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The Determinants of Carbon Dioxide Emissions in the five Asia Pacific Countries

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Abstract

This research was motivated by the high contribution and growth of CO_2 emissions in Asia Pacific. The study aims to analyze the influence of population, GDP per capita and hydroelectricity consumption on environmental degradation in 5 Asia Pacific countries using indicators of carbon dioxide emissions. The method used was regression analysis of panel data with the support of EViews 10 software. The Data obtained from BP Statistical Review of World Energy, World Bank and Worldometers which are combinations of cross section data, namely 5 countries in Asia Pacific region, including: China, India, Japan, South Korea and Indonesia and time series data from 2000-2019. The results of this study showed that the population, the GDP per capita and the hydroelectricity consumption has a positive effect on CO_2 emissions.

Keywords: ***Emissions, Population, GDP Per Capita, Hydroelectricity Consumption***

Abstrak

Penelitian ini dilatar belakangi oleh tingginya kontribusi dan pertumbuhan emisi CO_2 di Asia Pasifik. Studi ini bertujuan untuk menganalisis pengaruh jumlah penduduk, PDB per kapita dan konsumsi PLTA terhadap degradasi lingkungan di 5 negara Asia Pasifik dengan menggunakan indikator emisi karbon dioksida. Metode yang digunakan adalah analisis regresi data panel dengan dukungan software EViews 10. Data diperoleh dari BP Statistical Review of World Energy, World Bank dan Worldometers yang merupakan gabungan antara data silang tempat, yaitu 5 negara di kawasan Asia Pasifik, meliputi: China, India, Jepang, Korea Selatan dan Indonesia dan data runtut waktu dari tahun 2000-2019. Hasil dari penelitian ini menunjukkan bahwa jumlah penduduk, PDB per kapita dan konsumsi PLTA berpengaruh positif terhadap emisi CO_2.

Kata Kunci: Emisi, Jumlah Penduduk, PDB Per Kapita, Konsumsi PLTA

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INTRODUCTION

Environmentally friendly development is known as sustainable development (Pujiati, 2015). That is, economic activity must run together with the environment in order to create an ecological balance (Mehrizi et al., 2012). The existence of sustainable development goals as a new global action plan for the period 2016-2030 is expected to be able to end poverty, and inequality and protect the environment.

United Nations (2016) stated that the SDGs contain 17 goals and 169 targets in order to continue the efforts and achievements of the Millennium Development Goals (MDGs) which ended at the end of 2015, including: (1) eliminating poverty, (2) ending hunger, (3) good health and welfare, (4) quality education, (5) gender equality, (6) access to clean water and sanitation, (7) clean and affordable energy, (8) decent jobs and economic growth, (9) infrastructure, industry and innovation, (10) reduce inequality, (11) sustainable cities and communities, (12) responsible consumption and production, (13) handling climate change, (14) safeguarding marine ecosystems, (15) safeguarding terrestrial ecosystems, (16) strong peace, justice and institutional and (17) partnerships to achieve goals.

Climate change is a threat in the 21st century as global temperatures rise (Fauzi, 2017). Current and future climate change is no longer triggered by natural events such as solar radiation or volcanic eruptions, but rather caused by several human activities, for example through burning coal, oil, wood or forest clearing on a large scale.

The United Nations Frameworks Convention on Climate Change comes as an international consensus that came into force in 1994 aimed at stabilizing greenhouse gas concentrations. The Kyoto Protocol, an international treaty derived from the UNFCCC, intends to limit emissions in developed countries responsible for high concentrations of greenhouse gases, both through self-enterprise schemes or with international assistance.

The UNFCCC classifies greenhouse gases into 6 types, among others: CO_2 (carbon dioxide), CH_4 (methane), N_2O (nitrous oxide), HFCs (hydrofluorocarbons), PFCs (perfluorocarbons) and SF6 (sulfur hexafluoride). According to the IPCC (2014), the composition of the world's greenhouse gases is dominated by carbon dioxide (CO_2) as the main cause of global warming, namely by 76%, methane (CH_4) by 16%, nitrous oxide (N_2O) by 6% and high potential gases of global warming by 2% that can be seen on figure 1.

That is, the percentage of CO_2 reaches 3/4 of the world's total greenhouse gas emissions. Carbon dioxide is an essential greenhouse gas as the main cause of global warming buried in the atmosphere due to human activities (Pratama, 2019).

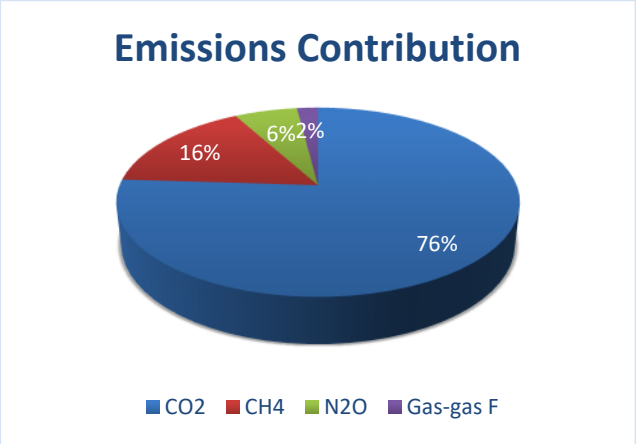

Figure 1. Composition of World GHG Emissions Source: Intergovernmental Panel on Climate Change, 2014

There is a need for cooperation between countries related to the current increase in emissions. Carbon dioxide emissions increased to 33,513 metric tons in 2018, bigger than the previous year's that is only 32,837 metric tons. Judging from figure 2 it can be concluded that the increase in CO2 emissions almost occurs every year and is experiencing an increasing trend (2009-2014 and 2016-2018).

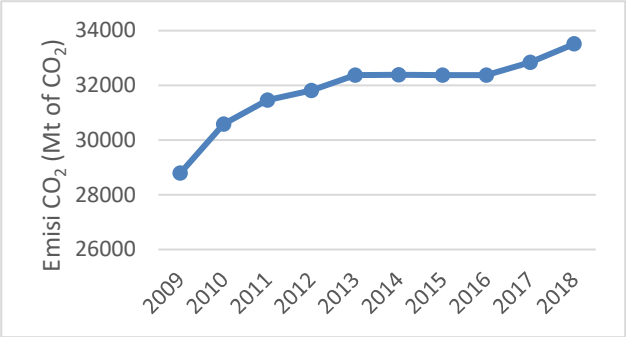

Figure 2. World CO2 Emissions in 2009-2018 (Metric Tons)
Source: International Energy Agency, 2021

The highest CO2 emissions in 2018 were due to Asia Pacific as the region with the highest contribution value when compared to 6 other regions in the world, including: North America, S. & Cent. America, Europe, CIS, Middle East, and Africa. According to data from the BP Statistical Review of World Energy (2020), the Asia Pacific region's contribution reached 50.5% in 2019 from the world's total CO2 emissions that can be seen on figure 3.

The Asia Pacific region, which contributes more than half of the world's total CO2 emissions, indicates that the region needs to get an extra attention to achieve sustainable development goals. According to the classification of regions in the world, Asia Pacific became the region that had the second largest growth value of carbon dioxide emissions in 2019, which was 2.4% after the Middle East region which took first place with a value of 2.8% (see table 1).

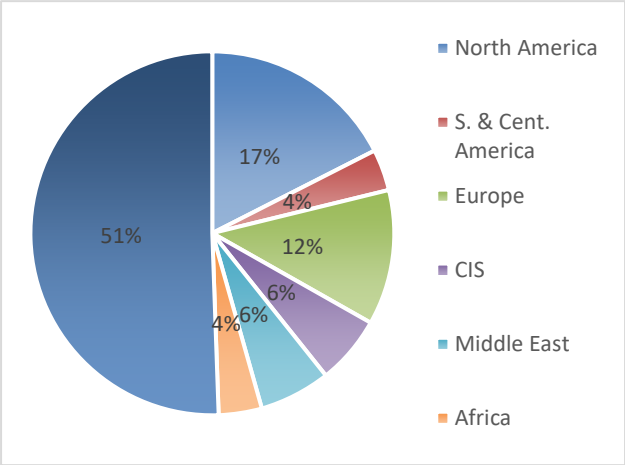

Figure 3. Contribution of Regional CO2 Emissions in the World in 2019 (Percent)
Source: BP Statistical Review of World Energy, 2020

While other regions have negative growth values, except the African region which indicates that the growth rate of CO2 emissions in the region is decreasing or is experiencing improvements in environmental quality, especially the European region which has the highest negative CO2 emission growth value, which is -3.2%. More than 18 countries are joining in Asia Pacific region.

According to the BP Statistical Review of World Energy (2020) report, China contributed the highest carbon dioxide emissions among other countries, amounting to 28.8% in 2019 of the world's overall CO2 emissions, followed by India at 7.3%, Japan at 3.3%, South Korea at 1.9%, and Indonesia at 1.8%. The focus of this study is on these 5 countries. Population is all a person domiciled in a particular region in accordance

with the provisions of applicable law. Population can be one of the factors that affect CO_2 emissions, because more and more people then the demand for goods and services increases which has an impact on the depletion of SDA and environmental pollution (Suparmoko, 1997).

Table 1. CO_2 Emissions Growth Region in the World in 2019 (Percent)

Area	CO_2 Emissions Growth
North America	-2,8%
S. & Cent. America	-0,7%
Europe	-3,2%
CIS	-0,5%
Middle East	2,8%
Africa	1,9%
Asia Pacific	2,4%

Source: BP Statistical Review of World Energy, 2020

According to Johnson et al. (2019) in his book entitled "An Introduction to Geology", the link between population numbers and carbon dioxide emissions is outlined in the Anthropogenic Global Warming Theory (AGW) which states that greenhouse gas emissions come from human activities that are a major factor in climate change.

China as the first rank contributor to carbon dioxide emissions has the highest population among all countries in the Asia Pacific region, even becoming the number 1 highest population in the world, which is 1,439,323,776 people or 18.47% of the total world population in 2020 (Worldometer, 2021). Similarly, India and Indonesia are ranked in the top 5 highest populations in the world, which amounted to 1,380,004,385 and 273,523,615 people (see table 1. 2). This situation causes the Asia Pacific region to be very vulnerable in producing greenhouse gas emissions in the form of carbon dioxide.

Table 2. Population of 5 Asia Pacific Countries in 2020 (Million People)

Country	Population	Population Share
China	1.439.324	18.47 %
India	1.380.004	17.70 %
Japan	126.476	1.62 %
South Korea	51.269	0.66 %
Indonesian	273.524	3.51 %

Source: Worldometer, 2021

Another factor affecting carbon dioxide emissions is economic growth. According to Kuznet in Jhingan (2013), economic growth is interpreted as the process of increasing long-term capacity in a country determined by technological, institutional, and ideological advances to provide various economic goods to its population. Economic growth can be seen and measured through the development of GDP Per Capita from year to year.

There are several theories that explain economic growth, one of them is the Environmental Kuznet Curve. The EKC hypothesis shows a link between environmental degradation and economic growth. Increased pollution and environmental degradation occur in the early stages of growth, then there is an improvement in the environment at a certain level of per capita income (Stern, 2004) In general, at high levels of economic development, environmental conditions tend to be better, but if development only focuses on increasing GDP, it will be bad for the environment (Pujiati, 2015).

Based on data from the World Bank publication (2021), the GDP per capita variable

as an indicator of economic growth in 5 Asia Pacific countries experienced positive growth due to an increase in the last 5 years. Recorded in 2015 GDP per capita in the region amounted to 85,242 USD then continued to increase until it reached 92,707 USD in 2019.

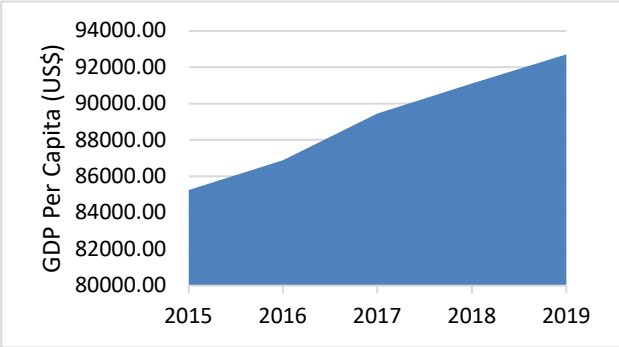

Figure 4. GDP Per Capita of 5 Asia Pacific Countries (USD)
Source: World Bank, 2021

Reducing emissions requires cooperation from all sectors of the economy, one of them is energy. As human being who carries out economic activity in various sectors, energy is a much needed thing (Srihardianti et al., 2016). Simply put, energy is considered a driver of economic progress. However, the energy consumption that acts as a transmission line puts so much pressure on the environment (Oktavilia et al., 2019).

Utilization of energy derived from non-renewable energy sources triggers an increase in CO_2 emissions (Alfisyahri et al., 2020). In this case, more research is needed to find out the influence of renewable energy sources that are expected to reduce CO_2 emissions.

Fuel consumption used in the 5 countries contributing the highest carbon dioxide emissions in Asia Pacific in 2019 showed that the most widely used energy source in various human activities related to environmental utilization was coal, followed by petroleum, natural gas, and hydroelectricity.

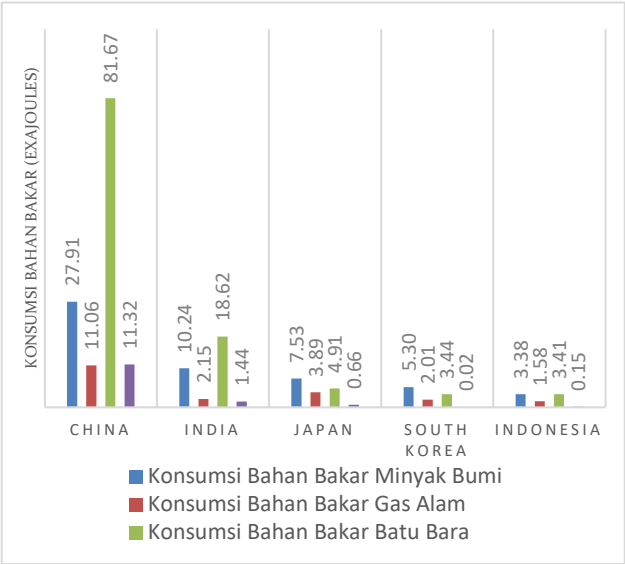

Figure 5. Energy Consumption of 5 Asia Pacific Countries in 2019 (Exajoules)
Source: BP Statistical Review of World Energy, 2020

In economic development or other anthropogenic human activities, it is inseparable from the use of energy resources that produce residues, such as the release of CO_2 (Nihayah et al., 2021). The presence of clean technology is needed to be gradually realized and disseminated to mitigate climate change. With energy efficiency and increasingly clean technology will provide a win-win solution, by allowing economic growth to continue while continuing efforts to prevent climate change.

The government should promote this type of energy choice by encouraging the use of environmentally friendly renewable energy-based technologies, called hydroelectricity. Hydroelectric energy is a form of renewable energy that uses moving hydropower to generate

electricity. The aim of the study was to analyze factors affecting carbon dioxide emissions in 5 Asia Pacific countries through variable population, GDP per capita and hydroelectricity consumption.

RESEARCH METHODS

Based on data analysis, the study uses a quantitative approach. The type of data is secondary data, namely research data sources obtained indirectly or through intermediary media either from books, archival documents, or web. Data analysis in this study used regression panel data to determine the effect of independent variables on dependent variables by combining time series data in the form of annual data from 2000-2019 and cross sections data in the form of research objects in 5 Asia Pacific countries.

The population in this study was all countries in Asia Pacific region in the period 2000-2019, but the sample used only included 5 countries with the highest levels of carbon dioxide emissions, which are: China, India, Japan, South Korea, and Indonesia. So, the observations in this study amounted to 100, namely 5 countries in Asia Pacific for 20 consecutive years.

The data used in this study are CO_2 emissions and hydroelectricity consumption sourced from the BP Statistical Review of World Energy, the population sourced from the Worldometers and GDP per capita sourced from the World Bank. The variables in this study consisted of dependent variables and independent variables. The dependent variables used are CO_2 emissions, while the independent variables used include the population is all people residing in 5 Asia Pacific countries in the period 2000-2019 using units of soul.

The GDP per capita, is a parameter of the level of welfare and prosperity of a country whose value is obtained from the average income of all residents in countries belonging to the Asia Pacific region. The unit used is in USD. The hydroelectricity consumption calculated based on the use of hydroelectricity energy types or hydroelectricity plants in 5 Asia Pacific countries in units of exajoules.

The panel data analysis was used to determine the effect of population, GDP per capita and hydroelectricity consumption on CO_2 emissions in 5 Asia Pacific region countries. The econometric model in question is:

$$\ln ECO_{it} = \beta_0 + \beta_1 \ln JP_{it} + \beta_2 \ln PK_{it} + \beta_3 \ln KH_{it} + \mu_{it} \quad \text{.....(1)}$$

Where ln ECO_{it} is Natural logarithm of CO_2 emissions, β_0 is Constant/intersep, β_1, β_2, β_3 is Regression coefficient on each independent variable, ln JP_{it} is Natural logarithm of population, ln PK_{it} is Natural logarithm of GDP per capita, ln KH_{it} is Natural logarithm of hydroelectricity consumption, μ_{it} is Error component at time t of individual cross section, I is Cross-section data from a number of countries in Asia Pacific and t is Time series data from 2000-2019.

There are three approaches to estimating regression models using panel data, including: pooling least square (common effect), fixed effect approach and random effect approach. The selection of one of the best models of the three approaches must first be tested, such as: Chow Test, Hausman Test and Lagrange Multiplier Test (LM).

After determining the best model, the classical assumption test is carried out to ensure that the regression equation obtained has

accuracy in estimation, unbiased and consistent or BLUE (best, linear, unbiased, estimation). The final step is to perform statistical tests, such as: coefficient of determination, test F and test t.

RESULTS AND DISCUSSION

Estimates of panel data regression models can be done in 3 ways, namely common effect (CEM), fixed effect (FEM) and random effect (REM). These three models are used to analyze variable influence of population, GDP per capita and hydroelectricity consumption on carbon dioxide emissions in 5 Asia Pacific countries. Test results from the three models can be seen on table 3.

Table 3. OLS Panel Data Estimate Result

No	Variable	Model		
		CEM	FEM	REM
1	Constant	-33,11185	-31,43541	-23,33708
2	Population	1,609914	1,756438	1,296194
3	GDP Per Capita	0,974608	0,488644	0,585971
4	Hydro Consumpt	-0,231036	0,063338	0,029021
5	R2	0,892142	0,996133	0,927204
6	Adj R2	0,888772	0,995839	0,924929
7	S.E. of regression	0,341055	0,065967	0,067602
8	F-Statistic	264,6867	3385,632	407,5832
9	Prob (F-Statistic)	0,000000	0,000000	0,000000
10	Durbin Watson-stat	0,025777	0,359553	0,311417

Source: Output Eviews Result 10.0, 2021

Model selection tests are conducted to obtain the right model in estimating regression of panel data. To determine the best model between CEM, FEM and REM using 2 model estimation techniques, namely chow test and hausman test. The Chow test determined the best model between CEM and FEM, while the Hausman test selected the best model between FEM and REM.

If the best model has not been found, it can be done with LM test that compares CEM and REM for use as a regression model for panel data. Based on table 4 it is explained that the probability value is 0.0000 or < α = 5%. It is concluded that Ho is rejected and H1 is accepted, so the model chosen to estimate regression of panel data is a fixed effect.

Based on table 5 obtained a probability value is 0.0499. The conclusion obtained from this test is to reject Ho and accept H1, then the best model chosen is fixed effect because the probability of cross-section random < α = 5%.

Table 4. Chow Test Result

Probability F	0,0000
Result	Probability F < □

Source: Output Eviews Result 10.0, 2021

Data processing with the FEM model refers to table 3 forming the following equations:

$$LNECO_{it} = -31{,}43541_{it} + 1{,}756438LNJP_{it} + 0{,}488644LNPK_{it} + 0{,}063338LNKH_{it} + \mu_{it} \quad \text{.....(2)}$$

To treat the problem of classical assumptions, the processing of FEM model data by gls method refers to table 8 forming the following equations:

$$LNECO_{it} = -36{,}41126_{it} + 2{,}025559LNJP_{it} + 0{,}456640LNPK_{it} + 0{,}058539LNKH_{it} + \mu_{it} \quad \text{.....(3)}$$

The coefficient of determination test aims to estimate how far the model's ability to explain the variation of dependent variables. Based on table 8 in the FEM column, the R2 value is

known at 0.996414. This means that variables in population, GDP per capita and hydroelectricity consumption can explain carbon dioxide emissions in 5 Asia Pacific countries by 99.64%, while the remaining 0.36% is explained by other variables outside the model.

Table 5. Hausman Test Result

cross-section random probability	0,0499
Result	cross-section random prob < α

Source: Output Eviews Result 10.0, 2021

The F test is a test to determine how much independent variables are capable of simultaneously influencing dependent variables. The F test is conducted by looking at the probability value of F and comparing the value of Fcount with Ftable. Based on table 8 in the FEM column, the Prob (F-Statistics) value is known at 0.000000.

Then by comparing the values of Fcount and Ftable obtained the results of F calculated is 3652,284 and F tables obtained from the degree of freedom for numerator (dfN1) and degree of freedom for denominator (dfN2). Known dfN1 = (k-1) = (4-1) = 3 and dfN2 = (n-k) = (100-4) = 96, then the value of F table is 2.70 with α = 5%. This means that variables in population, GDP per capita and hydroelectricity consumption simultaneously have a significant effect on carbon dioxide emissions, because the value of Prob F-stat 0.000000 < 0.05 and Fcount > Ftable (3652,284 > 2.70).

The t test is used to derive the influence of each independent variable on the dependent variable. In this case, partial testing will show the influence of population, GDP per capita and hydroelectricity consumption on carbon dioxide emissions. The t test can be done by comparing the probability value of each independent variable with the value of the α and comparing the tcount value with the ttable.

Table 6. GLS Panel Data Estimate Result

No	Variable	Model		
		CEM	FEM	REM
1	Constant	-29,60455	-36,41126	-23,33708
2	Population	1,456173	2,025559	1,296194
3	GDP Per Capita	0,912881	0,456640	0,585971
4	Hydro Consumpt	-0,163634	0,058539	0,029021
5	R^2	0,904227	0,996414	0,927204
6	Adj R^2	0,901234	0,996142	0,924929
7	S.E. of regression	0,312677	0,064939	0,067602
8	F-Statistic	302,1247	3652,284	407,5832
9	Prob (F-Statistic)	0,000000	0,000000	0,000000
10	Durbin Watson-stat	0,027295	0,573704	0,311417

Source: Output Eviews Result 10.0, 2021

Based on table 7 in the population column, obtained tcount and ttabel values are 9.742029 > 1.66088. Statistically, the test showed a positive influence on population numbers on carbon dioxide emissions in 5 Asia Pacific countries.

Based on table 7 in the GDP per capita column, obtained tcount and ttabel values are 10.60104 > 1.66088. Statistically, the test showed a positive influence of GDP per capita variable on carbon dioxide emissions in 5 Asia Pacific countries.

Based on table 7 in the hydroelectricity consumption column, obtained tcount and ttabel values are 3.136592 > 1.66088. Statistically, the test showed a positive influence of hydroelectricity consumption variable on carbon dioxide emissions in 5 Asia Pacific countries.

Table 7. t Test Result (Significance α = 5%)

Variable	t-stat	Prob.	t-table	Conclusion
JP	9,742029	0,0000	1,66088	Significant
PK	10,60104	0,0000	1,66088	Significant
KH	3,136592	0,0023	1,66088	Significant

Source: Output Eviews Result 10.0, 2021

Based on data at a confidence level of 95%, obtained the result that the population positively affects carbon dioxide emissions, with a coefficient value is 2.025559 and probability is 0.0000. It can be interpreted that any change in population increase by 1%, will increase CO_2 emissions by 2.02% assuming cateris paribus.

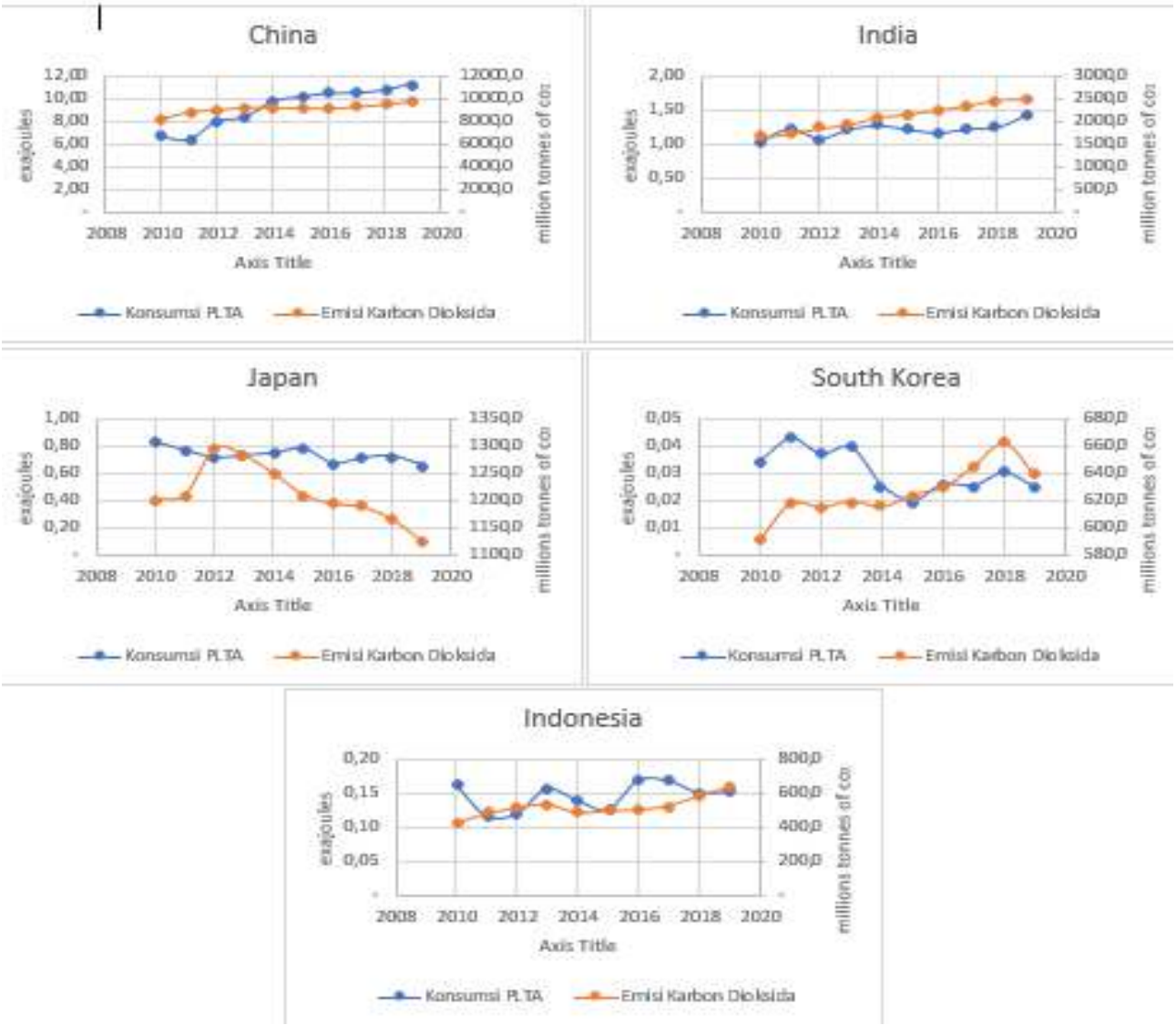

Figure 6. Comparison of hydroelectricity consumption and CO_2 emissions
Source: BP Statistical Review of World Energy, 2020

The Anthropogenic Global Warming theory and IPAT model are evident in Asia Pacific, where most of the climate change and global warming are caused by humans. This area

has a relatively high population, so various activities that increase greenhouse gas concentrations are inevitable.

Sasana & Aminata (2019) in their research explained the significant positive influence of population growth on CO2 emissions. The results of this study are in line with Rohani's research (2021) which states that the population has a positive and significant influence on carbon dioxide emissions in Indonesia. Furthermore, Widyawati et al. (2021) also revealed the results of its findings regarding the population of city residents who had a positive and significant effect on carbon dioxide gas emissions in ASEAN countries in 2000-2014. They say the high quantity of urban dwellers triggers a variety of activities that produce CO2 emissions.

Based on data at a confidence level of 95%, obtained the result that GDP per capita positively affects carbon dioxide emissions, with a coefficient value is 0.456640 and a probability is 0.0000. It can be interpreted that any change in GDP per capita increase of 1%, will increase CO2 emissions by 0.45% assuming cateris paribus. The IPAT model is evident in Asia Pacific, that affluance/GDP per capita causes environmental change. The change in question is a decrease in environmental quality in view of the increase in CO2 emissions because of GDP per capita that continues to increase.

Unlike the Environmental Kuznet Curve theory, which is inconclusive, because the variable used is only GDP per capita, without including GDP per capita squared. The phase in the study was not to prove the EKC hypothesis, but rather simply explained that GDP per capita has a positive influence on CO2 emissions.

In line with the results of this study, Rajagukguk's research (2018) revealed its findings the positive influence of GDP per capita on environmental degradation as measured through indicators of carbon dioxide emissions in Indonesia. However, the results of this study are inversely proportional to rohani research (2021) which found a significant negative influence GDP per capita on CO2 emissions.

Based on data at a confidence level of 95%, obtained the result that hydroelectricity consumption has a positive effect on carbon dioxide emissions, with a coefficient value is 0.058539 and a probability is 0.0023. It can be interpreted that any change in the increase in hydroelectricity consumption of 1%, will increase CO2 emissions by 0.05% assuming cateris paribus.

The results of this study do not match the hypothesis of the study. The positive effect of hydroelectricity consumption on carbon dioxide emissions in 5 Asia Pacific countries may be due to unstable hydroelectricity consumption trends (increases and decreases), thus forming a pattern that is not clear when compared to the trend of carbon emissions that tend to increase every year.

This reason is reinforced by Pata & Aydin (2020) who assumes that the effects of hydroelectricity energy on the environment are still controversial. Based on figure 6, it is explained that hydroelectricity consumption and carbon dioxide emissions fluctuate in 5 Asia Pacific countries. This factor causes the results of the study to be inversely proportional to the hypothesis, in contrast to the number of population and GDP per capita whose absolute value increases in the specified research period.

The results of this study are inversely proportional to research Bello et al. (2018) which found a significant influence of hydroelectricity consumption on carbon dioxide emissions in

Malaysia. Furthermore, bilgili et al. (2021) study also revealed the results of its findings related to the relationship between hydroelectric energy consumption and CO2 emissions that have a significant effect in the short and long term in the United States.

CONCLUSION

The population positively affects carbon dioxide emissions in 5 Asia Pacific countries. That is, the higher quantity of the population will have an impact on increasing environmental degradation as measured through of CO2 emissions indicators, and the opposite. The GDP per capita has a positive effect on carbon dioxide emissions in 5 Asia Pacific countries.

This proves the low awareness of society element about the importance of maintaining the environment. The hydroelectricity consumption has a positive effect on carbon dioxide emissions in 5 Asia Pacific countries. Fluctuations that occur in water energy consumption led to an increase in CO2 emissions.

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