International Journal of Business and Economics Research
2016; 5(6): 217-226
http://www.sciencepublishinggroup.com/j/ijber
doi: 10.11648/j.ijber.20160506.15
ISSN: 2328-7543 (Print); ISSN: 2328-756X (Online)

Renewable Energy Consumption, CO_2 Emissions and Economic Growth: A Case of Jordan

Khawlah Ali Ahmed AbdAlla Spetan

Department of Business Economics, the University of Jordan, Amman, Jordan

Email address:
khawlahs2000@yahoo.com, khawlah.spetan@ju.edu.jo

To cite this article:
Khawlah Ali Ahmed AbdAlla Spetan. Renewable Energy Consumption, CO_2 Emissions and Economic Growth: A Case of Jordan. *International Journal of Business and Economics Research.* Vol. 5, No. 6, 2016, pp. 217-226. doi: 10.11648/j.ijber.20160506.15

Received: October 19, 2016; **Accepted**: October 31, 2016; **Published**: November 23, 2016

Abstract: This study inspects the causal relationship between renewable energy consumption, CO_2 emissions, labor, capital and economic growth for Jordan over the period 1986-2012 within a multivariate framework. The time series cointegration test suggests a long-run equilibrium relationship among real GDP, renewable energy consumption, real gross fixed capital formation and labor force. The outcomes of the error correction models reveal that there is a unidirectional causality running from renewable energy consumption to real GDP. Also there is a unidirectional causality running from renewable energy consumption to carbon dioxide while unidirectional causality is revealed from real GDP to capital and finally bidirectional causality is detected between capital and renewable energy consumption in the short-run. Furthermore the error correction terms indicate that there is a long-run bidirectional causality between the variables except for labor model which is statistically insignificant. In addition the outcomes revealed that an increase in the usage of renewable energy has a desirable effect on environment as it reduces the CO_2 emissions.

Keywords: Jordan, Renewable Energy Consumption, CO_2, Economic Growth, Granger Causality, VECM

1. Introduction

The issues related to the economic growth, energy consumption and environment have an increasing concentration in the recent literature. The nexus between those variables in addition to labor and capital in Jordan has been the main core of this study.

One of the most challenging matters in the present discourse of sustainability is exploring the impact of renewable energy on economic growth. The quest for an alternative energy sources works as a way to alleviate the environmental impact of carbon dioxide emissions in the same time fulfilling the energy needs for economic growth. Many countries try to find ways to motivate social and economic growth by developing the renewable energy sector. It is likely that investment in renewable energy can create new basis of growth and extend the industrial sector and on the other hand it is a way to expand and diversify the sources of energy in the light of non-renewable energy sources depletion. Research papers done by Apergis and Payne (2010) [6], Menegaki A. N. (2011) [18], Leitao N. C. (2014) [16], Behboudi D. et al. (2013) [8], Apergis and Danuletiu (2014) [5], Nnaji Ch. E. et al. (2013) [19] and Hung-Pin L. (2014) [13], have studied the causality relationship between economic growth and renewable energy consumption as well as economic growth and carbon dioxide emissions for individual country and pool of countries with different stages of development and these studies have introduced different results and conclusions.

Jordan's energy market has experienced shortage of regular commercial energy resources which inflicted a burden on the government budget because of the high fluctuation in price of imported oil. It imports about 97 per cent of its energy use for year 2013 [27].[1] Table 1 reveals some energy indicators which underline the energy dependency towards abroad as it increases over time instead of decreasing. The net energy imports are calculated as energy consumption less production, both measured in oil equivalents. The Combustible renewable and waste as a percentage of total energy is very small during the period (1990-2013). Domestic energy stand for just about 3% of Jordan's total

1 The World Bank, World Development Indicators, http://wdi.worldbank.org/table/3.8.

energy needs [26].[2]

Jordan depends on external sources for its energy accordingly it is perceptible that any crisis or emergency in energy supply can destructively influence the economic growth. Therefore, any strategies that provide energy supply security should be employed. The development of renewable energy (RE) sector and other energy alternative resource is a necessity since it will help to diminish the dependence on foreign energy sources and alleviate the fluctuation of oil and natural gas prices on international markets; furthermore it contributes in reduction of the long-run environmental deterioration correlated with carbon emissions.

This study main purpose is to empirically explore the dynamic causal and long-run relationship among renewable energy consumption (REC), carbon dioxide (CO_2), labor (L), capital (K) and economic growth in Jordan for the period 1986-2012. The connection between renewable energy consumption, CO_2 emissions and economic growth has been discussed in many research studies for different countries categories but not specifically for Jordan. Whereas the present consumption of renewable energy as a percentage of total final energy consumption is quite low, an inspection of REC- CO_2 -economic growth relationship in Jordan may add to the enduring debate of feasibility of renewable energy in the execution of sustainable energy combination in such developing country. As in many of developing countries, Jordan may experience causal relationships running from renewable energy consumption and CO_2 to economic growth. It is important to explore the direction of the causality between the REC and economic growth on one hand and CO_2 and economic growth on the other hand through short-run and long-run relationships.

The study uses a production model to assess the causal nexus between renewable energy consumption, carbon dioxide and economic growth with inclusion of measures for capital and labor as means to avoid any possibility of omitted variable bias [6].[3]

The paper is structured in five parts: i) section one is the introduction; ii) Section 2 discusses an overview of the various theoretical and empirical findings of relationship between energy consumption and economic growth; iii) Section 3 describes the data and econometric methodology; iv) Section 4 presents the obtained empirical results; v) and finally in section 5 conclusions are provided.

2. Literature and Empirical Review

The existing literature on energy-emissions-economic growth link suggests that most studies focused on the relationship of the energy use and economic growth or environment and economics have indecisive and controversial results.

In exploring the relationship between energy usage and economic growth there were various studies have been conducted with different econometric methodologies, time periods and regions and countries. According to the different results of these studies four hypotheses (growth, conservation, feedback and neutrality) have been categorized regarding the nexus between energy and economic growth, the direction of causality relationship between these variables has important policy implications. Growth hypothesis is supported if there is a unidirectional causality running from energy consumption to economic growth. Thus, the energy consumption has significant impact on economic growth; therefore any reduction in energy consumption may have an adverse influence on economic growth. If there is unidirectional causality from economic growth to energy consumption a conservation hypothesis is confirmed and any adoption of conservative policies to reduce the energy consumption might not have unfavorable impact on economic growth. The feedback hypothesis asserts the bidirectional causality relationship between energy consumption and economic growth. Finally the neutrality hypothesis believes that the energy consumption has a little or no influence on economic growth and vice versa.

Studies such as Ucan O. et al. (2014) [31], Lee and Chang (2008) [14], Lee (2005) [15], Acaravci A. and Ozturk I. (2012) [1], Adom Ph. K. (2011) [2] Osigwe A. C. and Arawomo D. F. (2015) [20], Silva S. et al.(2011) [27], Payne J. E. (2009) [22], Shahbaz M. et al. (2015) [26] and Farhani S. (2015) [10] used multivariate framework for various countries with different developing stages incorporate the some or all of these variables; energy consumption, renewable energy consumption, carbon dioxide, labor and capital.

Empirical results on renewable energy consumption-growth and CO_2 -growth nexuses have produced mixed outcomes with respect of the energy-economic growth hypotheses on the causal relationship. Acaraci and Ozturk (2012) [1] examine the relationship between electricity consumption and economic growth in Turkey for 1968-2006 period using Granger causality in error correction model within a bivariate framework, their finds supported the growth hypothesis approach. In exploration of the nexus among electricity fuel consumption, CO_2 emissions and economic growth in Nigeria in multivariate framework Nanji et al. (2013) [19] find a short-run and long-run positive and statistically significant relationship between CO_2 emissions and fossil fuel consumption.

Ucan et al. (2014) [31] investigate the relationship among renewable energy, non-renewable, CO_2 missions and economic growth for fifteen European countries during the period 1990-2011. The causality tests show unidirectional causality between non-renewable energy and economic growth and the outcomes also indicates that an increase in renewable energy consumption cause an increase in real GDP which is in its turn has a positive relationship with greenhouse gas emissions. In panel study of the nexus between renewable energy and economic growth Apergis and

2 Khawlah A. Spetan et al., "A guide to Renewable Energy In Egypt and Jordan", Friedrich Ebert Stiftung, 2015.

3 Nicholas Apergis and James E. Payne, "Renewable Energy Consumption and Growth in Eurasia", Energy Economics, 32 (2010) 1392-1397.

Danuletiu (2014) [5] provide robust evidence of bidirectional causality relationship between renewable energy and economic growth for the total sample of 80 countries as well as across regions.

Adom (2011) [2] finds a unidirectional causality from economic growth to electricity consumption in Ghana for the 1971-2008 period. Using error correction model framework to test the granger causality of energy consumption, oil price and economic growth in Nigeria Osigwe and Arawomo (2015) [20] reveal bidirectional causality between consumption and economic growth emphasizing the feedback hypothesis. Leitao (2014) [16] inspects the correlation between renewable energy, carbon dioxide emissions, globalization and economic growth for the period 1970-2010 to Portugal and the study find a unidirectional causality between renewable energy and economic growth. A panel data co-integration methodology has been used for 12 MENA countries by [10] for the period of 1975-2008. Farhani (2015) [10] finds a unidirectional causality running from renewable energy consumption to CO_2 emissions with no evidence of causal relationship among renewable energy consumption and economic growth.

Shahateet et al. (2014) [25] explore the relationship between energy consumption and economic growth within productivity theory framework for Jordan covering the period of 1970-2011. Empirical results imply that there is a unidirectional causality running from real GDP to energy consumption, whereas Ajlouni (2015) [3] finds an evidence of positive bidirectional causality between energy consumption and economic growth as he employs Granger-causality test between Energy use and economic growth for Jordan covering the period of 1980-2012.

In this study a vector error correction model (VECM) based Granger non-causality test is employed to investigate the relationship between renewable energy, carbon dioxide emissions, labor, capital and economic growth within neoclassical production function framework and to test for causal relationship among these variables. The new thing about this study is the introducing of the impact of renewable energy on economic growth in Jordan, since there is a lack of such studies.

Table 1. *Some Energy Indicators in Jordan (1990-2013).*

Year	Fossil fuel energy consumption (% of total)	Energy imports, net (% of energy use)	Combustible renewable and waste (% of total energy)	Alternative and nuclear energy (% of total energy use)	Renewable energy consumption (% of total final energy consumption)	CO_2 emissions (metric tons per capita)
1990	98.13	95.05	0.065	1.80	2.77	3.10
1991	98.19	95.31	0.069	1.73	2.88	2.77
1992	98.52	95.50	0.062	1.56	2.54	3.28
1993	98.45	95.00	0.062	1.59	2.53	3.06
1994	98.47	93.26	0.064	1.47	2.34	3.28
1995	98.55	93.50	0.060	1.39	2.22	3.14
1996	98.59	93.77	0.058	1.36	2.20	3.19
1997	98.57	93.59	0.064	1.37	2.14	3.17
1998	98.56	93.68	0.063	1.38	2.21	3.15
1999	98.54	93.85	0.065	1.41	2.18	3.11
2000	98.46	94.12	0.063	1.41	2.09	3.25
2001	98.00	94.17	0.094	1.43	2.12	3.30
2002	97.98	94.81	0.090	1.38	2.09	3.42
2003	96.96	94.46	0.095	1.33	1.98	3.46
2004	97.67	95.27	0.080	1.15	1.83	3.72
2005	97.90	96.17	0.072	1.08	1.69	3.95
2006	97.89	95.76	0.075	1.45	2.28	3.82
2007	98.41	96.16	0.088	1.46	2.33	3.83
2008	98.01	96.10	0.087	1.64	2.74	3.55
2009	97.96	96.07	0.075	1.68	2.78	3.49
2010	97.35	96.17	0.088	1.82	2.97	3.25
2011	95.99	96.10	0.086	1.91	3.02	3.21
2012	97.32	96.53	0.080	1.85	3.07	3.55
2013	97.61	96.54	0.083	1.94	-	3.44

Source: The World Bank Indicatorhttp://databank.worldbank.org/data/reports.aspx?source.

3. Data and Methodology

3.1. Data and Model Specification

The study used a secondary data. The yearly-time series cover annual data from 1986 to 2012 for Jordan. The multivariate data framework comprises the economic growth (real GDP) (Y) and real gross fixed capital formation (K) both are measured in constant 2005 U.S. dollars, the labor force (L), total renewable electricity net consumption (REC) in million kilowatt hours and total carbon dioxide CO_2 from the consumption of energy in million metric tons. The data were obtained from the World Bank Development Indicators [30] and USA Energy Information Administration (eia) [9]. The parameters of the model can be explained as elasticity since all variables are converted into natural logarithm to reduce the heterogeneity among the variables.

Time series data are used to study the relationships between economic growth, fixed capital formation, labor force, renewable electricity net consumption and carbon dioxide emissions from the consumption of energy in Jordan. We get the following function:

$$Y = f(REC, L, K, CO_2) \quad (1)$$

The choice of these variables and the time period relied on the data accessibility. The following model was applied:

$$LY_t = \beta_0 + \beta_1 REC_t + \beta_2 LL_t + \beta_3 LK_t + \beta_4 LCO_{2t} + \varepsilon_t \quad (2)$$

Where the variables are as defined previously. The β_0 is a constant term, β_1 to β_4 are estimated parameters in the model, *t* is a time series data and ε_t is an error term.

***Table 2.** Descriptive statistics of main variables. 1986-2012.*

	LY	LL	LK	LREC	*LCO₂*
Mean	23.01	13.86	21.73	3.51	2.69
Median	22.95	13.95	21.69	3.74	2.73
Maximum	23.61	14.32	22.30	4.28	3.03
Minimum	22.44	13.26	21.12	2.08	2.23
Std. Dev.	0.38	0.31	0.34	0.67	0.26
Skewness	0.15	-0.65	0.32	-0.31	-0.48
Observatios	25	25	25	25	25

*where L refers to natural logarithm

3.2. Unit Root Tests

In order to explore the possibility of co-integration, the analysis should start with unit root tests for each particular variable. In order to have robust outcomes, three various unit root tests have been performed, specifically Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS).

ADF (1979) is a unit root test similar to the simple DF test, except that it includes adding an unidentified number of lagged first differences of the dependent variable to capture autocorrelated omitted variables that would otherwise enter the error term [11].[4] The realistic rule for determining the number of lags is to be relatively small since too many lags may lower the power of the test in the same time it has to be adequate to eliminate the serial correlation in the residual. PP (1988) test is an alternative approach of adding lagged first difference of the dependent variable that applies a non-parametric correction to take account of any possible autocorrelation.

The ADF test is based on estimating the following test regression:

$$\Delta y_t = \alpha y_{t-1} + \sum_{j=1}^{p} \beta_j \Delta y_{t-j} + X'_t \delta + \varepsilon_t \quad (3)$$

where $t = 1, 2, ..., T$ is the time period; X_t embodies the exogenous variables in the model, including any fixed effects or individual time trend; ρ is the lagged difference terms, Δy_{t-j}, are used to approximate the ARMA structure of the errors, and the value of ρ is set so that the error ε_t is serially uncorrelated[5]; y_t is the dependent variable; ε_t is a white-noise disturbance. The test involves the null hypothesis that is the variable has a unit root,

$$H_0 : \alpha = 0$$

against the alternative hypothesis which permits y_t to have a unit root,

$$H_1 : \alpha \prec 0$$

The KPSS (1992) is different from other two tests in that the series y_t is assumed to be stationary under the null hypothesis.

3.3. Co-Integration Test

After the examination of unit root tests, the next step is to test for the existence of a long-run co-integration among GDP and the independent variables. Cointegration implies that if two or more series are connected to create an equilibrium relationship spanning the long run then, despite the series themselves may hold stochastic trends, they will however move together over time with constant difference between them. This technique gives method of identifying and preventing spurious regressions produced by non-stationary series. Therefore, it is likely to determine the long-run relationship between the five variables.

The Johansen cointegration test procedure is conducted for this purpose. This test procedure not only verifies the number of cointegrating vectors but also provides the vectors estimates.

Johansen (1988) test use the maximum likelihood methodology, proposing two statistic ratio tests, the trace test and the maximum eigenvalues tests.

Johansen's methodology developed a vector autoregression (VAR)-based cointegration tests of order ρ as follows:

$$y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + Bx_t + \varepsilon_t \quad (4)$$

where t = 1,….., T refers to the number of observations over time; y_t is $n \times 1$ vector of non-stationary I(1) variables; x_t is a d vector deterministic variables and ε_t is a vector of innovations. The trace test and maximum eigenvalue test, given in equations (5) and (6) respectively:

$$\lambda_{trace} = -T \sum_{t=r+1}^{p} \ln(1 - \hat{\lambda}_t) \quad (5)$$

$$\lambda_{\max} = -T \ln(1 - \hat{\lambda}_{r+1}) \quad (6)$$

4Richard H. & Robert S., "Applied Time Series Modeling and Forecasting", Wiley, 2003.

5http://faculty.washington.edu/ezivot/econ584/notes/unitroot.pdf.

Where T is the size of the sample and $\hat{\lambda}_{t+1},.....,\hat{\lambda}_p$ denote the i-th largest eigenvalue of the canonical correlation [12].[6]

The null hypothesis of no co-integration is stated as there are r cointegration vectors against the alternative of ρ cointegration vectors in the trace test. While the maximum eigenvalues test investigates the null hypothesis of r cointegrating vectors against the alternative hypothesis of r +1 cointegrating vectors.

3.4. Regression Models

In the existence of a co-integrating relationship between variables, it is useful to highlight the long-run relationship between economic growth, renewable energy consumption, fixed capital formation, labor force and CO_2 emissions. Since the independent variables are co-integrated with constant, and hence a long-run equilibrium relationship exists among these variables through the unit root tests, the parameters of the co-integrated relationship in equation (4) will be estimated.

Following Apergis and Payne (2010) [6] and Lise W. and Montfort K. (2005) [17] the formulated equation was adopted as mentioned earlier:

$$LY_t = \beta_0 + \beta_1 LREC_t + \beta_2 LL_t + \beta_3 LK_t + \beta_4 LCO_{2t} + \varepsilon_t \tag{7}$$

In order to draw out the causality relationship between co-integrated variables a vector error correction model (ECM) is employed to execute Granger-causality tests to analyze the unidirectional or bidirectional causality between the variables. The ECM includes both short run and long run effects. The ECM equations are written as follows:

$$\Delta LY_t = \omega_{1j} + \sum_{k=1}^{q}\theta_{11k}\Delta LY_{t-k} + \sum_{k=1}^{q}\theta_{12k}\Delta LL_{t-k} + \sum_{k=1}^{q}\theta_{13k}\Delta LK_{t-k} + \sum_{k=1}^{q}\theta_{14k}\Delta LREC_{t-k} + \sum_{k=1}^{q}\theta_{15k}\Delta LCO_{t-k} + \lambda_1 ECT_{t-1} + u_{1t} \tag{8}$$

$$\Delta LL_t = \omega_{2j} + \sum_{k=1}^{q}\theta_{21k}\Delta LY_{t-k} + \sum_{k=1}^{q}\theta_{22k}\Delta LL_{t-k} + \sum_{k=1}^{q}\theta_{23k}\Delta LK_{t-k} + \sum_{k=1}^{q}\theta_{24k}\Delta LREC_{t-k} + \sum_{k=1}^{q}\theta_{25k}\Delta LCO_{t-k} + \lambda_2 ECT_{t-1} + u_{2t} \tag{9}$$

$$\Delta LK_t = \omega_{3j} + \sum_{k=1}^{q}\theta_{31k}\Delta LY_{t-k} + \sum_{k=1}^{q}\theta_{32k}\Delta LL_{t-k} + \sum_{k=1}^{q}\theta_{33k}\Delta LK_{t-k} + \sum_{k=1}^{q}\theta_{34k}\Delta LREC_{t-k} + \sum_{k=1}^{q}\theta_{35k}\Delta LCO_{t-k} + \lambda_3 ECT_{t-1} + u_{3t} \tag{10}$$

$$\Delta LREC_t = \omega_{4j} + \sum_{k=1}^{q}\theta_{41k}\Delta LY_{t-k} + \sum_{k=1}^{q}\theta_{42k}\Delta LL_{t-k} + \sum_{k=1}^{q}\theta_{43k}\Delta LK_{t-k} + \sum_{k=1}^{q}\theta_{44k}\Delta LREC_{t-k} + \sum_{k=1}^{q}\theta_{45k}\Delta LCO_{t-k} + \lambda_4 ECT_{t-1} + u_{4t} \tag{11}$$

$$\Delta LCO_t = \omega_{5j} + \sum_{k=1}^{q}\theta_{51k}\Delta LY_{t-k} + \sum_{k=1}^{q}\theta_{52k}\Delta LL_{t-k} + \sum_{k=1}^{q}\theta_{53k}\Delta LK_{t-k} + \sum_{k=1}^{q}\theta_{54k}\Delta LREC_{t-k} + \sum_{k=1}^{q}\theta_{55k}\Delta LCO_{t-k} + \lambda_5 ECT_{t-1} + u_{5t} \tag{12}$$

where Δ is the first difference operator, k is the lag length and u is the uncorrelated error term. The coefficient of the error correction term (ECT) λ measures the long run equilibrium (causality) relationship by examine the null hypothesis of statistical significance of t-test, whereas the θ represents the short-run causal relation.

4. Empirical Results

Many types of unit root tests are computed in order to appraise the stationary of the variables most of them indicates that each variable is integrated of order one I (1) at 5 percent of significance. The ADF, PP and KPSS tests in level failed to reject the null hypothesis of unit root for all the variables without intercept or trend, with intercept and with constant and trend except for REC variable. With that we still cannot reject the non-stationarity of REC in level with intercept at 1 percent of significance. In general, results suggest that the series are non-stationary in levels, and stationary in first differences. The

6 Erik Hjalmarsson and Pär Österholm, "Testing for Cointegration Using the Johansen Methodology when Variables are Near-Integrated", IMF Working Paper, WP/07/141,2007.

results of these tests are reported in table (3).

Table 3. *Unit root tests.*

Augmented Dickey-Fuller test statistic (Null hypothesis: has unit root)						
Variables	**Level**			**First Order Difference I(1)**		
	Non	**Individual Effect**	**I.E+ Trend**	**Non**	**Individual effect**	**I.E+ Trend**
LY	4.2359 (1.0000)	1.1872 (0.9972)	-2.5314 (0.3117)	-2.5548 (0.0127)	-3.5507 (0.0141)	-4.2731 (0.0116)
LL	5.0463 (1.0000)	-1.3296 (0.6008)	-1.3687 (0.8472)	-1.3362 (0.1636)	-4.4216 (0.0017)	-4.4886 (0.0071)
LK	1.7135 (.9759)	-1.0506 (0.7199)	-21484 (0.4974)	-4.9173 (0.0000)	-5.2741 (0.0002)	-5.12035 (0.0017)
LREC	0.5718 (.8333)	-3.2423 (0.0288)	-5.0314 (0.0022)	-7.2943 (0.0000)	-7.2108 (0.0000)	-6.8628 (0.0000)
LCO2	1.8501 (0.9818)	-2.0782 (0.2543)	-0.5957 (0.9710)	-4.6058 (0.0001)	-5.3165 (0.0002)	-6.1331 (0.0002)
Phillips-Perron test statistic (Null hypothesis: has Unit Root)						
Variables	Level			First Order Difference I(1)		
	Non	Individual Effect	I.E+ Trend	Non	Individual effect	I.E+ Trend
LY	3.4410 (0.9996)	0.5391 (0.9850)	-2.1424 (0.5006)	-2.5617 (0.0125)	-3.6203 (0.0120)	-3.6450 (0.0445)
LL	4.4856 (1.0000)	-1.3001 (0.6146)	-1.4968 (0.8056)	-2.5803 (0.0120)	-4.4171 (0.0018)	-4.4871 (0.0072)
LK	1.8681 (0.9825)	-1.0525 (0.7192)	-2.1484 (0.4974)	-4.9165 (0.0000)	-5.4556 (0.0001)	-5.2692 (0.0012)
LREC	0.9423 (0.9029)	-3.2049 (0.0312)	-4.9317 (0.0027)	-8.9122 (0.0000)	-10.4536 (0.0000)	-9.8894 (0.0000)
LCO2	1.9363 (0.9848)	-2.1596 (0.2246)	-0.3285 (0.9853)	-4.6438 (0.0000)	-5.3168 (0.0002)	-6.1218 (0.0002)
Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test statistic (Null hypothesis: is stationary)						
Variables	Level			First Order Difference I(1)		
	Non	Individual effect	I.E+ Trend	Non	Individual effect	I.E+Trend
LY	-	0.74619*	0.1495**	-	0.1861	0.0686
LL	-	0.7439*	0.1675**	-	0.1951	0.0927
LK	-	0.6584**	0.0970	-	0.0752	0.0762
LREC	-	0.7477*	0.0644	-	0.2335	0.1063
LCO2	-	0.7213**	0.1546**	-	0.4273***	0.0819

-Variables LY, LL, LK, LREC and LCO are expressed in natural logarithm (LN).
-In the third unit root test *, **, *** indicate that variable is statistically significant at 1%, 5% and 10% respectively.
-Lag length selection (Automatic) based on Schwarz Information Criteria (SIC).
-The probability is between parentheses.

Given the results of applied unit roots tests, it is likely to employ co-integration method in order to check for the existence of the long-run relation among the variables. The co-integration test proposed by Johansen (1988, 1991, 1995) is carried out.

The specification that permitted for a linear deterministic trend in data with an intercept but no trend in the co-integrating vector is employed. It is revealed that independent variables do contain co-integration in the long run for Jordan with respect to economic growth. The results of Johansen cointegration test for the model is reported in table 4. The cointegration trace confirms the presence of cointegration at a 5% significance level while the maximum eigenvalues statistics indicating of no-cointegration conflicts with the trace test results of r =1.

Table 4. *Unrestricted Cointegration Rank Test.*

(Trace & Maximum Eigenvalue Statistics)

Hypothesized No. of CE(s)	**Eigenvalues**	**Trace Statistic**	**Max-Eigen Statistic**
None	0.6821	72.5963* (69.8188)	28.6493 (33.8769)
At most 1	0.5392	43.9470 (47.8561)	19.3717 (27.5843)
At most 2	0.4373	24.5753 (29.7971)	14.3754 (21.1316)
At most 3	0.3060	10.1999 (15.4947)	9.1336 (14.2646)
At most 4	0.0418	1.0663 (3.8414)	1.0663 (3.841466)

-Trace test indicates 1cointegrating eqn. (s) at the 0.05 level.
-* denotes rejection of the hypothesis at the 0.05 level.
- Max-eigenvalue test indicates no cointegrating eqn(s) at the 0.05 level.
- The 0.05 critical values are between parentheses.
- lags interval at first differences (1).

Employing VAR lag order selection criteria the Schwarz Information Criterion (SIC) is used to find out the lag of length periods (1 lag) as shown in table 5.

In the model of Y, L, k, REC, CO_2 the trace test identifies one cointegrating vector at the 5% critical level as presented in table 4 since the null hypothesis of no co-integration (r ≤ 1) can be rejected at 5%.

Table 5. *VAR lag Order Selection Criteria for Johansen test.*

Lag	LogL	LR	FPE	AIC	SC	HQ
0	46.0468	NA	2.58e-08	-3.2837	-3.0399	-3.2161
1	153.125	162.7596*	3.81e-11*	-9.8500*	-8.3874*	-9.4443*
2	175.399	24.9466	6.23e-11	-9.6319	-6.9504	-8.8882

*indicates lag order selected by the criterion.
LR sequential modified LR test statistic (each test at 5% level); FPE:Final prediction error; AIC: Akaike information criterion; SC: Schwarz information criterion and HQ: Hannan-Quinn information criterion.

The next step is to explore the causality relationship among the targeted variables therefore vector error correction model equations (18 to 12) are estimated. In the VEC model the short-run dynamics in first equation shows that the renewable energy consumption has negative and statistically significant impact on economic growth while the carbon dioxide, the labor force and the fixed capital formation each have statistically insignificant impact on economic growth. This implies the absence of short-run causality running from carbon dioxide, labor force and capital to real GDP whereas a short-run causality running from renewable energy consumption to real GDP. For the second equation the results indicate that the real GDP, labor force and CO_2 each have statistically insignificant impact on renewable energy consumption while the gross fixed capital formation has a positive and statistically significant effect on renewable energy consumption in short run implying the presence of a short-run causality running from capital to renewable energy consumption.

The results in equations three and four do not give us any important information about short-run causality among the variables except that the renewable energy in third equation has a negative and statistically significant impact on Carbon Dioxide. Finally, with respect to equation five both RGDP and renewable energy consumption each have statistically significant impact on capital where the labor and CO_2 each have statistically insignificant influence on capital.

According to that we can conclude that there is a unidirectional causality from renewable energy consumption to real GDP. Also there is a unidirectional causality from renewable energy consumption to carbon dioxide while unidirectional causality has been detected from real GDP to capital. Finally, a bidirectional causality relationship is running among capital and renewable energy. Table 6 reported the results of short-run and long-run Granger-causality tests.

Table 6. *The causality test results for the variables Y, REC, CO_2 , L and K (1986-2012).*

Dependant Variable	Source of Causation (Independent Variables) Short Run					Long Run ECT
	DLY_{t-1}	$DLREC_{t-1}$	$DLCO2_{t-1}$	DLL_{t-1}	DLK_{t-1}	
DLY	- $R^2 = 0.72$	-0.1008* (0.0005) $F = 2.8$	-0.1244 (0.5243) HT: $\chi^2 = 346$ (0.25)	-0.0074 (0.9693) JB=7.5 (0.67)	-0.0511 (0.4758) LM(lag3) (0.83)	-0.0412** (0.0225)
DLREC	-0.6365 (0.6159) $R^2 = 0.56$	-- $F = 3.9$	1.0971 (0.2526) HT: $\chi^2 = 205$ (0.09)	-1.3716 (0.2781) JB=13.8 (0.18)	1.2540** (0.0191) LM(lag3) (0.104)	-0.8026* (0.0000)
$DLCO_2$	0.2306 (0.3401) $R^2 = 0.80$	-0.1169* (0.0001) $F = 4.5$	- HT: $\chi^2 = 346$ (0.25)	-0.1680 (0.3999) JB=10.5 (0.39)	0.1222 (0.1010) LM(lag3) (0.83)	-0126 (0.0000)*
DLL	-0.0294 (0.9050) $R^2 = 0.04$	-0.0012 (0.9599) $F = 0.14$	0.1142 (0.5394) HT: $\chi^2 = 205$ (0.09)	- J.B=22.76 (0.011)	-0.1761 (0.8636) LM(lag3) (0.10)	-0.006 (0.6840)
DLK	1.4105 (0.0185)** $R^2 = 0.51$	-0.2196 (0.0347** $F = 1.14$	-0.6074 (0.4035) HT: $\chi^2 = 346$ (0.25)	-0.3796 (0.5976) J.B=4.9 (0.89)	- LM(lag3) (0.83)	-0.2250** (0.0323)

HT: Residual white's heteroskedasticity tests.
JB: Jarque-Bera for normality test.
LM: LaGrange multiplier for residual serial correlation test with lag length up to 12(reported 3 lags).
ECT: is the error correction term.
The probability values are between parentheses where *, **, ***, refer to the level of significance at 1%, 5% and 10% respectively.

In terms of long run dynamics, the coefficients of the error correction terms in last column of table 5 reveal the speed of adjustment towards the long-run equilibrium. All the error correction terms revealed the negative sign that indicates to long-run bidirectional causality between the variables and are statistically significant at 1% and 5% levels except for labor equation which is statistically insignificant.

Furthermore the results of long-run effects of the independent variables on the economic growth show that the renewable energy is negatively related to the real GDP while the capital has positive and statistically significant impact on real GDP in the long run. The labor and carbon dioxide are statistically insignificance as can been noticed in Table 7.

The obtained results that describe the relationship between renewable energy and the economic relationship contradict with what Al-Zeaud (2014) [4] acquired in his study of causality relationship between energy consumption and economic growth. His results reveal a unidirectional causality from economic growth to energy consumption for Jordan over the period 1995-2013, this outcome was similar with the finding of Shahateet et al. (2014) [25] study. While the Ajlouni (2015) [3] investigations regarding the relationship among energy consumption and economic growth resulted in supporting the feedback hypothesis.

These results are not far away from what Rufael (2006) [23], Rufael and Menyah (2010) [24] and Squalli and Wilson (2006) [29] in terms of the negative unidirectional causality relationship running from electricity (energy) consumption to economic growth for samples comprise developing and developed countries such as Tunisia, Gabon, KSA, Bahrain, France and Japan.[7]

Table 7. *VECM Estimation.*

(long- run Coefficients)

Dependent Variable: LRGDP in first difference.			
Explanatory Variables	**Coefficient**	**t-statistics**	**Standard Error**
$LREC_{t-1}$	-0.8036*	-4.0039	0.2007
$LCO2_{t-1}$	1.4031	0.7431	1.8879
LL_{t-1}	-0.5203	-0.4381	1.1865
LK_{t-1}	1.6394*	3.995	0.4103

Where * refers to 5% level of significance.

A number of diagnostic tests have been applied to the residual of the VEC model; they are revealed in table 5. The normality test indicates that the residual term is normally distributed, LM test implies that there is no serial correlation and finally the null of no heteroskedasticity is not rejected for the five VECM equations. Hence, one can conclude that the vector error correction model passed successfully the required investigative tests.

7 For more information see the [23], [24] and [29].

5. Conclusion

The study explores the causal relationship between renewable energy consumption, Carbon dioxide emissions and economic growth using time series data for Jordan over the period 1986-2012. In light of Jordan's dependence on energy sources from abroad, it is clear that any problem in energy supply can dramatically affect the economic growth. On the other hand the fossil fuels consumption counts for about 97% of total energy consumption in Jordan reflecting serious environmental issues which make exploitation of renewable energy or new energy alternatives meaningful. The cointegration tests reveal a long-run equilibrium relationship exists between real GDP, renewable energy consumption, real gross fixed capital formation, and the labor force.

The outcome from the panel error correction models impart support the growth hypothesis as short-run unidirectional causality exists between renewable energy consumption and economic growth, whereas looking at the sign and the magnitude of the short-run coefficient reveals the negative statistical significant relationship between REC and economic growth. One must explain the result carefully as the renewable energy consumption accounts for round 3% of total final energy consumption in Jordan. The result obtained might not sufficient to lower the usage of renewable energy since Jordan usage of renewable energy represents a very small percentage of the total energy consumption. It may be attributed to the high cost of producing such type of clean energy including any institutional barriers confront investments in renewable energy technologies in Jordan. It is possible that time is needed with an advantage of economies of scale to have some positive impact of renewable energy on economic growth over time. On the other hand the positive bidirectional causality nexus among renewable energy consumption and gross fixed capital formation give a new dimension for analyzing the relationship between REC and economic growth since one of our finding asserts the positive long-run relationship between economic growth and gross fixed capital formation.

Jordan has crucial energy challenges as the country imports most of its energy requirements, running a persistent government budget deficit. The study shows that this source of clean energy has a negative impact on economic growth while in the same time increasing the usage of REC has a negative impact on CO_2 and support sustainability where replace of fossil fuel by renewable and green energy would mitigate the pollution.

Given that the country's annual daily average solar irradiance is one of the utmost records in the world. Policy makers ought to promote a multilateral endeavor to disseminate renewable energy and energy efficiency in Jordan. The country has an enormous capacity of renewable energy exploitation despite the result we got in this study as some energy consumption-growth link surveys reveal that empirical results have produced mixed results in terms of the four hypotheses connected to the sign and causal relationship between energy use and economic growth. The disparity in the observed results comes from the model specifications, time periods, variable selection and econometric methodology as described by Payne [21].

Furthermore, Jordan's authority must establish the proper inducement mechanism for developing renewable energy sector and enhance market accessibility for this particular clean energy source by includes for example tax credit or subsidies for renewable energy production and consumption, promote technology innovation and development community based projects in order to reduce the environmental pollution and increase the efficiency of this type of energy.

References

[1] Acaravci A. and Ozturk I., 2012. "Electricity consumption economic growth nexus: a multivariate analysis of Turkey". Amfiteatru Economic 14(31), 246–257.

[2] Adom Ph. K., 2011. "Electricity-Economic growth nexus: the Ghanaian case." International Journal of Energy Economics and Policy, vol. 1, no. 1, 18-31.

[3] Ajlouni S., 2015."Energy consumption and economic growth in Jordan: An ARDL bounds testing approach to cointegration". Jordan Journal of Economic Sciences, vol. 2, no. 2, 143-154.

[4] Al-Zeaud A. H., 2014. "The causal relationship between energy consumption and economic growth case of Jordan". Interdisciplinary Journal of Contemporary Research in Business, vol. 6, no. 5, 203-216.

[5] Apergis N. and Danuletiu D. C., 2014. "Renewable energy and economic growth: evidence from the sign of panel long-run causality." International Journal of Energy Economics and Policy, vol. 4, no. 4, 578-587.

[6] Apergis N. and Payne J. E., 2010. "Renewable energy and growth in Eurasia." Energy Economics, 32, 1392-1397.

[7] Apergis, N. and Payne, J. E., 2010b. "Renewable energy consumption and economic growth: evidence from a panel of OECD countries". Energy Policy, 38, 656–660.

[8] Behboudi D., Panahi H. and Moosavi S., 2013. "An Investigation of the contribution of renewable and non-renewable energy consumtion to economic growth in OIC countries". International Journal of Economics, Management, and Accounting 21, (2), 45-57.

[9] EIA, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=5&pid=5&aid=8.

[10] Farhani S., 2015. "Renewable energy consumption, economic growth and CO2 emission: evidence from selected MENA countries." IPAG Business School unpublished paper. http://www.ipag.fr/fr/accueil/la-recherche/publications-WP.html.

[11] Harris R. and Sollis R, 2003. "Applied Time Series Modeling and Forecasting", 1st edition, Wiley.

[12] Hjalmarsson E. and Österholm P, 2007. "Testing for Cointegration Using the Johansen Methodology when Variables are Near-Integrated", IMF Working Paper, WP/07/141, 2007.

[13] Hung-Pin L., 2014. "Renewable Energy Consumption and Economic Growth in Nine OECD Countries: Bounds Test Approach and Causality Analysis". The Scientific World Journal, vol. 2014, Article ID 919167, 6 pages.

[14] Lee Ch. and Chang Ch. P, 2008. "Energy consumption and economic growth in Asian economies: A more comprehensive analysis using panel data."Resource and Energy Economics 30, 50-65.

[15] Lee Ch.-Ch., 2004. "Energy consumption and GDP in developing countries: A cointegrated panel analysis", Energy economics, 27, 415-427.

[16] Leitao C. N., 2014. "Economic growth, carbon dioxide emissions, renewable energy and globalization". International Journal of Energy Economics and Policy vol. 4 (3), 391-399.

[17] Lise W. and Van Montfort K., 2005. "Energy consumption and GDP in Turkey: Is there a cointegration relationship?" EcoMod2005 International conference on policy modeling, Jun 29-Jul 2, Istanbul, Turkey.

[18] Menegaki A. N., 2011. "Growth and renewable energy in Europe: A random effect model with evidence for neutrality hypothesis". Energy Economics 33, 257-263.

[19] Nnaji, E. Ch, Chukwu o. J. and Moses N., 2013. "Electricity supply, fossil fuel consumption, CO_2 Coemissions and economic growth: implications and policy options for sustainable development in Nigeria". International Journal of Energy Economics and Policy, vol. 3, no. 3, 262-271.

[20] Osigwe A. C. and Arawomo D. F., 2015. "Energy consumption, energy prices and economic growth: causal relationships based on error correction model." International Journal of Energy Economics and Policy, vol. 5, no. 2, 408-414.

[21] Payne, J. E., 2010b. "A survey of the electricity consumption-growth literature." Applied energy 87, 723–731.

[22] Payne J. E., 2009. "On the dynamics of energy consumption and output in the U.S.". Applied Energy, 86, 575-577.

[23] Rufael W. Y., 2006. "Electricity consumption and economic growth: a time series experience for 17 African countries". Energy Policy, vol. 34, 1106-1114.

[24] Rufael W. Y. and Menyah K., 2010. "Nuclear energy consumption and economic growth in nine developed countries". Energy Economics, vol. 32, 550-556.

[25] Shahateet M. I. and Al-Majali K. A. & Al-Hahabashneh F., 2014. "Causality and Cointegration between Economic Growth and Energy Consumption: Econometric Evidence from Jordan". International Journal of Economics and Finance, vol. 6, No. 10, 270-279.

[26] Shahbaz M., Bhattacharya M. and Ahmed Kh. "Growt-Globalization-Emissions Nexus: The Role of Population in Australia", Department of Economics, Monash business School, ISSN 1441-5429, Discussion Paper 23/15, 1-31.

[27] Sliva S., Soares I. and Pinho C., March, 2011. "The Impact of renewable energy sources on economic growth and CO_2 emissions-A SVAR approach", FEP working papers, No.407, 1-25.

[28] Spetan Kh. A., Al-Salaymeh A., Mahmoud M., Elkhayat M. and Abu-Jeries A., 2015, "A guide to Renewable Energy in Egypt and Jordan", Friedrich Ebert Stiftung, 1st edit., Amman, Jordan, 126-169.

[29] Squalli J. and Wilson K., 2006. "A Bounds analysis of electricity consumption and economic growth in the GCC". Working Paper No. 06-09, EPRU, Zayed University.

[30] The World Bank, World Development Indicators, http://wdi.worldbank.org/table/3.8.

[31] Ucan O., Aricioglu E. and Yucel F., 2014. "Energy consumption and economic growth nexus: evidence from development countries in Europe." International Journal of Energy, Economics and Policy, vol. 4, no. 3, 411-419.