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| RESEARCH ARTICLE

Determining the Impact of Economic Growth, Carbon Emissions, Foreign Direct Investments, and Trade Openness on Energy Consumption in the Philippines

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| ABSTRACT
The Philippine energy sector is currently facing the problem of rising energy demand and the dominance of coal and natural gas in the energy mix. The current objective of the Philippine energy sector is to satisfy energy demand while maintaining its goal of reducing environmental effects. The paper explores the dynamic relationship between energy consumption in per capita terms and selected variables, namely, aggregate output, carbon emissions, foreign direct investment, and trade openness in the Philippines. The data spans the period from 1981 to 2017. The paper utilizes a multivariate framework based on the theoretical premises revolving around the energy-growth nexus. Time-series econometric modeling based on the OLS regression analysis is employed for this purpose. The results of the Johansen cointegration test confirm the presence of cointegrating relationships and finds a strong long-run relationship among the variables. The regression analysis results found that economic growth and carbon emission are significantly correlated with energy consumption. The paper finds that energy consumption is negatively correlated with economic growth and positively correlated with carbon emissions. The results suggest that policymakers can enforce energy conservation policies without hampering the economy too much. The results highlight the need for pollution-abatement policies and technologies in order to minimize the effect of the energy sector on the environment. Therefore, the share of renewable energy sources in the energy mix should increase.

| KEYWORDS

Economic growth, Carbon emissions, Foreign Direct Investment, Trade openness, Energy consumption

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1. Introduction

1.1. Background of the Study

Investigations about the crossing point among natural indications, environmental changes, and energy security in Asia and the Pacific are work that consists of social development. The extent of energy as a driving force on economic frameworks proposes solid connections with its security and stability. As a net energy importer, the Philippines produces oil, natural gas, and coal despite lessened consumption levels compared to its Southeast Asian counterparts (Energy Information Administration, 2020). In 2019, total primary energy consumption was 293297222222.22 kilowatt-hour (kWh) - the largest share was 45 percent petroleum and other liquids, and then 36 percent coal, 7 percent natural gas, 7 percent non-hydro power, and 4 percent hydroelectricity. The Philippines had 139 million barrels of proved crude oil, including lease condensate, reserves in 2019 (Oil & Gas Journal). That same year also saw total petroleum and other liquids production reach 37,000 barrels per day, while 474,000 barrels per day were consumed.

The lack of development in fossil energy utilization followed by the increase of worldwide climate change worsens the continuing air and water contamination. Thus, the hazard and threat multipliers proceed to impinge on public security. The Philippines has two active petroleum or offshore fields: 1) Galoc, in the Northwest Palawan Basic; and 2) Alegria, in the Province of Cebu. However, the Department of Energy (DOE) is working with Searcher Seismic for fresh hydrocarbon exploration potential, assessing more than 5,000 miles of the East Palawan Basin. Furthermore, a portion of the Spratly Islands in the South China Sea is Reed Bank, which has hydrocarbon stores and, albeit unexplored, is claimed by both China and the Philippines. In most developing countries, the production and supply of electricity are mainly achieved through non-renewable sources (Shahzad et al., 2021). These circumstances concerning the environment are only a fraction of a bigger aspect regarding ecological worries that undermine energy security, including land contamination, ranger service, and biodiversity loss. The nature of the increase in global climate change has social and scientific complexity and thus has great invocations of changes for the society and challenges for researchers (Anthes et al., 2006).

Climate change is a significant energy security concern not just in light of the fact that immediate flooding and common catastrophes can harm power plants and transmission lines, upset the conveyance of imported energy powers, and obliterate yields for biofuels. Additionally, it influences societal aspects of the government, which can affect food security. However, environmental change is a worldwide uncertainty, and it is turning into an issue rampant in Southeast Asia. Fundamental questions are raised, and well-established relationships between economic productivity and environmental quality are challenged. Implementing all-inclusive policies is an urgency needed for the understanding of dynamic linkages among geothermal energy consumption, carbon emissions, foreign direct investments, and trade openness. Understanding the nature of the relationships among the factors is a crucial case for the Philippines. This adversity has the power to restrain the electricity sector and constrain economic progress while employing caution in the management of negative externalities (Magazzino et al., 2021a). The findings from this study seek to help inform the energy security and sustainable development plans of other developing and emerging countries around the world.

1.2. Statement of the Problem

This research determines the relationship between energy consumption (EC) and selected independent variables: economic growth (GDP), carbon emissions (CO2), foreign direct investments (FDI), and trade openness (TO). This paper addresses the following questions:

- Is there a significant relationship between energy consumption and the selected independent variables in the Philippine context?
- Does the relationship between the variables move in a positive or negative direction?
- What is the effect of economic growth on energy consumption in the Philippine context?

1.3. Objectives of the Study

The study aims to determine the impact of economic growth, carbon emissions, FDI, and trade openness on energy consumption in the Philippine context. Furthermore, the study seeks to answer the following questions:

1. To determine the level of correlation of the selected independent variables to energy consumption in the Philippines;
2. To determine the direction of the relationship of each independent variable to energy consumption in the Philippines; and
3. To apply the economic inference to the empirical measurement of variables' relationships postulated by economic hypotheses, contributing to the international discussion of these variables' relationships.

1.4. Scope and Delimitations

The focus of the research is on the impact of economic growth, carbon emissions, FDI, and trade openness on energy consumption. While other economic issues related to contributing to energy consumption may be touched on for contextual purposes, they are not heavily covered. This study focuses on the determination of the existing linkages between the variables in the Philippines using data from 1981 to 2014. The results of this study are only applied to the stated locale of the study. They will not be applicable to any other country and time frame. Also, the study is limited to the hypotheses of the energy-growth nexus as its theoretical foundation. While there are other hypotheses that concern carbon emissions, FDI, and trade in relation to energy consumption, the researchers opt to limit the framework of the study to the four energy-growth nexus hypotheses. The mention of any other hypotheses is only there for contextual purposes.

The study is limited to testing and interpreting the results of the stated econometric model. Any other model on energy consumption is considered insignificant to the study. The Johansen Cointegration test is used to determine existing cointegrated relationships among the variables. Then, the study will utilize OLS regression analysis to test the dynamic associations between the variables. Moreover, the researchers employ EViews 11 Student Version Lite to analyze the model and variables relevant to the objectives of the study. The researchers assume that the EViews 11 Student Version Lite produces accurate results when testing the model and variables.

1.5. Significance of the Study

The researchers are establishing a correlational approach for this study about the impact of the aforementioned economic indicators. The compositions of the study will benefit the following individuals:

Policy-makers. This study can provide further evidence for policy-making guidelines in the Philippine energy sector. The policy recommendations can be used as foundations and supplementing concepts in the formulation of energy policies.

Data Scientists/Economists. Those who are part of industries that touch on economic theories or practices can be informed by this study about the indicators and their impact on the Philippine economy. The study can propose to them how data is continued to be disseminated to provide factual information in the field of Economics.

Students/Professionals. The study can provide awareness to students and professionals from various industries and different backgrounds.

Future Researchers. The study can serve as a guide and reference for future researchers who will be conducting a study with a similar research topic. Future researchers could also apply the provided recommendations to theirs to avoid possible shortcomings in their study.

2. Literature Review

2.1. Theoretical Review

The extant literature on the energy-growth-emissions-FDI-trade nexus evolved around economic hypotheses like the Environmental Kuznets Curve. More importantly, the body of literature developed hypotheses based on the repeating conclusions of papers written over the years. These ideas paved the way for the development of new approaches and methodologies for the 40-year-old body of literature.

2.1.1. Energy-Growth Nexus Hypotheses

The seminal work of Kraft and Kraft (1978) stimulated vibrant research in exploring the relationship between energy consumption and economic growth. The energy-growth nexus developed from the complementarity (or substitutability) of energy and other factor inputs in the manufacturing process. Through the development of the literature since Kraft and Kraft (1978), hypotheses formed as summaries of the results of published studies over the years, namely, the growth hypothesis, conservation hypothesis, feedback hypothesis, and neutrality hypothesis. These hypotheses assume the directions of the causal effect between energy consumption and economic growth. Determining the direction between energy consumption and economic growth is crucial in the formulation and implementation of policies surrounding energy and output.

2.1.1.1. Growth Hypothesis

The Growth Hypothesis entails that there is a unidirectional causal relationship between energy consumption and economic growth, running from EC to GDP. This hypothesis presents evidence of the crucial role of energy in stimulating economic growth. It is generally perceived in the literature that higher energy consumption is a symptom of higher levels of economic activity, leading to the stimulation of economic growth (Kyophilavong et al., 2017).

2.1.1.2. Conservation Hypothesis

The Conservation Hypothesis assumes that there is a unidirectional causal relationship between energy consumption and economic growth, running from GDP to EC. The increase in income level is what drives the consumption of energy. Studies that conform to the conservation hypothesis claim that energy conservation policies do not affect economic growth (Gorus & Aydin, 2019).

2.1.1.3. Feedback Hypothesis

The Feedback Hypothesis states that energy consumption and economic growth have a bidirectional causal relationship. This means that both variables are mutually determined and affected. A handful of researchers suggest taking caution in formulating and implementing energy policies due to the sensitivity and interdependence of both variables (Le, 2020).

2.1.1.4. Neutrality Hypothesis

The Neutrality Hypothesis argues that there is no existing causal relationship between energy consumption and economic growth. This means that energy policies, whether expansive or conservative, do not affect economic growth. Studies confirming the neutrality hypothesis allow the liberal implementation of energy policies in countries where the hypothesis is relevant. Thus, policies formulated toward the abatement of carbon emissions may be less rigid in such countries (Tuna & Tuna, 2019).

2.1.2. Environmental Kuznets Curve

The Environmental Kuznets Curve depicts the dynamic relationship between per capita income and income quality, which may be examined empirically and conceptually using contemporary analytics tools of economic phenomena. Furthermore, proponents of the hypothesis believe that income distribution varies depending on the stage of economic development growth. Simply put, income distribution appears to be becoming more balanced as the economy expands. When per capita income rises, income inequality grows first. Increases or gains in income disparity, according to Simon Kuznets (1955), would first grow after a maximum point begins to drop. Further economic development, services, higher technology, and knowledge sharing restrict an economy's material base, resulting in fewer environmental challenges.

Grossman and Krueger (1995) found no evidence that the quality of the environment degrades in synch with economic growth. Conversely, economic growth causes an initial period of degradation before entering a period of recovery for most measures. As Joshi and Beck (2018) point out that energy conservation should be a factor in the relationship between economic growth and environmental quality, a significant volume of empirical literature evolved around the interdependence of the three concepts.

The hypothesis claims that environmental degradation intensifies during the early stages of economic growth and development. Contrarily, the linkage appears to revert after each economic development stage. The inclusion of energy consumption as a factor in the relationship between income and the environment is crucial in the analysis of how each interaction between the three economic variables affects environmental preservation and sustainable development. Additionally, the literature shows that FDI and trade liberalization are crucial channels of technological innovation in which the economy accelerates to meet the tipping point (Wasti & Zaidi, 2020).

2.2. Empirical Review

The relationship of energy consumption to economic growth, carbon emissions, FDI, and trade openness is extensively studied in the literature for single-country and multi-country approaches with varying time periods and methodologies. The empirical literature shows that the studies about the causal relationship between energy consumption and the aforementioned independent variables give mixed results due to differences in econometric methodologies, model specification, variable selection, time periods, and selected countries (Chiou-Wei et al., 2016; Le, 2020; Le & Van, 2020; Smyth & Narayan, 2015, as cited in Nepal et al., 2021; Salim et al., 2017). Some studies cite failure to account for omitted variable bias as the reason for inaccuracies in the results of some studies (Aftab et al., 2021; Zhu et al., 2016). In addition, some cross-sectional studies ignore cross-sectional dependence and heterogeneity, which aggravates the lack of consensus among researchers about the energy-growth-emissions-FDI-trade nexus (Destek & Aslan, 2017; Muhammad & Khan, 2019; Munir et al., 2021).

2.2.1. Energy Consumption and Economic Growth

It is widely accepted that economic growth increases energy demand and accelerates energy efficiency, which, in turn, encourages economic growth. Upon surveying the recent literature on the energy-growth nexus, most studies in the genre primarily show that this is the case in many countries, validating the feedback hypothesis (Ibraheim & Hanafy, 2021; Kyophilavong et al., 2017; Le, 2020; Mavikela & Khobai, 2018; Muhammad & Khan, 2019; Nepal et al., 2021; Rahman, 2021; Tiba & Frikha, 2018; Wasti & Zaidi, 2020). Another study by Shahzad et al. (2021) confirms a bidirectional causality between energy consumption and economic growth in the Philippines.

On the other hand, some studies found a unidirectional causality stemming from energy consumption to economic growth, validating the growth hypothesis in several countries (Gorus & Aydin, 2019; Hao et al., 2018). Munir et al. (2020) and Shahbaz et al. (2017) confirm that the growth hypothesis applies to the Philippines. Chontanawat (2020) and Zhu et al. (2016) confirm the conservation hypothesis in the ASEAN-5 and 7 Asia-Pacific countries, respectively. Moreover, the neutrality hypothesis is found in Pakistan (Aftab et al., 2021).

In contrast with studies confirming a definite hypothesis in their locale, some studies yield mixed results in their multi-country approaches. Destek and Aslan (2017) use a panel data set of 17 emerging economies from 1980 to 2012, and Tuna and Tuna (2019) use a panel data set of the ASEAN-5 countries from 1980 to 2015. Both studies determine the relationship of both renewable and non-renewable energy consumption to selected independent variables. The only difference between the two is that Tuna and Tuna (2019) utilize both symmetric and asymmetric modeling techniques. Both papers confirm different energy-growth nexus hypotheses for different countries. Tuna and Tuna (2019) find that the results of the symmetric model differ from the asymmetric model. Both papers agree that non-renewable energy consumption is more crucial than renewable energy consumption in stimulating economic growth. The studies cite the reason for the dominant share of non-renewable energy sources in the energy mix of many countries.

Another study by Muhammad and Khan (2019) determines the relationship between energy consumption and economic growth with two variables affecting each other from different countries through foreign direct investments. The study used a panel data set of 34 host countries of Asia and 115 source countries from 2001 to 2012. In relation to inflows and outflows of foreign direct investments, the feedback hypothesis is confirmed in the host country. However, the study finds that the energy consumption of host countries negatively affects the economic growth of receiving countries.

In addition, replication studies cite inconsistent methodology (Mann and Sephton, 2019) and differences in data timeframe (Carfora et al., 2019) on lack or partial consensus among researchers regarding the relationship between energy consumption and economic growth. Mann and Sephton (2019) invalidate the results of Asafu-Adjaye (2000) due to the inappropriate use of asymptotic critical values. The researchers advised other researchers to disregard the original paper's result of a unidirectional Granger causality from energy to income and prices in four Asian countries (India, Indonesia, Philippines, and Thailand). On the other hand, Carfora et al. (2019) find partial conformity with the results of Asafu-Adjaye (2000), specifically for Thailand and the Philippines. The paper extends the data timeframe from 1971 to 2015. The researchers cite major changes during the last twenty years as the reason for inconsistent results for India and Indonesia between the original and replication study.

Throughout the literature review, some studies utilize proxy variables to represent economic growth like capital, financial development, and institutional capacity. Mavikela & Khobai (2018), Muhammad & Khan (2019), and Tiba & Frikha (2018) agree that capital has a positive causal relationship with energy consumption. Le (2020) and Shahzad et al. (2017) agree that financial development and energy consumption are interdependent with one another. However, Assi et al. (2021) find that financial development hinders renewable energy consumption. This leads the researchers to hypothesize that financial development generally affects the consumption of non-renewable energy. Also, Le (2020) confirms that institutional capacity stimulates energy consumption.

2.2.2. Energy Consumption and Carbon Emissions

A handful of studies in the literature found that energy consumption has a bidirectional causal relationship with carbon emissions (Aftab et al., 2021; Chontanawat, 2020; Gorus & Aydin, 2019; Nepal et al., 2021; Schneider, 2020; Wasti & Zaidi, 2020). On the other hand, some studies confirm a unidirectional relationship stemming between energy consumption to carbon emissions (Munir et al., 2020; Shahzad et al. (2017); Shahzad et al. (2021); Zhu et al., 2016). Ibraheim and Hanafy (2021) found that carbon emissions Granger cause energy consumption, while Tuna and Tuna (2019) found that both variables do not have a causal relationship.

Notably, Shahzad et al. (2017) determine the linear and nonlinear relationships between energy consumption and carbon emissions, and the threshold level of the effect of energy consumption starts to revert to its original effect. The study uses time-series data from Pakistan covering the period 1971 to 2011. The paper confirms a unidirectional causality stemming from energy consumption to carbon emissions. Meanwhile, the paper found that energy consumption and carbon emissions have an inverted U-shaped nonlinear relationship with a threshold level of 640 kg of oil equivalent, positively affecting the environment. This means that the energy consumption has a nonlinear inverse relationship until the threshold consumption of 640 kilograms of oil equivalent. After the threshold level, energy consumption starts to have a direct relationship with carbon emissions, negatively affecting the environment. The researchers found that Pakistan consumes energy below the threshold level, recommending full utilization of the energy sources up to 640 kilograms of oil equivalent.

It is generally perceived that renewable energy consumption reduces the level of carbon emissions while non-renewable energy consumption raises it. Upon reviewing the literature, this seems to be the case for many countries (Assi et al., 2021; Doğan et al., 2020; Shahzad et al. (2021). However, Hasnisah et al. (2019) found that renewable energy consumption does not affect carbon emissions for 13 Asian developing countries. The study cites the relatively low share of renewable energy in the energy mix for the countries, especially Iran, Iraq, Malaysia, and China, for the neutral effect of renewable energy consumption on the level of carbon emissions.

2.2.3. Energy Consumption and Foreign Direct Investment

It is generally recognized that FDI initiates the diffusion of energy-efficient technologies and processes, reducing the demand for energy consumption. However, it seems that the recent literature on the energy-FDI nexus does not have a consensus. Nepal et al. (2021), Rahman et al. (2021), and Salim et al. (2017) acknowledge that FDI reduces energy demand, in the long run, citing the inducement of energy efficiency through technological diffusion. Nepal et al. (2021) also claim that energy consumption negatively impacts the inflow of FDI.

On the other hand, Mavikela & Khobai (2018) found that FDI has a direct relationship with energy consumption in Argentina. The study uses time-series data from 1970 to 2018. The results state that a 1% increase in FDIs leads to a 0.013% increase in energy consumption.

Moreover, Adom et al. (2019) determined the nonlinear relationship between energy consumption and FDI. The study used a panel data set of 27 African countries from 2000 to 2014. The results state that FDI has a concave effect on energy consumption. This means that as FDI inflows rise, energy demand initially increases. Then, at a certain point, energy demand decreases as technological diffusion of energy-efficient methods are adapted. With FDI in the energy industry, there are learning and mimicking experiences, and these experiences are more efficient and effective when dealing with economies with higher technology absorptive capacities than those with lower technology absorptive capacities.

2.2.4. Energy Consumption and Trade Openness

Similar to the previous variables, recent literature does not have a consensus on the relationship between trade openness with energy consumption. Some studies confirm the unidirectional causality from trade openness to energy consumption (Ibraheim & Hanafy, 2021; Gregori & Tiwari, 2020; Ghazouani et al., 2020; Nepal et al., 2021). In response to the need for energy efficiency, these studies claim that trade openness plays a critical role in allowing the flow of funds and technology from other nations. In correlation with the goal of reducing environmental degradation, trade openness, together with FDI, enhances the demand to shift toward renewable energy (Ibraheim & Hanafy, 2021).

At the same time, some studies conclude that FDI and trade openness are interdependent (Amri, 2019; Kyophilavong et al., 2017; Rahman, 2021). "Reduction in energy supply will retard economic growth which will affect trade openness and resulting in decreased energy demand" (Kyophilavong et al.). Rahman (2021) indicates that countries with more liberal trade policies can adopt energy-efficient technologies and processes faster than countries with stricter borders.

Moreover, a few recent papers establish that energy consumption can also affect trade openness (Tiba & Frikha, 2018; Wasti & Zaidi, 2020). These studies express that energy consumption tends to stimulate trade liberalization by triggering increases in energy demand and, subsequently, the need for energy-efficient technology diffusion facilitated through trade. This causal relationship implies that energy conservation policies may slow down the traffic of imports and exports.

2.3. Synthesis

In view of the extant literature revolving around the energy-growth-emissions-FDI-trade nexus, researchers of the topic at hand have not been able to reach a consensus on the effect of economic growth, carbon emissions, FDI, and trade on energy consumption. The main reason for the discord in the literature is the difference in the means and objectives of studies. Authors utilize various methodologies, models, locales in producing results (Carfora et al., 2019; Chiou-Wei et al., 2016; Le, 2020; Le & Van, 2020; Smyth & Narayan, 2015, as cited in Nepal et al., 2021; Salim et al., 2017). In fact, a handful of papers fail to consider the implications of using inappropriate methodologies and disregarding relevant biases, which leads to inaccurate results (Aftab et al., 2021; Mann and Sephton, 2019; Zhu et al., 2016).

In light of the lack of consensus in the literature, it is vital to highlight the main assertions provided by previous papers. Generally, energy consumption and economic growth are interdependent. The sensitivity of both variables should be considered in making policy recommendations.

Further, energy consumption and carbon emissions have a bidirectional causal relationship. Energy consumption exacerbates carbon emissions through generally non-renewable sources. Rising carbon emission levels prompt the innovation of energy-efficient technologies and the usage of renewable energy consumption.

Also, FDI reduces energy consumption through technological diffusion of energy efficiency in relevant industries. Similar to FDI, trade reduces energy demand due to the facilitation of technological diffusion in relevant industries. FDI and trade interdependently function as channels of energy efficiency innovation and renewable energy shift.

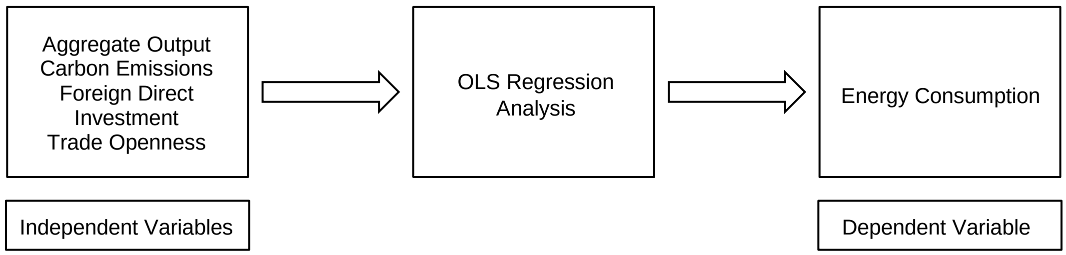
2.4. Research Gap

Upon reviewing the literature, the researcher noticed the lack of studies focused on the Philippines. It must be noted that the Philippines continues to suffer from energy supply deficiency (Shahzad et al., 2021). Considering the crucial role of the research interest in policymaking, the lack of papers studying the energy-growth-emissions-FDI-trade nexus in the Philippine context is concerning. Hence, the goal of the researchers with this paper is to provide evidence for Philippine energy policy-making guidelines.

2.5. Conceptual Framework

In developing the study's framework, the researchers follow the research paradigm outlined below (Figure 2.1). Developing countries like the Philippines need energy policy guidance in order to reduce environmental degradation while maintaining output growth. This research determines how output, CO2 emissions, FDI, and trade openness affect energy consumption to provide further evidence for policy guidelines. The study's framework is expressed through the Input-Process-Output (IPO) research model.

Figure 1. Conceptual Framework of the Study



In Figure 2.1, the different variables of this study are connected to formulate a causal relationship among the parameters. There are two main variables in this study which are the independent and dependent variables. Energy consumption is assumed to be Granger caused by four variables: output, CO2 emissions, FDI, and trade openness.

2.6. Formulating the Hypothesis

Based on the theoretical and empirical literature reviews, the researchers formulate the following hypotheses:

Hypothesis 1:
Null Hypothesis (H0): There is no significant relationship between energy consumption and economic growth.
Alternative Hypothesis (Ha): There is a significant relationship between energy consumption and economic growth.

Hypothesis 2:
Null Hypothesis (H0): There is no significant relationship between energy consumption and CO2 emissions.
Alternative Hypothesis (Ha): There is a significant relationship between energy consumption and CO2 emissions.

Hypothesis 3:
Null Hypothesis (H0): There is no significant relationship between energy consumption and FDI.
Alternative Hypothesis (Ha): There is a significant relationship between energy consumption and FDI.

Hypothesis 4:
Null Hypothesis (H0): There is no significant relationship between energy consumption and trade openness.
Alternative Hypothesis (Ha): There is a significant relationship between energy consumption and trade openness.

3. Methodology

3.1. Research Design

Researchers usually use four kinds of quantitative methods to validate the research analyses. They are descriptive, correlational, quasi-experimental, and experimental. The researchers decided to utilize a correlational approach to test the dynamic associations between energy consumption, output, carbon emissions, FDI, and trade openness.

Using either a true or quasi-experimental approach is not appropriate for the study's intent because it entails interfering with study subjects by modifying the regressand (Grove et al., 2014). An experimental approach is ideal for testing non-probabilistic causality (Geuens and De Pelsmacker, 2017). In contrast, the paper seeks to determine the mere association among the variables. The paper is not designed as an experiment, and it does not use random sampling or data manipulation.

The correlational approach is a non-experimental method for investigating the interaction between measured variables without implying non-probabilistic causality (Curtis et al., 2016). While results yielded from a correlational approach can be subjected to experiment (Thompson et al., 2005), it is not relevant to the paper for the data to be manipulated. It simply states the relationship between the variables given the data.

Also, Tinbergen (1947) claims that the regressand is affected by more than just the immediate regressors in reality. The correlational approach is employed to effectively address this issue of determining the approximate effect of omitted variables on the regressand, given the relevant regressors. Since the correlational design is fit to use in this study, it is appropriate for the paper to use methods and statistical treatment under the aforementioned research design.

The previous chapter provided literature as a basis for the possible general associations between energy consumption, GDP, CO2 emissions, FDI, and trade openness. To capture such associations, the researchers opt to employ the OLS multiple regression analysis to answer the hypotheses. Initially, the researchers will perform diagnostic testing to determine the conformity of the data to the CLRM assumptions. Then, the Johansen cointegration test will be performed to capture the level of possible cointegrating relationships among the variables. Lastly, the researchers will run the data through OLS regression analysis to determine the level of correlation among the variables and how much each independent variable affects the dependent variable given the model.

3.2. Data

The study uses quantitative variables derived from secondary time-series data ranging from 1981 to 2014. The energy consumption per capita (EC) in the Philippines is the data set for the dependent variable. In measurements, it is the total kilogram of oil equivalent across all consumed energy sources. The Philippine data on the gross domestic product per capita in constant Philippine pesos terms (GDP), carbon dioxide emissions in metric tons per capita (CO2), foreign direct investment inflows per capita (FDI), and trade openness as a percentage of the gross domestic product (TO) serve as the data sets for the independent variables. The data is retrieved from the databases of the World Development Indicators Databank website of The World Bank. The World Bank Open Data describes the study's variables as the following:

Energy consumption: "Energy use (consumption) refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport (World Development Indicators, 2012)."

> **GDP:** "GDP per capita is gross domestic product divided by midyear population. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant local currency (Philippines Pesos) (World Development Indicators, 2012)."
>
> **CO2 emissions:** "Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (World Development Indicators, 2012)." Data is in kiloton units.
>
> **FDI:** "Foreign direct investment refers to direct investment equity flows in the reporting economy. It is the sum of equity capital, reinvestment of earnings, and other capital. Direct investment is a category of cross-border investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is resident in another economy. Ownership of 10 percent or more of the ordinary shares of voting stock is the criterion for determining the existence of a direct investment relationship (World Development Indicators, 2012)."
>
> **Trade openness:** "Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product (World Development Indicators, 2012)."

The means of EC, GDP, CO2, FDI, and TO are 459.49, 96063.50, 0.80, 16.44, and 69.24, respectively. The data on energy consumption, carbon emissions, and trade openness have fewer outliers than a normal distribution, with kurtosis values being less than 3. Contrarily, the data on output and FDI have more outliers, with kurtosis values being greater than 3. Similarly, the data on energy consumption, carbon emissions, and trade openness are normal. The results of the Jarque-Bera test for the aforementioned variables yield p-values greater than 0.05, thus, accepting the null hypothesis of normality in the data. On the other hand, the data on output and FDI are non-normal. Moreover, the data on energy consumption, output, FDI, and trade openness are skewed right, while the data on carbon emissions is skewed left.

3.3. Model Specification

The study uses the energy-output-emissions-FDI-trade model proposed by Nepal et al. (2021) and Salim et al. (2017) to empirically substantiate the findings outlined in the second chapter of this paper. As mentioned earlier, the study aims to determine the relationship between energy consumption and selected independent variables (output, carbon emissions, FDI, and trade openness) in the Philippines context. Mathematically, this is expressed as:

$$\mathbf{EC_t} = f(\mathbf{GDP_t}, \mathbf{CO2_t}, \mathbf{FDI_t}, \mathbf{TO_t})$$

Thus, the econometric model is as follows:

$$\mathbf{EC_t} = \beta_0 + \beta_1\mathbf{GDP_t} + \beta_2\mathbf{CO2_t} + \beta_3\mathbf{FDI_t} + \beta_4\mathbf{TO_t} + \mathbf{u_t}$$

where ECt is defined as the total energy consumption of the Philippines in period t; GDP is the real Philippine output; FDI is total foreign direct inflows to the country; and TO is the sum of imports and exports as a percentage of the gross domestic product.

The researchers found that the direction of β1 is inconclusive upon reviewing the literature. Rahman (2021) states that energy consumption and economic growth are positively correlated with each other in BRICS and ASEAN-5 countries. On the other hand, Ghazouani et al. (2020) and Hao et al. (2018) explain that the effect of economic growth on energy consumption depends on the type of energy production. Economic growth is positively correlated with renewable energy consumption. The opposite is the case with non-renewable energy.

Similar to economic growth, the effect of carbon emissions on energy consumption is based on its production source. In the literature, the apparent leading hypothesis about the relationship between carbon emissions and energy consumption is that the coefficient is negative when renewable energy dominates the energy mix and positive when non-renewable energy is widely consumed (Assi et al., 2021; Doğan et al., 2020; Hasnisah et al., 2019). Thus, the researchers hypothesize that β2 is positive since non-renewable energy sources dominate the Philippine energy mix (Shahzad et al., 2021).

Moreover, the researchers hypothesize that β3 is negative since it is generally perceived by the literature that FDI induces technological diffusion in domestic industries (Adom et al., 2019; Nepal et al., 2021; Salim et al., 2017). Contrarily, the researchers assume β4 is positive since the literature states that trade stimulates economic activity that requires necessary energy to facilitate (Ghazouani et al., 2020; Wasti & Zaidi, 2020). Both FDI and TO play crucial roles in managing energy production and distribution by demand stimulation and production enhancement.

3.4. Statistical Treatment

This study will employ the Johansen Cointegration Test and OLS multiple regression analysis to determine the level of association between energy consumption and the selected independent variables: output, carbon emissions, FDI, and trade openness. EViews 11 Student Version Lite will be used to perform the analysis techniques discussed in the following sections.

3.4.1. Diagnostic Tests

The researchers will initially perform diagnostic tests, which were conducted to ensure the validity of the regression analysis. The Augmented Dicky-Fuller (ADF) test will be used to test for stationarity. The Ramsey Regression Equation Specification Error Test (RESET) test will be used to test for model misspecification; the Breusch-Pagan test is used for heteroscedasticity detection, and the Breusch-Godfrey test is used for serial correlation detection. To test for multicollinearity, the researchers will look at the Variance Inflation Factors (VIF) of the data series. These are done to determine if the data sets satisfy the assumptions of the CLRM.

3.4.2. Johansen Cointegration Test

The researchers will utilize the Johansen Cointegration test to determine whether the variables have a long-run relationship. The test determines the number of possible cointegrated relationships among the variables. The test assumes that the variables are at least integrated at their first difference. After testing for the stationarity of the variables with the ADF test, the variables will be run through an unrestricted cointegration rank test utilizing the range properties of trace and max eigenvalue. The null hypothesis of the test is that there exist cointegrated equations at a specific level. If the MacKinnon-Haug-Michelis p-value is less than the significance level, then the null hypothesis is rejected. The null hypothesis will also be rejected if the value of the trace or max eigenvalue test is lesser than the critical value of the significant level. In this case, the null hypothesis will be rejected if the yielded p-value is less than the significance level of 0.05.

3.4.3. OLS Regression

The OLS multiple linear regression analysis will be used to test the hypotheses. The OLS method is one of the most commonly used regression analysis techniques, and it is used to calculate parameter estimates and fit results (Moore et al., 2013; Zikmund et al., 2000). The researchers will use this approach to test the significance of the relationship between the regressand and the regressors through the given model. As mentioned, the diagnostic test will be performed to ensure the conformity of the model and variables to the CLRM assumption. After, the coefficient of determination and p-value will be examined to determine the level of significant correlation between the variables. Moreover, the beta coefficients will be interpreted as the correlational effect of the selected independent variables on dependent variables.

4. Results and Discussion

4.1. Diagnostic Tests

In order to assess if the assumptions of the data analysis techniques used in this study are satisfied and whether the results are unbiased, the researchers carry out diagnostic tests for the variables and model. The results of the diagnostic tests are shown below.

4.1.1. Unit Root

To evaluate the technique and analyze the stationarity of the variables, the researchers perform a cointegration analysis. Stationarity can be detected in a linear combination of non-stationary series (Engle & Granger, 1987). When such stationarity exists, the series are said to be cointegrated, with one of the requirements being that the series has the same order of integration. A unit root test is a requirement for the Johansen Cointegration test since the cointegration analysis assumes that the variables are non-stationary in their level and are in a similar order of integration, according to Johansen (1988). In this paper, the Augmented Dickey-Fuller (ADF) test is used to assess if all the data series are stationary or non-stationary. The test dictates that if the probability result is lower than the chosen critical value, then the null hypothesis that states the existence of a unit root in the series is rejected. For the purposes of this paper, if the resulting p-value is lower than 0.05, then the researchers will reject the null hypothesis.

Table 1 presents the results of the unit root test without trend and intercept. The results show that all the variables are non-stationary at their levels with the inclusion of trend and intercept to the ADF unit root test equation. On the other hand, all the variables are stationary in their first and second differences in general. As a result of these findings, it can be concluded that all series are integrated into their first and second differences. Hence, the Johansen cointegration test may be applied to analyze the variable in determining cointegrating relationships.

Table 1. Results of the ADF Unit Root Test with Trend and Intercept

	Level	1st Difference	2nd Difference
EC	0.5605	0.0331	0.0000
GDP	0.9686	0.0129	0.0001
CO2	0.6659	0.0028	0.0000
FDI	0.3180	0.0001	0.0000
TO	0.9775	0.0033	0.0000

Level of Significance $\alpha = 0.05$

4.1.2. Model Misspecification

To check whether the model is correctly specified, the Ramsey Regression Equation Specification Error Test (Ramsey RESET) is employed. The test indicates that a p-value greater than the level of significance is desirable since it indicates that the data or model are both valid. In this case, if the resulting p-value is greater than the significance level of 0.05, then the researchers reject the null hypothesis indicating the misspecification of the model.

Table 2 shows the results of the Ramsey RESET test. Both the t-statistic and F-statistic yielded a p-value of 0.4814. The likelihood ratio yielded a p-value of 0.4232. The p-values are all greater than the significance level of 0.05, which means that the null hypothesis indicating the correct specification of the model is accepted. This implies that the model is correctly specified.

Table 2. Results Summary of the Ramsey RESET Test for Model Misspecification

	Value	Probability
t-statistic	0.714379	0.4814
F-statistic	0.510338	0.4814
Likelihood ratio	0.641461	0.4232

Level of Significance α = 0.05

4.1.3. Heteroscedasticity
The Breusch-Pagan-Godfrey test is used to determine if the model was heteroskedastic. The test's null hypothesis indicates that the data are homoskedastic or that they have the same spread or variance. The null hypothesis of homoskedasticity is accepted if the p-value is greater than 0.05. A p-value, of less than 0.05, on the other hand, indicates that the data is heteroskedastic.

Table 3 shows the results of the Breusch-Pagan-Godfrey test. The p-value for the F-statistic test is 0.1346, which is greater than the critical value of 0.05. This means that the test's null hypothesis of homoskedasticity is accepted. Based on the given results, it can be stated that the model is free from heteroscedasticity.

Table 3. Results Summary of the Breusch-Pagan-Godfrey Test for Heteroscedasticity

F-statistic	1.861168	**Prob. F(4,29)**	0.1346
Obs*R-squared	8.458493	**Prob. Chi-square(4)**	0.1327
Scale explained SS	11.33485	**Prob. Chi-square(4)**	0.0451

Level of Significance α = 0.05

4.1.4. Serial Correlation
In order to detect serial correlation among the variables, the researchers employ the Breusch-Godfrey LM test. Like the previous test, the variables are considered to be autocorrelated when the p-value obtained from the test is less than the level of significance. In this paper, the null hypothesis of no autocorrelation is rejected if the p-value is larger than 0.05.

Table 4 shows the results of the Breusch-Godfrey LM test. With a default lag value of 2, the test yielded p-values of 0.4965 for the F-statistic test and 0.4071 for the chi-squared test, which is greater than 0.05. Given the results of the serial correlation test, the researchers accept the null hypothesis of no serial correlation up to 2 lags. This means that there is no serial correlation in the model.

Table 4. Results Summary of the Breusch-Godfrey LM Test for Serial Correlation

F-statistic	0.720114	**Prob. F(4,29)**	0.4965
Obs*R-squared	1.797546	**Prob. Chi-square(4)**	0.4071

Level of Significance α = 0.05

4.1.5. Multicollinearity
Examining the Variance Inflation Factors (VIF) of the independent variables is used to assess multicollinearity in the model. A Centered VIF value of 10 or above indicates that a given variable is responsible for multicollinearity in the model.

Table 5 shows the Centered VIF values of the independent variables in the model. All the variables have Centered VIF values lower than 10. This implies that there is no existence of multicollinearity in the variables.

Table 5. VIF of the Independent Variables to test for Multicollinearity

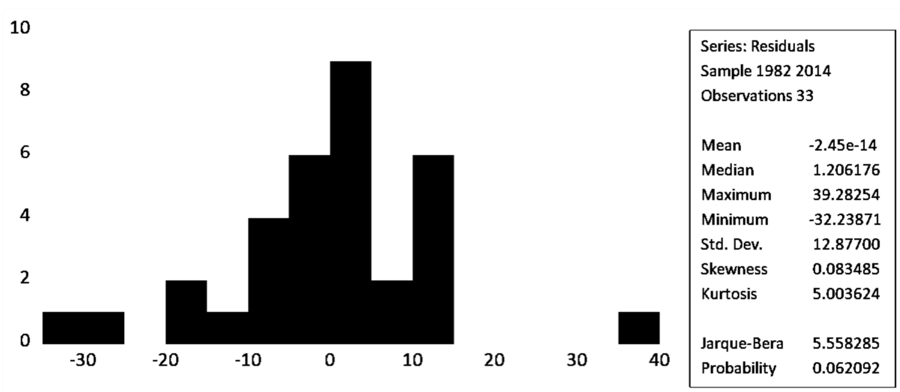
	Coefficient Variance	Uncentered VIF	Centered VIF
GDP	1.48E-07	235.8540	7.058079
CO2	3191.730	354.4744	9.966316
FDI	0.085974	6.382059	2.292774
TO	0.107210	92.58369	4.893694

4.1.6. Normality of the Error Terms

The Jarque-Bera test is used to determine whether the error terms are normal. Since the null hypothesis indicates that the error terms are regularly distributed, a p-value of more than the level of significance is preferable. In this case, the null hypothesis is accepted if the resulting p-value is greater than 0.05.

Figure 2 shows the histogram of the data distribution of error terms and the result of the Jarque-Bera test. The researchers judge the histogram of error terms as regularly distributed. Furthermore, the resulting p-value of the Jarque-Bera test is greater than 0.05, confirming that the residuals are regularly distributed.

Figure 2. Histogram of the Data Distribution of the Error Terms and Result of the Jarque-Bera Test for Normality of Error Terms



Level of Significance α = 0.05

4.2. Johansen Cointegration Test

To see if there are any cointegrating correlations between non-stationary variables, the Johansen cointegration test is employed. The test assumes that the variables are stationary in their first difference. The variables are run through an unrestricted cointegration rank test utilizing the range properties of trace and max eigenvalue under the Johansen test. The null hypothesis of the test is that there exist cointegrated equations at a specific level. If the MacKinnon-Haug-Michelis p-value is less than the significance level, then the null hypothesis is rejected. The null hypothesis will also be rejected if the value of the trace or max eigenvalue test is lesser than the critical value of the significant level. In this case, if the resulting p-value of either trace or max eigenvalue results is less than 0.05, then the null hypothesis is rejected. The same scenario applies to the results of the trace and max eigenvalue tests with the 0.05 critical value.

Table 6 shows the results of the cointegration test under trace statistics. Table 7 shows the results of the cointegration test under max eigenvalue. At the significance level of 0.05, the results of the trace test indicate that there are two (2) cointegrating relationships between the variables using their first difference. On the other hand, the results of the max eigenvalue test suggest that there is no cointegrating relationship between the variables. In view of the results, the researchers conclude that there is a long-run relationship between energy consumption, output, carbon emissions, foreign direct investment, and trade openness.

Table 6. Results Summary of the Johansen Cointegration Test using Trace Statistic

	Eigenvalue	Trace Statistic	Prob.
None*	0.630707	80.07550	0.0048
At most 1*	0.521119	49.19818	0.0372
At most 2	0.423451	25.63648	0.1399
At most 3	0.195157	8.014223	0.4639
At most 4	0.032787	1.066768	0.3017

*denotes rejection of the hypothesis at the 0.05 level

Table 7. Results Summary of the Johansen Cointegration Test using Maximum Eigenvalue

	Eigenvalue	Max-Eigen Statistic	Prob.
None	0.630707	31.87732	0.0850
At most 1	0.521119	23.56170	0.1508
At most 2	0.423451	17.62226	0.1446
At most 3	0.195157	6.947456	0.4954
At most 4	0.032787	1.066768	0.3017

*denotes rejection of the hypothesis at the 0.05 level

4.3. OLS Regression

The researchers use the statistical approach of analysis known as ordinary least squares (OLS) regression to estimate the correlational relationship between the variables. This approach estimates the link between the variables by minimizing the sum of the squares in the difference between the observed and predicted values of the dependent variable (Gujarati et al., 2012). The researchers test the correlation between the variables in the model by observing the coefficient of determination and beta coefficients of each variable. The coefficient of determination dictates the level of correlation between the dependent variable and the independent variables. The p-values of the F-statistic test of the beta coefficients determine the significance of the variables (Moore et al., 2013; Zikmund et al., 2000). If the p-values are lesser than the significance level, then the null hypothesis of the insignificance of the beta coefficient is rejected. In this case, a resulting p-value lesser than 0.05 means the rejection of the null hypothesis.

Diagnostic testing of the initial model states that the original equation is prone to bias due to violating the CLRM assumption of no serial correlation. See Appendix C and D for the results of the initial testing. In order to remove serial correlation from the analysis of the model, the researchers respecified the initial model by introducing a one-period-lagged dependent variable to the model as an independent variable. Gujarati et al. (2012) state that adding a one-period-lagged variable to the model as an independent variable account for the significant effect of variables absent from the model. In this case, a lagged EC accounts for the significant effect of absent variables in a period. The respecified model is as follows:

$$EC_t = \beta_0 + \beta_1 GDP_t + \beta_2 CO2_t + \beta_3 FDI_t + \beta_4 TO_t + \beta_5 EC_{(t-1)} + u_t$$

Table 8. Results Summary of OLS Regression

	Coefficient	StdError	t-statistic	Prob.
Intercept	273.8265	69.9048	3.9171	0.0006
GDP	-0.0013	0.0004	-3.4393	0.0019
CO2	190.4825	56.4954	3.3717	0.0023
FDI	-0.2761	0.2932	0.9416	0.3547
TO	-0.63092	0.3243	2.9693	0.0646
Multiple R^2 0.7550		**Prob. F** 0.000000		
Adjusted R^2 0.7097				

Level of Significance $\alpha = 0.05$

Table 8 shows the results of the OLS regression analysis on the model. The regression analysis yielded a coefficient of determination of 0.7550. R2 shows that the independent variables explain 76% of the variability of the dependent variable. The resulting R2 indicates a high correlation between the variables in the model (Moore et al., 2013; Zikmund et al., 2000). Moreover, the resulting p-value of the F-statistic test of the regression analysis of the sample is less than 0.0000. This states that the model is statistically significant at a level of significance of 0.01.

In terms of beta coefficients, the intercept, GDP, and CO2 are statistically significant at a significance level of 0.05, showing different directions of the variables' relationship with energy consumption. Meanwhile, FDI and TO are statistically insignificant, with p-values exceeding the significance level of 0.05. In view of the results, it may be stated that foreign direct investments and trade openness do not affect the variation in energy consumption according to the respecified model. Furthermore, the beta coefficient of GDP given EC indicates that a one-unit increase in output means there is a unit decrease by 0.0013 in energy consumption. The results express that GDP is negatively correlated with EC. Meanwhile, the beta coefficient of CO2 given EC indicates that a one-unit increase in carbon emissions means there is a unit increase by 190.4825 in energy consumption. The results express that CO2 is positively correlated with EC.

5. Conclusions and Recommendations

5.1. Conclusion

This paper investigates the correlational relationship between energy consumption, economic growth, carbon emissions, FDI, and trade openness for the Philippines over the period 1981 to 2014. As stated in Chapter 2, there is a lack of studies on the topic using a single-country approach in the Philippines. The researchers utilized the Johansen Cointegration test to determine the level of integration of each variable. The study employed the OLS regression analysis to determine the association of the independent variables with energy consumption. The results from the Johansen Cointegration test confirm the existence of cointegrated relationships among the variables. The study found that aggregate output is negatively correlated with energy consumption. A one-unit increase in GDP means there is a unit decrease of 0.0013 in EC. On the other hand, carbon emissions are found to be positively correlated with energy consumption. A one-unit increase in CO2 means there is a unit increase of 190.4825 in EC.

5.2. Policy Recommendations

The results indicate that energy consumption and energy growth have an inverse correlational relationship. This finding conforms to the conclusion of Doğan et al. (2020), indicating that non-renewable energy is negatively correlated with economic growth. In view of the results, policymakers can implement energy conservation policies without hampering economic growth. The goal of energy conservation policies is to limit the impact of energy production and consumption on the environment, seeing as energy consumption negatively affects the environment. The finding agrees with the results of Ibraheim and Hanafy (2021), stating that CO2 emissions trigger energy consumption, especially from renewable energy sources.

Several policy implications can be drawn out from the results. To address energy inefficiency, the researchers recommend that the Philippine government formulate a plan of action to increase energy efficiency as part of energy conservation policies. Similar to Schneider (2020), important energy efficiency initiatives, together with stringent fuel conservation measures, should be implemented, just as they are in other economies with high power demand. Specifically, the government should incentivize the most inefficient industries with such programs in order to establish a foundation for promoting and maintaining energy efficiency. If energy is efficiently produced and consumed, a reduction in energy generation can reduce its impact on the environment.

Second, The Philippine government should continue to invest in innovative pollution-reducing technologies in order to reduce pollution levels (Shahzad et al., 2021). In particular, it is beneficial for the government to cooperate with the private sector in researching and developing such pollution abatement technologies, especially in the energy sector. In this way, the procurement of pollution-reducing technologies is more efficient than the government managing research and development alone. The proximity of the private sector to trade and FDIs can benefit the procurement process through the efficiency of technological diffusion in inefficient industries and sectors (i.e., the energy sector) (Ibraheim & Hanafy, 2021).

Finally, in order to consolidate the rising energy demand, with sustainability goals in mind, the major deployment of renewable inputs in the country's energy mix should be initiated by the government. Non-renewable energy sources still dominate the energy mix (Shahzad et al., 2021). Thus, there is a need to lessen the share of non-renewable energy by setting benchmarks for the share of renewable energy in the energy mix. In order to avoid the curtailment effect of renewable energy, the government should reduce financial burdens, initial fixed costs, and medium-term low rate of return on renewable energy investments (Kumar & Zattoni, 2019).

5.3. Other Recommendations

Further research may utilize other significant variables such as human capital, oil prices, and economic complexity. Proxy variables, such as financial development and capital, may represent broad categories of variables like economic growth and environmental degradation. Moreover, emerging econometric methodologies, such as Bayer and Hanck cointegration approach and Hatemi-J causality analysis, may extend the limits of econometric analysis and contribute to the ever-expanding literature.

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