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Article

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Does Renewable Energy Consumption a Driver for Economic Growth? Panel Data Analysis in Selected OIC Countries

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ABSTRACT

This paper aims to examine the relationship between energy consumption from renewable energy sources, and economic growth expressed in GDP per capita in several OIC countries. The dataset used involves data from OIC (Organization of Islamic Cooperation) countries including Indonesia, Iran, Turkey, Saudi Arabia, Nigeria, Egypt, UAE, Malaysia, Bangladesh, and Pakistan for the period 2000-2018 obtained from the World Development Index. This study uses a dynamic panel estimation approach such as DOLS and FMOLS to determine the long-term relationship between variables. We also discuss how to use the panel Granger-causality test to estimate causality in the short term. The empirical result shows that in the long-run, renewable energy consumption doesn't have an effect on economic growth. Meanwhile, CO_2 emissions were found to have a significant positive relationship with economic growth. Furthermore, the conservation hypothesis theory is accepted between economic growth and consumption of renewable energy. Thus, the implementation of conservation policies can be applied by taking into account economic growth.

Keywords: Dynamic Panel, Renewable Energy, CO_2 Emissions, Economic Growth, OIC Countries
JEL Classifications: O13, O44, O47

1. INTRODUCTION

Climate change and global warming have emerged as some of the most important issues confronting the international community in recent years. The human impact on the climate system is undeniable, and current anthropogenic greenhouse gas emissions, particularly carbon emissions, are at historic highs (Ehigiamusoe and Lean, 2019). Human and environmental systems have both been affected by climate change. As a result, a great deal of focus has been placed on reducing carbon emissions and building a low-carbon economy around the world. Economic growth and energy consumption are the two most important factors in environmental degradation (Abid and Sebri, 2012; Rusydiana et al., 2021; Kais and Sami, 2016; Ntanos et al., 2018).

The expansion of energy-consuming activities in developed and emerging countries raises two major concerns: the depletion of the most easily accessible energy resources (i.e., oil, gas, and coal) and, as a result, the problem of global warming caused by rapidly rising emissions of greenhouse gases like carbon dioxide (CO_2) and methane (Apergis and Danuletiu, 2014). Because of the worldwide nature of energy concerns, renewable energy supplies must be properly managed anssd utilized (Bhattacharya et al., 2016). Solar, wind, geothermal, tide and wave energy, wood, waste, and biomass are all examples of renewable energy. Achieving energy sustainability is likely to result in a cleaner environment, more access to electricity, increased energy efficiency with low-carbon renewables, and increased investment in cleaner technology (Altinoz et al., 2020). In the global context, renewable energy deployment is expanding, which contributes to combating climate change and providing more electricity access to the billions of people currently living in poverty (Inglesi-Lotz, 2016).

A number of Muslim countries, especially those in the Organization of Islamic Cooperation (OIC), have abundant energy reserves. The OIC produces 63% of the world's crude oil and 62% of the world's natural gas (Anwar et al., 2017). Saudi Arabia is the world's largest oil producer (by holing 18% of the world total oil reserves). Iran, Iraq, Kuwait, and the United Arab Emirates are also major oil producers. In OIC member countries, the average rate of energy output increase was 2.4%, while the average primary energy consumption rate was 4%. When compared to oil, natural gas causes less environmental degradation. Iran, Qatar, Turkmenistan, Saudi Arabia, and the United Arab Emirates account for 70% of the OIC's natural gas reserves. Coal is another major source of energy that has been used since the 18th century, although OIC member countries are not particularly rich in it, accounting for about 5% of global coal reserves (Sopian et al., 2011).

Inadequate energy supply has an impact on many aspects of development, including social, economic, environmental, and even quality of life (Kahia et al., 2021). Greater agricultural output, increased industrial output, efficient transportation, adequate shelter, healthcare, and other human services are all examples of improvements in the standard of life, and all of these will necessitate an increase in energy consumption (Wing and Zhong, 2015). As a result, energy is regarded as a critical prerequisite for economic progress, as well as a possible impediment to economic and social development (Jamel and Abdelkader, 2016).

The relationship between economic growth and renewable energy consumption has become a major research topic (Anwar et al., 2017; Apergis and Danuletiu, 2014; Ntanos et al., 2018). Examining the relevance of causality direction between the two variables is particularly important, as it may provide policymakers with useful information. The literature has extensively explored the causal relationship between energy use and economic growth, with differing conclusions across countries. The presence of unidirectional causality from energy consumption to economic growth (growth hypothesis) indicates that the economy is energy-dependent, in which case energy conservation efforts could stifle economic growth. Energy conservation initiatives, on the other hand, may have little or no impact on economic growth due to unidirectional causality from economic growth to energy consumption (conservation hypothesis). It's also feasible that energy consumption and economic growth are causally linked in both directions (feedback hypothesis), demonstrating the dependency and potential complementarities between the two.

Finally, as there is no causal relationship between renewable energy consumption and economic growth (neutrality hypothesis), energy conservation initiatives would have very little impact on economic growth. With growing concerns about the environmental implications of fossil fuel emissions, high and fluctuating energy prices, and the geopolitical climate surrounding fossil fuel extraction, renewable energy sources have emerged as an essential component in the global energy mix.

The current evidence on energy consumption and economic growth is inconclusive, and the vast majority of studies do not show that energy use has long-term implications on overall economic growth. The purpose of this article is to explore the long-term relationship between renewable energy usage and economic growth, as well as to draw policy implications from the findings. To this end, we use a different approach to investigate the effect of renewable energy consumption on economic growth that uses dynamic ordinary least squares (DOLS) proposed by Stock and Watson (1993) and fully modified ordinary least squares (FMOLS) developed by Pedroni to identify the correlation and the long-run sign (2000).

Given the prominence of renewable energy in discussions about a sustainable energy future, it's critical to comprehend the dynamics of renewable energy and economic growth, which this study aims to do. Unlike other research, this one take into account the utilization of renewable energy to differentiate the relative influence of each on economic growth. Second, to avoid the problem of omitted variable bias, the study employs other macroeconomics variables that include broad money, trade, financial development, and labor force. Third, it looks at the long-run relationship as well as examines the sign and direction of panel Granger causality between renewable energy consumption and economic growth in selected OIC countries for the 1st time.

The rest of the paper is arranged as follows. Section 2 examines the literature on the relationship between renewable energy and economic growth in particular. Section 3 discusses the data, methodology, and data analysis technique. Section 4 provides the empirical results. Finally, Section 5 provides the conclusion and policy implications from the empirical findings.

2. LITERATURE REVIEW

The empirical literature on the causal relationship between energy consumption and economic growth can be broken down into four testable hypotheses: Feedback, growth, conservation, and neutrality (Bhattacharya et al., 2016). According to the feedback hypothesis, energy consumption and economic growth have a bi-directional causal link. It indicates that energy consumption and economic growth are linked, and that they may possibly be complementary. According to the growth hypothesis, there is a one-way causal relationship between energy consumption and economic growth. It suggests that energy consumption, plays a vital role in economic growth both directly and indirectly in the manufacturing process.

According to the conservation hypothesis, there is a one-way causation between economic growth and energy consumption, meaning that energy conservation initiatives have no negative influence on economic growth. Finally, the neutrality hypothesis indicates that energy use and economic growth are unrelated. Energy consumption is a minor part of overall output in this hypothesis, hence it has little or no impact on actual GDP. It suggests that energy consumption policies, whether conservative or expansive, have no impact on economic growth.

The idea of sustainable development is the reason that scholars focus on the link between energy resources and economic growth

(Altinoz et al., 2020; Khan, 2019; Le and Nguyen, 2019; Osobajo et al., 2020; Raza et al., 2019; Victor and Asumadu, 2019). The fact that many countries have decided to save energy and reduce CO_2 emissions has made energy consumption studies more appealing. However, the usage of renewable energy is a crucial factor in such research. Researchers have become more interested in the effects of renewable energy usage on economic growth as the importance of sustainable development has grown (Khan et al., 2020).

Farhani and Rejeb (2012) investigated the relationship between energy consumption, national output, and environmental deterioration in 15 Middle East and North Africa (MENA) nations using data from 1973 to 2008. The findings revealed that energy use, national output, and environmental degradation are all linked. In the short run, energy use can affect national output and environmental degradation without any feedback for either variable. Higher economic growth can lead to more environmental deterioration, which can raise healthcare costs in the MENA region.

Alkhathlan and Javid (2013) evaluated the short-and long-run correlations between CO_2 emissions, energy consumption, and national output in Saudi Arabia over the period 1980-2008., The empirical results indicated that there is a long-run link between energy consumption and national output using the autoregressive distributed lag model (ARDL) and vector error correction model (VECM) techniques. The Granger causality test also revealed that national output does not cause CO_2 emissions in the Granger sense. In light of this finding, as well as the fact that Saudi Arabia is the world's largest oil exporter and producer while also being the world's 14th greatest CO_2 emitter, restrictions limiting energy consumption have been recommended for the Saudi Arabia situation.

Dritsaki (2014) looked examined the causal link between energy consumption, national output, and CO_2 emissions in Southern Europe for the period 1960-2009. Fully modified ordinary least square (FMOLS) and dynamic ordinary least square (DOLS) experiments revealed that increased energy consumption can lead to increased CO_2 emissions in the countries. The findings of the individual ordinary least square (OLS) and DOLS tests in Greece and Spain indicated that there is a strong positive association between energy use and national output.

Omri et al., (2015) use dynamic simultaneous-equation panel data models for 17 industrialized and developing nations to study the causal relationship between two types of energy variables and economic growth. The findings show that in Belgium and Spain, there is a unidirectional causality from nuclear consumption to economic growth, while in Bulgaria, Canada, the Netherlands, and Sweden, there is a unidirectional causality from economic growth to nuclear consumption. Argentina, Brazil, France, Pakistan, and the United States show a bidirectional association, while Finland, Hungary, India, Japan, Switzerland, and the United Kingdom show no causality. Then, the results for the second nexus between renewable energy and economic growth show that in India, the Netherlands, Hungary, Sweden, and Japan, there is a unidirectional causality running from renewable consumption to economic growth, while in Switzerland, Argentina, and Spain there is a unidirectional causality running from economic growth to renewable consumption. United States, Bulgaria, Canada, Belgium, Pakistan, and France, the all favor a bidirectional relationship, while Brazil, Finland, and Switzerland do not. For the global panel, they discovered a bidirectional causation between nuclear use and economic growth, as well as a unidirectional causality going from economic growth to renewable energy consumption.

Inglesi-Lotz (2016) uses panel data techniques to evaluate the influence of renewable energy use on economic welfare in thirty-four OECD member countries, both developed and developing, using annual data from 1990 to 2010. The findings reveal that renewable energy consumption, or its percentage of the entire energy mix, has a positive and statistically significant impact on economic growth. Promoting renewable energies has policy implications that benefit not just the environment but also the countries' economic conditions.

Furthermore, Anwar et al., (2017) uses data from 29 OIC (Organization of Islamic Cooperation) countries to investigate the causal relationship between economic growth, renewable energy use, and oil prices. The information is from 1990 to 2014. In order to analyze the long term and causal link between the variables, the study uses panel co-integration and causality. Furthermore, the empirical findings point to the existence of co-integration between the variables. Renewable energy usage has a positive and considerable impact on economic growth. The unidirectional causation between renewable energy consumption, oil prices, and economic growth is revealed by the panel granger causality. Prakoso (2020) also investigate the short and long-term relationship between government size and economic growth in the Islamic Cooperation Organization (OIC) during the 2010 to 2018.

Ntanos et al., (2018) investigates the link between renewable energy usage and economic growth as measured by GDP per capita in 25 European nations from 2007 to 2016. The statistical analysis uses descriptive statistics, cluster analysis, and autoregressive distributed lag (ARDL) to reveal that all variables are related; this suggests a long-term relationship between the dependent variable of GDP and the independent variables of renewable energy sources (RES) and non-RES energy consumption, gross fixed capital formation, and labor force. Furthermore, the findings reveal that RES consumption is more closely linked to economic growth in countries with greater GDP than in those with lower GDP.

Then, Mehedintu et al., (2018) uses data from the Eurostat database for the period 1995-2016 to examine the trend in the share of renewable energy consumption in the EU 28. At the EU level, the analysis employs three macroeconomic indicators. The evolution of the fraction of renewable energy consumption in final energy consumption was estimated using five regression models (polynomial, ARIMA), all of which showed an increasing trend for this variable. A perturbed regression model was used to demonstrate the favorable influence of the EU Directive on raising this share. Forecasts for this share were obtained for the 2020 horizon, all indicating that the EU aim has yet to be met.

Second, based on ultimate energy usage, four groupings of EU countries were studied.

Although researchers have been studying the link between renewable energy use and economic growth for the past three decades, there is no strong consensus among them. As a result, discrepancies in empirical results in some prior research on the impact of energy consumption and CO_2 emissions on economic growth could be linked to inability to account for changes in country wealth levels. It could also be attributable to discrepancies in methodology, as well as an inability to account for some economic and econometric difficulties including heterogeneity, endogeneity, and cross-sectional dependence.

In conducting the analysis, this study uses panel unit root tests, cointegration tests, and estimation techniques to solve various economic and econometric problems using dynamic panel estimation techniques using DOLS and FMOLS approaches. In addition, we provide a causality estimation procedure using the Panel Granger-Causality test developed by Canning and Pedroni (2008). These diverse procedures allow us to examine the effects of various variables on economic growth in dynamic specifications in order to obtain robust results. The method commonly used for this case is the GMM application (Prakoso, 2022; 2021) or standard panel regression (Firmansyah, 2022; Ganiarti, 2022).

3. METHODOLOGY

3.1. Data

The annual time series data is employed for the selected OIC countries based on the Top 10 highest GDPs for the period 2000-2018. All relevant data comes from World Development Indicators which are published by World Bank. The variables used are economic growth (proxied in GDP per capita (constant 2017 US$)), the energy consumption (measured in % of total final energy consumption), CO_2 emissions (measured in metric tons per capita), broad money (current LCU), trade (% of GDP), financial development (total credit to the private sector as a ratio of GDP), and labor force participation rate (% of total population ages 15+).

3.2. Methods

Panel data analysis is getting more popular due to its utility in applied research comparing multiple countries. Panel data is a combination of time series data and cross-section analysis that represents a sample of qualities that countries have across time. The general model to be estimated is as follows:

$$Y_{i,t} = \alpha Y_{it\text{-}1} + \beta X_{it} + u_{it}$$

Where y_{it} is the dependent variable that varies with i (the number of nations) and t (the number of years), y_{it-1} is the lagged dependent variable, x_{it} are exogenous variables, and u_{it} denotes random perturbations.

Panel data has several advantages, including the ability to examine a larger number of observations with more and better information, the ability to support a larger number of variables, the ability to track all countries (observation units), and less multicollinearity between explanatory variables, as well as greater estimation efficiency. It also solves the problem of missing variables by using differences in variables that do not change over time to delete them. Because the data is more complex and no heterogeneity is treated, panel data has downsides and limits. If all of the country's traits aren't observable, errors will be associated with observations, and OLS estimators will be inconsistent.

3.3. Data Analysis Technique

The following are the estimate approaches employed in this study: First, panel unit root tests established by LLC's test (Levin et al., 2002), ADF-Fisher Chi-square (Augmented Dickey-Fuller, 1979), and PP-Fisher Chi-square tests (Phillips and Perron, 1988) are used to investigate the order of integration of the variables in the model. Second, the study uses Pedroni (1999), Kao (1999), and Johansen's (1988) Fisher cointegration tests to assess the cointegration connection between the variables. The Kao test requires homogeneous cointegrating vectors and coefficients, but the Pedroni cointegration test allows us to account for nation size and heterogeneity by allowing numerous cointegration vector regressors to vary across panel sections. Fisher's tests (trace test statistics) are used to support the presence of a cointegrated relationship between the variables in Johansen's (1988) Fisher panel cointegration test.

Third, the study uses estimators appropriate for cointegrated panels, such as dynamic ordinary least squares (DOLS) proposed by Stock and Watson (1993) and fully modified ordinary least squares (FMOLS) developed by Pedroni (2001), to estimate the impact of energy consumption, CO_2 emissions, broad money, trade, financial development, and labor force on economic growth. The DOLS is used since the traditional OLS is ineffective for cointegrated panels and produces erroneous findings. As a result, DOLS is expected to produce better results for panels with cointegration relationships, despite the fact that it ignores cross-sectional heterogeneity. This is the Stock-Watson DOLS model that was used in this research:

$$GDPP_{i,t} = \frac{Real\,GDP}{Population}$$

FMOLS is also used in the study to estimate long-run parameters since it takes into consideration cross-sectional heterogeneity (heterogeneous long-run coefficients), serial correlation, and endogeneity issues. Even in small samples, the FMOLS estimator produces consistent results (Pedroni 2000; Salahuddin et al., 2015).

Further, the idea of Granger causality is commonly used to examine the causation between any two stochastic events (GC). The concept of incremental predictability is built upon by Granger causality, which illustrates how far one process leads another. There are numerous bivariate GC tests available for determining the presence and/or direction of causation between any two macroeconomic variables. Traditional approaches to Granger causality have given fascinating results, but they neglect the possibility that the strength and/or direction of the Granger causality- if any-may change over time.

4. RESULTS AND ANALYSIS

4.1. Descriptive Statistics

Table 1 shows the summary of descriptive statistics.

4.2. Correlation Analysis

Table 2 shows the correlations between the panel data variables. The correlation analysis indicated a negative correlation between renewable energy consumption and economic growth. Economic growth is positively correlated with carbon emissions. Broad money and economic growth are negatively correlated. Trade, financial development, labor force and economic growth are positively correlated. A negative correlation exists between renewable consumption and carbon emissions.

4.3. Panel Unit Root Test

Table 3 shows the results of a test of the unit root panel data in level and first difference. The Levin, Lin, and Chu (LLC) test, ADF-Fisher test, and PP-Fisher test are then applied. In these tests, the null hypothesis is that all series are non-stationary, while the alternative hypothesis is that all series are stationary. The null hypothesis is accepted or rejected depending on the value of probabilities and statistics in relation to the tests. These probabilities are compared to a 5% threshold. We reject the null hypothesis if the probability are <5%, and we accept the null hypothesis if these probabilities are >5%.

The results of the stationary tests of all variables used in this paper are presented in Table above. All variables are not stationary in level, but they are stationary in first difference, as seen in this table. We can conclude that all variables are integrated in order 1 based on the statistics of the LLC test, ADF-Fisher test, and PP-Fisher test.

4.4. Panel Cointegration Test

Pedroni, Kao, and Johansen Fisher cointegration tests are applied to validate the long run relationship between variables used in this paper to examine the impact of renewable energy consumption, CO_2 emissions, broad money, trade, financial development and labor force on economic growth. Pedroni test presents two sets of cointegration tests: the first set is known as within dimension (include four statistics) and the second set is known as between dimension (include three statistics). Kao cointegration test is based on ADF t-statistic. Finally, Johansen Fisher test is based on Fisher statistic from trace test. The results of cointegration are presented in Tables 4-6.

4.5. Pedroni Cointegration Test

According to Pedroni test (within dimensions and between dimensions), we can confirm that there are no presence of a long-

Table 1: Descriptive statistics

Variables	Mean	Median	Maximum	Minimum	SD	Skewness	Kurtosis
GDPP	20333.63	10975.3	102494.0	1937.729	22637.90	1.835726	5.887863
RE consumption	23.52355	9.611800	88.74930	0.006600	27.21409	1.014534	2.876366
CO_2 emissions	6.096587	2.791550	29.14566	0.169594	7.097839	1.501561	4.347168
Broad money	7.09E+14	1.76E+12	1.62E+16	5.75E+10	2.19E+15	4.519704	26.24481
Trade	69.07043	48.80324	220.4068	20.72252	47.61760	1.560791	4.330845
Financial development	43.34291	34.11780	127.2322	80.77000	29.60000	1.357049	4.191033
Labor force	56.48719	55.00750	80.77000	29.60000	10.87902	0.415803	2.835565

SD: Standard deviation

Table 2: Correlation analysis

Variables	Ln GDPP	RE consumption	CO_2 emissions	Ln broad money	Trade	Financial development	Labor force
Ln GDPP	1	−0.7630125	0.89199279	−0.2921839	0.61819064	0.45747843	0.32020687
RE consumption	−0.7630125	1	−0.06094495	0.13989902	−0.5015070	−0.5809850	0.0563567
CO_2 emissions	0.89199279	−0.6094495	1	−0.2829293	0.57599466	0.33200079	0.46028180
Ln broad money	−0.2921839	0.13989902	−0.2829293	1	−0.3287792	−0.1701670	−0.1060490
Trade	0.061819064	−0.5015070	0.57599466	−0.3287792	1	0.80745698	0.59040366
Financial development	0.045747843	−0.5809850	0.33200079	−0.1701670	0.80745698	1	0.28378789
Labor force	0.32020687	0.05063567	0.46028180	−0.1060490	0.59040366	0.28378789	1

Table 3: Panel unit root test

Variable	Level			1st Difference		
	Levin, Lin, and Chu *t*	ADF-Fisher's Chi-square	PP-Fisher's Chi-square	Levin, Lin, and Chu *t*	ADF-Fisher's Chi-square	PP-Fisher's Chi-square
Ln GDPP	19.011	2.042	3.116	−0.990	49.347***	51.992***
RE consumption	−6.735***	58.317***	77.396***	8.651***	112.110***	112.190***
CO_2 emissions	4.813	8.956	4.186	−7.094***	96.421***	105.298***
Ln broad money	19.076	0.432	0.000	−0.323***	29.893*	41.239***
Trade	−0.988	22.599	28.396	−10.022	120.797***	121.486***
Financial development	3.167	10.501	10.086	−7.462***	87.745***	89.351***
Labor force	0.895	11.082	7.835	−9.779***	124.443***	130.428***

***, ** and *Significance level at 1%, 5% and 10% respectively

Table 4: Pedroni cointegration test

Pedroni test	*t*-statistic	Probability	Pedroni test	*t*-statistic	Probability
Within dimensions			**Between dimensions**		
Panel v-statistic	−3163143	0.9992			
Panel rho-statistic	2.369489	0.9911	Panel rho-statistic	3.376064	0.9996
Panel PP-statistic	0.431039	0.6668	Panel PP-statistic	−0.035089	0.4860
Panel ADF-statistic	0.329982	0.6293	Panel ADF-statistic	−0.033039	0.4868

*Significance level at 1%, 5% and 10% respectively

Table 5: Kao residual cointegration test

Kao test	*t*-statistic	Probability
ADF	−3.113184***	0.0009

***denote significance level at 1%

Table 6: Johansen Fisher cointegration test

Fisher test	Fisher's statistic* (from trace test)	Probability
None	0.000	1.0000
At most 1	0.000	1.0000
At most 2	214.1***	0.0000
At most 3	442.3***	0.0000
At most 4	364.5***	0.0000
At most 5	154.5***	0.0000
At most 6	66.76***	0.0000

***denote significance level at 1%

run relationship between all variables used in this paper, especially between renewable energy consumption, CO_2 emissions, broad money, trade, financial development and labor force.

4.6. Kao Residual Cointegration Test

Thus, the empirical findings of Kao test confirm long run relationship between variables (especially between renewable energy consumption, CO_2 emissions, broad money, trade, financial development and labor force).

4.7. Johansen Fisher Cointegration Test

Moreover, the results of Johansen Fisher test corroborate the presence of a long run nexus between renewable energy consumption, CO_2 emissions, broad money, trade, financial development and labor force.

4.8. Long-Run Estimates Using DOLS and FMOLS

Pedroni (2001, 2004) proposed a more powerful test than single equation techniques, which looks at the condition on the cointegrating vector that is required for a strong relationship to hold. Furthermore, these methodologies enable us to evaluate whether a substantial association between renewable energy consumption, CO_2 emissions, and other macroeconomic variables on economic growth holds consistently across all nations in the panel. Table 7 reports the results of individual and panel DOLS and FMOLS which indicates whether renewable energy consumption, CO_2 emissions, and other macroeconomic variables stimulate economic growth or not in OIC countries in the long-run.

The two approaches yield very similar results for each variable in terms of sign and significance, but in terms of magnitude, they differ slightly. For empirical interpretation, the results of DOLS and FMOLS statistically show that there is no relationship between Renewable Energy Consumption on economic growth in the long term. It can be seen that the probability value of both models is >5% significance level. Furthermore, the findings on the long-run elasticity of output show that together with the increase in CO_2 emissions, it plays an important role in the process of economic development in the selected sample countries. Furthermore, the broad money and labor force variables simultaneously affect economic growth significantly in the long term, while the trade and financial development variables show an opposite relationship in influencing economic growth.

Table 7: Result of DOLS and FMOLS Model

DOLS		FMOLS	
RE consumption	−1.437459	RE Consumption	−0.381834
CO_2 emissions	0.285786**	CO_2 emissions	0.358743***
Ln broad money	0.285408***	Ln broad money	0.270462***
Trade	−0.005007**	Trade	−0.002428***
Financial development	−0.002382*	Financial development	−0.004353***
Labor force	0.030403***	Labor force	0.021625***

***, ** and * denote significance level at 1%, 5% and 10% respectively.
DOLS: Dynamic ordinary least square, FMLOS: Fully modified ordinary least squares

Table 8: Panel-Granger causality test

Variable	*F*-statistic	Probability
RE consumption→Ln GDPP	0.75638	0.4668
Ln GDPP→RE consumption	2.49202*	0.0859
CO_2 emissions→Ln GDPP	3.91671**	0.0218
Ln GDPP→CO_2 emissions	6.29918***	0.0025
Ln broad money→Ln GDPP	0.40446	0.6680
Ln GDPP→Ln broad money	0.75992	0.4693
Trade→Ln GDPP	1.58424	0.2082
Ln GDPP→Trade	4.43557***	0.0133
Financial development→Ln GDPP	0.81636	0.4438
Ln GDPP→Financial development	6.64580***	0.0017
Labor force→Ln GDPP	0.07402	0.9287
Ln GDPP→Labor force	1.10212	0.3346
CO_2 emissions→RE consumption	1.46414	0.2343
RE consumption→CO_2 emissions	4.57893***	0.0116

***, ** and *Significance level at 1%, 5% and 10% respectively

There is no significant effect of the level of consumption of renewable energy on the economic growth of a country which can be caused by the minimal level of use of renewable energy in economic activity (Sinha et al., 2018). This happens because the proportion of renewable energy consumption from total energy consumption tends to be very low (Khansa and Widiastuti, 2022). Likewise in the OIC countries, most of which still rely on conventional energy sources. This result in line with research conducted by Fang et al., (2018), they establish no correlation between energy consumption and economic growth in Singapore from 1965 to 2011. In contrast to research conducted by Saad and Belloumi (2015), they found that energy consumption has a long-term positive impact on Saudi Arabia's economic growth.

4.9. Panel-Granger Causality Test

Once the long-run dynamics are established among the variables, the next step is to find the direction of causality in the short-run. For this purpose, we conduct a panel Granger-Causality test. The significance of this approach is that it assumes all the coefficients to be different across cross-sections. This test requires variables to be stationary, we therefore apply on the first difference of the series. Table 8 shows the results of Panel-Granger Causality test.

The result established unidirectional causality from RE Consumption to economic growth, economic growth to trade, financial development to economic growth and RE consumption to CO_2 emissions. We found that there is bidirectional causality between CO_2 emission and economic growth. But, we could not establish any unidirectional or bidirectional causality between broad money and economic growth in the short-run.

4.10. Findings

This causality result shows that in the short-run, there is a unidirectional correlation between renewable energy consumption and economic growth, in addition, the same unidirectional relationship occurs in renewable energy consumption and CO_2 emissions. These results indicate that higher economic growth will further encourage the consumption of renewable energy and increase CO_2 emissions. Thus, it can be concluded that the most suitable theory in measuring the causality between renewable energy consumption and economic growth in the OIC countries is the conservation theory (Khansa and Widiastuti, 2022; Sarkodie and Adams, 2018; Victor and Asumadu, 2019). The conservation hypothesis on renewable energy is accepted in the OIC countries, so that the implementation of policies to reduce dependence on conventional energy (coal, oil, and natural gas) by transitioning to renewable energy consumption will have an impact on economic growth. Then the policy that can be applied is the management of energy resources with Islamic economic principles by increasing conventional energy efficiency which will cause the intensity of energy use to be lower, cutting energy use in unproductive economic sectors, increasing energy reserves, implementing carbon taxes, and increasing investment in renewable energy.

The bidirectional causality between economic growth and CO_2 emissions can be explained by the fact that higher use of coal, oil, fertilizers and other energy-intensive economic activities is associated with higher CO_2 emissions. Energy resources, especially those that still rely on conventional energy, are the main inputs for agriculture and industry thereby stimulating economic growth (Mirza and Kanwal, 2017). In the end, if its use increases it will result in an increase in CO_2 emissions. The heavy reliance on energy resources for economic growth and the large CO_2 emissions indicate that economic growth in OIC countries is impossible without appropriate energy resources. It implies that, while energy is necessary for economic progress, it also contributes to increased CO_2 emissions and vice versa. By steadily increasing the amount of renewable energy resources in the overall energy mix of the country and enhancing emission abatement activities in the economy, the intensity of CO_2 emissions can be reduced without hurting the economy's growth potential.

The economic structure of the OIC is expected to develop into a post-industrial country, where the service sector is the majority of economic activity, so that economic growth can minimize carbon dioxide emissions and increase the use of renewable energy. The percentage of value added of the service sector to GDP per capita in industrialized countries is >70% (Yao et al., 2019). The government must divert subsidies from fossil fuels to renewable energy. Advances in technology will accelerate changes in the structure of the economy from the industrial sector to the service sector. OIC members who are developing countries can avoid the difficulties of "high growth, high pollution" by shifting their industrial structure from fossil fuels to renewable energy. In addition, it is also able to create a sustainable economy in addition to increasing productivity (Khansa and Widiastuti, 2022; Yao et al., 2019).

5. CONCLUSION

This paper investigated the relationship between renewable energy consumption, carbon dioxide (CO_2) emissions, and other macroeconomics variables on economic growth for a sample of 10 OIC countries. The paper uses dynamic panel estimating techniques such as DOLS and FMOLS to analyse various economic and econometric problems using panel unit root tests, cointegration tests, and estimation methodologies. We also give a strategy for estimating causality using the Panel Granger-Causality test.

The empirical result shows that in the long-run, renewable energy consumption doesn't have an effect on economic growth. Meanwhile, CO_2 emissions were found to have a significant positive relationship with economic growth. This is due to inequality in the consumption of renewable energy in several samples of the OIC countries, where conventional energy consumption is still a massive alternative. Furthermore, the conservation hypothesis theory is accepted between economic growth and consumption of renewable energy. Economic growth affects the resulting carbon dioxide emissions.

The government can implement conservation policies by paying attention to the economic side, including: OIC countries work together to manage energy resources according to Islamic economic principles by using energy efficiently, reducing energy use in unproductive economic sectors, increasing energy reserves, enacting carbon taxes, and increasing investment and equitable access to renewable energy.

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