
| RESEARCH ARTICLE

Macroeconomic Factors Affecting Carbon Dioxide Emissions in the Philippines: A Time Series Analysis

Cruz, Nicole Angela F¹ ✉, Dalumpines, Daphne P² and Canto, Danielle³

¹²³*Department of Economics, University of Santo Tomas, Manila, Philippines*

Corresponding Author: Cruz, Nicole Angela F, **E-mail:** nicoleangela.cruz.ab@ust.edu.ph

| ABSTRACT

This paper examines the relationship between macroeconomic variables (Gross Domestic per capita, Energy Consumption, Trade Openness, and Foreign Direct Investment) and CO₂ Emissions in the Philippines from 1981 to 2014. Using multivariate Ordinary Least Squares (OLS) regression, the results indicate that GDP per capita, Energy Consumption, and Trade Openness are significant and positively related parameters of CO₂ emissions. Conversely, Foreign Direct Investment is revealed to be positively related but insignificant to CO₂ emissions in the Philippines. Moreover, the R-squared of the model and the F-test results suggest that the overall model is robust and significant, respectively. The diagnostic tests employed (including Variance Inflation Factor, Breusch-Godfrey test, White test, Ramsey RESET test, and Jarque-Bera Test) show that the regression model has no evidence of multicollinearity, heteroscedasticity, non-normality, and misspecification. Finally, the researchers offer recommendations that open the potential for future studies and improve the econometric model.

| KEYWORDS

Environmental Kuznets Curve hypothesis, CO₂ emissions; Gross Domestic Product per capita; Energy Consumption; Trade Openness; net inflows of Foreign Direct Investment; OLS Regression Analysis

| ARTICLE DOI: [10.32996/jefas.2022.4.1.46](https://doi.org/10.32996/jefas.2022.4.1.46)

1. Introduction

1.1 Background of the Study

Environmental degradation is one of the most pressing issues of our time. The consequences of the heavy pollution going on for many years are alarming both locally and globally. This might have catastrophic consequences for all aspects of society, including poverty, hunger, unemployment, living conditions, and population health (Watson et al., 2001). Natural factors that alter the climate's global atmospheric composition are frequently related to this problem. In addition, scholars have also claimed that human activity and economic growth due to the emergence of industrialization are the causes of environmental issues based on the notion that increased production equals increased pollution. However, some argued that, with rising economic growth, individuals tend to have a greater ability to use resources to protect the environment (Pettinger, 2019). In a world where economies are continually evolving, and output is increasing, it is critical to comprehend the link between economic status and environmental deterioration, particularly in developing countries like the Philippines.

Since the industrial revolution, many economies have increased, with considerable energy consumption. The Philippines, as a newly industrialized country, has been transitioning from an economy based on agriculture to one based more on services and manufacturing (EY Reporting). Furthermore, the Philippines has experienced rapid economic and demographic growth in recent years. This may necessitate the use of natural resources, which could negatively impact the environment (Al-Mulali et al., 2016). Thus, this paper aims to identify the relationship between CO₂ emissions and vital economic variables contributing to economic growth.

Several empirical studies reported that GDP per capita is highly correlated with CO₂ emission, suggesting that a trade-off might exist between raising average living standards and controlling global warming. Moreover, questions are raised about how expansions of worldwide trade and the increasing integration of global value chains affect the environment (OECD). Foreign Direct Investment (FDI) has also been identified as one of the main engines of economic growth, a potential source of employment that has negative consequences for the environment (Demenea & Afesorgborb, 2020). Finally, as the world's population and urbanization rise, so does the energy demand. People's lifestyles have changed, and their living conditions have improved, stimulating energy consumption dramatically (Chontanawat, 2019). As a result, it is crucial to understand how the region's GDP per capita, trade openness, foreign direct investment, energy consumption, and carbon dioxide emissions have changed over the last few decades and how these variables interact with each other. More importantly, this research provides sufficient empirical evidence to completely comprehend the country's environmental quality to inform future government decisions on environmental degradation and its relationship to economic growth.

1.1.1 Philippine Context

This paper focuses on one country, the Philippines, and one air pollutant, carbon dioxide. The Philippines is one of Asia's fastest-growing economies, and the environmental consequences of this economic growth must be observed and addressed accordingly. Carbon dioxide accounts for approximately 64% of the greenhouse gases that cause global warming. The need to be cautious of increased carbon dioxide emissions due to internal and external factors dictates income growth. The Philippines is considered highly vulnerable to climate change due to its geographical location, topography, and current socio-economic structure. It's over 7000 islands put much of its land and people at risk from stronger tropical storms and flooding. Increased occurrence of extreme weather events will significantly reduce productivity in agriculture and services, sectors on which most Filipinos rely for a living.

The problem could be rooted in the unawareness of the government and policymakers about the degree of influence of economic growth on carbon emission in the country. There is a need for empirical evidence on the relationship of vital economic variables with carbon dioxide emissions to make sound policy choices. Greater awareness of the factors that affect it could help boost economic growth while stabilizing climate change and its consequences to the livelihoods of the future generation.

1.2 Statement of the Problem

The Philippines currently has a low level of per capita greenhouse gas emissions. However, emission levels are growing at an increasing rate, with a 4% annual growth between 2006 and 2012 (ADB, 2020). The country's energy system is becoming more carbon-intensive to satisfy escalating energy demand caused by strong economic growth. Accordingly, a need for empirical evidence on the relationship of key economic variables will guide the country's policymakers on making sound policy choices that would contribute to economic development without threatening the environment. Thus, the researchers sought to answer the following questions:

1. What are the changes that occurred to the following variables from 1981 to 2014 in the Philippines?
 - a) Carbon Dioxide (Co₂) Emission
 - b) Gross Domestic Per Capita
 - c) Energy Consumption
 - d) Trade Openness
 - e) Foreign Direct Investment
2. Is there a statistically significant relationship between Carbon Dioxide (Co₂) Emission and the independent variables (GDP per capita, Energy Consumption Trade Openness, and Foreign Direct Investment)?

1.2.1 Hypotheses of the Study

The null hypotheses of the study are the following:

Ho1: There is no significant relationship between Co₂ Emission and GDP per capita

Ho2: There is no significant relationship between Co₂ Emission and Energy Consumption

Ho3: There is no significant relationship between Co₂ Emission and Trade Openness

Ho4: There is no significant relationship between Co₂ Emission and Foreign Direct Investment

1.3 Scope and Limitations of the Study

The scope of this study involves the econometric analysis of relevant factors affecting Carbon Dioxide Emissions in the Philippines. The researchers used multiple regression analysis to assess the relationship between economic growth and carbon emissions. The study used time series data spanning from 1981 to 2014, with 34 observations. Due to financial and time constraints, the researchers relied on secondary resources from the World Bank's open statistics websites.

Furthermore, the researchers only collected annual data and ignored other periodicals because some of the indicators used in this study only had annual updates available. The CO₂, the dependent variable in the model, is measured using Carbon Dioxide Emissions in kiloton. On the other hand, the independent variables that are determined as the factors for the changes in CO₂ levels are as follows: GDP per capita, in current US dollars; Energy consumption, which is measured in a kilogram of oil per capita of energy use; Trade openness (share of trade in GDP) in percentage; and inflows of Foreign Direct Investment in current US Dollars. The researchers will not explore other determinants used in related studies and are not considered by this study's framework. Lastly, the data obtained and utilized through quantitative investigations are aggregate. Regional data and analysis of both dependent and independent variables will not be conducted.

1.4 Significance of the Study

Analyzing the relationship between Carbon Dioxide Emission and key economic variables is significant to the following:

Philippine Government. The foremost objective of this study is to help the Philippine government, particularly the environmental sector, develop analytical frameworks about the determinants of CO₂ Emissions in the Philippines through the lens of economics. The government can use the findings to formulate macroeconomic policies necessary to determine whether growth steadily worsens environmental conditions or if it eventually leads to an increase in environmental quality relative to their levels of economic activity. Furthermore, the findings can also significantly contribute to the literature on economic growth in the Philippines and create efficient ways and approaches to remedy the country's current environmental and economic-related issues.

Community. In addition to the market and the state, the community is regarded as the third pillar of the economic system. The study will help individuals understand an important and controversial issue – the impact of economic activity and policy on the community in which we live. In addition, this will also provide them insights about their roles in improving the quality of life while also ensuring nature's ability to operate over time by reducing waste, conserving energy, increasing efficiency, and developing local resources to help the economy thrive. Finally, in a sustainable community, humans, the environment, and economic elements are interrelated and must draw strength from one another.

Future Researchers. This study may serve as a guide and reference for students undertaking similar studies or testing other research findings' validity. The study will also serve as the cross-reference that will give them background information or an overview of the macroeconomic factors affecting Carbon Dioxide Emissions in the Philippines. Furthermore, information that will be obtained in this study is significant for future economists and may assist them in creating efficient solutions through economic policies to solve existing problems related to health care.

2 Review of Related Literature

Since the industrial revolution, pressures on the environment had begun to emerge when it reached a global scale. In addition, human-caused greenhouse gas emissions rapidly increased in recent years, and economic expansion is widely acknowledged as the primary cause of climate change (Mgbemene,2016). At the same time, empirical confirmation remains ambiguous and contentious to this day. As a result, various researchers have taken an interest in investigating the relationship between economic growth and CO₂ emissions, as evidenced by the following studies:

2.1.1 Carbon Dioxide Emission and GDP Per Capita

In recent decades, many studies have looked at the environmental consequences of GDP per capita. Some suggest that increasing GDP per capita leads to increased CO₂ emissions. However, some argue that a rise in income necessitates using resources to improve the environment. This highlighted the need for more research in this area. The following is a quick rundown of the growing body of literature on this subject.

Cederborg and Snöbohm (2016) examined the linkage between GDP per capita and CO₂ emissions. Using cross-sectional data, the analysis was conducted on 69 industrial and 45 developing nations. The empirical result of the cross-sectional study implies that the correlation between the two variables is positive, which suggests growing GDP per capita leads to increased CO₂ emissions. As some theories say, there is no tipping point where emissions fall when GDP reaches a certain level. According to the findings, market economic processes are insufficient to reduce emissions, so legal measures are required to prevent future environmental degradation.

Sun et al. (2020) investigated the relationship between income inequality, economic activity, and consumption-based greenhouse gas emissions for a few selected economies from 1990 to 2014. The study noted that an increase in GDP per capita causes a considerable upward movement in consumption-based carbon footprint per capita, implying the existence of a U-shaped model. The study also found significant associations between inequality and carbon footprint per capita for low-income inequality economies.

Moreover, Mohammed et al. (2019) studied the key factors contributing to the large amounts of CO₂ emission in the top 10 CO₂-emitting countries, including China, United States, India, Russia, Japan, Germany, South Korea, Iran, Canada, and Saudi Arabia. They used the Logarithmic Mean Divisia Index (LMDI) method to study how population, income per capita, energy intensity, and carbon intensity influence and change the CO₂ emission levels in these countries. In addition, the effect of CO₂ emission generated by different industries was analyzed, and the total CO₂ emission by 2030 was estimated. The results revealed that population and income significantly affect CO₂ emission, especially in China and the United States. Furthermore, the forecast for CO₂ emission in 2030 implied that the CO₂ level in all countries would increase.

Adeleye et al. (2021) investigated the importance of income per capita in reducing the carbon footprint of energy use from 28 selected African countries from 1990 to 2019. Their findings revealed, among others, that income appears to be a positive driver of emissions. On average, 0.87 percent to 0.84 percent of the gain is contributed. This presents a problem for African economies in their quest for growth, allowing for trade-offs. The researchers noted that governments should invest more in renewable energy as African countries seek to prosper while reducing carbon emissions.

In Southeast Asia, a study was conducted to explore the relationship between the economy and the environment. Phong et al. (2018) explored the effects of key socio-economic development factors in Vietnam, including GDP per capita, on Vietnam's CO₂ emissions. The autoregressive distributed lag method was used to analyze 31-year data from 1985 to 2015, and the bound test result denotes the long-run relationship between CO₂ emissions and its determinants. They discovered that energy consumption, industrialization, and GDP per capita increase CO₂ emissions in the long run. In contrast, globalization has the opposite effect, implying pragmatic recommendations for policymakers in promoting relevant strategies for sustainable economic development in Vietnam.

Riti et al. (2017) conducted a similar study using a different methodology. He examined the nexus of CO₂ emissions, economic growth, and energy consumption in China to provide additional evidence regarding the environmental Kuznets curve (EKC) occurrence throughout 1970–2015. The result revealed that CO₂ emission increases with the increase in GDP per capita. CO₂ emission also increases as energy consumption increases in the short and long run. Contrary to Phong et al. (2018), an increase in per capita GDP causes a decrease in CO₂ emissions in the long run. Concerning the existence of EKC, the result exposed some inconsistencies but still supported the hypothesis that a long-run improvement in the Chinese economy will result in the recovery of the environment.

2.1.2 Carbon Dioxide Emission and Energy Consumption

Given that rising CO₂ emissions have become a global concern, it is critical to investigate the causes of CO₂ emissions. According to prior studies, energy consumption is one of the most commonly reported sources of CO₂ emissions. Several studies have recently been conducted to better understand its relationship to environmental degradation; however, the association has been interpreted in various ways. The following summarizes and compares previous empirical studies that have been used to explain the relationship between energy use and CO₂ emissions.

Osobajo et al. (2020) studied the impact of energy utilization and financial development on CO₂ outflow levels of 70 nations from 1994 to 2013. Thus, it considers energy consumption, urbanization, industrialization, and growth in population as significant contributors to worldwide expansion in CO₂ emanation levels. The Granger causality tests revealed that the study's variables have a bi-directional causal relationship with CO₂ emissions, while energy consumption has a unidirectional relationship. As a result, this study supports the need for a global transition to a low-carbon economy, primarily through climate finance. This will encourage large-scale investments in clean energy, which are required to reduce CO₂ emissions significantly.

Using the same methodology, Vo et al. (2019) examined the causal connection between carbon CO₂ discharges, energy utilization, environmentally friendly power, populace development, and monetary development in ASEAN countries from 1971 to 2014. The findings revealed no long-run relationship between the variables of interest in the Philippines and Thailand, but there is one in Indonesia, Myanmar, and Malaysia. In addition, Granger causality among these important variables varies significantly across the countries studied. Malaysia, the Philippines, and Thailand have reported no Granger causality between carbon emissions, energy consumption, and renewable energy consumption. Indonesia experiences unidirectional causal effects from economic growth to renewable energy consumption and CO₂ emissions in the short and long run. Interestingly, only Myanmar has a unidirectional impact from GDP growth, energy consumption, and population to the adoption of renewable energy.

Mukhtarov et al. (2022) investigated the causal relationship between energy consumption and economic growth in Azerbaijan from 1990 to 2015. Using the Vector Auto-Regressive (VAR) model, it was discovered that there is bidirectional causality between energy consumption and economic growth. Furthermore, economic growth may necessitate more energy consumption, whereas

increased energy consumption may stimulate economic growth. Energy consumption and economic growth may be mutually beneficial, but energy conservation measures may hurt economic growth.

Moreover, Odugbesan and Rjoub (2020) focused on the comprehensive analysis of the synergistic relationship of economic growth, CO₂ emissions, urbanization, and energy consumption in MINT (Mexico, Indonesia, Nigeria, and Turkey) countries. This study utilized the Autoregressive Distributed Lag (ARDL) bounds test to analyze World Bank Development Indicators data from 1993 to 2017. The result indicated that unidirectional and bidirectional causalities are present among the countries. In addition, MINT countries exhibit a long-running causal relationship from economic growth, energy consumption, and CO₂ emissions to urbanization. Therefore, promoting green industries and developing energy conservation policies is critical in maintaining the steady path to urbanization without harming the environment.

Cai et al. (2018) studied the connection between clean energy consumption, economic growth, and CO₂ in G7 countries by utilizing a new bootstrap Autoregressive Distributive Lag (ARDL). The results indicated no cointegration among the variables in Canada, France, Italy, the US, and the UK. In contrast, cointegration exists in Japan when CO₂ emissions are the dependent variable. Similarly, the results for Germany implied the presence of cointegration when GDP per capita and CO₂ emission are selected as the dependent variables. Based on the results, the policies implemented in G7 countries to promote clean energy use are effective. Therefore, other developing countries must adopt similar approaches to achieve sustainability and green growth.

A similar study was conducted by Khan et al. (2020) using the same methodology. They investigated the relationship between energy consumption, economic growth, and CO₂ emissions in Pakistan using annual time series data from 1965 to 2015. Using the Auto- Regressive Distributive Lag, it was found that energy consumption and economic growth increase CO₂ emission in Pakistan both in the short run and long run. This indicated that policymakers in Pakistan should adopt and promote renewable energy sources to help meet the increased demand for energy by replacing old traditional energy sources such as coal, gas, and oil. In addition, usage of environment-friendly equipment, machinery, vehicles, and utilities to minimize the environmental degradations. Lastly, renewable energy sources are reusable and can reduce CO₂ emissions and ensure the sustainable economic development of Pakistan.

Muhammad, B. (2019) explored the effect of economic growth, energy consumption, and CO₂ emissions in MENA countries from 2001 to 2017. Using the Seemingly Unrelated Regression (SUR) and generalized method of moments for data analysis, it was discovered that economic growth increases with increased energy consumption in developed and emerging countries while decreasing in MENA countries. The findings suggest that policymakers in these countries should pursue strategies emphasizing environmentally friendly technologies to reduce CO₂ emissions.

Aye & Edoja (2017) found similar findings. They examined the effect of economic growth on CO₂ emission in 43 developing countries from 1971 to 1997. Utilizing the threshold panel methods revealed that energy consumption and population were also positively and significantly impact CO₂ emissions. The findings indicate the need to transform low-carbon technologies to reduce emissions while promoting sustainable economic growth.

Lastly, Bashir et al. (2019) explored the causality among economic growth, human capital, energy consumption, and CO₂ emissions in Indonesia by analyzing the development indicators from 1985 to 2017. They utilized the Vector Error Correction (VEC) model to process and analyze the data obtained from the database of the World Bank. The findings of this study can be summarized into five points. First, CO₂ emissions per capita and real (GDP) per capita do not share causality with human capital in the short and long runs. Second, causality exists between CO₂ emission and energy consumption in the short run. Third, human capital, energy consumption, and economic growth cause a change in CO₂ emission in the short run. Fourth, human capital, energy consumption, and CO₂ consumption trigger a change in real GDP capita in the short and long run. Finally, long-run balance causality exists only within the internal aspects of human capital and energy consumption. Based on the above results, the existing policies of the Indonesian government are beneficial in maintaining energy consumption and CO₂ emissions at acceptable levels.

2.1.3 Carbon Dioxide Emission and Trade Openness

According to economic theories, trade liberalization and economic growth have a significant association. Because trade openness can enhance productivity and revenue, it adversely affects CO₂ emissions. However, there are no apparent links between environmental quality and trade openness (Copeland and Taylor, 2005). We highlighted the following studies that have used theoretical models and experimental frameworks to examine the effects of trade on environmental quality.

Chen et al. (2021) studied whether growing trade openness leads to more serious environmental issues using panel data from 64 countries from 2001 to 2019. The empirical findings revealed that increased trade openness has a considerable positive influence on CO₂ emissions and that the impact varies depending on the level of CO₂ emissions. Furthermore, trade openness has a favorable indirect influence on CO₂ emissions via the economic effect, whereas it negatively affects CO₂ emissions via energy

substitution and technological impact. As a result, improving renewable energy consumption, lowering energy intensity, and formulating policies to minimize carbon emissions policies in local conditions are critical.

This is consistent with Ansari et al. (2019) when they looked into the effect of economic growth, international trade, and energy consumption on the global CO₂ emissions in the case of top CO₂ emitters from 1971 to 2013. The findings found that the growth-trade-pollution nexus in the United States, Canada, Iran, and France has one-way causality from economic growth and trade openness to CO₂ emissions. As a result, the quantity of trade should be reduced to lessen emissions, as the authors discovered that an increase in trade granger causes CO₂ emissions in the long run.

Moreover, Dou et al. (2021) explored the prospective impact and internal influencing mechanism of trade openness on China-Japan-ROK FTA countries' CO₂ emissions from 1970 to 2019. Their findings revealed that trade openness positively affects the greenhouse effect, and imports contribute to increased carbon emissions while exports significantly reduce carbon emissions in a country.

In addition, Wang and Zhang (2021) explored the effect of trade openness on the decoupling of carbon emissions from economic growth in 182 countries from 1990 to 2015. The findings indicated that trade openness reduced carbon emissions in high-income and upper-middle-income countries, increased in low-income countries, and had no effect on lower-middle-income countries. This suggests that while trade openness helps rich countries decouple economic growth from carbon emissions, it negatively affects developing countries. Furthermore, when individual incomes and populations rise, the decoupling of economic expansion from carbon emissions is distorted. This is contrary to the study conducted by Ansari et al. (2019) since most of the top CO₂ emitters are upper-middle-income countries.

Finally, Szymczyk et al. (2021) used panel data analysis to examine the impact of economic growth, energy consumption, energy management, urban population, trade openness, and financial development on CO₂ emissions in OECD countries from 1990 to 2014. The augmented dicker-fuller test revealed that among the economic variables used in the study, only trade openness is insignificant to CO₂ emissions.

2.1.4 Carbon Dioxide Emission and Foreign Direct Investment

One of the most common issues regarding foreign direct investment (FDI) is its potentially harmful impacts on the environment. The potential environmental cost due to increased emissions may outweigh the economic gains associated with increases in FDI inflow. In theory, FDI can negatively or positively impact the environment. Many empirical studies have addressed the theoretical uncertainty around the FDI-environment nexus, but their findings merely add to the debate because they provide different outcomes.

Huang et al. (2022) investigated the impacts of FDI inflows on CO₂ emissions of G20 economies from 1996 to 2018. The findings revealed that FDI inflows are positively related to carbon emissions and that both economic development and regulatory quality have adverse effects on FDI inflows' carbon emissions consequences. However, because the G20 economies have a high degree of development, FDI inflows reduced CO₂ emissions. It means that, while FDI inflows tend to increase CO₂ emissions, they are more likely to be reduced in nations with better levels of economic development and regulatory quality. As a result, a country must focus more on the quality of its economic development, which aids in mitigating carbon emissions generated by FDI inflows.

Dumru and Kılıçarslan (2017) found similar findings. They examined the relationship between foreign direct investment and pollution using the Johansen Cointegration test and vector error correction model in Turkey from 1974-2013. The results indicated that foreign direct investment positively affects carbon dioxide emissions in the long run. The researchers recommended that ecologically sensitive investments, cleaning technology investments, and environmentally friendly research and development activities should be promoted to improve the quality of the environment. Furthermore, tax regulations for polluting foreign investments should be observed to offset the detrimental impact of FDI on CO₂ emissions.

Moreover, Demena and Afesorbor (2019) conducted a meta-analysis of the effect of FDI on environmental emissions using 65 primary studies that produced 1006 elasticities. Contrary to the previous studies, their findings show that the underlying impact of FDI on environmental emissions is close to zero. However, after accounting for study heterogeneity, they found that FDI reduces environmental emissions significantly. After disaggregating the effect for countries at various stages of development and different pollutants, the results remain consistent. This indicated that FDI does not only improve economic growth but could also potentially reduce environmental pollution or emissions.

Efficiency, innovation, and regulation features are critical for a better understanding of the effects of FDI flows. From 2001 to 2017, Marques and Caetanoa (2020) investigated the impact of foreign direct investment on emission reduction targets in 21 countries

based on income level. According to the Panel Autoregressive Distributed Lag, FDI reduces emissions in high-income nations while raising them in the short run in middle-income countries, which supports the Pollution Haven Hypothesis. Nonetheless, for middle-income countries to prosper in the long run, their ability to absorb technology is critical. In middle-income countries, environmental regulation has a significant impact on trade openness.

For countries, foreign investment is becoming increasingly crucial. When choosing a country to invest in, investors consider the country's environmental policies. Foreign investments in host nations can have either beneficial or adverse environmental effects, depending on various factors such as their income level and technological capacity. Many research has been conducted on this topic, with varying outcomes. The majority of research in the literature shows that FDI raises CO₂ emissions in the host country. However, FDI has been demonstrated in several studies to lower CO₂ emissions. Some of the studies observed that the results supporting the two hypotheses were obtained according to the level of development of the countries participating in the analysis.

2.2 Synthesis

The majority of the related studies written above indicate a significant relationship between economic growth and carbon dioxide (CO₂) emissions. Most empirical studies suggest that the variables used in the analysis: GDP per capita, energy consumption, trade openness, and foreign direct investment, are the main contributing factor in increasing CO₂ emissions, regardless of their individual significance in the overall model. This supports the primary assumption of the Environmental Kuznets Curve, which states that the subsequent industrialization process damages the environment, but as income per capita increases, environmental legislation is introduced to reduce emissions and pollution. However, some researchers suggested that no such relationship exists in developing economies, making this one of the unsolved issues in understanding the trends of CO₂ emissions.

Many studies have looked at the effects of GDP per capita and energy consumption on carbon dioxide (CO₂) emissions. However, only a few studies have used trade openness and foreign direct investment to determine the levels of CO₂ emissions. Trade and investment are among the most influential determinants of economic growth. Due to its widespread effects, countries tend to improve it to achieve better financial results. These two variables are vital in this study because higher trade and investment in a country means more usage of natural resources, which eventually adversely impacts the environment.

In addition, our literature review revealed that the Philippines had received very little attention. Despite the fact that the researchers earlier indicated that Vo et al. (2019) published a study concentrating on ASEAN countries, including the Philippines. However, GDP per capita, trade, and net inflows of Foreign Direct Investments are excluded in the research domain.

Furthermore, the related studies were arranged coherently to indicate and emphasize the study's objectives. Understanding the existing body of knowledge about the subject being explored would aid the aforementioned research gaps. Applying the methods used in the related studies and knowing the findings would allow the researchers to examine thoroughly and contribute new knowledge that might not be present in the related studies. Other findings and indicators used in previous studies, such as population growth rate, urbanization, and gross capital formation, are not included in the study's framework and were not thoroughly explored by the researchers to become more specific to the purpose and intent of the study.

2.3 Theoretical Framework

The assumptions based on both theoretical and empirical results suggest that the expected changes in the Carbon Emission in the Philippines as an indicator for GDP per capita, energy consumption, trade openness, and foreign direct investment will be under significant influence of the changes in the economic growth of the Philippines and with improving the living standard and environmental conditions of the country. The following are the three theoretical hypotheses concerning the relationship between environmental degradation and economic growth:

2.3.1 Environmental Kuznets Curve

The Environmental Kuznets Curve (EKC) hypothesis describes the relationship between the environment and economic growth. It suggests that economic development initially leads to environmental deterioration but eventually reduces after a certain level of economic growth. This implies that the EKC follows an inverted U-shape where per capita income and CO₂ emissions are positively correlated.

In addition, the theory of EKC is also based on the transition of society from agricultural to industrial production. As industrial production becomes more intensive, pollution increases. In addition, due to rapid economic growth brought about by the rise in income and energy consumption, natural resources are being used, which leads to environmental deterioration. However, with time and higher income levels, a more high-technological and service-centralized production will be introduced, reducing the adverse effect on the environment.

Furthermore, several studies have used various factors of environmental depletion based upon the theory. The majority of the studies have looked into the impact of variables other than GDP per capita that may have a significant relationship with CO₂ emissions. Such economic variables include energy consumption, population growth, urbanization, international trade, and foreign direct investment. The importance of these variables can adequately explain a hypothetical relationship between economic growth and the environment (Beck, K & Joshi, P., 2017).

2.3.2 Trade Theory

According to trade theory, a marginal change in trade has three principal effects on emission levels: the scale effect, the composition effect, and the technique effect. First, the scale effect refers to an increase in emissions due to a higher level of economic activity. As a result, the scaling effect has a generally positive sign. Second, the composition effect occurs when there is a change in emissions due to a change in the relative shares of different items in production. If the exported goods emit many greenhouse gases, then trade liberalization will increase overall emissions. However, trade liberalization will reduce emissions due to a comparative advantage in 'clean' industries. Finally, the technique effect is a change in production methods on emissions. As demand for environmental quality rises, trade can help cut emissions per unit of output by enabling cleaner technologies or inducing regulatory changes (Grossman and Krueger, 1992)

2.3.3 Pollution Haven Hypothesis

The pollution haven hypothesis, also known as the pollution haven effect, holds that foreign investments with polluting industries will relocate to jurisdictions with laxer environmental regulations. This implies that developed countries impose stricter environmental policies than developing countries, causing existing patterns of comparative advantage to be distorted (Chatterjee, 2019). As a result, polluting industries shift operations from developed to developing countries, transforming developing countries into "pollution havens." Furthermore, it is based on the idea that multinational corporations use lands of developing countries to produce for the country of origin because environmental laws and regulations in the country of origin restrict the use of low-cost, environmentally harmful technologies (Güvercin, 2019).

2.4 Conceptual Framework

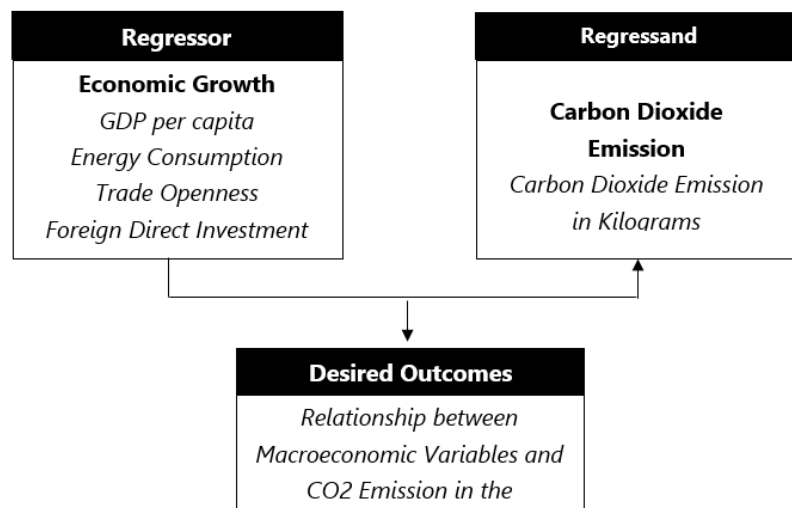


Figure 2.1 **Macroeconomic Factors Affecting Carbon Dioxide Emissions in the Philippines: A Time Series Analysis**

The Criterion-Predictor (CP) model was used in describing the conceptual framework of the study. This type of model is used when the study aims to determine the effects of two or more independent variables and estimate the strength of relationships and differences among the variables that will be used in the study (Cristobal & Cristobal, 2013).

Figure 2.1 indicates the changes in the Carbon Dioxide Emission in the Philippines, determined by the changes in GDP per capita, Energy Consumption, Trade Openness, and Foreign Direct Investment as key economic variables. Many countries are confronted with a major challenge: ensuring stable economic growth while also protecting the environment. The major contributor to the climate change threat is an increase in CO₂ emissions. Countries' economic growth necessitates greater energy use, increasing CO₂ emissions; thus, pollution is inextricably linked to economic growth. There are five economic variables that are frequently linked to the changes in Co₂ emissions.

3 Research Methodology and Design

3.1 Research Design

This paper aims to analyze the relationship between various indicators of Carbon Dioxide Emissions. In this case, a quantitative correlational approach will be applied. This type of approach assesses the statistical relationship between the dependent variable, CO2 Emission, and the independent variables – GDP per capita, Energy Consumption, Trade Openness, and Foreign Direct Investment with no influence from any extraneous variable. Moreover, quantitative correlational design can help the researchers investigate the changes in one phenomenon to comprehend and describe certain events and predict future economic conditions (Creswell & Plano Clark, 2011).

3.2 Data Description and Collection

The scope of this study involves the econometric analysis of relevant factors affecting CO2 emission in the Philippines. The CO2, the dependent variable in the model, is measured in kilotons. On the other hand, the independent variables that are determined as the factors for the changes in CO2 are as follows: (1) GDP per capita, in current US dollars; (2) Energy consumption in kilogram of oil per capita of energy use; (3) Trade openness (share of trade in GDP) in percentage; and inflows of Foreign Direct Investment in current US Dollars. The researchers did not explore other determinants used in related studies and were not considered by this study’s framework. The data obtained and utilized through quantitative investigations are annual and aggregate. With this, regional data and analysis of both dependent and independent variables were not conducted. The time-series data collected were from the World Bank, gathering observations from 1981 to 2014.

3.3 Econometric Model

This study adopted a Multivariate Ordinary Least Square (OLS) regression model presented as:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n + \epsilon$$

The econometric model shown below describes Carbon Dioxide Emissions (CO2) is affected by the explanatory variables (GDP, EC, TO, and FDI):

$$Co_2 = \beta_0 - \beta_1 GDP + \beta_2 EC + \beta_4 TO + \beta_4 FDI + \epsilon$$

Whereas:

CO2 = Carbon Dioxide Emissions

GDP = GDP per capita

EC = Energy Consumption

TO = Trade Openness

FDI = Foreign Direct Investment

ϵ = error term

Furthermore, since the unit of measurements of all variables differs from one another, a natural logarithm was employed for a convenient means of transforming a highly skewed variable into a more normalized dataset. The advantage of treating the variables in their log form is that small variations in the variable can be directly interpreted as percentage variations to an approximation that gives it a substantive sense (Gelman & Hill, 2007). In this case, the earlier multivariate OLS regression model changes to:

$$\text{Log } Co_2 = \beta_0 - \log \beta_1 GDP + \log \beta_2 EC + \log \beta_3 TO + \log \beta_4 FDI + \epsilon$$

The significance of the relationship between each variable was determined by hypothesis testing, and the macroeconomic factors affecting carbon dioxide emission were determined by the beta coefficients (n) of each variable, respectively.

Table 3.3.1 Assumptions for each variable

Independent Variables	Assumption	Expected Sign
Per capita Gross Domestic Product in real terms	As GDP per capita increases, CO2 emissions also increases and vice versa	(+)
Energy Consumption in kilograms of energy use	As energy consumption increases, CO2 emissions also increases and vice versa	(+)

Trade Openness (share of trade in GDP)	As trade openness increases, CO2 emissions also increases and vice versa	(+)
Foreign Direct Investment in current US Dollars	As foreign direct investment increases, CO2 emissions also increases and vice versa	(+)

3.4 Instrumentation

The researchers used MS Excel (Microsoft Excel) to transform the data set into logarithmic form and utilized EViews to conduct the multivariate OLS regression and the following treatments: R-squared for the model's goodness of fit; T-test and P-values for the individual significance test of each variable; and T-test and P-values overall significance test of the model. Moreover, considering that this study will be using secondary data, it may encounter issues that violate regression analysis assumptions, causing the estimation to be invalidated and may result in inaccurate conclusions. To avoid such problems, the researchers used the following test to see if such issues exist in the econometric model: Variance Inflation Factor for multicollinearity test; White test for heteroscedasticity; Breusch-Godfrey for serial correlation; Ramsey RESET test for specification error; and histogram of normality. In the statistical treatment section, the aforementioned tests are thoroughly explained.

3.5 Statistical treatment of the Data

The following treatments were completed according to the procedures provided by Gujarati (2004):

3.5.1 R-squared or Coefficient of Determination

The coefficient of determination, also known as r-squared, measures how close the regressors (GDP, EC, TO, and FDI) and the regressand (CO2) are to the fitted regression line. Generally, a lower r-square indicates none of the response data variability around its mean. On the other hand, a higher r-squared (close to 1 or 100%) tells that the model explains all the variability of the response data around its mean.

3.5.2 Hypothesis Testing for the Individual Significance (T-test)

The t-test is an inferential statistic used to examine if there is a significant difference among the regression coefficients or if it has a considerable impact on the regressand. In this method, the null hypothesis that the true difference among the regression coefficients is zero must be rejected to conclude that each regressor is significantly different from zero. To reject the null hypothesis, the t-statistics must be greater than the critical t-value. Another way would be to calculate the P-value. According to the decision criteria for this approach, the P-value must be less than the level of significance (5%) for the regressor to have a substantial impact on the regressand.

3.5.3 Hypothesis Testing for the Overall Significance (F-test)

The F-test is the ratio of two quantities expected to be roughly equal under the null hypothesis, which produces a value of approximately 1. This is used when examining the significance of the overall model because it is the measure of dispersion or how far the data are scattered from the mean. Larger values represent greater dispersion. In this method, F-statistics must be greater than the critical F-value to reject the null hypothesis, implying that all the regression coefficients are equal to zero.

3.5.4 Test for Multicollinearity

Multicollinearity is when more than two regressors in a multiple regression model are highly linearly related, making the model biased. The Variance Inflation Factor (VIF) and Tolerance statistics (TOL) were employed to test if there is multicollinearity. In this method, the computed value of VIF must not be greater than 10 to reject the null hypothesis of having no multicollinearity.

3.5.5 Test for Heteroscedasticity

Heteroscedasticity means unequal scatter. It occurs when datasets have an extensive range between the largest and smallest observed values, resulting in unreliable results. A white test was employed to determine if this problem is present in the data. In this method, the chi-square, r-squared, and p-value of the regressors should be greater than the level of significance; otherwise, we reject the null hypothesis and conclude that the residuals are heteroscedastic.

3.5.6 Test for Serial Correlation

Serial correlation or autocorrelation occurs when the error terms in a time series transfer from one period to another, violating one of the assumptions in the Classical Linear Regression Model (CLRM). To identify if a serial correlation exists in the model, the Breusch-Godfrey Serial Correlation LM test was employed. To avoid rejecting the null hypothesis of no serial correlation up to 3 lags, the chi-square probability of the auxiliary regression's product of observation and r-squared, as well as the p-value of the

regressors, are calculated automatically by economic software. The test estimate should be greater than the level of significance of 0.05.

3.5.7 Test for Misspecification

Specification error occurs when an omission and inclusion of relevant regressors or usage of an incorrect functional form yield inaccurate or misleading results. The Ramsey Regression Equation Specification Error Test (RESET) was employed to detect such a problem. In this test, the F-test of the auxiliary regression should exceed the value of the significance level to avoid rejecting the null hypothesis of having a correctly specified model.

3.5.8 Test for Normality

Normality tests are used to determine if a data set is well-modeled by a normal distribution and to compute how likely it is for a random variable underlying the data set to be normally distributed. The Jarque-Bera test (JB) was employed to detect this problem. In this test, the p-value should be higher than the level of significance; otherwise, we reject the null hypothesis and conclude that there is a non-normality of error in the model.

4 Results and Data Analysis

4.1 Trends of the Variables

In this section, the trends of each variable are presented, and their implications are discussed. Moreover, the study's findings are elucidated, including the multivariate Ordinary Least Square regression results and other statistical treatments applied. Furthermore, the discussion and analysis of changes in the variables over the years will provide insights into the regression results and relate them to the Philippine economic situation.

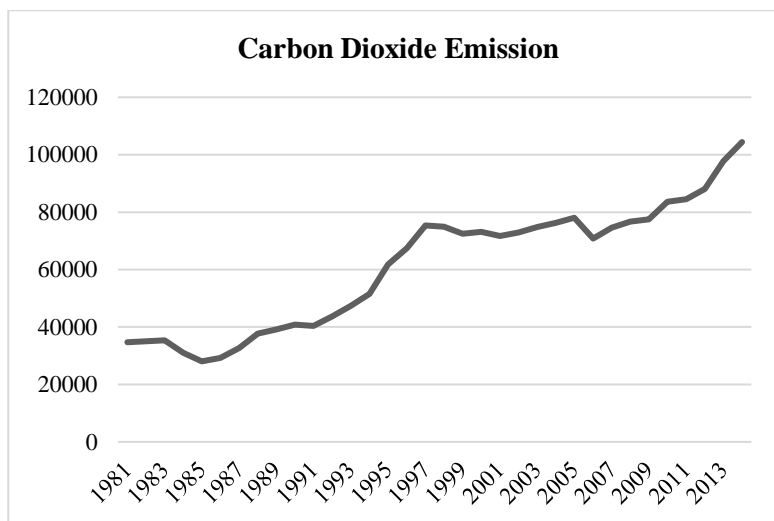


Figure 4.1.1 **Philippine Carbon Dioxide Emission (1981-2014)**

As presented in Figure 4.1.1, the Philippines' carbon dioxide emission per capita has shown an increasing trend from 1981 to 2014. Although the Philippines is a trivial contributor to global climate change, carbon emissions from the energy sector are expected to quadruple by 2030, while emissions from the transportation sector are expected to double. Furthermore, former Budget Secretary Florencio B. Abad stated that climate change caused by carbon emissions directly impacts development because weather patterns can damage infrastructure and jeopardize the well-being of communities in high-risk areas. As a result, effective programs and projects are required to mitigate climate change in the country (World Bank).

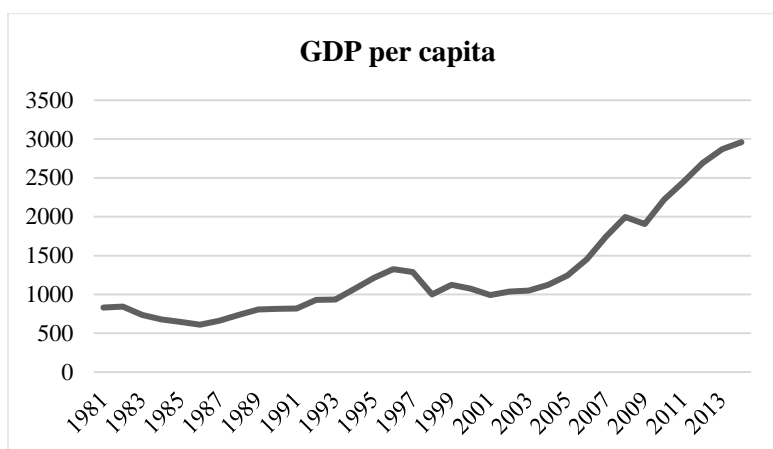


Figure 4.1.2 **Philippine GDP per capita (1981-2014)**

As shown in Figure 4.1.2, the Philippines' Gross Domestic Product per capita portrays an increasing trend from 1981 to 2014. In 2014, it increased by 3.2 percent over the previous year. This is consistent with Deluna and Peralta's (2014) analysis, which found that the Philippine GDP per capita increased from 1981 to 2010. In addition, GDP is regarded as a vital indicator of a country's economic strength, with a positive change indicating economic growth. This supports the statement by EY Reporting that the Philippines has emerged in recent years as one of the more dynamic Asia-Pacific economies with the potential for considerable further growth.

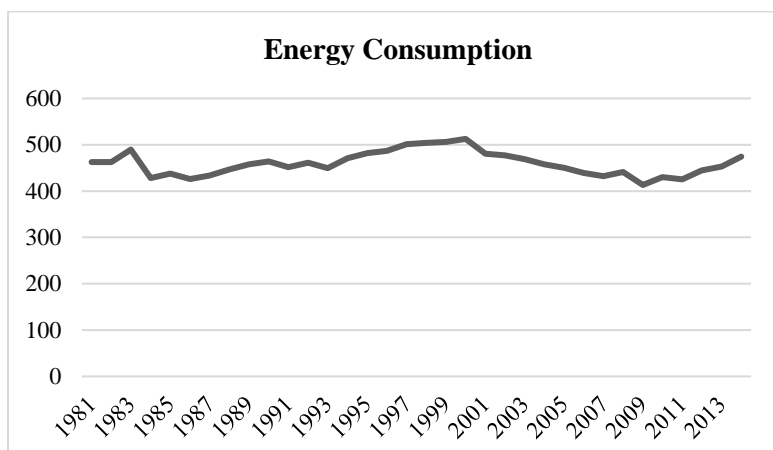


Figure 4.1.3 **Philippine Energy Consumption per capita (1981-2014)**

Energy is essential to human life and the global economy's social, economic, and environmental development. It is unlikely that mainstream commodities can be produced, delivered, or used without consuming energy. As a result, a lack of energy would hurt all economic sectors, including services, industry, and manufacturing. According to the U.S. Energy Information Administration, the Philippines is a net energy importer, despite its low consumption levels compared to its Southeast Asian neighbors. Coal, natural gas, and oil are all produced in the country. A significant portion of electricity output comes from geothermal, hydropower, and other renewable sources. As depicted by Figure 4.1.3, the energy consumption per capita in the Philippines shows a moderate trend from 1981 to 2014. Although the trend varies within the given range, the overall level of energy consumption remains high. This indicates that it will remain high regardless of the size of the variability, which has both positive and negative implications.

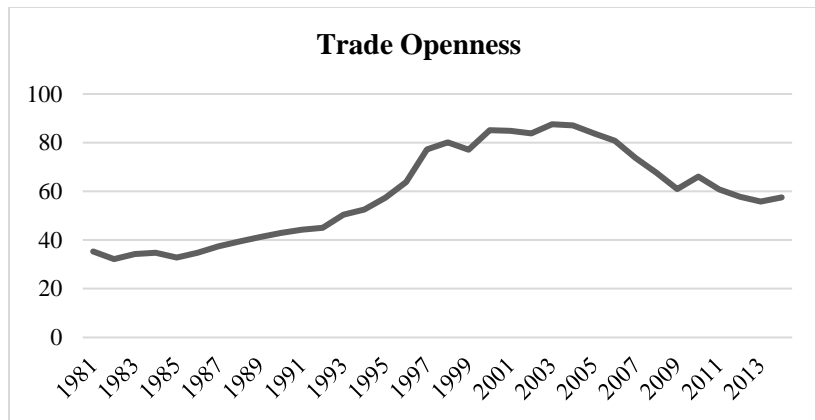


Figure 4.1.4 **Philippine Trade Openness (1981-2014)**

The literature on the Philippines' trade policies has grown in recent years. Throughout the decades, the Philippine trade policy has shifted dramatically. Tariff reform programs were implemented during the first half of the 1980s in response to the private sector's request for lower tariffs on capital, commodities, and raw materials to boost competitiveness (Parcon-Santos, 2012). As depicted by Figure 4.1.4, Trade Openness in the Philippines, with an average growth rate of 59.01% from 1981 to 2014, shows dramatic changes. In the first 16 years (1981 to 1997), trade openness shows an increasing trend. However, from 1997 to 2014, it portrays a significant decreasing trend, which incrementally fluctuates in 2010. Although some studies reported that open trade's effect on pollution was inverse and statistically unimportant, Shahbaz et al. found that trade openness improves pollution since free trade fosters a greater level of research and development.

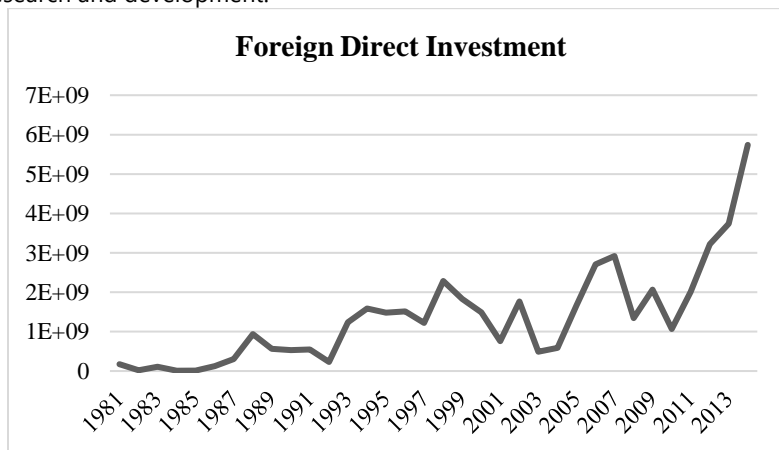


Figure 4.1.5 **Philippine net inflows of Foreign Direct Investment (1981-2014)**

As per Figure 4.1.5, from 1981 to 2014, the Philippines' trend of foreign direct investment tends to fluctuate from year to year, particularly from 1998 to 2011. However, it significantly increased from 2011 to 2014. This supports the insights of Sandler and Clune (2021) that the Philippines remains an emerging market for FDI. Significant improvements in the regulatory landscape in recent years have increased the attractiveness of the Philippines as a destination for capital deployment. In addition, from an environmental and economic standpoint, an increase in FDI lowers CO2 levels. It has a positive impact on the environment (Pazienza, 2015). Furthermore, as a country's level of development rises, so will its environmental regulations. However, because of their high pollution absorption capacity, low-income levels, and lack of environmental consciousness, most developing countries place little emphasis on environmental regulations (Dumrulb et al., 2017).

4.2 Regression Results

Table 4.2.1. Summary table of Results

Panel A – OLS Estimates		
Variable	Coefficient	Individual Significance (Prob.)
C	0.284403	0.7837
GDP	0.521989	0.0000
EC	0.733389	0.0001
TO	0.588453	0.0000
FDI	0.006061	0.4848

Panel B – Coefficient Determination and Overall Significance		
Number of Observations		34
R-squared		0.988191
Adjusted R-squared		0.986563
Prob(F-statistic)		0.000000

Panel C – Diagnostic Tests Results		
Tests	Results	
	C = NA	
	GDP = 2.307359	
Variance Inflation Factors (VIF)	EC = 1.341525	
	TO = 2.206089	
	FDI = 2.947232	
Breush-Godfrey Serial Correlation LM	1 lags = 0.3689	
	2 lags = 0.5665	
	3 lags = 0.3305	
White Test	Prob Chi(Square) *0.0909	
Ramsey Reset	Prob *0.4661	
Jarque-Bera	Prob *1.023048	

4.2.1 Regression Coefficient of CO2 Model

Given the information shown by Table 1, the empirical model that is presented in section 3 can be transformed into:

$$\text{Log Co}_2 = 0.284403 + 0.521989 + 0.733389 + 0.588453 + 0.006061 + \varepsilon$$

The model indicates that 0.284403 will be the estimated value of Y when the values of regressors are all zero. Then, 0.521989 will be the average change of Y when there is a 1-unit increase for X1 (GDP per capita), holding other regressors constant. Second, 0.733389 will be the average change of Y when there is a 1-unit increase for X2 (Energy Consumption), holding other regressors constant. Third, 0.588453 will be the average change of Y when there is a 1-unit increase for X3 (Trade Openness), holding other regressors constant. Lastly, 0.006061 will be the average change of Y when there is a 1-unit increase for X4 (Foreign Direct Investment), holding other regressors constant.

Given the regression coefficient results of the regressors in panel A, 0.521989, 0.733389, 0.588453, and 0.006061, respectively, the four regressors are positively related to CO2 emission. This supports the environmental curve and pollution haven hypothesis, which suggests that a rise in production brought by increased GDP per capita, energy consumption trade, and investment will lead to greater environmental damage. In addition, this supports Wang and Zhang (2021) when they looked at different development stages and found evidence of positive effects of economic growth on CO2 emissions for low-income countries.

4.2.2 Coefficient Determination

Panel B shows that the R-squared of the CO2 model implies that the variability in GDP per capita, energy consumption, trade openness, and foreign direct investment can explain 98.82% of the variability in CO2 emissions in the Philippines. This indicates that the overall model is robust since it is more than 80%. On the other hand, the adjusted R-squared of the CO2 model implies that the variability in GDP per capita, energy consumption, trade openness, and foreign direct investment can explain 96.66%, given the adjustment for degrees of freedom in CO2 emissions in the Philippines.

4.2.3 T-Statistics and Probabilities

The degree of influence of the regressors on the regressand has been established in the first part of the results (estimated coefficient). However, it is also important to know whether this influence is significant or not. According to the rule of the thumb, when the P-value is less than 0.05, the regressor is significant and can be used to explain the regressand. Given the p-values of each regressors, it is determined that GDP per capita, energy consumption, and trade openness are significant factors of CO2 emissions.

The individual significance of income is aligned to most of the surveyed related studies and the environmental Kuznets curve. They all argued that when production increases in intensity, by-products and pollution increase as a result. Likewise, the result on the significance of trade openness is supported by Mandal & Bernard (2016) that a 1% rise in trade openness increases CO2 emissions by 0.21%. This provides evidence for the developing and emerging economies becoming Pollution Havens with greater volumes of trade.

On the other hand, foreign direct investment is found insignificant. While related studies suggest a statistically significant relationship exists between carbon dioxide emissions and FDI, the magnitude of the impact is small, implying that manufacturing FDI in the Philippines do not use very dirty technologies or the Philippines has relatively low FDI inflow levels. As per Figure 4.1.5, the pattern fluctuates yearly, implying that the Philippines is still an emerging market for FDI. This explains its insignificant relationship with CO2 emissions in the Philippines.

4.2.4 Overall Significance of the Model

Panel B shows that the Prob (F-Statistic) value is less than 0.05. Therefore, there is a significant linear relationship among the regressors and the regressand. This implies that a linear regression model better fits the data than a model that contains no independent variables.

4.2.5 Multicollinearity

Panel C shows that the centered VIF of our independent variables is the following: 2.307359 for GDP per capita, 1.341525 for energy consumption, 2.206089 for trade openness, and 2.947232 for foreign direct investment. Following the rule of the thumb, since the VIF of all regressors is below 10. Therefore, there is no perfect multicollinearity among the regressors. This implies that there is a low correlation among the regressors.

4.2.5 Heteroscedasticity

Since the prob. chi-square of obs*r-squared and the regressors of the auxiliary regressions are greater than the significance level of 0.05, this implies that there is a goodness of fit and the residuals come from a normal distribution. Since the prob. chi-square of obs*r-squared and the regressors of the auxiliary regressions are greater than the significance level of 0.05, as presented by Panel C, the residuals of the study's regression model are not heteroscedastic or have constant variance.

4.2.6 Serial Correlation

Panel C shows that the prob. chi-square value at one lag is 0.3689, 0.5665 at two lags, and 0.3305 at three lags. Since the values are all greater than the significance level of 0.05, the proposed model structure has not included a serial correlation. Furthermore, the observations are not random, implying that previous values do not influence the future observations or the values of a regressor at one point in time do not obstruct the values of the regressor at other points in time.

4.2.7 Misspecification

Following the rule of the thumb, since the value is greater than the significance level of 0.05, H0 should be accepted, and H1 should be rejected. This implies that the study has no misspecification issues and the R-squared of the auxiliary regression is not different from zero. In other words, the model accounts for everything it should, does not have biased coefficients and error terms, and does not tend to have subjective parameter estimations. Therefore, H0 is accepted.

4.2.8 Histogram of Normality

As presented by Panel C, the histogram of residuals follows a normal distribution, and the probability value is greater than the significance level of 0.05. This implies that the residuals are normally distributed and that the results of both hypothesis testing for individual significance of parameters and the overall model are not misleading.

5. Conclusions and Recommendations

5.1 Summary

This study examined the relationship between key economic variables and CO2 emissions in the Philippines from 1981 to 2014. The Multivariate Ordinary Least Squares regression was used to achieve the study's goal, with CO2 emissions as the dependent

variable and GDP per capita, Energy Consumption, Trade Openness, and Foreign Direct Investment as the independent variables. The significance of the parameters was tested using the t-test and F-test for the hypothesis testing, and diagnostic tests have been conducted to detect model problems. The findings of the study are the following: (1) All of the independent variables, namely GDP per capita, Energy Consumption, Trade Openness, and Foreign Direct Investment, have a positive impact on CO2 Emission in the Philippines, and (2) only Foreign Direct Investment has an insignificant relationship on Philippine CO2 Emission. In terms of diagnostic tests conducted in this study, (3) no diagnostics were detected in the econometric model.

5.2 Conclusions

This paper investigated the relationship between key economic variables such as GDP per capita, energy consumption, trade openness, and foreign direct investment and CO2 emissions in the Philippines from 1981 to 2014 using the OLS estimation. Previous empirical studies have provided an understanding of the environmental consequences of economic growth both in developed and developing countries. This paper addresses this topic in the context of the Philippines. We considered the arguments and theories over the relationship between economic growth and CO2 emission and used the econometric time series analysis to develop a model. The results indicate the existence of dynamic relationships among the key variables of interest.

One of the most intriguing research areas in macroeconomics is how the economy sustains development in the face of environmental pollution. The Philippines, as one of ASEAN's centers of economic growth, is posed to pursue aggressive growth strategies. The findings obtained from using the Multivariate Ordinary Least Squares regression revealed that although there is a positive relationship between economic growth and CO2 emission in the Philippines, not all economic variables used in the study affect CO2 emissions. Out of four regressors, only three are significantly related to CO2 emissions: GDP per capita, energy consumption, and trade openness. This draws attention to the fact that human activities due to changes in GDP per capita, energy consumption, and trade openness have significantly contributed to the Philippines's CO2 emission levels.

The significant increase of GDP per capita from 832.08 US Dollars in 1981 to 2959.65 US Dollars in 2015 may be the reason behind this. The mechanism is straightforward indeed. Increased per capita GDP implies higher production - since the concept of GDP itself is defined as the sum of all goods and services produced in a particular period. By-products and pollutants rise together with increased production intensity. The rise in income implies that more natural resources were used, resulting in increased CO2 emission levels in the Philippines. As for energy consumption, it is found to be positively significant to CO2 emissions in the Philippines. This suggests that the increased energy consumption will increase the amount of carbon dioxide emissions. As a result, in a growing country like the Philippines, where industrialization is in progress, it is critical to limit the usage of fossil fuels and transition to renewable energy sources. Furthermore, if a factory produces excessive emissions, degrading the quality of the environment, the government is expected to establish regulations and strict law enforcement. As for trade openness, trade accounts for a large proportion of GDP, with an average GDP share of 59.01 percent from 1981 to 2014. This large proportion of trade entails the movement of goods and services, and hence, greater energy consumption and more carbon dioxide emissions. In addition, if environmental regulation stringency varies across nations, trade liberalization may lead to specialization in pollution-intensive activities in some countries.

On the other hand, although the association between carbon dioxide emissions and FDI is statistically established, the result shows that it is a positively related but insignificant factor of CO2 emission in the country. This implies that the Philippines' manufacturing FDIs are not using dirty technologies or have relatively low FDI inflow levels. As per Figure 4.1.5, the pattern fluctuates yearly, implying that the Philippines is still an emerging market for FDI. This explains its insignificant relationship with CO2 emissions in the Philippines. In addition, since the Pollution Haven hypothesis determines it as an important determinant of environmental deterioration, the aforementioned variable is still considered an important variable despite its insignificance in the study's regression. The Philippines' economic growth necessitates greater energy use, increasing CO2 emissions. This poses a significant risk to human well-being and the environment at large. As a result, policymakers must pay attention to making energy and related economic policies that promote economic growth with little to no contributing impact on CO2 emission. Introducing policies that will boost the development of both public and private sectors and generate income opportunities with efficient allocation and distribution of resources will increase economic growth without worsening environmental damage.

5.3 Recommendations

Despite the notable findings, this study has some limitations based on which it offers suggestions for future research. Access to data was limited, and only secondary annual time series data were available, limiting the analysis or altering the original questions the researchers sought to answer. Furthermore, like previous studies, the data used for analyzing the relationship between economic growth and CO2 emissions only rely on the World Bank indicator. This also limited the choice of variables and scope of time as the authors would have preferred adding other variables and extending the study horizon to a much more up-to-date year. Given the problem encountered by the researchers, the following are some recommendations that open potential for future studies and the improvement of this econometric model: (1) Look for other variables that are a better fit to the model (2) Use of

other estimation methods for more reliable results. (3) Use other hypothesis testing such as stationary, unit root, and granger causality tests. This would also provide an opportunity to verify the model's co-integration and learn more about the short- and long-term relationships between the regressors and the regressand. Lastly, (4) identify at which point the Philippines will achieve the EKC's inverted "U" shape or at what amount of income will CO₂ emission decline in the Philippines.

Funding: This research received no external funding

Conflict of Interest: The authors declare no conflict of interest

References

- [1] Adeleye, B. N., Osabohien, R., Lawal, A. I., & De Alwis, T. (2021). *Energy use and the role of per capita income on carbon emissions in African countries*. *PLOS ONE*, 16(11). <https://doi.org/10.1371/journal.pone.0259488>
- [2] Al-Mulali, U., Ozturk, I., & Solarin, S. A. (2016). *Investigating the environmental kuznets curve hypothesis in seven regions: The role of Renewable Energy*. *Ecological Indicators*, 67, 267–282. <https://doi.org/10.1016/j.ecolind.2016.02.059>
- [3] Ansari, M. A., Haider, S., & Khan, N. A. (2020). *Does trade openness affect global carbon dioxide emissions? Management of Environmental Quality: An International Journal*, 31(1), 32–53. <https://doi.org/10.1108/meq-12-2018-0205>
- [4] Asian Development Bank. (2020, July 22). *Pathways to low-carbon development for the Philippines*. Asian Development Bank. Retrieved November 15, 2021, from <https://www.adb.org/publications/pathways-low-carbon-development-philippines>.
- [5] Aye, G. C., & Edoja, P. E. (2017). *Effect of Economic growth on CO₂ emission in developing countries: Evidence from a dynamic panel threshold model*. *Cogen Economics & Finance*, 5(1). <https://doi.org/10.1080/23322039.2017.1379239>
- [6] Bashir, A., & Farhan, M. (2019). *The Causality between Human Capital, Energy Consumption, CO₂ emissions, and Economic Growth: Empirical Evidence from Indonesia*. *International Journal of Energy Economics and Policy*. <https://www.researchgate.net/publication/331768113>
- [7] Beck, K & Joshi, P., (2017). *Democracy and carbon dioxide emissions: Assessing the interactions of political and economic freedom and the environmental Kuznets curve*. *Energy Research & Social Science*, 39, 46–54. DOI: <http://dx.doi.org/10.1016/j.erss.2017.10.020>
- [8] Cai, Y., Sam, C. Y., & Chang, T. (2018). *Nexus between clean energy consumption, economic growth, and CO₂ emissions*. *Journal of Cleaner Production*. www.elsevier.com/locate/jclepro
- [9] Cederborg, J & Snöbom, S. (2016). *Is there a relationship between economic growth and carbon dioxide emissions?*, from <http://www.diva-portal.org/smash/get/diva2:1076315/FULLTEXT01.pdf>
- [10] Chen, F., Jiang, G., & Kitila, G. M. (2021). *Trade openness and CO₂ emissions: The heterogeneous and mediating effects for the belt and road countries*. *Sustainability*, 13(4), 1958. <https://doi.org/10.3390/su13041958>
- [11] Chontanawat, J. (2020). *Relationship between energy consumption, CO₂ emission and economic growth in ASEAN: Cointegration and Causality Model*. *Energy Reports*, 6, 660–665. <https://doi.org/10.1016/j.egy.2019.09.046>
- [12] Creswell, J., & Plano Clark, V. (2007). *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage
- [13] Deluna & Peralta. (2014). *Public Health Expenditures, Income and Health Outcomes in the Philippines*, from <https://mpru.ub.uni-muenchen.de/60115/>
- [14] Demena, B. A., & Afesorgbor, S. K. (2020). *The effect of FDI on environmental emissions: Evidence from a meta-analysis*. *Energy Policy*, 138, 111192. <https://doi.org/10.1016/j.enpol.2019.111192>
- [15] Dou, Y., Zhao, J., Malik, M. N., & Dong, K. (2021). *Assessing the impact of trade openness on CO₂ emissions: Evidence from China-japan-ROK FTA countries*. *Journal of Environmental Management*, 296, 113241. <https://doi.org/10.1016/j.jenvman.2021.113241>
- [16] *Foreign Direct Investment: Changes in the Philippines* | KWM. (n.d.). Retrieved March 10, 2022, from <https://www.kwm.com/de/en/insights/latest-thinking/fdi-philippines.html>
- [17] Gelman & Hill, (2007). *Andrew Gelman Hierarchical Models Hospital*. (n.d.). Retrieved November 15, 2021, from <https://www.find-hospital.info/andrew-gelman-hierarchical-models/>.
- [18] Güvercin, D. (1970, January 1). *The benefits and costs of foreign direct investment for sustainability in emerging market economies*. *IGI Global*. Retrieved November 15, 2021, from <https://www.igi-global.com/chapter/the-benefits-and-costs-of-foreign-direct-investment-for-sustainability-in-emerging-market-economies/230583>.
- [19] Grossman, G., and A. B. Krueger. (1992). "Environmental Impacts of a North American Free Trade Agreement," CEPR Discussion Papers 644, London.
- [20] Huang, Y., Chen, F., Wei, H., Xiang, J., Xu, Z., & Akram, R. (2022). *The impacts of FDI inflows on carbon emissions: Economic Development and regulatory quality as moderators*. *Frontiers in Energy Research*, 9. <https://doi.org/10.3389/fenrg.2021.820596>
- [21] Khan, M. K., Khan, M. I., & Rehan, M. (2020). *The relationship between energy consumption, economic growth, and carbon dioxide emissions in Pakistan*. *Financial Innovation*, 6(1). <https://doi.org/10.1186/s40854-019-0162-0>
- [22] Kılıçarslan, Z., & Dumrul, Y. (2017). *Foreign Direct Investments and CO₂ emissions relationship: The case of Turkey*. *Business and Economics Research Journal*, 8(4), 647–660. <https://doi.org/10.20409/berj.2017.73>
- [23] Marques, A. C., & Caetano, R. (2020). *The impact of foreign direct investment on emission reduction targets: Evidence from high- and middle-income countries*. *Structural Change and Economic Dynamics*, 55, 107–118. <https://doi.org/10.1016/j.strueco.2020.08.005>
- [24] Mohammed, a., Li, Z., Arowolo, A. O., Su, H., Deng, X., Najmuddin, O., & Zhang, Y. (2019). *Driving factors of CO₂ emissions and nexus with economic growth, development, and human health in the Top Ten emitting countries*. *Resources, Conservation & Recycling*. www.elsevier.com/locate/resconrec
- [25] Mgbemene, C. A., Nnaji, C. C., & Nwozor, C. (2016). *Industrialization and its backlash: Focus on climate change and its consequences*. *Journal of Environmental Science and Technology*, 9(4), 301–316. <https://doi.org/10.3923/jest.2016.301.316>
- [26] Muhammad, B. (2019). *Energy consumption, CO₂ emissions, and economic growth in developed, emerging, and the Middle East and North Africa countries*. *Energy*. <https://doi.org/10.1016/j.energy.2019.03.126>

- [27] Mukhtarov, S. (2022). *The relationship between renewable energy consumption and economic growth in Azerbaijan*. *International Journal of Energy Economics and Policy*, 12(1), 416–419. <https://doi.org/10.32479/ijeeep.11948>
- [28] Odugbesan, J. A., & Rjoub, H. (2020). *Relationship Among Economic Growth Energy Consumption, CO2 Emission, and Urbanization: Evidence from MINT Countries*. <https://us.sagepub.com/en-us/nam/open-access-at-sage>
- [29] Osobajo, O. A., Otitoju, A., Otitoju, M. A., & Oke, A. (2020). *The Impact of Energy Consumption and Economic Growth on Carbon Dioxide Emissions*. *Sustainability*, 12(19), 7965. <https://doi.org/10.3390/su12197965>
- [30] Parcon-Santos, H. C. (n2012). *Trade and Investment in the Philippines*. *Trade and Investment in the Philippines*.
- [31] Pazienza, P. (2015, September 16). *The relationship between CO2 and foreign direct investment in the Agriculture and fishing sector of OECD countries: Evidence and policy considerations*. *Intellectual Economics*. Retrieved November 15, 2021, from <https://www.sciencedirect.com/science/article/pii/S182280111500003X>
- [32] Pettinger, T., Tari, M., Lightness, save_ecosystems, Vaidya, S. C., & Morgan. (2021, May 25). *Environmental impact of economic growth*. *Economics Help*. <https://www.economicshelp.org/blog/145989/economics/environmental-impact-of-economic-growth/>.
- [33] Phong, L. H., Van, D. B., & Bao, H. G. (2018). *The Role of Globalization on Carbon Dioxide Emission in Vietnam Incorporating Industrialization, Urbanization, Gross Domestic Product per Capita and Energy Use*. *International Journal of Energy Economics and Policy*, 8(6), 275-283. <https://doi.org/10.32479/ijeeep.7065>
- [34] Reporting, E. Y. (2019, November 8). *How the Philippines is planning for a brighter future*. EY. Retrieved March 10, 2022, from https://www.ey.com/en_gl/assurance/how-the-philippines-is-planning-for-a-brighter-future
- [35] Riti, J. S., Song, D., Shu, Y., & Kamah, M. (2017). *Decoupling CO2 emission and economic growth in China: Is there consistency in estimation results in analyzing the environmental Kuznets curve?* *Journal of Cleaner Production*. www.elsevier.com/locate/jclepro
- [36] Streimikien D, Sun K, Bale T. (2020) *The Impact of Income Inequality on Consumption-based Greenhouse Gas Emissions at the Global Level: A Partially Linear Approach*. *Journal of Environmental Management*. 2020;267:110635. pmid:32349956
- [37] Szymczyk, K., Sahin, D., Bagci, H., & Kaygin, C. Y. (2021). *The Effect of Energy Usage, Economic Growth, and Financial Development on CO2 Emission Management: An Analysis of OECD Countries with a High Environmental Performance Index*. *Energies*. <https://doi.org/10.3390/en14154671>
- [38] *Trade and the environment*. OECD. (n.d.). Retrieved November 15, 2021, from <https://www.oecd.org/trade/topics/trade-and-the-environment/>.
- [39] *Technology*, 9(4), 301–316. <https://doi.org/10.3923/jest.2016.301.316>
- [40] Vo, Vo, & Le. (2019). *CO2 Emissions, Energy Consumption, and Economic Growth: New Evidence in the ASEAN Countries*. *Journal of Risk and Financial Management*, 12(3), 145. <https://doi.org/10.3390/jrfm12030145>
- [41] Wang, Q., & Zhang, F. (2021). *The effects of trade openness on decoupling carbon emissions from Economic Growth – evidence from 182 countries*. *Journal of Cleaner Production*, 279, 123838. <https://doi.org/10.1016/j.jclepro.2020.123838>
- [42] Watson, R., Albritton, D., Barker, T., Bashmakov, I., Canziani, O., Christ, R., Cubasch, U., Davidson, O., Gitay, H., Griggs, D., Houghton, J., House, J., Kundzewicz, Z., Lal, M., Leary, N., Magadza, C., McCarthy, J., Mitchell, J. F. B., Moreira, J., ... Zhou, D. (1970, January 1). [PDF] *Climate Change 2001: Synthesis report*. Semantic scholar. Undefined. Retrieved March 10, 2022, from <https://www.semanticscholar.org/paper/Climate-change-2001-%3A-synthesis-report-Watson-Albritton/75d1ce0d61d048d7d683c916aca3febb1d053343>