

The relationship between Renewable Energy Consumption and Economic Growth? Evidence from North Africa

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Abstract:

In fact, there is a universal consensus about the transition's obligation to renewable energy consumption. As the economic growth is countries' continuously striving goal, this study endeavours to investigate the relationship between renewable energy consumption and economic growth in North Africa countries (Algeria, Tunisia, Morocco, Mauritania and Libya) over the time period (1990-2020). The Panel autoregressive distributed lag (ARDL) focusing on PMG estimator is employed to examine this relationship. The findings of PMG estimator in long-run corroborate the existence of negative relationship, whereas the increase by 1% in renewable energy consumption leads to decrease the GDP by 16,60%. Also, they affirm the absence of any relationship in the short run. Moreover, the results of causality test confirm the conservation hypothesis through the existence of unidirectional relationship from economic growth to renewable energy consumption in North African countries over the period time 1990 to 2020.

Keywords:

*Renewable energy consumption;
Economic growth;
North Africa;
Panel (ARDL, PMG) model.*

JEL Classification Codes: Q2 ; Q42 ; O4.

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1. Introduction

It is axiomatic to consider the energy as substantial factor for making the converting processes that convert raw resources to consumable and useful resources. Globally, economies are depending on fossil fuels resources to spawn the needed energies for satisfying their desires and developing their economies. Unfortunately, these resources such as (oil, coal, natural gas, and nuclear fuel “uranium”) have two main shortages. Firstly, their environment detrimental, global warming and climate change. Indeed, almost 1.1 billion people still do not have electricity. Especially in Africa and Asia. Also, there are about \$ 2.9 billion people are depending on wood or other biomass fuels for cooking and heating, resulting in indoor and outdoor air pollution that causes 4.3 million deaths each year (Hilmi et al, 2017). Secondly, they are exhaustible and nonrenewable. Accordingly, this type of energy is antithesis to the principles and goals of sustainable development, which assumes the preservation of both the environment and the future generations rights.

Therefore, the necessity to oriented towards a best substitute of these fossil fuels is an urgently issue. An alternative which can be inexhaustible, regenerated and affordable. Thus, the renewable sources encompass wind, biomass (landfill gas and sewage gas), hydropower, solar power (thermal and photovoltaic), geothermal and ocean power are serving as the main alternative to those fossil fuels sources.

In fact, although the negative effects of fossil fuel energy it cannot be ignored its closely impact on enhancing economic growth in almost countries. According to Ayres and Nair in their

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proposed theory of Biophysical economic growth (1984), the energy is one of the main factors for growth. Additionally, the intermediate role of labour and capital factors (Hilmi et al., 2017). Moreover, empirically many research papers have proven its direct and indirect role in enhancing the economic growth in many countries. Nondo in 2010 conducted a study about 18 African countries (COMESA). His findings affirmed that economic growth and energy consumption move together in the long run, and they are positively relating. further, they have a bidirectional relationship (Nindo, 2010). Additionally, in a study conducted by Payne in 2010, in order to establish a literature infrastructure for researchers in the relationship between energy consumption and economic growth, he found that for specific countries surveyed, 36 high income countries, 22 upper middle-income countries, 31 lower middle-income countries and 22 low-income countries respectively the following results: 23.1 %, 21.4%, 28%, 27% and 17.8% are supportive the positive impact of energy consumption on economic growth in these countries (the growth hypothesis). Also, 28.2%, 32.1%, 29.4%, 21.2% and 26.1% are supportive the bidirectional relationship (the energy consumption impact positively on economic growth and vis versa) (Payne, 2010). In 2011, a study has been analyzed the causal relationship between real GDP and energy consumption for 23 OECD countries from 1971 to 2009. It also hinted that there existed a long-run equilibrium relationship. Furthermore, a bidirectional causal relationship in both the short and long run (Frauke, 2011). Further, in 2013 Alper et al., investigated this relationship in 47 states in USA over the period time 1997 to 2009. The findings proven that there was a long-run equilibrium relationship between real GDP and energy consumption. Additionally, there were a bidirectional relationship (causation

runs in both directions) in these states (Alper et al., 2013). However, there are many other studies confirm the conservation hypothesis which assumed that economic growth has an impact on energy consumption or they confirm the absence of any relationship between the energy consumption and economic growth (Payne, 2010; Nindo, 2010).

Recently, with the great pressures of the political, social and environmental organizations to the necessity for finding and creating rapid and effective solutions for environmental damages problems and the issue of how preserving the future generations' rights, many governments are always trying to invest in renewable energies and consume them instead of fossil fuels ones. Where the shares of renewable energy consumption in the world, high income, upper middle income and lower middle-income countries, respectively are: 13,87%, 15,76% and 8,93% in 2022 (Energy Institute - Statistical Review of World Energy, 2023).

In the context of energy transition many researchers investigated the relationship between renewable energy consumption and economic growth of countries (Kabiru, 2015 in Nigeria; Hilmi, 2017 in Iran; Kabiru et al, 2019 in West Africa; Smolovic et al, 2020 in European Union; Li & Leung, 2021 in Europe; Konuk, 2021 in NEXT 11 countries; Sebri & Ben Salha 2013 in BRICS, Inglesi-Lotz, 2016 in OECD; Marinas et al, 2018 in European countries; Bhuiyan et al, 2022)

In this regard, our research paper is trying to consider the log and short run relationship as well as, the causal relationship between renewable energy consumption and economic growth in Northern Africa (Algeria, Tunisia, Libya, Mauritania, Morocco). As there is a gap in literature reviews about this area

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over the period 1990 to 2020. In purpose to illustrate the level of their investments in renewable energy as a suitable substitute of fossil fuels energy and to investigate the impact of these renewable energy in enhancing their economic growth. Furthermore, it aims to attract the policy makers attention towards the usefulness of this sources of energy where they are considered as the outlet of the fossil fuels energy depletion.

In order to illustrate the object and procedure of this research it will be divided into five sections: firstly, section of introduction, section 2 is devoted to the literature review. Then presents the data, methodology in Section 3, section 4 presents the results and discussion. Finally, the conclusion section.

1.1. Literature review and hypothesis:

According to the globally greatest importance of renewable energies numerous studies have been interested by investigating their impact on economic growth, where they tested the relationship between renewable energy consumption and the economic growth in various countries. Some authors have been examined the relationship between renewable energy consumption and economic growth at the country level, Whereas, other researchers have oriented their examination to the aggregate level such as Africa, Asia, OECD, Europe, G7 and 11 countries. Furthermore, some studies have been focused in their countries' subdivision on the income level, high income, middle- and lower-income economies.

At the country level, a study has been conducted by Tiwari in 2011, aimed to analyze the renewable energy consumption dynamics on economic growth and CO₂ emissions. His results corroborated that there existed a positive shock on the

consumption of renewable energy led to increase the GDP and decreased the CO₂ emissions (Tiwari, 2011). Also, in 2015 Kabiru Maji studied the long and short run relationship between clean energy on economic growth in Nigeria over the period from 1971 to 2011. His findings underscored the significantly and the positively impact of renewable energy consumption on economic growth in the long run. While, in the short run there was a mixture of negative and positive relationship (Kabiru Maji in 2015). Moreover, in 2017 there was a study investigated the same relationship over the period 1983 to 2013 in Iran. Its findings proven that the increase of 1% in renewable energy consumption leads to an increase by 4.06% of economic growth in the long run. While, in the short run this increment was raised to 7,5% (Hilmi et al, 2017).

Then, at the aggregate level, for European studies, Smolovic' et al analyzed the relationship in the long and short run between renewable energy consumption and economic growth among the EU members over the period 2004 to 2018. His findings show that the impact is positive and statistically significant in the long run in both samples of countries (the sample is divided into two groups on depending to the similarities in economic and social development within the group). In the short term, the impact of renewable energy consumption on economic activity proved to be negative in new member states, while in traditional member states it had no statistically significant impact (Smolovic' et al, 2020). Li and Leung in 2021, examined the renewable energy and economic growth nexus in seven European countries for the 34-year period of 1985-2018. The results showed that no long run or short run causality relationship from renewable energy consumption to economic growth, but they confirmed that the economic growth is a main driver of renewable energy

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consumption (Li and Leung, 2021). Also, another study was conducted by Marinas et al in 2018 to tested the same relationship over the period 1990 to 2014 in central and eastern European countries. Its results affirmed that in short run the GDP and renewable energy consumption dynamics are independent in Romania and Bulgaria, while in Hungary, Lithuania and Slovenia an increasing renewable energy consumption improves the economic growth. further, there was bidirectional causality relationship in the long run for both the whole group of analyzed countries. Also, for African countries, researchers were trying to examined the relationship between renewable energy consumption and the economic growth. Kabiru Maji et al in 2019 have focused on West Africa with a sample of 15 countries over the period 1995 to 2014 to examined the long run. The study' findings have suggested that the consumption of renewable energies slow down their economic growth (Kabiru Maji et al, 2019). Also, a recent study conducted by Yuni et al in 2023 to consider this relationship in 43 Sub-Saharan African countries. The results showed that the increased share of renewable electricity in total electricity production and consumption increased significantly and contributed positively to economic development (Yuni et al, 2023). Moreover, OECD countries, a study in 2016 found a positive impact of renewable energy consumption on welfare over the period 1990 to 2010 (Inglsi-Lotz, 2016). Another study in 2014 has added the non-renewable energy consumption to the relationship over the period of 1980 to 2011. It confirmed the existence of a long-term equilibrium relationship among non-renewable sources, economic growth (Salim et al, 2014). Furthermore, there are a study focused on BRICS countries to examine the causality relationship over the period 1971 to 2010, and it also affirmed the

existence of long run equilibrium and bidirectional relationship among the competing variables. Also, other study tested the causal link between renewable energy consumption and economic growth by using a sample of 103 country in the 1995 to 2015 period. It confirmed that this relationship is depending on the amount of renewable energy consumption and it is positive and significant if and only if developing countries and non-OECD countries surpass a threshold of renewable energy consumption. Further, in developed countries there was no significant effect on their economic growth. While it was positively and significantly affected the economic growth in OECD countries (Chen et al, 2020). Another research was focused on G7 countries over the period 1980 to 2009. In order to test the long run and causal relationships between renewable energy and non-renewable energy consumption and economic growth, and its findings affirmed that either these two types of energy affected economic growth. in addition to the existence of bidirectional relationship for all these countries (Tugcu et al, 2012). In 2021, research specified biomass energy consumption to test its relationship with economic growth in NEXT 11 countries (except for Vietnam) over the period 1970 to 2017. It found that they act together in the long run (Konuk, 2021).

Finally, Namahoro et al in 2021, have adopted another method to subdivide their sample depending on the income levels, where they tested the impact of total and renewable energy consumption on economic growth in lower and middle and upper-middle income groups for a sample of 75 countries from 1980 to 2016. Its findings appeared a positive and significant effect of the both energies kind on the economic growth in the three income groups (Namahoro et al, 2021).

1.2. The hypotheses of the research paper

In fact, to investigate the causal relationship between renewable energy consumption and the economic growth in North African countries (Algeria, Tunisia, Morocco, Mauritania and Libya). There are four hypotheses must to be tested (Tugsu et al, 2012; Yildirim, 2014; Namahoro et al, 2021).

H1. The growth hypothesis, indicates that renewable energy consumption has an important part in the economic growth process directly and/or as a complement to capital and labor.

H2. The conservation hypothesis suggests that economic growth is the dynamic which causes the consumption of renewable energy sources.

H3. The feedback hypothesis, implies a bidirectional causal relation between renewable energy consumption and economic growth.

H4. The neutrality hypothesis testifies that renewable energy consumption does not affect economic growth and vice versa.

2. Methodology and Materials

This section shows a brief introduction of the data, mathematical model, cross-sectional dependence tests, panel unit root test, Westurland cointegration and causality tests,

The theoretical framework of this study is the endogenous growth theory. The theory argues that economic growth can be reached as a result of internal processes. The rationale of choosing this theory is that: First, the relevance of capital stock and human capital (labour) in economic growth has since been emphasized in the endogenous growth model. Second, the theory puts technological advancement and/or innovation component

that upgrades economic growth. This second reason provides a safe ground to include renewable energy in a growth model as an additional input requirement(Kaburi Maji et al, 2019).

Practically,the panel cointegration and panel causality models are be employed in this study. an autoregressive distributed lag model (ARDL) is used to capture the impact of renewable energy consumption on economic growth in the long and in the short-term.

Broadly, econometric modelling techniques entails five main steps (Li & Leung, 2021; Namahoro et al; 2021; Konuk et al, 2021).

- **Cross-sectional dependence tests:**Pesaran proposed Pesaran CD and standardized Lagrange Multiplier (LM) tests, and Breusch and Pagan proposed also Breusch-Pagan LM test for initially detecting cross-sectional dependence in panel data(Namahoro et al; 2021).
- **Panel unit root characteristics:** a cross-sectionally augmented Dickey-Fuller(ADF) is employed which aims to test the stationarity of research variables(Namahoro et al; 2021).
- **Pedroni's cointegration test:** in order to determine the existence of cointegration between series of the selected variable.
- **Testing the existing of long-run relationship by Panel cointegration tests:**Dynamic mean group estimators, namely the Pooled Mean Group (PMG) estimator was used as it provides consistent estimates of the parameters' averages despite the possible presence of endogeneity, because it

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includes and account for the lags of both dependent and independent variables (Smolovic et al, 2020).

- **Estimating the causality among the variables:** By employed Dumitrescu Hurlin test to determine the directional causal relationship among economic growth and renewable energy consumption (Smolovic et al, 2020).

2.1. Data collection

To investigate the relationship between renewable energy consumption and economic growth in Northern Africa (Algeria, Tunisia, Libya, Mauritania, Morocco) the panel data mined from The World Bank database for GDP, renewable energy consumption, Capital stock (K) and Labour (L)) have been employed. Taking into account that these data cover the period of time 1990 to 2020.

2.2. Variable Measurement

2.2.1. Dependent Variable

The gross domestic production per capita GDP (in constant 2015 U.S. dollars) for North African countries over the period (1990 to 2020) is taken as a proxy of economic growth, which is consistent with prior researches (Namahoro et al, 2021; Konuk, 2021; Salim et al, 2014; Tugusu et al, 2012).

2.2.2. Independent variables

Renewable energy consumption (REC) measured as a share of the total energy have been consumed in North African countries over the period 1990 to 2020. This is consistent with prior studies (Namahoro et al, 2021; Kabiru Maji, 2015; Smolovic, 2020).

2.2.3. Control variables

Capital stock(KS) is the amount of money used to take over the machinery, equipment and buildings (Hilmi, 2017). Here the gross fixed capital formation used as a proxy for capital stock and it has been measured as a percentage of GDP. Labour force (LF) expressed as the total labour force participation rate (% of total population ages +15 modeled ILO estimate) in the market (Smolovic, 2020; Namahoro, 2022).

In order to interpret the coefficients obtained by regressions as elasticities, all variables are converted to their natural logarithmic forms.

3. Research Model

In this study the augmented endogenous growth model for a panel of North African countries is adopted (Salim et al, 2014; Namahoro et al, 2021; Kabiru Maji et al, 2019; Slomovic et al, 2020; Li & Leung, 2021; Hilmi et al, 2017; Oh & Lee, 2004; Chen et al, 2020; NforYuni et al, 2023; Inglesi-Lotz, 2016)

3.1. Mathematical model

The mathematical equation which presents the relationship between renewable energy consumption and economic growth according to the augmented endogenous growth model is presented as follows:

$$Y_{it} = f(REC_{it}, LF_{it}, KS_{it}). \quad (1)$$

Y: presents the economic growth (GDP); REC: denotes renewable energy consumption, KS: indicates the capital stock; and LF indicates the labour force; $i=1, \dots, N$: represents the cross-section of countries; and $t=1, \dots, T$: represents the time period. Thus, the multivariate equation can be written as follows:

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$$Y_{it} = \beta_{0it} + \beta_{1it} REC_{it} + \beta_{2it} KS_{it} + \beta_{3it} LF_{it} + u_{it} \quad (2)$$

For β_{0it} is unobserved country fixed effect, from β_1 to β_3 are the long-run equilibrium coefficients, and u_{it} is error term.

In this model the lag orders of the variables are chosen by using the appropriate Akaike Information Criteria (AIC). Thus, the base model between economic growth and renewable energy consumption and the selected control variables as ARDL (p, q, z) is

$$\ln GDP_{it} = \sum_{j=1}^p \lambda_{ij} \ln GDP_{it-j} + \sum_{j=0}^q \delta_{ij}' \ln X_{it-j} + u_i + \varepsilon_{it}$$

$j=1, \dots, p$

Where $\ln GDP$: is the natural logarithm of GDP (independent variable); $\ln X$: is the natural logarithm of REC, KS and LF (dependent variables); u_i : stands for fixed effects; ε_{it} : is the disturbing component. As the cointegration of nonstationary variables is equivalent to an error correction (EC) process, the ARDL model has a reparameterization in EC form (according to Engle and Granger)(Slomovic et al, 2020).

$$\Delta \ln GDP_{it} = \varphi_i (\ln GDP_{it-1} - \theta' X_{it}) + \sum_{j=1}^{p-1} \lambda_{ij} \Delta \ln GDP_{it-j} + \sum_{j=0}^{q-1} \delta_{ij}' \Delta X_{it-j} + u_i + \varepsilon_{it}$$

Where the parameter $\varphi_i = - (1 - \sum_{j=1}^p \lambda_{ij})$: is the

Error correction speed of adjustment term.

λ_{ij} and δ_{ij}' present individual short-term coefficient. And θ' contains the long-run relationships between variables.

4. Results and Discussion

This section discusses the findings obtained of the energy growth nexus. The effect of labour force and capital stock are used for control.

4.1. Cross-sectional dependence results

Table (2) shows the results of cross-sectional dependence tests. Where the Pesaran CD, standardized Lagrange Multiplier (LM) and Breusch-Pagan LM tests are used for initially detecting cross-sectional dependence in panel data (Namahoro et al; 2021). Whereas, the null hypotheses of these tests indicate the existence of cross independence, while the alternative hypothesis assumes cross-dependence across the countries observed. Based on the finding of these tests the null hypotheses are rejected at a 1% level of significance, because of their (P-value = 0,000) which are less than 0,01. Thus, the alternative ones are been accepted. Therefore, there is a cross-sectional dependence across North Africa countries.

4.2. Panel Unit Root Test Results

The put forward results of Pasaran unit root test Table(3) indicate the order of integration between all our series in data set. The findings signalize that all series are stationary at 1st difference. Because all P-values are greater than 0,05 at levels while, they are less than 0,05 at the 1st difference. Thus, the null hypothesis is rejected which assumed that there is no stationarity and the alternative one is accepted.

4.3. Pedroni's cointegration test

After having proven the stationarity of InGDP, InREC, InKS and InLF series, we applied Pedroni's cointegration test. Knowing that this test takes into account heterogeneity. It consists of seven

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statistics for testing panel data cointegration which are divided into two groups of tests, four are based on the ‘within’ dimension, and the remaining three deal with the ‘between’ dimension (Smolovic’ et al, 2020). Table (4) states the results. The P-value of five tests among seven are less than 0,05. Accordingly, the null hypothesis is rejected. Thus, the alternative hypothesis which decide the existence of cointegration between variables is accepted.

4.4. Results of Autoregressivedistributed lag ARDL focusing on PMG model

With a view to indicate the impact of renewable energy consumption, capital stock and labour force variables on economic growth, error correction based on an autoregressive distributed lag ARDL (4,4,4,4) model was used, with a focus on the PMG model. The lag was enjoined according to the data limitations and confirmed by the Akaike Information Criteria (AIC). Table (5) presents the results of long run and short run estimations.

The empirical evidence clearly suggests the existence of negative relationship between economic growth and renewable energy consumption over the long run. Whereas, an increase by 1% of REC leads to decrease the GDP by 16,60%. In fact, this result is not surprising, as these countries have weak economies and they have not a strong industrialization framework. As well as, they mostly utilize energy in satisfying consumer needs as heating, cooking, lighting further than the productivity activities. Moreover, the consumption of renewable energy needs great investments financing especially in Algeria and Libya who are closely dependent to fossil fuel energies consumption and the transition to renewable energy demands big investments to

establish novel infrastructure for being able to exploit the cleaner resources and this kind of transition demands a long time. Therefore, the growth hypothesis is unfulfilled in the long run.

In short run the results suggest that there is no relationship between economic growth and renewable energy consumption. Thus, the neutrality hypothesis in short run is affirmed. However, the results of each country indicate the existence of positive relationship in Algeria where an increase by 1% in REC leads to increase GDP by 1%, also, in Mauritania it leads to increase its GDP by 76% and it is the most beneficial country of the renewable energy consumption. Moreover, the capital stock has a negative relationship with economic growth in the long run. That refers to the inappropriate utilization of the most materials and equipment. Which are more exploited in nonprofit organizations and they do not be oriented to the industrial and service activities. While, in short run, there is no relationship between the renewable energy consumption and economic growth. Meanwhile, there is a positive relationship between the labour force and economic growth in the long run. Nevertheless, it has no relationship in the short run.

4.5. Dumitrescu and Hurlin Causality Test Results and Hypotheses Analysis

The main intention here is to check both the direct and reverse causalities between renewable energy consumption and economic growth (Smolovic' et al, 2020). Table (6) shows that there is unidirectional causality relationship between economic growth and renewable energy consumption which validates the conservation hypothesis. Whereas, the economic growth is the dynamic which causes the consumption of renewable energy sources and rejects the growth, feedback and neutrality

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hypotheses. Also, there is a unidirectional relationship between economic growth and capital stock. Meanwhile, there is a bidirectional relationship between labour force and economic growth.

5. Conclusion

This paper investigates the short and long-run relationship between economic growth and renewable energy consumption in North African countries (Algeria, Tunisia, Morocco, Mauritania and Libya) over the period of time (1990 to 2020). For that purpose, error correction based on an Autoregression distributed lag ARDL (4,4,4,4) model was employed, with a focus on the PMG estimator. The findings corroborated that there is a negative and significant relationship between renewable energy consumption and economic growth in North African countries in long run where, the increasing by 1% in renewable energy consumption leads to a decreasing by 16,60% in their GDP. Thus, the growth hypothesis is not demonstrated in the long run. This is consistent with prior studies (K.Maji, 2015 in Nigeria; K.Maji, 2019 in West Africa; Namaharo et al, 2021 at regional level in low, lower and middle and upper-middle-income groups). However, in short run the results proven the neutrality hypothesis. This result is consistent with (Li & Leung, 2021 in Europe; Namaharo, 2021; Chen et al, 2020 in developed countries except OECD countries). Additionally, the results proven a great negative relationship between capital stock and economic growth where the increasing by 1% in capital stock might leads to decreasing the GDP by 159,50%. This could be referring to the inappropriate ways in exploiting this capital, especially when they concentrated on non-profitable and unproductive projects. Whilst, the labour force related strongly

and positively to economic growth, where the results affirms that the increase of 1% in labour force leads to increase the GDP by 359,73%.

Furthermore, the findings proven the conservation hypothesis that indicates a unidirectional causality relationship between economic growth and renewable energy consumption in North African countries. This result is differs with some previous studies that found a bidirectional relationship (K. Maji, 2019; Tugcu et al, 2012; A.Salim, 2014 in OECD countries; Marinas et al, 2018 in Central and Eastern European countries; Sebri et al, 2013 in BRICS countries).Also, there is a unidirectional relationship from economic growth to capital stock and a bidirectional relationship between labour force and economic growth in North African countries.

Suggested actions

- The most important consequence of this research is that great efforts should be oriented to establish more cleaner infrastructure to produce renewable energies from exploiting more clean and renewable resources.
- The necessity of orienting the fundings governments' efforts towards the renewable energy investments.
- The upgrading of innovation activities specifically in the field of renewable energy production and consumption.
- Integrating more labour force in the process of energy transition.
- Orient more capital stock amongst the productive projects which enhancing the economic growth and participate in energy transition processes.

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7. Appendices:

Table (1): variables name and Metrix

variable	Name	metrics	symb
Dependent variable	GDP per capita	GDP (in mil. Constant 2015US\$)/ population	GDP
Independent variables	Renewable energy consumption	Share of total energy consumption (%)	REC
Control variables	Capital stock	Gross Fixed Capital (% of GDP)	Ks
	labourforce	Labour force participation rate total (% of total population ages +15 (modeled ILO estimate)	LF

Table (2) Test for cross-sectional dependence

<i>Test</i>	<i>Statistic</i>	<i>P-Value</i>
<i>Breusch-Pagan LM</i>	40,07485	0,0000
<i>Pesaran Scaled LM</i>	6,724941	0,0000
<i>Pesaran Scaled CD</i>	4,966006	0,0000

Source: Authors' calculation

Table (3): Pasaran Unit Root Test Results

	LEVELS	P-V	1STdiffirence	P-V
<i>InGDP</i>	-1,25150	0,1054	-2,87174	0,0020
<i>INREC</i>	1,48444	0,9312	-7,25153	0,0000
<i>InKS</i>	0,64783	0,7415	-5,96829	0,0000
<i>InLF</i>	5,9	1,0000	-2,16400	0,0031

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Table (4): Pedroni Cointegration Test results

	<i>Tests</i>	<i>Statistics</i>	<i>P-value</i>
Within-dimension			
<i>Panel v-Statistic</i>		9,413007	0,0000
<i>Panel rho-Statistic</i>		-3,851756	0,0001
<i>Panel PP-Statistic</i>		-10,57433	0,0000
<i>Panel ADF-Statistic</i>		-3,617759	0,0001
Between-dimension			
<i>Group rho-Statistic</i>		-1,093729	0,1370
<i>Group PP-Statistic</i>		-4,671037	0,0000
<i>Group ADF-Statistic</i>		-0,228476	0,4096

Table (5): Panel short- and long-term coefficients: Pooled Mean Group Estimator.

<i>Variables</i>	<i>Coefficient</i>	<i>t-Statistics</i>	<i>P-value</i>
Long Run Equation			
<i>INREC</i>	-0,166089	-2,7726,6	0,0071
<i>InKS</i>	-1,595060	-7,006876	0,0000
<i>InLF</i>	3,597389	19,30178	0,0000
Short Run Equation			
Δ <i>INREC</i>	-0,058205	-208434	0,8355
Δ <i>InKS</i>	-0,400592	-1,310984	0,1940
Δ <i>InLF</i>	-16,64877	-9,948630	0,3460

Source: Authors' calculationResults

Table (6): Dumitrescu–Hurlin panel causality test.

Null hypothesis	W-Stat	Zbar-Stat	P-Value
<i>InREC does not homogeneously cause InGDP</i>	3,30933	1,05486	0,2915
<i>InGDP does not homogeneously cause InREC</i>	4,42439	2,09808	0,0359
<i>InKS does not homogeneously cause InGDP</i>	3,17869	0,93264	0,3510
<i>InGDP does not homogeneously cause InKS</i>	5,65655	3,25085	0,0012
<i>InLF does not homogeneously cause InGDP</i>	8,02306	5,46488	0,0000
<i>InGDP does not homogeneously cause InLF</i>	8,50597	5,91668	0,0000

Source: Authors' calculation.