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Renewable and non-renewable energy consumption and economic growth: Evidence from MENA Net Oil Importing Countries.

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Abstract:

In this paper, we use panel cointegration techniques to explore the relationship between renewable and non-renewable energy consumption and economic growth in a sample of 11 MENA Net Oil Importing Countries covering the period 1980–2012. The Pedroni (1999, 2004), Kao(1999) as well as Westerlund(2007) panel cointegration tests indicate that there is a long-run equilibrium relationship between real GDP, renewable energy consumption, non-renewable energy consumption, real gross fixed capital formation, and the labor force with elasticities estimated positive and statistically significant in the long-run. Results from panel error correction model expose that there is confirmation of bidirectional causality between renewable energy consumption and economic growth, between non-renewable energy consumption and economic growth as well as between renewable and non-renewable energy consumption that is evidence of their substitutability and interdependence in both the short and long-run supporting the feedback hypothesis. We suggest that Governments should implement policies that promote the development of renewable energy sector in order to realize economies of scale such as tax credits for renewable energy production, installation rebate for renewable energy systems as well as the establishment of markets for renewable energy certificates.

Keyword: Renewable and non-renewable energy consumption, Growth, Panel cointegration, MENA Net Oil Importing Countries.

JEL Classification: C33, Q43.

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1. Introduction:

Given the growing concerns about the environmental consequences of greenhouse gas emissions from fossil fuels, volatile energy prices and geopolitical climate, renewable energies have emerged as an essential component in the global energy consumption mix. According to International Energy Outlook (2013), renewable energy is expected to be the fastest growing sources of global electricity production, with an average annual increase of 2.8% per year during the period 2010-2040. In addition, the renewable energy share in global electricity production will increase by 18% in 2007 to 23% in 2035. This growth is being driven by the fact that renewable energy offers several solutions to the problems of energy security and climate change. Additionally, the anticipated growth in renewable energy can be attributed in part to government policies such as renewable energy production tax credits, installation rebates for renewable energy systems, renewable energy portfolio standards, and the creation of markets for renewable energy certificates (Kaygusuz et al., 2007; Kaygusuz, 2007; Sovacool, 2009). The MENA[2] region is highly exposed to the impacts of climate change due to the scarcity of water resources, the economic activities concentration in the coastal zone and its dependence on agriculture which is sensitive to climate variations. Despite gas emissions greenhouse volume relatively low compared to other regions, the countries of the MENA region are evidence for the third highest growth of carbon emissions in the world, which helps to increase the risk of climate change.

In addition, population growth, rapid urbanization and economic growth put pressure on the existing infrastructure and the demand for new investment is relatively high. The total demand for investment in the energy sector in MENA countries is expected to exceed 30 billion dollars per year over the next 30 years, or about 3% of the total GDP of the region (which is three times higher to the world average), (WDI, World Development Indicators 2013). Specifically, continues rising and volatile fuel prices put pressure on the financial resources of MENA Net Oil Importing Countries (NOIC). Given the appearance of renewable energy in the discussion of a sustainable energy future, it is essential to comprehend the dynamics between renewable energy consumption and economic growth, which this paper attempts to deal with. While the literature on energy consumption and economic growth has been extensively examined in the literature (Ozturk, 2010; Sharma, 2010; Payne, 2010a, b;

[2] The Middle East and North Africa

Tugcu et al, 2012), studies on renewable energy consumption have only recently been investigated. Unlike previous studies in this area, this investigation considers the simultaneous use of renewable and non-renewable energy consumption in order to differentiate the relative impact of each source on economic growth for a panel of eleven MENA Net Oil Importing Countries over the period 1980-2012 within a multivariate framework.

This paper is organized as follows: Next section is dedicated to the literature. Section 3 discusses the data, methodology, and empirical results. Section 4 provides concluding remarks.

2. Literature review:

The literature distinguishes four hypothetical relationships between energy consumption and economic growth developed by Tugcu et al. (2012): it is the growth hypothesis, the conservation hypothesis, the neutrality hypothesis and the feedback hypothesis (Apergis and Payne, 2009a, 2011a, 2012; Bowden and Payne, 2010; Ewing et al., 2007; Lee, 2006; Ozturk, 2010; Payne, 2010; Soytas and Sari, 2003):

H_1- The growth assumption implies an increase, respectively (decrease) in energy consumption causes an increase (decrease) in real GDP. In this case, the economy is greatly dependent on energy. According to Squalli (2007), the negative impact of energy consumption on real GDP can be attributed to excessive energy consumption in unproductive economy sectors, capacity constraint or inefficient energy supply (Chontanawat et al, 2008; Narayan and Smyth, 2008; Apergis and Payne ,2009a,b,2010b; Bowden and Payne ,2009; Belloumi, 2009; Soytas and Sari,2003, 2006).

H_2- The conservation assumption implies that political energy conservation resulting in a reduction of energy consumption does not have a negative impact on real GDP. This hypothesis is verified if an increase in GDP causes an increase in energy consumption (Lise and Montfort, 2007; Huang et al, 2008; Soytas and Sari, 2003, 2006; Lee, 2006; Akinlo, 2008; Ozturk et al, 2010).

H_3- The feedback hypothesis suggests that there is a bidirectional causal relationship between energy consumption and real GDP which proves their mutual relationship so that implementation of sustainable and efficient consumption policies has no negative effect on real GDP. (Apergis and Payne, 2009b, 2010a; Belke et al, 2011; Eggoh et al, 2011; Fuinhas and Marques, 2011; Kaplan et al, 2011; Soytas and Sari, 2003, 2006; Lee, 2006; Akinlo, 2008; Belloumi, 2009; Ozturk et al, 2010).

H_4- The neutrality assumption considers that the energy consumption is only a tiny part of the production components and its effect on real GDP is low or zero. This is true in case of absence of a causal relationship between energy consumption and real GDP. (Soytas et al, 2007; Lee, 2006; Akinlo, 2008).

The following strand is composed of the studies which analyze the relationship between renewable energy consumption and economic growth. For example Payne (2011) proved the validity of the growth hypothesis; Apergis and Payne (2010c, d; 2011a) proved the validity of the feedback hypothesis; and finally Menegaki (2011) proved the validity of the neutrality hypothesis. Furthermore Chien and Hu (2007), Fang (2011) and Tiwari (2011a) stated that a raise in the consumption of renewable energy sources positively contribute to economic growth, while Sadorsky (2009a) showed that the higher an economy grows, the more renewable energy sources are consumed.

Recently, the new trend in the literature of energy economics is to decompose the effects of renewable and non-renewable energy consumption on economic growth. Therefore, the third strand consists of the studies which examine the effects of renewable and non-renewable energy consumption on economic growth (Ewing et al, 2007; Payne, 2009; Apergis et al, 2010; Bowden and Payne, 2010; Tiwari, 2011b; Apergis and Payne, 2011b, 2012; Tugcu et al, 2012, U.Al-mulali et al, 2014). The present study, as a contribution to the third strand of the literature, aims to differentiate the relative impact of the two types of energy sources on economic growth in order to reveal their substitutability.

3. Data, methodology and results

Annual data from 1980 to 2012 were obtained from the U.S. Energy Information Administration, the Penn World Table (PWT8.0)[3] and World Bank Development Indicators on line data base. The MENA Net Oil Importing Countries (NOIC) included in the analysis are Lebanon, Israel, Jordan, Malta, Morocco, Tunisia, Turkey, Armenia, Cyprus, Georgia, and Mauritania[4].

[3] http://www.ggdc.net/pwt.

[4] Sources: U.S. Energy Information Administration. MIDDLE EAST & NORTH AFRICA.

Table 1 exposes renewable energy (defined in million of kilowatt hours as net geothermal, solar, wind and biomass energy) annual percentage growth rates computed over the period 1980–2012 in MENA Net Oil Importing Countries. In the period 1980-2012, the highest average annual growth rate of renewable energy consumption were recorded in Morocco (38% per year on average) and Tunisia (30% per year on average). Countries that have higher renewable energy consumption growth rates are usually those countries that are increasingly implementing government policies in place not only to encourage and to facilitate the rapid uptake of renewable energy consumption, but also to promote local economies all along the renewables value chain.

This interest is amplified by widespread concern to make available more domestic employment opportunities in the context of expanding populations. Additionally, governments recognize the renewables industry as a promising source of sustainable job creation, principally given the diverse renewable energy supply chain from technology to deployment. Morocco is the twenty-ninth most attractive country worldwide in renewable energy. It is ranked first in the MENA region and second in Africa, according to the new edition of the renewable energy Barometer "Renewable Energy Country Attractiveness Index" prepared by Ernst & Young.

Indeed, Moroccan geographical and weather conditions are extremely favorable for building an energy system based on green energies: the country can in fact count on wind, sunshine and space. Besides, its strategic location at the heart of the north-south energy hub and its already operational electrical interconnections with the Spanish and Algerian networks, offer Morocco the potential to become a major electricity supplier in the region.

Conscious of these strengths, Morocco has made the expansion of green energies its top priority. It is intending to achieve a production capacity of 6,000 MW by 2020, representing a 42% share of total energy production, regularly distributed between solar, wind and hydropower. In terms of solar energy, Morocco's potential is anticipated by The Moroccan Solar Agency (MASEN) at almost 2,600 kWh/m²/year.

To develop this potential, the Kingdom launched in 2009 the Moroccan Solar Energy Program that involves the building of five large solar parks located throughout the country (Aïn Beni Mathar, Ouarzazate, Foum Al Oued, Boujdour and Sebkhat Tah) and combines both photovoltaic and concentrated solar thermal technologies.

Tunisia was set up training program in order to qualify consulting offices, private companies, architectural firms and public administration collaborators in the field of renewable energy and energy efficiency. Thus, the service delivery quality of The National Agency for Energy Conservation (ANME) was significantly improved. A grid of six regional services of the National Agency for Energy Conservation (ANME) has been established and a legal framework based on subsidies and loans was created in order to enlarge the use of renewable energy and to improve energy efficiency.

This program has contributed to reducing the consumption of fossil fuels and thus reducing the cost of energy for the consumer. Note that since 2004, proxy measures of energy substitution and improving energy efficiency have saving more than 2,800 kilotons of oil equivalent on fossil energy. This has led to positive externalities for the economy of Tunisia. In the field of renewable energy and energy efficiency, about 3,400 new jobs have been created, particularly in the production and installation of systems, which operate with solar energy. In addition, the reduction of polluting emissions has contributed to the improvement of air quality in Tunisia and the protection of the global climate.

The institutional donors[5] have supporting the Tunisian policy makers in the creation of appropriate policy, legal and institutional frameworks in the field of renewable energy and energy efficiency. Since 2009, there have been, for the first time in Tunisia, the opportunity for households and private companies to produce electricity from renewable energy for their own consumption and to inject the surplus against rate subsidies in the national power grid[6].

Table 2 reveals real GDP percentage annual growth rates in MENA Net Oil Importing Countries. Morocco had the highest average annual growth rate over the sample period (4.62%), while Cyprus had the lowest average annual growth rate over the sample period (0.041%). In fact, Morocco is the fifth largest economy in Africa. The service sector accounts for 50% of the GDP and mining, construction and manufacturing for an additional 25%. The major contributors to country's growth are tourism, telecoms, and textiles. Morocco is the world's third-largest producer of phosphorus[7].

[5] The institutional donors are French Agency for Development (AFD), The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), (German cooperation) and The European Union (EU).

[6] http://www.leconomistemaghrebin.com/2013/01/05/promotion-des-energies-renouvelables-et-de-lefficacite-energetique-en-tunisie/#sthash.6riYaQx6.dpuf.

[7] http://www.tradingeconomics.com/morocco/gdp-growth.

Table 1: renewable energy growth rates in percent (1980-2012) in MENA Net Oil Importing Countries (NOIC).					
	Armenia	**Cyprus**	**Georgia**	**Israel**	**Jordan**
Mean	4.969767	6.37216	6.677054	25.39292	4.759692
Max	96.89521	73.6667	38.09003	533.3333	103.6036
Min	-45.3898	-40.333	-23.1689	-37.0370	-57.707
Std. Dev.	25.99225	18.06754	16.35188	99.6765	34.61927
Skewness	1.724985	1.608058	0.4610712	4.366977	1.340522
Kurtosis	7.36984	10.34083	2.357514	22.56155	5.120301
Median	1.234593	1.80366	2.833199	1.98362	-0.81967

	Lebanon	**Malta**	**Mauritania**	**Morocco**	**Tunisia**	**Turkey**
Mean	18.73442	16.94215	6.624745	38.04911	30.39063	7.867482
Max	155.0725	450	83.33334	383.3333	220.2946	56.71729
Min	-58.4745	-25.639	-41.93548	-70	-54.0456	-37.9626
Std.Dev.	58.74652	79.66933	19.10768	95.78473	80.65861	22.62588
Skewness	0.942114	5.123558	1.725735	2.229842	2.969751	0.368674
Kurtosis	2.811658	28.17415	10.43348	7.831909	7.764662	2.778676
Median	-1.50125	1.8025	4.15946	0.00632	1.93229	8.348221

Source: Author's calculation using the U.S. EIA and The World Bank Development Indicators on line data base.

Table 2: GDP growth rates in percent (1980-2012) in MENA Net Oil Importing Countries.					
	Armenia	**Cyprus**	**Georgia**	**Israel**	**Jordan**
Mean	3.813412	0.041134	3.424393	4.459337	3.424393
Max	12.21689	12.344	18.86911	18.66484	18.86911
Min	-6.57945	-44.9	-4.044697	-13.4521	-4.044697
Std. Dev.	4.534322	12.50953	4.55411	4.808343	4.55411
Skewness	-0.32632	-2.03305	0.9802696	-0.85161	0.9802696
Kurtosis	2.555987	7.043951	5.402599	9.149656	5.402599
Median	4.185404	4.553669	3.483646	4.437738	3.483646

	Lebanon	**Malta**	**Mauritania**	**Morocco**	**Tunisia**	**Turkey**
Mean	3.652315	3.460806	4.103134	4.623109	4.20327	4.408466
Max	44.47925	8.41424	9.4	23.67487	9.254878	9.485538
Min	-60.3024	-2.65258	-2.4	-41.8	-0.57553	-5.69747
Std. Dev.	20.10517	2.692603	2.901998	11.53375	2.387664	4.364811
Skewness	-1.15910	-0.34010	-0.21855	-2.17594	-0.20841	-0.95343
Kurtosis	5.860917	2.674649	2.635786	9.524605	2.480659	2.97336
Median	4.226727	3.831265	4.175003	6.728151	4.682465	5.15045

Source: Author's calculation using the World Bank Development Indicators on line data base and the Penn World Table (PWT8.0).

Referring to preceding work, we maintain the energy integration in the production function and we will use the production model of Chang and Lee (2008) which has extended by Payne (2009), Apergis et al. (2010), Bowden and Payne (2010) and Apergis and Payne (2011a,b, 2012). This choice is motivated not only by the ability of this model to determine the causality direction between economic growth and energy consumption but also its specificity to distinguish between long and short-run causality. The production modeling framework is given as follows in general notation:

$$Y_{it} = f\left(REC_{it}, NREC_{it}, K_{it}, LF_{it}\right) \quad (1)$$

Where Y_{it} denotes real GDP in millions of constant 2005 U.S. dollars; REC_{it} is total renewable electricity consumption defined in million of kilowatt hours as net geothermal, solar, wind and biomass energy[8]; $NREC_{it}$ is total non-renewable electricity consumption related to coal, natural gas, and petroleum and defined in million of kilowatt hours[9].

K_{it} represents real gross fixed capital formation in millions of constant 2005 U.S. dollars[10]; and LF_{it} is total labor force in millions. These variables are converted into natural logarithms to remove heteroskedasticity from the regression model.

We have carried out a set of panel data unit root test in order to check the robustness of the integration degree and stationarity properties of our series presented in **Table 3** and **Table 4**. Thus, we implement more particularly the following panel data unit root tests (Breitung(2000); Hadri (2000); Im, Pesaran and Shin(2003); Levin, Lin and Chu(2002) and Maddala and Wu (1999) who employ nonparametric methods in conducting panel unit root tests using the Fisher-ADF and Fisher-PP tests, which has the advantage of allowing for as much heterogeneity across units as possible).Note that we do not only apply the popular first generation panel unit root tests mentioned above, but also we recently introduced the second generation panel unit root tests: the CIPS (cross-sectionally augmented IPS) panel unit root tests by Pesaran (2007), which account for possible cross-sectional dependencies among the units included in the panel (Table-4). The difference between first and second generation tests is that the latter (Pesaran (2007)) take into account cross-sectional dependencies, whereas the former do not. A common characteristic of the panel tests mentioned above is that they maintained the null hypothesis of a unit root in all panel members (the only exception is the test by Hadri (2000), whose null hypothesis is stationarity for all panel units). The panel unit

8 Sadorsky (2009a,b) and Apergis and Payne (2010a,b, 2011a,b, 2012) utilize the same measure for renewable energy consumption.

9 Apergis and Payne (2011b, 2012) and Tugcu et al. (2012) utilize the same measure for non renewable energy consumption.

10 The use of real gross fixed capital formation follows Soytas and Sari (2007) and Apergis and Payne (2009 a,b, 2010a,b,c,d, 2011a,b, 2012) in that under the perpetual inventory method with a constant depreciation rate, the variance in capital is closely related to the change in investment.

root tests, as shown in **Table 3** and **Table 4**, expose that each variable is integrated of order one.

Table 3: Unit root tests in panel of MENA Net Oil-Importing Countries.

Variables	Levin, Lin & Chu		Im, Pesaran and Shin W-stat		ADF - Fisher Chi-square		PP - Fisher Chi-square	
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
Y	0.752	0.774	1.648	0.950	15.413	0.843	14.923	0.865
ΔY	- 4.348	0.000**	- 6.043	0.000**	77.106	0.000**	231.342	0.000**
REC	-1.605	0.054	0.067	0.527	23.792	0.640	24.516	0.320
ΔREC	- 6.256	0.000**	- 6.759	0.000**	86.056	0.000**	622.787	0.000**
NREC	- 1.364	0.086	0.584	0.720	25.809	0.260	25.426	0.277
ΔNREC	- 4.849	0.000**	- 6.212	0.000**	77.317	0.000**	160.066	0.000**
K	1.367	0.914	1.895	0.971	28.715	0.153	15.637	0.833
ΔK	- 4.596	0.000**	- 4.719	0.000**	75.449	0.000**	114.046	0.000**
LF	-1.155	0.124	1.229	0.890	12.916	0.935	9.934	0.986
ΔLF	- 4.482	0.000**	- 4.373	0.000**	63.337	0.000**	265.59	0.000**

Variables	Breitung t-stat		Hadri unit root test			
			Hadri Z-stat		Heteroscedastic Consistent Z-stat	
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
Y	0.895	0.814	9.726	0.000**	9.749	0.000**
ΔY	-5.285	0.000**	0.852	0.197	1.160	0.122
REC	-0.841	0.502	7.550	0.000**	5.424	0.000**
ΔREC	-1.887	0.029**	1.145	0.126	1.382	0.188
NREC	-0.106	0.457	5.272	0.000**	6.666	0.000**
ΔNREC	-4.323	0.000**	0.476	0.316	1.172	0.114
K	2.110	0.982	5.366	0.000**	3.508	0.000**
ΔK	-7.910	0.000**	0.576	0.717	0.009	0.503
LF	0.861	0.805	6.996	0.000**	7.417	0.000**
ΔLF	-4.373	0.000**	0.646	0.258	1.499	0.206

Note: Δ = First difference operator. Panel unit root tests include intercept and trend exceptionally Hadri unit root test, which includes intercept only. **denote significance at 5% level.

Table 4: Pesaran's CADF test

Variables	t-bar	cv10	cv5	cv1	Z[t-bar]	P-value
Y	-2.447	-2.660	-2.760	-2.930	-0.402	0.344
ΔY	-2.835	-2.660	-2.760	-2.930	-1.867	0.031**
REC	-2.146	-2.660	-2.760	-2.930	0.730	0.767
ΔREC	-2.879	-2.660	-2.760	-2.930	-1,896	0,046**
NREC	-1.689	-2.660	-2.760	-2.930	2.453	0.993
ΔNREC	-2.799	-2.660	-2.760	-2.930	-1.845	0,027**
K	-2.207	-2.660	-2.760	-2.930	0.502	0.692
ΔK	-2.868	-2.660	-2.760	-2.930	-1.882	0.041**
LF	-2.377	-2.660	-2.760	-2.930	-0.141	0.444
ΔLF	-2.820	-2.660	-2.760	-2.930	-1.841	0.020**

Note: Δ = First difference operator. Deterministic chosen: constant & trend. **denote significance at 5% level.

Given that all variables are integrated of order one, the next step is to test panel cointegration among the variables. Actually, there is a close similarity between panel cointegration tests and panel unit root tests. A number of the tests are based on group-mean estimates, others on pooled estimates. Some take into account cross-sectional dependencies, whereas others do not. We will apply three representative panel cointegration tests: the very popular Pedroni (1999, 2004) and Kao (1999) tests for panel cointegration and the recently introduced test by Westerlund (2007)[11]. The panel cointegration tests results of Pedroni (1999, 2004); Kao (1999) and Westerlund (2007) are presented in **Table 5**, **Table 6** as well as **Table 7**, respectively.

In fact, Pedroni (1999, 2004) undertook two sets of tests for cointegration: panel and group mean. The panel tests are based on the within dimension approach that includes four statistics: panel v, panel ρ, panel PP, and panel ADF-statistics. These statistics pool the autoregressive coefficients across different countries for the unit root tests on the estimated residuals and taking into account common time factors and heterogeneity across countries. The group tests are based on the between dimension approach, which includes three statistics: group ρ, group PP, and group ADF-statistics. These statistics are based on the individual autoregressive coefficients averages associated with the residuals unit root tests for each country in the panel. All seven tests are distributed asymptotically as standard normal[12].

Kao (1999) recommends estimating the homogeneous cointegration relationship through pooled regression allowing for individual fixed effects and he suggested testing the null hypothesis of no cointegration. In order to assess the robustness of our findings and to check the existence of a cointegration relationship for the period 1980-2012, we implemented the recent bootstrap panel cointegration test proposed by Westerlund (2007). The error correction based test by Westerlund (2007) does not only permit for various forms of heterogeneity, but also offers p values that are robust against cross-sectional dependencies passing through bootstrapping[13]. Brief, it is tested whether the null of no error correction can be rejected. If the null can be rejected, there is proof in favor of cointegration.

Kao (1999)'s residual cointegration tests, all seven panel cointegration tests of Pedroni (1999, 2004) as well as the Westerlund (2007) tests based on the bootstrapped p-values reject the null hypothesis of no cointegration at the 5% significance level. The results present even stronger evidence of cointegration. Thus, the results indicate that there is a long-run equilibrium

[11] A comprehensive survey on panel cointegration tests is exposed by Breitung et al (2005).

[12] See Pedroni (1999) for more details on the heterogeneous panel and group mean panel cointegration statistic end note.

[13] In favor of a description of the respective STATA procedure see Persyn and Westerlund (2008).

relationship between real GDP, renewable energy consumption, non renewable energy consumption, real gross fixed capital formation, and the labor force.

Table 5 : Pedroni (1999, 2004) Cointegration tests for MENA Net Oil-Importing Countries:

	Within-Dimension				Between-Dimension		
	Statistic	Prob.	Statistic	Prob.		Statistic	Prob.
Panel v-Statistic	1.736	0.0412**	2.698	0.0004**			
Panel rho-Statistic	-2.105	0.0176**	-1.988	0.0234**	**Group rho-Statistic**	- 4.732	0.0000**
Panel PP-Statistic	-8.631	0.0000**	-1.966	0.0246**	**Group PP-Statistic**	-7.336	0.0000**
Panel ADF-Statistic	-5.513	0.0000**	-1.742	0.0407**	**Group ADF-Statistic**	-2.434	0.0075**

Note: Null hypothesis: No cointegration.
Trend assumption: Deterministic intercept and trend.
Lag selection: Automatic SIC with a max lag of 5.
****Critical values at the 5% significance level.**

Table 6 : kao (1999) Cointegration test for MENA Net Oil-Importing Countries:

	t-Statistic	Prob.
ADF	-2.220	0.0132**
Residual variance	0.009404	
HAC variance	0.009103	

Note: Null hypothesis: No cointegration.
Trend assumption: No deterministic trend.
Automatic lag selection based on SIC with max lag of 6.
****Critical values at the 5% significance level.**

Table 7 : Westerlund(2007) ECM panel cointegration tests:

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-2,638	-3,335	0,001**	0.020**
Ga	-9.077	-1.578	0.048**	0.032**
Pt	-11.595	-2.882	0.002**	0.010**
Pa	-7.340	-2,829	0.001**	0.027**

Note: Optimal lag and lead length determined by Akaike Information Criterion with a maximum lag and lead length of 2. We allow for a constant and deterministic trend in the cointegration relationship. Number of bootstraps to obtain bootstrapped p-values which are robust against cross-sectional dependencies set to 400. Results for H0: no cointegration.
The Bartlett kernel window width set according to $4(T/100)^{2/9}$.
****Critical values at the 5% significance level.**

Given the presence of panel cointegration, the fully modified OLS (FMOLS) technique for heterogeneous cointegrated panels is performed to estimate the parameters of the cointegrated relationship (Pedroni, 2000)[14]. The FMOLS results for MENA Net Oil Importing Countries are shown in **Table 8** below.

[14] Note that the estimates from either FMOLS or DOLS are asymptotically equivalent for more than 60 observations (Banerjee, 1999). The panel data set of this study contains 363observations.

Table 8: Parameter estimation using FMOLS for MENA Net Oil Importing Countries:		
Variables	**Coefficient**	**Prob.**
Y	0.072	0.0018**
REC	0.570	0.0000**
NREC	0.387	0.0000**
K	0.517	0.0000**
LF	0.344	0.0003**
R-squared =0.979151	**Adjusted R-squared** =0.978285	**Durbin-Watson stat** = 1.835966

Note: ** denotes the significance at 5% level.

All the coefficients are positive and statistically significant at the 5% significance level and since all variables are expressed in natural logarithms, the coefficients can be interpreted as elasticity estimates. The results indicate that a 1% increase in renewable energy consumption increases real GDP by 0.570%; a 1% increase in non- renewable energy consumption increases real GDP by 0.387 %; a 1% increase in real gross fixed capital formation increases real GDP by 0.517%; and a 1% increase in the labor force increases real GDP by 0.344%. Subsequently, a panel vector error correction model is estimated to perform Granger-causality tests (Pesaran et al. 1999). The two-step procedure of Engle and Granger (1987) is performed by estimating the long run model specified in Eq. (2)[15] at first in order to obtain the estimated residuals. Then, the lagged residuals from Eq. (2) are used as the error correction terms for the dynamic error correction model as follows:

$$\Delta Y_{it} = \alpha_{1j} + \sum_{k=1}^{q} \theta_{11ik} \Delta Y_{it-k} + \sum_{k=1}^{q} \theta_{12ik} \Delta REC_{it-k} + \sum_{k=1}^{q} \theta_{13ik} \Delta NREC_{it-k} + \sum_{k=1}^{q} \theta_{14ik} \Delta K_{it-k} + \sum_{k=1}^{q} \theta_{15ik} \Delta LF_{it-k} + \lambda_{1i} \varepsilon_{it-1} + \mu_{1it} \qquad (3a)$$

$$\Delta REC_{it} = \alpha_{2j} + \sum_{k=1}^{q} \theta_{21ik} \Delta Y_{it-k} + \sum_{k=1}^{q} \theta_{22ik} \Delta REC_{it-k} + \sum_{k=1}^{q} \theta_{23ik} \Delta NREC_{it-k} + \sum_{k=1}^{q} \theta_{24ik} \Delta K_{it-k} + \sum_{k=1}^{q} \theta_{25ik} \Delta LF_{it-k} + \lambda_{2i} \varepsilon_{it-1} + \mu_{2it} \qquad (3b)$$

[15] $Y_{it} = \alpha_i + \delta_i t + \psi_{1i} REC_{it} + \psi_{2i} NREC_{it} + \psi_{3i} K_{it} + \psi_{2i} LF_{it} + \varepsilon_{it} \quad (2)$, Where i=1...N for each country in the panel and t=1, ...,T refers to the time period. The parameters α_i and δ_i allow for the possibility of country-specific fixed effects and deterministic trends, respectively. ε_{it} are the estimated residuals representing deviations from the long run relationship. Given that all variables are expressed in natural logarithms, the ψ parameters of the model can be interpreted as elasticity estimates.

$$\Delta NREC_{it} = \alpha_{3j} + \sum_{k=1}^{q} \theta_{31ik} \Delta Y_{it-k} + \sum_{k=1}^{q} \theta_{32ik} \Delta REC_{it-k} + \sum_{k=1}^{q} \theta_{33ik} \Delta NREC_{it-k} + \sum_{k=1}^{q} \theta_{34ik} \Delta K_{it-k} + \sum_{k=1}^{q} \theta_{35ik} \Delta LF_{it-k} + \lambda_{3i} \varepsilon_{it-1} + \mu_{3it} \qquad (3c)$$

$$\Delta K_{it} = \alpha_{4j} + \sum_{k=1}^{q} \theta_{41ik} \Delta Y_{it-k} + \sum_{k=1}^{q} \theta_{42ik} \Delta REC_{it-k} + \sum_{k=1}^{q} \theta_{43ik} \Delta NREC_{it-k} + \sum_{k=1}^{q} \theta_{44ik} \Delta K_{it-k} + \sum_{k=1}^{q} \theta_{45ik} \Delta LF_{it-k} + \lambda_{4i} \varepsilon_{it-1} + \mu_{4it} \qquad (3d)$$

$$\Delta LF_{it} = \alpha_{5j} + \sum_{k=1}^{q} \theta_{51ik} \Delta Y_{it-k} + \sum_{k=1}^{q} \theta_{52ik} \Delta REC_{it-k} + \sum_{k=1}^{q} \theta_{53ik} \Delta NREC_{it-k} + \sum_{k=1}^{q} \theta_{54ik} \Delta K_{it-k} + \sum_{k=1}^{q} \theta_{55ik} \Delta LF_{it-k} + \lambda_{5i} \varepsilon_{it-1} + \mu_{5it} \qquad (3e)$$

Where the term Δ denotes first differences; θ represents the fixed country effect; k (k=1,…,q) is the optimal lag length determined by the Schwarz Information Criterion[16] ; $\varepsilon_{i,t-1}$ is the estimated lagged error correction term which is derived from the long-run cointegration relationship of Eq. (2). The term λ is the adjustment coefficient and μ is the disturbance term assumed to be uncorrelated with zero means.

Table 9: Panel causality tests for MENA Net Oil Importing Countries (NOIC):

Dependante Variable	***Source Of Causation* (Independent variables) Short-run**					**Long -run**
	ΔY	ΔREC	$\Delta NREC$	Δk	ΔLF	**ECT**
ΔY $(3a)$	-	0.170 (0.003) **	0,115 (0.000) **	0,059 (0.000) **	0,012 (0.000) **	-0.079 (0.000) **
ΔREC $(3b)$	1,422 (0.000) **	-	-0,203 (0.000) **	0,261 (0.001) **	0,498 (0.763)	-0.205 (0.000) **
$\Delta NREC$ $(3c)$	0,421 (0.002) **	-1,673 (0.000) **	-	0,046 (0.031) **	0,253 (0.000) **	-0.064 (0.003) **
Δk $(3d)$	0.441 (0.001) **	1,173 (0.759)	0,098 (0.007) **	-	0,247 (0.000) **	-0.192 (0.000) **
ΔLF $(3e)$	0,266 (0.005) **	-1,112 (0.671)	0,034 (0.000) **	0,232 (0.000) **	-	-0.068 (0.000) **

Note:

- **ECT denotes the estimated coefficient on the error correction term.**
- **The sum of the lagged coefficients for the respective short run changes is performed.**
- **The vector error correction model is estimated using panel regression techniques with fixed effects for cross section and Heteroscedasticity robust standard errors.**
- **Wald chi-square tests reported with respect to short-run changes in the independent variables.**
- **** denotes the significance at 5% level.**
- **(.): Probabilities.**

[16] The optimum lag length was set at 2 as determined by the Schwarz information criteria.

Table 9 exposes the results from the panel error correction model. Thus, Eq. (3a) proves that renewable energy consumption, non-renewable energy consumption, real gross fixed capital formation, and the labor force each have a positive and statistically significant impact on economic growth in the short-run. Eq. (3b) indicates that real gross fixed capital formation and economic growth have a positive and statistically significant impact on renewable energy consumption while non-renewable energy consumption has a negative and statistically significant impact in the short-run. Moreover, the negative impact of non-renewable energy consumption on renewable energy consumption proves substitutability between the two types of energy sources. Besides, the labor force has a statistically insignificant impact in the short-run. With regard to Eq. (3c) for non renewable energy consumption, economic growth, real gross fixed capital formation and labor force each have a positive and statistically significant impact in the short-run. The negative and statistically significant impact of renewable energy consumption on non-renewable energy consumption confirms the substitutability revealed in Eq. (3b) between renewable and non-renewable energy consumption. Eq. (3d) exposes that economic growth, non-renewable energy consumption, and the labor force each have a positive and statistically significant impact on real gross fixed capital formation but renewable energy consumption has a statistically insignificant impact in the short-run. Last of all, for Eq. (3e) economic growth, non-renewable energy consumption and real gross fixed capital formation each have a positive and statistically significant impact on the labor force while renewable energy consumption has a statistically insignificant impact in the short-run. As for the long-run dynamics, the respective error correction terms in Eqs. (3a) to (3e) are statistically significant suggesting that economic growth, renewable energy consumption, non-renewable energy consumption, real gross fixed capital formation, and the labor force each respond to deviations from long-run equilibrium.

Consequently, the panel causality results are evidence for bidirectional causality between renewable energy consumption and economic growth as well as between non-renewable energy consumption and economic growth in both the short and long-run. In addition, the results also prove that renewable and non renewable energy consumption may serve like substitutes to each other. Consequently, renewable energy sources are looked as alternative in order to substitute the non renewable sources of energy given that the goal of these importing countries is primarily to reduce dependence on expensive imported oil so as to cut down their steep bills and to ensure energy security, resulting in the highest renewable energy growth rates to date. Further, the existence of bidirectional causality supports the feedback hypothesis for both renewable and non-renewable energy consumption and economic growth and provides evidence of their interdependence. In reality, the interdependence between the two types of energy sources and economic growth suggests that policies which enhance both renewable and non-renewable energy consumption have a positive influence on economic growth. Although renewable energy consumption has appeared as an essential energy source in the world energy consumption-mix while the traditional (non-renewable) energy sources are also needed. Besides, the bidirectional causal relationship between renewable and non-renewable energy consumption that is confirmation of their substitutability, suggests that the development of the renewable energy sector can reduce the greenhouse gas emissions and toxic waste generated by non renewable energy consumption, which can make the world a cleaner and safer place.

Governments of MENA Net Oil Importing Countries should put into practice policies that promote the development of renewable energy sector such as renewable energy production tax credits, installation rebates for renewable energy systems, renewable energy portfolio standards, and the creation of markets for renewable in order to control greenhouse gas emissions from non-renewable energy sources.

4. Concluding remarks:

The renewable energy consumption has emerged as an energy source that can moderate the growing concerns about CO2 emissions, high and volatile energy prices and reduce dependence on foreign sources energy. This paper considers the simultaneous use of renewable and non-renewable energy to differentiate the relative impact of each these sources on economic growth for a panel of eleven MENA Net Oil Importing Countries over the period 1980-2012 within a multivariate framework.

The panel cointegration tests of Pedroni (1999, 2004), Kao (1999) as well as the recently Westerlund(2007) show that there is a long-run equilibrium between real GDP (Y), renewable and non-renewable energy consumption, real gross fixed capital formation and labor force with elasticities estimated positive and statistically significant in the long-run. The panel causality results are evidence for bidirectional causality between renewable energy consumption and economic growth as well as between non-renewable energy consumption and economic growth in both the short and long-run supporting the feedback hypothesis. Consequently, the bidirectional causal relationship between renewable and non-renewable energy consumption is a confirmation of their substitutability and interdependence. The interdependence between the consumption of renewable and non-renewable energy and economic growth suggests that the two energy sources are vital for economic growth, which encourages the use of both energy sources. In the case of economic market of MENA Net Oil Importing Countries, which have experienced phenomenal growth, there has been a heavy reliance on non-renewable energy sources to meet the demand. Moreover, Bidirectional causal relationship between economic growth and renewable energy consumption in the short-run is not surprising because these economies are seeking to protect themselves from price volatility of fossil fuels and to move closer to energy independence.

Governments play a crucial role in the coordination of infrastructure development at local, national and international scale. As a matter of fact, Governments should implement policies that promote the development of renewable energy sector, which promotes economies of scale such as tax credits for renewable energy production, installation rebate for renewable energy systems and the creation of markets for renewable energy certificates.

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