International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2018, 8(6), 392-400.

Greenhouse Gas Emissions, Energy Consumption and Economic Growth: Empirical Evidence from Gulf Cooperation Council Countries

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Received: 18 August 2018 **Accepted:** 22 October 2018 **DOI:** https://doi.org/10.32479/ijeep.7269

ABSTRACT

This paper examines the relationship between greenhouse gas (GHG) emissions, energy consumption and economic growth with panel data of the six gulf cooperation council (GCC) countries - Saudi Arabia, Kuwait, United Arab Emirates, Qatar, Bahrain, and Oman over the period 1996–2017. This study empirical results show that exists of bidirectional causal relationship between energy consumption and economic growth. However, the results support the occurrence of unidirectional causality from energy consumption to GHG emissions without any feedback effects, and there exists bidirectional causal relationship between economic growth and GHG emissions for the region as a whole. The study suggests that environmental and energy policies should recognize the differences in the relationship between energy consumption and economic growth in order to maintain sustainable economic growth in GCC region.

Keywords: Environmental Kuznets Curve, Environmental Degradation, Energy Consumption, Economic Growth
JEL Classifications: N50, Q00, O13, O47

1. INTRODUCTION

The relationship between greenhouse gas (GHG) emissions, energy consumption and economic growth has been the subject of considerable academic research over the past few decades. According to the Environmental Kuznets curve (EKC) hypothesis, as output increases, GHG emissions increase as well until some threshold level of output was reached after which these emissions begin to decline. The main reason for studying GHG emissions is that they play a vital role in the current debate on the environment protection and sustainable development. Economic growth is also closely linked to energy consumption since higher level of energy consumption leads to higher economic growth. However, it is also likely that more efficient use of energy resources requires a higher level of economic growth.

In literature, the relationship between environment–energy–growth has attracted attention of researchers in different countries for a long time. Roughly, we can categorize past studies in this field into three strands. The first focuses on the validity of the EKC hypothesis. EKC is based on the theory asserted by Kuznets (1955) that an inverted U-shaped relationship exists between economic growth and income inequality. According to this theory, the wealth and capital accumulations of those who experience the first income growth due to industrialization, which is one of the first stages of economic growth, and industrial activities, will rise, thereby resulting in income inequality. Grossman and Krueger (1991; 1995), Shafik and Bandyopadhyay (1992), Panayotou (1993), Selden and Song (1994), Ang (2007) and Saboori et al. (2012) carried out such kind of relationship that environmental pollution levels increase as a country growth and industrialization are achieved, but begin to decrease as rising incomes pass beyond a turning point. Dinda (2004) offer extensive review surveys of these studies. Friedl and Getzner (2003) and Managi and Jena (2008) also study the same relationship. However, a higher level of national income does not necessarily warrant greater efforts to contain the GHG emissions. Jaunky (2010) investigated the Environment Kuznet's Curve (EKC) hypothesis for 36 high-income economies (including Bahrain, Oman and UAE) over the period 1980–2005. Unidirectional causality running from gross domestic product (GDP) per capita to GHG emissions per capita has been identified in both the short-and long-run. On the other hand, Richmond and Kaufman (2006) concluded that there is no significant relationship between economic growth and GHG emissions.

The second strand of researches focuses on the nexus between energy consumption and economic growth. This nexus suggests that higher economic growth requires more energy consumption and more efficient energy use needs a higher level of economic growth. Since the pioneer work of Kraft and Kraft (1978), Granger causality test approach has become a popular tool for studying the relationship between economic growth and energy consumption in different countries, e.g., Stern (1993), Belloumi (2009), Pao (2009) and Ghosh (2010). However, Belloumi (2009) has used a vector error-correction model (VECM) and showed that, in Tunisia, there is a causal relationship between energy consumption and income over the period of 1971–2004. Similarly, Altinay and Karagol (2004) investigated the causal relationship between electricity consumption and real GDP in Turkey over the period of 1950–2000. They showed that both used tests have yielded a strong evidence for unidirectional causality running from the electricity consumption to income. This implies that the supply of electricity is vitally important to meet the growing electricity consumption, and hence to sustain economic growth in Turkey.

Finally, most previous studies have shown that economic growth would likely lead to changes in CO_2 emissions. It has also found that energy consumption is often a key determinant of CO_2 emissions. It is therefore worthwhile to examine the nexus between economic growth, energy and CO_2 emissions by considering them simultaneously in a modeling framework. In this strand, Ang (2007) and Soytas et al. (2007) initiated this combined strand of research. Recent works include Halicioglu (2009) and Zhang and Cheng (2009) for a single country study. Halicioglu (2009) and Zhang and Cheng (2009) extended the above mentioned multivariate framework further by including the impacts of foreign trade and urban population, respectively into the nexus, in order to address omitted variable bias in econometric estimation. Also, based on panel error-correction model, Arouri et al. (2012) have tested the relationship between CO_2 emissions, energy consumption, and real GDP for 12 Middle East and North African Countries (MENA) over the period 1981–2005. They showed that the real GDP exhibits a quadratic relationship with CO_2 emissions for the region as a whole. The econometric relationships derived in this study suggest that future reductions in carbon dioxide emissions per capita might be achieved at the same time as GDP per capita in the MENA region continues to grow.

This paper used simultaneous equations based on structural modelling to study of the relationship between energy consumption, GHG emissions and economic growth in the gulf cooperation council (GCC) region. GCC region has the largest energy reserves in the world. Yet while the region is trying to industrialize and modernize its economies, they are facing the challenges of the GHG emission and energy consumption is the most significant source of pollution.

The paper examines the interrelationship between GHG emission, energy consumption and economic growth over the period 1996–2017 in case of six GCC countries by using generalized method of moments (GMM) technique. Study uses three structural equation models, which allows one to simultaneously examine the impact of GHG emissions and energy consumption on economic growth, GHG emissions and economic growth on energy consumption and economic growth and energy consumption on GHG emissions.

The rest of the paper is structured as follows. Section II, gives a brief review the theoretical background and empirical studies. Section III discusses the modeling framework and estimation results. Final section concludes the study and discusses the policy implications.

2. THEORY AND EVIDENCE

Since the early 1990s, a considerable number of empirical studies empirically examining the EKC hypothesis for many countries using a variety of indicators of environmental degradation (carbon dioxide emissions, sulphur dioxide emissions, exhaust emission, wastewater discharge, municipal waste and deforestation, etc.) and economic development indicators, and more particularly the EKC hypothesis, using the tools of econometric analysis a (linear, non-linear, pure-parametric, semi-parametric, non-parametric, and cubic). Typically, the empirical models analysing EKC assert an indicator of environmental degradation as a dependent variable vis-à-vis indicators of economic development.

Many past studies on the linkages between GHG emissions, energy consumption, and economic growth. Most of the studies dealing with the relationship between GHG emissions, energy consumption, and economic growth seem considerably but fewer than those dealing with causality between energy consumption and economic growth. Lean and Smyth's (2010) VECM analysis for five Association of Southeast Asian Nations (ASEAN) countries over the period 1980–2006 is a typical example of such an approach.

Holtz-Eakin and Selden (1995) examine the relationship between economic development and carbon dioxide emissions, a GHG central to global warming predictions by EKC hypothesis approach in 130 countries between 1951 and 1986. The results showed that diminishing marginal propensity to emit carbon dioxide as GDP per capita rises. Finally, their sensitivity analyses suggest that the overall pace of economic development does not dramatically alter the future annual or cumulative flow of CO_2 emissions.

Richmond and Kaufman (2006) examine the relationship between income and energy use and/or carbon emissions in 36 countries between 1973 and 1997. The results indicate that fuel mix, the specification for income, and the level of economic development affect conclusions about whether there is a turning point in the relationship between economic activity and energy use and carbon emissions. The results also indicate that forecasters and policy makers should not depend on a turning point in the relationship between income and energy use or carbon emissions to reduce either.

Saboori et al. (2012) examine the relationship between long-run as well as causal relationship between economic growth and carbon dioxide (CO_2) emissions for Malaysia by EKC hypothesis approach for the years 1980 and 2009. The results showed that the existence of a long-run relationship between per capita CO_2 emissions and real per capita GDP. Study found an inverted-U shape relationship between CO_2 emissions and GDP in both short and long-run, thus supporting the EKC hypothesis. The results also showed an absence of causality between CO_2 emissions and economic growth in the short-run while representing uni-directional causality from economic growth to CO_2 emissions in the long-run.

Stern (1993) examines the relationship between GDP and energy use for the period 1947-90 in the USA by using multivariate adaptation of the test-vector autoregression (VAR) model. A VAR of GDP, energy use, capital stock and employment is estimated and Granger tests for causal relationships between the variables are carried out. The results showed there is no evidence that gross energy use Granger causes GDP, a measure of final energy use adjusted for changing fuel composition does Granger cause GDP.

Yuan et al. (2007) examines the relationship between the existence and direction of causality between output growth and energy use for the period 1963–2005 in China at both aggregated total energy and disaggregated levels as coal, oil and electricity consumption. Using the Johansen cointegration technique, the result indicated that there exists long-run cointegration among output, labor, capital and energy use in China. Then using a VEC specification, the short-run dynamics indicated that there exists Granger causality running from electricity and oil consumption to GDP, but does not exist Granger causality running from coal and total energy consumption to GDP.

Belloumi (2009) examines the relationship between per capita energy consumption and per capita GDP for the period 1971–2004 in Tunisia by using vector error correction model (VECM). The results showed that per capita energy consumption and per capita GDP are related by one cointegrating vector and that there is a long-run bi-directional causal relationship and a short-run unidirectional causality from energy to GDP.

Ghosh (2010) examines the relationship between CO_2 emissions and economic growth for the period 1971-2006 in India by using ARDL bounds testing approach complemented by Johansen-Juselius maximum likelihood procedure in a multivariate framework. The result showed miscellaneous results such as study fails to establish long-run equilibrium relationship and long term causality between CO_2 emissions and economic growth; however, there exists a bi-directional short-run causality between the two. Results also suggest unidirectional short-run causality running from economic growth to energy supply and energy supply to carbon emissions.

Ang (2007) examines the the dynamic causal relationships between pollutant emissions, energy consumption, and output for the period 1960-2000 in France using cointegration and VECM techniques. The results provided an evidence for the existence of robust long-run relationship between the taken variables. The results also supported the argument that economic growth exerts a causal influence on growth of energy use and growth of pollution in the long run and unidirectional causality running from growth of energy use to output growth in the short run.

Apergis and Payne (2009) extended the work of Ang (2007) by examined the causal relationship between carbon dioxide emissions, energy consumption, and output within a panel vector error correction model for six Central American countries over the period 1971–2004 by using EKC hypothesis, panel VECM techniques. This study result found that in long-run equilibrium energy consumption has a positive and statistically significant impact on emissions while real output exhibits the inverted U-shape pattern associated with the EKC hypothesis and the short-run dynamics indicated unidirectional causality from energy consumption and real output, respectively, to emissions along with bidirectional causality between energy consumption and real output and bidirectional causality between energy consumption and emissions in the long-run.

Soytas et al. (2007) investigated the effect of energy consumption and output on carbon emissions for the period 1960–2004 in the United States by using EKC hypothesis, Granger causality test. The results showed that income does not Granger cause CO_2 emissions in the US in the long run, but energy use does.

Halicioglu (2009) examined the dynamic causal relationships between carbon emissions, energy consumption, income, and foreign trade in the case of Turkey using the time-series data for the period 1960–2005. The results indicated that there exist two forms of long-run relationships between the variables, first carbon emissions are determined by energy consumption, income and foreign trade and secondly long-run relationship so income is determined by carbon emissions, energy consumption and foreign trade.

Soytas and Sari (2009) also investigated the long run Granger causality relationship between economic growth, carbon dioxide emissions and energy consumption for the period 1960–2005 in Turkey by using auto regressive distributed lag (ARDL), vector error correct model (VECM) and Johansen–Juselius techniques. The result showed that carbon emissions seem to Granger cause energy consumption, but the bidirectional is not possible. The weak long run causal link between income and emissions may be implying that to reduce carbon emissions, Turkey does not have to forgo economic growth.

Zhang and Cheng (2009) investigated the existence and direction of Granger causality between economic growth, energy consumption, and carbon emissions for the period 1960–2007 in China by using multivariate model of economic growth, energy use, carbon emissions, capital and urban population. Results found that unidirectional Granger causality running from GDP to energy consumption, and a unidirectional Granger causality running from energy consumption to carbon emissions in the long run.

Chang (2010) investigated the case of China based on the aggregate data for the period 1981–2006 to re-examine the relationships between CO_2 emissions, energy and real economic output in China by considering the differences of various regions in economic development and energy consumption. The purpose of this study is to use China's provincial panel data to conduct such an empirical analysis using the model proposed by Ang (2007) and the novel econometric approach given by Apergis and Payne (2009).

Lean and Smyth (2010) analysed the relationship in between CO_2 emissions, Energy consumption and GDP nexus over the period 1980–2006 for five ASEAN countries by using VECM. Based on quadratic specification, they concluded, among other, that there is a statistically significant non-linear relationship between emissions and economic growth in support of EKC.

Ozturk and Acaravci (2010) examined relationship between economic growth, CO_2 emissions, energy consumption and employment ratio over the period 1968–2005 for Turkey by using autoregressive distributed lag (ARDL) bounds testing approach of cointegration. Results suggested a long-run relationship between the variables. Results also found that neither carbon emissions per capita nor energy consumption per capita cause real GDP per capita, but employment ratio causes real GDP per capita in the short run. The overall results indicates that energy conservation policies, such as rationing energy consumption and controlling carbon dioxide emissions, are likely to have no adverse effect on the real output growth.

Arouri et al. (2012) extended the findings of Liu and Muse (2005), Ang (2007) and Apergis and Payne (2009) to investigated the relationship between carbon dioxide emissions, energy consumption, and real GDP over the period 1981–2005 for 12 MENA Countries by using panel unit root tests and cointegration techniques. Results showed that in the long-run energy consumption has a positive significant impact on CO_2 emissions and real GDP exhibits a quadratic relationship with CO_2 emissions for the region as a whole. However, although the estimated long-run coefficients of income satisfy the EKC hypothesis in most studied countries. Kapusuzo˘glu (2014) uses variance decomposition within cointegration analysis to provide similar evidence on the causality from CO_2 emissions to GDP in developing economies, but not in OECD and European countries.

Heidari et al. (2015) investigated the relationship between economic growth, carbon dioxide (CO_2) emissions, and energy consumption with an aim to test the validity of the EKC hypothesis in five ASEAN countries by applying the panel smooth transition regression (PSTR) model as a new econometric technique. The results showed that energy consumption lead to increase CO_2 and supported the validity of the EKC hypothesis in the ASEAN countries.

Li and Yang (2016) examined the dynamic impact of non-fossil energy consumption on carbon dioxide (CO_2) emissions for the period 1965 and 2014 in China by using an autoregressive distributed lag model (ARDL). The results suggested that consumption of non-fossil energy plays a crucial role in curbing CO_2 emissions in the long run but not in the short term. The results also suggested that, in both the long and short term, energy consumption and trade openness have a negative impact on the reduction of CO_2 emissions, while GDP per capita increases CO_2 emissions only in the short term. Finally, the Granger causality test indicates bidirectional causality between CO_2 emissions and energy consumption.

GHG emission, energy consumption and economic growth are thus clearly related, and this relationship has occupied the minds of economists although the channels and even the direction of causality have remained unresolved in both theory and empirics.

3. MODEL AND RESULTS

The purpose of this paper is to examine the interrelationship between GHG emission, energy consumption and economic growth for six GCC countries using annual data over the period 1996–2017. We consider these variables are endogenous variables. Most existing literature showed that economic growth would likely lead to change in GHG emission and energy consumption is a key indicator for GHG emission. So it is worth investigating interrelationship between these three variables simultaneously in a modelling framework.

Following the standard growth theories we employ the Cobb–Douglas production function to investigate the three-way linkages between GHG emissions, energy consumption and economic growth including capital and labor as proxy variable of production. Menyah and Wolde-Rufael (2010), and Shahbaz and Lean (2012), among others, include the energy and GHG emissions variables in their empirical model to examine the impact of these two variables on economic growth. The general form of the Cobb-Douglas production function after the logarithmic transformation is as follows:

$$\ln(Yt)+\beta_0+\beta_1\ln(EC_t)+\beta_2\ln(GHG_t)+\beta_3\ln(K_t)+\beta_4(L_t)+\varepsilon_t \quad (1)$$

Where ε_t is the error term. Variable Y is real GDP per capita; E, C, K and L denote per capita energy consumption (EC), per capita GHG emission, the real capital and labor respectively. We have converted all the series into logarithms to linearize the form of the nonlinear Cobb–Douglas production. It should be noted that simple linear specification does not seem to provide consistent results. Therefore, to cover this problem, we use the log-linear specification to investigate the inter relationship between GHG emissions, energy consumption and economic growth in six GCC countries. The three-way linkages between these variables are empirically examined by making use of the following three simultaneous equations:

$$\ln(Yt)+\beta_0+\beta_1\ln(EC_t)+\beta_2\ln(GHG_t)+\beta_3(K_t)+\beta_4(L_t)+\varepsilon_t \quad (2)$$

$$\ln(EC_t)+\beta_0+\beta_1\ln(Y_t)+\beta_2\ln(GHG_t)+\beta_3\ln(FD_t)+\beta_4(POP_t)+\varepsilon_t \quad (3)$$

$$\ln(GHG_t)+\beta_0+\beta_1\ln(Y_t)+\beta_2\ln(EC_t)+\beta_3\ln(URBAN_t)+\beta_4(OPEN_t)+\varepsilon_t \quad (4)$$

Equation 2 examines the energy consumption, GHG emission on economic growth including labor and capital as the proxy variables. An increase in energy consumption leads to an increase in GDP per capita as also mentioned in study by (Sharma, 2010) that energy as input in the production process has directly proportionate to the county GDP. Moreover, the level of GHG emissions can influence GDP per capita (Apergis and Payne, 2009; Saboori et al., 2012). This implies that environmental degradation has a causal impact on economic growth, and a persistent decline in environmental quality may exert a negative externality to the economy.

Equation 3 examines the determinants of energy consumption per capita (EC). Economic growth, which is proxyed by GDP per capita, is likely to have a positive impact on energy consumption, i.e., an increase in the GDP per capita leads to an increase in energy consumption per capita (Lotfalipour et al., 2010; Zhang and Cheng, 2009). Past studies on EKC shows that the level of GHG emissions usually increases with energy consumption (Apergis and Payne, 2009; Halicioglu, 2009; Lean and Smyth, 2010). Financial development (FD), which is measured by total credit as a fraction of GDP, is likely to have a positive impact on energy consumption (Islam et al., 2013). POP indicates the total population. Islam et al. (2013) emphasized the importance of population in determining the level of GHG emissions.

Equation 4 examines the determinants of GHG emissions per capita. Energy consumption, which is measured by kg of oil equivalent per capita, is likely to have an increase in GHG emissions (Wang et al., 2011). Moreover, under the EKC hypothesis an increase in income is associated with an increase in GHG emissions. The URBAN indicates urbanization (% urban population of the total) (Hossain, 2011) has emphasized the importance of urbanization in determining the level of carbon dioxide emissions. OPEN indicates trade openness (% net expot of the GDP). On the other hand, Andersson et al. (2009) has insisted on the importance of foreign trade in determining the level of GHG emissions.

The generalized method of moments is the estimation method most commonly used in models with panel data and in the multiple-way linkages between certain variables. This method uses a set of instrumental variables to solve the endogeneity problem. It is well-known that the GMM method provides consistent and efficient estimates in the presence of arbitrary heteroskedasticity. Moreover, most of the diagnostic tests discussed in this study can be cast in a GMM framework. Hansen's test was used to test the over identifying restrictions in order to provide some evidence of the instruments' validity. The instruments' validity is tested using Hansen test which cannot reject the null hypothesis of over identifying restrictions. That is, the null hypothesis that the instruments are appropriate cannot be rejected. The Durbin-Wu-Hausman test was used to test the endogeneity. The null hypothesis was rejected, suggesting that the ordinary least squares estimates might be biased and inconsistent and hence the OLS was not an appropriate estimation technique.

This paper uses annual time series data for the period 1996–2017 which include the real GDP per capita (constant 2000 US$), energy consumption (kg of oil equivalent per capita), CO_2 emission as the proxy for GHG emissions (metric tons per capita), trade openness (% of net exports of GDP), FD (total credit to private sector as a ratio of GDP), urbanization (% urban population of the total population), total population (in thousands), capital stock (constant 2000 US$), and total labour force (% of total population) for six GCC countries, namely Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE which are considered for this panel analysis. The data are obtained from the World Bank's World Development Indicators. The selection of the starting period was constrained by the availability of data.

The detailed statistics, the standard deviation, the mean value, and the coefficient of variation of different variables for individuals and also for the panel are given below in Table 1. This table provides a statistical summary associated with the actual values of the used variables for each country.

Overall, for the GCC countries, Saudi Arab has the greatest means and volatilities of per capita emissions, energy consumption and GDP, while Oman has the lowest means and variances for per capita CO_2 emissions and energy consumption. Based on average trade, which is measured as a percentage of export and import values of total GDP, relatively low income countries are more open to trade compared to the high income countries. Based on urbanization, which is measured as the percentage of urban population to total population, relatively high income countries are more urbanized than low income countries.

The above simultaneous equations are estimated by making use of two-stage least squares (2SLS), 3SLS and the GMM. What follows, we only report the results of GMM estimation. While the parameter estimates remained similar in magnitude and sign, the GMM estimation results are generally found to be statistically more robust.

While estimating the three-way linkages between GHG emissions-energy consumption economic growth, FD, population (POP), urbanization (URBAN), trade openness (OPEN), capital (K) and labor force (L) are used as influential variables. For testing endogeneity, the study used the Durbin-Wu-Hausman. In addition, the Pagan-Hall test was used to test for the presence of significant heteroskedasticity. The null hypothesis of homoscedasticity was rejected suggesting that the GMM technique is consistent and efficient. Then, the validity of the instruments is tested using Hansen test. In the same order, we performed the augmented Dickey and Fuller (1979) and Phillips and Perron (1988) unit-root tests on the used variables. We find that all the series are stationary in level.

Based on the tests, the estimated coefficients of Equations (2), (3) and (4) are given in Tables 2-4 respectively. The empirical results about Equation (2) are presented in Table 2, which shows that energy consumption has a significant positive impact on GDP per capita for Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. This indicates that an increase in energy consumption tends to promote economic growth (Shahbaz et al., 2012; Shahbaz et al., 2013; Wong et al., 2013). Since energy is an important ingredient for economic growth, strong energy policies

Table 1: Descriptive Statistics

Detailed statistics	Saudi Arabia		Bahrain		Kuwait		Qatar		UAE		Oman	
	Means±SD	CV	Means±SD	CV	Means±SD	CV	Means±SD	CV	Means±SD	CV	Means±SD	CV
CO2 (metric tons per capita)	16.12±2.45	15.6	27.78±3.89	13.87	29.15±2.95	10.95	54.95±10.2	17.25	28.24±6.33	19.81	10.36±5.1	36.52
EC (kg of oil equivalent per capita)	6258.52±852.6	15.8	9122.36±787.69	8.96	9525.32±2598.14	29.88	17085.2±3088.02	18.61	12985.7±1465.84	16.28	4144.25±1589.63	40.88
GDP (constant 2000 $)	9628.85±301.89	2.14	13852.6±1635.3	12.58	2163.87±2228.04	10.1	29357.3±4685.36	17.86	31859.8±5110.02	16.28	8999.95±1610.26	17.58
K (constant 2000 $)	13121.2±4125.98	29.25	2152.98±3089.23	15.85	29995.6±6587.52	23.58	45886.3±6056.28	15.55	40991.8±8658.18	20.84	12586.7±3925.66	31.85
L (%)	60.25±4.25	5.87	68.65±3.85	29.56	69.22±3.82	39.84	75.58±2.66	3.84	79.84±2.85	3.42	60.52±9.36	26.3
FD (%)	30.85±11.69	36.45	58.1±17.69	32.01	52.65±20.62	36.84	30.27±6.85	20.54	42.65±18.91	55.56	35.65±9.96	26.69
POP (thousand)	20785.6±3258.96	14.25	800.1±298.54	37.25	2228.92±420.62	19.66	865.69±454.35	58.2	4025.22±1985.06	53.99	2298.36±256.96	11.27
URBAN (%)	80.25±2.01	3.57	92.26±0.18	0.2	98.58±0.096	0.099	96.25±1.75	1.28	85.51±2.95	3.15	72.58±1.952	2.9
OPEN (%)	73.47±13.98	16.46	165.85±19.74	13.83	95.52±13.65	14.03	80.36±9.61	10.85	109.51±30.88	32.54	87.08±7.64	8.08

SD: Indicates standard deviation, CV: Indicates coefficient of variation, CO2: Indicates per capita carbon dioxide emissions, EC: Indicates per capita energy consumption, GDP: Indicates per capita real GDP, K indicates real capital per capita, L indicates labor force, FD indicates level of financial development , POP indicates total population, OPEN: Indicates trade openness, URBAN: Indicates urbanization. SD: Standard deviation

are required to attain sustained economic growth. This result is consistent with the findings of Apergis and Payne (2010).

Regarding the pollutant variable, results are consistent with the findings of Shahbaz et al. (2012) that GHG emissions have a significant negative impact on GDP per capita for all GCC countries. The coefficient of capital is positive and significant for 3 countries out of 6. Only for Bahrain, Oman and Qatar have positively affects GDP per capita. But for Saudi Arabia, Kuwait and UAE have no significant relationship is found. The sign of labor is negative for all the countries The panel results of the regression equation with GDP per capita as dependent variable show that the coefficient of K is positive and significant and the coefficient of L is negative and statistically significant.

The negative impact of labor force on GDP per capita may be due to brain-drain, uneducated, unskilled and low productivity of labor force. Moreover, the results show that labor tends to decrease GDP per capita more than CO_2 emissions. This may be due to the fact that in developing countries, labor tends to be abundant and relatively cheaper.

The empirical results about Equation (3) are presented in Table 3. It appears that GDP per capita has a significant positive impact on energy consumption per capita for Bahrain, Oman, Saudi Arabia and the United Arab Emirates. However, for and it has a significant negative impact for Kuwait and Qatar. This indicates an increase in GDP per capita tends to decrease energy consumption per capita in Kuwait and Qatar. From these elasticities, it can also be inferred that due to increase in GDP per capita, energy consumption goes down more in Kuwait than in Qatar. For the panel estimation, it has a significant positive impact on GDP per capita (Ang, 2008); (Shahbaz et al., 2012); (Islam et al., 2013), (Altinay and Karagol, 2004).

Regarding the pollutant variable, we find that CO_2 emissions have a positive impact on energy consumption per capita for all the countries. It has a positive significant impact for Kuwait, Qatar, Saudi Arabia and the United Arab Emirates. Our results are in line with the findings of Menyah and Wolde-Rufael (2010) for the United States and Wang et al. (2011) for china. The coefficient of capital variable has a positive significant impact on energy consumption for Bahrain, Qatar and the United Arab Emirates. It has a significant negative impact only for Saudi, while for the remaining countries, no significant relationship is found. This indicates an increase in real capital decrease energy consumption per capita in Saudi Arabia. The labor force variable has a significant positive impact on energy consumption only in the case of the United Arab Emirates. It has a significant negative impact only for Kuwait. For the panel estimation, it has a significant positive impact of real capital on the energy consumption per capita (Sari et al., 2008) and (Lorde et al. 2010)

The variable of FD has a positive impact on energy consumption per capita for all countries. It has a significant impact only for Kuwait, and the United Arab Emirates. This implies that an increase in the domestic credit to the private sector increase the energy consumption per capita. For the panel estimation, FD has a significant positive impact on energy consumption per capita

Table 2: Results of panel GMM estimation for equation (2)

	Dependent variable: Economic growth (GDP)						
	Saudi Arabia	Bahrain	Kuwait	Qatar	UAE	Oman	Panel
Coefficient	7.85*	−3.51*	13.01*	−3.90*	3.40*	7.6	4.20*
EC	0.38*	0.83*	0.35**	0.55*	0.78*	0.30*	0.31**
GHG	−0.24**	−0.08***	−0.85*	−0.25*	−226**	−0.28*	−0.30**
K	0.19	0.41*	0.05	0.41*	−0.09	0.31***	0.28***
L	−0.1	−0.46*	−0.19	−0.34*	−0.36**	−0.69*	−0.41*
Hansen test (P-value)	0.19						
Durbin-Wu-Hausman test (P-value)	0.04						
Pagan-hall test (P-value)	0.01						

Author's estimation: All variables in natural logs. *Indicates significant at 1% level, **indicates significant at 5% level, ***indicates significant at 10% level. GMM: Generalized method of moments

Table 3: Results of panel GMM estimation for equation (3)

	Dependent variable: Energy consumption (EC)						
	Saudi Arabia	Bahrain	Kuwait	Qatar	UAE	Oman	Panel
Coefficient	4.70*	3.57*	−11.47*	−14.19*	−7. 45*	−8.37*	5.21*
GDP	0.52*	0.41*	−0.64*	−0.36*	0.40*	0.423**	0.40*
GHG	0.39**	0.05	0.28***	0.29**	0.75*	0.20	0.15
K	−0.19***	0.23***	0.06	0.18***	0.04	0.13	0.19***
L	−0.08	0.16	−0.19***	−0.13	0.43***	−0.06	0.04
FD	0.04	0.01	0.35**	0.18***	0.42*	0.18	0.23**
POP	0.20***	0.08	0.27**	0.13	−0.11	0.12	0.02
Hansen test (P-value)	0.10						
Durbin-Wu-Hausman test (P-value)	0.02						
Pagan-Hall test (P-value)	0.01						

Author's estimation: All variables in natural logs. *Indicates significant at 1% level, **Indicates significant at 5% level, ***Indicates significant at 10% level

(Sadorsky, 2010; 2011), (Shahbaz and Lean, 2012), (Islam et al., 2013), (Shahbaz et al. 2013), and (Wong et al., 2013).

The variable of population has a positive impact on energy consumption for all countries except for the United Arab Emirates. It has a significant positive impact for Kuwait and Saudi Arabia. This indicates that an increase in the population raises energy consumption. This is consistent with the findings of Batliwala and Reddy (1993) and Islam et al. (2013). For the panel estimation, it has an insignificant positive impact of population on energy consumption.

The empirical results pertaining to Equation (4) are presented in Table 4. They show that GDP per capita has a significant positive impact on CO_2 emissions per capita for Bahrain, Kuwait, Oman, Qatar and Saudi Arabia. It has a significant negative impact for the United Arab Emirates. This indicates that an increase in GDP per capita decrease the carbon emissions per capita in the United Arab Emirates. For the panel estimation, the GDP per capita has a significant positive impact on CO_2 emissions per capita. (Halicioglu, 2009); (Fodha and Zaghdoud 2010); (Wang et al. 2011); (Jayanthakumaran et al., 2012).

Regarding the energy variable, it is found that energy consumption per capita has a positive impact on CO_2 emissions per capita for all the countries. It has a significant impact for Bahrain, Kuwait and Saudi Arabia. This indicates that an increase in energy consumption increase the carbon emissions in these countries. For the panel estimation, energy consumption per capita has a significant positive impact on CO_2 emissions per capita. This implies that an increase in energy consumption increase the environment degradation (Soytas et al., 2007) (Halicioglu, 2009) and (Zhang and Cheng, 2009).

The urbanization variable has a positive significant impact on the CO_2 emissions for Kuwait and a negative significant impact only for the United Arab Emirates as the same result was concluded for the panel estimation by (Hossain, 2011). However for the remaining countries, no significant relationship is found.

Therefore, overall results conclude that there is a bidirectional causal relationship between energy consumption and economic growth; there is a unidirectional causal relationship from energy consumption to GHG emissions and a bidirectional causal relationship between economic growth and pollutant emissions for the region as a whole. These results validate the three-way linkages between environmental degradation, energy consumption and economic growth over the study period of 1996–2017 in six GCC countries.

4. CONCLUSION AND POLICY RECOMMENDATIONS

The study conclude that the energy consumption has positive impact on economic growth by finding a bidirectional causal relationship between energy consumption and economic growth which significantly reject the neo-classical assumption that energy is neutral for economic growth. Energy is a strong variable for the economic growth in GCC countries with a high level of energy demand. It's also found that energy conservation policies has also negative impact on economic growth and showed there is

Table 4: Results of panel GMM estimation for equation (4)

	Dependent variable: GHG emission (GHG)						
	Saudi Arabia	**Bahrain**	**Kuwait**	**Qatar**	**UAE**	**Oman**	**Panel**
Coefficient	15.446*	0.307**	−6.194*	−7.727*	−1.141**	−14.241	−4.624*
GDP	0.670*	0.498*	0.359*	0.871*	−0.223***	0.508*	0.261*
EC	0.219**	0.921**	0.178*	0.234	0.370	0.092	0.689*
URBAN	0.151*	0.201	0.337**	0.421	-0.299**	0.376	0.221**
OPEN	−0.071	−0.037	−0.049	−0.367	−0.058	−0.045	−0.062
Hansen test (P-value)	0.13						
Durbin-Wu-Hausman test (P-value)	0.00						
Pagan-Hall test (P-value)	0.02						

Author's estimation: All variables in natural logs. *Indicates significant at 1% level, **Indicates significant at 5% level, ***Indicates significant at 10% level. GMM: Generalized method of moments

a unidirectional causal relationship from energy consumption to GHG emission without feedback. So GCC countries are consuming more energy due to expansion of production which leads to pressure on the environment leading to more emission. Hence, it is very essential to apply some sorts of pollution control actions to the whole panel regarding energy consumption. It is found that bidirectional causality between economic growth and GHG emissions implies that degradation of the environment has a causal impact on economic growth, and a persistent decline in environmental quality may exert a negative externality to the economy through affecting human health, and thereby it may reduce productivity in the long run.

The policy recommendations from this study are:

1. Firstly these countries need to embrace more energy conservation policies to reduce GHG emissions and consider strict environmental and energy policies. The research and investment in clean energy should be an integral part of the process of controlling the GHG emissions and find sources of energy to oil alternative. These countries can use solar energy as the substitute of oil. Thus, implementing the environmental and energy policies and also reconsidering the strict energy policies can control GHG emissions. As a result, our environment will be free from pollution.
2. Secondly, high economic growth gives rise to environmental degrading but the reduction in economic growth will increase unemployment. The policies with which to tackle environmental pollutants require the identification of some priorities to reduce the initial costs and efficiency of investments. Reducing energy demand, increasing both energy supply investment and energy efficiency can be initiated with no damaging impact on the GCC countries' economic growth and therefore reduce emissions. At the same time, efforts must be made to encourage industries to adopt new technologies to minimize pollution.
3. Lastly the oil exporting countries should have given subsidy for energy transition from renewable to non-renewable resources without influence negatively to the economic growth of these countries and also eliminate the energy price distortions restrain.

REFERENCES

Altinay, G., Karagol, E. (2004), Structural break, unit root, and the causality between energy consumption and GDP in Turkey. Energy Economics, 26(6), 985-994.

Andersson, R., Quigley, J.M., Wilhelmsson, M. (2009), Urbanization, productivity, and innovation: Evidence from investment in higher education. Journal of Urban Economics, 66(1), 2-15.

Ang, J.B. (2007), CO_2 emissions, energy consumption, and output in France. Energy Policy, 35(10), 4772-4778.

Ang, J.B. (2008), Economic development, pollutant emissions and energy consumption in Malaysia. Journal of Policy Modeling, 30(2), 271-278.

Apergis, N., Payne, J.E. (2009), CO_2 emissions, energy usage, and output in Central America. Energy Policy, 37(8), 3282-3286.

Apergis, N., Payne, J.E. (2010), Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. Energy policy, 38(1), 656-660.

Arouri, M.E.H., Youssef, A.B., M'henni, H., Rault, C. (2012), Energy consumption, economic growth and CO_2 emissions in Middle East and North African countries. Energy Policy, 45, 342-349.

Batliwala, S., Reddy, A.K. (1993), Energy consumption and population. International Energy Initiative, 25(5), 1-10.

Belloumi, M. (2009), Energy consumption and GDP in Tunisia: Cointegration and causality analysis. Energy Policy, 37(7), 2745-2753.

Chang, C.C. (2010), A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. Applied Energy, 87(11), 3533-3537.

Dickey, D.A., Fuller, W.A. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366a), 427-431.

Dinda, S. (2004), Environmental Kuznets curve hypothesis: A survey. Ecological Economics, 49(4), 431-455.

Fodha, M., Zaghdoud, O. (2010), Economic growth and pollutant emissions in Tunisia: An empirical analysis of the environmental Kuznets curve. Energy Policy, 38(2), 1150-1156.

Friedl, B., Getzner, M. (2003), Determinants of CO_2 emissions in a small open economy. Ecological Economics, 45(1), 133-148.

Ghosh, S. (2010), Examining carbon emissions economic growth nexus for India: A multivariate cointegration approach. Energy Policy, 38(6), 3008-3014.

Grossman, G.M., Krueger, A.B. (1991), Environmental Impacts of a North American Free Trade Agreement (No. w3914). National Bureau of Economic Research.

Grossman, G.M., Krueger, A.B. (1995), Economic growth and the environment. The Quarterly Journal of Economics, 110(2), 353-377.

Halicioglu, F. (2009), An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy, 37(3), 1156-1164.

Heidari, H., Katircioğlu, S.T., Saeidpour, L. (2015), Economic growth, CO_2 emissions, and energy consumption in the five ASEAN countries. International Journal of Electrical Power Energy Systems, 64, 785-791.

Holtz-Eakin, D., Selden, T.M. (1995), Stoking the fires? CO_2 emissions and economic growth. Journal of Public Economics, 57(1), 85-101.

Hossain, M.S. (2011), Panel estimation for CO_2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. Energy Policy, 39(11), 6991-6999.

Islam, F., Shahbaz, M., Ahmed, A.U., Alam, M.M. (2013), Financial development and energy consumption nexus in Malaysia: A multivariate time series analysis. Economic Modelling, 30, 435-441.

Jaunky, V.C. (2011), The CO_2 emissions-income nexus: Evidence from rich countries. Energy Policy, 39(3), 1228-1240.

Jayanthakumaran, K., Verma, R., Liu, Y. (2012), CO_2 emissions, energy consumption, trade and income: A comparative analysis of China and India. Energy Policy, 42, 450-460

Kapusuzo˘glu, A. (2014), Causality relationships between carbon dioxide emissions and economic growth: Results from a multi-country study. International Journal of Economic Perspective, 6, 5-15.

Kraft, J., Kraft, A. (1978), On the relationship between energy and GNP. The Journal of Energy and Development, 3, 401-403.

Kuznets, S. (1955), Economic growth and income inequality. The American Economic Review, 45(1), 1-28.

Lean, H.H., Smyth, R. (2010), CO_2 emissions, electricity consumption and output in ASEAN. Applied Energy, 87(6), 1858-1864.

Li, D., Yang, D. (2016), Does non-fossil energy usage lower CO_2 emissions? Empirical evidence from China. Sustainability, 8(9), 874.

Liu, K., Muse, S.V. (2005), Power marker: An integrated analysis environment for genetic marker analysis. Bioinformatics, 21(9), 2128-2129.

Lorde, T., Waithe, K., Francis, B. (2010), The importance of electrical energy for economic growth in Barbados. Energy Economics, 32(6), 1411-1420.

Lotfalipour, M.R., Falahi, M.A., Ashena, M. (2010), Economic growth, CO_2 emissions, and fossil fuels consumption in Iran. Energy, 35(12), 5115-5120.

Managi, S., Jena, P.R. (2008), Environmental productivity and Kuznets curve in India. Ecological Economics, 65(2), 432-440.

Menyah, K., Wolde-Rufael, Y. (2010), Energy consumption, pollutant emissions and economic growth in South Africa. Energy Economics, 32(6), 1374-1382.

Ozturk, I., Acaravci, A. (2010), CO_2 emissions, energy consumption and economic growth in Turkey. Renewable and Sustainable Energy Reviews, 14(9), 3220-3225.

Panayotou, T. (1993), Empirical Tests and Policy Analysis of Environmental Degradation at Different Stages of Economic Development (No. 992927783402676). International Labour Organization.

Pao, H.T. (2009), Forecast of electricity consumption and economic growth in Taiwan by state space modeling. Energy, 34(11), 1779-1791.

Phillips, P.C., Perron, P. (1988), Testing for a unit root in time series regression. Biometrika, 75(2), 335-346.

Richmond, A.K., Kaufmann, R.K. (2006), Is there a turning point in the relationship between income and energy use and/or carbon emissions? Ecological Economics, 56(2), 176-189.

Saboori, B., Sulaiman, J., Mohd, S. (2012), Economic growth and CO_2 emissions in Malaysia: A cointegration analysis of the environmental Kuznets curve. Energy Policy, 51, 184-191.

Sadorsky, P. (2010), The impact of financial development on energy consumption in emerging economies. Energy Policy, 38(5), 2528-2535.

Sadorsky, P. (2011), Financial development and energy consumption in Central and Eastern European frontier economies. Energy Policy, 39(2), 999-1006.

Sari, R., Ewing, B.T., Soytas, U. (2008), The relationship between disaggregate energy consumption and industrial production in the United States: An ARDL approach. Energy Economics, 30(5), 2302-2313.

Selden, T.M., Song, D. (1994), Environmental quality and development: Is there a Kuznets curve for air pollution emissions?. Journal of Environmental Economics and Management, 27(2), 147-162.

Shafik, N., Bandyopadhyay, S. (1992), Economic Growth and Environmental Quality: Time-Series and Cross-Country Evidence. Vol. 904. Washington, D.C.: World Bank Publications.

Shahbaz, M., Khan, S., Tahir, M.I. (2013), The dynamic links between energy consumption, economic growth, financial development and trade in China: Fresh evidence from multivariate framework analysis. Energy Economics, 40, 8-21.

Shahbaz, M., Lean, H.H. (2012), Does financial development increase energy consumption? The role of industrialization and urbanization in Tunisia. Energy Policy, 40, 473-479.

Sharma, S.S. (2010), The relationship between energy and economic growth: Empirical evidence from 66 countries. Applied Energy, 87(11), 3565-3574.

Soytas, U., Sari, R. (2009), Energy consumption, economic growth, and carbon emissions: Challenges faced by an EU candidate member. Ecological Economics, 68(6), 1667-1675.

Soytas, U., Sari, R., Ewing, B.T. (2007), Energy consumption, income, and carbon emissions in the United States. Ecological Economics, 62(3-4), 482-489.

Stern, D.I. (1993), Energy and economic growth in the USA: A multivariate approach. Energy Economics, 15(2), 137-150.

Wang, S.S., Zhou, D.Q., Zhou, P., Wang, Q.W. (2011), CO_2 emissions, energy consumption and economic growth in China: A panel data analysis. Energy Policy, 39(9), 4870-4875.

Wong, S.L., Chang, Y., Chia, W.M. (2013), Energy consumption, energy R D and real GDP in OECD countries with and without oil reserves. Energy Economics, 40, 51-60.

Yuan, J., Zhao, C., Yu, S., Hu, Z. (2007), Electricity consumption and economic growth in China: Cointegration and co-feature analysis. Energy Economics, 29(6), 1179-1191.

Zhang, X.P., Cheng, X.M. (2009), Energy consumption, carbon emissions, and economic growth in China. Ecological Economics, 68(10), 2706-2712.