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The Role of Institutions in the Renewable Energy-Growth Nexus in the MENA Region: a Panel Cointegration Approach

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Abstract
Institutional quality plays an undeniable role in every goal of accelerating economic growth. While the MENA region offers many natural assets that can make investments in renewable energy profitable, this region suffers from several institutional quality issues. In this line of thinking, this paper examines the relationship between renewable energy and economic growth in MENA countries taking into account institutional measures. To get a deeper insight into the relationship between this triangle of annual variables spreading from 1986 to 2015, our study considered a broader set of institutional variables, namely, corruption, bureaucracy quality, democracy accountability, law and order, and ethnic tensions. Using panel cointegration tests, we found that renewable energy, economic growth, and any institutional measures, of all considered in this study, are cointegrated. Furthermore, we found a strong causality running from renewable energy and any institutional measure, except law and order, to growth. A reverse path is also observed since there is also a strong causality running from growth to renewable energy when the causal regression includes any institutional measure. Our findings corroborate the fact that establishing an attractive institutional framework in MENA countries could be of ultimate importance in the profitability of renewable energy investments and in accelerating economic growth.

Keywords Renewable energy · Institutions · Economic growth · Panel cointegration tests

1 Introduction

It is regularly observed, especially in the last years, that sudden fluctuations occur in the future prices of energy and the context has been tormented by rapid increase in demand of energy at the world level, essentially caused by rising standards of living in the developing countries and emerging countries ([51, 90]). Renewable energy is consequently considered as an attractive alternative in response to these continuous concerns. There are economic opportunities in the renewable energy sector. Undeniably, a decisive economic factor in favor of the use of these energies is that several technologies using them are competitive on the market [97].

The environmental issues have prompted governments to consider implementing an environmental policy based on the use of renewable energy. In a point of fact, the increase in carbon dioxide (CO_2) emissions has no doubt resulted in an increase in temperature and humidity levels ([122, 127]). Such an increase has even affected people's daily lives. According to the IPCC [62], total annual GHG emissions have remarkably increased. Over the past three decades, GHG emissions have increased on average by 1.6% per year with CO_2 emissions resulting from the use of fossil fuels being at the a rate of 1.9% per year. According to the IPCC Special Report on Emission Scenarios, by the end of the twenty-first century, we could expect CO_2 concentrations between 490 and 1260 ppm (75 to 350% above the concentration). These figures and their subsequences are all the more worrying as pre-industrial levels of CO_2 (before the start of the industrial Revolution) were about 280 ppm in volume, while current levels are about 405.85 ppm by volume; see Mishra et al. [85]. This will certainly generate more detrimental costs, in

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environmental terms, for our planet, if we continue in this direction any longer. Also, some countries are most vulnerable to climate change with high sensitivity, high exposure, and low adaptive capacity ([116, 118]).

In this spirit, sustainable development becomes a global challenge when issues of climate change and conventional energy resources reduction are considered [33, 123, 126]. In this respect, promoting renewable energies, in particular solar and nuclear energy, represents an alternative solution which allows for increasing economic growth while addressing environmental issues. Emerging countries are concerned with this objective. They are more and more investing in this type of energy resources to look for other roads for a desired level of growth while stopping environmental degradation.

The MENA region is known as the leading supplier of oil and gas around the world. However, in recent years, these countries have been facing challenges of population growth, increased demand for electricity, and limited investment in new generation capacity. Many governments in the region have thereby revised their energy policies and paid more attention to how to stimulate renewable energy investments. They started to implement the regulatory reforms needed to achieve these goals. To understand the status of renewable energy in MENA countries, we introduce some figures reported by Asnani [13]: the share of renewable energy in total electricity generation in the Middle East is expected to increase from 2% in 2010, to 12% in 2035. Furthermore, Algeria ranks first in terms of electricity consumption using renewable energies in the region followed by Turkey. Their net annual average of electricity consumption is 56.16 and 23.22%, respectively [45]. Likewise, renewable energy in the region represents less than 4% of primary energy consumption, an average of 17% for the rest of the world. Hydropower represented an overwhelming source of renewable capacity, dominated by Iran, Egypt, Iraq, and Morocco [135]. As pointed by Asnani [13], electricity generation increased from 260 MW in 2006 to around 1100 MW in 2012, mainly in Egypt, Tunisia, and Morocco. In addition to hydropower, this electricity generation has wind as the most common source. MENA countries witness a plethora of natural resources needed for a vibrant renewable energy sector: lots of sunshine, strong winds and, in some countries, huge rivers.

The effect of renewable energy consumption on economic growth is a theme that has been abundantly explored in the literature. Particulary, the causality direction between both variables represented an important field of research. Many studies like those of Bobinaite et al. [22], Apergis and Payne [10], Salim et al. [115], Ohler and Fetters [95], Hung-Pin [61], Inglesi-Lotz [64], Dogan and Seker [39], and Xu [141] have shown that the use of renewable energy is beneficial in terms of added value and pace of job creation. It allows for the creation of new industries with considerable commercial potential and contributes with a remarkable share of gross domestic product (GDP).

However, recent empirical and theoretical studies on the subject, for example those of Wirth [134], Cifor et al. [32], Chang and Wang [30], Mertzanis [83], and Bhattacharya et al. [21], highlighted the importance of having an adequate institutional infrastructure. Control of corruption, respect for democratic principles, and respect for the laws and the legislative authority are all important elements for a policy aimed at promoting the beneficial use of renewable energies to succeed. Indeed, it is interesting to note that the results of various studies, examining the contribution of institutional quality in explaining the relationship between renewable energies and economic growth, are mostly mixed. This lack of consensus may be the consequence of the differences in the samples, the techniques used, and the institutional variable selected. Our paper aims to contribute to this debate by considering a satisfactory set of institutional measures. The majority of the papers cited above limited their interest in a smaller set of institutional variables, while the analysis focused specifically on corruption.

To the best of our knowledge, our paper is the first to study the relationship between economic growth and renewable energy, while taking into account a fairly broad set of institutional measures in MENA countries. The choice of this region will be beneficial in two parts. First, as mentioned, this region is endowed with plethoric renewable energy resources. Second, some countries in this region have experienced revolutions and, in institutional terms, these countries are in a phase of transition. Structural changes should be taken into consideration. It is for that reason that we consider here an expanded set of institutional variables to capture the characteristics of populations and the nature of states, and especially to account for changes in institutional quality in this transitional period, characterized by disruptions in economic activities the accentuation of social conflicts in some MENA countries. Referring to the lexicon in question, we can say that we study here the role of institutions in sustainable growth in the MENA region. To this aim, we use several panel cointegration methods in the presence of structural breaks to account for changes that may be identified in the studied relationships. In particular, and to present a methodical approach, we employ the test of Pedroni [102], the test of Westerlund [131], and the test of Westerlund and Edgerton [132]. The first one is a residual based and it is a standard test used in most empirical works having tested cointegration in panel data. The no-cointegration null hypothesis of most residual-based tests may not be rejected even though economic theory strongly recommends cointegration. This can be explained by the fact that these tests require that the long-run parameters for the variables in their levels are equal to the short-run parameters for the variables in their first differences. Given this limitation, Westerlund [131] developed a test based on structural dynamics. The lack of cointegration could be attributed to omitted variables and/or to unobserved common factors as well (see [133]). The cross-sectional dependence hypothesis can be justified in our data. However, the first two tests ([102, 131]) did not consider it. In view of this, we opt also for the use of the test of Westerlund and Edgerton [132], which takes into account the cross-sectional dependence, through the use of unobserved common factors, and at the same time the structural changes affecting, as we mentioned above, the relationship studied in MENA countries.

The rest of the paper is organized as follows. Section 2 presents an overview of the literature, in particular the different relationships that may be determined between our studied variables. At this level, previous studies have seldom included all of our variables. This is why our overview of the relevant literature will focus on the pairwise relationships. Section 3 describes the data used in our study and presents the results of the cross-section dependence tests. Our empirical analysis is detailed in Section 5. We use here the cointegration tests of Pedroni [101], Westerlund [131], and Westerlund and Edgerton [132]. Section 5 presents our findings and policy implications are then presented.

2 Literature Review

2.1 Economic Growth–Renewable Energy Relationship

In the literature, many studies have examined the nexus between economic growth and renewable energy, without any consensus about the sense of causality between them. The obtained results can be classified into four types of assumptions: (i) the neutrality assumption, i.e., no causality relationship between economic growth and renewable energy; (ii) the conservation assumption maintains a unidirectional causality running from economic growth to renewable energy; (iii) the feedback assumption claims a bidirectional relationship between economic growth and renewable energy; (iv) the growth assumption supports a unidirectional causality relationship from renewable energy to economic growth.

The feedback assumption is promoted by some recent studies. Apergis and Payne [10] argue a bidirectional causality between economic growth and renewable energy consumption in 80 countries examined over the 1990–2007 period. Examining OECD countries data covering the 1980–2011 period, Salim et al. [115] found a short-run bidirectional causality relationship between GDP growth and renewable energy consumption using a panel cointegration method allowing for structural breaks. Ohler and Fetters [95] advanced a bidirectional relationship between different forms of renewable energy and economic growth in OECD economies between 1990 and 2008. Lin and Moubarak [78] examined China from 1977 to 2011 to study the link between renewable energy and economic growth by incorporating labor and CO_2 emissions in the multivariate model. They found evidence supporting the feedback assumption. Examining a panel data of 34 OECD economies observed over the 1990–2010 period, Inglesi-Lotz [64] argues for a bidirectional causality between renewable energy consumption and gross domestic product. Kahia et al. [68] found a long-term bidirectional causality relationship between economic growth and both renewable and non-renewable energy in MENA countries. Destek and Sarkodie [38] investigated the EKC hypothesis in 11 newly industrialized countries over the period of 1977–2013 using an augmented mean group (AMG) estimator and heterogeneous panel causality method. Their study found a bidirectional causality relationship between economic growth and ecological footprint and supported an inverted U-shaped environmental Kuznets curve hypothesis. Bekun et al. [19, 20] investigated the long-run causality relationship between resource rent, renewable, non-renewable energy, and carbon dioxide emissions in 16 EU countries over the period 1996–2014 using a panel ARDL model. The authors showed a bidirectional causality relationship between economic growth, renewable, and non-renewable energy consumption.

The conservation assumption was confirmed in some other studies. Sadorsky [112] studied 18 emerging countries, using fully modified ordinary least squares (FMOLS), and found that a 1% increase in real income per capita leads to a 3.5% increase in renewable energy consumption per capita. Kahia et al. [69] examined data of MENA Net Oil Exporting Countries (NOECs) over the period of 1980–2012 and found a unidirectional causality running from economic growth to renewable energy consumption. Ocal and Aslan [94] argue for a unidirectional causality going from economic growth to renewable energy in Turkey during the 1990 to 2010 period. Furouka [50] examined data on Baltic States covering the 1990–2011 period and found a unidirectional relationship running from economic development to renewable electricity consumption.

On the other hand, the growth assumption was supported by a number of authors. Fang [44] found that an increase in renewable energy consumption positively affects economic growth in China. Bowden and Payne [23] examined the USA during the 1949–2006 period and found a unidirectional causality running from industrial non-renewable energy use to economic growth using the Toda–Yamamoto causality method. In Brazil, Pao and Fu [98] found evidence about a one-way causality relationship running from total renewable energy use to economic growth during the 1980–2009 period. Emarah and Aykut [43] concluded a significant impact of renewable energy consumption on economic growth in Balkan and Black Sea Countries. Dees and Auktor [37] have assessed the nexus between economic growth and renewable energy in MENA countries over the period of 1990–2012 using a neoclassical growth function that includes capital, labor, and energy use as additional input factors. They found significant effects of renewable energy investments on economic growth in several MENA countries. Bekun et al. [20] examined the causality between energy use and economic growth in South Africa over the period 1960 to 2016. They reported a unidirectional causal relationship from energy use to economic growth. Moreover, Charfeddine and Kahia [31] studied the impact of renewable energy and financial development on CO_2 emissions and economic growth for 24 MENA's countries during the 1980 to 2015 period using a panel vector autoregressive (PVAR) model. They found a weak positive impacts of renewable energy consumption on economic growth. Also, Kahia et al. [70] have investigated the effects of renewable energy policies on economic growth in MENA countries from 1980 to 2012. Their results confirm that the treatment effect of renewable energy policies has a significant and positive impact on stimulating and promoting economic growth in MENA economies.

As for the neutrality assumption, Dogan and Seker [39] found no causality between renewable and non-renewable energy, real income, trade openness, and CO_2 emissions in the European Union over the 1980–2012 period using Dumitrescu-Hurlin causality method. Similarly, Yildirim et al. [137] examined data on the USA during the 1949–2010 period and found no relationship between different categories of renewable energy and GDP. Moreover, Menegaki [84] investigated the link between renewable energy consumption and GDP in Europe during the 1997–2007 period. They found no relationship.

2.2 Economic Growth–Quality of Institutions Relationship

Several economists have examined the effect of corruption on economic growth. World Bank [139, 140] pointed out that corruption takes the form of trading official contracts for cash, embezzlement of public funds, and bribes paid to government officials. Farooq et al. [46] reviewed the literature and pointed to some channels through which corruption reduces economic growth: undermining infrastructure, lowering public investment, lowering government revenues, and reducing expenditure on health and education.

Since the studies of Mauro [89], Murphy et al. [88], and Mo [86], many authors have investigated how corruption impedes economic growth. Mauro [89] argues that, other things being constant, one standard deviation decrease in the corruption index increases economic growth by 0.8%. Examining a panel of 67 countries, Mo [86] argues that corruption has an inverse impact on economic growth via cash flows, volatility, and political instability.

Many studies pointed out that rich countries are less corrupt than poor nations. Examining African countries, Gyimah-Brenpong [54] found that not only does corruption decrease economic growth but it also contributes to unequal income distribution. According to Rock and Bonnett [110], corruption significantly promotes economic growth in a panel of countries (China, Indonesia, Korea, Thailand, and Japan).

Later, Gyimah- Brenpong and Camacho [57], studying a sample of 61 countries, found regional differences in the impact of growth on corruption. Examining a panel data of 41 developing countries, Shabbir and Anwar [120] argue that increasing globalization and average income have reduced corruption level. Asiedu and Freeman [12] found a relationship between corruption and investment across transitional economies, and no relationship in Latin America and Sub-Saharan Africa countries. Ajilore and Elumilade [5] noted that corruption is cointegrated with economic growth in Nigeria with a significant negative unidirectional causality from corruption to economic growth. Tsaturgan and Bryson [128] examined the relationship between corruption and economic growth in 39 countries. They concluded that corruption hinders economic performance. Ahmad and Ali [3], examining a panel data of 38 countries, found that an increasing level of corruption impedes financial development. Similarly, Maiyaki [82] pointed out that corruption has a negative effect on growth and foreign investments. Paul [99] found a negative relationship between corruption and economic growth in Bangladesh. Johnson et al. [67] argue that corruption negatively affects growth and investment across countries. Ugur and Dasgupta [130] concluded to a negative relationship between corruption and economic growth in poor and high income countries. Moreover, Agostino et al. [34] noted that corruption leads to lower GDP per capita growth. Studying Nigeria, Ajie and Wokekoro [4] argue that corruption impedes economic growth. Studying Tunisia, Dridi [40] found that corruption negatively affects economic growth in the presence of political instability. Saha and Gounder [113] studied a panel data of 100 developed and developing economies and concluded that corruption has a negative impact on economic growth. Similarly, Shera et al. [121] found that corruption has an inverse impact on economic growth.

Therefore, we can conclude that most of the above studies seem to indicate that corruption negatively affects economic growth. In general and examining other institutional variables, Gwartney and Lawson [55, 56] show that sustainable and renewable energy investments require effective policies and public, political, and regulatory support. Moreover, effective institutional arrangements could prevent market failures and help to maintain growth momentum. Wu and Broadstock [136] studied the effect of financial development and institutional quality on the development of new energy infrastructure. Examining a panel of 22 emerging countries, observed over the 1990 to 2010 period, the authors highlight the positive effect of financial development and institutional quality on renewable energy consumption. Additionally, they concluded that governments aiming to promote energy infrastructure and encourage renewable energy consumption should develop a policy for a better coordination between financial development and targeted institutional improvement in new energy projects.

Chang and Wang [30] encourage seeting-up an institutional framework that will facilitate the establishment of relevant laws in China and legislative proposals tracing a legal perspective for better development of marine renewable energies. The authors conclude that the Chinese government should optimize the administrative management system, strengthen financial regulation, such as taxation, and focus on sustainable development.

2.3 Data and Cross-Section Dependence Tests

Our data are annual and cover the 1986 to 2015 period. The MENA countries included in this study are Algeria, Bahrain, Egypt Arab Rep, Irak, Iran, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, and United Arab Emirates. Real GDP is defined in billions of constant 2000 US dollars, whereas renewable energy consumption is defined in millions of kilowatt hours obtained from the online World Bank Development Indicators. We took the Nepierian logarithms of these two variables to be used later in our analysis. Accordingly, Y and RE respectively denote the logarithmic transformations of real GDP per capita and renewable energy consumption, respectively. On the other hand, institutional quality (InstQuality) is measured by five institutional variables: corruption, bureaucracy quality, democracy accountability, law and order, and ethnic tensions. These institutional variables are obtained from the International Country Risk Guide (ICRG) and are kept untransformed.

An important issue in the analysis of panel data is to take into account a possible dependency between countries. It is because the degree of economic and financial integration is frequently so high that one country may be definitely affected by economic shocks of other countries. This could be very intense, even typical, for the GDP variable. Renewable energy is no exception, nor the institutional variables. Increased convergence in renewable energy policies absolutely justifies the observed countries' dependence with respect to this variable. Similarly, governments would establish an appropriate institutional framework that can explain in large part dependence between countries with respect to institutional variables. For this latter reason, we first test for cross-sectional dependency and country-specific heterogeneity. To this end, we use the test of Pesaran [103] and the bias-adjusted LM of Pesaran et al. [106] (noted hereinafter LM_{adj}). The null hypothesis of these tests is no cross-section dependence. In addition, we will use two non-parametric tests: the first is that of Friedman [49] and the second was introduced by Frees [47]. The null hypothesis of both tests is non-zero cross-sectional correlations. Frees' test is powerful in detecting false null hypotheses even when there is much cross-sectional dependence left out in the disturbances; see Omotor [96]. The critical values of this test can be obtained from Frees [48].

In order to test slope homogeneity, the tests noted by Δ and Δ_{adj} and introduced by Pesaran and Yamagata [105] are used; see Eqs. (27) and (29) in Pesaran and Yamagata [105] for Δ and Δ_{adj} tests, respectively. We also use the modified version of Swamy's [124] test proposed by Pesaran and Yamagata [105]. All above tests refer to the following regression:

$$Y_{it} = \alpha_i + \beta_i RE_{it} + \delta_i \text{InstQuality}_{it} + \varepsilon_{it}, \tag{1}$$

where $i = 1, \ldots, N$ represents the 17 MENA countries and $t = 1, \ldots, T$ denotes each year of the 1990 to 2015 period. InstQuality refers to one of the five institutional variables mentioned above. Thus, in all, we have five regressions, and in each regression there is an output of a test among those mentioned above.

Table 1 shows that the null hypothesis of no cross-section dependence in the errors and slope homogeneity in our panel is strongly rejected (at a significance level less than 1%). This may indicate that a shock occurring in one of the studied countries seems to be transmitted to other countries—and interdependence factors, of different types, between the cross-section units should be taken into account and explored in our analysis. Moreover, as advocated by Adams et al. [2], the rejection of slope homogeneity implies that the causality analysis in a panel data leads to misleading inferences by imposing a homogeneity restriction on the variable of interest.

3 Empirical Analysis

We start our analysis by providing some descriptive statistics for all studied variables. More specifically, these statistics involve means, maximums, minimums, and standard deviations. The results exposed in Table 2 show that the average level of real GDP per capita and renewable energy cusumption are 24.517 and −0.179%, respectively. In regard to the institutional quality indices, we find that corruption reached an average of 2.387 with a minimum of 1 and a maximum of 4. The average level of law and order is 3.888, with a maximum value is 6 while its minimum value is 1. On the other side, the average value of bureaucracy is 1.801; its maximum value is 3 while its minimum value is 0. Regarding the democracy variable, the average level is 2.486; its minimum value is 0 and 5 as a maximum value. Finally, the mean of ethnic index is 3.274 with a maximum value and minimum value is 0.

Table 1 Tests of cross-sectional independence and slope homogeneity

	Corruption	Bureaucracy	Democracy	Law and order	Ethnic tensions
CD test	19.861	39.722	5.120	10.148	9.001
p value	0.0000	0.0000	0.0000	0.0000	0.0000
LM_{adj} test	33.82	34.99	29.61	29.66	34.11
p value	0.0000	0.0000	0.0000	0.0000	0.0000
Frees' test	4.685	4.178	3.550	3.322	3.224
Q distribution					
$\alpha = 10\%$	0.0861	0.0861	0.0861	0.0861	0.0861
$\alpha = 5\%$	0.1119	0.1119	0.1119	0.1119	0.1119
$\alpha = 1\%$	0.1598	0.1598	0.1598	0.1598	0.1598
Friedman's test	127.196	243.222	73.662	110.308	109.836
p value	0.0000	0.0000	0.0000	0.0000	0.0000
S_m	104.3124	112.1069	157.1745	73.8156	108.8855
p value	0.0000	0.0000	0.0000	0.0000	0.0000
Δ	14.9740	16.3107	24.0397	9.7438	15.7582
p value	0.0000	0.0000	0.0000	0.0000	0.0000
Δ_{adj}	15.7557	17.1623	25.2948	10.2525	16.5809
p value	0.0000	0.0000	0.0000	0.0000	0.0000

Notes: The CD test denotes The Pesaran's [103] test for cross-section dependence. LM_{adj} represent the bias-adjusted LM test of Pesaran et al. [106] for residual cross-section independence. The *Q* distribution refers to the quantiles of Frees' test. S_m denotes the modified version suggested by Pesaran and Yamagata [105] for the Swamy test. (1) Relative regression of corruption, (2) Relative regression of bureaucracy, (3) Relative regression of democracy, (4) Relative regression of law and order, and (5) Relative regression of ethnic

3.1 Panel Unit Root Tests

Analyzing unit roots and cointegration, the use of panel data can have the advantage of overcoming size and power problems associated with the use of time series. Accordingly, panel non-stationarity issues increasingly deserve special attention.

To test stationarity of our data, we used a variety of panel unit root tests. In particular, we used the tests of Levin, Lin, and Chu [75] [henceforth LLC] and Im, Pesaran, and Shin [63] [henceforth IPS]. All of these tests are considered first generation tests since they assume independence between the cross-section units. It may be noteworthy at this level that the IPS test corrected the restrictive hypothesis of the LLC test, notably the homogeneous nature of the autoregressive root under the alternative hypothesis. Within the heterogeneous specification of this root, we also considered the Maddala and Wu's [80] test whose principle is simple and uses a combination of significance levels (i.e., *p* values) of the individual unit root tests when the N cross-sections are independent. We also used the Carrion-i-Silvestre, Del Barrio-Castro, and López-Bazo's [28] test belonging to the same generation but with a different null hypothesis (i.e., stationarity) and by considering multiple structural breaks. We also have used Pesaran's [104] test, which is a second generation test since it assumes cross-section dependence. More specifically, Pesaran [104] suggests a cross-sectionally augmented version of the IPS test (henceforward CIPS test), where the cross-sectionally augmented Dickey-Fuller statistics for the units will not be cross-sectionally independent because of the presence of a common factor. Finally, we used the panel stationarity test introduced by Bai and Carrion-i-Silvestre [15] who considered the concurrent presence of multiple structural changes and common dynamic factors.

Table 2 Descriptive statistics

	Observations	Mean	Std.Dev	Minimum	Maximum
GDP	510	24.51746	1.6926	21.72316	38.48963
RE	510	−0.179386	2.014724	−4.795854	6.60123
Corruption	510	2.387337	0.7853844	1	4
Bureaucracy	510	3.888725	1.24913	1	6
Democracy	510	1.801634	0.6856558	0	3
Law	510	2.486944	1.281159	0	5
Ethnic	510	3.274542	1.227482	0	5.5

Table 3 Panel unit root tests with and without cross-section dependence and structural breaks

Variables	Without cross-section dependance and structural breaks			With cross-section dependence and without structural breaks	With structural breaks and without cross-section dependance	With cross-section dependance and structural breaks
	Levin, Lin, and Chu [75] t-stat	Im, Pesaran, and Shin [63] W-stat	Phillips and Perron Fisher Chi-square	Pesaran [104] CIPS*	Carrion-i-Silvestre et al. [28] LM(λ) test	Bai and Carrion-i-Silvestre [15] Z P_m P
Y	− 1.9504	− 1.8294	62.9020***	− 0.8580	1.3530	1.0113 1.2532 54.0789
ΔY	− 8.1471***	− 8.1484***	179.0020***	–	–	–
RE	− 1.5601*	− 1.7561**	42.1623	− 1.0700	− 4.5632	1.2981* 2.364*** 57.742***
ΔRE	− 7.8491***	− 9.5931***	266.4290*	–	–	–
Corruption	− 2.4350***	− 1.40242*	46.5513**	− 2.5700***	− 2.1360	0.8623 0.9521 53.0123
ΔCorruption	− 12.4034***	− 12.1811***	306.3360***	–	–	–
Bureaucracy	3.2696	4.8741	24.5620	− 3.5960***	− 2.7710	0.7776 0.8989 52.2354
ΔBureaucracy	− 2.1858**	− 6.4041***	181.7840***	–	–	–
Democracy	− 2.2206**	− 1.3120*	30.2564	− 1.8790	− 3.7750	07751 0.8846 51.6323
ΔDemocracy	− 9.7828***	− 7.7035***	133.4520***	–	–	–
Law	− 5.4175***	− 4.4216***	28.5083	− 1.6540	− 4.0120	0.8444 0.9236 53.0001
ΔLaw	− 11.6579***	− 10.9130***	191.6090***	–	–	–
Ethnic	− 2.8168***	− 1.5072*	44.1014**	− 1.9800	3.564***	1.7896** 2.1239** 56.3270*
ΔEthnic	− 7.6544***	− 8.7462***	198.5270***	–	–	–

Notes: ***, **, and * represent statistical significance at the 1, 5, and 10% levels, respectively. The Fisher-type tests are computed using an asymptotic Chi-square distribution while LLC and IPS tests assume asymptotic normality. The choice of lag levels for the IPS test are determined by empirical realizations of the Schwarz Information Criterion. The LLC and Fisher-PP tests were computed using the Bartlett kernel with automatic bandwidth selection. For the test of Pesaran [104], the number of common factors is set at 1. For the test of Carrion-I-Silvestre et al. [28], the number of breaks points has been estimated using LWZ information criteria allowing for a maximum $m = 5$ structural breaks. The long-run variance is estimated using the Bartlett kernel with automatic spectral window bandwidth selection as in Andrews [7]. The critical values of Bai and Carrion-I-Silvestre [15] test are obtained otherwise. The 1, 5, and 10% critical values for the standard normal distributed Z and P_m statistics are 2.326, 1.645, and 1.282, while the critical values for the chi-squared distributed P statistic are 71.201, 62.830, and 58.641, respectively. The numbers of common factors are estimated using the panel Bayesian information criterion proposed by Bai and Ng [16]

Referring to Table 3, we conclude that most of the used panel unit root tests indicate that the Y variable has a unit root. However, Maddala and Wu's [80] test excludes this finding by rejecting the unit root null hypothesis for this variable at the 1% significance level. Note also that the stationarity test of Carrion-i-Silvestre et al. [28] allows us to conclude that the Y variable is stationary. When this variable is in first difference, all the panel unit root tests tend to indicate that the transformed variable is stationary. We conclude then that the Y variable is order 1 integrated. This result is in line with what was found by, among others, Chang et al. [29] and Liddle and Lung [77]. Similarly, most of the panel unit tests indicate that the RE variable is likewise order 1 integrated; see, for example, Jin and Kiim [66] and Kahia et al. [70]. The behavior of institutional variables is slightly different. In fact, the inclusion of inter-individual dependencies when we only use Pesaran's CIPS statistics (2007) makes the institutional variables non-stationary, with the exception of Corruption and Bureaucracy

Table 4 Panel cointegration results of Pedroni's [102] tests

		Corruption	Bureaucracy	Democracy	Law and order	Ethnic
Panel statistics	Variance ratio	− 1.4677	− 0.8344	− 3.3800	− 0.5827	− 0.1327
	Rho stat	2.2070	2.1895	2.1577	0.8689	0.3302
	PP stat	0.9826	1.5587	1.3391	− 1.6056*	− 2.1613**
	ADF stat	− 1.2289	− 0.6890	0.6045	− 2.7287**	− 4.8102***
Group statistics	–	–	–	–	–	–
	Rho stat	2.7723	3.4390	2.9804	1.4080	1.7420
	PP stat	0.07565	1.4557	0.0609	− 2.7437***	− 3.7337***
	ADF stat	− 2.7437***	− 2.0635**	− 1.9291**	− 4.6917***	− 5.9074***

Notes: Pedroni's statistics are asymptotically distributed as standard normal. The variance ratio test is right-sided, while the other Pedroni tests are left-sided. ***,*,* and * indicate the rejection of the null of no cointegration at the 1, 5, and 10% levels, respectively

that are stationary at the 1% significance level. Taking into account the presence of structural changes, the test of Carrion-i-Silvestre et al. [28] allowed us to conclude to the stationarity of institutional variables with the exception of Ethnic which is non-stationary at the 1% significance level. However, we notice that the Ethnic variable becomes stationary at the 5% level when we use most of the statistics introduced by Bai and Carrion-i-Silvestre [15]. By and large, all variables (the institutional ones and the others) are non-stationary at the 5% level when we use at least two panel stationarity tests and unit root tests (such a result is in corroboration with Law et al. [72], Saidi et al. [114], Antonakakis et al. [8], and Sarkodie and Adams [117]).

In general, there are two approaches to deal with structural changes: the first conceives robust tests to such points (see, for instance, El Montasser et al. [41]) and the second one uses tests taking into account the breakpoints. Two main reasons justify our interest in structural changes. First, such breakpoints may have an impact on unit root tests. Second, these points will be more likely to be observed in the long term (see [15]). Therefore, whether we focus on either series observed over a long interval or long-term relationships between variables, structural breaks should be considered in order to date these infrequent changes and explore the various economic factors behind them. The below sub-section will deal with the likely presence of such long-run relationships between our variables in the panel cointegration analysis.

3.2 Panel Cointegration Tests

We first test if there is a long-run relationship between renewable energy, quality of institutions, and economic growth. To do so, we consider regression (1) and use three cointegration tests, notably those of Pedroni [101], Westerlund [131], and Westerlund and Edgerton [132].

Pedroni [100, 102] proposes two sets of cointegration tests: panel tests and group tests. The first set is based on the within dimension (i.e., panel cointegration statistics). More specifically, these tests yield four statistics: panel v-statistic, panel ρ-statistic, panel PP-statistic, and panel ADF-statistic. The main feature of these statistics is that they take into account common time factors and heterogeneity across countries. On the other hand, the group tests rely on the between dimension (i.e., group-mean panel cointegration statistics). These tests yield three statistics: group ρ-statistic, group PP-statistic, and group ADF-statistic. Asymptotically, all seven statistics are normally distributed.

Westerlund [131], using an ECM model, also introduced two types of tests: the group ones and the panel ones. At this level of analysis, referring to Westerlund et al. [133] may be

Table 5 Error correction panel cointegration results of Westerlund [131] tests

Statistics[+]		Corruption		Bureaucracy		Democracy		Law and order		Ethnic	
		Value	*p* value	Value	*p* value	Value	*p* value	Value	*p* value	Value	*p* value
Group-mean statistics	G_t	− 2.519	0.518	− 0.911	0.968	− 0.942	0.958	− 2.039	0.992	0.014	1.000
	G_a	− 5.332	1.000	− 0.640	1.000	− 0.610	1.000	− 5.346	1.000	− 1.662	0.999
Panel statistics	P_t	− 14.13***	0.000	− 4.300	0.371	− 4.993	0.198	− 18.43***	0.000	− 2.310	0.879
	P_a	− 16.52***	0.000	− 1.645	0.764	− 1.634	0.767	− 20.767**	0.000	− 0.455	0.957

Notes: ** and *** indicate the rejection of the null at the 5 and 1% levels, respectively. The *p* values are based on the normal distribution. The average AIC selected lag lengths are 2.47, 1.35, 1.47, 1.88, and 1.24, respectively, and the average AIC selected lead lengths are 0.82, 0.71, 1.41, 0.65, and 0.47, respectively. The statistics are calculated with deterministic terms included in the error correction model and are only a constant and a trend

Table 6 The Westerlund and Edgerton [132] panel cointegration tests with cross-section dependence and structural breaks of

	Corruption		Bureaucracy		Democracy		Law and order		Ethnic	
Model	$Z_\tau(N)$	$Z_\varphi(N)$	$Z_\tau(N)$	$Z_\varphi(N)$	$Z_\tau(N)$	$Z_\varphi(N)$	$Z_\tau(N)$	$Z_\varphi(N)$	$Z_\tau(N)$	$Z_\varphi(N)$
No break	− 5.22***	− 1.54***	− 5.28***	− 1.55***	− 2.223**	− 3.071**	− 1.506*	− 1.302*	− 1.666*	− 0.489
Mean shift	− 2.11**	− 1.43*	− 2.09**	− 1.33*	− 5.31***	− 2.51***	− 0.320	− 0.488	− 0.430	− 0.321
Regime shift	− 2.31***	− 1.72***	− 2.28***	− 1.75***	− 0.255	− 1.404*	− 0.885	− 0.772	− 0.350	− 0.299

Notes: These tests use the Campbell and Perron [27] automatic procedure to select the lag length. We use three breaks, which are determined by grid search at the minimum of the sum of squared residuals. The *p* values are for a one-sided test based on the normal distribution. The LM-based test statistics $Z_\phi(N)$ and $Z_\tau(N)$ are normal distributed. The number of common factors is determined by means of the information criterion proposed by Bai and Ng [17] and the maximum number is set to 5. ***, **, and * indicate significance at the 1, 5, and 10% levels, respectively

useful in clarifying some methodological issues. The authors have indeed raised a number of important highlights, which we summarize as follows: (i) The rejection of the null hypothesis of no cointegration, which can be achieved with Pedroni's tests, does not routinely imply that this hypothesis is rejected for all units; (ii) the preceding point can be explained by the fact that these tests are robust against the alternatives that show a mix of cointegrated and non-cointegrated units, and then, our conclusions should be drawn accordingly; (iii) the percentage of cointegrated units decreases as the number of regressors becomes smaller; and (iv) taking into account the omitted variables and the common factors, then it may be asserted that the panel is cointegrated as a whole. The methodological points of Westerlund et al. [133] are ultimately retained by the exclusionary tendancy of the common factors observed in many empirical studies. In fact, several researchers falsely reached the conclusion of cointegration for the whole panel as they did not consider the common factors beforehand. It is worth noting that unobserved common factors can be behind the cross-sectional dependence. It is exactly like the test of Westerlund and Edgerton [132] accounting simultaneously for cross-sectional dependence through the use of unobserved common factors and structural changes given that such breaks are highly likely to occur in long horizons as mentioned above.

Table 4 displays the results reported by Pedroni's [102] tests for the five regressions shown by Eq. (1). Clearly, we deduce there is some evidence of cointegration between GDP, renewable energy, and institutional quality measured by the five institutional variables: corruption, bureaucracy, democracy, law and order, and ethnic. More specifically, for each institutional variable, there is at least one test of the seven tests of Pedroni [102] which rejects the null hypothesis of no cointegration at the 5 and 1% significance levels.

In Table 5, the null hypothesis of no cointegration in the error correction model is rejected only for the regressions estimating the institutional variables of corruption and law and order (with the panels statistics, P_t and P_a reject the null hypothesis for both variables at the 1% level) while the group-mean statistics as a whole (G_t and G_a) accept the null hypothesis of no cointegration in the five regressions.

As a second step, we apply the panel cointegration LM-based tests proposed by Westerlund and Edgerton [132]. These tests simultaneously consider cross-section dependence

Table 7 Panel long-run estimations (dependent variable: GDP)

	(1)		(2)		(3)		(4)		(5)	
	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS	FMOLS	DOLS
RE	0.2059** (2.461)	0.1828** (2.1097	0.1626** (2.131)	0.1714* (1.872)	0.1601** (0.033)	0.1600* (1.943)	0.1720** (2.129)	0.1448* 1.778)	0.1579** (2.553)	0.1228* (1.758)
Corruption	− 0.201** (− 2.453)	− 2.230** (− 2.573)								
Bureaucracy			2.1417 (0.434)	5.3217 (0.981)						
Democracy					− 0.237** (− 2.139)	− 0.1715 (− 1.414)				
Law and order							0.2348 (1.367)	0.3274* (1.812)		
Ethnic									− 0.6043** (9.291)	− 0.5934** (8.197)

***, **, and * denote statistical significance at the 1, 5, and 10% levels, respectively. (1) Relative regression of corruption, (2) Relative regression of bureaucracy, (3) Relative regression of democracy, (4) Relative regression of law and order, and (5) Relative regression of ethnic and structural breaks. The use of such tests is all the more justified because the MENA countries have pursued a policy of economic liberalization and have tried to build strong economic relationships between them since the 1990s. This type of economic policy makes the MENA countries likely vulnerable to the same set of internal and external factors affecting the evolution of their economies. The above-mentioned assumptions justify the cross-section dependence hypothesis. On the other hand, since 1990, the MENA countries have seen structural changes persisitent in the same years or close years. This can be interpreted by some notable events in the international scene (1990 Gulf War and the recurrence of financial crises, etc.). In addition, during our study period 1986–2015, the MENA countries have experienced structural changes mainly due to new reforms to benefit further from renewable energy. These LM-based tests allow for heteroskedastic and serially correlated errors, and cross unit-specific time trends. In Table 6, both test statistics $Z\varphi(N)$ and $Z\tau(N)$ of Westerlund and Edgerton [132] yield evidence in favor of a long-run relationship between GDP, renewable energy, and institutional quality. These mixed conclusions drawn from the tests of Westerlund [131] and those of Westerlund and Edgerton [132] may be interpreted by the fact that the former did not take into account breakpoints. In other words, the null hypothesis of no cointegration is under-rejected when there are structural changes affecting the cointegrating relationships (see [60]).

Overall, there is fair evidence that our variables are order 1 integrated and are cointegrated. Such a result is consistent with Liddle [76], Rafindadi and Ozturk [109], and Tugcu and Topcu [129]. These authors concluded that there is a long-term relationship between energy and growth even in the presence of institutional variables On the other hand, there are some authors having found contradictory result with our. For example, Bulut and Muratoglu [26] examined the relationship between renewable energy consumption and GDP in Turkey over the period 1990–2015 and they found that GDP is not related to renewable energy consumption. Next, we use two techniques to estimate the long-term relationship already specified in (1): The Fully Modified Least Squares (FMOLS) and the Dynamic Ordinary Least Squares (DOLS). The results are shown in Table 7. We conclude that all the coefficients of the institutional variables are significant except for bureaucracy.

Likewise, renewable energy consumption has a positive association with real GDP per capita in the MENA countries, so that institutional quality contributes significantly to this relationship. This is borne out by several papers in the literature; see, for instance, Maldonado and Márquez [81], Tahvonen and Salo [125], Lee and Chang [74], Apergis and Payne [9], Alper and Oguz [6], and recently, da Silva et al. [35] and Nguyen and Kakinaka [92].

Table 8 Long-run causality results

Inst. Dep.	(1) F-stat.	(1) Wald stat.	(2) F-stat.	(2) Wald stat.	(3) F-stat.	(3) Wald stat.	(4) F-stat.	(4) Wald stat.	(5) F-stat.	(5) Wald stat.
Y	19.7726 (0.0000)	19.7726 (0.0000)	9.17119 (0.0026)	9.17119 (0.0025)	8.0588 (0.0047)	8.0588 (0.0045)	5.5957 (0.0185)	5.5957 (0.0180)	15.617 (0.0001)	15.617 (0.0001)
RE	99.551 (0.0000)	99.5518 (0.0000)	94.8492 (0.0000)	94.8492 (0.0000)	99.6427 (0.0000)	99.6427 (0.0000)	97.0737 (0.0000)	97.0737 (0.0000)	93.4549 (0.0000)	93.4549 (0.0000)

Notes: The numbers that fill the boxes are the values of F- and Wald statistics and those in parentheses are their corresponding *p* values. (1), (2), (3), (4), and (5) denote the ECM models including corruption, bureaucracy, democracy, law and order, and ethnic, respectively

Table 9 Short-run causality results, GDP is the dependent variable

	(1)		(2)		(3)		(4)		(5)	
	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat	Wald stat.
RE →*Y*	0.5976 (0.616)	1.7927 (0.616)	0.7482 (0.523)	2.2446 (0.523)	0.6913 (0.557)	2.0739 (0.557)	0.7157 (0.543)	2.1472 (0.542)	0.7154 (0.543)	2.1462 (0.542)
Corr → *Y*	2.3313 (0.073)	6.994 (0.072)	–	–	–	–	–	–	–	–
RE, Corr → *Y*	0.3094 (0.932)	1.8564 (0.932)	–	–	–	–	–	–	–	–
Bur →*Y*	–	–	0.0344 (0.991)	0.1031 (0.991)	–	–	–	–	–	–
RE, Bur → *Y*	–	–	0.3987 (0.879)	2.3921 (0.880)	–	–	–	–	–	–
Dem → *Y*	–	–	–	–	0.2657 (0.850)	0.7972 (0.850)	–	–	–	–
RE, Dem → *Y*	–	–	–	–	0.4732 (0.828)	2.8394 (0.828)	–	–	–	–
Law-order → *Y*	–	–	–	–	–	–	2.7421 (0.042)	8.2265 (0.041)	–	–
RE, Law-order → *Y*	–	–	–	–	–	–	0.6166 (0.717)	3.6998 (0.717)	–	–
Eth → *Y*	–	–	–	–	–	–	–	–	0.0307 (0.992)	0.0920 (0.992)
RE, Eth → *Y*	–	–	–	–	–	–	–	–	0.3958 (0.881)	2.3746 (0.882)

Notes: The numbers that fill the boxes are the values of F- and Wald statistics and those in parentheses are their corresponding p values. (1), (2), (3), (4), and (5) denote the ECM models including corruption, bureaucracy, democracy, law and order, and ethnics, respectively. The arrow indicates the direction of causality

3.3 Panel Error Correction Models

Using the two-step procedure of Engle and Granger [42], we consider the following panel (vector) error correction model:

$$\Delta Y_{it} = \alpha_{1i} + \sum_{j=1}^{m-1} \beta_{1ij}\Delta Y_{i,t-j} + \sum_{l=0}^{m-1} \varphi_{1il}\Delta RE_{i,t-l} + \sum_{r=0}^{m-1} \gamma_{1ir}\Delta \text{InstQuality}_{i,t-r} + \delta_1 EC_{i,t-1} + \epsilon_{i,t}, \quad (2)$$

$$\Delta RE_{it} = \alpha_{2i} + \sum_{j=1}^{m-1} \beta_{2ij}\Delta RE_{i,t-j} + \sum_{l=0}^{m-1} \varphi_{2il}\Delta Y_{i,t-l} + \sum_{r=0}^{m-1} \gamma_{2ir}\Delta \text{InstQuality}_{i,t-r} + \delta_2 EC_{i,t-1} + v_{i,t}, \quad (3)$$

$$\Delta \text{InstQuality}_{it} = \alpha_{3i} + \sum_{j=1}^{m-1} \beta_{3ij}\Delta \text{InstQuality}_{i,t-j} + \sum_{l=0}^{m-1} \varphi_{3il}\Delta Y_{i,t-l} + \sum_{r=0}^{m-1} \gamma_{3ir}\Delta RE_{i,t-r} + \delta_3 EC_{i,t-1} + w_{i,t}, \quad (4)$$

where EC denotes the error correction term (ECT) and InstQuality refers to one of the five institutional variables. There is no widespread agreement on the maximum number of the lagged terms in (2), (3), and (4), but as recommended by Westerlund [131], we will consider the maximum lag length as being equal to $4(\text{Int}(T/100))^{2/9}$, where Int($x$) denotes the integer part of x and T is the number of years covered by this study. Having fixed the maximum lag length, the optimal number of lagged terms included by the ECM models is then determined by the Schwarz information criterion (SIC). The above models highlight the long-term relationship and short-run adjustment mechanisms towards equilibrium. Moreover, with such models, one can carry out causality tests. We will indeed consider three types of causality: long-run causality, strong causality, and short-run causality. To estimate these three types, we take, by way of illustration, the ECM model (2): the corresponding null hypothesis of no long-run causality running from RE and the considered institutional variable to Y is H_0: $\delta_1 = 0$, while the null hypothesis of no short-run causality running from RE to Y can be formulated as H_0: $\varphi_{1i1} = \varphi_{1i2} = \ldots = \varphi_{1i,\ m-1} = 0$. Likewise, this null hypothesis can be extended and becomes H_0: $\varphi_{1i1} = \varphi_{1i2} = \ldots = \varphi_{1i,\ m-1} = \gamma_{1i1} = \gamma_{1i2} = \ldots = \gamma_{1im-1} = 0$ to test if there is a short-run causality running from jointly RE and the considered institutional variable to Y. Finally, the null hypothesis of no strong causality running from RE to Y is H_0: $\delta_1 = \varphi_{1i1} = \varphi_{1i2} = \ldots = \varphi_{1i,\ m-1} = 0$. This null hypothesis can be duly extended

Table 10 Short-run causality results, *RE* is the dependent variable

	(1)		(2)		(3)		(4)		(5)	
	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat	Wald stat.
$Y \rightarrow RE$	0.0061 (0.999)	0.0182 (0.999)	0.0109 (0.998)	0.0326 (0.998)	0.0187 (0.996)	0.0560 (0.996)	0.0265 (0.994)	0.0796 (0.994)	0.0109 (0.998)	0.0328 (0.998)
Corr $\rightarrow RE$	1.5692 (0.196)	4.7078 (0.194)	–	–	–	–	–	–	–	–
Y, Corr $\rightarrow RE$	0.7877 (0.579)	4.7261 (0.579)	–	–	–	–	–	–	–	–
Bur $\rightarrow RE$	–	–	0.0007 (1.000)	0.0020 (1.000)	–	–	–	–	–	–
Y, Bur $\rightarrow RE$	–	–	0.0058 (1.0000)	0.0348 (1.0000)	–	–	–	–	–	–
Dem $\rightarrow RE$	–	–	–	–	0.1165 (0.950)	0.3496 (0.950)	–	–	–	–
Y, Dem $\rightarrow RE$	–	–	–	–	0.0675 (0.998)	0.4051 (0.998)	–	–	–	–
Law-order $\rightarrow RE$	–	–	–	–	–	–	2.7414 (0.042)	8.2241 (0.041)	–	–
Y, Law-order $\rightarrow RE$	–	–	–	–	–	–	1.3853 (0.218)	8.3119 (0.216)	–	–
Eth $\rightarrow RE$	–	–	–	–	–	–	–	–	0.0131 (0.997)	0.0394 (0.997)
Y, Eth $\rightarrow RE$	–	–	–	–	–	–	–	–	0.012 (1.000)	0.0718 (1.000)

Notes: The numbers that fill the boxes are the values of F- and Wald statistics and those in parentheses are their corresponding p values. (1), (2), (3), (4), and (5) denote the ECM models including corruption, bureaucracy, democracy, law and order, and ethnic, respectively. The arrow indicates the direction of causality

accordingly in the same manner as the above test. We prefer to perform these tests only for the ECM models (2) and (3) because the underlying interpretations are more interesting than those that could be drawn if we apply these tests to the ECM model (4). We will not expose the estimated coefficients of both ECM models and their student statistics since we have actually two models for each institutional variable; in total, ten models of error correction. However, these estimation results are available upon request from the authors.

As pointed by Brooks [25], while the usual *t*- and *F-statistics* have satisfactory properties in the context of non-linear estimation, their drawback is, however, the lack of some requested flexibility. This is why we add the Wald statistics. Table 8 shows that there is a long-term causality running from Y and any considered institutional quality variable to *RE*. Likewise, this long-term causality is always supported by reversing the path, i.e., from *RE*, and any considered institutional measure to Y. The long-term relationship between Y and *RE* has actually been noted, quite remarkably, in the literature (see for example Apergis and Danuletiu [11] and Rafindadi and Ozturk [109]). However, in studies focusing on the relationship between both variables, there is a tendency to omit the role of institutional quality measures whose effects on both of them will be uncovered in the long run. Subsequently, Tables 9 and 10 reveal no short-run causality running from institutional variables to either renewable energy or growth. The exception is the short-run causalities running from corruption to growth and order and law to growth as shown in Table 9. The first causality has been widely mentioned in the literature where corruption has been shown to have short-term effects on growth (see, inter alia, Farooq et al. [46]). However, the second causality may indicate that law and order can sometimes have immediate effects on some sectors of the economy such as agriculture as pointed out by Dam [36]. On the other hand, non-respect of law and failure to comply with order can have remarkable harmful consequences on growth in the short term. We may recall here some disruptive events that took place in some MENA countries in 2011.

In Table 11, we notice that renewable energy does not cause growth in both the short and long term when the corresponding regression does integrate the law and order variable. This is true again when testing whether there is a strong causality going from both law and order and renewable energy to growth. This finding can be explained by the fact that non-compliance with law and low renewable energy investment legislation may dampen the expected positive effect of the *RE* variable on economic growth. While this seems to be a too negative statement, encouraging thus several companies to invest in renewable energies in this region, it does reveal a positive signal on the future role played by these energies in achieving sustainable development in these countries. Significant causalities running from each institutional variable to growth make this optimism all the more heightened.

Table 11 Strong causality results, GDP is the dependent variable

	(1)		(2)		(3)		(4)		(5)	
	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat	Wald stat.
ECT, *RE* → *Y*	5.5635 (0.000)	22.254 (0.000)	2.5688 (0.037)	10.275 (0.036)	2.2790 (0.060)	9.1161 (0.058)	0.9944 (0.410)	3.9777 (0.409)	4.3059 (0.002)	17.223 (0.001)
ECT, Corr → *Y*	4.9939 (0.0006)	19.9757 (0.0005)	–	–	–	–	–	–	–	–
ECT, *RE*, Corr → *Y*	3.1997 (0.0026)	22.3981 (0.0022)	–	–	–	–	–	–	–	–
ECT, Bur →*Y*	–	–	2.3736 (0.051)	9.4944 (0.049)	–	–	–	–	–	–
ECT, *RE*, Bur → *Y*	–	–	0.5110 (0.082)	3.5772 (0.082)	–	–	–	–	–	–
ECT, Dem → *Y*	–	–	–	–	2.0932 (0.080)	8.3729 (0.078)	–	–	–	–
ECT, *RE*, Dem → *Y*	–	–	–	–	0.8215 (0.056)	5.7503 (0.056)	–	–	–	–
ECT, Law-order → *Y*	–	–	–	–	–	–	4.2662 (0.002)	17.064 (0.001)	–	–
ECT, *RE*, Law-order → *Y*	–	–	–	–	–	–	0.7935 (0.593)	5.5543 (0.592)	–	–
ECT, Eth → *Y*	–	–	–	–	–	–	–	–	4.2798 (0.002)	17.119 (0.001)
ECT, *RE*, Eth → *Y*	–	–	–	–	–	–	–	–	2.5996 (0.012)	18.197 (0.011)

Notes: The numbers that fill the boxes are the values of F- and Wald statistics and those in parentheses are their corresponding *p* values. (1), (2), (3), (4), and (5) denote the ECM models including corruption, bureaucracy, democracy, law and order, and ethnic, respectively. The arrow indicates the direction of causality, and ECT denotes the error correction term

Table 12 gives new insights into the relationship between the studied variables unlike the findings in the previous table. Now economic growth causes renewable energy in both the long and short run regardless of the institutional variable included in the basic causal regression. Similarly and just like in the previous table, each institutional variable "strongly" causes the dependent variable, which is economic growth here. Finally, growth joint to any institutional variable "strongly" causes renewable energy. This shows once again the need to invest in renewable energy for this latter to play its role. Satisfactory economic growth and the establishment of a performing institutional framework are the conditions to lay down.

4 Results Discussion

The findings of the long-term relationship between energy and growth in the presence of institutional quality indicate that there is a positive effect of renewable energy on growth. Over the last 20 years, the investments in renewable energies have been indeed beneficial to MENA economies, particularly in terms of innovation and faster pace of job creation; see, among others, Kammen et al. [71]. Investments in this sector may grow national funds instead of spending them on fuel imports. On the other hand, and most importantly, renewable energies offer other opportunities to create value especially in service activities, education, and research and development. Our results corroborate those of Balcilar et al. [18] and Luqman et al. [79].

It is argued that the effects of renewable energy on growth should not be analyzed without paying attention to the role of the institutions. With regard to the set of the institutional measures, retained by our paper, except for bureaucracy, the other variables have significative influences on economic growth. The corruption level contributes negatively to growth suggesting that corruption slows economic development. In other words, the high level of corruption in MENA region reduces economic efficiency. More specifically, corruption reduces the tax-to-GDP ratio caused by long-term economic damage and, to the point, increases the share of the informal economy (14; 91). These results corroborate those of Rock and Bonnet [110], Guetat (53), and recently Bhattacharya et al. [21] and Brianzoni et al. [24] who supported the negative association between corruption and economic growth. On the other side, the law and order index is significantly positive on the growth. This proves that MENA countries should provide an effective justice system to accelerate economic growth by attracting more foreign and domestic investment. This sign is in accordance with all previous studies [58, 59, 87]. As for the

Table 12 Strong causality results, *RE* is the dependent variable

	(1)		(2)		(3)		(4)		(5)	
	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat.	Wald stat.	F-stat	Wald stat.
ECT, *Y*→ *RE*	N/A	N/A	23.712 (0.000)	94.849 (0.000)	24.910 (0.000)	99.642 (0.000)	24.268 (0.000)	97.073 (0.000)	23.363 (0.000)	93.454 (0.000)
ECT, Corr → *RE*	26.536 (0.000)	106.14 (0.000)	–	–	–	–	–	–	–	–
ECT, *Y*, Corr → *RE*	15.163 (0.000)	106.14 (0.000)	–	–	–	–	–	–	–	–
ECT, Bur → *RE*	–	–	23.712 (0.000)	94.849 (0.000)	–	–	–	–	–	–
ECT, *Y*, Bur → *RE*	–	–	13.549 (0.000)	94.849 (0.000)	–	–	–	–	–	–
ECT, Dem → *RE*	–	–	–	–	24.913 (0.000)	99.652 (0.000)	–	–	–	–
ECT, *Y*, Dem→ *RE*	–	–	–	–	14.236 (0.000)	99.652 (0.000)	–	–	–	–
ECT, Law-order → *RE*	–	–	–	–	–	–	27.121 (0.000)	108.48 (0.000)	–	–
ECT, *Y*, Law-order → *RE*	–	–	–	–	–	–	15.497 (0.000)	108.48 (0.000)	–	–
ECT, Eth → *RE*	–	–	–	–	–	–	–	–	23.611 (0.000)	94.446 (0.000)
ECT, *Y*, Eth→ *RE*	–	–	–	–	–	–	–	–	13.492 (0.000)	94.446 (0.000)

Notes: The numbers that fill the boxes are the values of F- and Wald statistics and those in parentheses are their corresponding *p* values. (1), (2), (3), (4), and (5) denote the ECM models including corruption, bureaucracy, democracy, law and order, and ethnic, respectively. The arrow indicates the direction of causality, ECT denotes the error correction term, and N/A refers to non-applicable calculations

democracy index, the negative sign shows that the political systems of the MENA region are a handicap for the economic growth, particularly in terms of lack of budget transparency and investment disconcertment. Our results are in line with Rachdi and Saidi [108], Salahodjaev [111], and Zuazu [143]. Furthermore, and with regard to ethnic tensions, the negative effect shows that racial discrimination does not promote economic growth. This result fasten most of the studies revealing that ethnic tensions reduce per capita growth rates, notably, Gören [52] and Lazarev and Mironova [73].

Overall, the inclusion of institutional quality in the relationship, renewable energy–economic growth shows that institutions contribute significantly in such a relationship. Indeed, the adoption of renewable energy technologies in a strong institutional environment can stimulate economic development and improve the well-being of rural people as for instance concluded by Bhattacharya et al. [21].

5 Concluding Remarks and Policy Implications

The role of renewable energy is not only about reducing CO_2 emissions nationally and globally, but also about supplying new resources that can help to achieve sustainable development. Wilkins [138] puts forward the view that renewable energy should be part and parcel of sustainable development strategies, a strategy for poverty reduction, and any other development plan and target. For this reason, studying the relationship between renewable energy and growth is needed to see if these goals have been achieved or will be achieved. Our paper examined this relationship while also considering institutional measures. To this end, we used the panel cointegration tests of Pedroni [100, 102], Westerlund [131], and Westerlund and Edgerton [132]. Our main results can be summarized as follows. First, renewable energy, growth, and any institutional variable of the five studied are cointegrated. Second, by estimating the coefficients of the long-term relationships with the FMOLS and DOLS techniques, we found that renewable energy has a significant positive impact on growth. Likewise, all institutional measures, with the exception of bureaucracy, have a significant impact on growth. Third, we found a long-run causality running from GDP and any institutional quality measure taken into account to RE. By reversing the path, i.e., from RE and any considered institutional measure to GDP, the corresponding long-run causality is undoubtedly noted. Fourth, each institutional measure strongly causes RE and GDP. Fifth, RE strongly causes GDP when the corresponding causal regression integrates all exceptional variables except for law and order. Sixth, economic growth causes renewable energies in both the short and long term, regardless of the institutional variable included in the basic causal regression. Thes results are in line with the previous works of Apergis and Payne [9], Pfeiffer and Mulder [107], Sebri [119], Adams et al. [2], Jehling et al. [65], and [142]).

Through this study, we revealed that the beneficial effects of renewable energy on growth require the establishment of adequate institutional arrangements. In other words, countries seeking to increase their economic growth must have a sound institutional and legal frameworks that allow them to take advantage of the benefits of renewable energy use. In this context, we studied a sample of MENA countries that have experienced remarkable growth after initiating economic reforms—perhaps the most important one is portrayed by making recourse to renewable energy as an alternative to the shortage in other energies. On the other hand, these countries are known by weak institutions, lack of transparency, a corrupt environment, and a decrease in the law index. As such, investment in renewable energy has not so far enabled these countries to benefit from their economic growth. As a result, government authorities in MENA countries should imperatively improve institutional quality in order to succeed in energy sector reforms and generate the greatest benefits from growth in which renewable energy will be one of its key determinants (see, e.g., Wirth [134], Adams et al. [1], and Njoh et al. [93]).

There are other facets to this topic which may be future lines of research. Of these, we mention the relationship between renewable energy with some macroeconomic aggregates by sectors such as industrial and agricultural production or their corresponding added values. In this respect, we can grant a special interest in this type of relationships while expanding the set of institutional measures since some of them have not been taken into account in our paper. Developed countries enjoy a reservoir of renewable energy profits undreamed of by the rest of the world wanting to invest in this sector. Inherent technology transfer could be an appealing issue therefore. Along with these theoretical questions, we can consider a non-linear panel ECM as the literature insists that these macroeconomic aggregates are rather non-linear.

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