# Economic growth and combustible renewables and waste consumption nexus in MENA countries

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**Abstract:** This paper is an attempt to investigate the causal relationship between economic growth and combustible renewables and waste consumption for 12 countries of the Middle East and North Africa (MENA) region during the period of 1975-2008 using panel cointegration techniques and panel causality tests. Granger causality test shows that there is evidence of no causality among variables in the short-run, while in the long-run the panel error correction model results reveal bidirectional causality between combustible renewables and waste consumption and economic growth. The results from OLS, FMOLS and DOLS panel estimates suggest that: *i)* The coefficient of combustible renewables and waste is positive and statistically significant. *ii)* The impact of economic growth on combustible renewables and waste is positive and statistically significant. In the long-run, a 1% increase in combustible renewables and waste increases real GDP in MENA countries by approximately 0.08%, and a 1% increase in economic growth increase combustible renewables and waste by approximately 0.43%. These results reveal that there is no strong relationship between variables given that the impact of each one on the other is quite small.

**Keywords:** Combustible renewables and waste consumption; Economic growth; Panel cointegration.

**JEL Classification:** C33, Q43

## 1. Introduction

Due to expansion of energy-intensive industries and population growth in MENA region, the consumption of energy has grown faster than what of any other region in the word. The growth of energy consumption increases rapidly the amount of greenhouse gas emissions that could cause damages to the environment and leads catastrophic consequences to the atmosphere. To avoid environmental disasters, it's necessary to take some crucial decisions to reduce emissions.

According to the Bloomberg New Energy Finance (BNEF)[2], the increasing cost of fossil fuels and the national economic policies to create job have motivated the increase of the

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[2] The Global Renewable Energy Market Outlook presents the latest forecasts from Bloomberg New Energy Finance on the future size of the world renewable energy markets.

global investment in renewable energy in recent year. Investment projects in renewable energy will increase rapidly from $195bn in 2010 to $460bn in 2030. Over the 20 next years, the MENA market of renewable energy will also grow quickly over 400% with investment from solar technologies. The Word Bank Group suggests that 700 tons and 450 tons of $CO_2$ emissions are produced using oil and gas to generate a gigawatt hour of electricity. Total MENA electricity demand is expected to increase 5-fold between 2010 and 2050, while currently the emissions are estimated to achieve 375 million tons a year. The emissions of $CO_2$ could rise to 1.500 million tons by 2050 by using conventional fossil fuels. In the MENA region, if renewable energy replaces fossil fuels the annual $CO_2$ emissions could be reduced to 265 million tons by 2050 (Word Bank, 2012).

## 2. Global Renewables

By International Energy Agency definition, renewable energy sources include renewable combustibles and waste, hydro, solar, wind and tide energy. Non-renewable waste sources are not included in renewables (IEA, 2009). Based on information data collected from the International energy agency, Table 1 reports the selected renewable indicators for 2004 in the world. In 2004, the total primary energy supply (TPES) was 11058.6 Mtoe of which 13.1% was produced from renewables and 2.7% was produced from renewables excluding combustible renewables and waste (CRW) in TPES (IEA, 2007). According to the data presented in table 1, it is easy to calculate the share of CRW in TPES which is equal to the share of total renewables (A) minus the share of renewables excluding combustible renewables and waste (B). The contribution of CRW in the total share of renewables was more raised than that of other new renewables (solar, wind…). However, Africa is the biggest consumer of CRW with a share of 47.6%, then Asia and China in the second rank with 29.4% and 13.5%, respectively. Middle Eastern countries are the smallest consumer of CRW with 0.2%.

**Table 1. Selected Renewables indicators for 2004**

| Country/region | TPES* (Mtoe) | Share of Renewables in TPES | |
|---|---|---|---|
| | | A(%) | B(%) |
| **Africa** | 586.0 | 49.0 | 1.4 |
| **Latin America** | 485.5 | 28.9 | 10.9 |
| **Asia** | 1289.4 | 31.8 | 2.4 |
| **China** | 1626.5 | 15.4 | 1.9 |
| **Non-OECD Europe** | 104.3 | 10.6 | 4.8 |
| **Former USSR** | 979.3 | 3.0 | 2.2 |
| **Middle East** | 479.8 | 0.7 | 0.5 |
| **OECD** | 5507.9 | 5.7 | 2.7 |
| **World** | 11058.6 | 13.1 | 2.7 |

Sources: IEA (2007).

A: Share of total renewables in TPES.

B: Share of renewables excluding combustible renewables and waste in TPES.

* Total primary energy supply calculated using the physical energy content methodology.

According to the International Energy Agency (IEA, 2009), the total primary energy supply (TPES) in 2007 was 12,026 Mtoe: Africa (630.9Mtoe), Latin America (551.1Mtoe), Asia (1377.0Mtoe), China (1969.5Mtoe), Non-OECD (105.8Mtoe), Former Soviet Union

(1015.6Mtoe), Middle East (548.3Mtoe), and OECD (5497.1Mtoe). We find 12.4% (1492 Mtoe), was produced from renewable energy sources. In Africa and Middle East, the share of renewables in TPES was 48.3% and 0.7%, respectively (see Table 2).

**Table 2. World Renewables indicators in 2007**

| Country/region | Total primary energy supply (Mtoe) | Of which renewables (Mtoe) | Share of renewables in TPES[a] (%) | Share of main fuel categories in total renewables (%) | | |
|---|---|---|---|---|---|---|
| | | | | Hydro | Geothermal, solar, wind, tide | Renewable combustibles and waste |
| **Africa** | 630.9 | 304.6 | 48.3 | 2.7 | 0.3 | 97.0 |
| **Latin America** | 551.1 | 168.3 | 30.5 | 34.2 | 1.6 | 64.2 |
| **Asia** | 1377.0 | 375.2 | 27.2 | 5.9 | 4.3 | 89.8 |
| **China** | 1969.5 | 241.3 | 12.3 | 17.3 | 2.1 | 80.6 |
| **Non-OECD Europe** | 105.8 | 10.1 | 9.6 | 37.6 | 1.3 | 61.1 |
| **Former Soviet Union** | 1015.6 | 30.7 | 3.0 | 69.3 | 1.5 | 29.2 |
| **Middle East** | 548.3 | 4.0 | 0.7 | 48.2 | 21.7 | 30.1 |
| **OECD** | 5497.1 | 357.9 | 6.5 | 30.2 | 13.2 | 56.6 |
| **Total World** | 12026.0 | 1492.2 | 12.4 | 17.7 | 4.9 | 77.3 |

Sources: IEA (2009).

"a" denotes the TPES which is the abbreviations of the total primary energy supply.

According to the definition of the IEA, we achieve that renewable energy takes into account the combustible renewables and waste which generate a lot of emissions in comparison with the "new" renewable energy (solar, wind…). With respect to the data detailed in table 2, Africa occupies the largest shares of renewables in TPES and renewable combustibles and waste with 48.3% and 97%, respectively. Middle Eastern countries consume the least significant parts with 0.7% and 30.1%, respectively.

## 3. Energy-economic growth nexus

The topic of causal relationship between energy consumption and economic growth have been studied in developing and non-developed economies (e.g. Akinlo 2008; Al-iriani 2006; Lee and Chang 2007; Narayan and Smyth 2008; Ozturk 2010; Ozturk *et al.*, 2010; among others). The empirical results from these studies are mixed and not similar, and it is so difficult to achieve definitively the direction of causality between them (see Ozturk 2010; for short-run and long-run causality results).

Turning to the causal relationship between renewable energy consumption and economic growth, there are a number of recent studies that have been investigated for panel and individual time series (see for example Apergis and Payne (2010, 2011 and 2012); Apergis et *al.*, (2011); Sadorsky (2009)). Apergis and Payne (2010a) examine the causal relationship between renewable energy consumption and economic growth for a panel of 20 OCDE countries over the period 1985-2005. The result from panel cointegration tests provides a long-run relationship between real GDP, renewable energy consumption, real gross fixed capital formation, and the labor force. In both short-run and long-run, the Engle and Granger test results show bidirectional causality between renewable energy consumption and economic growth. Apergis and Payne (2010b) examine the causal relationship between renewable energy consumption and economic growth for a panel of 13 countries within Eurasia over the period 1992-2007. The results from error correction models indicate bidirectional causality between variables in both short-run and long-run. They conclude that this finding supports the feedback hypothesis of the interdependent relationship between renewable energy consumption and economic growth. Another paper published by Apergis and Payne (2011) in which they study the causal relationship between renewable energy consumption and economic growth for six Central American countries over the period 1980-2006. The results from panel error correction model indicate bidirectional causality between renewable energy consumption and economic growth in both the short and long-run. Sadorsky (2009) estimates two empirical models of per capita renewable energy consumption and real income per capita for a panel of emerging economies. The panel cointegration estimates show that increases in real income per capita have a positive and significant impact on per capita renewable energy consumption. There are other econometric studies in which additional variables can be incorporated to explain the economic growth such as non-renewable energy. Apergis and Payne (2012) examine the relationship between renewable and non-renewable energy consumption and economic growth for 80 countries within a multivariate panel framework over the period 1990-2007. They conclude that renewable and non-renewable energy are two substitutable energy sources. These studies support that renewable energy consumption is statistically significant and have a positive impact on increasing economic growth in emerging and developed countries.

The present paper is not neither complementary nor similar to the previous studies that discuss association between energy consumption (renewable and non-renewable energy) and economic growth. The causal relationship between economic growth and combustible renewables and waste consumption is one of the most important topic studies that we try to explore in this paper. To date, no typical study has been carried out on the long-run linkages between these two variables in the world, and especially in MENA countries. There are only some theoretical studies (e.g. Demirbas, 2008; Sun, 2004). Demirbas (2008) suggest that combustible renewables and waste are mainly used in the residential sector in Non-OECD countries and that these latter are utilized in different economic sectors in the OECD. The author concludes that the sustainability of combustible renewables for energy use needs a high efficiency recycling of energy. Based on the International Energy Agency (IEA) database, Sun (2004) examines in this study the utilization of the combustible renewable and waste in the world the period 1973-2000 and he just found two interesting results. First, he suggests that, compared to the OECD countries, the richness of technological experience on the use of combustible renewables and waste is limited in the Non-OECD countries. Second, the data on combustible renewables and waste from 1996 to 2000 may have not been regulated.

In this study we use the panel cointegration techniques, Granger causality tests, and more powerful methods of long-run equilibrium estimation such as fully modified OLS (FMOLS) and dynamic modified OLS (DOLS). According to the World Bank online database, the combustible renewables and waste include solid biomass, liquid biomass, biogas, industrial waste, and municipal waste. It means that these sources of energies are not purely clean as renewable energy sources, but not too pollutant as fossil fuel (non-renewable energy), since in this study we consider the combustible renewables and waste as a substitutable or complementary to renewable energy sources.

Our paper differs to the previous studies by the fact that we try to examine the use of a combustible renewables and waste (solid biomass, liquid biomass…), which can be considered as a substitutable energy or complementary to the "new" renewable energy (solar, wind, hydraulic …) because it does not generate a lot of emissions (Demirbas, 2008)[3].

This present study is an attempt to explore the long-run relationship between economic growth and combustible renewables and waste consumption for 12 MENA countries during the period 1975-2008 by using Pedroni (1999, 2004) panel cointegration technique and Granger causality method. The results obtained from this empirical analysis are reliant on the selected sample, period of time, and methodology used for the study. The remainder of this paper is organized as follows: section 4 describes data, presents some descriptive statistics, and discusses empirical model. Finally, section 5 concluding remarks.

## 4. Data, descriptive statistics, and empirical analysis

### 4.1. Data

The panel data set is a balanced panel of 12 MENA countries followed over the years 1975-2008. The annual data were obtained from the World Bank Development Indicators (2011) online database for Algeria, Cyprus, Egypt, Iran, Israel, Jordan, Morocco, Saudi Arabia, Sudan, Syria, Tunisia, and Turkey. The panel data set is selected to include as many MENA countries with analysis variables. The bivariate framework includes real GDP ( $Y$ ) in constant 2000 US dollars, and combustible renewables and waste ($CRW$)[4] in metric tons of oil equivalent. All variables are converted into natural logarithms prior to conducting the empirical analysis.

### 4.2. Descriptive statistics

Fig (1-2) show the variation of log real GDP and log of combustible renewables and waste for the selected sample of MENA countries during the period 1975-2008, and Table 3 reports some summary statistics (Mean, Median, Maximum, Minimum).

**Table 3. Summary statistics for both series**

| Variables | Description | Mean | Median | Maximum | Minimum | Cross sections |
|---|---|---|---|---|---|---|
| $Y$ | real GDP (constant 2000 US$) | 24.19524 | 24.30028 | 26.65039 | 21.38079 | 12 |
| $CRW$ | Combustible renewables and waste (metric tons of oil equivalent) | 4.463877 | 4.629600 | 9.397225 | -0.729811 | 12 |

Sources: World Bank (2011) online database. All variables are in natural logarithms.

**Fig.1 The natural log of real GDP (constant 2000 US dollars)**

[3] Demirbas (2008) affirmed that the use of combustible renewables and waste generates a lot of emissions: "The sustainability of combustible renewables for energy use requires a high efficiency recycling of energy and low emissions of carbon compounds, NOx, persistent organics, and acidifying compounds and heavy metals due to biomass combustion".

[4] According to the World Bank online database, the combustible renewables and waste variable comprise solid biomass, liquid biomass, biogas, industrial waste, and municipal waste.

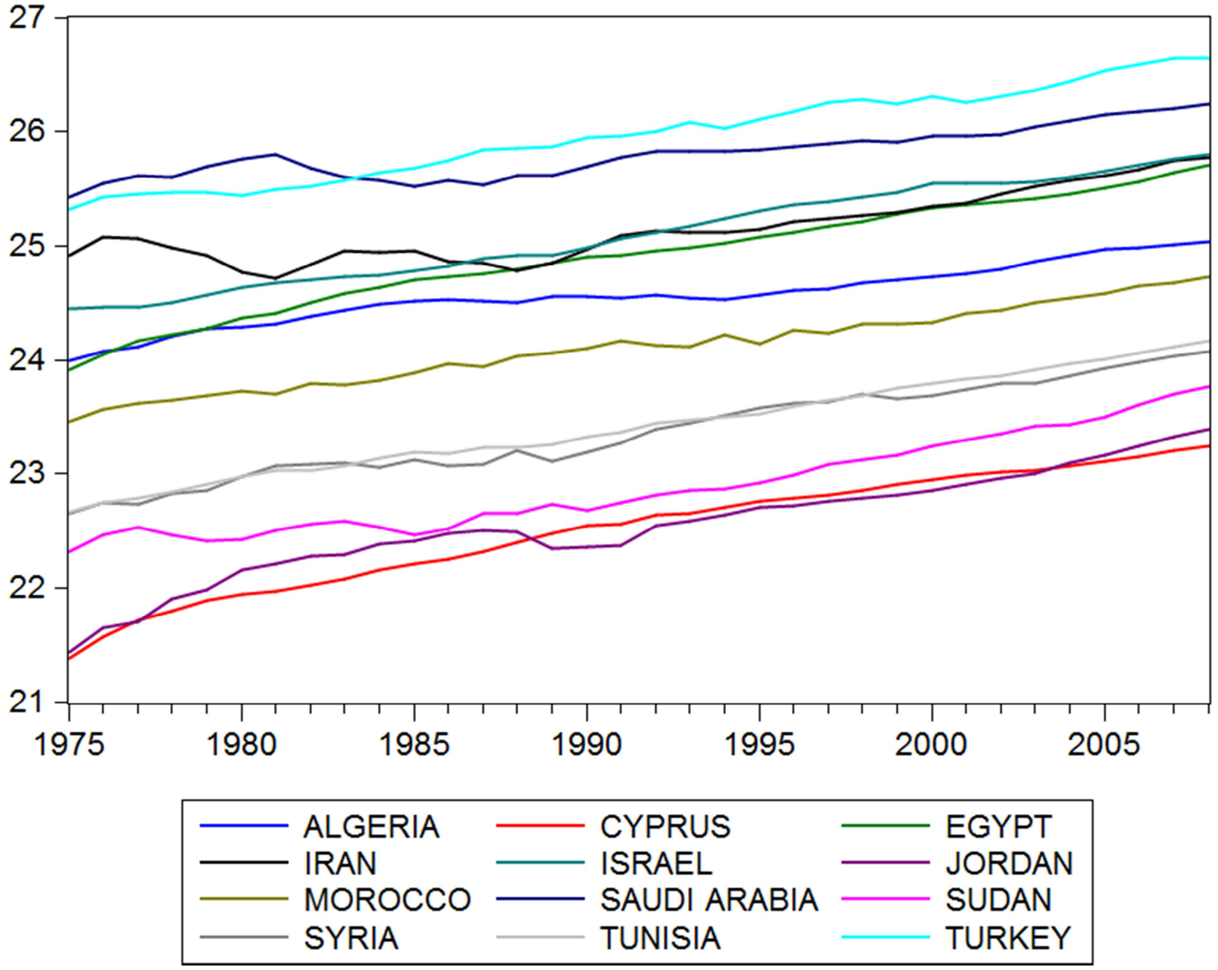


Fig.1 reports the variation of natural log of real GDP for the selected MENA countries over the years 1975-2008. Practically, the real GDP of the region has a trend upward across time. Turkey and Saudi Arabia have the highest value of real GDP while Cyprus and Jordan are the lowest.

**Fig.2 The natural log of combustible renewables and waste (metric tons of oil equivalent)**

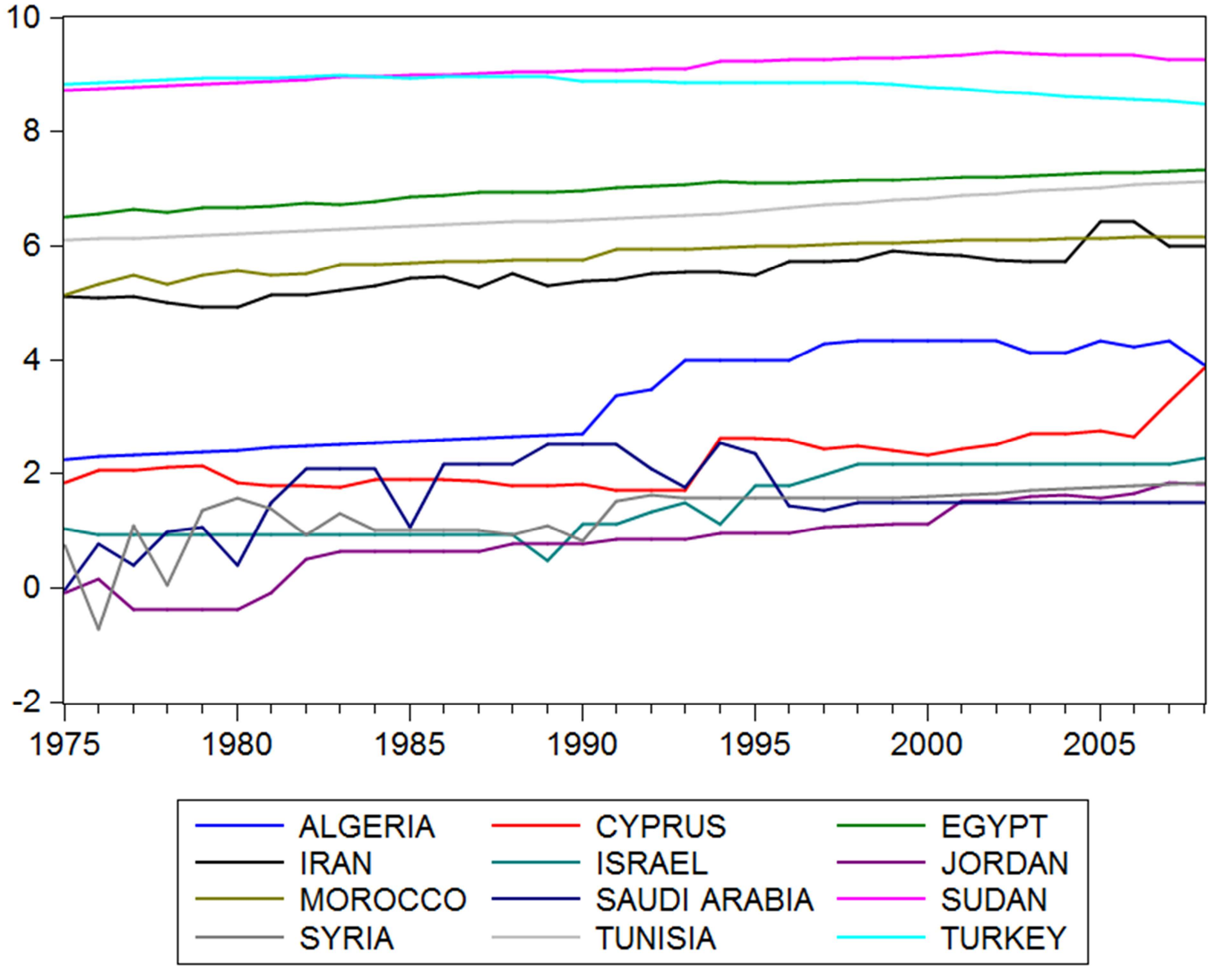


Fig.2 reports the variation of natural log of combustible renewables and waste consumption for the selected MENA countries during 1975-2008. The variation in the consumption of combustible renewables and waste in each country is almost constant across time. Sudan and Turkey are the largest consumers of combustible renewables and waste while Jordan and Saudi Arabia are two lowest consumers.

### 4.3. Empirical analysis

A linear equation which investigates the long-run causality between the natural logarithm of real GDP and the natural logarithm of combustible renewables and waste consumption for each country is implemented as follows:

$$Y_{it} = \beta_i + \delta_i t + \beta_{1i} CRW_{it} + \varepsilon_{it} \quad (1)$$

where $i = 1,...,12$ denotes the country and $t = 1975,...,2008$ denotes the time period; $\beta_i$ and $\delta_i$ denotes the country specific fixed effects and deterministic trends, respectively. $\varepsilon_{it}$ indicate the estimated residuals which characterize deviations from the long-run relationship.

#### *4.3.1. Panel unit root tests*

The analysis begins with the stationarity proprieties of each variable through unit root tests. In this study four types of unit root tests are computed in order to examine the order of integration of variables in level and in first difference. Levin *et al*. (2002), Im *et al*. (2003), tests of Fisher using Augmented Dickey and Fuller (ADF) (1979), and Phillips and Perron (1988). These tests are divided in two groups. The first group of tests includes LLC's test (Levin *et al*., 2002) that assumes a common unit root process across the cross-section. The other tests are IPS-W-statistic (Im et al., 2003); ADF-Fisher Chi-square (Dickey Fuller, 1979) and PP-Fisher Chi-square (Phillips and Perron, 1988) are included in the second group and assume individual unit root process across the cross-section. For all these tests, the null hypothesis is that there is a unit root test and the alternative hypothesis is that there is no unit root. We assume that the test regressions contain an intercept and no trend.

**Table 4. Panel unit root tests**

| **Method** | ***Y*** | | ***ΔY*** | | ***CRW*** | | ***ΔCRW*** | |
|---|---|---|---|---|---|---|---|---|
| | **Statistic** | **Prob[a].** | **Statistic** | **Prob[a].** | **Statistic** | **Prob[a].** | **Statistic** | **Prob[a].** |
| **Null: Unit root (assumes common unit root process)** | | | | | | | | |
| **Levin. Lin & Chu t*** | -1.994 | 0.026 | -13.425 | 0.000* | 0.607 | 0.728 | -16.923 | 0.000* |
| **Null: Unit root (assumes individual unit root process)** | | | | | | | | |
| **Im. Pesaran and Shin W-stat** | 3.773 | 0.999 | -14.970 | 0.000* | 1.798 | 0.963 | -18.577 | 0.000* |
| **ADF-Fisher Chi-square** | 20.488 | 0.668 | 209.435 | 0.000* | 29.304 | 0.205 | 224.421 | 0.000* |
| **PP-Fisher Chi-square** | 22.257 | 0.563 | 222.251 | 0.000* | 26.338 | 0.336 | 261.057 | 0.000* |

All units root tests regressions are run with constant.

Lag selection: Automatic selection of lags based on SIC: 0 to 1.

Newey-West bandwidth selection using Bartlett kernel.

"a", Probability for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

"*", indicates statistical significance at 1% level.

Table 4 reports the results of unit root tests for real GDP and combustible renewables and waste which indicate that the level values of all statistics are non-stationary except for one test on the real GDP variable. All variables are stationary at the 1% significance level of the first difference and the null hypothesis of a unit root can be rejected.

### *4.3.2. Panel cointegration tests*

To determine whether variables are cointegreted, this paper employs two kinds of panel cointegrations tests, i.e. Pedroni (1999, 2004) and Johansen (1988). Pedroni (1999, 2004) purposes two sets of cointegrartion tests. The first is a panel group based on four statistics and includes v-statistic, rho-statistic, PP-statistic and ADF-statistic. These statistics are classified on the within-dimension and take into account common autoregressive coefficients across countries. The second group is based on three statistics and includes rho-statistic, PP-statistic, and ADF statistic. These tests are classified on the between-dimension and based on the individual autoregressive coefficients for each country in the panel. All these tests are based on the residual of Eq. (1). The null hypothesis is that there is no cointegration ($H_0 : \rho_i = 1$) while alternative hypothesis is that there is cointegration between variables. The estimated residuals are defined as follows:

$$\hat{\varepsilon}_{it} = \rho_i \hat{\varepsilon}_{it-1} + w_{it} \quad (2)$$

**Table. 5 Pedroni panel cointegration tests**

| **Alternative hypothesis: common AR coefs. (within-dimension)** |
|---|

| | | | Weighted | |
|---|---|---|---|---|
| | **Statistic** | **Prob.** | **Statistic** | **Prob.** |
| **Panel v-Statistic** | 11.893 | 0.000* | 9.550 | 0.000* |
| **Panel rho-Statistic** | -0.732 | 0.231 | -0.579 | 0.283 |
| **Panel PP-Statistic** | -2.439 | 0.007* | -1.979 | 0.023** |
| Panel ADF-Statitic | -1.128 | 0.129 | -1.018 | 0.154 |
| **Alternative hypothesis: individual AR coefs. (between-dimension)** | | | | |
| | **Statistic** | | | **Prob.** |
| **Group rho-Statistic** | -0.865 | | | 0.193 |
| **Group PP-Statistic** | -3.400 | | | 0.000* |
| **Group ADF-Statistic** | -2.174 | | | 0.014** |

Null hypothesis: No cointegration.

Trend assumption: Deterministic intercept and trend.

Lag selection: Automatic SIC with a max lag of 7.

Newey-West bandwidth selection with Bartlett kernel.

"*", "**" indicate statistical significance at 1% and 5% levels, respectively.

Table 5 reports the results of both the panel and group statistics of heterogeneous panelcointegration tests which indicate that two panel statistics (v-statistic, PP-statistic) among four used of the within-dimension reject the null of no cointegratoin at the 1% significance level and approve that there is evidence of cointegration between variables and two group statistics (PP-statistic and ADF-statistic) among three used of the between-dimension reject the null of no cointegration at the 1% and 5% significance levels, respectively, and approve that there is cointegration between variables.

It is worth interesting to confirm the existing of cointegration between variables. However, we apply the Johansen (1988) Fisher panel cointegration test that is established on two different approaches. The first is the likelihood ratio trace statistics and the second is maximum eigenvalue value. These tests are based on the aggregates of the p-values of the individual statistics. If $p_i$ is the p-value from an individual cointegration test for cross-sections $i$, then under the null hypothesis the test statistic for the panel is given by:

$$-2\sum_{i=1}^{N}\log(p_i) \sim \chi^2_{2N} \quad (3)$$

Where the $\chi^2$ value is based on the MacKinnon-Haug-Michelis (1999).

**Table 6. Johansen (1988) panel cointegration test**

| Hypothesized No. of CE(s) | Fisher Stat.* (from trace test) | Prob. | Fisher Stat.* (from max-eigen test) | Prob. |
|---|---|---|---|---|
| **None** | 58.61[a] | 0.0001 | 61.69[a] | 0.0000 |
| **At most 1** | 20.31 | 0.6792 | 20.31 | 0.6792 |

"*" Probabilities are computed using asymptotic Chi-square distribution.

"a" indicates statistical significance at the 1% level.

Table 6 reports the results of Johansen (1988) cointegration test based on Fisher's tests (trace test statistic and max-eigen statistic) and confirm the Pedroni's (1999, 2004) panel results on presence of a cointegration relationship between real GDP and combustible renewables and waste at the 1% significance level.

### 4.3.3. Panel causality tests

After establishing the presence of a cointegration relationship between economic growth and combustible renewables and waste consumption, it is necessary to examine the direction of causality between these variables. Engle and Granger (1987) recommended a two-step procedure for cointegration analysis. The first step is to estimate the long-run equilibrium from Eq. (1) to recover the residuals considered as a lagged error correction term ( $ECT$ ). The second step is to estimate the dynamic error correction model as follows:

$$\Delta Y_{it} = \delta_{1i} + \sum_{k=1}^{p}\delta_{11ik}\Delta Y_{it-k} + \sum_{k=1}^{p}\delta_{12ik}\Delta CRW_{it-k} + \theta_{1i}ECT_{it-1} + u_{1it} \tag{4}$$

$$\Delta CRW_{it} = \delta_{2i} + \sum_{k=1}^{p}\delta_{21ik}\Delta Y_{it-k} + \sum_{k=1}^{p}\delta_{22ik}\Delta CRW_{it-k} + \theta_{2i}ECT_{it-1} + u_{2it} \tag{5}$$

where $\Delta$ denotes the first difference; $p$ denotes the lag length determined automatically by the Schwarz Information Criterion (SIC). The estimation of the long-run equilibrium from Eq. (1) gives the error correction term expressed as follows: $ECT_{it} = Y_{it} - \hat{\beta}_{0i} - \hat{\beta}_{1i}CRW_{it}$ .

**Table7. Panel Granger causality test results**

| **Dependent Variable** | **Sources of causation (independent variables)** | | |
|---|---|---|---|
| | **Short-run** | | **Long-run** |
| | ***ΔY*** | ***ΔCRW*** | ***ECT*** |
| ***ΔY*** | - | 0.028 (0.972) | -0.029 [-2.651]* |
| ***ΔCRW*** | 1.077 (0.341) | - | -0.022 [-1.859]*** |

The t-statistics are shown in brackets and p-values in parenthesis.

ECT represents the coefficient of the error correction term.

"*", "***" indicate statistical significance at the 1% and 10% levels, respectively.

Table 7 presents the panel causality test results of the pairwise Granger causality tests of short-run relationship and for vector error correction model (VECM) of long-run relationship. The short-run dynamics causality between variables is determined by Fisher statistic and the long-run dynamics causality are determined by using the statistical significance of t-test. The number of lags selected on real GDP and combustible renewables and waste consumption are set at 2 and determined automatically by the Schwarz Information Criterion (SIC). With respect to Eq. (4) and Eq. (5), Granger causality shows that there is no causal relationship between real GDP and combustible renewables and waste consumption in the short-run dynamics. It means that, in the short-run, any changes in the consumption of combustible renewable energy may not lead to affect economic growth and any variations in economic growth may not affect the consumption of combustible renewables and waste. The long-run dynamics are captured by the statistical significance of the error correction term (*ECT*) which indicates that there is evidence of a bi-directional causality between combustible renewables and waste consumption and economic growth[5]. It means that combustible renewables and waste consumption could play an important factor for the long-run equilibrium, and an increase in the consumption of combustible renewables and waste increase economic growth and vice versa.

### *4.3.4. Panel OLS, FMOLS and DOLS estimates*

After establishing the presence of cointegration and specified the short-run and the long-run causality relationship among variables, we determine the long-run equilibrium estimates between real GDP and combustible renewables and waste consumption using various techniques of panel estimates such as fully modified OLS (FMOLS) Pedroni (2001, 2004) and dynamic OLS (DOLS) reformed by Kao and Chiang (2000) and Mark and Sul (2003) to the case of panel data. Estimators calculated from these two techniques seem to be more powerful than the OLS estimation technique. The existence of the long-run relationship between variables is confirmed by the significance of the error correction term (*ECT*) of each equation. Given that the error correction term of Eq.(4) and Eq.(5) are negative and statistically significant at the 1% and 10%, respectively. Since, long-run estimates consider the two circumstances of estimation: the case where real GDP is dependent variable and the case where combustible renewables and waste is dependent variable.

**Table 8. OLS, FMOLS and DOLS Panel estimates results (Y as dependent variable)**

| **Country** | ***OLS*** | | ***FMOLS*** | | ***DOLS*** | |
|---|---|---|---|---|---|---|
| ***Algeria*** | -0.168 | (0.000)* | -0.175 | (0.000)* | -0.168 | (0.000)* |
| ***Cyprus*** | -0.141 | (0.000)* | -0.172 | (0.000)* | -0.141 | (0.012)** |
| ***Egypt*** | 0.821 | (0.002)* | 0.877 | (0.020)** | 0.821 | (0.042)** |
| ***Iran*** | 0.203 | (0.234) | 0.016 | (0.136) | 0.007 | (0.709) |
| ***Israel*** | 0.088 | (0.000)* | 0.094 | (0.001)* | 0.088 | (0.003)** |
| ***Jordan*** | 0.079 | (0.470) | 0.160 | (0.273) | 0.079 | (0.653) |
| ***Morocco*** | 0.016 | (0.865) | -0.082 | (0.604) | 0.016 | (0.904) |
| ***Saudi Arabia*** | -0.072 | (0.004)* | -0.103 | (0.011)** | -0.072 | (0.060)*** |
| ***Sudan*** | -1.135 | (0.000)* | -1.211 | (0.017)** | -1.135 | (0.000)* |
| ***Syria*** | 0.040 | (0.167) | 0.060 | (0.172) | 0.040 | (0.353) |
| ***Tunisia*** | 0.357 | (0.003)* | 0.449 | (0.000)* | 0.004 | (0.023)** |
| ***Turkey*** | -0.111 | (0.257) | -0.102 | (0.531) | -0.111 | (0.445) |
| ***Panel*** | 0.084 | (0.000)* | 0.096 | (0.059)*** | 0.084 | (0.097)*** |

Cointegrating equation deterministics: intercept and trend.

All variables are estimated in natural logarithms.

"*", "**", and "***" indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The results of panel and individual OLS, FMOLS and DOLS of selected MENA countries are presented in table 8. All of the variables are measured in natural logarithms. From the

[5] The ECT is negative and statistically significant for Eq. (4) and Eq. (5). It means that there is bidirectional causality between combustible renewables and waste and real GDP: in the long-run, there is evidence of : *i*) Long-run causality from combustible renewables and waste to real GDP at the 1% level of significance, and *ii*) Long-run causality from real GDP to combustible renewables and waste at the 10% level of significance.

long-run cointegration relationship, the coefficient estimated can be deduced as long-run elasticities. From the panel and individual long-run estimates, techniques used for estimation confirm that, when real GDP is defined as a dependent variable (per capita real GDP is explained by per capita combustible renewable and waste consumption), the coefficient is similar in sign across the estimation techniques. It means that the impact of combustible renewables and waste consumption on real GDP is positive and statistically significant. In most cases, the estimators are approximately similar which approve that the results of the OLS, FMOLS and DOLS are in agreement. A 1% increase in combustible renewables and waste increases real GDP by 0.09% from FMOLS, and a 1% increase in combustible renewables and waste increases real GDP by 0.08% from OLS and DOLS.

The results from the individual estimates show that combustible renewables and waste consumption affect real GDP in seven MENA countries among twelve. For Algeria, Cyprus, Saudi Arabia, Sudan and Turkey the impact of combustible renewables and waste consumption on real GDP is negative and statically significant, while from Egypt, Israel and Tunisia the combustible renewables and waste consumption have a positive and statically significant impact on real GDP.

**Table 9. OLS, FMOLS and DOLS Panel estimates results (CRW as dependent variable)**

| Country | *OLS* | | *FMOLS* | | *DOLS* | |
|---|---|---|---|---|---|---|
| ***Algeria*** | -3.676110 | (0.0000)* | -4.214271 | (0.0000)* | -3.676110 | (0.0000)* |
| ***Cyprus*** | -2.197391 | (0.0007)* | -2.994000 | (0.0025)* | -2.197391 | (0.0048)* |
| ***Egypt*** | 0.325683 | (0.0020)* | 0.193011 | (0.2749) | 0.325683 | (0.0403)** |
| ***Iran*** | 0.222353 | (0.2345) | 0.156551 | (0.3917) | 0.222353 | (0.2156) |
| ***Israel*** | 4.564226 | (0.0001)* | 5.603481 | (0.0001)* | 4.564226 | (0.0051)* |
| ***Jordan*** | 0.211826 | (0.4703) | 0.379221 | (0.3756) | 0.211826 | (0.6159) |
| ***Morocco*** | 0.058255 | (0.8653) | -0.162342 | (0.7027) | 0.058255 | (0.9057) |
| ***Saudi Arabia*** | -3.174227 | (0.0048)* | -3.903177 | (0.0060)* | -3.174227 | (0.0423)** |
| ***Sudan*** | -0.303420 | (0.0003)* | -0.335345 | (0.0090)* | -0.303420 | (0.0141)** |
| ***Syria*** | 1.484269 | (0.1670) | 2.028389 | (0.0527)*** | 1.484269 | (0.1294) |
| ***Tunisia*** | 0.667093 | (0.0039)* | 0.977355 | (0.0066)* | 0.667093 | (0.0795)*** |
| ***Turkey*** | -0.369953 | (0.2570) | -0.349772 | (0.5169) | -0.369953 | (0.5170) |
| ***Panel*** | 0.420122 | (0.0001)* | 0.448192 | (0.0772)*** | 0.420122 | (0.0984)*** |

Cointegrating equation deterministics: intercept and trend.

"*", "**", and "***" indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

The long-run elasticities of the impact of real GDP on combustible renewables and waste consumption for the individual and panel tests based on OLS, FMOLS, and DOLS estimator are reported in table 9. When combustible renewables and waste is defined as a dependent variable (which means that per capita combustible renewable and waste consumption is explained by per capita real GDP), the results suggest that for the panel as whole, the coefficient on real GDP is similar, positive and statistically significant across the three estimation techniques. Among the panel individual tests, six countries reject the null hypothesis at the 1% level for the FMOLS. However, the relationship between combustible renewables and waste and economic growth is rejected at the 10% level for Syria.

The overall results of this study show that there is not a robust relationship between combustible renewables and waste consumption and economic growth in most individual countries given that long-run estimates show that the coefficients estimated are not close to 1.

In the case where causality runs from real GDP to combustible renewables and waste the coefficient of combustible renewables and waste is very low in comparison to the case where this latter is defined as a dependent variable (causality runs from combustible renewables and waste to real GDP).

## 5. Concluding remarks

The objective of this paper is to investigate the relationship between real GDP and combustible renewables and waste consumption in MENA countries. To the best of our knowledge there is not published literature or empirical studies focused on the long-run dynamic relationship between these variables in this region. In this case we try to examine the long-run relationship between real GDP and combustible renewables and waste consumption for a sample of MENA countries during the period 1975-2008 by using Pedroni (1999, 2004) panel cointegration method.

The analysis begins with a panel unit root tests in order to assess the stationarity proprieties of each variable used for analysis. The result from panel unit root tests shows that all variables are integrated after first difference. Pedroni (2004) and Johansen (1988) panel cointegration tests ensure the presence of cointegration between real GDP and combustible renewables and waste consumption in the long-run equilibrium. It means that these two variables move together in the long-run. The results from Granger causality tests of the short-run and the long-run dynamic relationship suggest that there is evidence of no causality between variables in the short-run. It means that lagged changes in real GDP do not affect the consumption of combustible renewable and waste and the lagged changes of combustible renewables and waste do not affect real GDP. However, in the long-run the error correction term in each equation is negative and statistically significant. It means that there is evidence of bidirectional causality between real GDP and combustible renewables and waste.

The results of individual OLS, FMOLS and DOLS estimates approve that only from Egypt, Israel and Tunisia, combustible renewables and waste consumption have a positive and statistically significant impact on real GDP at 5% and 10% levels. The results of the panel tests show that a 1% increase in combustible renewables and waste consumption increases real GDP by approximately 0.08%. However, the contribution of the combustible renewables and waste to increase the economic growth still low. This result indicates that, for the panel as whole, economic policy of some MENA countries does not give great importance to combustible renewables and waste energy.

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