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RESEARCH ARTICLE

The nexus between renewable energy consumption and economic growth in Morocco

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Abstract

It is known that the transition to renewable energy can be a lever for the growth of both developed and developing countries. Thus, the whole world starts to become aware of the importance of the development of renewable energies, which became a priority for the future. In this context, Morocco belongs to the countries that set up some development policies for renewable energies in the short and medium term. Furthermore, this article investigates and analyzes the nexus and the relationship between renewable and non-renewable energy consumption, CO_2 emissions, and economic growth for Morocco over the period going from 1990 to 2014 using the auto-regressive distributed lag model approach and the Granger causality test. The empirical results support that renewable energies in Morocco start to give their positive effects on the economic dimension of sustainable development and it is found that there is causality from renewable energy consumption to economic growth and from economic growth to CO_2 emissions. However, the Moroccan government and private companies must look for innovative methods to finance renewable energy projects. In addition, these technologies can be the best substitute for fossil fuels: firstly, in order to reduce the burden of energy costs on the Moroccan economy (the energy bill in Morocco continues to rise, more than 100 billion DH in 2012); secondly, to strengthen its competitiveness without affecting the economic growth of the country.

Keywords Renewable and non-renewable energy consumption · Economic growth · ARDL · Morocco

Introduction

During the two last decades, the transition to renewable energy (RE) has become a topical issue around the world. For developing countries, RE is essential for economic development and for reducing carbon emissions, especially for countries that import almost all of their energy needs. In this context, the results of the study carried out by Ito (2017) for 42 developing countries showed that RE contributes to the reduction of CO_2 emissions and has a positive effect on economic growth in the long-term. For developed countries, Saidi and Mbarek (2016) concluded that RE is an essential element for economic growth. Moreover, thanks to renewable energies, Germany has been able to position itself as a leader in clean energy security by installing more solar and wind power. So it plans to produce 80% of its renewable energy by 2050 Rafindadi and Ozturk (2016). In addition, the country has decided to abandon its nuclear power by 2022 and focus on the production of green energy.

The use of RE (Table 1) is an alternative to fossil fuels as well as a solution to environmental problems and fight against global warming. In this context, Dincer (2000) recommends the use of RE as the best possible solution to combat climate changes and address environmental problems. Similarly, Broggio et al. (2014) estimate that the energy transition is considered as a substitution of renewable resources for fossil energies; also, the current energy system based on fossil resources is incompatible with objectives of sustainable development (Midilli et al. 2006).

The energy transition is the passage from an energy system based on the traditional energies (oil, natural gas,

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Table 1 List of abbreviations

ARDL: auto-regressive distributed lag model
DOLS: dynamic ordinary least square
ECM: error correction model
FMOLS: fully modified ordinary least square
GDP: gross domestic product
GHG : greenhouse gas
NRENC: non-renewable energy consumption
RE: renewable energy
RENC: renewable energy consupmtion
VECM: vector error correction model

etc.), which emit greenhouse gases and are exhaustible, to a more efficient, secure energy system based on the use of the renewable energies (solar, wind, hydro, biomass, geothermal, etc.). Furthermore, the transition to an energy system based on renewable energy will make it possible to achieve sustainable development (Dincer and Rosen 1999; del and Burguillo 2008; Bao and Fang 2013) and stop global warming (Dincer 2000; Sims 2004; Panwar 2011; Mathews 2014; DeRichter 2016). In fact, many scientists and experts in the world affirmed that RE can play a crucial and very important role in the economic growth (Alper and Oguz 2016), reducing greenhouse gas emissions (Kangyin et al. 2018; Kardooni et al. 2018) and creating jobs (Moreno and Lopez 2008; Arib 2014; IRENA 2017).

At this stage, Morocco belongs to the countries that set up some development policies for renewable energies in the short and medium term. The country was engaged by the ratification of the Protocol of Kyoto in 2002 to fight against the climatic changes and reduce greenhouse gas emissions (HCP 2015). In addition, Morocco has signed and ratified the main international conventions on the protection of the environment and sustainable development; also, in order to meet its commitments with international organizations in terms of sustainable development, the country has elaborated the national strategy of sustainable development in 2015 and will continue until 2030 SNDD (2015).

Currently, Morocco is seeking through its new energy strategy, to reduce its energy dependence and develop a green economy over the next decade with an energy savings of 5% by 2021, and an estimated energy savings of between 15% and 20% by 2030 IEA (2019). In order to carry out the national renewable energy policy, the Moroccan government has set up a set of research centers, organizations, and public institutions to steer renewable energy projects in Morocco and support the national energy strategy by identifying, defining, and carrying out applied research and development projects in the field of solar energy and other new technologies from renewable sources.

Also, Morocco is among the developing countries that invested more than 500 million dollars in renewable energy in 2015 REN21 (2016); with this figure, Morocco is one of the countries that have increased their investment in renewable energy these recent years (the fourth in the world in 2015 according to RECAI 2016). The country plans to increase the production of renewable energies to attain 42% and 52% by 2020 and 2030 respectively (AFDB 2019).

Moreover, Morocco has very favorable climatic conditions for the large-scale development of photovoltaic solar energy and concentrated solar thermal energy. The country wants to become self-sufficient in energy and have the best benefit from RE (solar and wind energy), because it profits from an important sunning and regular winds over the year. Furthermore, solar energy (a capacity of 20,000 MW) and wind resources (25,000 MW of capacity) are considered as promising sources for improving the balance energy by reducing the country's energy dependence and protecting the environment by combating climate change.

This energy dependency reduced from around 98% in 2009 to about 93% in 2017. Thus, this decrease can be explained by the RE projects carried out at the national level, which have enabled the part of wind and solar power in the installed capacity to increase from 2% at the beginning of 2009 to more than 13% in 2017 (MEME 2019). Also, electricity generated from RE in Morocco in 2017 was 4.6 TWh, including 3 TWh from wind power (IEA 2019).

To the best of our knowledge, this study is the only one to examine the relationship between economic growth and renewable energy consumption, including CO_2 emissions and non-renewable consumption in Morocco. The link between these variables has not been studied before for the case of Morocco, and this is the main objective of this document. Further, one major limitation of this paper is that it explores the link between REC and GDP in Morocco without employing regional comparison.

The choice of Morocco for this study is motivated by the following reasons: Morocco faces several socio-economic and environmental challenges. The first challenge is to succeed in the national energy transition, as the country is highly dependent on fossil fuels which generate environmental problems. The second challenge is to exploit the renewable energy potential in the country. The last challenge is that the development of renewable energy in Morocco could contribute to creating job opportunities and reduce the rate of unemployment in the country. Moreover, the choice to move towards renewable energy and appreciate its role in reconciling socio-economic and environmental interests has become a necessity. Then, to seize the opportunities offered by this sector, which is capable of improving the quality of life for citizens. Creating jobs and providing clean and environmentally friendly energy require the adoption of long-term strategies.

The study of the effect of RE on economic growth has generated a considerable amount of empirical research, such as Tugcu et al. (2012), Ibrahiem (2015), Mbarek et al. (2018), Bao and Xu (2019), Maji et al. (2019), Razmi et al. (2020), Le and Bao (2020), Rahman and Velayutham (2020) and Koengkan et al. (2020). Furthermore, Chen et al. (2020) estimated that the impact of RE on economic growth depends on RE used. In addition, the effective results can be obtained in economic development process while determining energy policies (Tuna and Tuna 2019).

The rest of this research paper is structured as follows: literature review is drawn in the second section; empirical methodology, results of the study, and discussion are detailed in Sections Materials and methods, Results, and Discussion respectively. Conclusion and some policy implications are presented in the last section.

Literature review

The impact of RENC on the economic dimension of sustainable development has generated several empirical studies, which use diverse methods for both developed and developing countries. A list of studies on the nexus between RENC and GDP is presented in Table 2. Therefore, the empirical results of these studies are contradictory. Some works find a two-way causality between renewable energy consumption and economic growth, while some studies find that there exists a unidirectional causality from RENC to GDP where the reverse.

More recently, Koengkan et al. (2020) employed a panel vector autoregression to analyze the link between CO_2 emissions, RENC, NRENC, and GDP in the Southern Common Market from 1980 to 2014. Their empirical analysis revealed that there is bidirectional causality between NREC, GDP, RENC, and CO_2 emissions. The nexus between RENC, NRENC, and GDP has been examined in five South Asian countries, over the period of 1990–2014 in the study conducted by Rahman and Velayutham (2020). Applying DOLS, panel FMOLS, and causality tests, they believe that there is a unidirectional causality running from economic growth to RENC. It is also revealed that a positive effect of RENC exists on economic growth.

In very recent work, Yo and Hao (2020) investigated the link between GDP and RENC in the case of the 31 Chinese provinces over the period 2000–2015. Using the VECM and FMOLS, they estimated that the GDP and RENC have a long-run stable relationship. In addition, the authors find that there is unilateral causality from GDP to RENC in the long run. In the same context, the study conducted by Chen et al. (2019) analyzes the linkages between GDP, CO_2 emissions, RENC, and NRENC for China covering the period 1980–2014. The authors used the ARDL approach and VECM. Their empirical results indicate that there is a long-run relationship among those variables.

Mbarek et al. (2018) applied the Granger causality test and VECM model to examine the relationship between GDP, RENC, NRENC, and CO_2 emissions in Tunisia over the period 1990–2015. The empirical analysis pointed to the existence of a bidirectional causal relationship between energy use and CO_2 emissions. Also, there are a unidirectional links running from energy use to economic growth in the short run. A similar investigation was carried out by Ito (2017) who applied panel data to investigate the nexus between GDP, CO_2 emissions, RENC, and NRENC based on data of 42 developed countries over the period 2002– 2011. He estimated that RENC positively contributes to economic growth in the long run and NRENC has a negative impact on economic growth.

Cherni and Jouini (2017) investigated the nexus between RENC, CO_2 emissions, and economic growth in Tunisia from 1990 to 2015 via the ARDL approach. They concluded that the economic growth generated an increase in fossil fuel consumption, which is the main reason for CO_2 emissions and they reported that the solution is to use renewable energy as it is important for economic growth in Tunisia. Also, we can cite the study conducted by Rafindadi and Ozturk (2016) who applied several econometric techniques to verify and investigate the linkage between the factors of the RENC and the economic growth based on data of 1971 up to 2013 in Germany. The authors showed that RENC in Germany plays a very important role in the country's economic growth.

Bhattacharya et al. (2016) investigated the impact of REC on GDP in 38 top RE consuming countries. Their findings show that REC has a significant positive impact on GDP for 57% of the selected countries. Similarly, Apergis and Payne (2011) and Apergis and Payne (2010) explore the causal link between REC and GDP in Central America and Eurasia, respectively. They reported that there is bidirectional causality between these two variables.

We can classify the empirical results of this works into two categories. The first category includes the studies which have found a positive link between RENC and economic growth (Ito 2017; Rahman and Velayutham 2020), and the second category includes the studies that found a negative relationship between these two variables (Ocal and Aslan 2013; Maji et al. 2019; Bao and Xu 2019; Razmi et al. 2020).

Materials and methods

Correlation between the variables

Table 3 shows the results of multicollinearity possible between the variables in our model by employing the correlation matrix. First, GDP, NRENC, and CO_2 are

Table 2 A list of studies on the nexus between RENC and GDP

References (years)	Period	Country	Methodology	Variables	Conclusions
Le and Bao (2020)	1990–2014	16 Latin America and Caribbean Emerging Market and Developing Economies	Second-generation panel data techniques	GDP RENC	RENC increases GDP
Rahman and Velayutham (2020)	1990–2014	5 South Asian countries	Panel FMOLS DOLS	GDP RENC	GDP→ RENC
Razmi et al. (2020)	1990–2014	Iran	ARDL	RENC GDP	RENC does not affect GDP
Maji et al. (2019)	1995–2014	15 West African countries	Panel dynamic ordinary least squares	GDP RENC	RENC slows down GDP
Cherni and Jouini (2017)	1990–2015	Tunisia	ARDL Granger causality test	CO_2 GDP RENC	GDP↔ RENC
Fethi (2017)	1980–2012	Algeria	ARDL Granger causality test	GDP RENC	RENC→ GDP
Rafindadi and Ozturk (2016)	1971–2013	Germany	ARDL Granger causality test	GDP ERC	feedback effect between RENC and GDP
Alper and Oguz (2016)	1990–2009	8 European countries	ARDL	GDP RENC	GDP→ RENC
Bhattacharya et al. (2016)	1991–2012	38 countries	FMOLS	GDP RENC	RENC increases GDP
Ibrahiem (2015)	1980–2011	Egypt	ARDL	RENC GDP	GDP↔ RENC
Lin and Moubarak (2014)	1977–2011	China	ARDL Granger causality test	GDP RENC	RENC↔ GDP
Salim and Rafiq (2012)	1980–2006	Brasil, China, India, Indonesia, Philippines, Turkey	Granger causality test	RENC CO_2 Income	RENC↔ Income
Apergis and Payne (2011)	1980–2006	Central America	Heterogeneous panel Granger causality test	RENC GDP	RENC↔ GDP
Apergis and Payne (2010)	1992–2007	13 countries within Eurasia	Heterogeneous panel Granger causality test	RENC GDP	RENC↔ GDP
Sadorsky (2009)	1980–2005	G7 countries	DOLS	GDP RENC	GDP→ RENC

Table 3 Correlation matrix

Correlation	LRENC	LGDP	LNRENC	LCO_2
LRENC	1.000000			
LGDP	0.741443	1.000000		
LNRENC	0.277340	0.339130	1.000000	
LCO_2	0.704302	0.962753	0.502700	1.000000

correlated positively on RENC. Second, CO_2 and NRENC are positively correlated to the GDP. Finally, there is a positive correlation between NRENC and CO_2 emissions.

Model and data

Within the framework of our study, we seek to determine the impact of renewable energy consumption on economic growth in Morocco, by integrating two variables: non-renewable energy consumption and CO_2 emissions.

In addition, we want to examine and analyze the linkages between these variables by developing the following model:

$$GDP_t = \alpha_0 + \alpha_1 RENC_t + \alpha_2 NRENC_t + \alpha_3 CO2_t + \varepsilon_t \tag{1}$$

where GDP, RENC, NRENC, CO_2, and ε_t represent: real GDP per capita, renewable energy consumption, non-renewable energy consumption, CO_2 emissions, and error term, respectively.

All data are converted into natural logarithm to avoid the problem associated with the distributional properties of the data series (Paramati et al. 2016; Paramati et al. 2017; Ummalla and Samal 2019). Thus, the logarithmic form of Eq. 1 is presented as follows:

$$LGDP_t = \alpha_0 + \alpha_1 LRENC_t + \alpha_2 LNRENC_t + \alpha_3 LCO2_t + \varepsilon_t \tag{2}$$

We used the annual data covering the period going from 1990 up to 2014. The data of our study is obtained from the World Bank (Bank 2019) and the Energy Information Administration (EIA 2019). The ARDL approach developed by Pesaran et al. (2001) and the Granger causality test are used in order to estimate the linkages between GDP, RENC, NRENC, and CO_2 emissions with the analysis of the short run and long term.

The ARDL approach of Eq. 2 of the model is as follows:

$$\begin{aligned}\Delta LGDP_t = {} & \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta LGDP_{t-1} \\ & + \sum_{i=1}^{p} \alpha_{2i} \Delta LRENC_{t-1} \\ & + \sum_{i=1}^{p} \alpha_{3i} \Delta LNRENC_{t-1} \\ & + \sum_{i=1}^{p} \alpha_{4i} \Delta LCO2_{t-1} \\ & + \Phi_1 LGDP_{t-1} + \Phi_2 LRENC_{t-1} \\ & + \Phi_3 LNRENC_{t-1} \\ & + \Phi_4 LCO2_{t-1} + \varepsilon_t \end{aligned} \tag{3}$$

where α_0 and ε_t mean the drift component and the white noise respectively. The procedure of the ARDL approach has several steps. First, to select the optimal lag length, the Schwarz information criterion (SC) is used in this study. The second one is to perform the co-integration test using the F-test. The choice of the ARDL model makes it possible to estimate the long-term relationship between all variables. Once this relationship is established, the ECM can be estimated.

A general ECM of Eq. 3 is presented below:

$$\begin{aligned}\Delta LGDP_t = {} & \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta LGDP_{t-1} \\ & + \sum_{i=1}^{p} \alpha_{2i} \Delta LRENC_{t-1} \\ & + \sum_{i=1}^{p} \alpha_{3i} \Delta LNRENC_{t-1} \\ & + \sum_{i=1}^{p} \alpha_{4i} \Delta LCO2_{t-1} \\ & + \omega ECT_{t-1} + \varepsilon_t \end{aligned} \tag{4}$$

where Δ and (ECT_{t-1}) mean the first difference operator and the error correction term respectively, which (ECT_{t-1}) represents the long-run relation.

Unit root test

In this study, we chose the stationarity tests of augmented Dickey-Fuller (ADF) and of Phillips Perron (PP) in order to check the stationarity of the series. The aim is to determine the order of integration because the ARDL approach can be applied whether the variables are I(0) or I(1). However, in the presence of I(2) variables, the procedure will collapse (Frimpong and Oteng-Abayie 2006).

Granger causality test

The VECM is used to examine the nature of causality and distinguish a short and long-run relationship among economic growth, CO_2 emissions, renewable energy consumption and non-renewable energy consumption. The VECM is as follows:

$$\begin{aligned}\triangle LGDP_t = {} & \mu_0 + \sum_{i=1}^{p} \mu_{1i} \triangle LGDP_{t-1} \\ & + \sum_{i=1}^{p} \mu_{2i} \triangle LRENC_{t-1} \\ & + \sum_{i=1}^{p} \mu_{3i} \triangle LNRENC_{t-1} \\ & + \sum_{i=1}^{p} \mu_{4i} LCO2_{t-1} \\ & + \phi_1 ECT_{t-1} + \varepsilon_{1t}\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta LRENC_t = {} & \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta LRENC_{t-1} \\ & + \sum_{i=1}^{p} \beta_{2i} \Delta LGDP_{t-1} \\ & + \sum_{i=1}^{p} \beta_{3i} \Delta LNRENC_{t-1} \\ & + \sum_{i=1}^{p} \beta_{4i} \Delta LCO2_{t-1} \\ & + \phi_2 ECT_{t-1} + \varepsilon_{2t}\end{aligned} \tag{6}$$

$$\begin{aligned}\Delta LNRENC_t = {} & \gamma_0 + \sum_{i=1}^{p} \gamma_{1i} \Delta LNRENC_{t-1} \\ & + \sum_{i=1}^{p} \gamma_{2i} \Delta LGDP_{t-1} \\ & + \sum_{i=1}^{p} \gamma_{3i} \Delta LRENC_{t-1} \\ & + \sum_{i=1}^{p} \gamma_{4i} \Delta LCO2_{t-1} \\ & + \phi_3 ECT_{t-1} + \varepsilon_{3t}\end{aligned} \tag{7}$$

$$\begin{aligned}\Delta LCO2_t = {} & \theta_0 + \sum_{i=1}^{p} \theta_{1i} \Delta LLCO2_{t-1} \\ & + \sum_{i=1}^{p} \theta_{2i} \Delta LGDP_{t-1} \\ & + \sum_{i=1}^{p} \theta_{3i} \Delta LRENC_{t-1} \\ & + \sum_{i=1}^{p} \theta_{4i} \Delta LNRENC_{t-1} \\ & + \phi_4 ECT_{t-1} + \varepsilon_{4t}\end{aligned} \tag{8}$$

where Δ and (ECT_{t-1}) correspond to the first difference operator and the error correction term, respectively.

Results

Unit root test

Table 4 indicates the results of both ADF and PP tests. All variables are stationary at the first difference and they are I(1).

ARDL co-integration tests

Before carrying out the co-integration test of Pesaran et al. (2001), it is necessary to determine an appropriate lag length for our model. The Schwarz information criterion (SC) selected lag 1 and the result is detailed in Table 5. Our ARDL model (1.2.0.2) is selected on the basis of the SC.

The results of Tables 6 and 7 show that the coefficient of RENC has a positive impact on economic growth but statistically non-significant in the short and long run, as a 1% increase in RENC will enhance the GDP by 0.042% and 0.061% in the short run and the long run, respectively. It indicates that renewable energies in Morocco start to give their positive effects on the economic dimension of sustainable development. These findings are similar to the results of Adams et al. (2018) and Luqman et al. (2019). However, the result is contradictory to the findings of Ocal and Aslan (2013) and Razmi et al. (2020).

In fact, the impact of NRENC on economic growth is negative and statically significant. Furthermore, an increase of 1% of the NRENC involves a reduction in GDP of 0,12% in the short run and 0.18% in the long run which reveals that the economic development in Morocco does not depend on NRENC.

The outcomes of the ARDL co-integration test (Table 8) indicate the appearance of a co-integration link between RENC, NRENC, GDP, and carbon emissions. In fact, the calculated F-statistic (7.7114) is higher than the superior and inferior critical bound value at the 10%, 5%, and 1% significance.

Causality test

In regard to the relationship between economic growth, CO_2 emissions, and renewable and non-renewable energy consumption, the Granger causality test is carried out on four variables. The VECM model (Table 9) reveals that at the 10% significance level, we find that there is unidirectional causality from RENC to GDP and from GDP to CO_2 emissions at the 1% significance level in the short run. This last finding is consistent with the one

Table 4 Unit root test

	ADF		PP	
	Intercept	Intercept and trend	Intercept	Intercept and trend
LGDP	−0.7924	−2.2737	−0.7469	−2.9447
LRENC	−1.8067	−3.3694	−1.8067	−3.2450
LNRENC	−2.2578	−2.4663	−2.2578	−2.4663
LCO_2	−1.0756	−2.4259	−1.2046	−2.4601
Δ LGDP	−9.8292***	−1.2759	−9.0706***	−10.7678***
Δ LRENC	−4.8266***	−4.8230***	−5.6303***	−5.5918***
Δ LNRENC	−5.6136***	−5.4752***	−5.8144***	−5.6579***
Δ LCO_2	−5.6297***	−5.6307***	−5.7843***	−5.7440***

Δ denotes the first difference operator. ***p value < 1%; **p value < 5%; *p value < 10%

Table 5 Lag length criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	94.82888	NA	3.05e-09	−8.257171	−8.058799	−8.210440
1	157.2136	96.41274*	4.64e-11	−12.47396	−11.48211*	−12.24031
2	175.7538	21.91112	4.37e-11*	−12.70489	−10.91955	−12.28431
3	194.1437	15.04627	5.81e-11	−12.92215*	−10.34332	−12.31466*

*The optimal lag chosen by each criterion

Table 6 Short-run analysis

Dependent variable: LGDP				
Variable	Coefficient	Std. Error	t-statistic	Prob.*
ΔLNRENC	−0.125606	0.259925	−0.483237	0.6364
ΔLRENC	0.042346	0.012559	3.371823	0.0046
Δ LCO_2	0.318611	0.124575	2.557587	0.0228
CointEq (ECM)(-1)	−0.700033	0.144242	−4.853196	0.0003
R-squared	0.994187			
Adjusted R-squared	0.990865			

Table 7 Long-run analysis

Variable	Coefficient	Std. Error	t-statistic	Prob.
LCO_2	0.646784	0.036675	17.635467	0.0000
LNRENC	−0.179428	0.371909	−0.482452	0.6369
LRENC	0.061324	0.023447	2.615456	0.0204
C	1.661996	1.645108	1.010265	0.3295

Table 8 F-bounds test

Test statistic	Value	Signif.	I(0)	I(1)
F-statistic	7.711402	10%	2.72	3.77
k	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61

Table 9 Granger causality test

Dependent variable	Short-run			Long-run	
	Δ LGDP	Δ LRENC	Δ LNRENC	Δ LCO_2	ECT (−1)
Δ LGDP	–	5.743 (0.056)*	0.334 (0.846)	0.045 (0.977)	−0.806 [−6.336]***
Δ LRENC	4.276(0.117)	–	0.462 (0.793)	0.825 (0.661)	−11.73 [−4.962] ***
Δ LNRENC	1.628(0.443)	1.232 (0.540)	–	0.840 (0.656)	0.033 [0.235]
Δ LCO_2	12.621 (0.001)***	4.303 (0.116)	2.781 (0.248)	–	0.223 [0.618]

***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

of Ocal and Aslan (2013) for Turkey and Rahman and Velayutham (2020) for five Asian countries. Indeed, at the 1% significance level, the (ECT_{t-1}) for GDP and RENC are significant because their lag error terms have the expected negative signs revealing the existence of one-way causality running from RENC to GDP, GDP, and RENC to CO_2 emissions in the long-run.

Parameter stability

The instability of the parameters of our model can influence the results, so we will test the evolution of these parameters over the long term. In fact, in order to check the robustness of the results and test the short- and the long-run parameter stability in the co-integrating equation where GDP is the dependent variable, we applied the cumulative sum of recursive residuals (COSUM) and the COSUM of square (COSUMs) tests. Figures 1 and 2 demonstrate that the curve is within the critical interval at 5% significance level, which indicates that the ARDL model used in this study is stable and there is no problem of heteroscedasticity.

Discussion

The findings show that RENC has a positive impact on GDP but statistically non-significant, indicating that the RE sector does not play its expected role in improving economic growth. This can be explained by Moroccan's economic growth is non-significantly related to the RENC. Additionally, the negative effect of NRENC on GDP is awaited because Morocco depends on the imports of energy (93.6% in 2013 according to HCP (2015)). To face this problem of dependence, the country should diversify its sources of RE production, while seeking other potential measures to reduce its energy dependence. Moreover, the energy invoice reaches 45.038 billion dirhams from January to July 2018 and 45.997 billion dirhams 1 year before. Thus, the part of this invoice in the total of the imports is 15.5% from January to July 2019 against 16.4% in 2018 Exchange_Office (2019).

Considering the importance of RE and their necessity for sustainable development with the presence of many policies implemented to promote them in Morocco, the

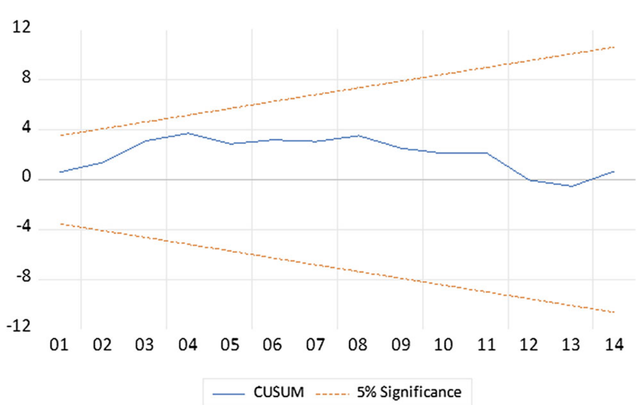

Fig. 1 CUSUM

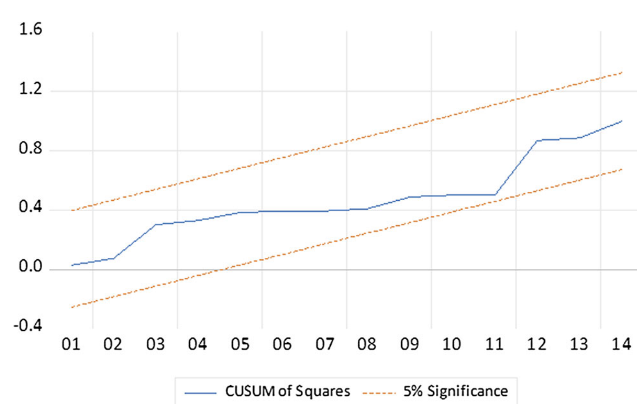

Fig. 2 CUSUM of squares

achievement of the desired objectives by the state (around 42% in 2020 and 52% by 2030 IRENA 2017) requires a strong involvement of local communities. In this context, Morocco has some of the largest solar parks in the world, in particular NOOR Ouarzazate solar complex inaugurated in February 2016. This project is composed of three power plants NOOR I, NOOR II, and NOOR III and a photovoltaic plant NOOR IV. Its total power is estimated to be 582 MW with a total area of about 3000 ha and its investment amount is estimated to be 28 billion dirhams. The objective of the NOOR solar complex is to develop a total electric power generating capacity of at least 2000 MW from solar energy by 2020.

Thus, it will make it possible to reduce the country's energy dependence, develop a national resource (the country enjoys a significant amount of sunshine), create a long term competitive energy advantage, and reduce GHG emissions. NOOR Ouarzazate project will make it possible to avoid the emission of 762,000 tons of CO_2 emissions annually, with 19 million tons over the 25 years of its operation (MASEN 2011; AFDB 2019). Also, focusing on the implementation of the strategy adopted in 2009 by developing other plans and other policies contributing to the balance between the three dimensions of sustainable development in Morocco.

Conclusion and policy implications

This paper examines the relationship between economic growth, CO_2 emissions, and renewable and non-renewable energy consumption in Morocco by applying the ARDL approach and the VECM Granger causality test. The findings of this document can be summarized in two important points. First, we found that the renewable energies start to give their positive effects on economic growth in the country, as a 1% increase in RENC will enhance the GDP by 0.042% in the short and 0.061% in the long run. However, the impact of NRENC on economic growth is negative and statically significant. Second, we also found that there is unidirectional causality from renewable energy consumption to economic growth and from economic growth to CO_2 emissions. Our findings suggest that the link between RENC and economic growth depends on the amount of RE used.

Therefore, we can say that the main problem of the transition from an energy system based on traditional energies to an energy system based on the use of renewable energies in Morocco is a very big difficulty to find funding for these new technologies. Consequently, due to the high cost of renewable energies, these new technologies can not play a crucial role in Morocco without the implementation of a policy aimed at creating a local industry especially for the one of solar energy, including of course the manufacturing of all required equipment linked to this sector.

It is clear that in Morocco, there is great potential for the installation of other solar energy projects in the South East including Tinghir and Zagora and other wind projects based in the south and north of Morocco. Thus, the renewable energies projects can be integrated into the main agriculture regions in Morocco to enhance the production and decrease the energy invoice. However, the Moroccan government and private companies must look for innovative methods to finance renewable energy projects. In addition, these technologies can be the best substitute for fossil fuels, firstly in order to reduce the burden of energy costs on the Moroccan economy and secondly to strengthen its competitiveness without harming the economic growth of the country.

In conclusion, the current study mainly employed the linear ARDL approach to explore the link between REC and GDP. For further research, the use of non-linear ARDL is highly desirable to investigate the asymmetric association between REC, GDP, and CO_2 emissions.

Author contributions Soufiane Bouyghrissi: Original draft preparation, methodology, software.
Abdelmoumen Berjaoui : supervision and reviewing.
Maha Khanniba : methodology , software, and writing.

Data availability The data of our study is obtained from the World Bank (Bank 2019) and the Energy Information Administration (EIA 2019).

Compliance with ethical standards

Conflict of interest The authors declare that there are no conflicts of interest.

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