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Renewable Energy, Quality of Institutions and Economic Growth in MENA Countries: a Panel Cointegration Approach

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Abstract: In this paper, we examine the relationship between renewable energy and economic growth taking into account institutional measures. Using panel cointegration tests, we found that these two variables and any institutional measure, of all considered in this study, are cointegrated. Furthermore, we found a strong causality running from renewable energy and any institutional measure, except for 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. Policy implications are accordingly derived.

Keywords: Cross-section dependence; Panel unit root tests; Panel cointegration tests

JEL Classification codes: C33; Q29

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1. Introduction

Sustainable development becomes a global challenge when issues of climate change and conventional energy resources reduction are considered. 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, being concerned with this objective, are now 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 not long ago paid more attention to how to stimulate renewable energy investments. They started indeed 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 (2013): 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 annual average net electricity consumption is 56.16% and 23.22%, respectively (Farhani, 2015). 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 (World Energy Council, 2016). As pointed by Asnani (2013), 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. In particular, the causality direction between both variables represented an important field of research. Many studies like those of Bobinaite et al. (2011) Apergis and Payne (2012) Salim et al. (2014) Ohler and Fetters (2014) Hung-Pin (2014), Inglesi-Lotz (2016), Dogan and Seker (2016), Xu (2016) 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 GDP.

However, recent empirical and theoretical studies on the subject, for example those of Wirth (2014), Cifor et al. (2015), Chang and Wang (2017), Mertzanis (2018) Bhattacharya et al. (2017) highlighted the importance of having an adequate institutional infrastructure. Control of corruption, respect for democratic principles, 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. As we have pointed out, in this paper we study the role of institutions in sustainable growth in the MENA region. To this aim, we make use of several robust panel cointegration methods in the presence of structural breaks to account for changes that may be identified in the studied relationships.

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 4. We use here the cointegration tests of Pedroni (2001), Westerlund (2007) and Westerlund and Edgerton (2008). Section 5 presents our findings and policy implications are then presented.

2. Literature Review

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 (2012) argue for 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. (2014) 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 (2014) advanced a bidirectional relationship between different forms of renewable energy and economic growth in OECD economies between 1990 and 2008. Lin and Moubarak (2014) examined China from 1977 to 2011 to study the link between renewable energy and economic growth by incorporating labor and CO₂ 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 (2016) argues for a bidirectional causality between renewable energy consumption and gross domestic product. Kahia et al. (2017a) found a long-term bidirectional causality relationship between economic growth and both renewable and non-renewable energy in MENA countries.

The conservation assumption was confirmed in some other studies. Sadorsky (2009) studied 18 emerging countries, using fully modified ordinary least squares (FM-OLS), 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. (2017b) 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 (2013) argues for a unidirectional causality going from economic growth to renewable energy in Turkey during the 1990 to 2010 period. Furouka (2017) 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 (2011) found that an increase in renewable energy consumption positively affects economic growth in China. Bowden and Payne (2010) examined the US 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 (2010)

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 (2017) concluded to the significant impact of renewable energy consumption on economic growth in Balkan and Black Sea Countries. Amri (2017) found that in both developing and developed countries renewable energy consumption leads to economic growth. A 1% increase in renewable energy consumption would boost economic growth by 0.873% in developed countries and by 0.678% in developing countries.

As for the neutrality assumption, Dogan and Seker (2016) found no causality between renewable and non-renewable energy, real income, trade openness and CO₂ emissions in the European Union over the 1980–2012 period using Dumitrescu-Hurlin causality method. Similarly, Yildirim et al. (2012) examined data on the United States during the 1949–2010 period and found no relationship between different categories of renewable energy and GDP. Moreover, Menegaki (2011) investigated the link between renewable energy consumption and gross domestic product (GDP) in Europe during the 1997–2007 period. They found no relationship.

Economic growth – quality of institutions relationship:

Several economists have examined the effect of corruption on economic growth. The World Bank (1997, 2001) 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. (2013) 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 (1995), Murphy et al. (1991) and Mo (2001), many authors have investigated how corruption impedes economic growth. Mauro (1995) argue 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 (2001) 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 (2002) found that not only does corruption decrease economic growth but it also contributes to unequal income distribution. According to Rock and Bonnett (2004), corruption significantly promotes economic growth in a panel of countries (China, Indonesia, Korea, Thailand and Japan)

Later, Gyimah- Brenpong and Camacho (2006), 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 (2007) argue that increasing globalization and average income have reduced corruption level. Asiedu and Freeman (2009) found a relationship between corruption and investment across transitional economies, and no relationship in Latin America and Sub-Saharan Africa countries. Ajilore and Elumilade (2007) noted that corruption is cointegrated with economic growth in Nigeria with a significant negative unidirectional causality from corruption to economic growth. Tsaturgan and Bryson (2009) examined the relationship between corruption and economic growth in 39 countries. They concluded that corruption hinders economic performance. Ahmad and Ali (2010), examining a panel data of 38 countries. found that an increasing level of corruption impedes financial development. Similarly, Maiyaki (2010) pointed out that corruption has a negative effect on growth and foreign investments. Paul (2010) found a negative relationship between corruption and economic growth in Bangladesh. Johnson et al. (2011) argue that corruption negatively affects growth and investment across countries. Ugur and Dasgupta (2011) concluded to a negative relationship between corruption and economic growth in poor and high income countries. Moreover, Agostino et al. (2012) noted that corruption leads to lower GDP per capita growth. Studying Nigeria, Aje and Wokekoro (2012) argue that corruption impedes economic growth. Studying Tunisia, Dridi (2013) found that corruption negatively affects economic growth in the presence of political instability. Saha and Gounder (2013) 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. (2014) 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. More generally and examining other institutional variables, Gwartney and Lawson (2004, 2007) 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 (2015) 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 (2017) encourage setting 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.

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 U.S. 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 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 are 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 bias-adjusted LM of Pesaran et al. (2008). The null

hypothesis of this test is no-cross section dependence (noted hereinafter LM_{adj}). In addition to Pesaran's test, we will use two nonparametric tests: the first is that of Friedman (1937) and the second was introduced by Frees (1995). 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 (2015). The critical values of this test can be obtained from Frees (2004).

In order to test slope homogeneity, the tests noted by $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ and introduced by Pesaran and Yamagata (2008) are used; see equations (27) and (29) in Pesaran and Yamagata (2008) for $\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$ tests, respectively. We also use the modified version of Swamy's (1970) test proposed by Pesaran and Yamagata (2008).

All above tests refer to the following regression:

$$Y_{it} = \alpha_i + \beta_i RE_{it} + \delta_i InstQuality_{it} + \varepsilon_{it}, \quad (1)$$

where $i = 1, \dots, N$ represents the 17 MENA countries and $t = 1, \dots, T$ 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: Tests of cross-sectional independence and slope homogeneity

| | Corruption | Bureaucracy | Democracy | Law and Order | Ethnic tensions |
|------------------------|------------|-------------|-----------|---------------|-----------------|
| Pesaran's CD test | 19.861 | 39.722 | 5.120 | 10.148 | 9.001 |
| 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 |
| pvalue | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $\tilde{\Delta}$ | 14.9740 | 16.3107 | 24.0397 | 9.7438 | 15.7582 |
| pvalue | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| $\tilde{\Delta}_{adj}$ | 15.7557 | 17.1623 | 25.2948 | 10.2525 | 16.5809 |
| pvalue | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Notes: The Q distribution refers to the quantiles of Frees' test. S_m denotes the modified version suggested by Pesaran and Yamagata (2008) for the Swamy test.

Table 1 shows that the null hypothesis of no cross-section dependence 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, 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.

4. Empirical analysis

4.1 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 nonstationarity 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 (2002) [henceforth LLC], Im, Pesaran and Shin (2003) [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 (1999) 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 (2005) 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 (2007) test, which is a second generation test since it assumes cross-section dependence. More specifically, Pesaran (2007) 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 (2009) who considered the concurrent presence of multiple structural changes and common dynamic factors.

Table 2 : Panel unit root tests with and without cross-section dependence and structural breaks

| Variables | Without cross section dependence and structural breaks | | | With cross section dependence and without structural breaks | | With structural breaks and cross section dependence | | With cross section dependence and structural breaks | |
|----------------------|--|---------------------------------------|-----------------------------------|---|---|--|--|---|--|
| | Levin, Lin & Chu (2002) t-stat | Im, Pesaran and Shin (2003) W-stat | Phillips and Perron Fisher square | and Chi-Pesaran (2007) CIPS* | Carrion-i-Silvestre and al.(2005) LM(λ)-test | Bai and Carrion-i-Silvestre (2009) Z P _m P | | | |
| GDP | -1.9504 | -1.8294 | 62.9020*** | -0.8580 | 1.3530 | 1.0113 1.2532 54.0789 | | | |
| Δ GDP | -8.1471*** | -8.1484*** | 179.0020*** | - | - | - | | | |
| RE | -1.5601* | -1.7561** | 42.1623 | -1.0700 | -4.5632 | 1.2981* 2.364*** 57.742*** | | | |
| Δ RE | -7.8491*** | -9.5931*** | 266.4290* | - | - | - | | | |
| Corruption | -2.4350*** | -1.40242* | 46.5513** | -2.5700*** | -2.1360 | 0.8623 0.9521 53.0123 | | | |
| Δ Corruption | -12.4034*** | -12.1811*** | 306.3360*** | - | - | - | | | |
| Bureaucracy | 3.2696 | 4.8741 | 24.5620 | -3.5960*** | -2.7710 | 0.7776 0.8989 52.2354 | | | |
| Δ Bureaucracy | -2.1858** | -6.4041*** | 181.7840*** | - | - | - | | | |
| Democracy | -2.2206** | -1.3120* | 30.2564 | -1.8790 | -3.7750 | 07751 0.8846 51.6323 | | | |
| Δ Democracy | -9.7828*** | -7.7035*** | 133.4520*** | - | - | - | | | |
| Law | -5.4175*** | -4.4216*** | 28.5083 | -1.6540 | -4.0120 | 0.8444 0.9236 53.0001 | | | |
| Δ Law | -11.6579*** | -10.9130*** | 191.6090*** | - | - | - | | | |
| Ethnic | -2.8168*** | -1.5072* | 44.1014** | -1.9800 | 3.564*** | 1.7896** 2.1239** 56.3270* | | | |
| Δ Ethnic | -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 (2007), the number of common factors is set at 1. For the test of Carrion-I-Silvestre and al. (2005), 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 (1991). The critical values of Bai and Carrion-I-Silvestre (2009) 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 (2002).

Referring to Table 2, we conclude that most of the used panel unit root tests indicate that the GDP variable has a unit root. However, Maddala and Wu's (1999) 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. (2005) allows us to conclude that the GDP 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 GDP variable is order 1 integrated. Similarly, most of the panel unit tests indicate that the RE variable is likewise order 1 integrated. 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 that are stationary at the 1% significance level. Taking into account the presence of structural changes, the test of Carrion-i-Silvestre et al. (2005) allowed us to conclude to the stationarity of institutional variables with the exception of Ethnic which is nonstationary 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 (2009). 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.

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 Bai and Carrion-i-Silvestre, 2009). 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 relationships between our variables in the panel cointegration analysis.

4.2 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 (2001), Westerlund (2007) and Westerlund and Edgerton (2008).

Pedroni (1999, 2004) 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 (ie, 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 (2007), using an ECM model, also introduced two types of tests: the group ones and the panel ones. Compared to Pedroni (1999), Westerlund (2007) takes into account cross sectional dependence. At this level of analysis, referring to Westerlund et al. (2015) may be 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. (2015) are ultimately retained by the exclusionary tendency 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 for this reason that we will use the test introduced by Westerlund and Edgerton (2008) to account simultaneously for common factors and structural changes given that such breaks are highly likely to occur in long horizons as mentioned above.

Table3: Panel Co-integration results of Pedroni's (2004) 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 * indicates the rejection of the null of no cointegration at the 1%, 5% and 10% levels, respectively.*

Table 3 displays the results reported by Pedroni's (2004) 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 (2004) which rejects the null hypothesis of no-cointegration at the 5% and 1% significance levels.

Table 4: Error-Correction Panel Cointegration results Of Westerlund (2007) 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 are only a constant and a trend.*

In table 4, 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 Pa 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 (2008). These tests simultaneously consider cross-section dependence 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 persistent 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...). In addition, during our study period 1990-2015, 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 5, both test statistics $Z\phi(N)$ and $Z\tau(N)$ of Westerlund and Edgerton (2008) yield evidence in favour of a long-run relationship between GDP, renewable energy and institutional quality. These mixed conclusions drawn from the tests of Westerlund (2007) and those of Westerlund and Edgerton (2008) 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 Haug et al., 2011).

Table 5: The Westerlund and Edgerton (2008) Panel Co-integration tests with cross-section dependence and structural breaks of

| | Corruption | | Bureaucracy | | Democracy | | Law and order | | Ethnic | |
|--------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Model | $Z_{\tau}(N)$ | $Z_{\phi}(N)$ | $Z_{\tau}(N)$ | $Z_{\phi}(N)$ | $Z_{\tau}(N)$ | $Z_{\phi}(N)$ | $Z_{\tau}(N)$ | $Z_{\phi}(N)$ | $Z_{\tau}(N)$ | $Z_{\phi}(N)$ |
| 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 (1991) 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 (2004) and the maximum number is set to 5. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Overall, there is fair evidence that our variables are order 1 integrated and are cointegrated. 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 6. We conclude that all the coefficients of the institutional variables are significant except for bureaucracy. Likewise, renewable energy has a significant effect on growth.

Table 6: 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 * denotes 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.

4.3 Panel error correction model

Using the two- step procedure of Engle and Granger (1987), 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 (1), (2) and (3), but as recommended by Westerlund (2007), we will consider the maximum lag length as being equal to $4(\text{Int}(T/100))^{2/9}$, where $\text{Int}(x)$ 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 (1): the corresponding null hypothesis of no long-run causality running from RE and the considered institutional variable to GDP is $H_0: \delta_1 = \mathbf{0}$, while the null hypothesis of no short-run causality running from RE to GDP can be formulated as $H_0: \varphi_{1i1} = \varphi_{1i2} = \dots = \varphi_{1i,m-1} = \mathbf{0}$. Likewise, this null hypothesis can be extended and becomes $H_0: \varphi_{1i1} = \varphi_{1i2} = \dots = \varphi_{1i,m-1} = \gamma_{1i1} = \gamma_{1i2} = \dots = \gamma_{1i,m-1} = \mathbf{0}$ to test if there is a short-run causality running from jointly RE and the considered institutional variable to GDP. Finally, the null hypothesis of no strong causality running from RE to GDP is $H_0: \delta_1 = \varphi_{1i1} = \varphi_{1i2} = \dots = \varphi_{1i,m-1} = \mathbf{0}$. This null hypothesis can be duly extended 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). As pointed by Brooks (2008), while the usual t- and F-statistics have satisfactory properties in the context of nonlinear estimation, their drawback is, however, the lack of some requested flexibility. This is why we add the Wald statistics. Table 7 shows that there is a long-term causality running

from GDP 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 GDP. The long-term relationship between GDP and RE has actually been noted, quite remarkably, in the literature (see for example Apergis and Danuletiu, 2014 and Rafindadi and Ozturk, 2017). 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 8 and 9 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 8. 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.*, 2013) . 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 (2006). 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 10, 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 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.

Table 7: Long-run causality results

| Inst. | (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. |
| GDP | 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 8: 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.

Table 9: 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 → 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 → RE | 1.5692 (0.196) | 4.7078 (0.194) | - | - | - | - | - | - | - | - |
| Y, Corr → RE | 0.7877 (0.579) | 4.7261 (0.579) | - | - | - | - | - | - | - | - |
| Bur → RE | - | - | 0.0007 (1.000) | 0.0020 (1.000) | - | - | - | - | - | - |
| Y, Bur → RE | - | - | 0.0058 (1.0000) | 0.0348 (1.0000) | - | - | - | - | - | - |
| Dem → RE | - | - | - | - | 0.1165 (0.950) | 0.3496 (0.950) | - | - | - | - |
| Y, Dem → RE | - | - | - | - | 0.0675 (0.998) | 0.4051 (0.998) | - | - | - | - |
| Law-order → RE | - | - | - | - | - | - | 2.7414 (0.042) | 8.2241 (0.041) | - | - |
| Y, Law-order → RE | - | - | - | - | - | - | 1.3853 (0.218) | 8.3119 (0.216) | - | - |
| Eth → RE | - | - | - | - | - | - | - | - | 0.0131 (0.997) | 0.0394 (0.997) |
| Y, Eth → 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.

Table 10: 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 11: 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.

5. Concluding remarks and policy implications

The role of renewable energy is not only about reducing CO2 emissions nationally and globally, but also about supplying new resources that can help to achieve sustainable development. Wilkins (2002) 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 (1999, 2004), Westerlund (2007) and Westerlund and Edgerton (2008). 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.

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.

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 nonlinear panel ECM as the literature insists that these macroeconomic aggregates are rather non-linear.

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