able to

increase co2 emissions according to research (Li & Zhou, 2019). The increase in emissions occurs through the industrialization process. The more industries that are established, the higher the absorption of labor, thereby increasing CO_2 emissions. During the process of expansion of the industry, high energy consumption is also required, resulting in an increase in CO_2 emissions.

Research by Li & Zhou (2019) and Yudatama & Fafurida (2022) states that an increase in population affects an increase in co2 emissions. A high population stimulates increased emissions through burning fossil fuels in the transportation sector and household needs such as cooking etc. A high population supports high mobility from one place to another, so high energy consumption is required. According to research by Farabi & Abdullah (2020), increasing energy consumption can increase CO_2 emissions because countries in the world still depend on fossil energy as the main fuel that produces large amounts of CO_2 emissions, such as coal and oil.

The increase in FDI affects the increase in co2 emissions according to the pollution hypothesis theory. The hypothesis explains that companies will prefer to invest in countries that have looser environmental regulations. So industries that pollute the environment will move from countries with strict regulatory systems to countries with loose regulations.

One of the reasons for the absence of employment in the industry on economic growth is the existence of workers who have labor unions who will try to fight for the interests of workers by decreasing wages. If wages are lowered, people's income will decrease, so purchasing power is low. This causes public consumption to decline thereby lowering prices and then the level of productivity will decrease which will affect economic growth.

The population has no effect on CO_2 emissions through economic growth because the population variable has no effect on economic growth. The research of Yenny & Anwar (2020) explains that a large population does not make a productive contribution to an area. This is because the people in it do a lot of import spending outside the region so the large population does not affect economic growth. Energy consumption has no effect on CO_2 emissions through economic growth. This is because there is no influence of energy consumption on economic growth.

Michael & Jamelkova (2013) state that the shape of a country's economic structure is efficient in using energy. In addition, this is due to the economic structure of a country that is at the stage of a service-industry-based state. So that the share of GDP for industry and services is only slightly adrift, this causes energy consumption to have no effect on economic growth. The effect of FDI on CO_2 emissions through economic growth according to Shao (2018) FDI has proven to have a very large impact on destination countries compared to origin countries, especially in increasing environmental damage caused by CO_2 emissions.

Foreign direct investment is also indicated to be capable of causing environmental damage through investment in the manufacturing sector, while non-manufacturing FDI investment is not indicated to increase environmental damage in developing countries. Then FDI is also detected to have an influence on CO_2 emissions in middle-income countries compared to low-income countries. investors tend to invest in middle-income countries because of infrastructure

readiness as well as economic stability and political conditions.

CONCLUSION

Employment in industry, population, energy consumption, and FDI variables have a direct effect on CO_2 emissions. Then FDI partially affects CO_2 emissions through economic growth. Meanwhile, employment in industry, population, and energy consumption partially have no effect on CO_2 emissions through economic growth in 7 Asian countries from 2010-2019. Regions so that large population has no effect on economic growth.

Based on the results of this study, it can be concluded that economic activities should use good technology that is friendly and safe for the environment. Thus, it has an impact on reducing pollution and the resulting pollution. In addition, the use of environmentally friendly technology can reduce the operating costs of economic actors.

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