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Economic growth, financial development, urbanisation and electricity consumption nexus in UAE

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ABSTRACT

This study aims to explore the relationship between economic growth, urbanisation, financial development and electricity consumption in United Arab Emirates for the period 1975–2011. The ARDL bounds testing approach is employed to examine the long-run relationship between the variables in the presence of structural breaks. The VECM Granger causality is applied to investigate the direction of causal relationships between the variables. Our empirical exercise validated the cointegration between the series in the case of United Arab Emirates. Further, results reveal that an inverted U-shaped relationship is found between economic growth and electricity consumption. Financial development adds in electricity consumption. The relationship between urbanisation and electricity consumption is also an inverted U-shaped. This implies that urbanisation increases electricity consumption initially and, after a threshold level of urbanisation, 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 urbanisation Granger cause each other. The feedback hypothesis is also found between urbanisation and financial development, financial development and economic growth, and the same is true for electricity consumption and urbanisation.

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1. Introduction

The objective of the current study is to assess the relationship among economic growth, financial development, urbanisation and electricity consumption in the United Arabs Emirates (UAE), applying the electricity demand function. The UAE is a federation of seven emirates namely: Abu Dhabi (the capital emirate), Ajman, Dubai, Fujairah, Ras al-Khaimah, Sharjah and Umm al-Quwain. Since the early 1960s, when oil was discovered, the UAE profile has been moving from a fishing and agricultural-based economy to an oil-based economy. The UAE holds the seventh-largest proved reserves of oil at 97.8 billion barrels

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with a capacity of around 2.9 barrels/day (IEA, 2007). Added to its vast oil reserves, the UAE has 215 trillion cubic feet of proved natural gas reserves, although, a big part of its natural gas reserve is a sour gas, which requires filtering from sulphur. This has driven the UAE to become a net importer of natural gas to meet to local fast growing demand.

The UAE has witnessed buoyant economic growth in the last decades boosted by high oil prices. After the 1970s' oil price shocks and the sudden decline of Dubai's oil production in 1990, a wide range of projects has been set up and structural reforms have been implemented to diversify the economy. The focus was on trade, finance, infrastructure and tourism. The development of free zones, such as Jebel Ali Free Zone (JAFZ), formed in Dubai in 1985, has attracted a valuable amount foreign investment (http://www.jafza.ae). 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. Beyond that, different festivals are running around the year, including the Dubai Shopping Festival, Dubai International Jazz Festival and Abu Dhabi among others. To face rapid economic growth and radical landscape changes, the UAE infrastructure is developing very quickly (even with a notable delay). The maritime infrastructure is also very developed and keeps expanding to handle growing trade volume. The road network is extensive and serves major urban cities.

The developed infrastructure definitely has a direct impact on urbanisation. The most used measures of the degree of urbanisation are urban population and rate of urbanisation. World Urbanisation Prospects (the 2011 Revision) reports that the UAE's urban population jumped from 54.4% in 1950 to 84.4% in 2010. The urbanisation rate reached 2.9% during the 2005–2010 period, which is one of the highest rates 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 (Hashmi, 2007). 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 (http://www.centralbank.ae). 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 exist to integrate the seven Emirate's gas distribution networks (EIA, 2013). Electricity consumption in 2010 is estimated at 79.3 billion (KWh) in the UAE and installed capacity reached 23.25 GW in 2009.

Rapid economic growth, financial development and urbanisation may affect electricity consumption by various channels. For instance, economic growth increases purchasing power of households for using energy-efficient electrical appliances, which may impact electricity consumption (Ozturk, 2010). Financial development may affect electricity consumption via consumer effect, business effect and wealth effect (Sadorsky, 2010). Urbanisation affects electricity demand via raising demand for houses, public transport, public utilities (health and education facilities), easy access to electrical appliances and boosting economic activity (Mishra, Sharma, & Smyth, 2009). This shows that there is a dire need to explore the relationship between economic growth, financial development, urbanisation and electricity consumption empirically using UAE data. The empirical findings would help the UAE economy in designing a comprehensive economic policy for using economic growth, financial development and urbanisation as economic tools by utilising electricity consumption for sustainable economic development in the long-run.[1]

This paper contributes to existing literature as follows. (i) This paper augments the energy demand function by incorporating financial development and urbanisation as potential determinants of economic growth and electricity consumption. (ii) We have applied the unit root test and cointegration approach in order to determine the integrating properties (of the variables) and cointegration (between the variables) in the presence of structural breaks. (iii) We accommodate structural breaks for investigating their impact on electricity consumption both in long-run and short-run. (iv) The causal relationship between the variables is examined in the presence of structural breaks. (v) The impulse response function is applied to test the extent of causality relationship between the variables. The results show the inverted-U shaped association between economic growth and electricity consumption. Financial development is positively linked with electricity consumption. The relationship between urbanisation and electricity consumption is inverted-U shaped.

2. Literature review

2.1. Economic growth and electricity consumption

It is evident that electricity has played a key role in the evolution of human life. It has contributed to the progress and development of major needs: transportation, communication and manufacturing. Economists are usually attracted by finding a new determinant (variable) of economic growth (Hossain & Saeki, 2012; Jbir & Charfeddine, 2012). Electricity consumption has been one of those variables. The literature investigating the relationship between electricity consumption and economic growth is enormous. It has 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 (Ozturk, 2010).

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, Dah, and Ghosh (2009) for Lebanon; Odhiambo (2009a) for Tanzania; Adebola (2011) for Botswana; and Acaravci and Ozturk (2012) for Turkey confirmed the presence of a growth-driven electricity consumption hypothesis, i.e. growth hypothesis. On the contrary, studies such as Ghosh (2002) for India; Narayan and Smyth (2005) for Australia; Hu and Lin (2008) for Taiwan; Adom (2011) for Ghana and Shahba; and Feridun (2012) for Pakistan showed the validity of conservation hypothesis, i.e. economic growth Granger causes electricity consumption. Akpan and Akpan (2012) supported the neutrality hypothesis in Nigeria.

Similarly, some studies suggested the existence of feedback hypotheses such as Yang (2000); Jumbe (2004); Yoo (2005); Zachariadis and Pashouortidou (2007); Odhiambo (2009b); Ouédraogo (2010); Lorde, Waithe, and Francis (2010); Shahbaz and Lean (2012) and Bildirici (2013) confirmed the existence of bidirectional Granger causality between electricity consumption and economic growth in Taiwan, Malawi, Korea, Cyprus, South

Africa, Burkina Faso, Barbados, Pakistan, Gabon, Ghana and Guatemala. This implies that energy exploration policies should be encouraged to sustain economic growth in the long run.

In the Gulf region, we noted that Hamdi et al. (2014) examined the relationship between electricity consumption and economic growth in the case of Bahrain. Their empirical analysis reported that electricity consumption and economic growth are interdependent, i.e. bidirectional causality. Sbia, Shahbaz, and Hamdi (2014) incorporated foreign direct investment in the energy demand function as an additional determinant of economic growth and energy consumption. They documented that economic growth Granger causes foreign direct investment and electricity consumption but the feedback effect exists for foreign direct investment and electricity consumption. Similarly, Shahbaz, Sbia, Hamdi, and Ozturk (2014) showed that electricity consumption is the cause of economic growth, by using a carbon emissions function. Recently, reported the feedback effect between electricity consumption and economic growth. The relationship between electricity consumption and economic growth provides conflicting empirical findings. These studies are facing the omission problem of relevant variables for the electricity demand function and such ambiguous results may provide less reliability for policy makers to design a comprehensive economic and energy (electricity) policy.

2.2. 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 in 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 the case of Central and Eastern European frontier economies using 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 the relationship between financial development and energy consumption. Their empirical evidence reported that primary energy consumption Granger causes financial development. Later on, Xu (2012) revisited the relationship between financial development and energy consumption in 29 Chinese provinces. The existence of a long-run relationship was conditioned by the measure of financial development.

Kaker, Khilji, and Khan (2011) applied a production function to examine the relationship between economic growth, financial development and energy consumption using Pakistani data. They concluded that the 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 by applying the energy demand function in the 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. In the case of Malaysia, Tang and Tan (2014) investigated the relationship between financial development and energy consumption by incorporating relative prices and foreign direct investment energy demand function. The empirical results reveal the positive impact of economic growth, foreign direct investment and financial development on energy consumption. A feedback hypothesis is found between financial development and energy consumption, both in the short and long runs. Islam, Shahbaz, and Alam (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 the long run. In the short run, financial development Granger causes energy consumption. Shahbaz, Khan, and Tahir (2013) investigated the production function by incorporating financial development and energy consumption in the case of China. They applied the ARDL bounds testing approach to cointegration and the VECM Granger causality to examine the long-run and causality relationship between the series. Their results indicated that energy consumption and financial development exert a positive impact on energy consumption. They also noted that financial development is a Granger cause of energy consumption. Ozturk and Acaravci (2013) examined the causal relationship between financial development, trade, economic growth, energy consumption and carbon emissions in Turkey for the 1960–2007 period. The bounds test for cointegration yields evidence of a long-run relationship between variables. The results show that an increase in foreign trade to GDP ratio results in an increase in per capita carbon emissions, and the financial development variable has no significant effect on per capita carbon emissions in the long run. These results also support the validity of the EKC hypothesis in the Turkish economy.

Sbia et al. (2014) investigated the relationship between FDI, clean energy, trade openness, carbon emissions and economic growth in case of UAE covering the period 1975Q1–2011Q4. They tested the unit properties of variables in the presence of structural breaks. The ARDL bounds testing approach was applied to examine the cointegration by accommodating structural breaks stemming from the series. Their empirical findings confirm the existence of cointegration between the series. They find that FDI, trade openness and carbon emissions decrease energy demand. Economic growth and clean energy have a positive impact on energy consumption. Salahuddin, Gow, and Ozturk (2015) investigated the relationship between carbon dioxide emissions, economic growth, electricity consumption and financial development in the Gulf Cooperation Council (GCC) countries using panel data for the period 1980–2012. Electricity consumption and economic growth have a positive long run relationship with carbon dioxide (CO_2) emissions whilst a negative and significant relationship was found between CO_2 emissions and financial development. The findings imply that electricity consumption and economic growth stimulate CO_2 emissions in GCC countries while financial development reduces it. Granger causality results reveal that there is a bidirectional causal link between economic growth and CO_2 emissions and a unidirectional causal link running from electricity consumption to CO_2 emissions.

2.3. Urbanisation and electricity consumption

Urbanisation is one of the major phenomena of economic development (Jones, 1991). Further, it affects the social and urban structure of the country. Urbanisation impacts could be observed via population migration and growing size, the extension of the transport network and intensification of industrial and service activities, the expansion of public utilities such as health and education for urban citizens. Duan, Yan, Zheng, and Zhao (2008) found a relationship between urbanisation and energy consumption in China, which was confirmed by the elasticity coefficient of energy consumption Unit Geometric Average (ECUGA) in the long run. Liu (2009) applied the ARDL bounds testing and factor decomposition model to examine the relationship between urbanisation and energy consumption. The empirical evidence reported the presence of cointegration among the population, urbanisation and energy use. The factor decomposition model analysis revealed that urbanisation causes energy consumption and a neutral effect exists between population and energy consumption. It seems that urbanisation nullifies the impact of population on energy consumption.

On the contrary, Xie, Tan, Hou, and Wang (2009) applied the error correction model, the Granger causality test, impulse response and variance decomposition to examine short- and long-run relationships between electricity consumption and urbanisation in China since start of the reform and opening up. Their results showed that there is a long-term and steady equilibrium relationship between electricity consumption and urbanisation in China. In the long run, the feedback effect is found between electricity consumption and urbanisation. In the short run, the neutral hypothesis exists between both variables. The magnitude effects are obviously different too. Electricity consumption greatly impacts urbanisation, yet the impact of urbanisation on electricity consumption is not enormous. The overall results imply that urbanisation is the cause of electricity consumption in China. Poumanyvong, Kaneko, and Dhakal (2012) applied the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model to examine the relationship between urbanisation and residential energy consumption in low-, middle- and high-income countries. They found a negative (positive) impact of urbanisation on residential energy use in low- (high-) income countries. They found that the relationship between urbanisation and resident energy consumption is non-linear. In middle-income countries, residential energy initially falls with urbanisation then rises with a turning point at around 70% of urbanisation.

Zhang and Lin (2012) indicated that urbanisation 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 urbanisation 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 urbanisation increases energy consumption and CO_2 emissions in China. However, the effects of urbanisation 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, Atashi, and Elahi (2012) investigated the relationship between population growth, urbanisation and energy consumption, and reported that population growth and urbanisation increases energy demand in the long run.

Islam et al. (2013) applied the energy demand function to examine the impact of economic growth and population on energy demand in Malaysia. They applied the bounds testing and the VECM (vector error correction model) Granger causality to the cointegration and causality relationship between the variables. Their analysis revealed that population and economic growth exert positive impact on energy consumption. The causality analysis indicated the feedback effect between population and energy demand. In China, Xia and Hu (2013) reinvestigated the determinants of electricity consumption intensity by applying a Finite Mixture Model (FMM) and including industrial structure, electricity prices, urbanisation and temperature as determinants in an electricity demand function. They found that industrial development and urbanisation raises electricity demand but electricity prices and temperate decreases it.

Recently, Liddle and Lung (2013) examined the nature of long-run causality between electricity consumption and urbanisation using heterogeneous panel methods and data from 105 countries spanning 1971–2009. They consider total, industrial and residential aggregations of electricity consumption per capita, three income-based panels, and three geography-based panels for non-OECD countries. Their findings show that long-run Granger causality runs from electricity consumption to urbanisation. In addition, nearly all countries' urbanisation series contained structural breaks, and the most recent post-break annual change rates suggested that nearly all countries' rates of urbanisation change were slowing. A recent literature review on urbanisation and energy consumption is given in the study of Liddle and Lung (2013).

Shahbaz et al. (2014) examine the relationship between economic growth, electricity consumption, urbanisation and environmental degradation in the case of United Arab Emirates (UAE). The study covers the quarter frequency data over the period of 1975–2011 by applying the bounds testing approach to examine the long run relationship between the variables in the presence of structural breaks. The results show the existence of cointegration among the series. Further, they found an inverted U-shaped relationship between economic growth and CO_2 emissions, i.e. economic growth raises energy emissions initially and decreases them after a threshold point of income per capita (EKC exists). Electricity consumption decreases CO_2 emissions. The relationship between urbanisation and CO_2 emissions is positive. Exports seem to improve the environmental quality by lowering CO_2 emissions. The causality analysis validates the feedback effect between CO_2 emissions and electricity consumption. Economic growth and urbanisation Granger cause CO_2 emissions. Al-Mulali and Ozturk (2015) examined the events that caused the environmental degradation in the MENA (Middle East and North African) region. The results concluded that energy consumption, urbanisation, trade openness and industrial development increases environmental damage while political stability lessens it in the long run. In addition, the Granger causality revealed that the used variables have a short run and long run causal relationship with the ecological footprint.

The existing literature on financial development and energy consumption ignores the role of structural breaks in the series. These structural breaks may affect financial development, economic growth as well as energy consumption. This enriches the existing literature by solving the issue of structural breaks in the series.

3. The data, model construction and estimation strategy

The data on real GDP, electricity consumption (kWh), domestic credit to the private sector as a share of GDP and urban population have been obtained from world development indicators (CD-ROM, 2012). We have used total population to formulate all series into per capita. The study covers the period 1975–2011 using quarter frequency data over the period of 1975QI–2011QIV. We transformed the annual frequency data of all indicators into quarter frequency by applying the quadratic match-sum approach in order to avoid the problem of sample size. We used the quadratic match sum method to transform all the variables into quarter frequency following Romero (2005) and McDermott and McMenamin (2008). It is noted that the quadratic match-sum method adjusts seasonal variations in the data while transforming data from low frequency into high frequency. Therefore, we prefer the quadratic match-sum method due to its convenient operating procedure to transform annual data into quarterly data following Denton (1971).

The paper deals with the empirical investigation of the relationship between economic growth, financial development, urbanisation and electricity consumption using UAE data. 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:

$$E_t = f(Y_t, Y_t^2, F_t, U_t, U_t^2) \tag{1}$$

where E_t is electricity consumption, $Y_t(Y_t^2)$ is economic growth (square of economic growth), F_t is financial development, and $U_t(U_t^2)$ is urbanisation (square of urbanisation). We have transformed all the series into natural-log form to avoid sharpness in the data (Shahbaz, 2012). The log-linear equation is modelled as:

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

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 proxy for economic growth (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 urbanisation[2] (natural log of square of urbanisation) and μ_i represents the 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 a positive impact on economic growth. As a result, economic growth raises electricity demand via growth in income per capita and the capitalisation effect in the country. In the long run, electricity consumption starts to fall due to the adoption of electricity efficient equipment 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 the macro level. The energy-EKC reveals that economic growth raises energy demand initially and decreases it once; economy is matured after a threshold level of income per capita. Over the selected period of time, we find that the top priorities of the UAE government were to improve the well-being of Emirates citizens and to diversify the economy to reduce the oil dependence. This provides the rationale to incorporate both linear and non-linear terms of real GDP per capita in the electricity demand function.

A greater value of financial development indicators can be translated to a good position of banks to provide funds for investment (Minier, 2009; Sadorsky, 2010; Shahbaz, Shamim, & Aamir, 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 the financial market on the quantity and quality of investments. Financial development also requests advanced accounting and reporting standards. These impacts improve investors' confidence (Shahbaz, 2012) 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 behaviour, sustains a strong economic growth and increases energy consumption. The financial sector also offers loans to individuals for durable items such as televisions, computers, washing machines, furniture, houses, cars, etc. which affects energy demand is termed as consumer effect (Islam et al., 2013). We expect the sign to be positive.

Economic growth stimulates industrialisation. Urbanisation is a cause of both economic growth and industrial development. Urbanisation creates economic activities and pockets of dense population which results in increasing electricity consumption (Mishra et al., 2009; Shahbaz & Lean, 2012). Poumanyvong et al. (2012) reported an inverted U-shaped relationship between urbanisation and electricity consumption. They argued that urbanisation increases electricity demand initially and after a threshold level of urbanisation, electricity consumption starts to decline due to having more access to electric appliances at the home level and improvements in the urban transport sector as well as adoption of energy-efficient technology at the production-side. Economic growth leads to industrialisation, which causes urbanisation. Economic growth, industrialisation and urbanisation increase the demand for financial services (Shahbaz & Lean, 2012) and, as a result, the financial sector expands in economic hubs in the country and affects energy consumption. We expect an inverted U-shaped relationship between urbanisation and electricity consumption.

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 root tests, namely Clemente, Montañés, and Reyes (1998) with single and double structural breaks occurring in the series. Clemente et al. (1998) augmented the statistics of Perron and Vogelsang (1992) to the case of two structural breaks in the mean. Therefore, we hypothesise that:

$$H_0: x_t = x_{t-1} + a_1 DTB_{1t} + a_2 DTB_{2t} + \mu_t \tag{3}$$

$$H_a: x_t = u + b_1 DU_{1t} + b_2 DU_{2t} + \mu_t \tag{4}$$

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 the error term assumed to be normally distributed. The 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 the innovative outlier contains two structural breaks, then unit root hypothesis can be tested by estimating the following equation (5):

$$x_t = u + \rho x_{t-1} + d_1 TB_{1t} + a_2 TB_{2t} + d_3 DU_{1t} + d_4 DU_{2t} + \sum\nolimits_{i=1}^{k} c_j \Delta x_{t-1} + \mu_t \tag{5}$$

From this equation, we can estimate the minimum value of the t-ratio through simulations. The value of the simulated t-ratio can be used to test if the value of the 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 the largest window size.

Additionally, assuming $\delta_1 < \delta_2 + 1$ helps us to eliminate cases where break points exist in repeated periods (see Clemente et al., 1998). A two-step approach is used to test the unit root hypothesis if shifts are in a better position to explain additive outliers. In the first step, we exclude the deterministic part of the variable by following equation (6) for estimation:

$$x_t = u + d_5 DU_{1t} + d_6 DU_{2t} + \hat{x} \tag{6}$$

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

$$\hat{x}_t = \sum_{i=1}^{k} \varphi_{1i} TB_{1t-1} + \sum_{i=1}^{k} \varphi_{2i} TB_{2t-1} + \rho \hat{x}_{t-1} + \sum_{i=1}^{k} c_i \Delta \hat{x}_{t-1} + \mu_t \tag{7}$$

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

$$\min t_{\rho\ t}^{IO}(\delta_1, \delta_2) \rightarrow \inf_{\gamma} = \wedge \frac{H}{[\delta_1(\delta_2 - \delta_1)]^{1/2} K^{1/2}} \tag{8}$$

We employ the autoregressive distributed lag (ARDL) bounds testing approach to cointegration developed by Pesaran, Shin, and Smith (2001) to explore the existence of a long-run relationship between economic growth, financial development, urbanisation and electricity consumption in the presence of a 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:

$$\begin{aligned} \Delta \ln E_t = {} & \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_F \ln F_{t-1} + \alpha_U \ln U_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta \ln E_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta \ln Y_{t-j} \\ & + \sum_{k=0}^{r} \alpha_k \Delta \ln F_{t-k} + \sum_{l=0}^{s} \alpha_l \Delta \ln U_{t-l} + \alpha_D D_1 + \mu_t \end{aligned} \tag{9}$$

$$\begin{aligned} \Delta \ln Y_t = {} & \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_F \ln F_{t-1} + \alpha_U \ln U_{t-1} + \sum_{i=1}^{p} \beta_i \Delta \ln E_{t-i} + \sum_{j=0}^{q} \beta_j \Delta \ln Y_{t-j} \\ & + \sum_{k=0}^{r} \beta_k \Delta \ln F_{t-k} + \sum_{l=0}^{s} \beta_l \Delta \ln U_{t-l} + \beta_D D_2 \mu_t \end{aligned} \tag{10}$$

$$\begin{aligned} \Delta \ln F_t = {} & \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_F \ln F_{t-1} + \alpha_U \ln U_{t-1} + \sum_{i=1}^{p} \vartheta_i \Delta \ln F_{t-i} + \sum_{j=0}^{q} \vartheta_j \Delta \ln E_{t-j} \\ & + \sum_{k=0}^{r} \vartheta_k \Delta \ln Y_{t-k} + \sum_{l=0}^{s} \vartheta_l \Delta \ln U_{t-l} + \vartheta_D D_3 + \mu_t \end{aligned} \tag{11}$$

$$\begin{aligned} \Delta \ln U_t = {} & \alpha_1 + \alpha_T T + \alpha_E \ln E_{t-1} + \alpha_Y \ln Y_{t-1} + \alpha_F \ln F_{t-1} + \alpha_U \ln U_{t-1} + \sum_{i=1}^{p} \rho_i \Delta \ln U_{t-i} + \sum_{j=0}^{q} \rho_j \Delta \ln E_{t-j} \\ & + \sum_{k=0}^{r} \rho_k \Delta \ln Y_{t-k} + \sum_{l=0}^{s} \rho_l \Delta \ln F_{t-l} + \vartheta_D D_4 + \mu_t \end{aligned} \tag{12}$$

where Δ is the first difference operator, D is the dummy for structural break point and μ_t is the 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 the 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: $\alpha_E \neq \alpha_Y \neq \alpha_F \neq \alpha_U \neq 0$. Accordingly, Pesaran et al. (2001) computes two sets of critical values (lower and upper critical bounds) for a given significance level. The 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 favour 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, the inference would be inconclusive. When the order of integration of all the series is known to be I(1) then a 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 check for normality of the error term, serial correlation, autoregressive conditional heteroscedasticity, white heteroscedasticity and the functional form of the 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:

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

where the 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 the significance of the coefficient of the lagged error correction term using the 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 cause of electricity consumption if $a_{11,i} \neq 0 \forall_i$.

4. Results

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

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 KPSS.[3] 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 urbanisation ($\ln U_t$) are not found to be stationary at level with constant and time trend. All the variables are stationary at first difference. This shows that the variables are integrated at I(1).

The results of AFD, PP and KPSS unit root tests may be biased because these tests do not have information about a structural break occurring in the series. The appropriate information about a structural break would help policy makers in designing inclusive energy, economic, financial and urban policy to boost economic growth for the long run. The issue of a structural break is resolved by applying the Clemente et al. (1998) test with one and two unknown structural breaks arising in the macroeconomic variables. The results are detailed in Table 3. We find, while applying the Clemente et al. (1998) test with a single unknown break, that electricity consumption, economic growth, financial development and urbanisation have a unit root at level with constant and time trend. The structural breaks are found in electricity consumption, economic growth, financial development and urbanisation in 1998, 1984 and 2000, respectively. The variables are found to be stationary at first 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).

The unique integrating order of the variables lends support to testing the existence of cointegration between the variables. In doing so, we apply the ARDL bounds testing approach in the presence of a 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

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

Source: Authors' calculations.

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

The diagnostic tests, such as normality of error term, serial correlation, autoregressive conditional heteroscedasticity, white heteroscedasticity 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 the same inference is noted for autoregressive conditional heteroscedasticity. 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.

The marginal impact of independent variables on the 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 the square term of the real income per capita (scale and technique effects) have a positive and negative impact on electricity

Table 2. Unit root analysis.

Variables	ADF	PP	KPSS
$\ln E_t$	−3.3681 (1)	−2.7074 (3)	0.2614 (3)
$\Delta \ln E_t$	−3.4400 (0) ***	−3.7472 (3) **	0.1395 (2) *
$\ln Y_t$	−1.3934 (1)	−1.3820 (3)	0.2645 (2)
$\Delta \ln Y_t$	−3.3629 (1) ***	−4.2220 (3) **	0.1427 (4) *
$\ln F_t$	−2.1712 (1)	−2.6412 (3)	0.6933 (2)
$\Delta \ln F_t$	−6.4687 (2) *	−6.3606 (3) *	0.2048 (3) *
$\ln U_t$	−1.6703 (1)	0.0427 (3)	0.7242 (3)
$\Delta \ln U_t$	−3.5782 (4) **	−3.0954 (3) ***	0.2037 (4) *

Note: * (**) and *** denote the significance at 1% (5%) and 10% levels respectively. Figure in the parenthesis is the optimal lag structure for ADF and KPSS tests, and bandwidth for the PP test
Source: Authors' calculations.

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.
Source: Authors' calculations.

consumption. It is statistically significant at the 5% level respectively. This reveals that a rise in income per capita raises electricity demand while scale and technique effects decrease electricity consumption. It also shows that, initially, economic growth raises electricity consumption but the adoption of advanced technology, i.e. energy efficiency, to enhance domestic production, saves energy and reduces the usage of electricity consumption, once the economy is matured, i.e. an inverted U-shaped relation between both variables. The delinking point between economic growth and electricity consumption is AED 190,535 (before that threshold level income per capita, economic growth raises electricity demand and decreases it after that point). Trying to implement the state-of-the-art standards and regulation, the UAE government set up in 2009 the Emirates Authority for Standardisation and metrology. The authority is responsible for implementing Energy Efficiency Standardisation and Labelling (EESL) programme (for household appliances). It started with Phase 1, for non-ducted room air-conditioners in 2011. The target of the next phase is to implement the Energy Management (ISO 50,001) for big industries, hotels and shopping malls.

A positive effect of financial development on electricity consumption is found and it is statistically significant at the 1% level. A 1% increase in domestic credit to the private sector (financial development) adds in electricity consumption by 0.1353% keeping other things constant. Financial development was 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 increased energy consumption. Our results are supported by Sadorsky (2010, 2011) and Shahbaz and Lean (2012).

The relationship between urbanisation and electricity consumption is inverted U-shaped. This implies that urbanisation initially raises electricity demand and, after the threshold

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	DW 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% level	7.527	8.803				
5% level	5.387	6.437				
10% level	4.477	5.420				

Note: *(**) and *** represents significant at 1(5)% and 10% levels respectively.
Source: Authors' calculations.

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

Source: Authors' calculations.

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	
$\chi^2 RAMSEY$	0.8310	0.3692	

Note: *, ** represent significance at 1% and 5% levels respectively. $\chi^2 NORMAL$ is for the normality test, $\chi^2 ARCH$ for autoregressive conditional heteroscedasticity, $\chi^2 WHITE$ for white heteroscedasticity and $\chi^2 REMSAY$ for Ramsey Reset test.
Source: Authors' calculations.

level, it decreases energy demand. The coefficient of the linear term of urbanisation is 2.2645 and non-linear term of urbanisation is –0.9467. Both coefficients are statistically significant at the 5% level of significance. The threshold point of urbanisation is 79.85–80.23%, which implies that before 79.85% of urbanisation electricity demand (electricity consumption) is increased, and after 80.23% of urbanisation, electricity demand is decreased due to the use of electricity-efficient technology by government as well as electric appliances by consumers (individuals). The UAE infrastructure started approximately from scratch in the 1950s. The increase in urbanisation increased electricity demand to a certain threshold. When the UAE became a net importer of natural gas for electricity production and desalinisation, the government set a very restrictive electricity use policy, implemented many federal initiatives for renewable energy production and a national campaigns to rationalise the use of electricity and water (Bachellerie, 2012). The long-run results fulfil the assumptions of CLRM confirming the normality of the error term, the absence of autoregressive conditional heteroscedasticity as well as white heteroscedasticity and the functional form of the model.

The short run results are reported in Table 7. The results reveal that an 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 the 1% level. The relationship between urbanisation and electricity demand is also an inverted U-shaped one. This relationship is statistically significant at the 5% level of significance. 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% every year towards long-run equilibrium and may take 5 years and 11 months to reach a stable long-run equilibrium path.

The lower segment of Table 7 deals with diagnostic tests. The results indicate that the error term has a normal distribution. There is no evidence of autoregressive conditional heteroscedasticity and the same inference is drawn for white heteroscedasticity. The functional

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	0.3558		
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	
$\chi^2 RAMSEY$	1.7317	0.1532	

Note: * and ** represent significance at 1% and 5% levels respectively. $\chi^2 NORMAL$ is for normality test, $\chi^2 ARCH$ for autoregressive conditional heteroscedasticity, $\chi^2 WHITE$ for white heteroscedasticity and $\chi^2 REMSAY$ for the Ramsey Reset test.
Source: Authors' calculations.

form of short-run model is well constructed, as confirmed by the Ramsey Reset test statistic. The results of stability tests such as CUSUM and CUSUMsq are shown in Figures A1 and A2 (see the Appendix).

The results of the CUSUM test indicate the stability of the ARDL parameters but the diagram of the CUSUMsq reveals the instability of the ARDL parameters. The CUSUMsq test shows a structural break in the first quarter of 1996. This structural break deals with the global oil production peaks in 1996. The oil production reached 100% of its capacity. However, after the January spike the production starts decreasing with a rate of approximately 7% annually. The Chow forecast test is applied to test the validation of the structural break in the first quarter of 1996. Leow (2004) suggested applying the Chow forecast test which is superior to the CUSUM and CUSUMsq tests.[4] The results indicate the absence of a structural break over the mentioned time period. This confirms the reliability and efficiency of the ARDL parameters.

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 the appropriate energy, financial and urban policies for sustainable economic growth in the case of UAE. Table 8 reports results in the direction of long- and short-run causality. In the 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 the same inference is drawn for urbanisation and electricity consumption. Financial development and economic growth Granger-cause each other. The bidirectional causality is found between urbanisation and financial development and, urbanisation and economic growth are also interdependent, i.e. a bidirectional causal relationship exists between urbanisation and economic growth.

In the short run, financial development Granger causes electricity consumption but the same is not true from the opposite side. Financial development Granger causes economic growth and the reverse is true from economic growth to financial development. Economic

Table 8. The VECM Granger causality analysis.

	Direction of causality				
	Short run				Long run
Dependent variable	$\Delta \ln E_{t-1}$	$\Delta \ln Y_{t-1}$	$\Delta \ln F_{t-1}$	$\Delta \ln U_{t-1}$	ECT_{t-1}
$\Delta \ln E_t$	…	1.7375	3.7879**	0.7406	−0.0580**
		[0.1975]	[0.0494]	[0.4866]	[−2.0350]
$\Delta \ln Y_t$	2.8869**	…	6.8113*	0.5887	−0.1712**
	[0.0475]		[0.0064]	[0.5731]	[−2.7763]
$\Delta \ln F_t$	2.5013	3.3894**	…	3.4747	−0.6599*
	[0.1013]	[0.0492]		[0.1034]	[−3.8383]
$\Delta \ln U_t$	1.8396	0.1114	1.7286	…	−0.0823**
	[0.1790]	[0.8950]	[0.1973]		[−2.1595]

Note: * and ** show significance at 1 and 5 per cent levels respectively.
Source: Authors' calculations.

growth is the Granger cause of electricity consumption. Urbanisation Granger causes financial development. There is no causality running from electricity consumption, economic growth and financial development to urbanisation.

We have also conducted IR analysis to extend the results of Granger test by providing the information on the magnitude/strength of the causal interference (See Figure 1). We use the generalised impulse response approach, which is superior to the 'orthogonalised' impulse responses. The generalised impulse response approach is insensitive to the order of vector autoregression (VAR) variables (Hurley, 2010). The results show that innovative shocks that occur in economic growth raises electricity consumption until 4 time horizon. This shows that the relationship between economic growth and electricity consumption is an inverted U-shape, i.e. EKC hypothesis between economic growth and electricity consumption. Electricity consumption responds positively due to innovative shocks to financial development. The relationship between urbanisation and electricity consumption is an inverted U-shaped. This reveals that electricity consumption increases with urbanisation increases and electricity consumption declines.

5. Conclusion and policy implications

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

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

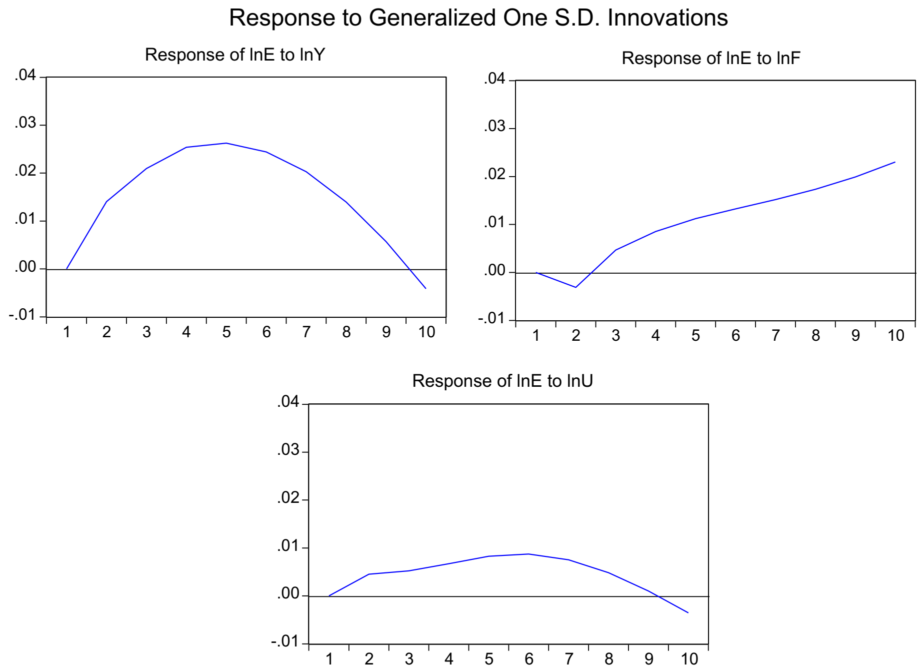

Figure 1. Impulse response function. Source: Authors' calculations.

consumption decreases after the threshold level of urbanisation. The causality analysis exposed bidirectional causality between electricity consumption and economic growth. The feedback hypothesis is found between financial development and electricity consumption. The financial development Granger causes economic growth and the same is true from the opposite side. Economic growth and urbanisation are interdependent. The bidirectional causality exists between urbanisation and electricity consumption and the same is true between urbanisation and financial development.

Our findings suggest that there is unidirectional Granger causality running from electricity consumption to economic growth in the short run, while there is bidirectional causality in the long run. The different Granger causality results between the short- and long-run imply the need for different policies for the short and long runs. Short-run causality results show that electricity consumption Granger-causes economic growth, which means that the UAE is an energy-led growth economy (Sweidan, 2012). Consequently, environmentally friendly policies, such as electricity conservation, including efficiency improvement measures and demand-side management policies, which target a decreasing the wastage of electricity, would stimulate economic activity in the short-run. Further, our empirical results also reveal that electricity consumption and economic growth have bi-directional causality in the long-run. In particular, as explained above, the UAE became a net importer of natural gas because the of big jump in electricity production needs. Moreover, the 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. Our analysis indicate the threshold point, i.e. Dirham 190,535 UAE between electricity consumption and economic growth that must be used as a policy tool to lower electricity demand.

Bi-directional causality between electricity consumption and financial development in the 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 the other hand, an 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. This shows that financial development should be used as a policy tool to lower electricity consumption by directing the financial sector to sanction loans at a cheaper cost to those firms or industries that adopt advanced and energy-efficient technology during production processes and who are environmentally friendly.

Finally, short-run urbanisation does not Granger-cause any of the variables. Moreover, either of the variables does Granger-cause urbanisation. However, in the long-run there is bi-directional causality between urbanisation and economic growth, electricity consumption, and financial development. Increasing the rate of urbanisation may contribute in boosting the economic output by providing a labour factor of production. A prospering economy would develop its infrastructure (electricity network, transport, housing) and services (financial services) to maximise the efficiency, satisfy the population and attract international tourism, especially in urban areas.

This study can be augmented for future research by incorporating other potential variables while estimating the electricity demand function. For example, Karanfil (2009) indicated the interest rate and exchange rate (devaluation) as potential determinants of economic growth and electricity consumption. Shahbaz, Mallick, Mahalik, and Sadorsky (2016) also noted that globalisation affects energy consumption via income effect, technique effect, composite effect and comparative advantage effect. The electricity demand function may provide biased empirical evidence if globalisation is excluded. Finally, the presence of asymmetries in time series data due to the implementation of economic and energy polices warrant applying non-linear empirical approaches such as Non-linear ARDL, developed by Shin, Yu, and Greenwood-Nimmo (2014), rather than linear empirical approaches.

Notes

1. The causal links between economic growth, financial development, urbanisation (and/or globalisation) and electricity consumption for single countries have been studied in previous literature (see Gurgul & Lach, 2010, 2012a,b, 2014). In this, we apply a multivariate electricity consumption function by considering economic growth, financial development and urbanisation as contributory factors. We have accommodated a structural break to examine their impact on long-run as well as short-run electricity consumption. The presence of structural breaks in the macroeconomic valuable may change the causal relationship between the variables. These merits make our study unique in existing literature.
2. Urbanisation is measured by urban population as share of total population.
3. Hobijn, Franses, and Ooms (2004) argue that the KPSS unit root test is oversized due to highly autoregressive processes by employing a semiparametric heteroscedasticity.
4. Results are available upon request from the authors.

Disclosure statement

No potential conflict of interest was reported by the author.

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Appendix

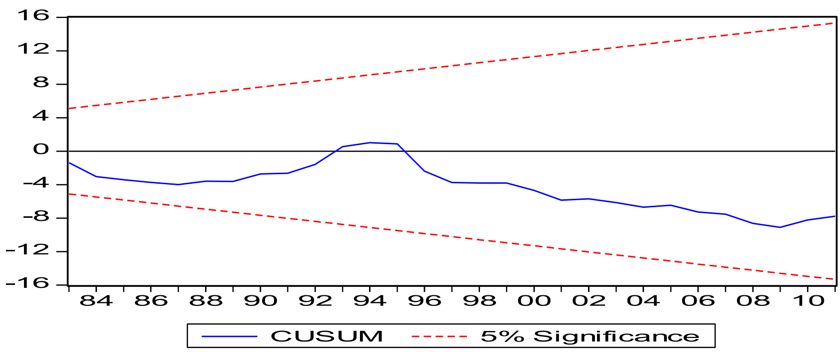

Figure A1. Plot of Cumulative Sum of Recursive Residuals. Source: Authors' calculations.
Note: The straight lines represent critical bounds at the 5% significance level.

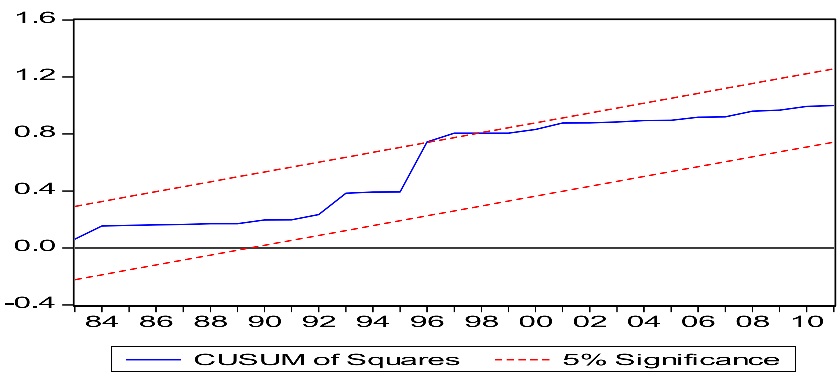

Figure A2. Plot of cumulative sum of squares of recursive residuals. Source: Authors' calculations.
Note: The straight lines represent critical bounds at the 5% significance level.