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# Causal Interaction among Electricity Consumption, Financial Development, Exports and Economic Growth in Jordan: Dynamic Simultaneous Equation Models

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**ABSTRACT**

The goal of this paper is to examine the empirical dynamic relationship among the electrical consumption (ELC) and economic growth (proxies by gross domestic product [GDP] per capita), export, and financial development (domestic credit to the private sector as a percentage of GDP) in Jordan over the 1976-2011 period. Annual time series data and the autoregressive distributed lag model are used. The augmented Dickey–Fuller, F-bound testing, Granger causality, GIRF, and cumulative sum of recursive residuals, cumulative sum of squares tests were applied to test the stationary, co-integration, causality and stability, respectively, among the variables. There is evidence of a long-term equilibrium relationship between electricity consumption and the economic growth, and a unidirectional relationship runs from real GDP to ELC. This is indicating that per capita increase in economic growth may cause a perpetual rise in the ELC in Jordan.

**Keywords:** Electricity Consumption, Economic Growth, Co-integration, Autoregressive Distributed Lag, Causality, Jordan
**JEL Classifications:** C32, O13, O20, Q43

## 1. INTRODUCTION

Numerous studies have examined the relationship between energy consumption and economic growth (gross domestic product [GDP]), especially in the past four decades started with the study of Kraft and Kraft (1978). Also, there are intense debates in the literature suggesting a strong relationship between the electrical consumption (ELC) and economic growth. This implies that an increase in ELC directly impacts economic growth and that economic growth also stimulates further electricity consumption (Yoo, 2006; Wolde-Rufael, 2006; Morimoto and Hope, 2004; Zamani, 2007; Odhiambo, 2009; Narayan and Smyth, 2009; Lorde et al., 2010; Apergis and Payne, 2011; Lai et al., 2011).

Most of these studies are used the directions of causal relationship between the electricity consumption and the economic growth that could be classified into four types: First, neutrality assumption states that the neutrality hypothesis is supported if there is no causal relationship runs from ELC to GDP. Neutrality assumption clarifies that electricity preservation policies will have no influence on economic growth. Second, the unidirectional assumption runs from economic growth to electricity consumption. In this case, electricity preservation policies prepared to decrease electricity consumption and waste will have a tiny or no influence on economic growth. Third, the bidirectional assumption states that there is two-ways causality relationships existed between GDP and ELC. It is necessary to attain whether there is an existence of causal relationship between GDP and ELC and the way of that causality. This is because the direction of causality has significant policy implications for governments for constructing and application of their electricity policy. Fourth, growth assumption which implies that causality runs from electricity consumption to economic growth. The growth assumption suggests that electricity consumption plays a vital role in the economic growth. In this state, the depression in electricity consumption due to electricity preservation policies may have a destructive effect on economic growth (Ozturk and Acaravci, 2011).

Due to the current situation of the Jordanian economy (Section 2), this paper aims to evaluate the impacts of economic growth on the ELC in developing country (Jordan) with limited resources such as oil resources, agricultural land, and scarce water. However, despite this ordeal and a troubled regional environment, Jordan keeps a stable economic growth rate compared to other emerging economies in the Middle East countries. This is due to the recent extensive economic improvement by the government, resulting in the opening up of key sectors to foreign direct investment (FDI) and vibrant economic activity beside different developments, innovations and regulations.

This study is important for different parties like policy makers, domestic and foreign investors, corporations and government. However, the significance of this paper stems from the reason that electricity bill reflects a notable share in the GDP for Jordan. Also, the prices of electric bill affected by oil have gone up very high, especially during the 2003-2013 period due to different political and economic crisis events in the Middle East. Thus, the increase in the oil prices has affected on the prices of electricity positively. Over the past decades the relationship between economic growth and ELC has been extensively researched in developed countries. Yet, there seems to be no consensus regarding the relationship in Jordan. Furthermore, this study will be the first study that examines the relationship between economic growth and ELC particularly in Jordan to fill the gap in the existing literature.

The current paper adopts one of the contemporaneous time series analysis techniques, the autoregressive distributed lag (ARDL) bound testing approach developed by Pesaran et al. (2001). ARDL is a popular and standard technique for examining co-integration among financial variables. Subsequently, we hypothesized a long-run equilibrium relationship between the ELC and economic growth represented by GDP per capita with a bidirectional causality relationship between them.

The rest of the paper is organized as follows: The next section sheds light on Jordanian economy and the ELC in Jordan. Section 3 explores the literature review. Section 4 provides data and model specification. Section 5 illustrates methodology. Section 6 reports the empirical results while managerial implications, conclusions, and limitation are presented in the last section.

## 2. AN OVERVIEW OF JORDANIAN ECONOMY AND ELECTRICITY SECTOR

The Hashemite Kingdom of Jordan is a middle income country with a population of 6.5 million. Jordan is a small open economy with few natural resources and little manufacturing, but has a large skilled population that works abroad. Jordan has incompetent supplies of water with a large proportion of desert soil and around 4% arable land. However, the main natural resources in Jordan are phosphate and potash. Currently, the main challenges facing Jordan are reducing the budget deficit, reducing foreign grants and dependence, and creating investment incentives to promote job creation. A fundamental percentage of the population, 38% are under the age of fourteen resulting in a rapid increase in the working age population (Amara, 2008; Bekhet and Al-Smadi, 2015).

During the past decades, Jordanian economy witnessed many political events and conflicts that occur in the Middle East, such as Gulf-War 1991 and Iraqi-War 2003. These events caused massive resource shortages. For example, Jordanian economy struggled heavily as a result of the 1991 Gulf-War that the Gulf countries council decided to limit economic relations by declining their worker recruitment, traditional export markets, substantial foreign aid revenues, and oil supplements. However, Jordan's favorable trade relations with Iraq had ended and years of tardily discounted and even free oil stopped. IMF (1991) estimated that Jordan's GDP declined by 15-20% and the unemployment rate had risen near 25%, making Jordan a main victim after Kuwait and Iraq themselves of the Gulf-War (Park and Agtmael, 1994). Also, a new challenge to the Jordanian economy was the Amman bombing 2005 and recently the 2011 Arab revolutions (Arab Spring) especially in Syria and instability in Iraq.

The electrical power system in Jordan consists of two main power stations, 132 kilovolt (KV) and 400 KV transmission network. This transmission network interconnects the power stations with the load centers and different areas in the kingdom. The system also includes the 230 KV, 400 KV connects line with Egypt and 400 KV connect the lines with Syria. The electrical networks are serving about 99.9% of the total population in Jordan. Furthermore, there are included, some private power stations, which are coinciding with the rest of the power stations in the integrated network. Also, there are a few private power stations, which are not connected to the interconnected network and serve only their owners (Al-Ghandoor et al., 2011).

Figure 1 shows the growth rate of Jordan's GDP, which was at 5.5% for the (1976-2011) period. It, also, indicates a gradual upward trend over the targeted period. Despite the global financial crisis affect and other events during this study period, Jordan's GDP reached US $16 billion in 2011. Over the 2000-2009 period, Jordan's economy has largely declined due to the global and regional retraction. It was consistent with the global economic slowdown, in 2009 where output growth fell sharply and economic activity is risen modestly (IMF, 2010; Bekhet and Matar, 2011; 2012a).

In addition, the ELC grew notably during the 1976-2011 period where the average annual growth rate during this period was 4.5%. The greatest amount of ELC was in 2011 with 2610 KW, the greatest consumption came from the household sector that consumed about 41% of the total, followed by the industrial sector, which consumed 25% of the total then commercial sector with consumption share of 17%, followed by water pumping sector that consumed 14% then by street lighting sector which consumed 3% (Figure 2).

Recently, many energy policies have applied such as; privatization operations were executed in the electricity sector, which resulted in the partial privatization of the sector. However, the price index for mineral fuels and lubricants category increased by 32% due to the increase in the prices of oil. Therefore, the fuel and electricity category, price index has increased by 49%. Theoretically, ELC is considered a dependent variable of other related independent variables such as GDP per capita that affect the consumption of electricity variable positively, besides the price of electricity variable that affect the consumption of electricity variable negatively.

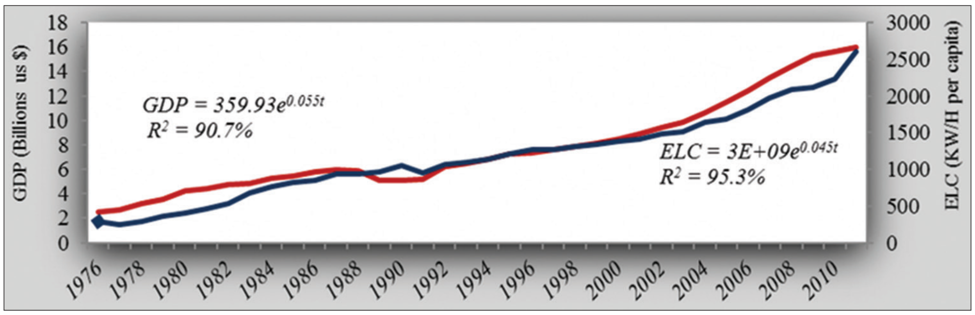
Figures 3 reveals that both of exports (X) and financial development (FD) for Jordan's economy are gradually raising with growth rate of 4.7% and 2.1%, respectively. In 1976 the exports started with a modest amount of $ 982.2 million, while FD with 32.3% of GDP. However, both indicators (X and FD) are gradually increasing to reach the highest amount at the end of 2007. Also, these indicators are shown a several fluctuations during the study period due to the different political and economic events that faced the world economies and particularly the Jordan's economy.

## 3. LITERATURE REVIEW

Over the recent decades the relationship between electricity consumption and economic growth has been extensively researched in different countries. In the current paper, the literatures are categorized based on the direction of the causality test into 3-folds (unidirectional, bidirectional, and no causal [neutral] relationships among the variables) as summarized in the Table 1.

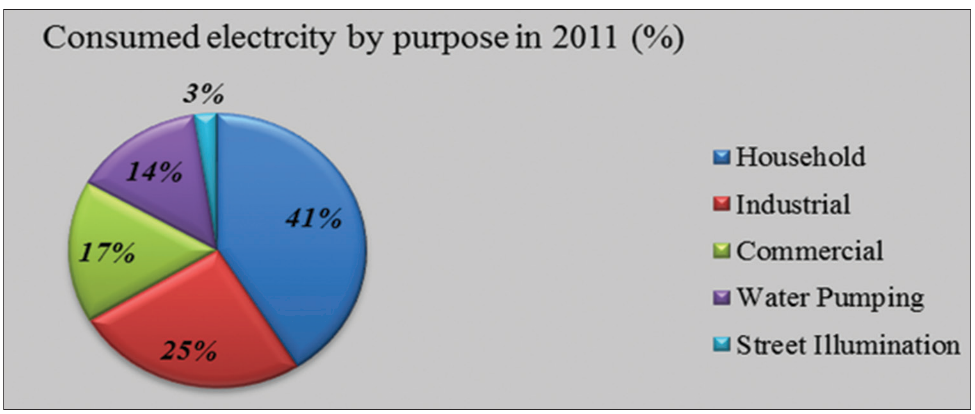
Recently, the relationship between energy consumption, electricity consumption, and economic growth has attracted many researchers, for instance see, Ozturk and Uddin, 2012; Acaravci and Ozturk, 2012; Ozturk and Acaravci, 2013; Ozturk et al., 2013; Yildirim et al., 2014; Bouoiyour et al., 2014; Sierzchula et al., 2014; Shahbaz et al., 2014; Hamdi et al., 2014; Bloch et al., 2015;

**Figure 1:** Time trend of the gross domestic product and electrical consumption in Jordan



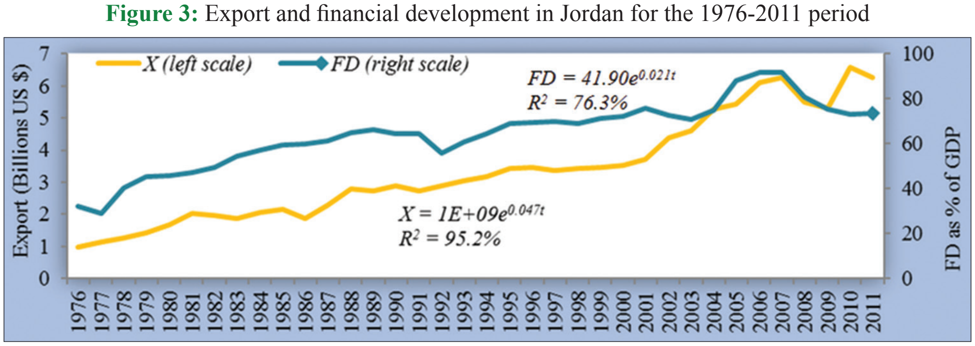

Source: World Bank (2013), Jordan data, Available from: http://data.worldbank.org/country/jordan

**Figure 2:** Electrical consumption in Jordan in 2011 (by purpose)




Source: Department of Statistics, Jordan (2013), Available from: http://www.dos.gov.jo/dos_home_a/main/jorfig/2011/14.pdf

**Figure 3:** Export and financial development in Jordan for the 1976-2011 period




Source: World Bank (2013), Jordan data, Available from: http://data.worldbank.org/country/jordan

**Table 1: Summary of electricity consumption nexus economic growth literature**

| Author | Country | Variables | Methodology | Causality results |
|---|---|---|---|---|
| Aqeel and Butt (2001) | Pakistan | ELC and GDP | VAR | ELC → Y |
| Ghosh (2002) | India | ELC per capita and RGDP per capita | VAR | Y → ELC |
| Shiu and Lam (2004) | China | ELC and real GDP | VECM | ELC → Y |
| Thoma (2004) | USA | Total electricity usage and IP | VAR | IP → ELC<br>IP → CELC<br>IP → IELC<br>OELC — IP<br>RELC — IP |
| Fatai et al. (2004) | Australia | ELC, RGDP, and CPI | ARDL and Granger Causality | Y → ELC |
| Morimoto and Hope (2004) | Sri Lanka | ELP and RGDP | VAR | ELP → Y |
| Jumbe (2004) | Malawi | ELC, GDP, and agricultural GDP | VECM | ELC → Y |
| Narayan and Smyth (2005) | Australia | ELC per capita, RGDP per capita, and ME | ARDL | Y → ELC<br>MEMP → ELC |
| Yoo (2005) | Korea | ELC and RGDP | VECM | ELC ↔ Y |
| Lee and Chang (2005) | Taiwan | ELC and RGDP per capita | VECM | ELC → Y |
| Wolde-Rufael (2006) | 17 African countries | ELC per capita and RGDP per capita | ARDL and Granger Causality | Y → ELC |
| Yoo and Kim (2006) | Indonesia | ELC, ELP and RGDP | VAR and Granger Causality | Y → ELC<br>Y → ELP |
| Yoo (2006) | ASEAN 4 | ELC per capita and RGDP per capita | VAR and Granger Causality | ELC ↔ Y<br>(Singapore & Malaysia)<br>Y → ELC<br>(Thailand and Indonesia) |
| Yuan et al. (2007) | China | ELC and real GDP | VECM | ELC → Y |
| Soytas and Sari (2007) | Turkey | MI, EC, MRFI and ME. | VECM | IELC → MVA |
| Squalli (2007) | Algeria | ELC per capita and RGDP per capita | ARDL | Y → ELC |
| Ho and Siu, (2007) | Hong Kong | ELC and RGDP | VECM | ELC ↔ Y |
| Chen et al. (2007) | China, Hong Kong, India, Indonesia, Malaysia, Philippines, Singapore, Korea, Thailand, and Taiwan | ELC and RGDP | VECM | ELC — Y<br>ELC ↔ Y<br>Y → ELC<br>ELC → Y<br>Y → ELC<br>Y → ELC<br>Y → ELC<br>Y → ELC<br>ELC — Y<br>ELC — Y |
| Narayan and Singh (2007) | Fiji | ELC, RGDP, and L | ARDL | ELC → Y and<br>ELC → L |
| Mozumder and Marathe (2007) | Bangladesh | ELC per capita and RGDP per capita | VECM | Y → ELC |

***(Cond...)***

**Table 1:** ***(Continued...)***

| Author | Country | Variables | Methodology | Causality results |
|---|---|---|---|---|
| Narayan and Prasad (2008) | 30 OECD countries | ELC and RGDP | Granger Causality | ELC — Y (Canada, USA, Belgium, Denmark, Austria, France, Germany, Greece, Ierland, Japan, Luxembourg, New Zealand, Mexico, Poland, Norway, Turkey, Sweden, Switzerland, and Spain) ELC → Y (Australia, Slovak Republic, Portugal, Italy, and Czech republic) Y → ELC (Hungary and Finland) ELC ↔ Y (UK, Iceland, and Korea) |
| Yuan et al. (2008) | China | ELC, RGDP, L, and K | VECM | ELC ↔ Y |
| Huang et al. (2008) | 82 countries | GDP and EC | VAR | Bi-directional positive feedback relationship between GDP and EC |
| Tang (2008) | Malaysia | ELC per capita and RGNP per capita | ARDL | ELC → Y |
| Sari et al. (2008) | USA | Disaggregate energy variables, IP, and L | ARDL | Co-integration among EC, L and IP |
| Hu and Lin (2008) | Taiwan | ELC and RGDP | VECM | Y → ELC |
| Abosedra et al. (2009) | Lebanon | ELC growth, real import growth, L, and relative humidity | VAR and Granger Causality | ELC → IMP |
| Odhiambo (2009) | Tanzania | ELC per capita and RGDP per capita | VAR and Granger Causality | ELC → Y |
| Ghosh (2009) | India | Electricity supply, RGDP, and L | ARDL | Y → ELC |
| Narayan and Smyth (2009) | Kuwait, Iran, Israel, Oman, Saudi, and Syria | ELC per capita, RGDP per capita, and real exports per capita | VECM and Granger Causality | ELC ↔ Y in MENA panel |
| Lorde et al. (2010) | Barbados | ELC, RGDP, capital stock, L, and technology | Granger Causality | ELC ↔ Y |
| Yoo and Kwak (2010) | 7 South American countries | ELC per capita and RGDP per capita | ECM and Granger-Causality | ELC → Y (Brazil, Argentina, Ecuador, Chile, and Columbia) ELC ↔ Y (Venezuela) |
| Odhiambo (2010) | Sub-Saharan African countries | EC per capita, RGDP per capita, and CPI | ARDL and Granger Causality | EC → Y (South Africa and Kenya) Y → ELC (Congo) |
| Wolde-Rufael (2010) | India | Nuclear EC, RGDP per capita, real GFCF, and L | ARDL and Granger Causality | NEC → Y |
| Tsani (2010) | Greece | EC and RGDP | Granger- Causality and Toda and Yamamoto (1995) | EC → Y |
| Apergis and Payne (2011) | 88 Countries | ELC, RGDP, RGFCF, and L | VAR Panel and Granger Causality | ELC ↔ Y (high income and upper-middle income country panels) ELC → Y (Lower-middle income country panel and the low income countries) |
| Bekhet and Othman (2011) | Malaysia | ELC, GDP, FDI, and consumer expenditure | VECM | ELC → Y |
| Lai et al. (2011) | China | ELC and GDP | VAR and Granger-Causality | A long-run equilibrium relationship between EC and GDP |
| Dagher and Yacoubian, (2012) | Lebanon | EC and economic growth (GDP) | ECM and Granger Causality | EC ↔ Y |
| Pirlogea and Cicea (2012) | Romania, Spain, and European Union | EC and GDP per capita | Granger Causality | EC → Y (Romania) |

***(Cond...)***

**Table 1: *(Continued...)***

| Author | Country | Variables | Methodology | Causality results |
|---|---|---|---|---|
| Sebri and Abid, (2012) | Tunis | ELC per capita, EC per capita, oil consumption per capita, TO, and AV per capita | Granger Causality | TO and both aggregated and disaggregated energy consumption Granger cause AV |
| Muhammad and Lean (2012) | Pakistan | ELC, RGDP, L and K | ARDL and Granger Causality | ELC ↔ Y |
| Islam et al. (2013) | Malaysia | EC, RGDP, population, and FD | VECM and Granger Causality | Co-integration between FD, EC, aggregate production, and population in Malaysia. Also, EC is influenced by GDP and FD, both in the short- and the long-run |
| Hamdi et al. (2014) | Bahrain | EC, FDI, K and GDP | ARDL | EPC ↔ Y |
| Sbia et al. (2014) | UAE | $CO_2$, TO, FDI, clean energy, and GDPL | ARDL | Y → EC |
| Tang et al. (2014) | Malaysia | ELC, EC, GDP, EX, FD, and FDI | ARDL | ELC, EC, GDP, EX and FD are positively related to the inward FDI |

→, ↔, —, Denotes, unidirectional causality, bidirectional causality, and neutral, respectively. ELC: Electricity consumption, EC: Energy consumption, ELP: Electricity production, NEC: Nuclear energy consumption, FD: Financial development, ME: Manufacturing employment, IELC: Industrial electricity consumption, CELC: Commercial electricity consumption, OELC: Other sector electricity consumption, NEMP: Non-farm employment, AELC: Agricultural electricity consumption, RELC: Residential electricity consumption, AVA: Agricultural value added, IVA: Industrial value added, MRFI: Manufacturing real fixed investment, MVA: Manufacturing value added, IMP: Imports, Y: Real or nominal GDP or GNP, IP: Industrial production, EMP: Employment, TO: Trade openness, MI: Manufacturing industry, J-J: Johansen-Juselius, ARDL: Autoregressive distributed lags, VAR: Vector autoregressive, VECM: Vector error correction model, GDP: Gross domestic product, CPI: Consumer price index, FDI: Foreign direct investment

Omri et al., 2015. In Malaysia, Tang et al. (2014) analyzed the relationship between FDI and ELC. The results suggested that FD, GDP, exchange rate, and macroeconomic uncertainty are positively related to inward FDI in electricity sector. Wolde-Rufael (2014) examined the causal relationship between economic growth and electricity consumption for 15 countries. The results indicated bidirectional causality in Ukraine; a unidirectional running from electricity consumption to economic growth in Bulgaria and Belarus; and no causality in Albania, Moldova, Serbia, and Slovenia. Cowan et al. (2014) found different results for the Granger causality relationship (unidirectional, bidirectional, and neutral) between GDP, electricity consumption, and $CO_2$ for the BRICS countries.

## 4. METHODOLOGY AND DATA

In the current paper, annual data for ELC per capita, real GDP per capita, export of goods and services (X), and FD variables at constant prices (2000=100 in US $) covering 1976-2011 period have been collected from the World Bank (2013). Following the empirical literature in ELC (Abosedra et al., 2009; Narayan and Smyth, 2009; and Sebri and Abid, 2012), it is plausible to form the long-run relationship between ELC, GDP, X, and FD in linear form, with a view of testing the long-run, short-run and causality relationships between these variables in Jordan as clarified in Equation (1).

$$ELC_t = f(GDP_t, X_t, FD_t) \tag{1}$$

Where, an ELC represents the ELC per capita measures in kW/h; GDP per capita is a proxy for the growth in real gross domestic product (economic growth); X is the export of goods and services, if granger cause run from ELC to X reducing ELC could prevent the X development (Nayaran and Smyth, 2009). FD is a proxy of domestic credit to the private sector as a percentage of GDP obtained from the banking sector, includes the gross credit to various sectors with the exception of credit to the central government (Islam et al., 2013).

To avoid the hestroscedasticity problem and stimulates the stationarity in variance covariance matrix (Bekhet and Al-Smadi, 2014; Lau et al., 2014), all variables have been transformed into natural logarithmic (*l*). E-views 7.2, and Microfit version 4.1 software's are used. Thus, the Equation (1) is rewritten as in Equation (2):

$$lELC_t = \alpha_0 + \lambda_1 lGDP_t + \lambda_2 lX_t + \lambda_3 lFD_t + \varepsilon_t \tag{2}$$

Equation (2) represents ELC as a linear function of all variables. $\alpha_0$ - is constant term; $\lambda_1, \ldots, \lambda_3$ - are the coefficients of the model; $\varepsilon_t$ - is the error term. Numerous studies have used Engle and Granger (1987) and Johansen and Juselius (1991) and Johansen (1991) techniques to test the co-integration between ELC and economic growth (Table 2). These techniques oblige that all regressors in the system must be stationary with the same order of integration. Pesaran et al. (2001) has developed a model to introduce a delegate co-integration technique known as ARDL bound testing approach which has many advantages over the previous co-integration techniques (Pesaran et al., 2001; Ghatak and Siddiki, 2001; Jayaraman and Choong, 2009; Ozturk and Acaravci, 2011; Bekhet and Al-Smadi, 2015): First, no need to examine the non-stationary property and order of integration. This means that we can apply ARDL whether underlying regressors are purely I(0) or purely I(1), while other co-integration techniques require all the regressors to be integrated of the same order. Second, it has more proper considerations than the Johansen–Juselius and Engle–Granger techniques for testing the co-integration among variables in small sample size. Comparatively, the Johansen co-integration techniques need large data sample for validity. Third, the ARDL application allows the variables

**Table 2: Screening data and interrelationship matrix**

| Data | *lELC* | *lGDP* | *lX* | *lFD* |
|---|---|---|---|---|
| Mean | 6.910 | 22.652 | 21.819 | 4.132 |
| Median | 7.021 | 22.616 | 21.861 | 4.181 |
| Maximum | 7.867 | 23.495 | 22.607 | 4.519 |
| Minimum | 5.518 | 21.646 | 20.705 | 3.372 |
| Standard deviation | 0.612 | 0.487 | 0.507 | 0.258 |
| Skewness | −0.768 | −0.026 | −0.294 | −1.142 |
| Kurtosis | 2.821 | 2.410 | 2.361 | 4.272 |
| Jarque-Bera | 3.593 | 0.525 | 1.131 | 10.265 |
| Probability | 0.165 | 0.768 | 0.567 | 0.005 |
| *lELC* | 1 | | | |
| *lGDP* | 0.740*** | 1 | | |
| *lX* | 0.899*** | 0.891*** | 1 | |
| *lFD* | 0.563*** | 0.419*** | 0.571*** | 1 |

***Denotes statistical significant level at 1%, two-tails. Source: Output of the E.Views Software, version 7.2. ELC: Electricity consumption, FD: Financial development, GDP: Gross domestic product

that may have different optimal lags, while it is impossible with conventional co-integration procedures. Fourth, the ARDL model has become increasingly popular in recent years.

Based on these advantages, this paper employed bound test for testing co-integration among the variables in the current study. To examine the co-integration among the variables (Equation 1), the ARDL approach is derived from the unrestricted error correction model and formulated for each variable as in Equations (3-6).

$$\Delta lELC_t = \alpha_{01} + \sum_{i=1}^{n1} \Pi_{11} \Delta lELC_{t-i} + \sum_{i=0}^{n2} \Pi_{12} \Delta lGDP_{t-i} + \sum_{i=0}^{n3} \Pi_{13} \Delta lX_{t-i} + \sum_{i=0}^{n4} \Pi_{14} \Delta lFD_{t-i} + \Omega_{11} lELC_{t-1} + \Omega_{12} lGDP_{t-1} + \Omega_{13} lX_{t-1} + \Omega_{14} lFD_{t-1} + \varepsilon_{t1} \quad (3)$$

$$\Delta lGDP_t = \alpha_{02} + \sum_{i=1}^{n1} \Pi_{21} \Delta lGDP_{t-i} + \sum_{i=0}^{n2} \Pi_{22} \Delta lELC_{t-i} + \sum_{i=0}^{n3} \Pi_{23} \Delta lX_{t-i} + \sum_{i=0}^{n4} \Pi_{24} \Delta lFD_{t-i} + \Omega_{21} lELC_{t-1} + \Omega_{22} lGDP_{t-1} + \Omega_{23} lX_{t-1} + \Omega_{24} lFD_{t-1} + \varepsilon_{t2} \quad (4)$$

$$\Delta lX_t = \alpha_{03} + \sum_{i=1}^{n1} \Pi_{31} \Delta lX_{t-i} + \sum_{i=0}^{n2} \Pi_{32} \Delta lELC_{t-i} + \sum_{i=0}^{n3} \Pi_{33} \Delta lGDP_{t-i} + \sum_{i=0}^{n4} \Pi_{34} \Delta lFD_{t-i} + \Omega_{31} lELC_{t-1} + \Omega_{32} lGDP_{t-1} + \Omega_{33} lX_{t-1} + \Omega_{34} lFD_{t-1} + \varepsilon_{t3} \quad (5)$$

$$\Delta lFD_t = \alpha_{04} + \sum_{i=1}^{n1} \Pi_{41} \Delta lFD_{t-i} + \sum_{i=0}^{n2} \Pi_{42} \Delta lELC_{t-i} + \sum_{i=0}^{n3} \Pi_{43} \Delta lGDP_{t-i} + \sum_{i=0}^{n4} \Pi_{44} \Delta lX_{t-i} + \Omega_{41} lELC_{t-1} + \Omega_{42} lGDP_{t-1} + \Omega_{43} lX_{t-1} + \Omega_{44} lFD_{t-1} + \varepsilon_{t4} \quad (6)$$

Where, $\Delta$ is the first difference operator; $\alpha_{01}, \ldots, \alpha_{04}$ are the constant terms, $\Pi_{11} \ldots \Pi_{44}$ represent the short-run coefficients; while $\Omega_{11}, \ldots, \Omega_{44}$ represent the long-run coefficients; $n_1, \ldots, n_4$ are the lag length; and $\varepsilon_{t1}, \ldots, \varepsilon_{t4}$ are error terms. For testing the existence of the short- and long-run relationship among the above variables (Equations 3-6), we can formulate the $H_0$ and $H_1$ hypotheses as the following:

| Short-run | | Long-run | |
|---|---|---|---|
| **$H_0$: There is no relationship** | **$H_1$: There is relationship** | **$H_0$: There is no relationship** | **$H_1$: There is relationship** |
| $\Pi_{11}=\Pi_{12}=$ | $\Pi_{11}\neq\Pi_{12}\neq$ | $\Omega_{11}=\Omega_{12}=$ | $\Omega_{11}\neq\Omega_{12}\neq$ |
| $\Pi_{13}=\Pi_{14}=0$ | $\Pi_{13}\neq\Pi_{14}\neq 0$ | $\Omega_{13}=\Omega_{14}=0$ | $\Omega_{13}\neq\Omega_{14}\neq 0$ |
| $\Pi_{21}=\Pi_{22}=$ | $\Pi_{21}\neq\Pi_{22}\neq$ | $\Omega_{21}=\Omega_{22}=$ | $\Omega_{21}\neq\Omega_{22}\neq$ |
| $\Pi_{23}=\Pi_{24}=0$ | $\Pi_{23}\neq\Pi_{24}\neq 0$ | $\Omega_{23}=\Omega_{24}=0$ | $\Omega_{23}\neq\Omega_{24}\neq 0$ |
| $\Pi_{31}=\Pi_{32}=$ | $\Pi_{31}\neq\Pi_{32}\neq$ | $\Omega_{31}=\Omega_{32}=$ | $\Omega_{31}\neq\Omega_{32}\neq$ |
| $\Pi_{23}=\Pi_{24}=0$ | $\Pi_{23}\neq\Pi_{24}\neq 0$ | $\Omega_{23}=\Omega_{24}=0$ | $\Omega_{23}\neq\Omega_{24}\neq 0$ |
| $\Pi_{41}=\Pi_{42}=$ | $\Pi_{41}\neq\Pi_{42}\neq$ | $\Omega_{41}=\Omega_{42}=$ | $\Omega_{41}\neq\Omega_{42}\neq$ |
| $\Pi_{43}=\Pi_{44}=0$ | $\Pi_{43}\neq\Pi_{44}\neq 0$ | $\Omega_{43}=\Omega_{44}=0$ | $\Omega_{43}\neq\Omega_{44}\neq 0$ |

Pesaran et al. (2001) suggested the procedures to take a decision (reject or accept $H_0$). These are: First. If $F_s >$ upper bound, I(1), then reject $H_0$ and the variables are co-integrated. Second, If $F_s <$ lower bound, I(0), then accept $H_0$ and the variables are not co-integrated. Third, but if I(0) $F_s$ I(1) then the decision is inconclusive (under such circumstance, Banerjee et al. (1998) suggested that the error correction method is appropriate).

Where, $F_s$ is: F-statistic.

Furthermore, the next step is the multivariate Granger causality test is used to test the short and long-run causality relationship among the variables. This step shows the presence of bidirectional, unidirectional or neutral causality relationship by using the vector error correction model (VECM). If the variables are co-integrated, VECM can be formulated as in Equation (7).

$$(1-B)\begin{bmatrix} lELC \\ lGDP \\ lX \\ lFD \end{bmatrix}_t = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{bmatrix} + \sum_{i=1}^{k}(1-B) \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} & \beta_{14} \\ \beta_{21} & \beta_{22} & \beta_{23} & \beta_{24} \\ \beta_{31} & \beta_{32} & \beta_{33} & \beta_{34} \\ \beta_{41} & \beta_{42} & \beta_{43} & \beta_{44} \end{bmatrix} \begin{bmatrix} lELC \\ lGDP \\ lX \\ lFD \end{bmatrix}_{t-i} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \end{bmatrix} \begin{bmatrix} ECT_1 \\ ECT_2 \\ ECT_3 \\ ECT_4 \end{bmatrix}_{t-1} + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \\ \mu_{4t} \end{bmatrix} \quad (7)$$

Where, (1−B) is the first difference operator; $lELC_t$, $lGDP_t$, $lX_t$, and $lFD_t$ are the study variables as defined in section (4); $\alpha_1, \ldots, \alpha_4$ are the constant terms; $\beta_{11}, \ldots, \beta_{44}$ are the short-term coefficients for the variables; $ECT_{1t-1}, \ldots, ECT_{4t-1}$ are the error correction terms;

**Table 3: Unit root tests**

| | ADF | | | PP | | |
|---|---|---|---|---|---|---|
| Variables | Computed statistics | P value | Order of integration | Computed statistics | P value | Order of integration |
| *lELC* | −3.4763[b] | 0.0149 | *I (0)* | −1.865 | 0.344 | *I (0)* |
| *lGDP* | −1.7637 | 0.3912 | | −1.347 | 0.596 | |
| *lX* | −1.9651 | 0.3001 | | −1.965 | 0.300 | |
| *lFD* | −1.9334 | 0.3135 | | −2.830* | 0.064 | |
| *ΔlELC* | −5.1414[a] | 0.0002 | *I (1)* | −5.141[a] | 0.000 | *I (1)* |
| *ΔlGDP* | −4.3996[a] | 0.0014 | | −4.138[a] | 0.002 | |
| *ΔlX* | −5.7390[a] | 0.0000 | | −5.739[a] | 0.000 | |
| *ΔlFD* | −4.7940[a] | 0.0005 | | −5.355[a] | 0.000 | |

ELC: Electricity consumption, FD: Financial development, GDP: Gross domestic product, [a,b,c]denotes statistical significant level at 1%, 5%, 10% respectively. Source: Output of the E.Views Software, version 7.2. ADF: Augmented Dickey–Fuller, PP: Phillip–Perron

$\delta_1,\ldots, \delta_6$ are the coefficients of the error-correction terms that describe the adjustment speed back to equilibrium (Pesaran and Pesaran, 2009); and $\mu_{1t},\ldots, \mu_{4t}$ are the error terms. Theoretically, it is possible that one variable Granger causes the other; whilst in actual evidence, no causal relationship can be detected between two variables (Huang et al., 2000). Eventually, the word (causality) according to Granger-causality does not mean that movements of one variable cause movements of another, it means that only a correlation between the current value of one variable and the past values of others (Brooks, 2008).

## 5. RESULTS AND DISCUSSION

The descriptive statistics and correlation matrix for the selected variables are revealed in Table 2. These results show that all variables are normally distributed except for the FD as confirmed by Jarque-Bera test. As noticed, ELC has a strong significant and positive correlation with each of FD, GDP, and X variables, which are consistent with the existing literature (Narayan and Smyth, 2009; Bekhet and Othman, 2011; Lai et al., 2011; Islam et al., 2013; Ivy-Yap and Bekhet, 2015). These interrelationships between GDP, FD, and X are very important determinants for ELC and appropriate indicator to forecast the further behaviour of the ELC changing positions.

Table 3 shows the results of stationary tests (augmented Dicky–Fuller, 1991; 1988; Phillip–Perron, 1991) for all variables, both in I(0) and I(1). However, at I(0), we can accept the $H_0$ of unit roots for all variables except the *lELC* (stationary at the level, I(0)), while, at I(1), the $H_0$ is rejected of each variable. So, we can confirm that all the variables of the study are stationary at the I(1).

Since the variables are mutually stationary of I(0) and I(1), the most appropriate model in this case is the bound testing approach (ARDL). Besides, it is appropriate to test whether the variables are co-integrated or not. Besides, choosing the optimal lag length is very important step before testing the existence of co-integration among the selected variables. This is based on the most popular criteria of selecting leg's length. These are: Schwarz Bayesian information criterion, Akaike information criteria, Hannan–Quinn criterion, final prediction error, and log-likelihood ration in vector autoregressive (VAR) model. The results of these tests are presented in Table 4 which shows that the optimal lag length is one.

**Table 4: Lag length selection criterion for co-integration**

| Lag | Log L | LR | FPE | AIC | SBC | HQ |
|---|---|---|---|---|---|---|
| 0 | 58.962 | - | 4.63 | 3.233 | −3.053 | −3.171 |
| 1 | 201.107 | 242.482 | 2.80* | −10.653 | −9.755* | −10.347* |
| 2 | 217.429 | 24.003 | 2.87 | −10.672* | −9.056 | −10.121 |

*Indicates lag order selected by the criterion. LR: Sequential modified LR test statistic (each test at 5% level of significance). Source: Output of the E.Views software, version 7.2. SBC: Schwarz Bayesian information criterion, AIC: Akaike information criteria, HQ: Hannan–Quinn criterion, FPE: Final prediction error, LR: Log-likelihood ration

Bound F-statistics bounds are used for long-run relationship test among the variables with one lag based on the optimal lag (Table 4). These results are presented in Table 5 which shows the long-run equilibrium relationships among the variables.

Table 5 reveals that the F-statistic for the *lELC* model is higher than the upper bound value. Therefore, the null hypothesis ($H_0$, no co-integration among the variables) cannot be accepted. On the other hand, when the process was repeated for the rest of the models, the computed F-statistics are less than the upper and lower bound at all levels of significance. Clearly, there is only one long-run relationship implied a unique co-integration relationship among the variables in Jordan's, ELC model (Table 6). Besides, all the regressors can be treated as long-run forcing variables for the per capita consumption of electricity. The coefficients are significant for all variables except for *lX* at the 5% level of significance which signals a positive impact on ELC in the long-run.

Furthermore, Table 7 represents the results of the short-run dynamic relationship between the ELC and the regressors. The $ECT_{t-1}$ indicates the speed adjustment back to equilibrium in the dynamic model. When $ECT_{t-1}$ is significant with correct sign (negative) in the short-run model confirms the existence of a long-run equilibrium relationship among the variables (Nayaran and Smyth, 2005). The magnitudes of the coefficients of $ECT_{t-1}$ denote the speed of adjustment back of any disequilibrium into equilibrium situation (Pesaran and Pesaran, 2009). Besides, the $ECT_{t-1}$ coefficient is found to be negative and significant (−0.211, 0.001) which is highly significant at the 1% level with the correct sign. This implies a high speed adjustment back to equilibrium, where 21% of disequilibrium from previous year can back to long-run equilibrium in the current year. In addition, the regressions for the underlying ARDL model passed the diagnostic tests of serial correlation, hetroscedasitcity, and normality tests. Also, the results of *lELC* model reveal no evidence of any misspecification.

**Table 5: Bound F-statistic test results**

| Model | F-statistics | I (1)-I (0) bounds at (%) | | | Decision |
|---|---|---|---|---|---|
| | | 10 | 5 | 1 | |
| $F_{ELC}(lELC / lGDP, lX, lFD)$ | 5.009[b] | 2.711-3.800 | 3.219-4.378 | 4.385-5.615 | Co-integration |
| $F_{GDP}(lGDP / lELC, lX, lFD)$ | 1.684 | 2.711-3.800 | 3.219-4.378 | 4.385-5.615 | No co-integration |
| $F_X(lX / lELC, lGDP, lFD)$ | 1.023 | 2.711-3.800 | 3.219-4.378 | 4.385-5.615 | No co-integration |
| $F_{FD}(lFD / lELC, lGDP, lX)$ | 2.525 | 2.711-3.800 | 3.219-4.378 | 4.385-5.615 | No co-integration |

The critical value bounds are taken from Table F in pesaran and pesaran (2009, p. 544), with an intercept and no trend. [b]denotes statistical significant level at 5%. Source: Output of the Microfit Software, version 4.1. ELC: Electricity consumption, FD: Financial development, GDP: Gross domestic product

**Table 6: ARDL results**

| Estimated long-run coefficients using the ARDL (1,0,0,0) model | | | | |
|---|---|---|---|---|
| **Dependent variable=*lELC*** | | | | |
| **Variables** | **Coefficients** | **t-statistic** | **P value** | **Standard error** |
| Constant | −13.4048[a] | 3.8070 | 0.001 | 3.5211 |
| $lGDP_t$ | 1.1085[b] | 2.1385 | 0.041 | 0.5183 |
| $lX_t$ | 0.3300 | 1.1722 | 0.250 | 0.2816 |
| $lFD_t$ | 1.2048[a] | 2.5692 | 0.015 | 0.4689 |
| **Diagnostic tests** | | | | |
| **Test statistics** | **Statistic value** | | **P value** | |
| Serial correlation | 0.0058 | | 0.939 | |
| Hetroscedasticity | 1.4611 | | 0.227 | |
| Normality | 0.3392 | | 0.844 | |
| DW-test | 1.7299 | | | |
| $R^2$-adjusted | 99% | | | |

[a,b,c]denotes statistical significant level at 1%, 5%, 10%, respectively. Source: Output of the Microfit Software, version 4.1. ELC: Electricity consumption, FD: Financial development, GDP: Gross domestic product, ARDL: Autoregressive distributed lags

**Table 7: The analysis of ECM and short-run relationship**

| Error-correction representation for the selected ARDL (1,0,0,2) model | | | | |
|---|---|---|---|---|
| **Dependent variable=*ΔlELC*** | | | | |
| **Variables** | **Coefficients** | **t-statistic** | **P value** | **Standard error** |
| $\Delta lGDP_t$ | 0.2338[a] | 3.0953 | 0.004 | 0.0755 |
| $\Delta lX_t$ | 0.0696 | 0.96969 | 0.340 | 0.0718 |
| $\Delta lFD_t$ | 0.2541[b] | 2.3361 | 0.026 | 0.1088 |
| $ECT_{t-1}$ | −0.2109[a] | 3.5452 | 0.001 | 0.0595 |
| **Panel 2: Diagnostic tests** | | | | |
| F-statistic - 7.2761*** | | SBC - 44.8352 | | |
| DW-test - 1.7279 | | AIC - 48.7236 | | |
| RSS - 53.723 | | Mean of dependent variable - 0.0629 | | |

[a, b, c]denotes statistical significant level at 1%, 5%, 10%, respectively. Source: Output of the Microfit Software, version 4.1. ECM: Error-correction model, ELC: Electricity consumption, FD: Financial development, GDP: Gross domestic product, ARDL: Autoregressive distributed lags, SBC: Schwarz Bayesian information criterion, AIC: Akaike information criteria

Subsequently, the direction of the causality relationship among the variables has been checked by running the multivariate Granger causality test. The results are shown in Table 8 at the 1%, 5%, and 10% levels of significance. It reveals that there are three unidirectional causal relationships among the variables. Besides, the electricity consumption in the short-term is affected by GDP and exports variables on one hand and the FD affected by the exports on the other hand.

The cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares (CUSUMQ) have employed to check the stability of the long-run coefficients with the short-run dynamics between ELC and its causes (Brown et al., 1975; Pesaran and Pesaran, 1997; and Bahmani-Oskooee and Bohl, 2000). If the plot of CUSUM and CUSUMSQ statistic stays within the critical values at 5% significance level (within the two straight lines) the null hypothesis that all coefficients in the error correction model are stable, and cannot be rejected (Bahmani-Oskooee and Ng, 2002). If either of the lines is crossed, the null hypothesis of coefficient stability can be rejected at the 5% significance level. Figure 4 reveals that the plot of both CUSUM and CUSUMQ statistics stays within the critical boundaries. These plots are confirmed the stability of the ELC model. As such, this result is in coincidence with previous literature (Ghosh, 2009; Islam et al., 2013; Hamdi et al., 2014; Sbia et al., 2014).

Eventually, the impulse response function (IRF) details the adjustment of the dynamics interaction among the variables. It used to trail the dynamic response of the ELC to one standard deviation shock to each of the explanatory variables. This study formulates the IRF based on the estimated VAR model over the 10-year timeframe. As noticed from Figure 5, the most effective impact of one standard deviation shock on ELC is for the GDP. As can be noticed, the shock takes a positive jump on the GDP and increases in the period of the 2nd year, and in the next year it eventually raises in upward trending and does not die out after 10 years. In addition, the responses of ELC to the FD and X variable are also positive after 10 years.

## 6. CONCLUSION AND POLICY IMPLICATIONS

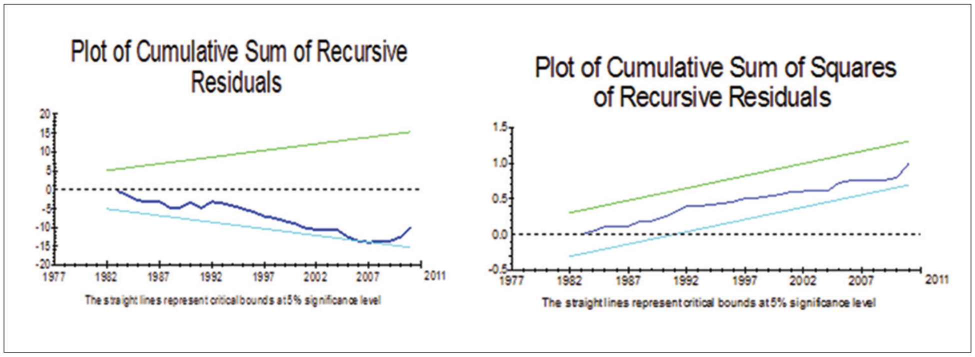
The current paper examined the relationship between the ELC, GDP, X and FD. It has employed the ARDL time series approach for the 1976-2011 period. The empirical results provided strong evidence against the null hypotheses of unit roots in most of the series under investigation. The results of ARDL approach showed the existence of long-run equilibrium relationship between the ELC and the real GDP per capita, export, and FD variables in Jordan. The negative and significant $ECT_{t-1}$ coefficient implies a high speed adjustment back to equilibrium (−0.211, 0.001), where 21% of disequilibrium from previous year can back to long-run equilibrium in the current year. Moreover, the multivariate granger

**Table 8: Multivariate causality results**

| Dependent variables | Short-run causality | | | | Long-run causality | Direction of causality |
|---|---|---|---|---|---|---|
| | $\Delta lELC_{t-1}$ | $\Delta lGDP_{t-1}$ | $\Delta lX_{t-1}$ | $\Delta lFD_{t-1}$ | $ECT_{t-1}$ | |
| $\Delta lELC_t$ | - | 0.4651 | 0.3883 | 0.9521 | −0.210[a] | $lGDP \rightarrow lELC$ |
| $\Delta lGDP_t$ | 8.463[a] | - | 0.0553 | 0.1964 | −0.1389[c] | $lX \rightarrow lELC$ |
| $\Delta lX_t$ | 7.738[a] | 0.0148 | - | 3.358[c] | −0.15627 | $lX \rightarrow lFD$ |
| $\Delta lFD_t$ | 1.9077 | 0.4914 | 0.0170 | - | −0.3689[b] | |

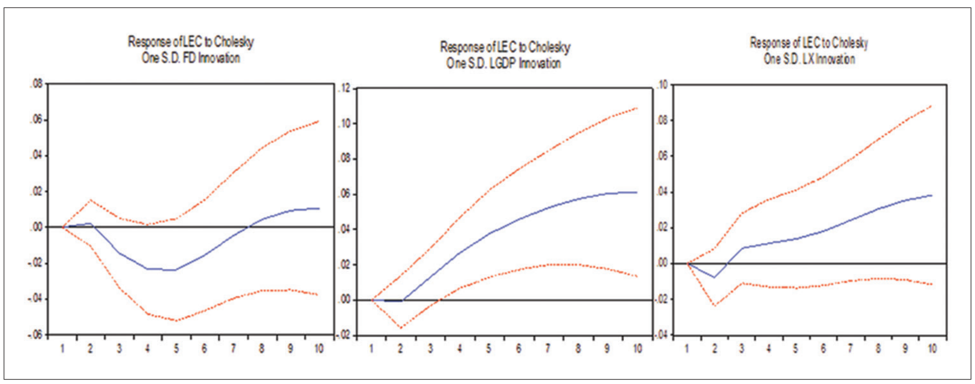
The (→) represents the unidirectional Granger causality. [a,b,c]denotes statistical significant level at 1%, 5%, 10%, respectively. Source: Output of the Microfit Software, version 4.1. ELC: Electricity consumption, FD: Financial development, GDP: Gross domestic product

**Figure 4:** Plots of cumulative sum of recursive residuals and cumulative sum of squares underwriting electrical consumption




Source: Output of the Microfit Software, version 4.1

**Figure 5:** Impulse response function of *lELC* to one standard deviation of each variable

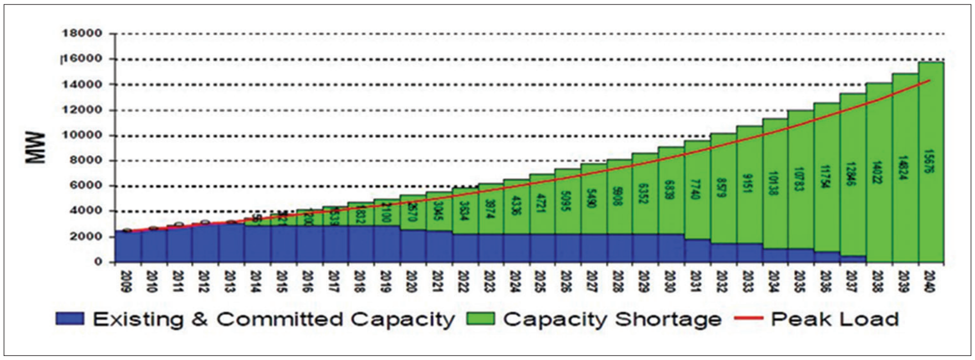



Source: Output of the Microfit Software, version 4.1

causality test suggests a unidirectional relationship run from the real GDP to the ELC; this implies that the reduction of the per capita ELC will not impact the future economic growth in Jordan. Besides, the stability tests (CUSUM and CUSUMQ) reveal that the coefficients of the error correction model are stable. Subsequently, the results are consistent with the earlier findings (Ghosh, 2002; Fatai et al., 2004; Narayan and Smyth, 2005; Yoo and Kim, 2006; Squalli, 2007; Mozumder and Marathe, 2007; Ghosh, 2009; Bekhet and Matar, 2012b; Bekhet and Matar, 2013a; Bekhet and Matar, 2013b; Tang et al., 2014).

In the current study, we add to the existing literature by employing the most popular approach in examining the long-run relationship between ELC and GDP in Jordan and fill the gap in the literature. In addition, studying the relationship between ELC and GDP can shed some light on the energy response to economic factors in Jordan since the prices of electricity start rise in recent couple years. This study is very important for different parties like, policymakers, energy sectors, and academic researchers. The policymakers will need to pay more attention to the increase in the rate of consumption by the population; this will help to reduce the imports of oil as the main source of electricity running. The most relevant implication that the recent capacity increases in ELC should be made a national priority to make a trade-off between economic growth and ELC because any shortage in electrical capacity will positively affect the economic growth (Dagher and Yacoubian, 2012). Figure 6 shows the planned electricity demand translates into a total electricity generation capacity need of more than 15,000 megawatts (MW) by 2040 (up from 2662 MW in 2007), with an annual growth rate of around 6% (white paper on nuclear energy in Jordan, 2011). This is another challenge that needs from further researchers and Jordanian policy makers to pay more attention (Section 2). In addition, the implication of the main finding that GDP granger causes ELC indicates that the high rate of economic growth will lead to high growth in ELC. Thus, it is difficult to meet ELC demand if the government

**Figure 6:** Forecasting the available and committed electrical capacities




Source: Jordan Atomic Energy Commission (2011), White Paper on Nuclear Energy in Jordan

wants to sustain the current growth prosperity. The Jordanian government should utilize the potential of renewable or alternative energy for electricity generation, such as the solar energy as this will apart from decreasing Jordan's certainty imported fuels; activate Jordanian economic growth, the electrical power generation from nuclear power, and controlling current account deficits. According to IMF (2010), the adoption of nuclear power plant process will enhance the Jordanian GDP growth and total economic development and decreasing the unemployment rate. On the electrical demand side, citizens should be made aware of the importance of effective use of electricity, particularly given our results that electricity consumption positively contributes to economic growth in Jordan. Finally, for further studies, we suggest more factors that may cause the obvious structural breaks on ELC, such as consumer price index, pollutions, and political events.

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