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The Weight of Economic Growth and Urbanization on Electricity Demand in UAE

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Abstract:
This study aims to explore the relationship between economic growth, urbanization, financial development and electricity consumption in case of United Arab Emirates. The study covers the time period of 1975-2011. We have applied the ARDL bounds testing to examine long run relationship between the variables in the presence of structural breaks. The VECM Granger causality is applied to investigate the direction of causal relationship between the variables. Our empirical exercise found cointegration between the series in case of United Arab Emirates. Further, results reveal that inverted U-shaped relationship is found between economic growth and electricity consumption i.e. economic growth raises electricity consumption initially and declines it after a threshold level of income per capita. Financial development adds in electricity consumption. The relationship between urbanization and electricity consumption is also inverted U-shaped. This implies that urbanization increases electricity consumption initially and after a threshold level of urbanization, electricity demand falls. The causality analysis finds feedback hypothesis between economic growth and electricity consumption i.e. economic growth and electricity consumption are interdependent. The bidirectional causality is found between financial development and electricity consumption. Economic growth and urbanization Granger cause each other. The feedback hypothesis is also found between urbanization and financial development, financial development and economic growth and same is true for electricity consumption and urbanization.

Keywords: Economic growth, urbanization, electricity consumption

Introduction

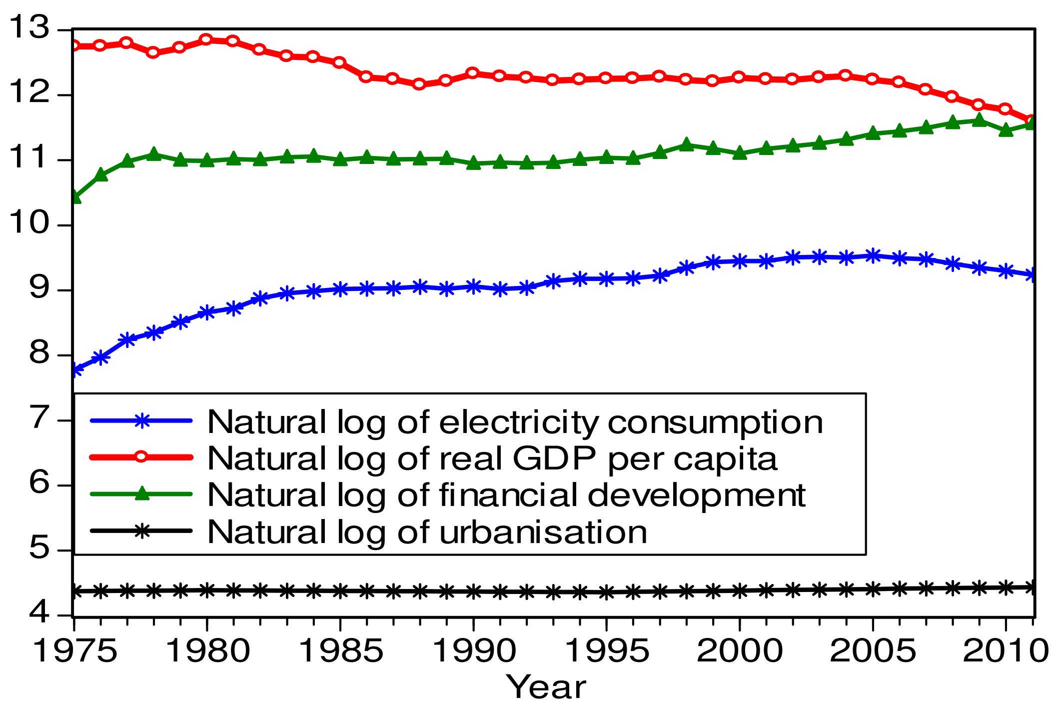
The objective of present study is to assess the relationship among economic growth, financial development, urbanization and electricity consumption in United Arabs Emirates (UAE) applying electricity demand function. The UAE[1] is a federation of seven emirates namely: Abu Dhabi (the capital emirate), Ajman, Dubai, Fujairah, Ras al-Khaimah, Sharjah and Umm al-Quwain. Since early 1960s, when oil was discovered, the UAE profile has been moving from fishing and agricultural-based economy to an oil-based economy. A member of the Organization of the Petroleum Exporting Countries (OPEC) since 1967, the UAE is one of the biggest oil producers in the world. The UAE holds the seventh-largest proved reserves of oil at 97.8 billion barrels with a capacity of around 2.9 barrels/day (IEA, 2007). Add to its vast oil reserves, the UAE has 215 trillion cubic feet of proved natural gas reserves, ranking it 7th in the world. Although, a big part of its natural gas reserve is a sour gas, which requires filtering from sulphur. This drives the UAE to become a net importer of natural gas to meet to local fast growing demand. One of the major solutions to resolve natural gas shortage is the Dolphin gas Project's export pipeline. The pipeline goes from Qatar to Oman via the UAE.

The UAE has witnessed buoyant economic growth in the last decades boosted by high oil prices. After 1970s oil price shocks and sudden decline of Dubai's oil production in 1990, a wide range of projects have been set up and structural reforms have been implemented to diversify the economy. Focus was on trade, finance, infrastructure and tourism. The development of free zones as Jebel Ali Free Zone (JAFZ), formed in Dubai in 1985, has attracted valuable amount foreign investments. JAFZ allows the international companies who relocate there to get advantage from corporate tax exemption for fifteen years, no personal income tax, no imports and exports, no restriction on currency and availability of cheap workforce. It hosts around 5500 firms (comprising banks) from over 120 countries including Standard Chartered Bank, Citibank, Ericsson, Kraft Foods and L'Oreal among other. The success of JAFZ has inspired further free zones in Dubai and in the other emirates. The country's landscape has changed drastically and the UAE has become one of the most attractive and exiting destinations of regional and global tourism. One can find in UAE extravagant and unique landmarks, including the world's tallest building, artificial island (The Palm and World map), first Ferrari them park, first shopping mall with indoor ski-resort (Dubai mall). Beyond that, different festivals are running around the year including Dubai Shopping Festival, Dubai International Jazz Festival and Abu Dhabi among other. According to Arabian Travel Market, the number of foreign visitors to the UAE reached 9 million in 2011. To face rapid economic growth and radical landscape changes, the UAE infrastructure is developing very quickly (even with notable delay). The UAE's air transport is considered as global hub thanks to massive public spending and its strategic location between Asia, Africa and Europe. Maritime infrastructure is also very developed and keeps expanding to handle growing trade volume. The road network is extensive and serving major urban cities. In 2009, Dubai metro was opened and there is a plan to build a national network.

Developed infrastructure has definitely a direct impact on urbanization. The most used measures of the degree of urbanization are urban population and rate of urbanization. The former describes the percentage of the total population living in urban areas, as defined by the country. The later describes the projected average rate of change of the size of the urban population over a given period of time. World Urbanization Prospects (the 2011 Revision) reports that the UAE's urban population jumped from 54.4 % in 1950 to 84.4 % in 2010. The urbanization rate reached 2.9%

during 2005-2010 period which is one of the highest rate in the world. The country's escalating economic growth, large contribution of trade in the economy, foreign investments and large portion of expatriate workforce have helped in the establishment of a sound banking system and financial market. It was reflected in the great expansion in the activities of the banks operating in the country. Credit facilities granted to the private sector by banks operating in the country increased from AED 25.17 billion in 1980 to AED 730.86 billion in 2011(UAE central bank annual report).

Figure-1: Trends of variables in United Arab Emirates



Similarly, foreign assets increased from AED 19.41 billion to AED 237.76 billion. Furthermore, the UAE has three domestic stock markets. The Dubai Financial Market (DFM), the Abu Dhabi Securities Market (ADSM) and the Dubai International Financial Exchange (DIFX). Most of the UAE's electricity is generated using gas-fed thermal generation, and plans to integrate the seven

Emirate's gas distribution networks. The electricity consumption in 2010 is estimated at 79.3 billion (KWh) in the UAE and installed capacity reached 23.25 Giga watts in 2009[2]. The historical trends of electricity consumption per capita, income per capita, financial development and urbanization are shown in Figure-1.

II. Literature Review

II.I Economic Growth and Electricity Consumption

It is evident that electricity has played a key role in the evolution of human-being life. It has contributed in the progress and development of major needs: transportation, communication and manufacturing. Economists are usually attracted by finding a new determinant (variables) of economic growth. Electricity consumption has been one of those variables. The literature investigating the relationship between electricity consumption and economic growth is enormous. It was produced an extended range of studies since the pioneering work of Kraft and Kraft, (1978). Rosenberg, (1998) examined the role played by electricity in the course of industrial development over the past century. However, one can distinguish four different streams according to the type of the relationship between both the variables: (i) electricity consumption-led growth hypothesis (or growth hypothesis), (ii) feedback hypothesis, (iii) growth-led electricity consumption hypothesis (or conservation hypothesis) and,(iv) neutrality hypothesis.

For many countries, growth hypothesis has been confirmed. This means that electricity consumption Granger causes economic growth. For example, Shiu and Lam, (2004) for China;Ho and Siu, (2007) for Honk Kong; Gupta and Chandra, (2009) for India; Abosedra et al.

(2009) for Lebanon; Chandran et al. (2009) for Malaysia; Odhiambo (2009a) for Tanzania; Adebola (2011) for Botswana and Kouakou (2011) for Cote d'Ivoire. For other countries, studies such as Ghosh, (2002) for India; Narayan and Smyth, (2005) for Australia; Hu and Lin, (2008) for Taiwan; Yoo and Kim, (2006) for Indonesia; Mozumder and Marathe, (2007) for Bangladesh; Jamil and Ahmad, (2010) and; Shahbaz and Feridun, (2012) for Pakistan; Ciarreta and Zarraga, (2010) for Spain; Sami, (2011) for Japan; Adom, (2011) for Ghana showed the validity of conservation hypothesis i.e. economic growth Granger causes electricity consumption. Yusof and Latif, (2007) in case of Malaysia and Akpan and Akpan, (2012) in case of Nigeria supported the neutrality hypothesis. This reveals that implementation of energy (electricity) conservation polices would not adversely affect economic growth.

Similarly, some studies suggested the existence of feedback hypothesis such as Yang, (2000); Jumbe, (2004); Yoo, (2005); Zachariadis and Pashouortidou, (2007); Tang, (2008); Aktas and Yilmaz, (2008); Acaravci, (2010); Odhiambo, (2009b); Ouédraogo, (2010); Lorde et al. (2010); Shahbaz et al. (2011); Shahbaz and Lean, (2012) and Shahbaz et al. (2012) confirmed the existence of bidirectional Granger causality between electricity consumption and economic growth in Taiwan, Malawi, Korea, Cyprus, Malaysia, Turkey, South Africa, Burkina Faso, Barbados, Portugal, Pakistan and Romania. This implies that energy exploration policies should be encouraged to sustain economic growth in long run.

II.II Financial Development and Electricity Consumption

There is a large literature exploring the relationship between economic growth and financial development but the impact of financial development on energy demand has received very little attention. For example, Sadorsky, (2010) used multiple indicators of financial development to 22 emerging economies. He concludes that the impact of financial development on energy demand is positive but has a small magnitude. Sadorsky, (2011) examined the impact of financial development on energy consumption in case of Central and Eastern European frontier economies using from dynamic panel demand models. The results showed a positive relationship between financial development and energy consumption. In case of China, following Karanfil, (2009); Dan and Lijun, (2009) applied the bivariate model to explore relationship between financial development and energy consumption. Their empirical evidence reported that primary energy consumption Granger causes financial development. Latter on; Xu, (2012) revisited the relationship between financial development and energy consumption in 29 Chinese provinces. The existence of long run relationship was conditioned by the use of the ratio of loan in financial institutions as measure of financial development.

Kaker et al. (2011) applied production function to examine the relationship between economic growth, financial development and energy consumption using Pakistani data. They concluded that neutrality hypothesis between financial development and economic growth exists but energy consumption Granger causes financial development. Shahbaz and Lean, (2012) examined the impact of financial development on energy consumption applying energy demand function in case of Tunisia. They concluded that financial development increases energy demand by boosting stock market development and stimulating real economic activity. The results show that financial development and energy consumption Granger-cause each other. However, financial development impacts magnitude on energy consumption is greater. In case of Malaysia, Tang and Tan, (2012) investigated the relationship between financial development and energy consumption by incorporating relative prices and foreign direct investment energy demand function. The empirical results reveal positive impact of economic growth, foreign direct investment and financial development on energy consumption. Feedback hypothesis is found between financial development and energy consumption, both in short and long runs. Islam et al. (2013) exposed that financial development and economic growth have positive impact on energy consumption. They found bidirectional causality between financial development and energy consumption in long run. In short run, financial development Granger causes energy consumption.

II.III Urbanization and Electricity Consumption

Urbanization is one of the major phenomena of economic development (Jones, 1991). Further it affects social and urbane structure of the country. Urbanization impacts could be observed via population migration and growing size, extension of transport network and intensification of industrial and service activities. Duan et al. (2008) found relationship between urbanization and energy consumption in China which was confirmed by the elasticity coefficient of energy consumption Unit Geometric Average (ECUGA) in long run. Using the ARDL approach, Liu (2009) found long run relationship among population, urbanization and energy use. He found unidirectional causality from urbanization to energy consumption. On contrary, Xie et al. (2009) applied error correction model, Granger causality test, impulse response and variance decomposition to examine short-and-long runs relationship between electricity consumption and urbanization in China since the reform and opening start. Their results showed that there is a long-term and steady equilibrium relationship between electricity consumption and urbanization in China. However, the short-term and long-runs reveal different results. In long run, feedback effect is found between electricity consumption and urbanization. In short run, neutral hypothesis exists between both variables. The magnitude effects are obviously different too. Electricity consumption greatly impacts urbanization, yet the impact of urbanization on electricity consumption is not enormous. Overall results imply that urbanization is cause of electricity consumption in China. Apart from that Poumanyvong et al. (2012) found negative (positive) impact of urbanization on residential energy use in low (high) income countries. In middle income countries, residential energy initially falls with urbanization then rises with a turning point at around 70 per cent of urbanization.

Zhang and Lin, (2012) indicated that urbanization accelerates in China and urban areas play a leading role in energy consumption and CO_2 emissions. Contrary to existing literature, their paper is an analysis of the impact of urbanization on energy consumption and CO_2 emissions at the national and regional levels using the STIRPAT model. They used provincial panel data from 1995 to 2010 in China. The results showed that urbanization increases energy consumption and CO_2 emissions in China. However, the effects of urbanization on energy consumption vary across regions and decline continuously from the Western region to the Central and Eastern regions. Their results supported the argument of compact city theory. Using Iranian time series data, Abouie-Mehrizi et al. (2012) investigated the relationship between population growth, urbanization and energy consumption, and reported that population growth and urbanization increases energy demand in long run.

III. The Data, Model Construction and Estimation Strategy

The data on real GDP, electricity consumption ((kWh), domestic credit to private sector as share of GDP and urban population as share of total population have been obtained from world development indicators (CD-ROM, 2012). We have used series of population variable to formulate all series into per capita. The study covers the period of 1975-2011 using quarter frequency data. The paper deals with the empirical investigation of relationship between economic growth, financial development, urbanization and electricity consumption using data of UAE. We construct our model for empirical purposes following Yoo and Lee, (2010); Sadorsky, (2010); Shahbaz and Lean, (2012) and Poumanyvong et al. (2012).The function form of our general model is as following:

$$E_t = f(Y_t, Y_t^2, F_t, U_t, U_t^2) \qquad (1)$$

We have transformed all the series into natural log-form to avoid the sharpness in the data (Shahbaz, 2012). The log-linear equation is modeled as given below:

$$\ln E_t = \beta_1 + \beta_Y \ln Y_t + \beta_{Y^2} \ln Y_t^2 + \beta_F \ln F_t + \beta_U \ln U_t + \beta_{U^2} \ln U_t^2 + \mu_i \qquad (2)$$

where $\ln E_t$ is natural log of electricity consumption ((kWh) per capita, $\ln Y_t$ ($\ln Y_t^2$)for natural log of real GDP per capita (natural log of square of real GDP per capita), $\ln F_t$ is natural log of real domestic credit to private sector proxy for financial development, $\ln U_t$ ($\ln U_t^2$) is natural log of urban population per capita (natural log of square of urban population per capita) and μ_i

represents error term assumed to be normally distributed with zero mean and finite constant variance.

Energy (electricity consumption) is considered a very important stimulus to enhance domestic production. This implies that electricity consumption has positive impact on economic growth. In resulting, economic growth raises electricity demand via growth in income per capita and capitalization effect in the country. In long run, electricity consumption starts to fall due to adoption of electricity efficient equipments by individuals and technology by producers. Yoo and Lee, (2010) explored the inverted-U shaped relationship between economic growth and electricity consumption i.e. energy-EKC at macro level. The energy-EKC reveals that economic growth raises energy demand initially and declines it once; economy is matured after a threshold level of income per capita.

A greater value of financial development indicators could be translated to a good position of banks to provide funds for investment (Minier, 2009; Sadorsky, 2010; Shahbaz et al. 2010). There are two theoretical arguments, which justify that the increase in financial markets activities would stimulate investment activities and thus economic growth. (i) The level effect demonstrates the positive effect of financial market on the quantity and quality of investments. Financial development also requests for advanced accounting and reporting standards. These impacts improve investors' confidence (Shahbaz, 2009) and attract foreign investment which are usually risk-averse (Sadorsky, 2010). (ii) The efficiency effect implies that financial development improves liquidity and allows asset allocation to appropriate ventures. Financial development enhances investment behavior, sustains a strong economic growth and increases energy consumption. We expect the sign to be positive.

Economic growth stimulates industrialization. Urbanization is a cause of both economic growth and industrial development. Urbanization creates economic activities and pocket of dense population which in resulting increases electricity consumption (Mishra et al. 2009; Shahbaz and Lean, 2012). Poumanyvong et al. (2012) reported inverted U-shaped relationship between urbanization and electricity consumption. They argued that urbanization increases electricity demand initially and after a threshold level of urbanization, electricity consumption starts to decline due to having more access to electric appliances at home level and improvements in urban transport sector as well as adoption of energy-efficient technology at production-side.

The usual first step is to confirm the integration properties of the series. We proceed towards achieving this objective through using two different structural break unit roots tests namely Perron and Volgelsang, (1992) and Zivot-Andrews, (1992) unit root tests, which allow one structural break. Clemente et al. (1998) augmented the statistics of Perron and Volgelsang, (1992) to the case two structural breaks in the mean. Therefore, we hypothesize that:

$$H_0 : x_t = x_{t-1} + a_1 DTB_{1t} + a_2 DTB_{2t} + \mu_t \quad (1)$$

$$H_a : x_t = u + b_1 DU_{1t} + b_2 DU_{2t} + \mu_t \quad (2)$$

DTB_{it} denotes the pulse variable equal to one if $t = TB_i + 1$ and zero otherwise. Moreover, $DU_{it} = 1$ if $TB_i < t (i = 1,2)$ and zero otherwise. μ_t is error term assumed to be normally distributed. Modified mean is represented by TB_1 and TB_2 time periods when the mean is being modified. Further, it is simplified with assumption that $TB_i = \delta_i T (i = 1,2)$ where $1 > \delta_i > 0$ while $\delta_1 < \delta_2$ (see Clemente et al. 1998). If innovative outlier contains two structural breaks, then unit root hypothesis can be tested by estimating the following equation-3:

$$x_t = u + \rho x_{t-1} + d_1 TB_{1t} + a_2 TB_{2t} + d_3 DU_{1t} + d_4 DU_{2t} + \sum_{i=1}^{k} c_j \Delta x_{t-1} + \mu_t \qquad (3)$$

From this equation, we can estimate the minimum value of t-ratio through simulations. The value of simulated t-ratio can be used for testing if the value of autoregressive parameter is constrained to 1 for all break points. To derive the asymptotic distribution of said statistics, it is assumed that $\delta_2 > \delta_1 > 0, 1 > \delta_2 - 1 > \delta_0$. δ_1 and δ_2 obtain the values in interval i.e. $[(t+2)/T, (T-1)/T]$ by appointing largest window size.

Additionally, assuming $\delta_1 < \delta_2 + 1$ help us to eliminate cases where break points exist in repeated periods (see Clemente et al. 1998). Two steps approach is used to test unit root hypothesis, if shifts are in better position to explain additive outliers. In first step, we exclude deterministic part of the variable by following equation-4 for estimation:

$$x_t = u + d_5 DU_{1t} + d_6 DU_{2t} + \hat{x} \qquad (4)$$

The second step is related to search the minimum t-ratio by a test to test the hypothesis that $\rho = 1$:

$$\hat{x}_t = \sum_{i=1}^{k} \phi_{1i} TB_{1t-1} + \sum_{i=1}^{k} \phi_{2i} TB_{2t-1} + \rho \hat{x}_{t-1} + \sum_{i=1}^{k} c_i \Delta \hat{x}_{t-1} + \mu_t \tag{5}$$

We have included the dummy variable DTB_{it} in the estimated equation so as to make sure that $\min t^{IO}_{\rho\ t}(\delta_1, \delta_2)$ congregates i.e. converges to distribution:

$$\min t^{IO}_{\rho\ t}(\delta_1, \delta_2) \rightarrow \inf_{\gamma} = \wedge \frac{H}{[\delta_1(\delta_2 - \delta_1)]^{1/2} K^{1/2}} \tag{6}$$

We employ the autoregressive distributed lag (ARDL) bounds testing approach to cointegration developed by Pesaran et al. (2001) to explore the existence of long run relationship between economic growth, financial development, urbanization and electricity consumption in the presence of structural break. This approach has multiple econometric advantages. The bounds testing approach is applicable irrespective of whether variables are I(0) or I(1). Moreover, a dynamic unrestricted error correction model (UECM) can be derived from the ARDL bounds testing through a simple linear transformation. The UECM integrates the short run dynamics with the long run equilibrium without losing any long run information. The UECM is expressed as follows:

$$\Delta \ln E_t = \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_F \ln F_{t-1} + \alpha_U \ln U_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta \ln E_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta \ln Y_{t-j} + \sum_{k=0}^{r} \alpha_k \Delta \ln F_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta \ln U_{t-l} + \alpha_D D_1 + \mu_t \quad (7)$$

$$\Delta \ln Y_t = \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_F \ln F_{t-1} + \alpha_U \ln U_{t-1} + \sum_{i=1}^{p} \beta_i \Delta \ln E_{t-i} + \sum_{j=0}^{q} \beta_j \Delta \ln Y_{t-j} + \sum_{k=0}^{r} \beta_k \Delta \ln F_{t-k} + \sum_{l=0}^{s} \beta_l \Delta \ln U_{t-l} + \beta_D D_2 \mu_t \quad (8)$$

$$\Delta \ln F_t = \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_F \ln F_{t-1} + \alpha_U \ln U_{t-1} + \sum_{i=1}^{p} \vartheta_i \Delta \ln F_{t-i} + \sum_{j=0}^{q} \vartheta_j \Delta \ln E_{t-j} + \sum_{k=0}^{r} \vartheta_k \Delta \ln Y_{t-k} + \sum_{l=0}^{s} \vartheta_l \Delta \ln U_{t-l} + \vartheta_D D_3 + \mu_t \quad (9)$$

$$\Delta \ln U_t = \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_F \ln F_{t-1} + \alpha_U \ln U_{t-1} + \sum_{i=1}^{p} \rho_i \Delta \ln U_{t-i} + \sum_{j=0}^{q} \rho_j \Delta \ln E_{t-j} + \sum_{k=0}^{r} \rho_k \Delta \ln Y_{t-k} + \sum_{l=0}^{s} \rho_l \Delta \ln F_{t-l} + \vartheta_D D_4 + \mu_t \quad (10)$$

Where Δ is the first difference operator, D is dummy for structural break point and μ_t is error term assumed to be independently and identically distributed. The optimal lag structure of the first differenced regression is selected by the Akaike information criteria (AIC). Pesaran et al. (2001) suggests F-test for joint significance of the coefficients of the lagged level of variables. For example, the null hypothesis of no long run relationship between the variables is $H_0 : \alpha_E = \alpha_Y = \alpha_F = \alpha_U = 0$ against the alternative hypothesis of cointegration $H_a : \alpha_E \neq \alpha_Y \neq \alpha_F \neq \alpha_U \neq 0$[3]. Accordingly Pesaran et al. (2001) computes two set of critical value (lower and upper critical bounds) for a given significance level. Lower critical bound is applied if the regressors are I(0) and the upper critical bound is used for I(1). If the F-statistic exceeds the upper critical value, we conclude in favor of a long run relationship. If the F-statistic falls below the lower critical bound, we cannot reject the null hypothesis of no cointegration. However, if the F-statistic lies between the lower and upper critical bounds, inference would be inconclusive. When the order of integration of all the series is known to be I(1) then decision is made based on the upper critical bound. Similarly, if all the series are I(0), then the decision is made based on the lower critical bound. To check the robustness of the ARDL model, we apply diagnostic tests. The diagnostics tests are checking for normality of error term, serial correlation, autoregressive conditional heteroskedasticity, white heteroskedasticity and the functional form of empirical model.

After examining the long run relationship between the variables, we use the Granger causality test to determine the causality between the variables. If there is cointegration between the series then the vector error correction method (VECM) can be developed as follows:

$$\begin{bmatrix}\Delta \ln E_t \\ \Delta \ln Y_t \\ \Delta \ln F_t \\ \Delta \ln U_t\end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix} + \begin{bmatrix} B_{11,1} & B_{12,1} & B_{13,1} & B_{14,1} \\ B_{21,1} & B_{22,1} & B_{23,1} & B_{23,1} \\ B_{31,1} & B_{32,1} & B_{33,1} & B_{34,1} \\ B_{41,1} & B_{42,1} & B_{43,1} & B_{44,1} \end{bmatrix} \times \begin{bmatrix}\Delta \ln E_{t-1} \\ \Delta \ln Y_{t-1} \\ \Delta \ln F_{t-1} \\ \Delta \ln F_{t-1}\end{bmatrix} + \ldots + \begin{bmatrix} B_{11,m} & B_{12,m} & B_{13,m} & B_{14,m} \\ B_{21,m} & B_{22,m} & B_{23,m} & B_{24,m} \\ B_{31,m} & B_{32,m} & B_{33,m} & B_{34,m} \\ B_{41,m} & B_{42,m} & B_{43,m} & B_{44,m} \end{bmatrix}$$
$$\times \begin{bmatrix}\Delta \ln E_{t-1} \\ \Delta \ln Y_{t-1} \\ \Delta \ln F_{t-1} \\ \Delta \ln U_{t-1}\end{bmatrix} + \begin{bmatrix}\zeta_1 \\ \zeta_3 \\ \zeta_3 \\ \zeta_4\end{bmatrix} \times (ECM_{t-1}) + \begin{bmatrix}\mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \\ \mu_{4t}\end{bmatrix} \qquad (11)$$

where difference operator is $(1-L)$ and ECM_{t-1} is the lagged error correction term, generated from the long run association. The long run causality is found by significance of coefficient of lagged error correction term using t-test statistic. The existence of a significant relationship in first differences of the variables provides evidence on the direction of short run causality. The joint χ^2 statistic for the first differenced lagged independent variables is used to test the direction of short-run causality between the variables. For example, $a_{12,i} \neq 0 \forall_i$ shows that economic growth Granger causes electricity consumption and economic growth is Granger of cause of electricity consumption if $a_{11,i} \neq 0 \forall_i$.

IV. Results and their Discussion

Table-1 reports the findings of descriptive statistics and correlation matrix. The empirical evidence finds that the series of electricity consumption, economic growth, financial development and urbanization are independently and identically distributed confirmed by Jarque-Bera statistics. The correlation analysis reveals negative association between electricity consumption and economic growth. Financial development and urbanization are positively correlated with electricity consumption. Urbanization and financial development are inversely correlated with economic growth. A positive correlation exists between urbanization and financial development.

Table-1: Descriptive Statistic and Correlation Matrix

Variable	$\ln E_t$	$\ln Y_t$	$\ln F_t$	$\ln U_t$
Mean	9.0609	12.3273	11.1210	4.3876
Median	9.1399	12.2620	11.0384	4.3826
Maximum	9.5342	12.8449	11.6085	4.4355
Minimum	7.7773	11.5962	10.4240	4.3607
Std. Dev.	0.4321	0.2919	0.2380	0.0201

Skewness	-1.3198	-0.0706	0.0611	0.9095
Kurtosis	4.3433	2.9880	3.9262	2.8811
Jarque-Bera	1.3524	0.0309	1.3455	0.51229
Probability	0.5016	0.9846	0.5102	0.7719
$\ln E_t$	1.0000			
$\ln Y_t$	-0.7267	1.0000		
$\ln F_t$	0.7364	-0.7184	1.0000	
$\ln U_t$	0.3299	-0.4709	0.8023	1.0000

The assumption of the ARDL bounds testing is that the series should be integrated at I(0) or I(1) or I(0) / I(1). This implies that the none of variables is integrated at I(2). To resolve this issue, we have applied traditional unit root tests such as ADF, PP and DF-GLS. The results of unit root tests are reported in Table-2. Our empirical exercise finds that electricity consumption ($\ln E_t$), economic growth ($\ln Y_t$), financial development ($\ln F_t$) and urbanization ($\ln U_t$) are not found to be stationary at level with constant and trend. All the variables are stationary at 1st difference. This shows that the variables are integrated at I(1).

Table-2: Unit Root Analysis

Variables	ADF	PP	DF-GLS
$\ln E_t$	–3.3681 (1)	–2.7074 (3)	–1.0419 (1)
$\Delta \ln E_t$	–3.4400 (0)***	–3.7472 (3)**	–3.7074 (0)**

$\ln Y_t$	–1.3934 (1)	–1.3820 (3)	–1.7544 (2)
$\Delta \ln Y_t$	–3.3629 (1)***	–4.2220 (3)**	–3.4279 (2)**
$\ln F_t$	–2.1712 (1)	–2.6412 (3)	–2.0427 (2)
$\Delta \ln F_t$	–6.4687 (2)*	–6.3606 (3)*	–3.5706 (1)**
$\ln U_t$	-1.6703 (1)	0.0427 (3)	-2.1675 (1)
$\Delta \ln U_t$	-3.5782 (4)**	-3.0954 (3)***	-2.8947 (3)***
Note: * (**) and *** denote the significance at 1% (5%) and 10% levels respectively. Figure in the parenthesis is the optimal lag structure for ADF and DF-GLS tests, and bandwidth for the PP test.			

The results of AFD, PP and DF-GLS unit root tests may be biased because these tests do not have information about structural break occurring in the series. The appropriate information about structural break would help policy makers in designing inclusive energy, economic, financial and urban policy to boost economic growth for long run. The issue of structural break is resolve by applying Clemente et al. (1998) with one and two unknown structural breaks arising in the macroeconomic variables. The results are detailed in Table-3. We find, while applying Clemente et al. (1998) test with single unknown break, that electricity consumption, economic growth, financial development and urbanization have unit root at level with intercept and trend. The structural breaks are found in electricity consumption, economic growth, financial development and urbanization in 1998, 1984 and 2000 respectively[4]. The variables are found to be stationary at 1st difference. This implies that series have same level of integration. The robustness of results is validated by applying Clemente et al. (1998) with two unknown structural breaks. Our findings indicate that variables are integrated at I(1).

Table-3: Clemente-Montanes-Reyes Detrended Structural Break Unit Root Test

Model: Trend Break Model								
	Level data				First difference data			
Series	T_{B1}	T_{B2}	Test statistics	K	T_{B1}	T_{B2}	Test statistics	K
$\ln E_t$	1998	---	-4.213	0	1982	----	-4.936**	2
	1983	1995	-3.783	1	1982	2005	-5.557**	3
$\ln Y_t$	1984	---	0.572	6	1998	----	-4.300**	1
	1984	2006	-3.208	4	1981	1987	-5.905**	6
$\ln F_t$	2000	---	-4.113	6	1992	----	-5.623**	4
	1995	2003	-4.194	3	1997	2002	-5.784*	4
$\ln U_t$	2000	---	-2.202	2	1994	---	-4.799**	3
	1980	1994	-4.419	2	1979	1994	-9.562*	4

Note: T_{B1} and T_{B2} are the dates of the structural breaks; k is the lag length; * and ** show significant at 1% and 5% levels respectively.

The unique integrating order of the variables lends a support to test the existence of cointegration between the variables. In doing so, we apply the ARDL bounds testing approach in the presence of structural break to examine cointegration between the variables. The results are reported in Table-4. The lag order of the variable is chosen following Akaike information criterion (AIC) due to its superiority over Schwartz Bayesian criterion (SBC). AIC performs relatively well in small samples but is inconsistent and does not improve performance in large samples whilst BIC in contrast appears to perform relatively poorly in small samples but is consistent and improves in performance with sample size (Acquah, 2010).

The appropriate lag section is required because F-statistic variables with lag order of the variables. The lag order of the variables is given in second column of Table-4. The results reported in Table-4 reveal that our computed F-statistics are greater than upper critical bounds generated by Narayan, (2005) which are suitable for small data set. We find four cointegrating vectors once electricity consumption, economic growth, financial development and urbanization are used as predicted variables. This validates that there is long run relationship between electricity consumption, economic growth, financial development and urbanization in case of UAE over the period of 1975-2011.

Table-4: The Results of ARDL Cointegration Test

Bounds Testing to Cointegration				**Diagnostic tests**		
Models	Optimal lag length	F-statistics	Break Year	R^2	$Adj-R^2$	D. W test
$E_t = f(Y_t, F_t, U_t)$	2, 2, 2, 2	11.139*	1998	0.8677	0.7179	1.9733
$Y_t = f(E_t, F_t, U_t)$	2, 2, 2, 2	8.569*	1984	0.8185	0.6129	2.4810
$F_t = f(E_t, Y_t, U_t)$	2, 2, 1, 2	7.199**	2000	0.7201	0.4402	2.1801
$U_t = f(E_t, F_t, Y_t)$	2, 2, 1, 2	5.670***	2000	0.9521	0.8502	1.9643
Significant level	Critical values					
	Lower bounds $I(0)$	Upper bounds $I(1)$				
1 per cent level	7.527	8.803				
5 per cent level	5.387	6.437				
10 per cent level	4.477	5.420				

Note: *(**) and *** represents significant at 1(5) per cent and 10 per cent levels respectively.

The diagnostic tests such as normality of error term, serial correlation, autoregressive conditional heteroskedasticity, white heteroskedasticity and functional form of the model are also examined. The results of stability tests are reported in Table-5. We find that error terms have normal distributions in all models. There is no evidence of serial correlation and same inference is noted for autoregressive conditional heteroskedasticity. The results indicate that homoscedasticity is found and the ARDL models are well articulated. This implies that the assumptions of CLRM (classical linear regression model) have been fulfilled.

Table-5: Diagnostic Tests

Model	$\chi^2 NORMAL$	$\chi^2 SERIAL$	$\chi^2 ARCH$	$\chi^2 REMSAY$	CUSUM	CUSUMsq
$E_t = f(Y_t, F_t, U_t)$	0.9527	0.0080	1.3058	0.2023	Stable	Stable
$Y_t = f(E_t, F_t, U_t)$	1.3544	0.3036	0.7314	1.8913	Stable	Stable
$F_t = f(E_t, Y_t, U_t)$	1.3541	0.4551	1.5575	1.8044	Stable	Stable
$U_t = f(E_t, F_t, Y_t)$	0.5344	0.0048	0.0273	1.4705	Stable	Stable

The marginal impact of independent variables on dependent variable can be examined after finding cointegration between the variables. The results are reported in Table-6. We find that real income per capita (income effect) and square term of real income per capita (scale and technique effects) have positive and negative impact on electricity consumption. It is statistically significant at 5% level respectively. This reveals that rise in income per capita raises electricity demand while scale and technique effects decline electricity consumption. It also shows that initially economic growth raises electricity consumption but the adoption of advanced technology i.e. energy efficient to enhance domestic production, saves energy and reduces the usage of electricity consumption, once economy is matured i.e. inverted U-shaped relation between both variables. The delinking point between economic growth and electricity consumption is Dinar 190535 UAE (before that threshold level income per capita, economic growth raises electricity demand and declines it after that point)

Trying to implement the state of art standards and regulation, UAE government set up in 2009 the Emirates Authority for Standardization and metrology. The authority is responsible to implement Energy Efficiency Standardization and Labeling (EESL) program (for household appliance). It started with phase 1for non-ducted room air-conditioners in 2011. Next phase target is to implement the Energy Management (ISO 50001) for big industries, hotels and shopping malls.

The positive affect of financial development on electricity consumption is found and it is statistically significant at 1% level. A 1% increase in domestic credit to private sector (financial development) adds in electricity consumption by 0.1353% keeping other things constant. Financial development boosted by oil revenues and long-run plans of infrastructure development projects which increased energy demand. Easy access of credit, high salary level, and generosity of ruling families (paying all local loans time to time) represent incentives for high consumption which lead to increase energy consumption. Our results are supported by Sadorsky, (2010, 2011) and Shahbaz and Lean, (2012).

The relationship between urbanization and electricity consumption is inverted U-shaped. This implies that urbanization initially raises electricity demand and after threshold level, it declines energy demand. The coefficient of linear term of urbanization is 2.2645 and non-linear term of urbanization is -0.9467. Both coefficients are statistically significant at 5% level of significance. The threshold point of urbanization is 79.85%-80.23%, which implies that before 79.85% of urbanization electricity demand (electricity consumption) is increased and after80.23% of urbanization, electricity demand is decreased due to use of electricity efficient technology by government as well as electric appliances by consumers (individuals).The UAE infrastructure started approximately from scratch in 1950s. Increase in urbanization increased electricity demand to a certain threshold. When UAE became a net importer of natural gas for electricity production and desalinization, the government has set a very restrictive electricity use policy, implement many federal initiatives for renewable energy production and national campaigns to rationalize the use of electricity and water.

The long run results fulfill the assumptions of CLRM confirming the normality of error term, absence of autoregressive conditional heteroskedasticity as well as white heteroskedasticity and functional form of the model.

Table-6: Long Run Analysis

Dependent Variable = $\ln E_t$			
Variables	Coefficient	T-Statistic	Prob. Values
Constant	-5.1094**	-2.5996	0.0142
$\ln Y_t$	2.2545**	2.3879	0.0232

$\ln Y_t^2$	-0.9467**	-2.4699	0.0192
$\ln F_t$	0.1353*	5.1468	0.0000
$\ln U_t$	2.2685**	2.4885	0.0184
$\ln U_t^2$	-0.2588**	-2.4923	0.0182
R^2	0.8646		
$Ajd-R^2$	0.8427		
F-statistic	39.5933*		
Diagnostic Test			
Test	F-statistic	Probability	
$\chi^2 NORMAL$	0.7099	0.2843	
$\chi^2 ARCH$	0.9754	0.3302	
$\chi^2 WHITE$	1.5629	0.1861	
$\chi^2 REMSAY$	0.8310	0.3692	
Note: *, ** represent significance at 1% and 5%level respectively. $\chi^2 NORMAL$ is for normality test, $\chi^2 ARCH$ for autoregressive conditional heteroskedasticity, $\chi^2 WHITE$ for white heteroskedasticity and $\chi^2 REMSAY$ for Resay Reset test.			

The short run results are reported in Table-7. The results reveal that inverted U-shaped relationship is found between income per capita and electricity consumption but it is statistically insignificant. The impact of financial development on electricity consumption is positive and statistically significant at 1% level. The relationship between urbanization and electricity demand is also inverted U-shaped. This relationship is statistically significant at 5% level of significance levels respectively. The significant and negative coefficient of lagged ECM_{t-1} (-0.1682) confirms the established long run relationship between the variables. The term is significant at the 5% level (lower segment of Table-7), which suggests that short run deviations in electricity consumption are corrected by 16.82 per cent every year towards the long run equilibrium and may take 5 years and 11 months to reach stable long run equilibrium path.

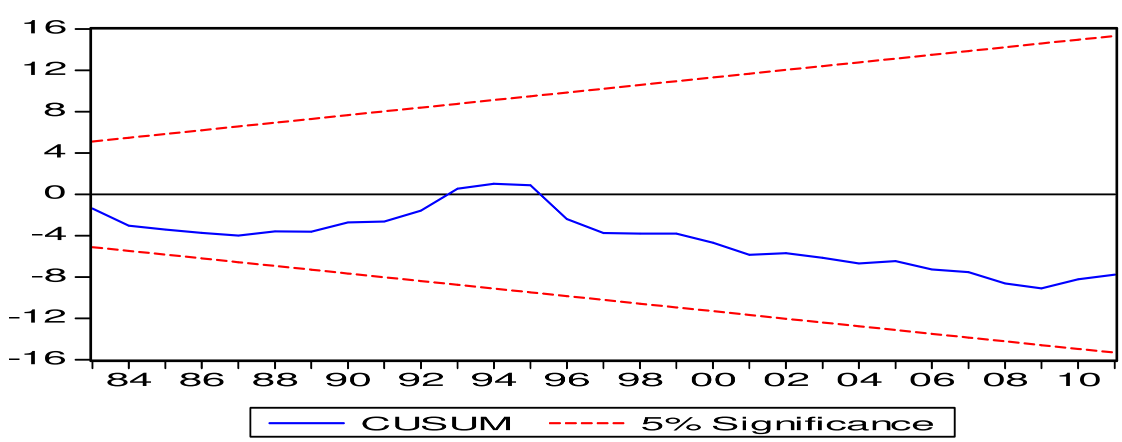
Table-7: Short Run Analysis

Dependent Variable = $\Delta \ln E_t$			
Variables	Coefficient	T-Statistic	Prob. Values
Constant	0.0541*	4.4366	0.0001
$\Delta \ln Y_t$	2.1246	0.3861	0.7022
$\Delta \ln Y_t^2$	-0.0824	-0.3714	0.7130
$\Delta \ln F_t$	0.3515*	2.9472	0.0063
$\Delta \ln U_t$	2.2589**	2.7126	0.0111
$\Delta \ln U_t^2$	-0.2578**	-2.7159	0.0110
ECM_{t-1}	-0.1682**	-2.6125	0.0141
R^2	0.5491		
$Ajd-R^2$	0.4558		
F-statistic	5.8877*		
Diagnostic Test			

Test	F-statistic	Probability	
$\chi^2 NORMAL$	1.3068	0.5202	
$\chi^2 ARCH$	0.5259	0.4738	
$\chi^2 WHITE$	0.4824	0.9047	
$\chi^2 REMSAY$	1.7317	0.1532	
Note: *, ** represent significance at 1%, 5% level respectively. $\chi^2 NORMAL$ is for normality test, $\chi^2 ARCH$ for autoregressive conditional heteroskedasticity, $\chi^2 WHITE$ for white heteroskedasticity and $\chi^2 REMSAY$ for Resay Reset test.			

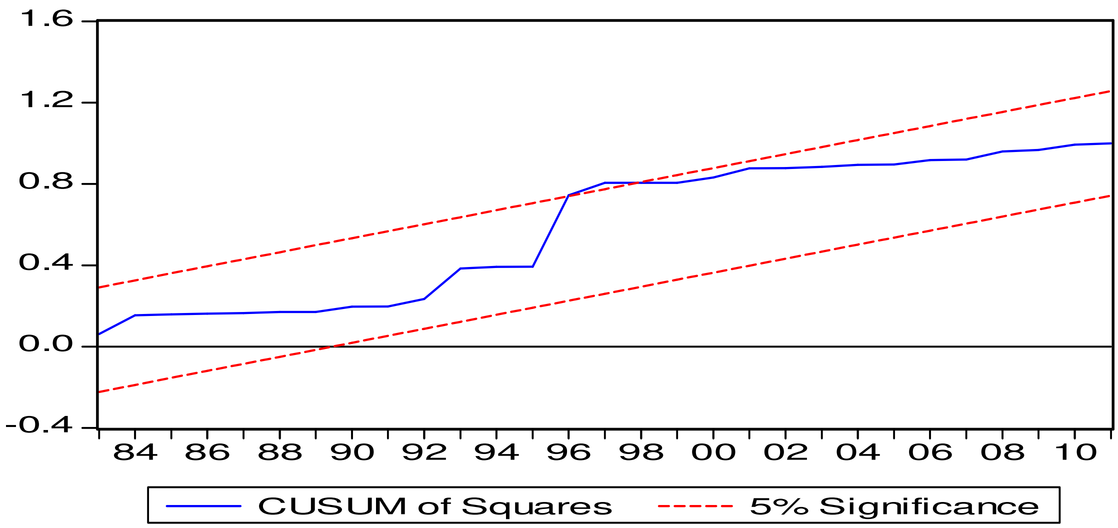
The lower segment of Table-7 deals with diagnostic tests. The results indicate that error term has normal distribution. There is no evidence of autoregressive conditional heteroskedasticity and same inference is drawn for white heteroskedasticity. The functional form of short run model is well constructed confirmed by Ramsey Reset test statistic. The results of stability tests such as CUSUM and CUSUMsq are shown in Figure-2 and 3.

Figure-2: Plot of Cumulative Sum of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

Figure-3: Plot of Cumulative Sum of Squares of Recursive Residuals



The straight lines represent critical bounds at 5% significance level

The results of CUSUM test indicate the stability of the ARDL parameters but diagram of the CUSUMsq reveals the instability of the ARDL parameters. The CUSUMsq test shows structural break in the 1st quarter of 1996. This structural break deals with the global oil productions peaks in 1996. The oil production reached 100% of its capacity. However after January spike the production starts decreasing with approximately a rate of 7% annually.

Table-8: Chow Forecast Test

Chow Forecast Test: Forecast from 1996 to 2011			
F-statistic	1.2548	Probability	0.3438
Log likelihood ratio	33.6210	Probability	0.0061

The Chow forecast test is applied to test the validation of structural break in the 1st quarter of 1996. Leow, (2004) suggested to apply the Chow forecast test which is superior to the CUSUM and CUSUMsq tests. The results are reported in Table-8. The results indicate the absence of structural break over the mentioned time period. This confirms the reliability and efficiency of the ARDL parameters.

The VECM Granger Causality Analysis

If cointegration is confirmed, there must be uni-or bidirectional causality between/ among the series. We examine this relation within the VECM framework. Such knowledge is helpful in crafting appropriate energy, financial and urban policies for sustainable economic growth in case of UAE. Table-9 reports results on the direction of long and short run causality. In long run, our results find that bidirectional causality exists between electricity consumption and economic growth. The feedback effect is found between electricity consumption and financial development and same inference is drawn for urbanization and electricity consumption. Financial development and economic growth Granger cause each other. The bidirectional causality is found between urbanization and financial development and, urbanization and economic growth are also interdependent i.e. bidirectional causal relationship exists between urbanization and economic growth.

Table-9: The VECM Granger Causality Analysis

Dependent Variable	Direction of Causality	
	Short Run	Long Run

	$\Delta\ln E_{t-1}$	$\Delta\ln Y_{t-1}$	$\Delta\ln F_{t-1}$	$\Delta\ln U_{t-1}$	ECT_{t-1}
$\Delta\ln E_t$	….	1.7375 [0.1975]	3.7879** [0.0494]	0.7406 [0.4866]	-0.0580** [-2.0350]
$\Delta\ln Y_t$	2.8270*** [0.0775]	….	6.8113* [0.0064]	0.5887 [0.5731]	-0.1712*** [-1.7993]
$\Delta\ln F_t$	2.5013*** [0.1013]	3.3894** [0.0492]	….	2.4747*** [0.1034]	-0.6599* [-3.8383]
$\Delta\ln U_t$	1.8396 [0.1790]	0.1114 [0.8950]	1.7286 [0.1973]	….	-0.0826*** [-2.0595]
Note: *, ** and *** show significance at 1, 5 and 10 per cent levels respectively.					

In short run, the feedback effect is found between financial development and electricity consumption. Financial development Granger causes economic growth and reverse is true from economic growth to financial development. Economic growth is Granger cause of electricity consumption. Urbanization Granger causes financial development. There is no causality running from electricity consumption, economic growth and financial development to urbanization. The summary of long run as well as short run causality results is given in Table-10.

Table-10: Summary of Causality Analysis

Directional of Causality	Short Run	Long Run
$\ln E_t$ Granger causes $\ln Y_t$	Significant at 10%	Significant at 10%
$\ln E_t$ Granger causes $\ln F_t$	Significant at 10%	Significant at 1%

$\ln E_t$ Granger causes $\ln U_t$	No causality	Significant at 10%
$\ln Y_t$ Granger causes $\ln E_t$	No causality	Significant at 10%
$\ln Y_t$ Granger causes $\ln F_t$	Significant at 1%	Significant at 5%
$\ln Y_t$ Granger causes $\ln U_t$	No causality	Significant at 10%
$\ln F_t$ Granger causes $\ln E_t$	Significant at 5%	Significant at 5%
$\ln F_t$ Granger causes $\ln Y_t$	Significant at 1%	Significant at 10%
$\ln F_t$ Granger causes $\ln U_t$	No causality	Significant at 10%
$\ln U_t$ Granger causes $\ln E_t$	No causality	Significant at 5%
$\ln U_t$ Granger causes $\ln Y_t$	No causality	Significant at 10%
$\ln U_t$ Granger causes $\ln F_t$	No causality	Significant at 1%

V. Conclusion and Policy Implications

This study has explored the relationship between economic growth, financial development, urbanization and electricity consumption applying electricity demand model in case of United Arab Emirates. We have used time series data over the period of 1975-2011. The structural break unit root test and the ARDL bounds testing approach in the presence of structural break stemming in the series are applied to examine integrating order of the variables and long run relationship between the variables. The direction of causality is investigated by applying the VECM Granger causality approach.

Our results found the cointegration for long run relationship between economic growth, financial development, urbanization and electricity consumption in case of UAE. We find that economic growth initially raises electricity consumption and declines it, once economy is matured i.e. inverted U-shaped relationship between economic growth and electricity consumption. Financial development increases electricity consumption. An inverted U-shaped relationship exists between urbanization and electricity consumption, revealing that urbanization is linked with high electricity consumption and electricity consumption declines after threshold level of urbanization.

The causality analysis exposed bidirectional causality between electricity consumption and economic growth. The feedback hypothesis is found between financial development and electricity consumption. Financial development Granger causes economic growth and same is true form opposite side. Economic growth and urbanization are interdependent. The bidirectional causality exists between urbanization and electricity consumption and the same is true between urbanization and financial development.

Our findings suggest that there is unidirectional Granger causality running from electricity consumption to economic growth in short-run, while there is bidirectional causality in long-run. The different Granger causality results between short and long-run imply the need for different policies at different time span. As short-run causality results show that electricity consumption Granger-causes economic growth, which mean that UAE is energy-led growth economy. Consequently, environmental friendly policies such as electricity conservation, including efficiency improvement measures and demand-side management policies, which target to decrease the wastage of electricity, would negatively affect the economic activity in short-run.Further, our empirical results also reveal that electricity consumption and economic growth have bi-directional causality in long-run. Trade-off between electricity shortage, clean environment and economic growth in short-run, exploration of alternative environmentally friendly, or renewable, energies such as solar, hydro, and wind power, should be utilized instead of fossil fuels. Especially, as explained above, UAE became a net importer of natural gas because the big jump of electricity production needs. Moreover, UAE should increase investment in energy infrastructure to ensure that the supply of energy is sufficient and support research and development (R&D) to design new energy savings technology. Therefore, electricity consumption can be reduced without affecting economic growth and development in the UAE economy.

Bi-directional causality between electricity consumption and financial development in short and long-run reveals that electricity consumption and financial development are complementary. On one hand, financial development causes electricity consumption by providing easy access of financial resources to households and firms. On other hand, increase in electricity consumption requires more financial services and leads to financial development. At the same time, financial development requires more energy and energy as an important input of production may improve the productivity and output. Last but not least, in short-run urbanization does not Granger-cause any of the variables. More, either of the variables does Granger-cause urbanization. However, in long-run there is bi-directional causality between urbanization and economic growth, electricity consumption, financial development. Increasing rate of urbanization may contribute in boosting the economic output by providing labor factor of production. A prosper economy would develop its infrastructure (electricity network, transport, housing) and services (financial services) to maximize the efficiency, satisfy the population and attract international tourism.

Footnotes

1. The emirates established independence from Britain in 1971 and formed the federation of six states. Later, Ras al-Khaimah joined the federation.
2. It is important to mention that electricity domestic prices are subsidized which contribute to wasteful energy practices.
3. Inclusion of dummy is based on the findings of Clemente et al. (1998). D = 1 after structural break date otherwise 0.
4. The structural break in electricity consumption corresponds to the implementation of Law no (2) in 1998 concerning the regulation of water and electricity Sector in the Emirate of Abu Dhabi. It was a starting of unique program for privatization of water and electricity sector based on foreign partnership. Economic growth shows structural break in 1984 dealing with a global excess supply of oil, global recession and drop in oil prices. This started since 1982 when Saudi flood market by cheap oil and its production reached 12.5 million barrels per day. In resulting, UAE economic growth was hit as it is an oil-based economy. The structural break in the series of financial development in 2000 linked with the federal government announcement to decree in establishing public regulatory Securities and Commodities Authority (SCA) with a purpose of improving efficiency of national financial market and protecting investors from discriminating and unsuitable practices. The urbanization series also shows break point in 2000 which linked with massive construction projects (Artificial islands, Towers, Very high standing Hotel and Palaces, etc.) to attract global tourist in UAE.

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