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The Effect of Energy Consumption Towards Economic Growth: The Case of 11 Asian Countries

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ABSTRACT

This research aims to determine and analyze the effect of Coal Consumption per capita (Kwh), Oil Consumption per capita (Kwh), Gas Consumption per capita (Kwh), and Renewable energy consumption per capita (Kwh) towards GDP per capita (current US$). This research uses GDP Per Capita (current USD) data sourced from world banks with a period from 1994 to 2021 and Data for Coal Consumption per capita (Kwh), Oil Consumption per capita (Kwh), Gas Consumption per capita (Kwh), and Renewable energy consumption per capita (Kwh) from Our Wold within a period from 1994 to 2021. The data used is data from 11 Asian countries, which is Mainland China, The Republic of Korea, Japan, India, Bangladesh, Pakistan, Thailand, Indonesia, Malaysia, Philippines, and Viet Nam. The analysis method used is Panel Data Econometrics, with Ordinary Least Square and Fixed Effect Model. The result from this research shows that Oil Consumption per capita (Kwh), Coal consumption per capita (Kwh), Gas Consumption per capita (Kwh), and Renewable energy consumption per capita (Kwh) have a positive significant effect towards GDP per capita (current USD).

Keywords: GDP Per Capita, Energy Consumption Per Capita, 11 Asian Countries, EGLS Panel Data Econometrics
JEL Classifications: Q43, N70, P18

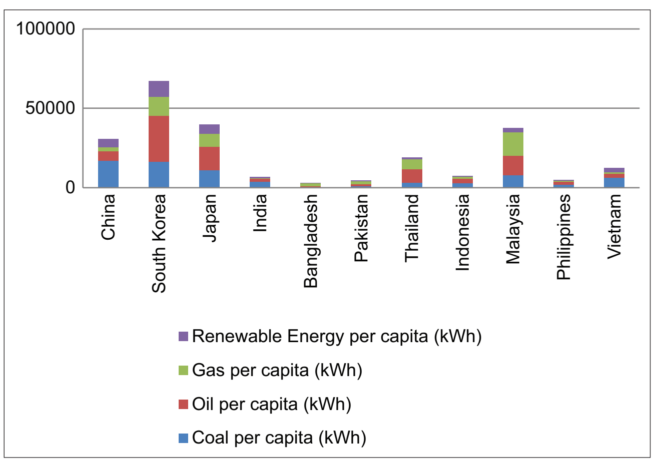
1. INTRODUCTION

Over time, energy consumption has consistently played a pivotal role in driving economic growth, a relationship well-documented in the literature. Khan, Rabnawaz and Yusheng (2020) underscored this correlation by highlighting those countries boasting substantial energy production, such as China, the USA, and India, tend to experience rapid economic expansion. However, this growth often comes at a cost, as energy production contributes to environmental degradation, leading to potential economic bottlenecks. This concern is echoed in Yan et al. (2022) study, which revealed that pollution and emissions have hindered economic growth in China. Given these challenges, there is an urgent call for transitioning towards renewable energy sources in a nation's energy consumption profile, particularly in developing countries across Asia. This imperative shift requires support from institutions. Xu et al. (2023) shed light on this aspect, highlighting the positive correlation between trade openness, institutional quality, and green financing. They found that institutional quality plays a crucial role in driving the adoption of renewable energy, emphasizing the pivotal role of institutions in catalyzing the transition towards greener energy sources in South Asian countries. The literature underscores the intricate relationship between energy consumption, economic growth, and environmental sustainability, emphasizing the urgent need for transitioning towards renewable energy sources, with institutions playing a key role in driving this transformation and setting incentives for greener energy adoption.

From the Figure 1, most Asian countries' energy consumption is still sourced from non-renewable sources, which can result in bottlenecks within the economy. Therefore, this paper was created to analyze energy consumption sources, and which one contributes the most to the Gross Domestic Product per Capita for 11 Asian countries and to find out whether renewable energy has a significant effect on Gross Domestic Product per capita. Those countries are China, The Republic of Korea, Japan, India, Bangladesh, Pakistan, Thailand, Indonesia, Malaysia, Philippines, and Vietnam. Each of those countries has its own unique characteristics, However, one of the main characteristics that ties them together is the exhibition of economic growth within these countries. This continuous growth has sparked an increase in the manufacturing sector of these countries. The relation between economic growth and also the growth of manufacturing growth has been proved by a study, according to Sankaran (2019) there is a short run and long run relationship effect of electricity consumption towards manufacturing output. In addition to the aforementioned factors, the impact of renewable energy on economic growth is a crucial topic warranting discussion due to its numerous advantages. A study conducted by Khan et al. (2023) sheds light on this matter, revealing that renewable energy serves as a significant driver of economic growth across 35 Belt and Road Initiative (BRI) countries spanning the period from 1985 to 2019. These findings highlight the importance of renewable energy in fostering economic development and its potential to contribute positively to growth trajectories. Such insights underscore the urgency of transitioning towards renewable energy sources, recognizing their pivotal role in shaping sustainable and resilient economies.

Table 1 illustrates the robust manufacturing output growth experienced by 11 Asian countries. This growth inevitably leads to increased energy consumption, primarily reliant on non-renewable

Figure 1: Energy Consumption by Source



Source: World Bank

Table 1: Manufacturing Output (US$) Growth

Country	Initial Year	End Year	Growth (%)
China	2006	2021	82
South Korea	2006	2021	42
Japan	2006	2021	4
India	2006	2021	64
Bangladesh	2006	2021	88
Pakistan	2006	2021	57
Thailand	2006	2021	51
Indonesia	2006	2021	56
Malaysia	2006	2021	49
Philippines	2006	2021	56
Vietnam	2006	2021	86

Source: World Bank

sources across these nations. Mehmood and Tariq (2023) delve into the environmental repercussions of this manufacturing surge driven by globalization, particularly focusing on its contribution to CO2 emissions in South Asian countries.

Their study reveals intriguing findings: a U-shaped relationship between globalization and CO2 emissions in Nepal, Afghanistan, Bangladesh, and Sri Lanka, contrasted with an inverted U-shaped pattern observed in Pakistan and Bhutan. A "U-shaped" correlation implies that as globalization increases, CO2 emissions initially rise, but then they begin to decline after reaching a certain point. This pattern suggests that there may be an optimal level of globalization beyond which further increases lead to a reduction in CO2 emissions. Conversely, an "inverted U-shaped" relationship indicates that as globalization increases, CO2 emissions initially decrease, but then they start to rise after reaching a certain threshold. This pattern suggests that there may be a point where the benefits of globalization in reducing CO2 emissions diminish, and further globalization exacerbates environmental pollution. Furthermore, they identify a reciprocal causality between globalization and CO2 emissions in Pakistan, Bangladesh, and Nepal, indicating that globalization drives up CO2 emissions, subsequently influencing economic growth

By analysing how different energy sources affect Gross Domestic Product per Capita, we gain valuable insight into the trade-offs associated with transitioning towards renewable energy. This analysis underscores the importance of understanding how renewable energy sources can impact economic growth and environmental sustainability. The findings from Mehmood and Tariq's research emphasize the urgent need to shift towards sustainable growth models reliant on renewable energy to mitigate environmental degradation while fostering economic development in South Asian countries and beyond.

2. LITERATURE REVIEW

Energy consumption is one of the useful metrics to understand the productivity of a nation. Therefore, to measure productivity, this research will use the metric of Gross Domestic Product. This is supported by a study by Thaker (2019) titled “Electricity Consumption and Economic Growth: A Revisit Study of Their Causality in Malaysia” which analyzed the long-term relationship and causality between electricity consumption and economic growth, sourced from International Financial Statistics and World Development Indicators (WDI). The study found that electricity consumption has a positive and significant impact on economic growth, and there is a unidirectional relationship between electricity consumption to Real Gross Domestic Product. On the other hand, the study by Vo (2019) titled “CO_2 Emissions, Energy Consumption, and Economic Growth: New Evidence in the ASEAN Countries” analyzed the relationship between CO_2 emissions, energy consumption, and economic growth in ASEAN countries using the Vector Error Correction Model (VECM) and Granger causality test. The study used data from the period of 1971-2014, with variables including CO_2 emissions per capita, energy consumption per capita, and real GDP, sourced from the World Bank’s World Development Indicators. The study found that there is a cointegration or a long-term relationship between economic growth and energy consumption. Another study by Nguyen (2019) titled "Energy Consumption and Economic Growth: Evidence from Vietnam" analyzed the impact of energy consumption on economic growth in Vietnam using Autoregressive Distributed Lag (ARDL) model and Granger causality test. The study used data from the period of 1980-2014, with variables including electricity consumption, oil consumption, and GDP, sourced from UNCTAD and IEA. The study found that electricity consumption positively impacts GDP per capita in both short and long term, and the Granger causality test showed a unidirectional relationship between energy consumption and GDP. A study conducted by Bhattacharya (2016) titled "The effect of renewable energy consumption on economic growth of major renewable energy consuming countries in the world within the period of 1991 to 2012".

The method used for this paper is panel estimation. The result from this paper is that renewable energy sources as a significant driver in economic growth for countries such as Austria, Bulgaria, Canada, Chile, China, the Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Kenya, Republic of Korea, Morocco, the Netherlands, Norway, Peru, Poland, Portugal, Romania, Spain, and the United Kingdom. The occurred because there is precedent to set the targets towards changing into renewable energy. Other countries such as India, Ukraine, the United States, and Israel experienced a negative effect from renewable energy sources. This is because those countries are based around the abundance of non-renewable energy. Lastly, countries such as Australia, Belgium, Brazil, Ireland, Japan, Mexico, Slovenia, South Africa, Sweden, Thailand and Turkey established that renewable energy is not significant driver or barrier to economic growth. One possible explanation for the results for these countries is that they have not been able to make use of renewable energy sources effectively in the production process, and it therefore has almost no impact on the economic output. Another study by Ivanovski (2021) titled "The effect of renewable and non-renewable energy consumption on economic growth. The study encapsulates OECD and non-OECD countries within the period of 1990 to 2015. The results of this study concluded that both renewable and non-renewable energy consumption are positively associated with economic growth. But it must be noted that renewable energy consumption is positively associated with economic growth.

But it must be noted that renewable energy consumption has little effect on economic growth. The reasoning behind this is the use of dirty technologies that are still entrenched in OECD countries' economies, therefore creating a high cost of retiring existing fossil fuel-fired power stations. A study conducted by Shahbaz et al. (2020), titled "the effects of renewable energy consumption on economic growth: Evidence from the renewable energy country attractive index". This paper uses three methods of analyses, which are: Dynamic Ordinary Least Squares (DOLS), FMOLS, and Heterogeneous non-causality approaches. This paper takes a sample of 38 countries within the period from 1990 to 2018. The variables used for this paper are economic growth, consumption of renewable energy, non-renewable energy use, capital, and labor, where economic growth is the dependent variable. The results of the paper regarding the empirical findings are that: there is a positive and significant impact of capital on economic growth, positive and significant impact of labor on economic growth, positive and significant effect of renewable energy on economic growth, and there is a positive and significant relationship between non-renewable energy consumption and economic growth. There is also a short run causality relationship between variables.

The results are bidirectional causality relationship between the consumption of renewable energy and economic growth, one-way casual association from non-renewable energy to economic growth, economic growth causes capital, labor is caused by economic growth, and non-renewables in the shot run influences economic growth.

The paper also shows results regarding the long run elasticities of economic output, long run elasticities of economic output with respect to capital and long run elasticities of economic output with respect to the consumption of non-renewable. A study done by Zaman and Moemen (2017) titled "Energy consumption, carbon dioxide emissions and economic development: Evaluating alternative and plausible environmental hypothesis for sustainable growth". This study examines the interrelationship between energy consumption, economic growth, and energy induced emissions.

This study is done under a few hypotheses which are the Environmental Kuznets Curve (EKC), Pollution Haven Hypothesis (PHH), population-based emissions (IPAT), energy led emissions, sectoral growth emissions and Emissions emancipated Human Development Index (eHDI). The data used for this study is within the period of 1975 until 2015 and encapsulated low-, middle- and high-income countries. The results of this study is that eHDI and PHH in the panel of selected countries.

In evaluating the IPAT hypothesis, the impact of population growth increases CO_2 emissions in the panel of high-income countries. The sectoral growth associated emissions including industry value added tend to increase CO_2 emissions in low and middle-income countries, and high-income countries, while agricultural value added decreases the CO_2 emissions in the panel of total 90 selected countries. The impact of energy demand on CO_2 emissions is positive and significant in the panel of selected countries. A study done by Rahman and Velayutham (2020) titled "Renewable and non-renewable energy consumption-economic growth nexus: New evidence from South Asia". The study done by them uses the method of Fully Modified Ordinary Least Squares and panel Dynamic Ordinary Least Squares estimation techniques. The result from the study is that an increase in 1% of renewable energy consumption will increase economic growth by 0.66%, 1% of non-renewable energy consumption will increase economic growth by 0.10%, and an increase of 1% of capital increase economic growth by 0.58%. Another paper by Gozgor et al. (2018) titled "Energy consumption and economic growth: New evidence from OECD countries" research regarding economic growth from 29 OECD countries within the period from 1990 to 2013. The method used for this paper is autoregressive distributed lag and panel quantile regression. The result of this paper is that non-renewable and renewable energy consumption are positively associated with a high rate of economic growth. A paper researching energy consumption and economic growth was published by Ucan, et al. (2014) titled "Energy Consumption and Economic Growth Nexus: Evidence from Developed Countries in Europe". This paper used fifteen European Union countries within the period of 1990-2011 using a heterogenous panel cointegration test. The result of this paper is that there is long run equilibrium relationship between real GDP, renewable and non-renewable energy consumption with greenhouse gas emission and research and development. Lastly a paper by Komarova et al. (2022) titled "Energy consumption of the countries in the context of economic development an energy transition." research regarding the dependence of economic growth on energy consumption within countries. The result from this study is that there is an impact of energy consumption on GDP but are stronger for non-OECD countries. Therefore, there is a precedent that renewable and non-renewable energy consumption does have a positive relationship and is also one of the driving forces of economic growth within Asian countries and other countries and even if renewables still have a little impact towards economic growth.

3. METHODS

3.1. Data and Data Sources

Secondary data was used for this study in the form of a data panel within a period from 1994 until 2021 in eleven Asian countries. The dependent variable for this study is Gross Domestic Product per Capita (current US$). The independent variables are the Consumption of Coal per Capita (kWh), Consumption of Oil per Capita (kWh), Consumption of Gas per Capita (kWh), and Consumption of Renewable Energy per Capita (kWh).

3.2. Research Model

To see the model that affects Consumption of Coal per Capita (kWh), Consumption of Oil per Capita (kWh), Consumption of Gas per Capita (kWh), and Consumption of Renewable Energy per Capita (kWh), Consumption of Gas per Capita affect the Gross Domestic Product per Capita (Current US$) in eleven Asian countries within the period of 1994 until 2021, the model will be estimated as follows:

$$LnGDP_{nt} = f\begin{pmatrix} LnCOAL_{nt}, LnOIL_{nt}, LnGAS_{nt}, \\ LnRENEWEABLE_{nt} \end{pmatrix} \quad (1)$$

Based on the function above, it can be turned into an econometric equation as follows:

$$LnGDP_{nt} = \beta 0 + \beta 1 LnCOAL_{nt} + \beta 2 LnOIL_{nt} + \beta 3 LnGAS_{nt} + \beta 4 LnRENEWABLE_{nt} + e_{nt} \quad (2)$$

Where:

LnGDP = Logarithm of Gross Domestic Product per Capita (Current US$)
LnCOAL = Logarithm of Consumption of Coal per Capita (kWh)
LnOIL= Logarithm of Consumption of Oil per Capita (kWh)
LnGAS= Logarithm of Consumption of Gas per Capita (kWh)
LnRENEWABLE = Logarithm of Consumption of Renewable Energy per Capita (kWh)
n = Mainland China, The Republic of Korea, Japan, India, Bangladesh, Pakistan, Thailand, Indonesia, Malaysia, Philippines, and Viet Nam.
t= 1994 – 2021
e_{nt} = error term
β_0 = intercept
β_1, β_2, β_3, β_4 = regression coefficient

3.3. Analysis Tools

This study will consist of two analytical tools, which are regression analysis and descriptive analysis. Regression analysis is used to see whether Consumption of Coal per Capita (kWh), Consumption of Oil per Capita (kWh), Consumption of Gas per Capita (kWh), and Consumption of Renewable Energy per Capita (kWh), Consumption of Gas per Capita affect the Gross Domestic Product per Capita (Current US$) of 11 Asian countries from 1994 to 2021. Descriptive analysis will analyze how the independent variables effect the dependent variables. The researchers of this paper will use EGLS panel data analysis to achieve this. There are several steps in choosing the final model for this study; those steps are as follows.

3.3.1. Chow test

The Chow test is a test that is conducted to determine whether the model used should be either a common effect model or a fixed effect model in the estimating panel data. Two hypotheses are used for this, which are the following:

H_0= Common Effect Model
H_a = Fixed Effect Model

The criteria for choosing either the common effect model or fixed effect model is whether F-statistic is greater than the critical value from F-distribution at a chosen significance level. Therefore, we chose the common effect model. We choose the fixed effect model if the calculated F-statistics is less than the critical value from the F-distribution at a chosen significance level. (Gujarati and Porter, 2021)

3.3.2. Hausman test

The Hausman test is a statistical test used to determine whether the fixed or random effects models are more appropriate in panel data regression models. This test will be done after getting a fixed effect model from the Chow test. The next step is to examine whether the model should use a fixed effect model or a random effect. Two hypotheses are used for this test, which are the following:

H_0= Random Effect Model
H_a = Fixed Effect Model

The criteria of choosing either random effect model or fixed effect model is whether the P-value of the chi-square test is greater than the chosen significance level; therefore, we choose a random effect model. If the p-value of the chi-square test is less than the chosen significance level, therefore we choose a fixed effect model (Gujarati and Porter, 2021).

3.3.3. Classic assumption test

According to Gujarati and Porter (2021), the assumption test is important to assess the validity of assumption that underline the regression models. These assumptions are crucial for ensuring the accuracy and reliability of the regression results. This classical assumption test includes: the Multicollinearity Test, Heteroscedasticity Test, Autocorrelation Test, Normality Test, and Linearity Test.

3.3.4. Multicollinearity test

The Multicollinearity test is a statistical test to determine whether there is a high correlation among the independent variables in the regression model. According to Gujarati and Porter (2021), high correlations among predictors can cause parameter estimates to vary significantly across different samples, leading to unstable and unreliable coefficient estimates. Some common methods for detecting multicollinearity are Varian Inflation Factor (VIF), Correlation Matrix, Eigenvalue Test, and Tolerance. In this study, the multicollinearity test that will be used is the Correlation Matrix. In this paper, the Correlation Matrix will be used, the following is the criteria for the test:

H_0= There is no multicollinearity
H_a = There is multicollinearity

The criteria for the correlation matrix are that if the correlation between two independent variables is greater than 0.85, therefore the null hypothesis is rejected. If the value of the independent variable is smaller than 0.85, therefore the null hypothesis is accepted.

3.3.5. Heteroskedasticity test

Heteroscedasticity is a statistical test that is used to know why an unequal variance in regression model. This is important because heteroscedasticity can lead to biased and inefficient coefficient estimates and can affect the validity of the statistical test. According to Gujarati and Porter (2021), the Heteroscedasticity test can be done through the Part test, White test, Glesjer test, Spearman correlation test, GoldFled-Quuandt test, and Breusch-Pagan test. Therefore, will be using the Glesjer test. The following is the Heteroscedasticity test hypothesis:

H_0= There is no Heteroscedasticity
H_a = There is Heteroscedasticity

The criteria of the Glesjer test is that if the probability value of the independent variable is larger than the level of the significance, then the null hypothesis is rejected. If the value of the independent variable is smaller than the level of significance, then the null hypothesis is not rejected. (Biørn, 2017).

3.3.6. Autocorrelation test

Autocorrelation is a statistical test that measures the degree of similarity between values of the same variables over successive time intervals (Gujarati and Porter, 2021). It is important to detect autocorrelation as it can lead to biased and inefficient estimates of regression coefficients, and it is hard to identify the true underlying relationship between variables as it may obscure the actual relationship. The tests that can be done to identify and autocorrelation are the Durbin-Watson test, the Ljung-Box test, the Breusch-Godfrey test, and the Cochrane-Orcutt procedure. For this study, the Durbin-Watson test will be used. The hypothesis for the Durbin-Watson test is as follows:

H_0= There is no Autocorrelation
H_a = There is Autocorrelation

There are three criteria for autocorrelation. The first one is if the value of Durbin Watson is smaller than the value of the lower critical value or if the lower critical value is bigger than the lower critical value minus four, therefore, the null hypothesis is rejected. The second criterion is If the value of the upper critical value is smaller than the value of Durbin Watson, and when the value of the Durbin Watson is smaller than the upper critical value when minus by four, therefore the null hypothesis is not rejected. The third criterion is then when the lower critical value is when is smaller than Durbin Watson.

3.3.7. Normality test

The normality test is to determine whether a data is well modeled by a normal distribution. One of the methods to test this is by using Jarque-Bera test, which is a goodness to fit test for a regression model. The hypothesis is for the Jarque-Bera test is as follows:

H_0= The residual does not have a normal distribution
H_a = The residual has a normal distribution

The criteria is when the Jarque-bera probability value is less than the significant level of 0.05%; therefore we accept the null hypothesis and reject the alternative hypothesis. Therefore, if the Jarque-bera probability value is bigger than the significant level of 0.05% therefore, we reject the null hypothesis and accept the alternative hypothesis.

3.3.8. Statistic test

The statistical test will consist of three things which are: joining regression coefficient test (F-test), partial regression coefficient test (T-test), and determination efficiency test.

The F-test is a test to find out whether the independent variables have a significant effect on the dependent variables. This is done through testing whether or not the F-statistic is greater than the critical value, vice versa (Gujarati and Porter, 2021). Therefore the hypothesis for the test are as follows for each variables:

H_0= There is no significant effect
H_a = There is significant effect

The criteria is that if the F-statistics value is larger than the value of F-table and the F-statistics value is smaller than the critical value of 1%, therefore the null hypothesis is rejected and the alternative

Table 2: Chow test results

Effect Test	Statistics	d.f	Probability
Cross – section F	123.456819	(10,293)	0.0000
Cross-section Chi-square	508.587994	10	0.0000

α = 5%

hypothesis is accepted. If the F-statistics value is smaller than the value of F-table and F-statistics value is bigger than the critical value of 1%, therefore the null hypothesis is accepted and the alternative hypothesis is rejected.

The t-test is done to find out whether the dependent variable has a significant effect towards the independent variables (Gujarati and Porter, 2021). Therefore, the hypothesis for the test is as follows for each variable:

H_0= There is no significant effect
H_a = There is significant effect

The criteria is that if the T-statistics value is larger than the value of the T-table and the probability value is smaller than the critical value of 1%, therefore the null hypothesis is rejected, and the alternative hypothesis is accepted. If the T-statistics value is smaller than the value of the T-table and the probability value is larger than the critical value of 1%, therefore the null hypothesis is accepted and the alternative hypothesis is rejected.

4. RESULTS AND DISCUSSION

There are three estimations models that can be used for the data panel, which are: the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) (Gujarati and Porter, 2021). To find out the right mode for this study, researchers will conduct two tests to determine the right model. Those tests are the Hausman and Chow test.

4.1. Chow Test Result

The Chow test will be used to compare which model to be used, which are the Common Effect Model or Fixed Effect Model. The following is the Chow test conducted using E-Views 12 (Table 2).

The results above show that the probability value of Chi-square is 0.0000, which shows that it is <1%. Therefore, the null hypothesis is rejected. Therefore, the best model to use for this regression model is fixed effect.

4.2. Hausman Test Result

The Hausman test will be used to compare which mode to be used, which is between Random Effect Model or Fixed Effect Model. The following is the Hausman test conducted by the researcher using E-Views 12.

The results in Table 3 show that the probability value of the cross-section is 0.0000, which shows that it is <1%. Therefore, the null hypothesis is rejected. Therefore, the best model to use for this regression model is fixed effect. Other papers have used fixed effect model as the regression method to analyze energy use. Reseach by Jarboui (2021) which uses fixed effect model as the method to evaluate the environmental and operation efficiency. Since the existence of renewable energy, oil and gas companies shift energy. Therefore, this paper wants to evaluate whether renewable energies promote the environmental and operational efficiency of petroleum another paper by Ostadzad (2022) also uses fixed effect model to analyze whether innovation on per capita CO_2 be the same on the threshold with different levels of renewable energy consumption and the results is shows that innovation where direct more towards clean and renewable energies can reduce CO_2 considerably.

4.3. Multicollinearity Test Result

The Multicollinearity test determines whether any high correlations among predictors can cause parameter estimates to very significantly across different samples. This will be done through a correlation matrix.

The results from the Table 4 shows that all of the correlation values are less than 0.85, which indicates that the regression model there is no multicollinearity

4.4. Hetereoscedasticity Test Result

Heteroskedasticity is a statistical test that is used to know why an unequal variance in the regression model. In this study, researchers will use the Glejser test.

The Table 5 shows that variables X2, X3, and X4 probabilities values are larger than 0,05 which indicates that those variables doesn't have heteroscedasticity. However, X1 is smaller than 0,05 which indicates that X1 there is heteroscedasticity. Therefore, to overcome this, the researcher has used EGLS for the data panel (Gujarati and Porter, 2021).

Table 3: Hausman test results

Test Summary	Chi-Sq. Statistics	Chi-Sq. d.f.	Probability
Cross – section F	28.2980363	4	0.0000

α = 5%

Table 4: Multicollinearity test results

	LN (X1)	LN (X2)	LN (X3)	LN (X4)
LN (X1)	1.000000	0.786723	0.357098	0.843486
LN (X2)	0.786723	1.000000	0.595846	0.834736
LN (X3)	0.357098	0.595846	1.000000	0.336878
LN (X4)	0.843486	0.834736	0.336878	1.000000

Table 5: Heteroskedasticity test results

Variables	Probability
LN (X1)	0.0000
LN (X2)	0.9644
LN (X3)	0.6558
LN (X4)	0.8698

Table 6: Autocorrelation test results

DW value	DU value	DL value	4-DU value	4-DL value
0.243457	1.78766	1.83991	2.16009	2.21234

Table 7: Normality test results

Prob. Jaque Bera
0.238966

Table 8: F-test results

F-statistic	Prob
723.1619	0.0000

Table 9: T-test results

Variable	T-statistics	Probability
LN (Coal)	10.11118	0.0000
LN (Oil)	8.913743	0.0000
LN (Gas)	7.525204	0.0000
LN (Renewable)	9.737587	0.0000

Table 10: Final regression model

Methods	EGLS Panel (Cro-section weights)
Variable	PDB PERCAPITA
LN (COAL)	0.29625
	(10.11118)*
LN (OIL)	0.702518
	(8.913743)*
LN (GAS)	0.154318
	7.525204*
LN (RENEWABLE)	0.412118
	9.737587*
C	−3.765248
	−8.169422*
Weighted statistics	
R-squared	0.971874
Adjusted R-squared	0.970530
F-statistics	723.1619
Prob (F-statistic)	0.000000

4.5. Autocorrelation Test Result

Autocorrelation is a statistical test that measures the degree of similarity between values of the same variables over successive time intervals. This will be tested using the Durbin-Watson test.

From the Table 6, it is shown that the DU value is smaller than the DL value, and the DL value and DU value is smaller than 4-DU value. This then confirms that the null hypothesis can be rejected and indicates that no autocorrelation happens within the regression model.

4.6. Normality Test Result

The normality test determines whether data is well modeled by a normal distribution. In this study, the Jaque-Bera test will be used to determine whether normality occurred within the regression model.

The Table 7 shows that the value of the Jaque-Bera probability is larger than 0,05. This then indicates that the residuals are distributed normally.

4.7. F-Test Result

From Table 8 the F-statistic is 723.1619 and the F-table value is 3.078. The F-statistic is 723.1619 and the F-table value is 3.078. Since the F-statistic is greater than the F-table value, it can be concluded that the variables Coal per Capita (X1), Oil per Capita (X2), Gas per Capita (X3), and Renewable Energy per capita (X4) together have a significant effect on the dependent variable GDP Per Capita. This means that the null hypothesis, which states that the regression coefficients of all independent variables are equal to zero, can be rejected. Therefore, it can be concluded that the independent variables have a significant effect on the dependent variable. The probability value of 0.0000 is smaller than the significance level of 0.01 or 1%. Therefore, it can be concluded that the variables Coal per Capita (X1), Oil per Capita (X2), Gas per Capita (X3), and Renewable Energy per capita (X4) have a significant effect on GDP Per Capita (Current US$).

This means that the null hypothesis, which states that the regression coefficients of all independent variables are equal to zero, can be rejected. The result indicates that the independent variables have a significant effect on the dependent variable, and the model can be used to predict the value of GDP Per Capita (Current US$).

4.8. t-Test Result

The results of the T-test are divided into where the research will first show the results of the T-test using T-statistics and T-table, the second will be the results using probabilities of each variable (Table 9).

4.8.1. LN(COAL)

The t-statistics for the Coal per Capita variable is 10.11118 with a significance level of 5%, and the t-table value is 2.34. Since the t-statistic is greater than the t-table value, it can be concluded that the Coal per Capita variable has a positive and significant effect on the GDP Per Capita (Current US$) variable.The probability value of 0.0000 is smaller than the significance level (α) of 1%. It can be concluded that the Coal per Capita variable has a positive and significant effect on the GDP Per Capita (Current US$) variable. The noteworthy impact of Coal per Capita on GDP per Capita has been identified in a study conducted by Zou and Chau (2023). Their research findings underscore the substantial influence of coal on economic growth, indicating a significant effect of 5% in China.

4.8.2. LN(OIL)

The t-statistic for the Oil per Capita variable is 8.913743 with a significance level of 1%, and the t-table value is 2.34. Since the t-statistic is smaller than the t-table value, it can be concluded that the Oil per Capita variable does not have a significant effect on the GDP Per Capita (Current US$) variable. The probability value of 0.0000 is greater than the significance level (α) of 1%. It can be concluded that the Oil per Capita variable does not have a significant effect on the GDP Per Capita (Current US$) variable. The significant impact of Oil per Capita on growth per capita has been corroborated in a separate study conducted by Zou and Chau. (2023). Their research findings indicate a notable relationship between oil energy consumption and per capita growth, particularly highlighting a significant effect of 1% in China. This further reinforces the validity and relevance of our own findings regarding the influence of Oil per Capita on economic growth.

4.8.3. LN(GAS)

The t-statistic for the Gas per Capita variable is 7.525204 with a significance level of 1%, and the t-table value is 2.34. Since the t-statistic is greater than the t-table value, it can be concluded that the Gas per Capita variable has a positive and significant effect on the GDP Per Capita (Current US$) variable.The probability value of 0.0000 is smaller than the significance level (α) of 1%. It can be concluded that the Gas per Capita variable has a positive and significant effect on the GDP Per Capita variable. This result is parallel with the findings of Algarini. (2019), where they stated that the growth of electricity produced from oil and gas causes growth of CO2 emission in Saudi Arabia.

4.8.4. LN(RENEWABLE)

The t-statistic for the Renewable Energy per capita variable is 9.737587 with a significance level of 5%, and the t-table value is 2.34. Since the t-statistic is greater than the t-table value, it can be concluded that the Renewable Energy per capita variable has a positive and significant effect on the GDP Per Capita (Current US$) variable. The probability value of 0.0000 is smaller than the significance level (α) of 1%. It can be concluded that the Renewable Energy per capita variable has a positive and significant effect on the GDP Per Capita (Current US$) variable. This positive effect is important since according to Munir, Q., Lean, H.H., Smyth, R. (2020), economic growth can be expected to adversely affect the environment in Malaysia, Philippines, Singapore and Thailand. The only way it doesn't if it has reached a turning point. Therefore, the result of the significance and positive affect of renewable toward GDP shows that it is the right momentum to invest in renewable and achieve that turning point.

4.9. Final Result

The data panel presented in Table 10 represents the culmination of our regression modeling, processed using EViews software and drawing upon datasets sourced from the World Bank. The cross-section was taken from 11 Asian countries which are China, The Republic of Korea, Japan, India, Bangladesh, Pakistan, Thailand, Indonesia, Malaysia, Philippines, and Viet Nam. While the time series data is within the period from 1994 to 2021. Where LN(COAL) is coal energy consumption per capita, LN(OIL) is oil energy consumption per capita, LN(GAS) is gas energy consumption per capita, LN(RENEWABLE) is renewable energy consumption per capita, and C is Gross Domestic Product per Capita (Current US$). The main goal of this study is to analyze the effect of the independent variables towards the dependent variable. The economic interpretation of the dependent variable, which is Gross Domestic Product per Capita (Current US$), is that it has a negative impact towards coal energy consumption per capita, oil energy consumption per capita, gas energy consumption per capita, and renewable energy consumption per capita. This means with a constant value of -3.765248 and when coal energy consumption per capita, oil energy consumption per capita, gas energy consumption per capita, and renewable energy consumption per capita remain equal, this will result in a decrease of Gross Domestic Product per Capita of 3.765248%. The coefficient value of Gross Domestic Product per Capita is based on the estimation results of the fixed effect model with EGLS is 0,971874. Which means that The statement means that 97.19% of the variation in GDP per capita is explained by the model, while the remaining 2.81% is explained by other variables outside the model. According to the estimation results of the EGLS model, the following are the positive effects of energy consumption on Gross Domestic Product per capita (Current US$):

Coal consumption per capita: The coefficient value is 0.296205, which means that coal consumption per capita has a positive effect towards GDP per capita. This implies that when there is an increase in coal consumption per capita by 1%, there will be an increase of GDP per capita by 0.296205%, assuming ceteris paribus.

Oil consumption per capita: The coefficient value is 0.702518, which means that oil consumption per capita has a positive effect towards GDP per capita. This implies that when there is an increase in oil consumption per capita by 1%, there will be an increase of GDP per capita by 0.702518%, assuming ceteris paribus.

Gas consumption per capita: The coefficient value is 0.154318, which means that gas consumption per capita has a positive effect towards GDP per capita. This implies that when there is an increase of gas consumption per capita by 1%, there will be an increase of GDP per capita by 0.154318%, assuming ceteris paribus.

Renewable energy consumption per capita: The coefficient value is 0.412118, which means that renewable energy consumption has a positive effect towards GDP per capita. This implies that when there is an increase of renewable energy consumption per capita by 1%, there will be an increase of GDP per capita by 0.412118%, assuming ceteris paribus.

These findings suggest that energy consumption is an important factor in economic growth, and policymakers should consider investing in various energy sources to promote sustainable economic development.

5. CONCLUSION

From the results of the analysis that has been conducted using EGLS panel data on the effect of Coal Consumption per capita (Kwh), Oil Consumption per capita (Kwh), Gas Consumption per capita (Kwh), and Renewable energy consumption per capita (Kwh) towards Gross Domestic Product per capita(current US$) has a significant and positive effect within the period of 1994 to 2021. Therefore, based on the results several points can be made:

1. Coal Consumption per capita (Kwh) has a positive and significant effect towards Gross Domestic Product per capita (current US$) within the period 1994 to 2021.
2. Oil Consumption per capita (Kwh) has a positive and significant effect towards Gross Domestic Product per capita (current US$) within the period 1994 to 2021.
3. Gas Consumption per capita (Kwh) has a positive and significant effect towards Gross Domestic Product per capita (current US$) within the period 1994 to 2021.
4. Renewable energy consumption per capita (Kwh) has a positive and significant effect towards Gross Domestic Product per capita (current US$) within the period 1994 to 2021.

Based on the results of the analysis conducted regarding energy consumption's effect on Gross Domestic Product per Capita there are a few key takeaways and suggestion:

- Oil Consumption per capita (Kwh) has one of the largest effects on Gross Domestic Product per capita (current US$), because when there is an increase in oil consumption per capita by 1%, there will be an increase of GDP per capita by 0.702518% (ceteris paribus). This shows to you that when a shift towards renewable energy sources happens, the biggest trade-off that policymakers might face is the reduction of Oil consumption which in return might yield less Gross Domestic Product per Capita.
- Renewable energy consumption per capita (Kwh) positive and significant effect on Gross Domestic Product per capita

(current US$) and can be an incentive for policymakers to put more emphasis and urgency on developing renewable energies as it can still sustain economic growth.

- Further research on this topic is expected to put more emphasis on CO_2 emissions per capita as a dependent variable and where Gross Domestic Product per Capita, renewable energy consumption, and non-renewable energy consumption as the independent variable within a certain period and a larger scope of countries.

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