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| RESEARCH ARTICLE

The Determinants of Carbon Dioxide Emissions in the Philippine Setting

Arianne Lauren F. Ronario[1] ✉ Jose Mari R. Rosal[2] and Carlos L. Manapat[3]
[123]UST Faculty of Arts and Letters, Department of Economics, University of Santo Tomas, Manila, Philippines
Corresponding Author: Arianne Lauren F. Ronario, **E-mail**: ariannelauren.ronario.ab@ust.edu.ph

| ABSTRACT
The main objective of this study is to determine the relationship between carbon dioxide emissions with other study variables such as economic growth, energy consumption, population growth, and gross capital formation in the case of the Philippines set during the period 1976 to 2014. This paper employs various econometric techniques: the Augmented Dickey-Fuller unit root test, Johansen Cointegration test, and Ordinary Least Squares (OLS) estimation regression to prove that there is a relationship between the study variables. The outcome of the unit root test states that all variables are stationary, and cointegration tests prove that there is a long-run relationship among the study variables involved. The Ordinary Least Squares (OLS) estimation shows that energy consumption, population growth, and gross capital formation have a significant relationship with carbon dioxide emissions while economic growth is insignificant. Energy consumption and gross capital formation show a direct relationship between carbon dioxide emissions, while economic growth and population growth are indirectly related.

| KEYWORDS
Carbon dioxide emissions; economic growth; energy consumption; population growth; gross capital formation

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1. Introduction
The increase in carbon dioxide emissions is one of the pressing issues being faced throughout history as it brings continuous environmental degradation throughout the years across the whole world. Environmental degradation exists in developed and developing countries, where all nations face severe threats from environmental destruction. Greenhouse gases, precisely the substance of carbon dioxide emissions, are one of the main drivers of climate change due to the continuous exhaustion of natural resources and increasing human activities such as the burning of fossil fuels which may lead to a harmful effect on environmental health, such as the continuous rise of global temperature which may lead to global warming, as these harmful chemical substances are released into the atmosphere. Environmental degradation also causes the vulnerability of every individual to be at risk of experiencing various health complications such as cardiovascular disease, lung cancer, and other known respiratory diseases (Sun & Zhu, 2019), especially the harmful substances such as carbon dioxide being emitted into the atmosphere may increase the risk of asthma towards children (Sun, Zhou, Huang & Li, 2020). One of the main factors of the continuous increase in carbon dioxide emissions, which are responsible for the continuous worsening environmental degradation, maybe the increasing economic growth, energy consumption, population growth, and gross capital formation.

Economic growth, explicitly indicating the gross domestic product, is relevant for every country to sustain. It indicates how many total values of goods and services in a specific country have been produced depending on a period. It may be believed that carbon dioxide emissions continuously increase since sustaining economic growth and productivity is inevitable where economic activity flourishes as individuals continuously consume energy-intensive products such as automobiles and other technological appliances that may be harmful to the environment, which may lead to environmental concerns such as the worsening condition of climate change and global warming (Danish, 2019). It was also mentioned that countries that attained solid economic growth with the help of technical development are vulnerable to environmental problems such as pollution (Xiong, 2020).

The use of energy is essential as it plays a vital role in sustaining economic, technological, and social development. Therefore, it is likely impossible to produce, deliver, or use mainstream commodities without consuming energy. Insufficient energy use would negatively impact the performance of other sectors in the economy (Yildrim, 2017). The increase in energy consumption is also considered one of the main concerns of environmental degradation. It involves the production and consumption of various goods and services, such as power consumption, industrial, residential, and transportation activities, which leads to increased carbon dioxide emissions (Danish, 2019). The increase in energy consumption is considered a threat to the global ecosystems, leading to prolonged droughts, rising sea levels, and temperatures.

Concerning the Philippine context, the country is recognized among the ASEAN countries that have continuously maintained a strong economic growth performance for several decades due to its positive trajectory brought by different sectors in the economy. Moreover, as the Philippine economy grows, rapid population growth and urbanization have coincided. The social economy of the Philippines evolves at an unprecedented rate in tandem with industrialization and urbanization, eventually increasing natural resource use. That is why the country may be considered vulnerable to domestic and geographical risks regarding environmental degradation. Despite considering the contributions of industrialization in promoting a country's economic growth and improving people's livelihood, this has led to the inevitability of facing the issue of increasing greenhouse emissions which leads to worsened environmental degradation. Gills and Morgan (2020) stated many challenges are being faced, like the scale and economic composition, in comparison to primary industries and manufacturing, the share of services in the gross domestic product, and technical transition potentials to minimize environmental consequences of output and consumer choices while driving economic growth.

The study aims to determine and aim to fill in the gap in similar research like this in the country, proving the relationship between economic growth, energy consumption, population growth, and gross capital formation on carbon dioxide in the Philippines setting by gathering time-series data to determine the trend and relationship between carbon dioxide (CO2) emissions, economic growth, energy consumption, population growth, and gross capital formation from 1976 to 2014.

As the researcher aims to prove the relationship between carbon dioxide (CO2) emission with the GDP per capita, energy consumption, urban population growth, and gross capital formation, the researcher's objective is to ask the following questions:

1. What is the trend in the following variables?
   1.1. carbon dioxide emissions
   1.2. economic growth
   1.3. population growth
   1.4. energy consumption
   1.5. gross capital formation
2. Is there a significant relationship between carbon dioxide emissions with economic growth?
3. Is there a significant relationship between carbon dioxide emissions with energy consumption?
4. Is there a significant relationship between carbon dioxide emission with population growth?
5. Is there a significant relationship between carbon dioxide emission with gross capital formation?

The study is beneficial because it may provide a better understanding and awareness of the issue where environmental degradation exists at present. This study may contribute to guiding the public sectors, which include the National Economic and Development Authority (NEDA), Department of Health (DOH), Department of Science and Technology, and other government institutions, to provide feasible solutions to eliminating possible external costs that are caused by the production and consumption of specific goods and services to ensure in prioritizing both in protecting the environment and public health while sustaining economic growth in the country. Moreover, this study is also considered significantly beneficial to other future researchers, both academic and institutional researchers, for this study may be used as a primary or supplementary reference for possible future use, especially for further studying the relationship between economic growth and carbon dioxide emissions in the Philippines as the variables being studied changes over time.

2. Literature review

2.1 Carbon dioxide emissions and economic growth

There were reports in the previous years that the greenhouse gas emissions increased in the Philippines by 54 MtCO2e between 1990 and 2012, averaging 2.1% annually, while GDP grew 134%, averaging 4% annually (US AID, 2016). Another report regarding a study that quantified the driving forces of changes in the Philippines' carbon dioxide emissions from 1991 to 2014 discussed its findings that most of the increases in carbon dioxide emissions come from economic activities due to lifestyle changes of the population where there is an increase in the usage of coal as a source of energy, especially in the electricity sector (Sumabat et al., 2016).

In other countries, related studies, such as those conducted in China, investigated the relative importance of various factors of carbon dioxide emissions, such as economic growth in China, using the Least Absolute Shrinkage and Selection Operator (LASSO) method from the period of 2002 to 2014 using panel data that encompasses 284 cities in the country and found out that carbon dioxide emissions were mainly driven by the economic growth and followed by the population growth in China (Shum & Ma, 2021).

Another related study investigated the effect of economic growth on the carbon dioxide emissions in every 50 states of the United States from 1990 to 2017, which used Ordinary Least Squares (OLS) estimates regression analysis to test the hypothesis and found out that there was a positive relationship between the growth of the economy and carbon dioxide emissions in the United States (Jackson, 2020).

Another related study examined 69 industrial countries and 45 developing countries using cross-sectional data as it investigated the relationship between GDPs per capita and CO2 emissions to observe the possible influence of economic growth on environmental degradation and found that there is a positive correlation between the two variables based on conducting the cross-sectional study (Cederborg, 2016).

Manu and Sulaiman (2017) tested the impact of energy consumption and economic growth on carbon dioxide emissions in the country from the period 1965 to 2015 in Malaysia using the unit root test, cointegration test, and Ordinary Least Squares (OLS) regression analysis. They found that all variables are stationary and cointegrated with each other. The test revealed that carbon emissions decrease when there is an increase in economic growth and the Environmental Kuznets Curve (EKC) is nonexistent. At the same time, trade openness has a significant increase in carbon emissions in the country.

A study conducted by Batool & Jamil (2018) has investigated the socioeconomic determinants of environmental degradation, which includes the independent variables of economic growth and financial development, in developed and developing countries over the time of 1996 to 2016 with the use of pooled data Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) which showed a positive and direct relationship between carbon dioxide emissions with economic growth and financial development.

Moreover, a related study conducted in India investigates the nexus between carbon dioxide emissions and economic growth in the country using time-series data from 1975 to 2017 through the methods of ARDL and modified Wald test of Toda Yamamoto Causality and found that there is a negative relationship between carbon dioxide emissions and economic growth and the results showed that there is a unidirectional relationship between carbon dioxide emissions and the economic growth (Udemba & Bekun, 2020).

2.2 Carbon dioxide emissions and energy consumption

According to the ADB (2017), electric consumption in the Philippines has proliferated by 4 percent between 2011 and 2013. The most significant contributor to consuming energy is the transport sector (33 percent), followed by the industrial sector (26 percent), residential sector (25 percent), and other sectors, including the commercial and agriculture sector with a percentage of 10.9 and 1.4 respectively. In addition, it was stated that the transport sector has led to harm to the environment as 23.4 metric tons of carbon dioxide have been released in the country.

In other related studies, Rahman and Kashem (2017) have studied the causality between carbon emissions, energy consumption, and industrial growth in Bangladesh and found a short and long run nexus between industrial production and CO2 emissions using ARDL Bounds testing and Granger causality. The results of this study showed that there is a unidirectional relation between energy consumption and economic growth to carbon emissions.

Moreover, Rahman (2017) also investigated the relationship between carbon dioxide emissions, energy use, economic growth, and population density for a panel of 11 Asian countries from 1960 to 2014, which also used the panel Johansen cointegration test and panel Granger causality test to examine the relationship between the study variables. The results showed a unidirectional relationship between economic growth and energy consumption to carbon dioxide emissions.

Osobajo and Oitoju (2020) have determined the effects and relationship between energy consumption and economic growth and other variables involved in carbon dioxide emissions of 70 countries between 1994 and 2013 using various tests such as unit root test, panel cointegration test, Granger causality, and pooled Ordinary Least Squares (OLS) as a methodological process in the study. The unit root test conducted in all variables is stationary. Cointegration tests revealed a long-run relationship with carbon dioxide emissions among the independent variables such as energy consumption. The Granger causality tests revealed a unidirectional relationship between energy consumption with carbon dioxide emissions. Lastly, the Ordinary Least Squares (OLS) multivariate regression analysis revealed that all variables used in the study are positively significant, and the econometric model used is considered goodness-of-fit.

Antonakakis et al. (2017) has also investigated the relationship between energy consumption, carbon dioxide emissions, and real GDP per capita growth using panel VAR Analysis and panel Granger causality based on 106 countries classified by different income groups from 1971 to 2011. The results showed that bidirectional causality between total economic growth and energy consumption. However, the results revealed that renewable energy consumption had no significant effect on economic growth, and there was no evidence supporting the EKC hypothesis.

Ahmed, Rehman, and Ozturk (2017) also studied the relationship between carbon dioxide emissions, energy use, income, trade openness, and population using data from five South Asian economies from 1971 to 2013. One of the methodological procedures implemented, including panel cointegration tests (Pedroni-Kao and Johansen-Fisher panel cointegration), has proven that all variables are cointegrated, making all variables have a long relationship with each other. Moreover, the Fully Modified Ordinary Least Squares (FMOLS) revealed that increasing energy use, trade openness, and population harm the climate. The causality test shows a one-way causal relationship between energy use, trade openness, and population and carbon dioxide emissions.

Lastly, Bekhet et al. (2017) investigated the relationship between financial development, carbon emissions, economic growth, and energy consumption from 1980 to 2011. This article shows that economic growth and energy usage have led to increased carbon emissions in some countries such as Qatar and Saudi Arabia.

2.3 Carbon dioxide emissions and population growth

Greenhouse gas emissions, especially carbon dioxide emissions, are also due to the rise in population and rapid urbanization (Regmi, 2017). Urban cities in the country, including the National Capital Region in the Philippines, are considered one of the rapidly urbanizing megacities. It is projected that the population may reach 14.8 million by 2025 (Regmi, 2017). Like other megacities of developing countries, it has also experienced problems related to urbanization, such as the deterioration of air quality and increasing greenhouse gas emissions (Regmi, 2017).

A related study analyzed the effect of population growth on the environment within 22 European countries with a total dataset of 1,062 regions between 1990 and 2006 in which data were analyzed using panel regressions, spatial econometric models, and propensity score matching and found that population growth itself acts as a scale factor for environmental degradation in the Western Europe regions compared to Eastern Europe due to more land use. (Weber & Sciubba, 2018).

Another related study investigated the relationship between urbanization and carbon dioxide emissions in less developed countries from 1960 to 2010 and found out that the effect of growth or decline in urban population on carbon dioxide emissions is asymmetrical in which it was stated that a decline in urbanization reduces emissions to a much greater degree than urbanization increases emissions (McGee & York, 2018).

A related study conducted in Taiwan studies the impact of population growth and economic growth on carbon dioxide emissions in the country based using the analytical tool of Stochastic Impacts by Regression on Population (STIRPAT) using national data from the period 1990 to 2014 to test the significance of the proposed model and found out that the continuous increase of the population of the country indicates a significant factor in the increase of carbon emission in Taiwan (Yeh & Liao, 2016).

A study conducted by Liu and Bae (2018) examined the causal relationship between carbon dioxide emissions per capita, energy intensity, gross domestic product, and urbanization in China from 1970 to 2015. To verify co-integration and short- and long-run estimates, the researchers used autoregressive distributed lag (ARDL) technology and the vector error correction model (VECM) to examine directional causation among time series data variables involved. According to long-run parameter estimates, energy intensity, real GDP, industrialization, and urbanization increase CO_2 emissions by 1.1 percent, 0.6 percent, 0.3 percent, and 1.0 percent, respectively. Carbon dioxide emissions, economic growth (real GDP), and industrialization have long-run Granger causality.

Reviewing other studies conducted in Africa, researchers including Kais & Mbarek (2017) investigated the causal relationship between the selected variables such as carbon dioxide emissions, economic growth, and energy consumption for the three selected North African countries on data covering 1980 to 2012. Using a panel cointegration test, the researchers found interdependence between energy consumption and economic growth in the long run. After viewing the results, the researchers have encouraged policymakers to provide comprehensive policies for environmentally friendly and sustainable economic growth in the long run.

A study conducted in Nigeria studies the involvement of the population growth on carbon dioxide emissions in Nigeria from 1970 to 2010 using various tests, including the Autoregressive Distributed Lag Model (ARDL), Dynamic Ordinary Least Squares (DOLS), and Fully Modified Ordinary Least Squares (FMOLS) and found out that the population growth is not considered a determinant to carbon emissions in the long-run but only in the short-run whereas this concludes that population itself could be a short-run effective measure in lowering the emission level in the country (Sulaiman & Abdul-Rahim, 2018).

A study conducted in Malaysia investigated the impact of urbanization growth on carbon emissions. The F-bound test and VCEM Granger causality were used as methodological tools. The results revealed a bidirectional causality between carbon emissions and urbanization in the long run (Bekhet & Othman, 2017).

2.4 Carbon dioxide emissions and gross capital formation

A study conducted in Turkey and Kuwait investigated the relationship between CO2 emissions and gross capital formation from 1971 to 2014. It was analyzed using the unit root test and Toda and Yamamoto Granger causality tests. The study's findings concluded that the bidirectional links between all variables, especially for carbon dioxide emissions and gross capital formation, of interest in Turkey and Kuwait suggest significant policy implications (Satrovic, Muslija & Abdul, 2020).

Kobayakawa (2021) has investigated the carbon footprint from capital formation, which evolves along various countries' development pathways using multi-regional input-output models, and found out that developing countries are more invested in capital formation, which has led to the increase in carbon emissions in these countries.

Another related study conducted by Rahman and Ahmad (2019) tested the relationship between carbon dioxide emissions and gross capital formation in Pakistan for the period 1980 to 2016 by using Nonlinear Auto-Regressive Distributed Lag (NARDL) to determine if the effect changes in gross capital formation on carbon dioxide emissions is asymmetric or symmetric for the country of Pakistan, which leads Pakistan to be one of the main contributors to carbon dioxide emissions in Asia. The results show that there is an existence of an asymmetric effect of GCF shocks on CO2 emissions both in the short and long term. The researchers also believed that coal and oil consumption significantly contribute to CO2 emissions both short and long term. Moreover, the results show that the EKC hypothesis exists both in the long and short term, which concludes an inverted U-shaped connection between per capita growth and CO2 emissions in Pakistan.

Pala (2020) also investigated the relationship between economic growth, energy use, labor use, and gross capital formation in G20 countries from 1995 to 2016 using the panel cointegration test, FMOLS, and DOLS and found that gross capital formation itself has a long-run equilibrium relationship with carbon dioxide emissions.

Mitic et al. (2020) also examined the relationship between some of the independent variables, especially gross capital formation, on carbon dioxide emissions for a panel of Balkan countries over the period of 1996 to 2017 using the panel unit root test, cointegration test, and causality test and found out that there is a unidirectional causal relationship from capital formation to carbon dioxide emissions.

2.5 Theoretical Framework

The Environmental Kuznets Curve theory focuses on determining the relationship between economic growth and environmental pollution, applicable to all countries (Jiang, Kim, & Woo, 2020). The theory of Simon Kuznets, known as the Environmental Kuznets Curve (EKC), is relevant and applicable to the researcher's study for it determines if Kuznets' theory may have the probability have the same results as the researcher's study that if there is an increase in the country's per capita revenue, then environmental pollution increases (Allard & Takman, 2018). In this theory, it was stated that pollution itself grows faster since the material and productivity output is prioritized, for there is a high usage of natural resources to attain a higher level of development (Usenata, 2018). The higher usage of natural resources leads to a higher level of pollutants which degrades and reduces environmental quality (Usenata, 2018). Attaining economic growth usually requires a higher amount of capital, labor, and other resources, which subsequently leads to a higher amount of waste being generated in the environment, including emission of gasses and fumes, which are harmful to the health of every individual (Usenata, 2018). The EKC model states an inverted U-shaped relationship between income level and environmental degradation (Jiang, Kim, & Woo, 2020). The Kuznets curve of the EKC model is also considered relevant for empirical and figurative economic analysis (Jiang, Kim, & Woo, 2020). The EKC model argues that there is clear evidence that economic growth usually leads to environmental degradation, especially during the early stages of the process (Beyene & Kotosz, 2020), where this may also occur in countries with lower levels of economic development that use energy-intensive production to boost economic productivity which may lead to the increase of pollutant emissions (Jiang, Kim, & Woo, 2020). The EKC depicts the link between per capita income and environmental degradation (See Figure 1). That is, as income rises, environmental deterioration rises with it. However, after a certain level of revenue is attained, the degradation slows down. The EKC refuted the commonly agreed idea that wealthier countries damage the environment greater than poorer nations. Wealthy countries were supposed to use natural resources at a much higher pace, causing their environment to deteriorate faster by manufacturing and consuming large quantities of products and services (MacDermott et al., 2019).

Figure 1: The Environmental Kuznets Curve Framework

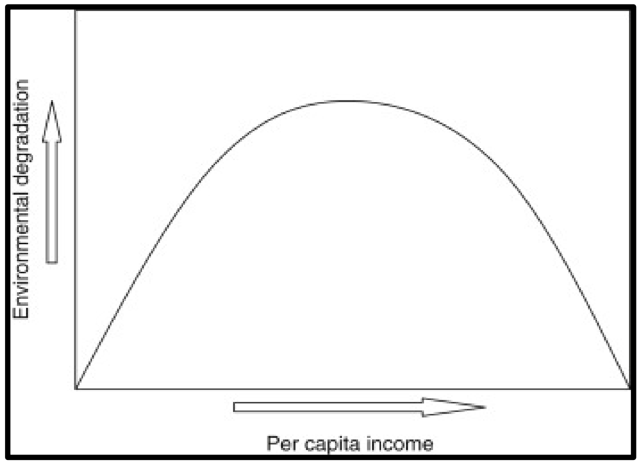


Figure 1 shows that as income rises, environmental deterioration rises with it. After a certain level of income is attained, deterioration slows down.

2.6 Conceptual Framework

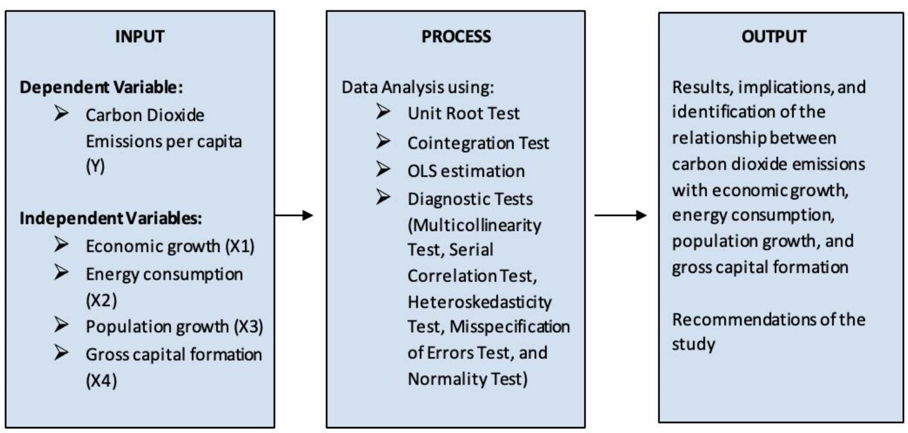


Figure 2: Conceptual Framework of the study using the IPO diagram

The graphical illustration above shows the IPO diagram of the study. As stated in the input diagram, the study applies the theory of the Environmental Kuznets Curve as the following variables are used for conducting the study. The stated independent variables such as the gross domestic product per capita, energy consumption, population growth, and gross capital formation show how these factors impact the dependent variable, the carbon dioxide emissions per capita. Moreover, it is stated in the process diagram that these data will undergo multiple regression analysis using the unit root test, Johansen Cointegration test, and Ordinary Least Squares (OLS) estimation to determine the relationship between the variables involved. During the study process, the study also needs to undergo statistical and econometric tests such as the coefficient of determination, the R-squared, the F-test, and the T-test. Diagnostic Tests such as the Durbin-Watson test, Multicollinearity Test, Serial Correlation Test, Heteroscedasticity Test, Normality Test, and Misspecification of Errors Tests will be done to validate that the econometric model does not violate The Classical Linear Regression Model (CLRM) assumptions. Finally, it is stated in the output diagram that once the researchers have implemented, gathered, and analyzed the results, possible recommendations are expected to be relayed by the researchers.

2.7 Synthesis

Most of the literary studies conducted in regions show that the significant determinants of carbon dioxide emissions are the regressors used in this study, specifically economic growth, energy consumption, population growth, and gross capital formation. The studies above indicate that carbon dioxide emissions are detrimental to the people, and as time goes by, the rise in population and industrialization cause a rise in energy consumption. Carbon dioxide emissions are caused by various factors, including power generation, manufacturing, population growth, and other activities such as transportation. Researchers looking into the topic urge readers to look for ways to minimize negative externalities to protect the environment.

2.8 Research Gap
As the researchers have gathered relevant theories and perspectives that were useful for this study, it was discovered that the gaps and discrepancies from such works would be considered in the empirical analysis of this study. Based on the researchers' understanding, only a few research publications in the Philippines investigated this problem. Specifically, a lack of resources reveals the rise in carbon dioxide emissions in the Philippines. Furthermore, it was discovered that they all utilize carbon dioxide emissions as an indicator of environmental deterioration.

3. Methodology
3.1 Research Design
The study is descriptive and quantitative research conducted through systematic procedures through gathering quantitative data and analyzing the results through statistical and econometric techniques to determine between the variables involved in the study. The use of quantitative data would effectively contribute to interpreting accurate results in coming up with the study's conclusion. The researchers will undergo multiple regression analysis using Ordinary Least Squares (OLS) by utilizing econometric computer software to determine if there is a relationship between the dependent variable with each of the independent variables. The dependent variable studied is the Philippines' carbon dioxide emissions. In contrast, the study's independent variables are the country's gross domestic product, energy consumption, population growth, and gross capital formation in the Philippines.

3.1 Variables and Data Collection
To achieve the study aim, the variables involved are gross domestic product, energy consumption, population growth, and gross capital formation as the independent variables, and carbon dioxide emissions as the dependent variable found in the table below.

Table 1: Variables Units and Sources

Variables	Description	Units	Sources
CO2	Environmental Degradation/ Pollution	CO2 emissions (kt)	(The World Bank, 2021)
GDP	Economic Growth	GDP per capita (constant 2010 US$)	(The World Bank, 2021)
EU	Energy Consumption	Energy use (kilograms of oil equivalent per capita)	(The World Bank, 2021)
POPG	Population Growth	Population growth (annual percentage)	(The World Bank, 2021)
GCF	Capital Stock	Gross Capital Formation (percentage of GDP)	(The World Bank, 2021)

The following variables used in the study are further explained below:

- *Carbon Dioxide emissions (kt)*: The total amount of kilotons of carbon dioxide (CO2) emitted in the country because of all relevant human activities such as the production and consumption of solid, liquid, and gas fuels and gas flaring substances (The World Bank, 2021). Therefore, this leads to the combustion of various fossil fuels into the atmosphere. Carbon dioxide emissions serve as the dependent variable in this study.

- *GDP per capita (constant 2010 US$)*: is the measurement of a country's economic performance, expressed in constant 2010 US dollars. This is known as the sum of gross value added by all resident producers in the economy minus the subsidies that are not included in the product's value. Hence, the researchers expect a positive relationship between carbon dioxide emissions and GDP growth, whereas if the GDP per capita increases, it may increase the carbon dioxide emissions in the country.

- *Energy Consumption (kg of oil equivalent per capita)*: this pertains to the energy consumption per head of the country's population. As energy consumption is expected to increase, carbon dioxide also increases in the following years. Hence, the researchers expect a positive relationship between carbon dioxide emissions and energy consumption.

- *Population Growth (annual percentage)*: this variable refers to the annual population growth rate every year. The percentage is based on the country's total population, counting all individuals residing in the country regardless of the individual's legal status or citizenship. A high population percentage may increase carbon dioxide emissions as prevalent deforestation and energy use arises. Hence, the researchers expect a positive relationship between carbon dioxide emissions and the urban population.

- *Gross Capital Formation (percentage of GDP)*: It refers to the outlays on additions to the fixed assets (land rehabilitation, construction of facilities, plant, machinery, and equipment purchases) of the economy plus net changes in the level of inventories of the country (such as stocks of goods held by firms), which is expressed in percentage of gross domestic product (The World Bank, 2021). The gross capital formation helps develop infrastructure, contributing to industrialization and economic development. Hence, the positive relationship between carbon dioxide emissions and gross capital formation increases.

3.2 Sample and Sampling Technique
The researchers used time-series data to conduct the study from 1976 to 2014, with thirty-nine (39) observations, to test the significant relationship between the studied variables. In choosing the methods of collecting data, the researchers preferred the registration method in which gathering information (with the use of secondary sources of data) from the official website of The World Bank will be adequate for the researchers to test and represent the given variables for this study. The researchers preferred using secondary data to show accuracy and reliability in the research paper study.

3.3 Statistical Treatment of Data
In conducting the study, the researchers preferred the selected software, the EViews Student Version 11 Lite, in conducting the multivariate Ordinary Least Squares (OLS) regression model as the testing of data for the benefit of the study. Moreover, the researchers conducted various statistical and econometric tests to prove the research hypothesis of the study that the mentioned variables have a significant relationship with each other. These statistical and econometric tests include the following:

- ***Augmented Dickey-Fuller Test (Unit Root Test)***
  Using the unit root test method is essential, especially in conducting time series data analysis, to determine whether the selected variables for the study are stationary or non-stationary. The presence of a unit root means the selected time series variable is non-stationary. However, if there is no unit root in the selected time series variable, it is considered stationary. In conducting unit root tests, all variables being tested and studied should be stationary before conducting the Ordinary Least Square (OLS) method. One of the standard methods of unit root test is the Augmented Dickey-Fuller test, which will be used in conducting the researcher's study.

- **Johansen Cointegration Test (Cointegration Test)**
  Cointegration is a type of test in determining if the selected time series variables are cointegrated and assessing the validity of a cointegrating relationship between time series in the long term. The method of Johansen Cointegration Test will be used in conducting the study, which allows for testing one or more cointegrating relationships. In addition, this method is used to find the number of relationships and as a tool to estimate relationships.

- **The F-test and T-test (Hypothesis Testing)**
  The F-test compares what is known as the mean number of squares for the model's residuals and the data's overall mean. On the other hand, the T-test is known to be one of the methods of inferential statistics used to determine and evaluate whether there is a significant difference between the means of the two groups.

- **The R-squared (Goodness-of-Fit Test)**
  The R-squared is known for conducting tests for determining if the linear regression model is considered goodness of fit or how close the data are to the fitted regression line. In analyzing the R-squared, the value closer towards is a good indicator that the model is considered goodness of fit. This shows the percentage of variation in the dependent variable that the independent variables account for when taken together.

- **The Variance Inflation Factor or VIF (Multicollinearity Test)**
  In regression analysis, the variance inflation factor (VIF) detects if there is a presence of multicollinearity in the regression model. If there is a correlation between predictors and the independent variables in a model, it is known as multicollinearity, which can negatively affect the regression performance. The VIF calculates how much multicollinearity in the model has inflated the variance of a regression coefficient.

- **Durbin-Watson Test**
  The Durbin Watson test is a statistic that detects and measures autocorrelation in regression analysis residuals. The Durbin Watson is known for testing for first-order serial correlation, and it ranges the value from 0 to 4. It was stated that if the value of the Durbin Watson is almost near the value of 2, then the model is considered "autocorrelation-free."

- **Breusch Godfrey Test (Serial Correlation Test)**
  This is an alternative way of testing the presence of autocorrelation errors in the regression model of the study. This test is known for its use to test for higher-order ARMA errors and applies to whether there is a presence of lagged dependent variables. Moreover, the Breusch Godfrey test recommends accurately determining if the regression model of the study has a presence of autocorrelation.

- **White Test (Heteroskedasticity Test)**
  This is also known as one of the methods of heteroskedasticity tests in determining whether there is an error in regression analysis. The White Test is known for asymptotic tests, which are meant to be used on large samples.

- **Ramsey RESET Test (The Testing of Specification)**
  The Ramsey RESET test is also known as the Regression Specification Error Test, which helps determine if there are misspecification errors in the regression model. It examines whether non-linear combinations of the fitted values aid in explaining the response variable. It examines if non-linear combinations of explanatory variables, specifically their powers, can aid in explaining the dependent variable.

- **Jarque-Bera Test (Normality Test)**
  It is a type of Lagrange Multiplier test which tests if the given series is considered normally distributed. This test is helpful for it may determine the matches of the skewness and kurtosis of data to see if it has a normal distribution.

3.4 Data Analysis

In conducting the study, the researchers will use a quantitative approach. The study will undergo multiple regression analysis with the use of Ordinary Least Squares (OLS) and T-test in EViews Student Version 11 Lite in evaluating and analyzing the relationship between the dependent variable (carbon dioxide emissions) with the independent variables (GDP per capita, energy consumption, population growth, and gross capital formation). Moreover, the selected variables such as carbon dioxide emissions (CO2), gross domestic product per capita (GDP), and energy consumption (EU) will be transformed into a logarithmic form.

The econometric model stated below will show the effects of the independent variables (GDP, EU, POPG, GCF) on the dependent variable (CO2), which is shown in the table below.

Figure 3: The econometric model

$$lnCO2 = \beta_0 + B_1 lnGDP + B_2 lnEU + B_3 POPG + B_4 GCF + \varepsilon i$$

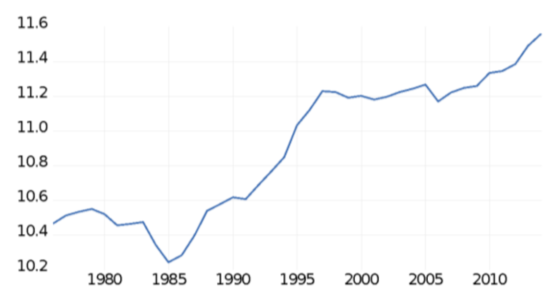
The abbreviated variables designed in the econometric model are as follows:

CO2 – carbon dioxide emissions
β_0– constant or the Y-intercept
β_1– is the slope of economic growth (GDP per capita)
β_2 – is the slope of energy consumption
β_3 – is the slope of population growth
β_4– is the slope of gross capital formation
εi – the error term

The researchers will determine if there is a significant relationship between the study variable by interpreting the t-test statistics results, and the coefficient of determination or R-squared will be interpreted. In addition, the researchers will undergo various series of tests in regression analysis to diagnose whether there is a unit root, misspecification, cointegration, multicollinearity, autocorrelation, and heteroscedasticity.

4. Results & Discussion

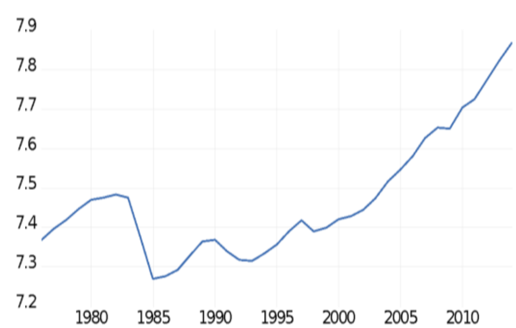
4.1 Trendline of the Variables



Descriptive Statistics	LNCO2
Mean	10.89683
Median	11.03166
Maximum	11.55608
Minimum	10.2417
Std. Dev.	0.396177
Skewness	-0.098573
Kurtosis	1.468691
Sum	424.9762
Sum Sq. Dev	5.964334

Figure 4: Trendline and Descriptive Statistics of CO2 emissions (kt)

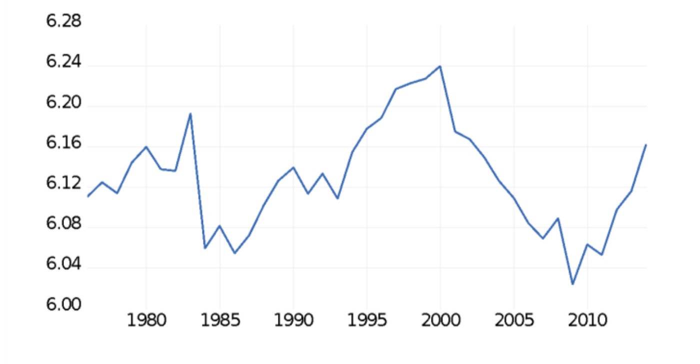
Figure 4 shows the trendline and descriptive statistics of CO_2 emissions (kt) in the Philippines. It shows that there has been an upward trend in carbon dioxide emissions in the country from 1976 to 2014. An increase in CO_2 emissions being polluted in the atmosphere may result in environmental degradation. It has a mean of 10.89683, a median of 11.03166, a standard deviation of 0.396177, and a skewness of -0.098573.



Descriptive Statistics	LNGDP
Mean	7.468959
Median	7.41981
Maximum	7.868199
Minimum	7.268776
Std. Dev.	0.154651
Skewness	1.016829
Kurtosis	3.168101
Sum	291.2894
Sum Sq. Dev	0.908843

Figure 5: Trendline and Descriptive Statistics of GDP per capita (constant 2010 US$)

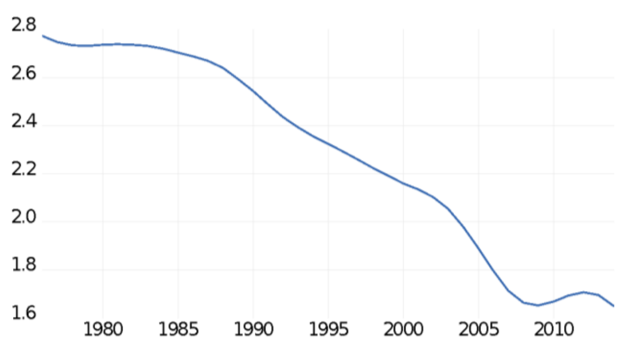
Figure 5 shows the trendline and descriptive statistics of GDP per capita (constant 2010 US Dollars) in the Philippines. An upward trend in the GDP per capita implies that the Philippines has continuously sustained economic growth and development from 1976 to 2014. It has a mean of 7.468959, a median of 7.41981, a standard deviation of 0.154651, and skewness of 1.016829.



Descriptive Statistics	LNEU
Mean	6.128875
Median	6.126392
Maximum	6.239783
Minimum	6.02396
Std. Dev.	0.052061
Skewness	0.251212
Kurtosis	2.52941
Sum	239.0261
Sum Sq. Dev	0.102993

Figure 6: Trendline and Descriptive Statistics of Energy Use (kg of oil equivalent per capita)

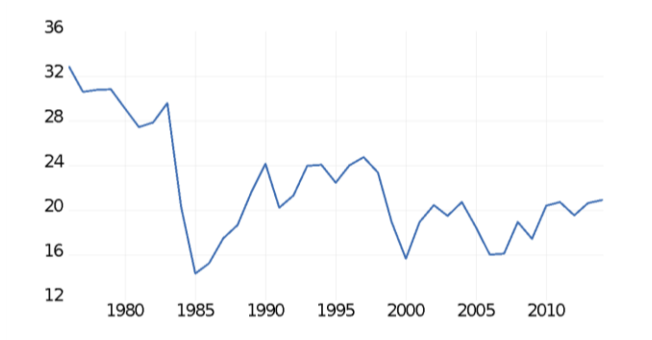
Figure 6 shows the trendline of primary energy consumption (kg of oil equivalent per capita) in the Philippines. The illustration shows a stable trend in energy consumption from 1976 to 2014. It has a mean of 6.128875, a median of 6.126392, a standard deviation of 0.052061, and a skewness of 0.251212.



Descriptive Statistics	POPG
Mean	2.281465
Median	2.324215
Maximum	2.773085
Minimum	1.646689
Std. Dev.	0.407258
Skewness	-0.324137
Kurtosis	1.647923
Sum	88.97712
Sum Sq. Dev	6.302652

Figure 7: Trendline and Descriptive Statistics of Population Growth (annual percentage)

Figure 7 shows the Philippines' urban population (percentage of the total population). It shows here that the population growth rate in the country is slowly decreasing from the year 1976 to 2014. It has a mean of 2.281465, a median of 2.324215, a standard deviation of 0.407258, and skewness of -0.324137.



Descriptive Statistics	GCF
Mean	22.02358
Median	20.73101
Maximum	32.85801
Minimum	14.34682
Std. Dev.	4.818224
Skewness	0.622968
Kurtosis	2.522723
Sum	858.9194
Sum Sq. Dev	882.1808

Figure 8: Trendline and Descriptive Statistics of Gross Capital Formation (percentage of GDP)

Figure 8 shows the trendline of gross capital formation (percentage of GDP) in the Philippines. It shows here that the gross capital formation has a stable trend from 1976 to 2014. It has a mean of 22.02358, a median of 20.73101, a standard deviation of 4.818224, and skewness of 0.622968.

4.2 Augmented Dickey-Fuller Info Root Test - Schwarz Info Criterion

Table 2: Augmented Dickey-Fuller Info Unit Root Test - Schwarz Info Criterion				
Variables	**Level**		**1st difference**	
	C (Intercept)	**C&T (Trend and Intercept**	**C (Intercept)**	**C&T (Trend and Intercept**
LNCO2	0.9768	0.3159	0.0094**	0.0345**
LNGDP	0.9997	0.9837	0.0416**	0.0058**
LNEU	0.2334	0.5329	0.0144**	0.0000**
POPG	0.9827	0.1078	0.0000**	0.0000**
GCF	0.1021	0.3679	0.0001**	0.0003**

H0: There is a unit root (**) stationary

H1: There is no unit root ( ) non-stationary

Table 2 shows the results of the Augmented Dickey-Fuller Unit Root test – Schwarz Info Criterion. In interpreting the test, if the probability is less than 0.05, there is a need to reject the null hypothesis (which states that there is no unit root and that the variable is stationary). On the other hand, if the probability is more than 0.05, there is a need to accept the H0 (which states that there is a unit root, the variable is non-stationary).

It is evident that all variables being tested at the level are considered non-stationary. The values for the intercept (C) and trend and intercept (C & T) have more than 5% or 0.05 significance. Meanwhile, at the first difference, all variables being tested for the intercept (C) and trend and intercept (C & T) have values less than 5% or 0.05 level of significance. Therefore, all variables in the first difference are stationary.

4.3 Johansen Cointegration Test

Table 3: Results of Johansen Cointegration Test				
Hypothesized No. of CE (s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob****
None*	0.781740	138.2011	79.34145	0.0000
At most 1*	0.604925	84.92867	55.24578	0.0000
At most 2*	0.496350	52.42488	35.01090	0.0003
At most 3*	0.370880	28.41930	18.39771	0.0014
At most 4*	0.294287	12.19912	3.841465	0.0005

H0: There is no cointegration equation
H1: There is a cointegration equation

Table 3 shows the overall results of the Johansen Cointegration test. In interpreting the data for this test, if the probability is less than 0.05, there is a need to reject the null hypothesis (H0); therefore, there is a cointegration equation. However, if the probability has more than a 0.05 level of significance, there is a need to accept the null hypothesis (H0); therefore, there is no cointegration equation. The results show that probabilities are less than 5% or 0.05 level of significance; therefore, the null hypothesis is rejected, concluding that there is cointegration.

4.4 Regression Results

This section will indicate the results of the regression analysis of the variables. It will show below the table of the estimation regression of the variables wherein the coefficients and standard error of the parameters will be given:

4.4.1 Regression Coefficients of the Economic Model

Table 4. Regression Coefficients of the Economic Model

Variables	**Coefficients**	**Standard Errors**
C (Intercept)	1.029156	2.021942
GDP per capita	-0.218497	0.138153
Energy consumption	2.241703	0.218841
Population growth	-1.077123	0.060095
Gross capital formation	0.009895	0.003248

Thus, the econometric model can be expressed as previously presented in the table below; the study can be formulated as follows:

$$lnCO2 = 1.029156 - 0.218497\ (lnGDP) + 2.241703\ (lnEU)$$
$$- 1.077123(POPG) + 0.009895\ (GCF) + \varepsilon i$$

Table 4 shows the results of the regression coefficients of the economic model. With the carbon dioxide emissions (CO2) as the dependent variable, it is shown that the b0 or the slope-intercept is 1.029156. The b1, or the slope of the gross domestic product (GDP), a one-unit increase in GDP means that the CO2 emissions decrease by -0.218497; thus, the mentioned variables have a negative relationship. Third, the b2, or the slope of energy consumption (EU), means that CO2 emissions increase by 2.241703 when there is a one-unit increase in the EU; thus, CO2 and the EU have a positive relationship with each other. Moreover, the b3, or the slope of the population growth (POPG), means that CO2 emissions decrease by -1.077123 when there is a one-unit increase in POPG; thus, CO2 and the POPG have a negative relationship with each other. Lastly, the b4 or the slope of GCF shows that CO2 increases by 0.009895 when there is a one-unit increase in GCF; thus, CO2 and GCF have a positive relationship.

4.4.2 T-statistics and Probabilities

Table 5. T-statistics & Probabilities

Variables	**T-statistics**	**Probability**
C (Intercept)	0.508994	0.6140
GDP per capita	-1.581563	0.1230
Energy consumption	10.24354	0.0000
Population growth	-17.92360	0.0000
Gross capital formation	3.046214	0.0045

Table 5 shows the results of the probability of the T-statistic test in identifying whether each of the selected independent variables has a significant relationship with the dependent variable. The t-test will confirm if a selected independent variable is significant to the dependent variable if the probability is less than 5% or 0.05 level of significance. In GDP per capita and CO2 emissions, the t-test shows a p-value of 0.1230, which means it is not significantly related. Energy consumption states that it is significantly related to CO2 emissions because it has a p-value of 0.0000. Moreover, population growth and CO2 emissions are considered significantly related because it has a p-value of 0.0000. Lastly, gross capital formation and CO2 emissions are also considered significantly related, with a p-value of 0.0045.

4.4.3 Coefficient of Determination

Table 6. Coefficient of Determination of CO2 Model	
R-squared	0.977725
Adjusted R-squared	0.975105

Table 6 shows that the R-squared of the CO2 model implies the variability in GDP per capita, energy consumption, population growth, and gross capital formation can explain 0.977725 or 97.77% of the variability in CO2 emissions in the Philippines. Therefore, results show that the R-squared is that the overall model for the study is to be considered goodness-of-fit since it is more than 80%. Moreover, the adjusted R-squared of the CO2 model implies that the variability in GDP per capita, energy consumption, population growth, and gross capital formation can explain 0. 0.975105 or 97.51%, given the adjustment for degrees of freedom of the variability in CO2 emissions.

4.4.4 F-statistics and Probabilities

Table 7. F-statistics and Probabilities	
F-statistics	373.1008
Probability (F-statistic)	0.000000

Based on Table 7, the F-statistic value is 373.1008, and the F-statistic probability or p-value is 0.0000. The F-statistic probability is at 0, which means a significant relationship exists between carbon dioxide emissions and gross domestic product, energy consumption, population growth, and gross capital formation.

4.5 Diagnostic Tests
4.5.1 Variance Inflation Factor (Multicollinearity Test)

Table 8. Variance Inflation Factor (Test for Multicollinearity)	
Auxiliary Regression	**VIF**
C (Intercept)	N/A
GDP per capita	4.439299
Energy consumption	1.262325
Population growth	5.825197
Gross capital formation	2.382037

H0: There is no multicollinearity

H1: There is multicollinearity

Based on Table 8, the value of the variance inflation factor (VIF) of each variable is stated, GDP per capita with 4.439299, energy consumption with 1.262325, population growth with 5.825197, and gross capital formation with 2.382037. In testing for the detection of multicollinearity on each variable, the Centered VIF should be greater than 10. As seen with the results in Table 8, the values of each independent variable are less than 10; therefore, there is no presence of multicollinearity, and there is a need to accept the null hypothesis.

4.5.2 Durbin-Watson Test

Table 9. Durbin-Watson Test	
d-statistics	1.538785

Table 9 shows that the Durbin-Watson statistic has a value of 1.538785. Therefore, the model is not suffering from an autocorrelation problem.

4.5.3 Breusch-Godfrey (Serial Correlation Test)

Table 10. Breusch-Godfrey (Serial Correlation Test)			
Obs. R-squared	4.670816	**Prob. Chi-Square**	0.0968

H0: There is no serial correlation

H1: There is a serial correlation

The Breusch-Godfrey test also detects if an autocorrelation problem exists. In interpreting the Breusch-Godfrey test, if the given Prob. Chi-Square is less than 0.05 level of significance; there is a need to reject the null hypothesis (H0); thus, there is a serial correlation. However, if the given Prob. Chi-Square is more than the 0.05 level of significance; there is a need to accept the null hypothesis; thus, it implies that there is no serial correlation.

The results show that the Prob. Chi-Square at lag 2 is higher than the 0.05 level of significance with the value of 0.0968; therefore, there is no serial correlation.

4.5.4 White Test (Heteroscedasticity Test)

Table 12. White Test (Heteroscedasticity Test)			
Obs. R-squared	16.07876	**Prob. Chi-Square**	0.2449

H0: The residuals are homoscedastic

H1: The residuals are heteroscedastic

Table 12 shows the value of Prob. Chi-square is 0.2449, and the Obs. R-squared is 16.07876. In interpreting the heteroskedasticity test, if the Prob. Chi-Square is less than the 0.05 level of significance; there is a need to reject the null hypothesis (therefore, the residuals are heteroscedastic). On the other hand, if the Prob. Chi-Square is more than the 0.05 level of significance; there is a need to accept the null hypothesis (therefore, the residuals are homoscedastic).

The results show that the Prob. Chi-Square for the White test is higher than the 0.05 level of significance with 0.2449; therefore, the residuals are homoscedastic. There is a need to accept the null hypothesis.

4.5.5 Ramsey RESET Test

Table 13. Ramsey RESET Test (Test for Misspecification Errors)

F-test	**df**	**Probability**
1.306785	(1, 33)	0.2612

H0: There are no specification errors

H1: There are specification errors

Table 13 shows that the value of probability is 0.2612. Since the value of probability F is greater than the significance level of 0.05, no specification errors are found. Therefore, there is no need to reject the null hypothesis.

4.5.6 Jarque-Bera Test (Normality Test)

Table 14: Jarque-Bera Test (Normality Test)

Jarque-Bera	Probability
5.343988	0.069114

H0: Residuals are normally distributed

H1: Residuals are not normally distributed

Table 14 shows that the probability value of 0.069114 is greater than the 0.05 level of significance, considering that the residuals are normally distributed. Therefore, there is a need to accept the null hypothesis.

5. Conclusion

Based on the findings conducted by the researchers, the Augmented Dickey-Fuller unit root test revealed that all the study variables involved in the study were stationary at the first difference, and the Johansen cointegration test shows that there is a long-run relationship between the study variables. Moreover, the researchers tested the variables' significance, whereas the p-values of the t-test show are the following: (1) carbon dioxide emissions have no significant and indirect relationship with economic growth. (2) Energy consumption is significantly and positively related to the increase in carbon dioxide emissions in the country, where carbon dioxide increases whenever there is an increase in energy consumption among households and different sectors. Third., (3) population growth in the country has a significant but inverse relationship with carbon dioxide emissions due to its slow growth over the past year based on the trendline results. Fourth, the (4) gross capital formation has proven that it has a significant and positive relationship with carbon dioxide emissions. Moreover, there are no violations in the CLRM assumptions, whereas the econometric model is significant, normally distributed, with no signs of multicollinearity, serial correlation, heteroscedasticity, and misspecification errors.

Since carbon dioxide emissions are steadily increasing, primarily due to energy consumption and gross capital formation, the researchers suggest embracing the promotion of carbon and energy intensity identification in the Philippines. This can be done by implementing more green energy initiatives while maintaining and sustaining the nation's economic momentum. Operations will promote sustainable growth to carry out successful policies regulating the country's energy and manufacturing sectors. There is a need for the government to reduce carbon dioxide emissions by implementing such environmental-friendly policies towards the contributors to excessive energy consumption usage. In addition to this, energy usage should be regulated and thought of as an alternative solution via incorporating renewable energy sources such as solar panels, hydropower, and wind energy sources. Mandating the recommendations will help maintain the country's sustainable economic growth and development. The Philippine government should also invest in environmentally friendly infrastructures to alleviate carbon dioxide emissions in the future to protect the environment.

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