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Macroeconomic Determinants of Renewable Energy Consumption: a Cross-sectional based Analysis

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ABSTRACT

Countries throughout the world have plans to enhance renewable energy usage through the integration of funds, income, and economic regulations. However, traditional energy sources involve significant amounts of greenhouse gases, which contribute to rising temperatures and environmental damage. To maintain an acceptable temperature and decrease global warming, fossil fuels must be substituted with renewable energies. To guarantee stability and ecological sustainability, all governments, particularly those that produce oil, must prioritise the emergence of renewable energies. In this context, we use the cross-sectional autoregressive distributed lags (CS-ARDL) model to investigate whether economic policy uncertainty (EPU), financial openness (FO), oil rents (OILR), exchange rate (EXR), and income might encourage the shift from fossil fuels to clean energy supplies. This study observed that FO and EXR boost the REC, while income proves to be inconsequential. Specifically, the EPU along with the OILR have a detrimental impact on green energy use. The article investigates possible policy proposals. With empirical data, it is advised that the government implement policies for financial stability and improved conditions for foreign investors in order to generate continuous growth in clean energy sources transformation and economic integration.

1. INTRODUCTION

Clean energy is critical to the advancement of the evolution of humanity and socioeconomic prosperity [1]–[5]. Numerous nations rely on carbon-based fuels like gas, gasoline, coal, plus oil to meet their energy needs. However, fossil fuels are harmful to the environment, deplete at a quicker pace, and will eventually run out. Oil and gas are renewable energies that may pose a danger to human survival in the future. The energy environment of oil-rich states, like that of the rest of the world, is fast changing, with far-reaching consequences. There are several difficulties in this energy transfer. Nonetheless, most estimates offered by various organisations suggest that the percentage of renewable sources of energy (RE) within the energy portfolio is increasing. Considering the features of the energy networks of oil-rich nations such as OPEC countries, building a framework for energy targeting sustainability is highly significant in offering an opportunity towards moving from an unhealthy energy structure to an energy system that is more environmentally friendly. Aghahosseini *et al.* [6] projected a 100% clean energy grid for Iran by 2030. Their model solely includes generation of electricity, non-energy commercial synthesised fossil fuel creation, and water treatment. Consequently, the levelized cost of electricity (LCOE) in its overall scenario revealed that green energy production choices are by far the most viable and least-cost choice amongst all possibilities to achieving a net emissions-free energy infrastructure [7]-[10].

The global usage of clean energy has lately surged as a result of global warming. Green energy usage and production are increasing daily, and they may be significantly raised or decreased depending on globalisation designs and levels of financial growth [11]-[15]. Uncertainty in financial markets and economic policy may have a big detrimental and positive impact on renewable energy. Furthermore, increased financial openness and fiscal responsibility in technology progress (innovations) are necessary to expand sustainable energy sources. However, the rise of clean energy sources and globalisation present serious questions about energy efficiency and utility [16]. The insufficient supply of renewable energy creates a delay in the planned increase of green energy usage. As such, energy policies and economists are emphasising increased renewable output in order to encourage long-term use of renewable energy [17]–[19]. Furthermore, clean energy holds the ability to significantly fulfil energy demands while lowering CO_2 emissions [17]. As such, the world economy is depicting a great desire in improving the production of clean energies and upholding the essentials of employing renewable energies. Energy manufacturing technologies needs to be established to provide efficient use of energy and

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sustainable practises in order to buffer against anticipated environmental changes or to ensure ecological existence. As a result, governments must modernise their energy technical developments to incorporate renewable energy production techniques, notably wind and solar generation. It has advocated for the deployment of efficient energy and lesser reliance on emitted fuels for energy. Green energy ought to be promoted as an environmentally friendly fuel and an alternative for fossil fuels since it can meet rising energy demand. Globalisation has greatly aided access to technological developments, increasing the prospect for renewable energy sources [20]. Globalisation also fosters higher investment and facilitates technical transformation in the energy industry [11]. Similarly, [21] emphasised the need for more modern technologies to create renewable energy at higher capacity. Through the advancement of green energy technology, globalisation has a chance to significantly increase the supply of sustainable energy. Globalisation enables the exchange of technology across borders, which helps all nations by growing and encouraging the usage of renewable energy.

Green energy expansion and distribution activities are strongly reliant on financial transparency and spending. Financial investments have been closely linked to the transfer of knowledge from indigenous innovation to their destination countries [9]. Green energy, from the other hand, needs greater capital rewards than other forms of energy because green energy programmes necessitate higher upfront expenditures. A greater degree of financial soundness may significantly contribute to the growth of the banking sector and capital markets by making more resources easily available for capital investment [10]. Financial transparency may significantly aid renewable energy ventures by cutting the cost of funding. Increased openness in finance has significantly attracted foreign capital proceeds, which increases country welfare [1], [22]. According to studies, globalisation is critical not just in terms of increased energy consumption, but also in terms of technological transfer and financial investment. More funding for low-cost clean energy generation is made clear by an enhanced financial development sector. Financial globalization, from the other hand, enhances cleaner energy generation by moving innovations from a country to the next. However, [11] maintains that financial openness has little effect on demand for energy. Openness in finance entails some unpredictability owing to policy and timeline changes. When economic policies are unexpected, finance growth suffers significantly.

Nonetheless, economic policy uncertainty is expected to harm economic activity. Increased uncertainty over economic policy may hinder not just economic activity but additionally financial sector operation, causing new funding projects to be postponed. Economic policy uncertainty, in particular, is influencing the governance and political structures, resulting in fluctuations in finance, investment possibilities, and possible flow of funds. Because of the uncertainties surrounding economic policy, all economic processes must be altered. In addition, economic concerns, such as when, how, and whether nations will ultimately be able to handle regulation uncertainties regarding energy generation and policies, can't be predicted correctly. The rate of energy generation and national regulation, that can be adjusted as a consequence of economic policy uncertainty, are critical to economic growth. Energy efficiency research is critical since it is predicted to be positively related with the approaching energy policy strategy. Uncertainty in economic policy impede the growth of green energy consumption [23]. However, instability in economic regulations increases the expansion of cleaner energy use [25]. According to [26], instability in economic regulations decreases investment, especially in financial assets.

Financial openness facilitates the transmission of green technological breakthroughs from one nation to the next, boosting a country's sustainable energy producing capacity while simultaneously improving its energy performance. This can largely reduce not just the price of energy demand, yet the amount of individuals who use renewable energy, enabling for a future that is ecologically sound. Financial transparency supports the financial industry by increasing the availability of financial services and wealth accumulation within and beyond the nation's borders. This may not only provide financial protection and wealth generation yet boost cleaner energy producing capacity. Openness in finances enhances energy performance and financial growth through the interchange of technical breakthroughs and financial services, which considerably helps to increasing productivity growth via strengthening of energy, innovations, and finance. To achieve greater levels of prosperity, financial progress, and green energy efficiency, strong monetary policies are needed. This study believes that beneficial economic regulation ambiguities are most appropriate for a country's overall development if any changes to economic policies cause uncertainty. SDG-7 states that renewable energy is essential for every country globally.

In numerous ways, this study adds to the increasing corpus of academic research on renewable energy use. (i) The scope of this study is limited to 12 OPEC member nations. Because of their great reliance on fossil fuels, a study of OPEC nations is critical. Furthermore, their large population proportion indicates that these countries have an abundance of people resources. As a result, the energy taken by these nations' sectors is projected to grow soon, making these trade blocs possible candidates for a new study. (ii) In contrast to previous research, this study examines the influence of economic policy uncertainty, financial openness, income, currency rate, and oil rent on cleaner energy demand in 12 OPEC members from 1990 to 2020. These factors describe institutional contexts and are likely to provide intriguing insights that will aid in renewable energy policies. (iii) Particularly in the methodological section, this study adds to the bulk of research on renewable energy. To clarify our findings, this study used sophisticated panel data econometric methodologies to evaluate the data. This study determined that the cross-sectional autoregressive distributed lag (CS-ARDL) model was appropriate for the empirical study based on preliminary econometric testing. This method solves several econometric concerns, including cross-sectional dependency, cross-sectional issues, and parameter heterogeneity. Finally, the study's conclusions are expected to influence a wide range of stakeholders, notably governments, enterprises, and environmentalists. The findings of the empirical study help in the implementation of climate change legislation, the creation of measures to reduce environmental degradation, including the advancement of growth in renewable energy sources.

2. LITERATURE REVIEW

Economic policy uncertainty may exert a positive or negative influence on cleaner energy demand. [26], for instance, investigated the association between uncertain economic policy and the production of energy in China from 1995 to 2019. They observed that uncertainties in economic policies have considerable beneficial impact on energy generation. In a similar vein, [27] explored the association between uncertain economic policies and green energy demand in G7 nations. Their empirical findings suggest that uncertain economic policy boosts renewable energy demand. [28] studied the impact of uncertain economic policy on 52 Chinese energy enterprises and found that economic policy instability affects green energy industry investment considerably. Using monthly data, [21] investigated the role of uncertain economic regulations on cleaner energy demand, evident from USA. They observed that heightened instability in economic regulations affects cleaner energy demand considerably. Their research also demonstrates a bidirectional causation association between uncertain economic policies and clean energy demand. [29] examined the influence of uncertain economic policies on cleaner energy demand in BRIC economies. Their findings show an inverse link between uncertain economic policies and green energy consumption. [30] investigated the impact of economic uncertainties on renewable energy consumption in the United States using the ARDL technique. They observed that instability in economic regulations significantly affect but unfavourable influence on cleaner energy demand. [19] investigated the influence of instability in economic regulations on cleaner energy demand in 20 economies and discovered that instability in economic regulations adversely and insignificantly associated to green energy use.

Financial openness significantly boosts cleaner energy demand by moving innovative technologies between countries, resulting in higher output of green energy utilisation. For example, [31] examined the influence of globalisation on cleaner energy use in an OECD panel from 1970 to 2015. Their data indicate that globalisation significantly boosts the use of cleaner energy. Similarly, [10] used data from 30 OECD countries from 1970 to 2015 to assess the influence of economic globalisation on renewable energy consumption, and they discovered that greater levels of economic globalisation considerably boost the consumption of green energy. [22] used the ARDL technique to investigate the impact of globalisation on renewable energy use in eleven Latin American nations from 1980 to 2014. Their data suggest that globalisation benefits renewable energy consumption. [32] studied the influence of globalisations, including economic, social, and political globalisations, on consumption of energy and GDP development in 23 developing countries from 1970 to 2015. According to the empirical data, these three globalisation measures have no significant influence on energy use.

Over the last ten years, there has occurred a significant increase in energy associated research in the discipline of economics, and this can be traced to growing issues regarding the risks presented by growing greenhouse gas climate issues. Many causes are associated to a rise in atmosphere change, prompting various studies on prospective methods for lowering global atmosphere emissions within a certain time period [24]. Economists are historically concerned in the way oil rents (OILR) impact green energy consumption. In this context, this study studied the influence of oil rents on the use of clean energy in various nations. [33] applied distinguished cointegration techniques to analyse the role of oil rents, economic expansion, and greenhouse gases on REC in G7 nations. Yearly records dating from 1980 untill 2005 are deployed to make the estimate. He observed that, despite productivity growth and greenhouse gases exert a favourable and empirically significant influence for REC, OILR had the opposite effect. [34] assessed the effect of oil rent on REC using the GMM approach and observed it to be statistically negligible for 24 EUs. [35] examined the link between REC, real GDP, and OILR using panel FMOLS, DOLS, and ARDL techniques for six developing countries. The data show that oil rents exert a negative and substantial influence on REC in both countries of Asia, but not in Brazil, India, the nation of the Philippines, or Turkish. Also, the DOLS-FMOLS data suggested that the influence of oil rent is none-statistically meaningful. Similarly, [36] demonstrated no evidence of causality relating actual oil rents with REC in the context of the United States from 1949 to 2009. [37] investigated the link between REC, OILR, GDP, emissions, along with proven oil in seven OPECs. It deployed panel techniques to undertake an empirical examination of data from 1980 until 2006. According to the data, the OILR has little to no effect on REC. [38] examined the effect of OILR on REC in 25 OECDs from 1980 until 2011. It observed that a rise in real oil rents leads to a spike in REC as time passes.

In general, almost all of the research that investigated the link between financial growth and green energy consumption. Their empirical findings are uncertain and will most certainly vary depending on the study's size, time duration, and nations chosen. Furthermore, how the 12 OPEC member states oversee their policies, particularly in view of the current situation of policy uncertainty, and how they manage their financial links with other nations in order to boost the potential for producing clean energy, should be considered when carrying out an empirical assessment. However, no research has been conducted on the interactions between FO, OILR, EPU, INC, on RE for the 12 OPEC member nations. These countries are effectively expanding their ability to create renewable energy, attracting more international investment, attempting to sustain significant economic progress, and working to establish a stable financial system.

3. METHODOLOGY

3.1 Model Specification

Uncertainty about economic policies and financial openness have grown into more important variables in a nation's renewable energy consumption growth. According to [39], higher financial openness considerably increases the use of cleaner energy. Instability in economic regulations, according to research, has an impact on capital and financial securities. Furthermore, they discovered that financial openness increases renewable energy generation by facilitating technical transfer from one country to the next [11]. By altering supporting policies, economic policy uncertainty might play a positive role on the increase of cleaner energy demand. The relationship between OILR and RE consumption promotes renewable energy utilisation [20]. Income can have an influence on cleaner energy demand through financial assets and resources, either appreciatively or depreciatively. Last, income may impact cleaner energy demand depending on whether these nations divert their rising revenue beyond conventional energies and towards renewable energy supplies. The larger usage of energy function is modelled as follows, based on the theoretical framework described above:

$$REC_{it} = f(EPU_{it} + FO_{it} + OILR_{it} + INC_{it} + EXR_{it\_}\varepsilon_{it} \quad (1)$$

Where REC, EPU, FO, OILR, INC, EXR and ε_{it} denotes cleaner energy demand, instability in economic regulations, financial openness, income, exchange rate, alongside error term. Also, nations and periods are shown by subscripts i and t.

This research is based on yearly statistics for 12 OPEC member nations from 1990 to 2020. According to World Bank standards, these OPEC countries remain significantly reliant on petroleum and natural gas. Petroleum-based energy keeps being the primary engine of productivity growth as far as of global exchange profits, as well as the principal supplier of energy for these economies' expanding energy demand.

3.2 Data

This research is based on yearly statistics for 12 OPEC member nations from 1990 to 2020. According to World Bank standards, these OPEC economies remain significantly reliant on petroleum and natural gas. Petroleum-based energy has largely remained the main propellant of economies as far as of international exchange earnings and is also the principal provider of energy to those countries' expanding energy use. This study calculated RE using the total quantity of non-hydro RE installed, encompassing wind, solar photovoltaic, biological energy, bagasse, various solid biofuels, plus biogas, as reported on the Global Renewable Resources website. Income per capita reflects our income parameter, which is the sum of money made by each person in a country. It is computed through dividing GDP by populations and can be found on the World Development Indicators (WDI) website. The exchange rate describes the value at which one the nation's currency trades for another. In this example, it is assessed by nations' local currency compared to the US dollar, which is likewise collected from WDI. Oil rent denotes the distinction between the market value of crude oil supplied and the mean cost of generating it, as calculated by WDI. The Economic Policy Unpredictability Index (EPUI) is a tool for quantifying economic policy uncertainty. Finally, the Chin and Ito index is utilised to evaluate the financial openness created [40].

3.3 Cross-sectional Dependence

The most common problem in panel series analysis is that of cross-sectional dependency. The CD issue might be caused by unobserved disruptions that skew the findings. The authors utilise the [11] technique to address this problem. The following is the evaluation equation:

$$the\ the\ CD\ = \sqrt{\frac{2T}{N(N-1)\left[\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\partial}_{ij}\right]}} \quad (2)$$

Where $\hat{\partial}_{ij}$ depicts the correlation residuals sample, T alongside N represents cross-section alongside period.

3.4 Homogeneity Test

After studying cross-sectional link, it is vital to investigate the heterogeneity since nations differ in terms of populace, finance, and sociocultural structure. The Pesaran as well as Yamagata slope homogeneous test is employed to reach this purpose. These are the evaluation equations:

$$\Delta_{Sh} = (N)\frac{1}{2}(2f)\frac{1}{2}\left[\frac{1}{N}S - f\right] \quad (3)$$

$$\Delta_{ASh} = (N)\frac{1}{2}\left(\frac{2f(T-f-1)}{T+1}\right)\frac{1}{2}\left[\frac{1}{N}S - f\right] \quad (4)$$

Δ_{Sh} and Δ_{ASh} denotes the delta tilde and adjusted delta tilde, respectively.

3.5 Unit Root Test

The heterogeneous unit roots evaluations are needed to check the combined features of parameters while confirming the CD alongside variability within slope coefficients. Pesaran's cross-sectional augmented Dickey-Fuller and Pesaran-Shin unit estimations are deployed in this context. These tests outperform the homogeneous unit root analysis with regard to effectiveness and accuracy, which are best employed with heterogeneity.

3.6 Co-Integration Test

The long-term cointegration connection of the fundamental variables is obtained after the stationarity diagnostic. The ECM group cointegration assessment devised by Westerlund [40] is deployed in this work. In the setting of heterogeneity alongside cross-sectional dependency, this test produces efficient findings. The approach was used to study the relationships between financial openness, oil rent, currency rate, income, unstable economic policies, and cleaner energy use in the 12 OPEC member countries. According to [41], when the error elements are cross-sectionally reliant, this test is accurate and robust. The equations are as follows:

$$\delta i(L)\Delta y_{it} = y2_{it} + \beta_i(y_{it} - 1 - \delta_i x_{it}) + \aleph_i(L)V_{it} + \varphi_i \tag{5}$$

This test equations are:

$$G_t = \frac{1}{N}\sum_{i-1}^{N}\frac{\delta_i}{SE(\delta_i)} \tag{6}$$

$$G_\delta = \frac{1}{N}\sum_{i-1}^{N}\frac{Y\delta_i}{\delta_i(1)} \tag{7}$$

$$P_r = \frac{\delta}{SE(\delta)} \tag{8}$$

$$P_\delta = Y\delta \tag{9}$$

Equations 6 and 7 indicate group averages stats for Ga alongside Gt. Whereas Equations 8 with 9 provide the panel stats for Pa alongside Pt. The approach includes null alongside option hypotheses of "no cointegration" and "cointegration," as appropriate.

3.7 Estimation: CS-ARDL

This study employed the cross-sectional-autoregressive distributed lag method to ascertain the coefficient estimate. This approach accounts for variability by calculating common associated effects. Equation 10 is the following mathematical expression:

$$C_{i,t} = \sum_{i=0}^{pw} y_{1,i}w_{i,t} + \sum_{i=0}^{pz}\beta_{1,i} + e_{i,t} \tag{10}$$

The preceding equation is for autoregressive distributed lag (ARDL); cross sections change Equation 11. This was created to remove disrespectful remarks regarding CD made by Chudik and Pesaran.

$$C_{i,t} = \sum_{i=0}^{aw} y_{1,i}C_{i,t} + \sum_{i=0}^{az}\beta_{1,i}Z_{i,t-1} + \sum_{i=0}^{az}\acute{\alpha}_{1,i}I\bar{X}_{i,t-1} + u_{i,t} \tag{11}$$

Predictor delays are represented by aw, az, and axe. Cit denotes renewable energy consumption, while Zi,t is the exogenous predictor. Furthermore, X demonstrates an average of CD to overcome the overrun holdings. The CS-ARDL approach calculates long-term figures with short-term figures.

4. RESULTS AND DISCUSSION

Tables 1 alongside 2 illustrate descriptive summary and a correlation assessment for the studied 12 OPEC member nations. Table 1 lists all of the variables utilised in this analysis, as well as their units of estimation, averages, standard deviations, skewness, along with kurtosis with regard to the selected economies from 1990 to 2020. The variables for this study include the use of renewable energy (REC), openness to finance (FO), conversion rate (EXR), uncertain economic policy (EPU), oil rent (OILR), and income (INC). The Kurtosis and Skewness scores indicate an unbalanced data. However, should the values of Kurtosis alongside Skewness turn 0 alongside 3, this suggests that the distribution is normal. The variables' stats from Jarque-Bera coefficients provided the average frequency distributions. Likewise, an average score for OILR is 2.453, which equates to a standard variation of 0.515, as opposed to the mean score of 26.864 for economic policy uncertainty, which translates to a standard variation of 8.628. The mean income figure is 12.431, which corresponds to a standard variation of 0.347. Whereas financial openness is 4.541 on average, having a standard variation of 1.092. Finally, the exchange rate has a mean of 5.930 and a standard variation of 2.427. Notably, all the variables differ significantly between nations, which clarifies why the standard variations are lower than the mean for the data.

Table 2 shows the correlation indices of the parameters in our experimental model. The correlation coefficients of all variables indicate that there exists an exact linear connection between these variables without multicollinearity in the model. Following the central limit theorem, the properties of the sample match the features of the general population variable as sample size grows. As a result, screening for non-normality when the sample size exceeds 30 is not required.

Table 1. Descriptive statistics summary.

Variables	Mean	Standard deviation	Skewness	Kurtosis	Jarque-Bera
$lnREC_{it}$	6.065	0.024	0.819	1.295	10.520*(0.000)
$lnOILR_{it}$	2.453	0.515	-1.002	3.014	5.041* (0.070)
$lnEPU_{it}$	26.864	8.628	0.018	2.450	3.440 (0.174)
$lnINC_{it}$	12.431	0.347	0.012	1.634	3.656 (0.171)
$lnFO_{it}$	4.541	1.092	0.827	2.361	4.084 (0.132)
$lnEXR_{it}$	5.930	2.427	-0.328	3.046	5.721 (0.532)

Table 2. Correlation matrix summary.

	$lnREC_{it}$	$lnOILR_{it}$	$lnEPU_{it}$	$lnINC_{it}$	$lnFO_{it}$	$lnEXR_{it}$
$lnREC_{it}$	1.000					
$lnOILR_{it}$	0.112	1.000				
$lnEPU_{it}$	0.123	0.125	1.000			
$lnINC_{it}$	0.231	0.123	0.114	1.000		
$lnFO_{it}$	0.317	0.102	0.105	0.217	1.000	
$lnEXR_{it}$	0.251	0.116	0.125	0.142	0.172	1.000

4.1 Outcomes of Cross-sectional Dependence

When dealing with panel data, there is a chance of certain unnoticed common volatility components over cross-sectional units, argued by Pesaran. This association across segments may exhibit cross-sectional dependency in error terms, resulting in biases across calculated average errors and discrepancies in the outcomes. Investigating for the existence of CD is thus a routine step when working with panel information. The substantial p-value of the Pesaran CD within random effect contradicts the null hypothesis of no CD at a 5% significance. Nevertheless, both the Breush-Pagan (LM) and Pesaran's CD tests reject the null hypothesis of CD presence among the error terms of the cross-sectional components. As a consequence, the general results support the existence of CD, supporting the use of the CR-ARDL framework in the empirical study.

Table 3. Cross-sectional dependence tests.

Parameters	Pesaran (CD)	Breush-Pagan
$lnREC_{it}$	5.137*	85.677*
	(0.000)	(0.000)
$lnOILR_{it}$	3.076*	22.559*
	(0.000)	(0.000)
$lnEPU_{it}$	4.192*	19.149**
	(0.000)	(0.038)
$lnINC_{it}$	5.379*	22.039**
	(0.000)	(0.014)
lnFOit	3.271*	24.201*
	(0.000)	(0.007)
$lnEXR_{it}$	3.742*	20.961*
	(0.000)	(0.001)

4.2 Homogeneity Results

The article also considers heterogeneity to properly determine the best panel techniques to use. The outcomes of the heterogeneity in the research are provided in Table 4 below. Considering the estimated numbers of the delta and modified delta, as well as their corresponding P-values, the estimation decisively rejects H_0 hypothesis scores of none heterogeneity at significance 1%.

Table 4. Slope homogeneity tests.

Group	Statistic
Delta	-3.381*
Adjusted Delta	-4.117*

4.3 Unit Root Result

Table 5 shows the outcome of the panel unit root assessment. To investigate the stationarity of the parameters, this study employed the cross-section Pesaran alongside cross-sectional enhanced dicky fuller unit-root. According to the outcomes, the parameters OILR, EPU, INC, and FO have unit-root at level, but REC and EXR have o unit-root at level. As a result, this study discovered a mixed integration order in the observed parameters. Besides, we employ first difference after which all those with unit-root at level become stationary at I(1). Notably, none of the parameters has I(2) stationarity. The findings of the unit-root analysis validate the use of the CR-ARDL model.

Table 5. Unit root outcomes.

Variable	CIPS		CADF first difference	
	level	first difference	Level Z[t	Z[t
$lnREC_{it}$	-6.13	-7.23*	-4.11*	-6.72*
$lnOilR_{it}$	-6.62*	-7.21*	-4.61*	-7.82*
$lnEPU_{it}$	-6.92*	-7.42*	-4.37*	-6.87*
$lnINC_{it}$	-6.53*	-7.13*	-5.51*	-6.01*
lnFOit	-6.69*	-7.13*	-4.79*	-6.38*
lnEXRit	-6.03	-7.28*	-4.01	-6.65*

Table 6. Co-integration outcomes.

Stats	With trend figures	Without trend figures
G_t	-4.826*(0.003)	-5.577 (0.001)
G_a	-12.173 (0.052)	-13.360** (0.011)
P_t	-6.720*(0.000)	-9.631* (0.000)
P_a	-17.714*(0.001)	-19.551* (0.000)

4.4 Co-integration Test Results

A Westerlund co-integration study produced the table below, which depicts the cointegration connection between FO, OILR, EPU, INC, EXR, and REC. The results reveal that the null hypothesis of no co-integration is therefore rejected at constant and trend, since group statistics (G_t and G_) and panel statistics (P_t and P_) emerge significant at 1% and 1%. This shows a long-term association among financial openness, oil rent, economic policy uncertainty, income, and demand for renewable energy.

4.5 Estimation Results

The actual aim of this work is to look at the role of financial openness and economic policy uncertainty on cleaner energies. To achieve the study's goal, 12 OPEC member nations were chosen as panels, and this study used a novel approach to deduce cross-sectional dependencies in the data. After determining the CS dependencies, this study deployed a heterogeneous unit-root test to eliminate the CS concerns. Furthermore, the CS-ARDL test is thought to be the ideal approach for testing panel cross-country macroeconomic concerns and identifying long- and short-run relationships between variables. Table 4.7 displays the estimation findings. In the table, this study shows the coefficient, standard error, z-test, and value of probability for every parameter. The R^2, which shows the model's fit, demonstrates that the model described 55% cross-country variance. At this point, the F-value of 95.195, which shows 1% significance, demonstrates that both parameters are jointly significant. As a result, the model's statistical analysis evaluates the cumulative effect of all components, demonstrating that EPU and OILR are adversely related to REC. FG is both positive and statistically significant concerning REC, but INC is negligible. Except for INCit, the coefficients of these relationships for EPUit and OIPit are negative and significant at 1%. Nonetheless, the FG is significant by 5%.

To begin, the outcomes show that EPU is considerable and has a negative association with REC. A 1% increase in EPU translates in a 0.029% drop in REC. It means that volatility in government economic regulations have lessened throughout the REC transition, particularly in these OPEC member nations, and it is viewed as a vulnerable determinant that influences community alongside industry behaviour. These outcomes are congruent with those of [42], who believe that EPU is directly tied to micro and macroeconomic developments, financial markets, and corporate behaviour in any nation. [43] employ a non-linear econometric technique to predicting the fluctuations in energy demand from sustainable energy supplies in the US. The long-term connection findings reveal that EPU has a negative and significant impact on REC in the United States. Based on the research results, national policymakers and corporate agents are recommended to maintain continuity in their economic policies in order to boost the usage of renewable energy. Second, our outcomes unveils that financial transparency is crucial in boosting cleaner energy use in the OPEC member countries analysed. Financial transparency may aid in improving environmentally friendly by boosting the use of cleaner energies. Our findings are comparable with those of [44] who found that globalisation decreases total energy consumption while enhancing environmentally friendly through increasing cleaner energies.

Third, the outcome of oil rents has a significant and unfavourable role on cleaner energy utilisation. These nations continue to profit from high oil rents due to the inverse elasticity of oil rents, which deter the movement from fossils to sustainable energies. Many nations continue to profit from growing oil rents due to the negative coefficient of oil rent, impeding the transition to renewable energy sources. The outcome of this study aligns with the outcomes of [45] in the context of the G7 nations, [46] for Indonesia alongside China, and [47] for Kazakhstan.

Income does not appear to have a significant role on cleaner energies consumption. Income with a small impact suggests that the economies failed to divert their expanding oil profits out from traditional energy sources and towards renewable energy usage. For low-income nations, our findings are similar with [48]. Fifth, long-run exchange rates appeared to be positively associated with cleaner energies use, which is consistent with Shah *et al.* [7], who suggest that depreciation of the currency stimulates economic activity, which leads to increased energy consumption. This conclusion is further corroborated by Foye's [48] work.

Table 7. Cross-sectional autoagressive distributive lag.

	Coef.	Std. Err.	z	P>z
Short Run Est.				
EPU_{it}	-0.573	0.201	-2.85	0.000
FO_{it}	0.051	0.012	4.25	0.000
$OILR_{it}$	-0.160	0.024	-6.66	0.000
INC_{it}	0.472	0.513	0.92	0.065
EXR_{it}	0.318	0.095	3.35	0.000
Adjust. Term	-0.216	0.078	-2.76	0.006
lr_eup	-0.283**	0.061	-4.63	0.000
lr_fo	0.067*	0.022	3.04	0.000
lr_oilr	-0.134	0.032	-4.18	0.000
lr_inc	0.528	0.615	0.85	0.076
lr_exr	0.056	0.015	3.73	0.000
R-squared	0.55			
Adj. R-squared	0.46			
F (95, 195)	2.8	(0.000)		
CD Statistic	3.34	(0.000)		

Note: * Shows statistical significance at a 1 % level, while ** signifies the 5% level.

5. CONCLUSION AND POLICY IMPLICATION

OPEC members are truly concerned about rising global competition and, as a result, strive to increase output and productivity. Meanwhile, these nations have been working closely with international organisations to raise the consumption of renewable energy sources in order to contribute to the fight against global warming and create a new trend in the field of energy demand. In this vein, our research looks at how financial openness, the human development index, oil rent, financial development, information technology, and income affect renewable energy usage. All parameters have a mixed order of integration (I(0) and I(1)), according to the unit root tests. As a consequence, the chances of a long-run connection may be investigated. The long-term test revealed that the parameters move in tandem. The implications of economic policy uncertainty on renewable energy demand are highlighted. The CR-ARDL modelling approach is used to estimate the long-term coefficients. This study discovered that financial transparency has a favourable influence on the demand for renewable energy. Furthermore, in the panel dataset of the nations analysed, a higher level of financial openness stimulates the use of cleaner energies. The data also shows a negative long-term association between EPU and REC. This shows that these nations' economic policy uncertainty is impeding the transition to renewable energy sources and is viewed as a risk factor for affecting social and economic behaviour. Although income may appear insignificant, it suggests that these nations have not leveraged their growing affluence to shift away from traditional energy sources and towards green energy sources. However, oil rents have a detrimental influence on the uptake of renewable energy. These countries continue to profit from increased oil rents as a result of this negative coefficient, ignoring the objective of renewable energy transition.

Based on the data above, the following recommendations may be made:

1) Because financial globalisation has been proved to enhance renewable energy use, these nations should become more financially integrated to the global economy. In this regard, authorities should

enhance financial openness, *i.e.*, the political system should permit greater inflows of foreign money. These overseas monies, on the other hand, should be invested in ecologically friendly industrial techniques.

2) Furthermore, taking into consideration study findings, it is established that economic policy uncertainty, meaning the presence of instability in macro basic concepts, plays a negative role in the shift from fossil energy to green energies application. As a result of empirical data, it is advised that the government implement policies for economic stability and a better environment for foreign investors in order to generate progressive expansion of the renewable energy transition as well as inclusion in the economy.
3) For states with large assets, such that oil income translates to over 50% of growth, there exists a considerable chance of obtaining and using greater quantities of oil money amid increased oil prices. considering this context, our findings regarding the unfavorable effect of rising oil rents on cleaner energy demand could be interpreted as a negligence of the economies to convert their rising oil earnings during the oil boom into more cleaner and efficient forms of energies, such as renewable energies. In a nutshell, our studies show that these nations aren't as liberal in making investments in renewable energies when conventional forms of energy seem to be less costly. It is recommended that excess oil earnings be used to achieve an acceptable level of financing for research and development in environmentally friendly and renewable sources of energy.

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