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Electricity Consumption and Economic Growth in Jordan: A Multivariate Approach

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Abstract: This paper aims to examine the impact of electricity consumption on economic growth in Jordan using annual data over the period 1985-2013. To achieve the goal, an Autoregressive Distributed Lag (ARDL) approach is implemented to estimate a logarithmic form of the traditional production function (Cobb-Douglas), where output is a function of electricity, capital and labour. According to the results of the estimation,the estimated long-run elasticities of output with respect to electrical energy, capital and labor are 0.742, 0.194 and 0.422, respectively; while the short-run estimates are 0.330, 0.086, and 0.343, respectively. Granger-Causality test has shown a positive unidirectional relationship directed from electrical energy consumption towards economic growth supporting the hypothesis.

Keywords: Jordan, Economic growth, Electricity Consumption, ARDL, Granger Causality

I. INTRODUCTION:

Many studies have investigated the factors that may affect economic growth. Electrical Energy consumption has been mentioned in several studies about economic growth models. Most of the previous studies have explained economic growth in terms of a production function. Neoclassical growth models usually consider capital, labor and land the main factors of production, while energy is considered an intermediate input produced by the major factors of production (Solow, 1974). The relationship between electricity consumption and national income has been investigated for many countries. Until now, there is no consensus about this relationship (Sami and Makun, 2011). Many of these studies have examined this relationship regardless of the other variables that may affect it, which falls into deletion variable bias. Recent studies have included variables such energy prices and employment (Chang et al., 2001; Govindaraju et al., 2010; Masih, 1997; Narayan and Smyth, 2005).

Given that, this study investigates the impact of electricity consumption on economic growth through implementing ARDL technique. A Microfit software is utilized to test the variables of the study; it can show long- and short-run estimations that have been econometrically analyzed to indicate the actual impact of electricity consumption on economic growth. Afterwards, the co-integration test is utilized to examine the electricity consumption and

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economic growth. Thus, the existence of the long run relationship between electricity consumption and GDP is checked within a multivariate framework for an emerging market economy of Jordan.

The electricity sector in Jordan has recently been facing a rapid increase in demand for all energy resources; electricity, oil, gas, and the shortage for one of these energy resources -like gas- may cost the Jordanian government several millions or billions of dollars yearly. Such an increase may cause the Jordanian electrical sector to have some financial crises. Many studies investigated the relationship between electricity consumption and economic growth; however, there is no consensus about this relationship until now (Sami and Makun, 2011).

This study determines whether the electricity consumption has an impact on economic growth and the nature of this impact if it exists. It examines also the direction of causality between electricity consumption and economic growth in Jordan over the period (1985-2013).

II. LITERATURE REVIEW AND PREVIOUS STUDIES:

In recent years, many studies have established econometric models to explain the relationship between energy consumption and economic growth. The main part of empirical research is devoted to test the impact of electricity consumption on economic activity. These models could be divided into three types based on their subjects (Shahateet and Bdour, 2010), or could be classified based on other standards. The first type includes a number of theoretical models associated with the relationship between economic growth and electricity on one side and consumption of petroleum derivatives on the other side (Bernard et al., 2007; Berndt and Wood, 1975).

While the second type of models could be recognized as single-country models. In a study conducted in the United States, Kraft and Kraft (1978) discussed the relationship between energy consumption and economic growth using data from 1947 to 1974. They found that there is a causality direction from economic growth to energy consumption in countries like China (Yuan et al., 2008), Malaysia (Tang, 2008).

As for the third one, it could be classified as more than one country models. In a study of more than one hundred countries, the causal relationship between energy consumption and economic growth may appear more clearly in the developed countries than in the developing ones (Chontanawat et al., 2008).

Adom (2011), divided the empirical investigations basically into the causal relationships between energy consumption and economic growth, which can be analyzed through two groups; the hypothesis criteria (Apergis and Payne, 2009) and the generation criteria (Guttormsen, 2004). Table (1) shows some previous studies and its categories. The hypothesis approach analyzes the causation in light of whether studies concluded that electricity consumption causes economic growth, otherwise or both; as follows:

1. Neutrality hypothesis: it means no causality exists between energy consumption and economic growth. Yoo (2006) also did not find an evidence of co-integration between electricity consumption and economic growth in Indonesia, Malaysia, Philippines, Singapore and Thailand, Brunei, Burma (Myanmar), Cambodia, Laos, and Vietnam.
2. Conservation hypothesis or Growth - led- Energy hypothesis: it means that, there is unidirectional causality running from economic growth to electrical energy consumption. This hypothesis is, for example, adopted in Yuan et al.'s (2008) study of China.
3. Growth hypothesis or Energy - led- Growth hypothesis: the unidirectional causality running from energy consumption to economic growth. This hypothesis is

discussed in Kwak's (2010) study of South American countries.

4. Feedback hypothesis or Energy - led - Growth - led - Energy hypothesis: it implies that both energy consumption and economic growth Granger cause each other. Mahadeven and Asafu-Adjaye (2007) as an example in a study for developed and developing Countries sets an example of this hypotheseis.

The direction of causation between energy consumption and economic growth implies the implication of a particular policy. For instance, if the result shows that unidirectional causality runs towards economic growth, then conserving (or reducing) energy could retard economic growth. On the other side, if there exists unidirectional Granger causality running from economic growth to energy consumption, it may be implied that energy conservation policies may be implemented with negative effect or no effects on economic growth as shown by the neutrality hypothesis as mentioned above, which means that conservative policies related to electrical energy consumption have an effect on economic growth.

Along the lines proposed by Guttormsen (2004), studies on the empirical investigations of electrical energy-economic growth have been classified into four types; the first generation studies, the second generation studies, the third generation studies, and the fourth generation studies. The first generation studies consist of studies that basically used the traditional Vector Autoregressive Models (Sims, 1972) and the standard Granger causality test. The weakness point of this generation of studies is that they assume the series to be stationary. The second generation of studies proposed co-integration (Johansen and Juselius, 1990) as the appropriate tool to use in analyzing the causal relationship between energy consumption and economic growth. Thus, in the second generation of studies, pairs of variables were tested for co-integration relationship and an error correction model was estimated to test for causality (Engle and Granger, 1987). Given the possibility of more than one co-integration vectors, the second generation studies approach was deemed inappropriate, and which led to the next generation. The third generation of studies proposed a multivariate approach. This approach facilitates estimations of systems where restriction on co-integration relationship can be tested and information on short-run adjustment can be investigated. There are two main disadvantages of the third generation studies: Firstly, it imposes restrictions that the variables should be integrated of order one. Secondly, the variables will have to be co-integrated before a test of causality can be possible. This has led to the fourth generation of studies. The studies related to the fourth generation use the Toda and Yomamoto Granger Causality test, which is based on the Autoregressive distributed lag model. In this generation of studies, restrictions are not imposed on the variables. Thus, causality is still possible even when variables are integrated of order zero, one or both. i.e., this approach allows for the test of causality even when variables are not co-integrated.

Ozturk (2010) classified the various studies of the energy-growth relationship into country-specific and multi-country studies on energy (electricity consumption) and economic growth. According to this classification, the multi-country studies and country-specific studies on the causality between energy consumption and economic growth reveal different results. However, the results of the country-specific studies on the causality between electricity consumption and economic growth reveal that there exists a positive causality which runs from electricity consumption to economic growth, but the multi-country studies on the causality between electricity consumption and economic growth show dissimilar results.

On the other hand there is another group of models applied to Africa (see Akinlo, 2008). In addition, there are models for Organization of Petroleum Exporting Countries (OPEC) as included in Mehrara (2007). In these models the negative impact of energy consumption on economic growth could be due to excessive energy consumption in unproductive sectors of the economy, capacity constraints, or an inefficient energy supply. The conservation hypothesis says that energy conservation policies formed to reduce energy consumption and waste will not negatively affect real GDP. This hypothesis is supported if an increase in real GDP causes an increase in energy consumption. However, it is probable that a growing economy restricted by political, infrastructural, or mismanagement of resources could generate inefficiencies and the shortage in the demand for goods and services, including energy consumption.

Al-Iriani (2006) studied a group of six Gulf Cooperation Countries and found a unidirectional causality running from economic growth to energy consumption. Developing countries were also studied by Lee (2005) and Sari and Soytas (2007) whose findings indicate that energy was an important factor of production. Boyd and Pang (2000) measured productivity using regression analysis at the plant level in the flat glass industry and the container glass industry. They estimated how the difference in energy intensities was attributed to differences in plant level productivity and other economic variables. Their results showed that there is an important relevancy between energy intensity and plant level productivity.

As shown in Table (1) below, results from electricity consumption and economic growth relationship studies with mixed results are mainly due to the varying data sets and methodology used and the varying country characteristics.

Also, there are some recent studies about this topic such as Francis et al. (2010) who found a long run relationship between electricity consumption and economic growth in Barbados. Abosedra and Ghosh (2008) found a long run relationship between electricity consumption and real GDP for Lebanon.

Ahmad and Islam (2011) conducted a study on Bangladesh. They found a short-run unidirectional causality running from per capita electricity consumption to per capita GDP without feedback applying co-integration and VECM based Granger causality test for the period (1971-2008). They also found a long-run bidirectional causality running from per capita electricity consumption to per capita consumption and economic growth but no causal relationship exists in the short run.

Recently, Buysse et al. (2012) investigated the existence of dynamic causality among electricity consumption, energy consumption, carbon emissions and economic growth in Bangladesh. The results indicate that unidirectional causality exists from energy consumption to economic growth both in short and long runs. While a bi-direction long run causality exists between electricity, consumption and economic growth, no causal relationship exists in the short run.

On the other side, Tang (2008) has studied the relationship between electricity consumption and economic growth in Malaysia and did not find any evidence of co-integration. Yoo (2006) also did not find any evidence of co-integration between electricity consumption and economic growth in Association of South-East Asian Nations which is called the “ASEAN” countries: (Indonesia, Malaysia, the Philippines, Singapore and Thailand, Brunei, Burma (Myanmar), Cambodia, Laos, and Vietnam).

Regarding Jordan, a study done by Ajlouni (2015) aimed to examine the role of energy consumption in stimulating economic growth in Jordan over the period 1980-2012. The results have shown that there is a bi-directional relationship between energy consumption and economic growth. The difference between our study and Ajlouni’s study is that the latter

Table 1
Summary of Studies on the Causality Between Electricity Consumption and Economic Growth

Author	Period of the Study	Methodology	Hypothesis	Country	Generation of study
Haciciglou (2007)	1968-2005	Granger causality & Bounds testing	Growth-led-electricity	Turkey	Fourth generation
Tang (2008)	1972-2003	ECM based F-test& ARDL	Growth-led-electricity-led-growth	Malaysia	Fourth generation
Morimoto and Hope (2004)	1960-1998	Standard granger causality	Electricity-led-growth	SriLanka	First generation
Shiu and Lam (2004)	1971-2000	Co-integration & ECM	Growth-led-electricity-led-growth	China	Second generation
Odhiambo (2009a)	1971-2006	ARDL Bounds test	Electricity-led-growth	South Africa	Fourth generation
Odhiambo (2009b)	1971-2006	Standard granger causality	Growth-led-electricity-led-growth	South Africa	First generation
Akinlo (2009)	1980-2006	VEC Granger causality	Electricity-led-growth	Nigeria	Third generation
Ghosh (2009)	1970-2006	ARDL Bounds test	Growth-led-electricity	India	Fourth generation
Ghosh (2002)	1950-1997	Multivariate Granger causality	Growth-led-electricity	India	First generation
Narayan and Smyth(2005)	1966-1999	Standard granger causality	Growth-led-electricity	Australia	Third generation
Twerefo et al (2008)	1975-2006	VEC Granger causality	Growth-led-electricity	Ghana	Third generation
Wolde-Rufael (2006)	1971-2001	Toda and Yomamoto Granger causality test	Growth-led-electricity	Cameroon, Ghana, Nigeria, Senegal, Zambia, Zimbabwe	Fourth generation

used energy consumption in the traditional production function, whereas our study focused on electricity consumption as a part of energy consumption.

III. THE TREND OF REAL GDP VERSUS ELECTRICITY CONSUMPTION OVER TIME:

Figure (1) describes the historical movements of total electricity consumption and real GDP over the time period 1985 to 2013. Both series show upward trend among the whole period except that GDP at the beginning of the period, which might be referred to the First Gulf War and its impact on the Jordanian economy, decline in the Jordanian dinar exchange rate of $ 3.3 price to $ 1.4 and the resulting sharp rise in prices. As a result, the Government planned program to reform the economy again, and that appears clearly after 1991.

Unlike Real GDP , Electricity consumption has approximately a positive slope for the period of study. The annual increase in consumption

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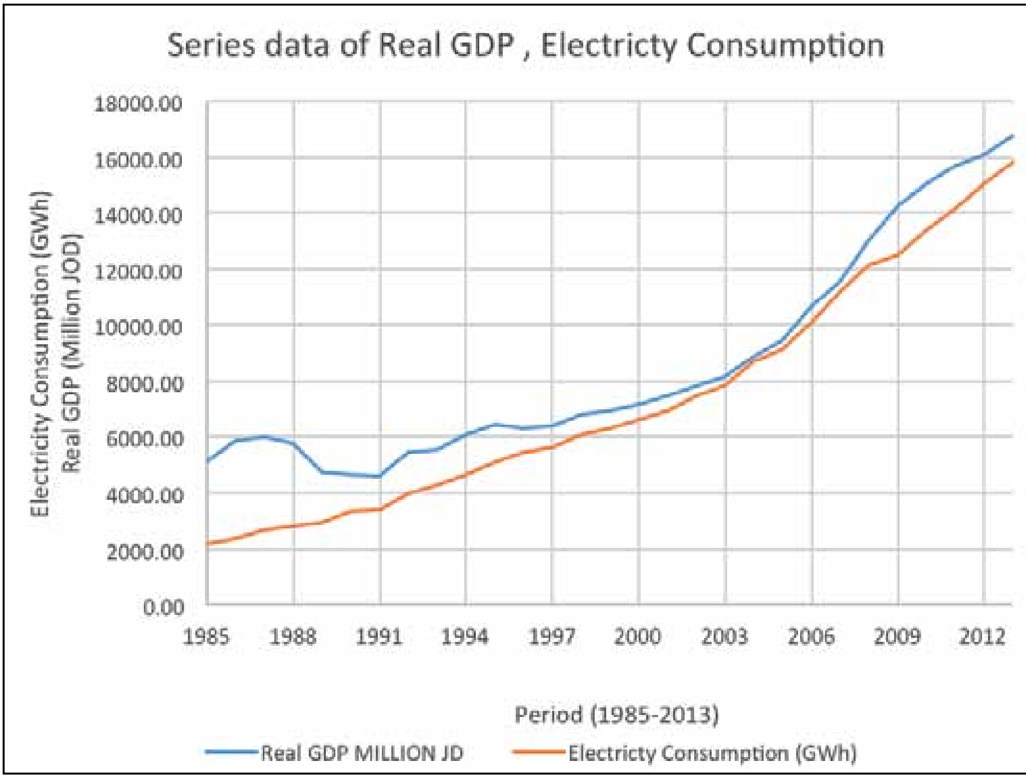
Figure 1: Historical Trends of Total Electricity Consumption (GWh) and Real GDP



NOTE: This is drawn by the researchers.

may be explained by the exposure of population through the period and increased projects that depend mainly on electricity. Consequently, the demand for electricity went up.

IV. MODEL SPECIFICATION AND ECONOMETRIC METHODOLOGY

Econometric models are the most commonly used for empirical studies, and one of the most important tools used to explain most of relationships among the variables. It helps economists explain some changes in variables and forecast the future changes in their path and their relevancy to each other.

Methodology:

This study is based on an econometric analysis to study the impact of electricity consumption on economic growth in Jordan during the period (1985-2013), using time series data.

Definitions of the Variables and the Data Sets :

Annual time series data for the model variables over the period (1985-2013) are used, as follows:

1. Gross Domestic Product (GDP): the GDP at constant market prices (1994=100) measured in million Jordanian Dinars (JD million). To get real figures, this series is adjusted using the Consumer Price Index (CPI) series for the period 1985-2013.
2. Electricity Consumption (EC): electricity consumption measured in Giga-watt hour (GWH).
3. Capital Stock (K): proxied by Gross Fixed Capital Formation at local current unit.
4. Labor (L): this variable is proxied by the compensation of employees. To get real figures, this series is also adjusted using CPI series for the period 1985-2013.

Model Specification :

Many studies concerning the causality between electricity consumption and economic growth use a bivariate framework, where the only variables under investigation are electrical energy consumption and GDP. Lütkepohl (1982) agreed with Yuan et al. (2008) who stated that "Though bivariate model has merit that they can be employed with scarce data, recently its limitation to describe energy–economy interactions has been criticized". That means that there is potential of bias caused by the deletion of some relevant variables or addition of unsuitable variables. So, drawing conclusions about the relationship among some of economic variables if other relevant variables are not included into the model may be difficult to extract. But Stern (1993) states the advantages of multivariate framework that the inclusion of capital stock and labor as a part of a VAR model might be useful in estimating the correlation between electrical energy and output. Furthermore, multivariate framework allows for the investigation of direction and existence of causation between electrical energy and GDP (Stern, 1993; Lee and Chiang, 2008). Moreover, as Stern (2000) points out the multivariate framework captures substitution effects between energy and the other factors of production such as capital and labor.

Following Lee and Chiang (2008), neoclassical production function is implemented for exploring the relationship between electricity consumption and economic growth, the output (which is proxied by GDP) is expressed as a function of three factors of production: electricity consumption, capital stock and labor:-

GDP = f(Electrical consumption, Capital, Labor) (1)

Equation (1) shows that the form of the Cobb-Douglas production function which was applied to capture the long-run relationship between aggregate output and the factors of production in logarithmic form:

$$\log(GDP) = \alpha + \beta_1 \log EC_t + \beta_2 \log K_t + \beta_3 \log L_t + \mu_t \quad (2)$$

Where log denotes logarithm. The coefficients: α, β_1, β_2 and β_3 are parameters to be estimated. α is interpreted as the intercept, β_i , i =1,2,3 are interpreted as the elasticities of output with respect to electricity consumption, capital, and labor respectively. GDP_t is real GDP, EC_t is electricity consumption, K_t denotes capital stock, L_t stands for labor and μ_t is a stochastic error term assumed to be normally distributed. The subscript ***t*** represents time.

Data Sources :

The data of the variables (real GDP, the net compensation of employees (L), and the Gross Fixed Capital Formation (K)) were obtained from of the Department of Statistics in Jordan, Central bank of Jordan, and World Bank online Database. As for Electricity consumption, the data were collected mainly from the annual reports of the Ministry of Energy and Mineral Resources (MEMR), the annual reports of the Energy and Mineral Resources Regulatory Commission (EMRC) in Jordan.

V. EMPIRICAL RESULTS:

Some tests were applied before estimating the model of the study such as Stationarity, Lag-Length selection, Cusum stability, Co-integration, diagnostic, and Granger Causality tests.

By utilizing the above tests, the researchers have reached to the following empirical results:

Unit Root Test (ADF-PP) :

To detect the order of the integration of the variables, ADF were used with intercept as shown in the Table (2)**:**

Phillips-Perron test is also used to support the results of Augmented Dickey Fuller test as table (3) shows:

Based on the ADF test, the variables shown above were not stationary at their level. But after taking their first differences, the absolute calculated values of t became greater than the absolute tabulated values of t at significance

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Table 2: Augmented Dickey-Fuller Test

Variable	Sign. Level	t-statistics	t-calculated	
log(GDP)	5%	-2.976263	-3.405419	1st lag
	10%	-2.62742		
	5%	-2.981038	-7.211969	2nd lag
	10%	-2.629906		
log(EC)	5%	-2.976263	-6.665548	1st lag
	10%	-2.62742		
	5%	-2.981038	-11.90288	2nd lag
	10%	-2.629906		
log(K)	5%	-2.976263	-3.274342	1st lag
	10%	-2.62742		
	5%	-2.981038	-5.876506	2nd lag
	10%	-2.629906		
log(L)	5%	-2.976263	-2.8015	1st lag
	10%	-2.62742		
	5%	-2.976263	-5.800202	2nd lag
	10%	-2.62742		

Table 3 : Phillips-Perron test

Variable	**Sign. Level**	**t-statistics**	**t-calculated**	
log(GDP)	5%	-2.976263	-3.487861	1st lag
	10%	-2.62742		
	5%	-2.981038	-7.292065	2nd lag
	10%	-2.629906		
log(EC)	5%	-2.976263	-6.576991	1st lag
	10%	-2.62742		
	5%	-2.981038	-25.77155	2nd lag
	10%	-2.629906		
log(K)	5%	-2.976263	-3.274342	1st lag
	10%	-2.62742		
	5%	-2.981038	-5.876506	2nd lag
	10%	-2.629906		
log(L)	5%	-2.976263	-2.843399	1st lag
	10%	-2.62742		
	5%	-2.981038	-3.711457	2nd lag
	10%	-2.629906		

levels 5%, for all variables except for log(L) which is stationary at 10% level of significance. So, the null hypothesis is rejected, i.e. all the variables don't have a unit root at 10% significance, so the data will be stationary. Then the variables are integrated of the first order, i.e. I(1). Besides, the results of Philips- Perron test, as shown in Table (3), completely support the results of Augmented Dickey–Fuller test.

To apply the co-integration test, the variables should be of the same order of stationarity (Engle and Granger, 1987).

Lag- Length Selection Test:
According to all criteria the optimal lag length is 4. As shown in Table (4).

Bounds Test for Cointegration :
The bounds test for co-integration can be used since none of the series is I(2); therefore the Unrestricted ECM given in the following Equation (3) is estimated using OLS, and then the restricted form is estimated in order to calculate the F-value (Wald-test):

$$\Delta \log GDP_t = p0 + \Sigma^{p}_{i=1}\, \delta_i\, \Delta \log GDP_{t-i} + \Sigma^{q}_{j=0}\, \delta_j\, \Delta \log EC_{t-j} + \Sigma^{r}_{m=0}\, \delta_m\, \Delta \log K_{t-m} + \Sigma^{s}_{n=0}\, \delta_n\, \Delta \log L_{t-n} + \delta_{11}\, ECT_{t-1} + \mu_{1t} \quad ....(3)$$

Table 4 : Lag Length Test

Lag	FPE	AIC	SC	HQ
0	4.57E-7	-3.24708	-3.05206	-3.192989
1	5.92E-11	-12.22119	-11.24609	-11.95074
2	5.31E-11	-12.44161	-10.68643	-11.95480
3	6.9E-11	-12.49577	-9.960508	-11.79260
4	**3.87e-12***	**-16.12006***	**-12.80472***	**-15.20052***

Note: (AIC): Akaike Info Criterion, (SIC): Schwarz Info Criterion, (HQ): Hannan – Quinn, (FBE): Final Prediction Error criterion

Table 5: Bounds Testing to Co-integration

Equation	F-Statistic (Calculated)	Decision
F_{GDP} (GDP_t/EC_t, K_t, L_t)	11.3198 *	Co-integration
F_{EC} (EC_t/GDP_t, K_t, L_t)	10.4668 *	Co-integration
F_K (K_t/EC_t, GDP_t, L_t)	4.0020 **	Co-integration
F_L (L_t/EC_t, K_t, GDP_t)	4.3574 *	Co-integration
At 5%: Lower bound critical = 2.7878 and Upper bound critical value = 4.1384 At 10%: Lower bound critical = 2.2228 and Upper bound critical value = 3.3845		

Note: *, ** indicate the significance at the 5% and 10% levels; respectively.
Source: Pesaran et al. (2001): Table CI (iii) Case III: Unrestricted intercept and no trend.
Number of regressors $k = 3$

If F-statistic lies above the UCB, then the null hypothesis is rejected, meaning that the variables are co-integrated. If F-statistic lies below the (LCB), then the null hypothesis is accepted, meaning that the variables are not co-integrated. If F-statistic lies between UCB and LCB, then the results are inconclusive. (Pesaran et al., 2001).

This process is repeated for the models given in Equations 4, 5, and 6 as follows:

$$\log EC_t = p_t + \Sigma^p{}_{i=0}\, \delta_i\, \Delta \log GDP_{t-i} + \Sigma^q{}_{j=0}\, \delta_j\, \Delta \log EC_{t-j} + \Sigma^r{}_{m=0}\, \delta_m\, \Delta \log K_{t-m} + \Sigma^s{}_{n=0}\, \delta_n\, \Delta \log L_{t-n} + \delta_{22}\, ECT_{t-1} + \mu_{2t} \quad (4)$$

$$\Delta \log K_t = p_2 + \Sigma^p{}_{i=0}\, \delta_i\, \Delta \log GDP_{t-i} + \Sigma^q{}_{j=0}\, \delta_j\, \Delta \log EC_{t-j} + \Sigma^r{}_{m=0}\, \delta_m\, \Delta \log K_{t-m} + \Sigma^s{}_{n=0}\, \delta_n\, \Delta \log L_{t-n} + \delta_{33}\, ECT_{t-1} + \mu_{3t} \quad (5)$$

$$\Delta \log L_t = p_3 + \Sigma^p{}_{i=0}\, \delta_i\, \Delta \log GDP_{t-i} + \Sigma^q{}_{j=0}\, \delta_j\, \Delta \log EC_{t-j} + \Sigma^r{}_{m=0}\, \delta_m\, \Delta \log K_{t-m} + \Sigma^s{}_{n=0}\, \delta_n\, \Delta \log L_{t-n} + \delta_{44}\, ECT_{t-1} + \mu_{4t} \quad (6)$$

Where: p_i , i = 0,1,2,3 are the intercepts. Also, δ_{11}, δ_{22}, δ_{33}, δ_{44}, represent the speed of adjustment parameter. ECT_{t-1} represents a one period lagged error correction term derived from the cointegration equation. The determination of the direction of causality in the short run depends on the significance of, δ_i, δ_j, δ_m, δ_n, while in the long run, the direction of causality is determined by the significance of. δ_{11}, δ_{22}, δ_{33}, δ_{44} .

As reported in Table 5, the results support the hypothesis that all the variables are co-integrated.

Estimation of Long-Run Elasticities :

The existence of co-integration relationship implies the existence of a long run relationship between the variables expressed in Equation (2). The results of estimating Equation (2) are given in Table (6) where the dependent variable is log *GDP*. In one particular scenario suggested by Pesaran et al. (2001) they are reported as follows:

Table 6: Estimated Log Run Coefficients ARDL Approach (1, 0, 0, 2) based on SBC

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
Intercept	-2.380	0.345	-6.900[.000]
log *ECt*	0.742	0.103	7.201[.000]
log *Kt*	0.194	0.060	3.220[.005]
log *Lt*	0.422	0.125	3.373[.003]
R-Bar-Squared: 0.985		**R-Squared: 0.972**	
F-stat.: 19.9 [0.000]		**S.E. of Regression: 0.201**	

Dependent variable is Log *GDP* SBC: Schwarz Bayesian Criterion was used

As shown in table (6), the coefficients have positive signs as expected by the economic theory. Moreover, β_1 β_2 and β_3 are significant at 1% level. In other words, a 1% increase in electricity consumption leads to 0.742 percent increase in GDP. Also, a 1% increase in capital stock causes GDP to increase by 0.194%. Finally, a 1% increase in labor results in 0.422% increase in GDP. The long run model is given by:

$$\log (GDP_t) = 2.380 + 0.742 \log EC_t + 0.194 \log K_t + 0.422 \log L_t \quad (7)$$

These results may not be consistent with the findings of other studies, but this is expected for several reasons, such as the differences in the type of the data set implemented for each one, the time span of the studies, the definition of the variables and the econometric methods used in the studies. In contrast to this study which uses time series data over the period 1985-2013, Lee and Chiang (2008) use panel data set over the period 1971-2002. Moreover, lee and Chiang use the figures of labor force and real gross capital formation as provided the World Bank, while this study uses compensation of employees as a proxy variable for labor. Finally Lee and Chang utilize Panel data techniques to test for unit root, co-integration and Granger causality; in comparison, this study uses ARDL and Granger causality in the context of time series analysis.

Estimation of Short-Run Elasticities :

Short run results are found by estimating the error correction representation of the following equation:

$$ECT_t = y_t - \alpha_1 - \Sigma^p{}_{i=1} \beta_i y_{t-i} - \Sigma^q{}_{j=0} x_{t-j} \forall j \quad (8)$$

All coefficients of the short-run equation are coefficients relating the short-run dynamics of the model's convergence to equilibrium; β represents the speed of adjustment (Duasa, 2007). The results of estimating Equation 8 are reported in Table 7.

Table 7: Vector Error Correction Model

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
intercept	-1.057	0.350	-3.014[.007]
LogEC	0.330	0.095	3.473[.002]
LogK	0.086	0.020	4.446[.000]
LogL	0.343	0.143	2.398[.026]
LogL1	-0.284	0.106	-2.678[.014]
ECT(-1)	-0.444	0.109	-4.074[.001]
R-Bar-Squared: 0.755		**R-Squared: 0.690**	
F-stat.: 11.771 [0.000]		**S.E. of Regression: 0.030**	

From the table above, there are some notes on the result of VECM. Firstly, short run elasticities are smaller than long run elasticities. Empirical evidence indicates that electricity consumption affects GDP positively and is significant at 1% level and a 1% increase in electricity consumption leads to a 0.33% increase in GDP. Also, it is noticed that capital stock affects GDP positively and is significant at 1% level. A 1% increase in capital stock increases GDP by 0.086%. Finally, labor affects GDP positively and is significant at 1% level and that a 1% rise in labor causes an increase in GDP by 0.34%. Secondly, the coefficient of lagged error correction term ECT_{t-1} has the correct sign (negative) and is significant at 1% level. This result suggests that there is a long run relationship among the variables. Thirdly, the value of the coefficient of ECT_{t-1} can be interpreted as the speed of adjustment or convergence towards long run equilibrium. In details, about 44% of disequilibrium from the past year will be corrected in the next year, i.e., this adjustment following a shock towards long run equilibrium takes around 2.27 years.

CUSUM and CUSUM Q Stability Test:

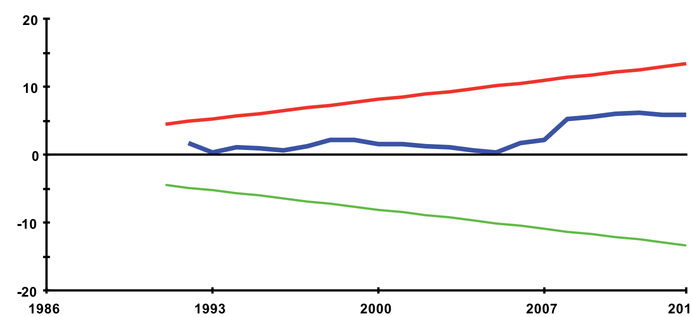
According to CUSUM and CUSUM Square tests for stability of the parameters, as shown in Figure (2), clearly, the variables have high degree of stability. So, there is no need to divide the study period (1985-2013) into sub-periods, this supports considering the whole period of study as one period.

Granger Causality Test:

To make the results more concrete, the researchers have resorted to the Granger

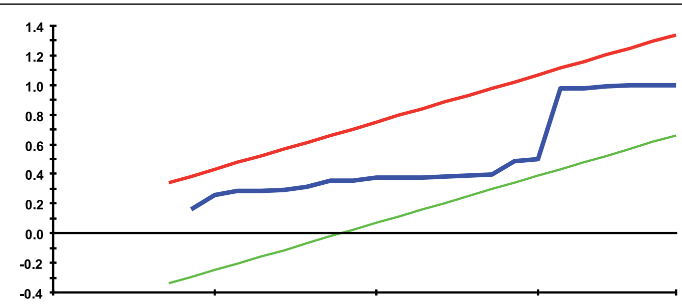
Figure 2: CUSUM and CUSUM Square Test

Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5%significance level

Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5%significance level

Table 8: Granger Causality

		Short run t-statistics Granger causality				**Long run Granger causality**
EQ. No.	**Dependent Variable**	**LogGDP**	**LogEC**	**logK**	**logL**	ECT_{t-1}
13	**LogGDP**	-	3.4733[.002] *	4.4459[.000] *	2.3978[.026] **	-4.0738[.001] *
14	**LogEC**	2.3382[.031] **	-	3.5722[.002] *	1.6271[.121]	0.0394[.969]
15	**logK**	1.7761[.091] ***	4.8607[.000] *	-	-.29285[.773]	-4.1008[.001] *
16	**logL**	2.3259[.031] **	-1.1194[.276]	.11855[.907]	-	-4.5746[.000] *

T- ratio without [ ] and Probability between [ ]
Note: *,**and *** indicates 1%,5% and 10% significant level respectively

Causality test. The results of this test are reported in Table (8) as follows:

1. Short run case: to check for the existence and the direction of the Granger causality, the VECM equations (3 to 6) are estimated and the results are shown in Table (8). Starting from the first equation in the VECM model, it can be seen that the independent variables are statistically significant, which implies the existence of a short run causality running from Electricity consumption, capital and labor to GDP. For the second equation, the results indicate that there is a short run causality directed from GDP and capital to electricity consumption. The results for the third equation indicate the existence of a short run causality running from GDP, electrical energy to capital. Finally, for the fourth equation, short run causality is running from GDP to labor.

   From the previous results, there is a bi-directional causality between electricity consumption and GDP, between labor and GDP, and between capital and GDP. Also, there is a bi–directional causality between capital and electricity consumption, Uni-directional causality is directed from labor to capital.

   This result disagrees with Buysse et al. (2012) who found a bi-directional relationship between GDP and Electricity Consumption in long run and no causal relationship exists in the short run, it however agrees with Akinlo (2009).
2. Long run case: as shown in table (8) the coefficients of the error correction terms ECT_{t-1} have the correct sign and are statistically significant for all the VECM equations except electricity consumption, implying the existence of a long run bi-directional causality among the variables. The coefficients of VECM are (-4.0738, 0.0394, -4.1008, and -4.5746 for the equations (3 to 6)), respectively. It is noticed that the four equations exhibit significance at one percent level except for the energy equation which is insignificant. So, it is very clear that there is only a unidirectional causality from electricity consumption toward GDP.

The results concerning causality between energy and GDP are consistent with Bekhet and Othman's (2011).

Table 9: Diagnostic Tests

Diagnostic Test	Test Statistic [Prob. values]
Serial correlation	F(1,18) = 0 .0215[0.885]
Chi - Normality test	χ^2 (2) = 4.467[0.701]
Heteroscedasticity test	F(1,24) = 0.161[0.691]
Functional Form	F(1, 18)= 2.630[.122]

Diagnostic Tests:
Diagnostics tests are applied to test model specification. As shown in Table (9), the diagnostic tests show that the model passed successfully tests of serial correlation, functional form, normality, and heteroscedasticity. The empirical evidence shows that no serial correlation exists, the functional form of the model is well specified, the residual term is normally distributed and the null of heteroscedasticity is not rejected since the probability of all tests are higher than 10% significance level.

VI RESULTS, RECOMMENDATIONS AND POLICY IMPLICATIONS

This study aimed to investigate the impact of Electricity Consumption on Growth rates in GDP represented by real economic growth during the period (1985-2013) in the Jordanian economy. The study depended on the use of multiple time series method (Multivariate Time Series Model) in the analysis, applied the Granger Causality, and Vector Error Correction model by implementing ARDL Model (Autoregressive Distributed Lag). The findings and recommendations of the study can be summarized as follows:

Results:
This research implemented ARDL bounds test to co-integration to investigate the short-run and long-run relationship between electricity consumption and economic growth in a multivariate framework in Jordan. Also, it employs the Granger-Causality to test for the existence and direction of causality between economic growth and energy consumption in Jordan. The Cobb–Douglas production function is used to estimate the relationship assuming that the output is a function of electrical energy, capital and labor.

The long-run elasticities estimated of output with respect to energy, capital and labor are 0.742, 0.194 and 0.422, respectively. Also, the short-run estimates are 0.330, 0.086 and 0.343, respectively.

The Granger-Causality test shows a unidirectional relationship between electrical energy consumption and economic growth supporting the hypothesis; under this hypothesis, energy consumption and real GDP are related to each other.

Recommendations and Policy implications:
This paper may play a role in the formulation of policies that will conserve economic growth. Any policy regarding electricity consumption should be reviewed and reevaluated to ensure that it will affect economic growth. Imposing taxes to reduce electricity consumption or implementing a conservation policy regarding those types of energy will affect economic growth negatively because the results show that those electrical energy consumptions would influence economic growth.

So, the results of this study suggest the following recommendations:

1. Separating the time period into short and long-run periods. This segmentation is important for policymakers to understand the relationship between electricity consumption and economic growth in order to sketch effective energy and environmental policies.
2. The causality between electricity consumption and economic growth demonstrates a "growth hypothesis". Nowadays, the Jordanian government prepares plans to promote the efficiency of the usage of energy through implementing building energy regulations such as energy standards, codes etc., for the sake of reducing building energy consumption bill.
3. The Jordanian government should encourage private-public sectors to utilize the electrical energy in high efficiency rates through encouraging projects of generation or distribution that uses alternative energy sources such as solar systems, wind energy, etc., by facilitating the process of building these projects and reducing the taxes imposed.

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