The effects of electricity consumption, economic growth, financial development and foreign direct investment on CO_2 emissions in Kuwait

Abstract

This study examined the empirical effects of economic growth, electricity consumption, foreign direct investment (FDI), and financial development on carbon dioxide (CO_2) emissions in Kuwait using time series data for the period 1980-2013. To achieve this goal, we applied the autoregressive distributed lag (ARDL) bounds testing approach and found that cointegration exists among the series. Findings indicate that economic growth, electricity consumption, and FDI stimulate CO_2 emissions in both the short and long run. The VECM Granger causality analysis revealed that FDI, economic growth, and electricity consumption strongly Granger-cause CO_2 emissions. Based on these findings, the study recommends that Kuwait reduce emissions by expanding its existing Carbon Capture, Utilization, and Storage plants; capitalizing on its vast solar and wind energy; reducing high subsidies of the residential electricity scheme; and aggressively investing in energy research to build expertise for achieving electricity generation efficiency.

1. Introduction

Kuwait is a small open economy, rich in hydrocarbon resources with 9% of the world's reserves of oil and gas. Because of a growing economy, it has huge energy demands and energy requirements, mostly for electricity generation. Total electricity consumption has increased significantly over the past decade, from 17.66 TWh in 1995 to 32.94 TWh in 2005 to 50.57 TWh in 2015 (Enerdata, 2016). The increasing domestic demand for

energy, especially for electricity, may jeopardize Kuwait in terms of its future energy security. At 69.5 Mt of carbon dioxide (CO_2) emissions per capita, Kuwait is considered one of the largest per capita CO_2 emitters in the world (Hertog and Luciani, 2009). A growing economy along with an increasingly wealthy population and harsh weather conditions are driving domestic electricity demand. As such, the sustainability of the energy systems in Kuwait is likely to be vulnerable if the anticipated energy crisis – in particular, the electricity crisis and CO_2 emissions issues – are not addressed appropriately.

Kuwait's primary energy demand has been growing at an annual average rate of 5-7% (REEET, 2017). Although economic growth is always accompanied by increasing domestic demand for energy, this is not the case with Kuwait. The country has experienced very high rates of per capita electricity consumption, which has already surpassed the average level of major industrial countries (Hertog and Luciani, 2009). The most important reason for this staggering increase is the government's electricity and water subsidy program (El-Katiri et al., 2011). The government has been providing subsidies of more than 95% on electricity costs since 1996, leading to fast-growing and wasteful consumption. In addition, lack of administrative efficiency is responsible for failure to reach electricity bill collection targets, resulting in irresponsible consumption of electricity. Although the public policy aims to maximize social welfare by providing huge subsidies, such policy is not supported by energy conservation efforts, causing inefficient allocation of natural resources. The recent growth in energy demand, and electricity demand in particular, has generated significant environmental concerns, particularly CO_2 emissions (Bekhet et al., 2017).

In light of the above environmental adversity, this study investigates the long-run effects of electricity consumption, economic growth, foreign direct investment (FDI), and financial development on CO_2 emissions for Kuwait for the period 1980-2013. Although numerous time series and panel studies have examined such associations (e.g., Begum et al., 2015; Salahuddin et al., 2015; Omri et al., 2014; Ozcan, 2013; Ozturk & Acaravci, 2011), to the best of the authors' knowledge, no study has yet been undertaken to determine such causal relationships in the context of Kuwait, which is potentially a very important country for such investigation. The current study is an attempt to fill this gap.

The rest of this paper is structured as follows: Section 2 discusses the empirical evidence from the literature; Section 3 is devoted to methodology and data; Section 4 discusses the results; and conclusions and policy implications are covered in Section 5.

2. Literature review

2.1 CO_2 emissions, energy consumption, and economic growth

To date, a significant volume of literature has evolved regarding the association between economic growth, energy consumption, and environmental pollution. Numerous time series and panel data studies have examined their relationship, and some have examined the validity of the environmental Kuznet curve (EKC) hypothesis. Ouyang and Lin (2017) analyzed the factors responsible for CO_2 emissions in China and Japan using cointegration analysis. Their findings indicated that China and Japan differ significantly in terms of per capita CO_2 emissions, energy structure, and energy intensity, although they experienced similar characteristics of stable growth during their urbanization process. The future CO_2 emissions reduction potential of China is determined through scenario analysis. The authors concluded that China can take lessons from Japan's experiences in reducing energy intensity for its low-carbon planning and transition.

Behera and Dash (2017) estimated two models for a panel of 17 South and South-East Asian countries (SSEA) for the period 1980-2012. The first panel examined the empirical association between primary energy consumption, urbanization, FDI, and CO_2 emissions, and the second panel examined the empirical association between fossil fuel consumption, urbanization, FDI, and CO_2 emissions. The authors subsampled these countries into three income categories: low-, middle- and high-income countries. The study found a cointegrating relationship among the variables for all countries for the first panel, while such association existed only for the middle-income countries for the second panel.

Ouyang and Lin (2015), in another investigation, found that industrial activity causes a rise in CO_2 emissions while carbon mix and carbon intensity reduce CO_2 emissions. They found that long-run significant relationships exist between CO_2 emissions and energy consumption, industrial value added, labor productivity and fossil

fuel consumption. Saboori et al. (2014) investigated the bidirectional long-term relationship between energy consumption, CO_2 emissions, and economic growth in the road transport sector of Organization of Economic Cooperation and Development (OECD) countries. Using the Fully Modified Ordinary Least Squares (FMOLS) method, the study confirmed that there are positive significant bidirectional relationships between CO_2 emissions and economic growth, road sector energy consumption and economic growth, and CO_2 emissions and road sector energy consumption. Their findings further indicated that most of these CO_2 emissions occur due to energy consumption. The study emphasized the need for long-term policies aimed at enhancing energy efficiency and shifting to alternative energy options such as biofuel, renewable sources, and nuclear.

Lin and Ouyang (2014) examined the determinants of energy demand in China using panel cointegration modeling. The authors also applied scenario analysis to forecast China's energy demand. China and the USA were found to go through similar characteristics during their rapid urbanization process. The study concluded that China's energy sustainability largely depends on energy price reforms. In another study, Lin and Ouyang (2014) applied the Log Mean Divisia Index (LMDI) method to assess the emissions reduction potential in the non-metallic mineral products industry of China. The study found that industrial activity contributes most towards CO_2 emissions in China, while energy intensity reduces it. Ouyang and Lin (2014), in a further empirical exercise, projected the future electricity intensity and conservation potential in the building materials industry of China. They estimated the long-run equilibrium relationship between electricity intensity and factors including technology, power tariff, enterprise scale, and value added per worker. Findings indicated that aggressive energy conservation policy would potentially reduce CO_2 emissions caused by huge electricity consumption.

Al-Mulali et al. (2012) conducted a study involving seven regions: East Asia–Pacific, Eastern Europe–Central Asia, Latin America–Caribbean, Middle East–North Africa, South Asia, Sub-Saharan Africa, and Western Europe. They estimated the relationship between urbanization, energy consumption, and CO_2 emissions. The results provided support for a positive long-run relationship between the variables in 84% of the

countries. The findings for the other 16% of the countries were mixed: some demonstrated a negative relationship while others did not demonstrate any relationship.

Stable long-term relationships were found for France (Ang, 2007) and Malaysia (Ang, 2008). In the former, a unidirectional causality was observed running from economic growth to energy consumption and CO_2 emissions in the long run. In the latter, GDP per capita stimulates CO_2 emissions and energy consumption. Ozturk and Acaravci (2010) studied the relationship between income, energy consumption, CO_2 emissions, and employment in Turkey. The application of the Toda-Yamamoto (TY) Granger causality test showed that neither CO_2 emissions per capita nor energy consumption per capita cause real GDP growth per capita. Ghosh (2010) confirmed the absence of any causal association between CO_2 emissions and economic growth in India in the long run. Pao and Tsai (2011a) examined the dynamic relationship between pollutant emissions, energy consumption, and energy output for Brazil. They found that in the long run, emissions appear to be output-inelastic and energy-elastic. Pao et al. (2011) applied the cointegration technique and conducted a causality test to examine the dynamic relationships between CO_2 emissions, energy use, and real output for Russia for the period 1990-2007. They did not find any support in favor of the EKC hypothesis; another more recent study (Ozokcu and Ozdemir, 2017) also did not find any support in favor of this hypothesis.

Adom et al. (2012) investigated the short- and long-term equilibrium relationship between CO_2 emissions, economic growth, technical efficiency, and industrial structure for Ghana, Senegal, and Morocco. Their findings suggested a multiple long-term relationship between the variables for Ghana and Senegal but only a one-way long-term relationship for Morocco. The TY Granger causality test showed that CO_2 emissions did not Granger-cause in Senegal but they were a limiting factor for Ghana and Morocco.

Begum et al. (2015) investigated the dynamic impacts of GDP growth, energy consumption, and population growth on CO_2 emissions for Malaysia for the period 1970-2009. The results from this empirical analysis indicated that CO_2 emissions per capita declined with increased GDP growth per capita in the 1970-1980 period, but for the 1980-2009 period, an increase in GDP per capita led to a rise in CO_2 emissions.

Ghosh and Kanjilal (2014) conducted an empirical analysis for India using data for the period 1971-2008. They employed threshold cointegration tests complemented by the Autoregressive Distributed Lag (ARDL) model and the Johansen and Juselius maximum likelihood procedures. The results indicated a long-run cointegrating relationship between the variables in the presence of structural breaks. A unidirectional causal link running from energy consumption to economic activity and from economic activity to urbanization was also observed. Salahuddin et al. (2015) tested the robustness of the association between electricity consumption, CO_2 emissions, economic growth, and financial development for a panel of Gulf Cooperation Council (GCC) countries. A battery of econometric techniques to assess the robustness found the long-term association among the variables to be robust across different econometric specifications. They concluded that electricity consumption and economic growth stimulate CO_2 emissions but financial development reduces it.

Salahuddin and Gow (2014) examined the association between economic growth, energy consumption, and CO_2 emissions using panel data for GCC countries for the period 1980-2012. They also calculated the decoupling trend for these countries. Their findings indicated that despite some relative decoupling, energy consumption stimulates CO_2 emissions while economic growth increases energy consumption. Also, a bidirectional causal link was observed between energy consumption and CO_2 emissions. The study further noted a unidirectional causality running from economic growth to energy consumption.

Al-Mamun et al. (2014) estimated the relationship between economic growth and CO_2 emissions using panel data for 136 countries for the period 1980-2009. Following World Bank country classifications, they divided the sample countries into five distinct groups: lower-income countries; lower middle-income countries; upper middle-income countries; high-income OECD countries; and high-income non-OECD countries. The study found the presence of EKC across all regions except for high-income OECD countries. The research also found that high-income OECD countries cause more CO_2 emissions than other countries, which was in contrast to general expectations. The authors also noted that industrial value addition contributes to increased pollution; and it

was observed across all regions in the study that population growth increases CO_2 emissions and economic liberalization reduces CO_2 emissions.

Saboori and Sulaiman (2013) examined the empirical link between energy consumption, CO_2 emissions, and economic growth for selected South-East Asian nations. They found a significant positive relationship between CO_2 emissions and energy consumption, both in the short and long run. Further, the study found evidence in support of the EKC hypothesis for Singapore and Thailand, and also a long-run bidirectional causal link between CO_2 emissions and economic growth in these countries. Wang et al. (2012) examined the relationship between CO_2 emissions and economic growth for a panel of 98 countries to find a threshold effect. The results did not corroborate the EKC hypothesis.

Sahzabi et al. (2011) investigated the relationship between energy consumption and CO_2 emissions for Iran and found a strong positive correlation. Belke et al. (2011) found that financial development dominates the long-run relationship between energy consumption and real GDP in OECD countries. Pao and Tsai (2011b), in a study on BRICS (Brazil, Russia, India, China, and South Africa) countries, recommended managing both energy demand and FDI and increasing investment in energy supply and energy efficiency to reduce CO_2 emissions.

Apergis and Payne (2011) investigated six Central American economies. It was evident that energy consumption is positively linked with CO_2 emissions. Lean and Smyth (2010) concluded similarly for ASEAN countries. Empirical evidence from Narayan and Narayan (2010) also supported the EKC hypothesis for 43 low-income countries. In addition, Lean and Smyth (2010) noted long-term causality running from energy consumption and CO_2 emissions to economic growth in ASEAN countries. However, Apergis and Payne (2010a,b) found that energy consumption and economic growth cause CO_2 emissions, while energy consumption and economic growth also cause each other.

Salahuddin and Alam (2015) examined the effects of Internet usage and economic growth on electricity consumption for Australia for the period 1985-2012. The results indicated a significant positive association of Internet use and economic growth with electricity consumption in the long term. However, the short-term relationship among

these variables was not found to be significant. Ozturk and Al-Mulali (2015) used a multivariate framework to analyze panel data to determine the effect of natural gas consumption on economic growth for GCC countries for the period 1980-2012. They found a cointegrating relationship between natural gas consumption and economic growth for these countries. They also found a significant long-term association between natural gas consumption and GDP growth in the region.

Sohag et al. (2015) assessed the effects of technological innovation on energy use in Malaysia. They analyzed annual data for the period 1985-2012 and concluded that an increase in GDP causes an increase in energy demand, and trade openness increases domestic energy use in the long term. The empirical findings indicated that technological innovation contributes significantly towards reduced energy use and improved energy efficiency. Hasanov et al. (2017) reviewed the energy–growth nexus for 10 oil-exporting countries. The findings indicated that a growth hypothesis dominates in the primary energy consumption–growth nexus while a neutrality hypothesis dominates in the residential electricity consumption–growth nexus for these countries.

Ozturk and Acaravci (2016) examined the long-run causal association between economic growth, CO_2 emissions, energy consumption, the foreign trade ratio, and the employment ratio for Cyprus and Malta for the period 1980-2006. They found a long-run relationship and a subsequent causal link for Malta only. Furuoka (2017) investigated the empirical association between renewable and non-renewable electricity consumption and economic development for three transition economies – Estonia, Latvia, and Lithuania – for the period 1992-2011. They found support for the conservation hypothesis, which means that economic development causes increased use of renewable electricity, but not vice versa. Ozturk and Acaravci (2011) addressed short- and long-term causality issues between electricity consumption and economic growth in 11 Middle East and North African (MENA) countries using annual data for the period 1971-2006. They did not find any positive association between electricity consumption and economic growth for most of these countries.

The results achieved by Cowan et al. (2014) supported the neutrality hypothesis for Brazil, India, and China, indicating no link between electricity consumption and economic growth. However, regarding a GDP–CO_2 emissions nexus, a feedback

hypothesis was found for Russia. Also, a one-way Granger causality test running from GDP to CO_2 emissions and a reverse relationship were found for Brazil. Sbia et al. (2013) found a positive relationship between economic growth and energy consumption. The authors also determined that CO_2 emissions have a negative impact on energy demand in a time series study involving the United Arab Emirates (UAE). Alkhatlan and Javid (2013) found a positive relationship between CO_2 emissions and economic growth in the case of Saudi Arabia.

Solarin and Shahbaz (2013) found a bidirectional causal link between electricity consumption and economic growth in Angola. Burnett et al. (2013) concluded that economic growth drives the intensity of CO_2 emissions in the USA rather than the CO_2 emissions themselves. Alves and Moutinho (2013) examined the intensity of CO_2 emissions in Portugal using a 'complete decomposition' technique. Results showed that the intensity declined significantly during the 1996-2009 period. It is argued that the replacement of fossil fuels with lower-polluting fuels was the key reason for this success.

Acaravci and Ozturk (2012) investigated the short- and long-run causality between electricity consumption and economic growth in Turkey for the period 1968-2006. They found that electricity consumption stimulates economic growth in Turkey. The role of electricity in enhancing economic growth was highlighted in the study. Pao et al. (2012) undertook an empirical exercise to forecast CO_2 emissions, energy consumption, and economic growth in China. A long-run relationship between the variables was observed. CO_2 emissions were found to be output-inelastic, while energy consumption is output-elastic.

He et al. (2010) used a scenario analysis approach and projected China's possible CO_2 emissions for the period 2010-2020. Lotfalipour et al. (2010) investigated the causal link among economic growth, CO_2 emissions, and fossil fuel consumption in Iran. Their empirical findings supported unidirectional causal linkages running from GDP and energy consumption to CO_2 emissions. No causal link was found between fossil fuel consumption and CO_2 emissions in the long run. The results further indicated that gas consumption rather than CO_2 emissions, energy consumption, and fossil fuel consumption lead to economic growth. Based on the findings, they recommended China should pursue a low-carbon industrialization model for the sustainability of its economy.

Soytas and Sari (2009) investigated the relationship between CO_2 emissions, income, energy, and total employment in five OPEC countries, including Saudi Arabia. They found a cointegrating relationship between the variables.

Arouri et al. (2012), in a study of 12 MENA countries, showed that energy consumption has a positive significant impact on CO_2 emissions and that real GDP demonstrates a quadratic relationship with CO_2 emissions. Omri et al. (2014) resolved that there is a bidirectional causal link between energy consumption and economic growth in MENA countries. Li et al. (2011) showed that there is a positive long-term relationship between real GDP per capita and energy consumption variables. Liao and Cao (2013), for a panel study of 132 countries, found that factors like urbanization, population density, trade, energy mix, and the economic environment impact on the absolute level of CO_2 emissions. Al-Mulali et al. (2013) determined that 60% of Latin American and Caribbean countries have a positive bidirectional long-run relationship between energy consumption, CO_2 emissions, and economic growth. Chang (2013) found a bidirectional causal link between GDP and energy consumption, and GDP and CO_2 emissions. They suggested that increased energy consumption will stimulate CO_2 emissions. The EKC hypothesis was recently tested by Apergis and Ozturk (2015), Shahbaz et al. (2015), and Al-Mulali et al. (2015b) with various datasets and econometric approaches. The findings of these studies were mixed and inconclusive.

2.2 CO_2 emissions, FDI, and financial development

Literature investigating the relationship between CO_2 emissions and FDI is relatively scarce, although FDI has been found to be an important variable affecting emissions (Al-Mulali and Tang, 2013). A significant chunk of available literature has addressed the one-way causal relationship between FDI and CO_2 emissions, however, only a few studies have focused on the bi-directional link between FDI and CO_2 emissions. The impact of FDI on CO_2 emissions is mixed in the literature. Some studies found a positive relationship between FDI and CO_2 emissions, lending support to the pollution haven hypothesis (Cole et al., 2006; Wang et al., 2012), while others found a negative relationship, supporting the pollution haven hypothesis (Lan et al., 2011; Atici, 2012; Al-Mulali and Tang, 2013). From this brief discussion, it is evident that there is no

consensus as yet on the validity of the pollution haven hypothesis. Nevertheless, the relationship between CO_2 emissions and FDI has important implications for energy policy, especially for a country like Kuwait. Therefore, this study includes FDI as an explanatory variable in the model.

The effect of financial development on emissions has also been examined in the literature. Tamazian et al. (2009) found that a high degree of financial development improves environmental conditions. Jalil and Feridun (2011) reported that financial development has a negative effect of on CO_2 emissions in China. Zhang (2011) found that financial development is one of the factors responsible for the increase in the level of CO_2 emissions. Financial development also contributes towards a rise in energy consumption and CO_2 emissions in Sub-Saharan African countries (Al Mulali, 2012). Ozturk and Acaravci (2013) reported that the association between financial development and CO_2 emissions is insignificant in the long run for Turkey. Overall, literature on the financial development–emissions nexus provides mixed results; therefore, further investigation of this relationship seems to be worthy.

3. Empirical model and econometric methods

An econometric model of the following form was estimated in the current study.

$$C_t = \beta_0 + \beta_1 FDI_t + \beta_2 GDPPC_t + \beta_3 EC_t + \beta_4 FD_t + \varepsilon_t \tag{1}$$

The coefficients β_1, β_2, β_3, and β_4 represent the long-run elasticity estimates of CO_2 emissions with respect to FDI, real GDP per capita, energy consumption, and financial development proxied by private sector credit as a share of GDP, respectively.

To investigate the relationships, data for the following variables were sourced:

- Per capita CO_2 emissions (C)
- Per capita energy consumption (EC)
- Per capita real GDP (GDPPC)
- Financial development (FD), i.e., domestic credit available to the private sector as share of GDP

- FDI as share of GDP

The World Development Indicators database 2014 was the source of the data for all these variables (World Bank, 2015). Real GDP per capita (Y), which is measured at constant 2000 US$, was used; per capita energy consumption (kWh) and per capita CO_2 emissions were estimated by dividing total energy consumption and CO_2 emissions by the mid-year population. The variables were then transformed into natural logs. This transformation was intended to overcome the problem of heteroscedasticity between the variables.

3.1 Estimation procedures

3.1.1 Unit root tests

Since all the conventional unit root tests fail to identify the presence of structural break, if any, in the series (Baum, 2004), we conducted the Zivot and Andrews (1992) unit root test, which accommodates a single structural break point in the level. If we consider our series as X, the structural tests take the following form;

$$\Delta X_t = a + aX_{t-1} + bT + cD_t \tag{2}$$

$$\Delta X_t = \beta + \beta X_{t-1} + ct + bDT_t + \sum_{j=1}^{k} d_j \Delta X_{t-j} + \varepsilon_t \tag{3}$$

$$\Delta X_t = \gamma + \gamma X_{t-1} + ct + dDT_t + \sum_{j=1}^{k} d_j \Delta X_{t-j} + \varepsilon_t \tag{4}$$

$$\Delta X_t = \Omega + \Omega X_{t-1} + ct + dD_t + dDT_t + \sum_{j=1}^{k} d_j \Delta X_{t-j} + \varepsilon_t \tag{5}$$

where D is a dummy variable and shows the mean shift at each point, and DT_t is a trend shift variable. The null hypothesis in Zivot and Andrews (1992) is c=0 implies the presence of unit root in the absence of a structural break in the data, against the alternative that the series is trend stationary with an unknown time break. Then, this unit root test selects that time break which reduces the one-sided t-statistic to test c(=c-1)=1.

3.1.2 ARDL bounds testing approach

Uddin et al. (2013) suggested that conventional cointegration techniques do not provide reliable results when data are plagued with structural breaks. Therefore, this study

employed the Autoregressive Distributed Lag (ARDL) bounds testing approach developed by Pesaran (1997) and Pesaran et al. (2001) to estimate the cointegrating or long-run relationship between the variables. The ARDL technique has already proved to be efficient in cases of small sample size (Pesaran et al., 2001) and potentially removes the problems of omission bias and autocorrelation. In addition, the technique generally provides unbiased estimates of the long-run model and valid t-statistics, even in the presence of the problem of endogeneity (Harris and Sollis, 2003). The empirical formulation of the ARDL equation for our study was specified as follows:

$$\Delta C_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 C_{t-1} + \beta_4\, FD_{t-1} + \beta_5\, NET_{t-1} + \beta_6\, FDI_{t-1} + \beta_7\, GDPPC_{t-1} + \beta_8 EC_{t-1} + \sum_{i=1}^{P} \beta_9\, \Delta C_{t-j}$$

$$+ \sum_{J=1}^{q} \beta_{10}\, GDPPC_{t-k} + \sum_{k=0}^{r} \beta_{11}\, \Delta FD_{t-l} + \sum_{l=0}^{s} \beta_{12}\, \Delta NET_{t-m} + \sum_{m=0}^{t} \beta_{13}\, \Delta FDI_{t-m} + \sum_{n=0}^{u} \beta_{14}\, \Delta EC_{t-n} + \mathcal{E}_t \qquad (6)$$

$$\Delta NET_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 NET_{t-1} + \beta_4\, FD_{t-1} + \beta_5\, C_{t-1} + \beta_6\, FDI_{t-1} + \beta_7\, GDPPC_{t-1} + \beta_8 EC_{t-1} + \sum_{i=1}^{p} \beta_9\, \Delta NET_{t-j}$$

$$+ \sum_{J=1}^{q} \beta_{10}\, GDPPC_{t-k} + \sum_{k=0}^{r} \beta_{11}\, \Delta FD_{t-l} + \sum_{l=0}^{s} \beta_{12}\, \Delta C_{t-m} + \sum_{m=0}^{t} \beta_{13}\, \Delta FDI_{t-m} + \sum_{n=0}^{u} \beta_{14}\, \Delta EC_{t-n} + \mathcal{E}_t \qquad (7)$$

$$\Delta FD_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 FD_{t-1} + \beta_4\, NET_{t-1} + \beta_5\, C_{t-1} + \beta_6\, FDI_{t-1} + \beta_7\, GDPPC_{t-1} + \beta_8 EC_{t-1} + \sum_{i=1}^{p} \beta_9\, \Delta FD_{t-j}$$

$$+ \sum_{J=1}^{q} \beta_{10}\, GDPPC_{t-k} + \sum_{k=0}^{r} \beta_{11}\, \Delta NET_{t-l} + \sum_{l=0}^{s} \beta_{12}\, \Delta C_{t-m} + \sum_{m=0}^{t} \beta_{13}\, \Delta FDI_{t-m} + \sum_{n=0}^{u} \beta_{14}\, \Delta EC_{t-n} + \mathcal{E}_t \qquad (8)$$

$$\Delta FDI_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 FDI_{t-1} + \beta_4\, NET_{t-1} + \beta_5\, C_{t-1} + \beta_6\, FD_{t-1} + \beta_7\, GDPPC_{t-1} + \beta_8 EC_{t-1} + \sum_{i=1}^{p} \beta_9\, \Delta FDI_{t-j}$$

$$+ \sum_{J=1}^{q} \beta_{10}\, GDPPC_{t-k} + \sum_{k=0}^{r} \beta_{11}\, \Delta NET_{t-l} + \sum_{l=0}^{s} \beta_{12}\, \Delta C_{t-m} + \sum_{m=0}^{t} \beta_{13}\, \Delta FD_{t-m} + \sum_{n=0}^{u} \beta_{14}\, \Delta EC_{t-n} + \mathcal{E}_t \qquad (9)$$

$$\Delta GDPPC_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 GDPPC_{t-1} + \beta_4 \, NET_{t-1} + \beta_5 \, C_{t-1} + \beta_6 \, FD_{t-1} + \beta_7 \, FDI_{t-1} + \beta_8 EC_{t-1} +$$

$$\sum_{I=1}^{P} \beta_9 \, \Delta GDPPC_{t-j} + \sum_{J=1}^{q} \beta_{10} \, FDI_{t-k} + \sum_{k=0}^{r} \beta_{11} \, \Delta NET_{t-l} + \sum_{l=0}^{s} \beta_{12} \, \Delta C_{t-m} + \sum_{m=0}^{t} \beta_{13} \, \Delta FD_{t-m} + \sum_{n=0}^{u} \beta_{14} \, \Delta EC_{t-n} + \mathcal{E}_t \quad (10)$$

$$\Delta EC_t = \beta_0 + \beta_1 T + \beta_2 D + \beta_3 EC_{t-1} + \beta_4 \, NET_{t-1} + \beta_5 \, C_{t-1} + \beta_6 \, FD_{t-1} + \beta_7 \, FDI_{t-1} + \beta_8 GDPPC_{t-1} +$$

$$\sum_{I=1}^{P} \beta_9 \, \Delta EC_{t-j} + \sum_{J=1}^{q} \beta_{10} \, FDI_{t-k} + \sum_{k=0}^{r} \beta_{11} \, \Delta NET_{t-l} + \sum_{l=0}^{s} \beta_{12} \, \Delta C_{t-m} + \sum_{m=0}^{t} \beta_{13} \, \Delta FD_{t-m} + \sum_{n=0}^{u} \beta_{14} \, \Delta GDPPC_{t-n} + \mathcal{E}_t \quad (11)$$

3.1.3 Gregory and Hansen cointegration test and ARDL estimation

To check whether the cointegrating relationship between the variables from the ARDL bounds test is robust, we employed the Gregory and Hansen (1996) residual-based test of cointegration, which allows for a single change in the cointegrating parameters. The Gregory and Hansen test involves the testing of four models – level, trend, intercept or shifts in the intercept, and slope. Once the cointegrating relationship is confirmed, long-run and short-run coefficients are estimated with the application of ARDL. The short-run estimation also involves an error correction term, which reflects the speed of convergence of short-run disequilibrium towards the long-run equilibrium.

3.1.4 Diagnostic tests

A number of diagnostic tests such as the Lagrange Multiplier (LM) test for serial correlation, the Ramsey RESET test for model specification, the normality test for heteroscedasticity, and model stability graphical plot tests (e.g. CUSUM and CUSUMS) were conducted.

3.1.5 The VECM Granger causality test

According to Granger (1969), once the variables are integrated of the same order, the vector error correction model (VECM) short-run Granger causality test is appropriate to estimate their causal link. Since all the variables in this study are first difference

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stationary [I(1)], we proceeded further to determine the short-run and long-run causal directions between them. The exact direction of the causal link helps with better policy implications of the findings (Shahbaz et. al., 2013). The potential causality pattern for this study was represented by the following VECM specification in a multivariate framework:

$$\Delta lnY_t = \beta_{0i} + \sum_{i=1}^{p} \beta_{1i} \Delta lnY_{t-i} + \sum_{i=0}^{p} \beta_{2i} \Delta NET_{t-i} + \sum_{i=0}^{p} \beta_{3i} \Delta FD_{t-i} + \mathcal{E}_t \qquad (12)$$

4. Empirical results and analysis

Table 1 reports summary statistics for all the variables in order to determine the nature of the data distribution. The data of all the series are nearly normally distributed, as the values of the standard deviations of these distributions are within a reasonable range, which imply that application of standard estimation techniques is not likely to provide spurious findings. Nevertheless, the data are free from the threat of multicollinearity, as evidenced from the Variance Inflation Factor (VIF) results depicted in Table 2. Figure 1 depicts the logarithmic trend of all the variables for the sample period, which is more or less stable for all the variables.

<Please insert Table 1 here>

<Please insert Figure 1 here>

<Please insert Table 2 here>

The results of the Zivot and Andrews (1992) unit root structural break test are presented in Table 3, and detect a number of break points in 1987, 1991, 1992, and 1996. The results further confirm that all the series are first difference stationary, i.e., I (1) in the presence of single structural breaks in the series. The structural break in 1987 implies that the Kuwait economy slowed down a little bit during the late 1980s, while it was aggravated further with the gulf war in the early 1990s. This is evident from the existence of structural breaks in 1992 and 1996.

<Please insert Table 3 here>

Results from the Gregory-Hansen tests with change in level, in regime, and in both regime and trend are reported in Tables 4A, 4B, and 4C, respectively. All these tests indicate a cointegrating relationship among the variables, as the null hypothesis of no cointegration is rejected in all cases at the 5% level of significance. This indicates the

potential of a long-run relationship among the variables. The findings of the cointegrating association are also expected for an oil-based economy like Kuwait, which is characterized by high electricity consumption. In addition, infrastructure investment, GDP growth and foreign direct investment in Kuwait have been steady during the last decade.

<Please insert Tables 4A, 4B and 4C here>

Table 5 provides long-run coefficients from ARDL estimates. The reported results indicate that there is a highly significant (at the 1% level of significance) long-run relationship between FDI and CO_2 emissions, which supports the pollution haven hypothesis for Kuwait. A 1% increase in FDI causes a .001% rise in CO_2 emissions. Despite the fact that the coefficient is still small, such an effect must not be undermined as Kuwait is likely to require FDI with favorable terms of trade due to the expected shrinkage in the economy in the near future as a consequence of continuously depleting oil resources accompanied by a subsequent decline in oil prices. Economic growth and electricity consumption also have a positive significant association with CO_2 emissions. A 1% increase in economic growth and electricity consumption leads to a 0.66% and 0.71% rise in CO_2 emissions, respectively. The magnitude of these coefficients reveals that despite efforts for increased use of renewable resources in the energy sector, especially in electricity generation, a significant reduction in emissions is still far from reality. The estimation results find no significant long-run relationship between financial development and CO_2 emissions. The key potential reason for such an outcome is that Kuwait has been a financially developed market for a while.

<Please insert Table 5 here>

Table 6 reports the short-term effects of the independent variables on CO_2 emissions. The findings indicate that FDI causes CO_2 emissions to rise in the short run and the coefficient of this effect is stronger. The variables of economic growth and electricity consumption also stimulate CO_2 emissions. Financial development has no significant effect on CO_2 emissions in the short run. The coefficient of the error correction term, ECT_{t-1}, is -0.814 and has the expected sign. It also implies a very speedy convergence (the short-term deviations being corrected at the speed of 81% towards the long-term equilibrium each year).

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<Please insert Table 6 here>

Table 7 displays the results of the diagnostic tests carried out from the ARDL estimates. The LM test confirms no serial correlation, while Ramsey's RESET test suggests that the model (Equation 1) has the correct functional form. The normality test reveals that the disturbance terms are normally distributed and are homoscedastic, as supported by the heteroscedasticity test. The stability of the short- and long-run estimates over time is justified by the graphical plots of CUSUM and CUSUM of Squares (Figures 2A and 2B). It shows that estimated coefficients lie between the upper and lower critical bounds (blue lines in the figure) at the 5% significance level.

<Please insert Table 7 here>

<Please insert Figures 2A and 2B here>

The results from the Dynamic Ordinary Least Squares (DOLS) estimation are reported in Table 8. Although the coefficients vary, the DOLS estimation produces similar results, confirming that our long-run findings are robust across different methods of estimation.

<Please insert Table 8 here>

Table 9 presents the values of the VECM short-run and long-run Granger causality F-test statistics. It is evident from the table that the coefficients of the error correction term (ECT) and FDI are significant in the CO_2 emissions equation, which indicates that long-run and short-run causality run from FDI to CO_2 emissions. It further shows that FDI strongly Granger-causes CO_2 emissions, but there is no reverse causality between them. There is also a strong unidirectional causal linkage running from electricity consumption to CO_2 emissions and from economic growth to CO_2 emissions. A weak causality running from economic growth to financial development is also observed. A bidirectional causal association exists between economic growth and electricity consumption both in the short and long run. The effects of CO_2 emissions, FDI, and electricity consumption on financial development and the effects of CO_2 emissions, electricity consumption, and economic growth on FDI are neutral.

Thus, the short-run and long-run Granger causality results support in favor of the proposition that FDI, electricity consumption, and economic growth strongly cause CO_2

emissions in Kuwait. While electricity consumption causes emissions to rise, Kuwait's economic growth also depends on electricity consumption.

5. Conclusions and policy implications

This study investigated the effects of economic growth, electricity consumption, FDI, and financial development on CO_2 emissions using time series data for Kuwait for the period 1980-2013. Results from the ARDL estimates indicate that the variables FDI, economic growth, financial development, and electricity consumption have a positive and significant relationship with CO_2 emissions for Kuwait, both in the short and long run. However, both the short-run and the long-run relationships between financial development and CO_2 emissions are insignificant. The robustness of the long-run relationship between the variables was checked by the application of the DOLS estimation method, which produced similar results. The VECM Granger causality test reveals that FDI, electricity consumption, and economic growth strongly Granger-cause CO_2 emissions. A unidirectional weak causality running from economic growth to financial development is also observed. There is also a bidirectional causal association between economic growth and electricity consumption.

Based on the findings of this study, it is obvious that in the face of enormously growing energy demand, it would be very challenging for Kuwait to pursue an energy conservation policy. To meet the growing energy demand, electricity is mostly generated from fossil fuel sources, therefore, Kuwait is in dire need of seeking alternative sources of power generation along with other potential measures to reduce CO_2 emissions. As such, it should channel more resources and logistics into minimizing its CO_2 emissions. Kuwait also has the potential to reduce CO_2 emissions through a variety of measures, especially by improving electricity generation efficiency. To achieve this goal, Kuwait needs to continue expanding its existing Carbon Capture, Utilization, and Storage (CCUS) facilities, as such actions have already proved to be an effective method for combatting CO_2 emissions in all GCC countries, including Kuwait itself (Al-Saleh et al., 2012). Two other measures – post-combustion capture (Qadir et al., 2013) and carbon pricing (emissions trading) – may also be cost-effective methods to reduce emissions.

Without a price signal, consumers cannot be expected to rationalize their behavior. From a policy perspective, the government needs to ensure a more conducive regulatory framework for promoting CCUS-based activities and a reform of energy price to reduce the growth in electricity consumption.

In addition, like other GCC countries, Kuwait is very rich in renewable resources such as wind and solar. Kuwait is rated as excellent in terms of its potential for solar energy due to its very high average daily irradiation and ambient temperatures. Use of solar energy to produce electricity is perhaps the ideal renewable source of energy for Kuwait (Ramadhan and Naseeb, 2011). Therefore, the government must invest more to promote the use of solar energy. Wind is another potential renewable energy source that should be considered as a priority alternative for electricity generation.

Kuwait should reduce unexpected wastage of electricity use. Given that it has a highly subsidized electricity program that encourages massive and sprawling consumption of electricity, it is very important that its efforts to rationalize electricity consumption are given priority as this would reduce the social and environmental costs of such a highly subsidized project of the government. Since the success of electricity bill collection is very disappointing in Kuwait, which in turn results in significant wastage of this resource, it is time to rethink whether Kuwait is able to afford this kind of flexibility anymore. Also, due to population growth and rapid urbanization, the transport sector has expanded at phenomenal speed in Kuwait over the last two decades. It is argued that the transport sector is also responsible for a significant proportion of emissions – a possibility that cannot be ruled out for a country like Kuwait. Therefore, due attention must also be given to reducing emissions from this sector. Achieving electricity use efficiency is also important to reduce its consumption. Key measures may include encouraging technological development and innovation, and incentivizing consumers to replace inefficient appliances and build more energy-efficient homes.

Despite the drastic recent fall in global oil prices, the economy of Kuwait is still characterized by relatively large liquid balances. This study strongly recommends that Kuwait undertake aggressive investment in building energy expertise and promoting energy research in order to achieve technological breakthroughs that will potentially enable it to produce more output with fewer emissions. Any technology that is able to

recycle billions of tons of CO_2 emissions into renewable energy is likely to be a catalyst for a country like Kuwait to combat emissions. Therefore, additional investment in research and development on developing low-carbon technologies and renewable sources of energy could be useful in reducing CO_2 emissions without any detrimental effects on Kuwait's economic growth.

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Table 1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
LCO2C	33	3.104	0.412	1.628	3.542
LGDPC	33	10.088	0.426	9.193	10.492
LFD	33	3.997	0.458	2.842	4.570
LFDI	33	-2.639	3.229	-10.120	6.958
LEU	33	9.039	0.396	7.204	9.349

Table 2: Variance Inflation Factors

	Coefficient	Centered
Variable	Variance	VIF
LEU	0.010321	1.320708
LFD	0.009861	1.632587
LFDI	0.000139	1.144816
LGDPC	0.008999	1.331181
C	1.747027	NA

Table 3: Zivot–Andrews structural break unit root test

Variable	Z&A test for level			Z&A test for 1st difference		
	T-Statistic	TB	Outcome	T-Statistic	TB	Outcome
LGDPC	-3.192	1994	Unit Root	-5.607***	1991	Stationary
LFD	-3.299	1993	Unit Root	-4.869***	1992	Stationary
LFDI	-3.970	1987	Unit Root	-5.448***	1987	Stationary
LCO_2	-4.421**	1992	Stationary	-9.172***	1996	Stationary
LEU	-4.026	1992	Unit Root	-5.993***	1996	Stationary

Note: ** and *** denote 5% and 1% levels of significance, respectively.

Table 4A: Gregory-Hansen Test for Cointegration with Regime Shifts (Model: Change in Level)

Test Statistic	Statistic	Breakpoint	Date	Asymptotic Critical Values		
				1%	5%	10%
ADF	-5.37	21	2000	-6.05	-5.56	-5.31
Zt	-4.99	15	1994	-6.05	-5.56	-5.31
Za	-28.86	15	1994	-70.18	-59.40	-54.38

Table 4B: Gregory-Hansen Test for Cointegration with Regime Shifts (Model: Change in Regime)

Test Statistic	Statistic	Breakpoint	Date	Asymptotic Critical Values		
				1%	5%	10%
ADF	-5.62	16	1995	-6.92	-6.41	-6.17
Zt	-5.71	16	1995	-6.92	-6.41	-6.17
Za	-33.25	16	1995	-90.35	-78.52	-75.56

Table 4C: Gregory-Hansen Test for Cointegration with Regime Shifts (Model: Change in Regime and Trend)

Test Statistic	Statistic	Breakpoint	Date	Asymptotic Critical Values		
				1%	5%	10%
ADF	-5.96	15	1994	-7.31	-6.84	-6.58
Zt	-6.00	14	1993	-7.31	-6.84	-6.58
Za	-34.86	14	1993	-100.69	-88.47	-82.30

Table 5: Estimated long-run coefficients using the ARDL (1,1,1,1,0) selected based on AIC

Regressor	Coefficient	Standard Error		T-Ratio [Prob]	
LGDPC	0.431	0.092		4.650 [.000]	
LFD	0.013	0.115		0.120 [.905]	
LFDI	0.001	0.012		0.127 [.010]	
LEU	0.875	0.153		5.695 [.000]	
C	-9.222	1.207		-7.636 [.000]	
		95 %		90 %	
		LB	UB	LB	UB
F Statistic	6.998	3.285	4.689	2.731	3.9919

Table 6: Error correction representation for the selected ARDL (1,1,1,1,0) selected based on AIC

Regressor	Coefficient	Standard Error	T-Ratio [Prob]
dLGDPC	0.666	0.122	5.448 [.000]
dLFD	0.195	0.131	1.489 [.148]
dLFDI	0.017	0.008	2.111 [.044]
dLEU	0.713	0.085	8.330 [.000]
ecm(-1)	-0.814	0.095	-8.537 [.000]

Table 7: Diagnostic tests

Test	Statistic	Test	Statistic
R Square	0.93	Adjusted R Square	0.90
Serial Correlation	1.070 [0.301]	Normality	1.735 [0.420]
Functional Form	0.246 [0.619]	Heteroscedasticity	0.037 [.846]

Table 8: Results from DOLS estimation

| Variables :	LCO2C
LGDPC	0.167***
	(0.0606)
LFD	-0.469***
	(0.0987)
LFDI	0.0214**
	(0.0102)
LEU	1.310***
	(0.135)
Constant	-8.482***
	(0.840)
Observations	30
R-squared	0.969

Notes: *, **, and *** denote 10%, 5%, and 1% levels of significance, respectively. Corresponding p values are in parentheses.

Table 9: VECM short-run and long-run Granger causality results

Dependent variable	Short run					Long-run ECT(-1)
	ΔLCO2	ΔLFD	ΔLFDI	ΔLEU	ΔLGDPC	
ΔLCO2	---------	4.037(.253)	0.001(0.051)**	1.244(0.023)*	0.397(0.013)**	-2.12147**
ΔLFD	0.324(0.573)	----------	0.001(0.974)	16.37(0.897)	3.229(0.048)**	-5.44048
ΔLFDI	1.976(0.020)	0.806(0.036)*	----------	0.127(0.723)	0.002(0.147)	-4.71230
ΔLEU	0.001(0.973)	1.336(0.257)	0.204(0.654)	----------	0.322(0.004)*	-5.02545**
ΔLGDPC	0.994(0.2627)	0.072(0.789)	0.018(0.892)	0.779(0.384)**	----------	-5.88687**

Notes: *, **, and *** denote 10%, 5%, and 1% levels of significance, respectively. Corresponding p values are in parentheses.

Figure 1: Logarithmic trends in GDP per capita, CO_2 emissions, electricity consumption, and financial development in Kuwait for the period 1980-2012
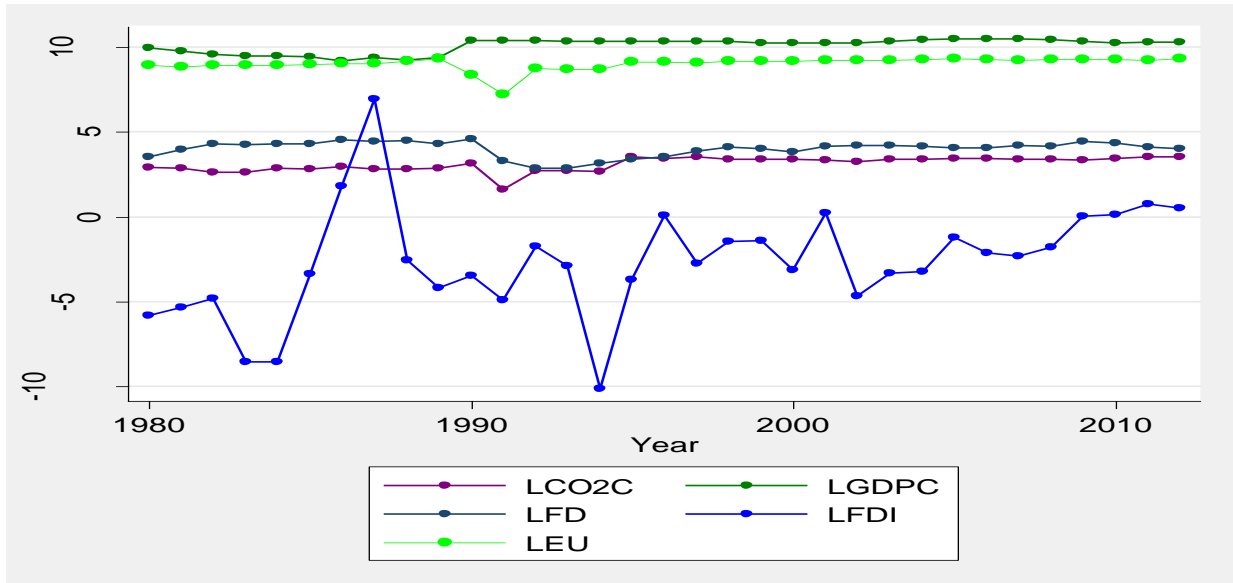
Source: World Bank Development Indicators database, The World Bank

Figure 2A: Plot of the Cumulative Sum of Recursive Residuals

Plot of Cumulative Sum of Recursive Residuals

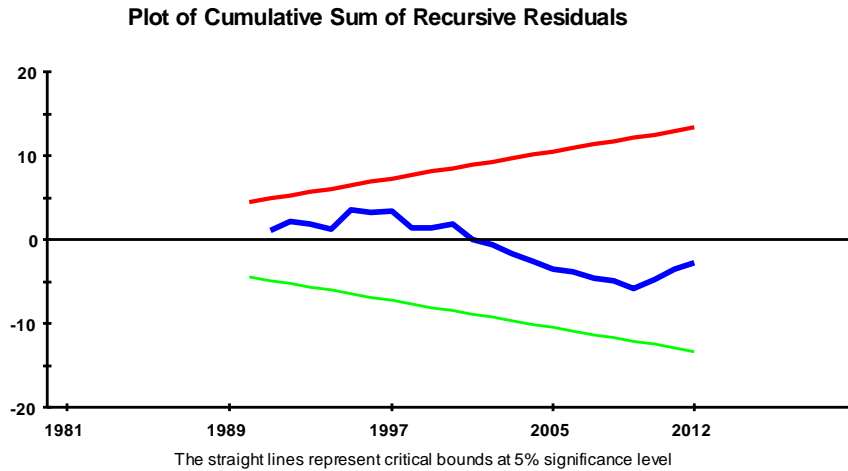The straight lines represent critical bounds at 5% significance level

Figure 2B: Plot of the Cumulative Sum of Squares of Recursive Residuals

Plot of Cumulative Sum of Squares of Recursive Residuals

The straight lines represent critical bounds at 5% significance level