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An Empirical Investigation of the Relationship between Economic Growth, Urbanization, Energy Consumption, and CO_2 Emission in GCC Countries: A Panel Data Analysis

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Abstract

The faster growing energy consumption and urbanization are supporting economic growth but are contributing in the environmental degradation. The existing empirical literature has been remained silent on this serious issue in case of GCC countries. The present study captures these rectangular relationships amongst these variables in the GCC countries by using panel unit root and cointegration tests for a period 1980-2011. The study finds the first difference stationarity and existence of cointegration among the concerned variables. Further, urbanization has the positive impact on CO_2, energy consumption and economic growth. Economic growth has a positive impact on CO_2 and has a negative impact on energy consumption. Energy consumption has a positive impact on CO_2 and CO_2 has a positive impact on energy consumption and economic growth. The causality tests also confirm the direction of relationships in the most of GCC countries in the country-specific analysis. The results of the study suggest the urban planning and clean energy consumption to avoid the pollutant emissions and to achieve sustainable development for GCC countries in the long run.

Keywords: carbon dioxide emission, energy consumption, economic growth, urbanization

1. Introduction

The Gulf Co-operation Council (GCC) (Note 1) countries are one of the world's most urbanized economic regions in the world. According to a Qatar National Bank (QNB) study, the GCC gross domestic product (GDP) is predicted to reach $ 1.5 trillion in 2013, and on average its per capita income was as high as US $19,800 in 2008 (Note 2). Consequently, the region has witnessed strong surge in urbanization process with the use of all modern amenities and modern life style enjoyed by its citizens. The average urbanization rate is more than 70% and countries like Kuwait and Qatar are 100% urbanized (UN Habitat, 2012). According to UN (Habitat, 2012), GCC countries are home of about 39 million population of which around 67% live in Saudi Arabia. The possible explanations of rapid growth of urbanization in GCC are internal migration and huge inflow of expatriate workers coming mainly from neighbouring and South Asian region. The high growth rate of population in some of the GCC countries like Saudi Arabia and Oman have also forced these economies to undertake prudent urban development measures to revive the infrastructure facilities in the existing cities. It is noteworthy that due to welfare oriented concentrated development in most of the GCC countries, it is expected that this region will be able to achieve The Arab Millennium Development Goals (MDGs). Despite these rosy economic scenarios, there is increasing concern that the high rate of consumption of energy is expected to aggravate the problem of environmental degradation in GCC. As the recent Figures of average energy consumption in GCC indicate that there is increasing trend in energy consumption and CO_2 emission. This realization has prompted us to probe the cumulative influence of population explosion, energy consumption, and urbanization on CO_2 emanation. Subsequently, the present study attempted to address the following significant questions as well First, how are urbanization, energy consumption and carbon emissions are interrelated? Second, how far emissions can be explained by factors like urbanization and economic growth? Third, assuming that urbanization and high energy consumption contribute to carbon emission, what policy measures could be recommended for these economies? So far many studies have examined the energy-growth relationship in case of GCC countries but there are very limited study that has examined the relationship amongst energy consumption urbanization and carbon emission in the context of GCC. The incorporation of macroeconomic variables like economic growth, population growth and urbanisation help in finding out the relationship more robustly.

The study is structured along the following lines: Section 2 discusses the background of the study. A review of the literature follows in section 3. Section 4 enlists the objectives of the study. Section 5 deals with the mode of data collection, models and methodology. Section 6 analyzes the collected data to interpret findings. Section 7, the concluding section, offers suggestion for modifications and based on the conclusion drawn in section 6.

2. Stylized Facts of the GCC Countries

There is a positive relationship between energy consumption and CO_2 emanation in case of GCC. The distribution of energy consumption and carbon emission exhibit an interesting trend (See Figure 1). A careful study of Figure 1 reports that energy consumption and carbon emission increased by 12.36 % and 6.65% respectively from 2008 to 2011. Similarly, in CO_2 emission, UAE is the highest emitting country followed by Oman and Saudi Arabia during 1980-1985 (see Figure 3). If we look at Figure (2), it appears that the distribution of energy consumption has not been even across countries in GCC. Among six member countries of GCC, the highest energy consuming country appears to be UAE followed by Oman. Bahrain appears to be the only country which has relatively stabilized its energy consumption. Similarly, in CO_2 emission, UAE is the highest emitting country followed by Oman and Saudi Arabia. If we look at Figure (4), it appears that the distribution of energy consumption has not been even across countries in GCC. During 1980-1995, UAE was the biggest energy consumer followed by Oman and Saudi Arabia. While, during 1986-1990, the growth declined sharply in UAE and Saudi Arabia. Similarly, during 1991-1996, Kuwait was the largest consumer of energy followed by Qatar. But during 2008-2011, the growth in energy consumption has increased sharply in Oman, Saudi Arabia and UAE. While, Bahrain, Kuwait and Qatar have stabilized the growth in energy consumption. Overall it can be said that though there is increasing trend in growth rate of energy consumption among GCC consumption, it has stabilized over the year.

Analysing the average growth of carbon emission in the same dimension (see Figure 5), the results indicate that among GCC countries, during 1980-1985, UAE was the largest emitter of carbon followed by Oman and Saudi Arabia while lowest emitting countries were Kuwait and Qatar. But in 1986-1990, the trends seem to be different as there is sharp decline in carbon emission during this period. Saudi Arabia appears to be least emitting country followed by Kuwait and Bahrain. Among GCC countries, the largest emitter is Oman followed by UAE and Qatar. During 2008-2011, Oman and UAE exhibit the highest growth in carbon emission followed by Saudi Arabia. To sum up, the analysis of individual countries clearly demonstrate the healthy relationship between energy consumption and CO_2 emanation in GCC. After analyzing all the results, it appears that there is common trend of rising level of energy consumption and carbon emanation. The obvious factors that could explain such relationship could be the increase in the growth rates of population and rapid urbanization. As mentioned above, GCC economic region has one highest urbanized areas in the world. The average population growth rate in this region is fastest in the world. Looking at Figure (6), it can be seen that among GCC countries, the highest growth rate of population appears to be in Qatar followed by Kuwait, Saudi Arabia and UAE. Qatar observed the highest growth during 2005-2010 of around 10% followed by UAE more than 5% in 1995-2000. But it is projected that by 2030, the population growth trend of these countries will see the considerable decline since the low growth trend has already started.

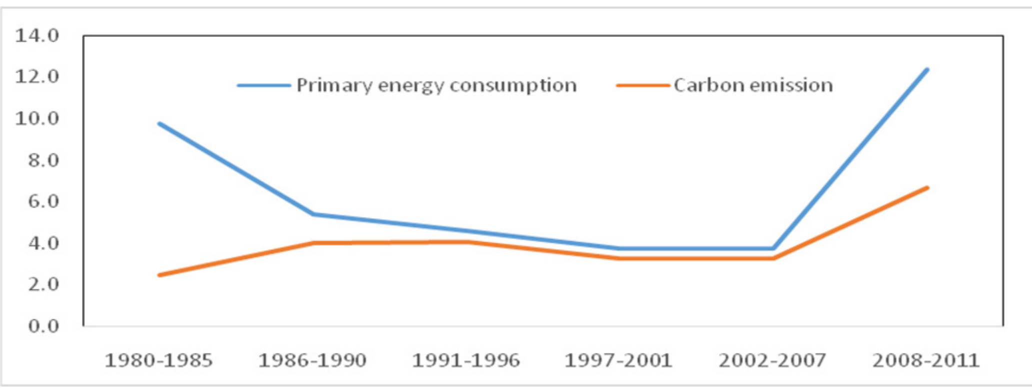

Figure 1. Average trend in energy consumption and carbon emission in GCC countries
Source: Energy Information Administration (EIA)

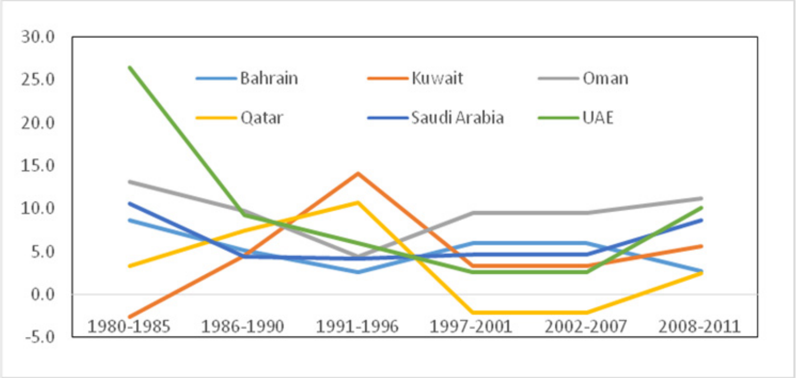

Figure 2. Average growth rates of energy consumption in GCC countries
Source: Energy Information Administration (EIA)

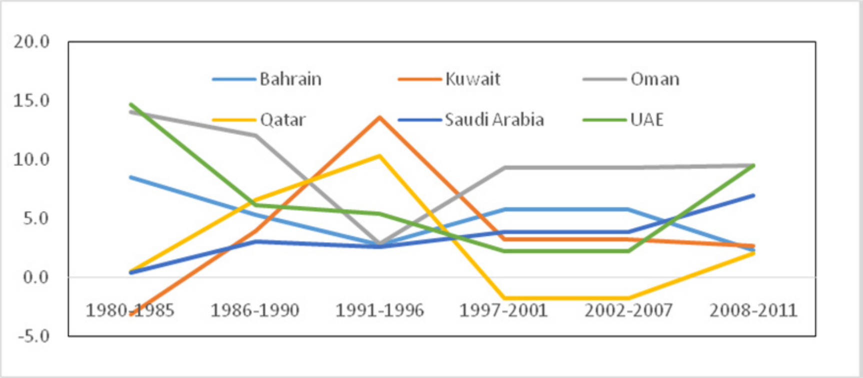

Figure 3. Average growth rates of carbon emission in GCC countries
Source: Energy Information Administration (EIA)

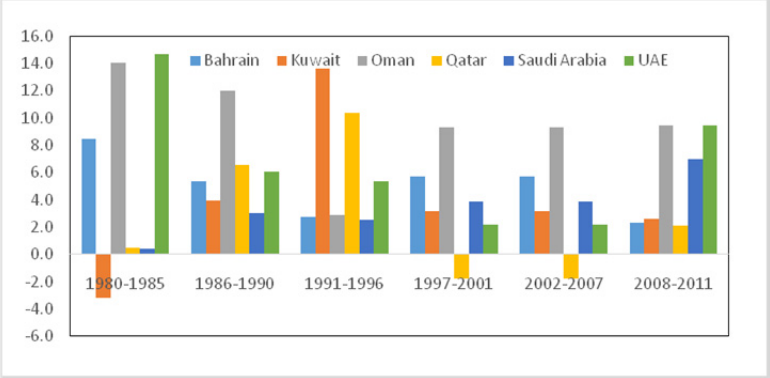

Figure 4. Average growth rate of energy consumption in individual countries of GCC
Source: Energy Information Administration (EIA)

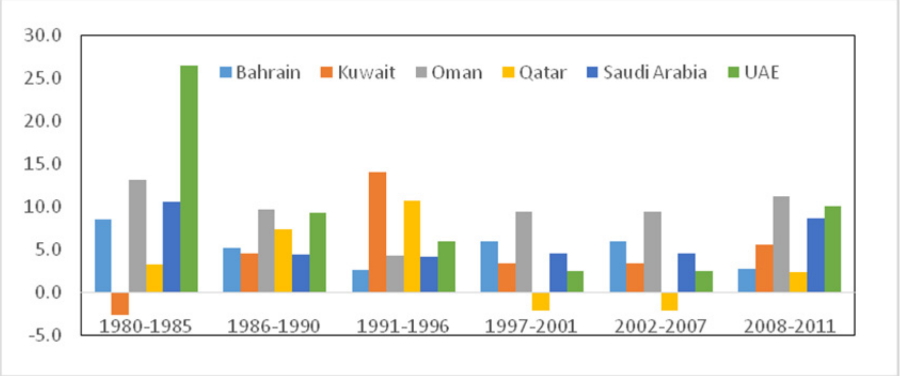

Figure 5. Average growth rate of carbon emission in individual countries of GCC
Source: Energy Information Administration (EIA)

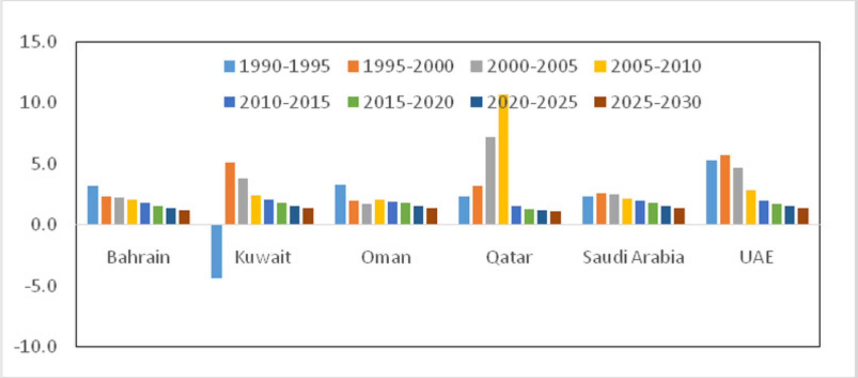

Figure 6. Growth rate of population in GCC countries
Source: State of Arab Cities 2012/2013, UN Habitat

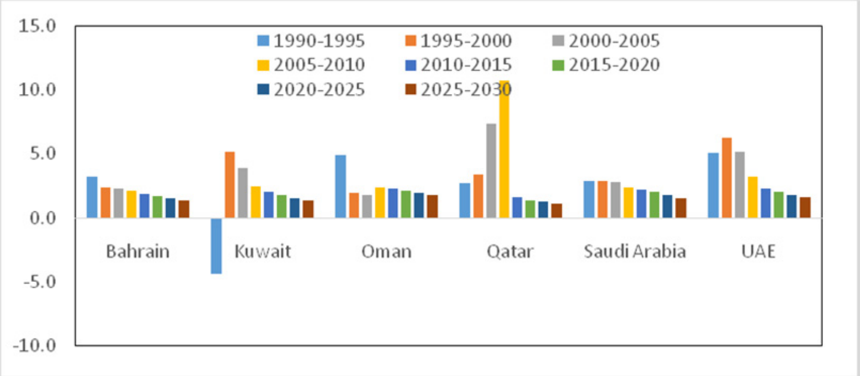

Figure 7. Growth rate of urbanization in GCC countries
Source: State of Arab Cities 2012/2013, UN Habitat

3. Review of Literature

In the literature, the examination of relationship between urbanization and environmental issues such as energy consumption and carbon emission has been one of the important topics of research with mixed empirical results. Some studies have shown that there is direct and positive relationship between urbanization and carbon emission because rapid urbanization augments the demand for energy consumption, generating more emissions (Jones, 1991; Parikh & Shukla, 1995; Cole & Neumayer, 2004; York, 2007). Nevertheless, some researchers argue affirm that urbanization reduces carbon emission significantly because it implies creation of new amenities and public goods such as public transport and better living standards. These developments lead to better use of energy and low rate of emission (Newman & Kenworthy, 1989; Liddle, 2004; Chen et al., 2008). Despite these agreements, some of the major studies in recent years are examining the relationship between urbanization, energy consumption and CO_2 emission are (Wei & Liu, 2007; Liu, 2009; Liu & Xie, 2009; Parshall, et al., 2010; Donglan et al., 2010; Poumanyvong & Kaneko, 2010; Xiangyang & Guiqiu, 2011; Liu et al., 2011; Hossain, 2011; Li et al., 2012; Zhang & Lin, 2012; Shahbaz & Lean, 2012; Poumanyvong et al., 2012; Al-mulali et al., 2012; Wang et al., 2013; Jones, 1991) empirically examined the effect of urbanization on Carbon emission for a large basket of developing economies. Based on its empirical results, the study reported that there is significant impact of urbanization in CO_2 emission. Parikh and Shukla (1995) in their studies have discussed the impact of development transition on energy used. Their focus is based on the highlighting the variation in energy requirements with the process of development in general and urbanization in particular. His period of study ranges between 1965-87 taking into account of developed and developing countries using the double logarithmic regression model based on ordinary least square estimate on the pooled time series and cross section data, they have established that urban population increases per capita fuel consumption and carbon emission. In case of large countries such as China and United States, the studies of (Donglan et al., 2010; Parshall et al., 2010; Li et al., 2012; Zhang & Lin, 2012; Wang et al., 2013) reported strong evidence of urbanization on energy consumption and subsequently on carbon emission. Zhang and Lin (2012) have highlighted the relationship between urbanization, energy consumption and CO_2 emission not only at national level but also at regional levels in china. The result shows that urbanization has increased energy consumption and CO_2 emission in China but their effects varies across the regions. Khathlan Al Khalid et al. (2012) reported a positive relationship between carbon emission and economic growth in the long run in case of Saudi Arabia. They find that in the short run energy conservation policies and controlling carbon dioxide emissions are likely to have no adverse impact on economic growth in Saudi Arabia but highlighted that long run income leads to greater carbon dioxide emissions in the country. Their study has used multivariate model analysis techniques for investigation .Most studies in the literature have highlighted the role of urbanization in energy consumption and carbon emission. Very limited attention has been paid on examining these relationships in the context of Middle East and North African (MENA) countries and GCC countries.

In a recent attempt, study by (Al-Mulali et al., 2013) examined the relationship between urbanization, energy consumption and CO_2 emission in case of Middle East and North Africa (MENA) countries, covering the sample period of 1980-2009. Using dynamic panel data models and Vector Error Correction Model (VECM) based panel Granger causality, the study reported strong relationship among sample variables. Based on the empirical results, the study found strong evidence of impact of urbanization on energy consumption and subsequently on carbon emission. Based on its findings, the study suggested that the slowdown in urbanization process may help these economies to control upon carbon emission related pollution. To the best of our knowledge and similar to our objectives of this study, this is the only study that covers almost all the GCC countries. But this study fails to provide a deeper understanding about GCC countries carbon emission related issues. The study also uses the data up to 2009 and hence ignores many recent developments and policy measures to curb on carbon related pollution. The present study aims to fill these research gaps.

The findings of the present study are expected to add value to the existing literature in several ways: First, the outcome of this study provides contemporary overview about the impact of recent surge in economic activities and urbanization on the environment degradation of GCC countries. This is important because this will further guide the policy makers and concerned stakeholders to tackle the issue of climate change. Second, in the literature, very few studies have studied the role of energy consumption in driving economic growth for GCC countries. This study attempts to add value to the literature by examining this relationship especially at the time when economic growth of GCC economies are heavily dependent upon energy consumption. Most of the GCC economies are striving to reduce their oil-dependence and there is heavy investment made to diversify the economic activities with more focus on increasing the manufacturing base and adoption of import substitution policy. Third, after the Kyoto protocol, climate change has become one of the most debatable topics among academia, researchers and urban planners. Hence, understanding the various channels of CO_2 may help in curbing the emission of greenhouse gas. In this process, this study provides important policy direction by highlighting the inter-relationship between urbanization and CO_2 emission in GCC countries. Fourth, the study is particularly important for urban planners, because it may provide important policy guidance to either slow down the urbanization process or reduce the level of pollution by investing heavily in clean energy technology.

A close reappraisal of existing literature reveals that the literature on this subject is limited and little has been done to establish the relationship between urbanization, economic growth energy consumption, CO_2 emission for GCC countries. From policy perspective, this study is important as it promises to bring new insight by discovering the association between the energy consumption, CO_2 emission and urbanization and provides the answer to the question of whether urbanization is a vital cause of the energy consumption and CO_2 emission rise in the GCC countries. Globally, there is increasing concern regarding the adverse effect of climate change on the living things. Efforts are continuously made to undertake necessary policy measures to keep the healthy relationship between energy consumption and economic growth. There is still lack of unanimous debate on the sustainability of this relationship. In recent years, this issue has garnered the attention of researchers and policy makers due to the rapid urbanization process and higher economic growth found in case of emerging economies and Gulf region. Consequently, these economies have also witnessed enormous rise in CO_2 emissions.

Nevertheless, one has to investigate the impact of urbanization on energy consumption and carbon emission for different levels of economic growth and development as variation across levels are not clear. Therefore, it is imperative to undertake further studies with careful consideration of different development stages.

4. Objectives of the Study

In the light of above discussions and outcomes, the important objectives of this study are as follows:

1) To explore the association between energy consumption, economic growth, CO_2 emanation, and urbanization in the GCC countries.

2) To investigate whether urbanization is a major cause of the energy consumption and CO_2 emission increase in the GCC countries.

3) To provide an overview about the energy policy of GCC countries from regulatory perspective.

4) To provide policy suggestions on the need to reduce the CO_2 emission in case of GCC countries.

5. Data and Methodology

We have used the following economic indicators in order to fulfill the objectives of this study. Total primary energy consumption (in quadrillion Btu) with total carbon dioxide emission from the energy consumption measured in million metric tons have been retrieved from the Energy Information Administration. Gross Domestic Product (GDP) at constant 2005 US $ is used to proxy the economic growth of GCC. For the urbanization level of GCC, total urban population (in millions of people) are sourced from the World Development Indicators (WDI), of World Bank. Only four countries of GCC namely Bahrain, Oman, Saudi Arabia and United Arab Emirate (UAE) are considered for our analysis according to data accessibility for the 1980-2011. All variables have been converted into the log form to avoid the problem of heterokedasticity.

5.1 Estimation Technique

It has been suggested through recent literature that panel unit root tests are more powerful than unit root based on single time series. Two types of panel unit root test: Levin, Lin and Chu (2002), Breitung (2000), Im, Pesaran and Shin (2003) and Fisher-ADF test based on Augmented Dicky Fuller test and Fillips Perontest have been used. As per the model specification, both LLC and Breitung test consider a general unit root process over the cross sections sample. For all these tests it is considered that there is unit root presence in case of null hypothesis while there is no unit root with the alternative hypothesis. Considering the empirical literature, we undertake the model as follows.

$$\begin{aligned} LEM_{it} &= \beta_0 + \beta_1 URBAN_{it} + \beta_2 GDP_{it} + \beta_3 ENC_{it} + \mu_{it} \\ LENC_{it} &= \beta_0 + \beta_1 URBAN_{it} + \beta_2 GDP_{it} + \beta_3 EM_{it} + \mu_{it} \\ LGDP_{it} &= \beta_0 + \beta_1 URBAN_{it} + \beta_2 ENC_{it} + \beta_3 EM_{it} + \mu_{it} \end{aligned} \quad (1)$$

Where URBAN represent the urban population which has been used as an indicator of urbanization. EM is the CO_2 emission and ENC is energy consumption. GDP is GDP growth rate. t denotes time and i denotes the cross section (countries).

5.2 Panel Unit Root Tests

According to Cointegration technique irrespective of non- stationary time series, their linear combinations might be stationary. Therefore, before employing Panel cointegration techniques it is necessary to evaluate the stationarity of variables. The panel unit root tests have higher power than the unit root test based on the individual time series. Panel unit root test offers additional information through pooled cross-section time series to increase test power. Therefore, panel unit root tests are applied to assess the null hypothesis that the process is non- stationary against the alternative that the panel series is stationary. The panel unit tests of all variables are verified both in levels and in first differences in Table (1).

5.3 Panel Cointegration Test

When the variables are stationary at the first difference, the (Pedroni, 1999, 2001) heterogeneous panel cointegration test is used to probe long run relationship between economic growth, urbanization, energy consumption and CO_2 emission. The test permits for cross section mutual dependence with different individual effects. The model is projected as follows:

$$\begin{aligned} LEM_{it} &= \alpha_i + \delta_i t + \gamma_{1i} URBAN_{it} + \gamma_{2i} GDP_{it} + \gamma_{3i} ENC_{it} + \varepsilon_{it} \\ LENC_{it} &= \alpha_i + \delta_i t + \gamma_{1i} URBAN_{it} + \gamma_{2i} GDP_{it} + \gamma_{3i} EM_{it} + \varepsilon_{it} \\ LGDP_{it} &= \alpha_i + \delta_i t + \gamma_{1i} URBAN_{it} + \gamma_{2i} ENC_{it} + \gamma_{3i} EM_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

Where i=1….N for each country in the panel and t=1…….T refers to the time period. The parameters α_i is the country specific intercept or fixed effects parameter which is allowed to vary across individual country and δ_i is deterministic time trend which are specific to individual countries to the panel. ε_{it} denotes the estimated residuals which represent deviations from the long-run relationship. All variables are expressed either in natural logarithms or percentage of GDP so that γ 's parameters of the model can be interpreted as elasticities. To test for the null hypothesis of no cointegration $\rho_i = 1$, the following unit root test is conducted to the residuals as follows:

$$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + \omega_{it} \tag{3}$$

Pedroni (1999, 2001) puts forward two tests for cointegration. The panel tests are based on within dimension approach which comprise four statistics: panel v, panel ρ, panel PP and panel ADF statistics. They essentially integrate the autoregressive coefficients across different countries for the unit root tests on the estimated residuals. Secondly, they also considers common time factors and heterogeneity across countries. Moreover these tests are built on the between dimension approach which includes three statistics: group ρ, group PP and group ADF statistics. They include averages of the individual autoregressive coefficients associated with unit root tests of the residual of each country in the panel data set. The seven statistics for each panel data set reject the null hypothesis of no cointegration at the given level of significance. Following Pedroni (1999, 2001) the heterogeneous panel and heterogeneous group mean panel cointegration statistics for the multivariate panel regression are calculated as follows.

Panel v- statistic:

$$Z_v = \left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{\varepsilon}_{it-1}^{2}\right)^{-1}$$

Panel ρ-statistic:

$$Z_\rho = \left(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{\varepsilon}_{it-1}^{2}\right)^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\left(\hat{\varepsilon}_{it-1}\,\Delta\hat{\varepsilon}_{it}-\hat{\lambda}_i\right)$$

Panel PP-statistic:

$$Z_t = \left(\hat{\sigma}^2\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{\varepsilon}_{it-1}^{2}\right)^{-1/2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\left(\hat{\varepsilon}_{it-1}\,\Delta\hat{\varepsilon}_{it}-\hat{\lambda}_i\right)$$

Panel ADF-statistic:

$$Z_t^{*} = \left(\hat{s}^{*2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\,\hat{\epsilon}_{it-1}^{*2}\right)^{-1/2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\left(\hat{\varepsilon}_{it-1}^{*}\,\Delta\hat{\epsilon}_{it}^{*}\right)$$

Group ρ-statistic:

$$\tilde{Z}_\rho = \sum_{i=1}^{N}\left(\sum_{i=1}^{T}\hat{\varepsilon}_{it-1}^{2}\right)^{-1}\sum_{i=1}^{T}\left(\hat{\varepsilon}_{it-1}\,\Delta\hat{\varepsilon}_{it}-\hat{\lambda}_i\right)$$

Group PP-statistic:

$$\tilde{Z}_t = \sum_{i=1}^{N}\left(\hat{\sigma}^2\sum_{i=1}^{T}\hat{\varepsilon}_{it-1}^{2}\right)^{-1/2}\sum_{i=1}^{T}\left(\hat{\varepsilon}_{it-1}\,\Delta\hat{\varepsilon}_{it}-\hat{\lambda}_i\right)$$

Group ADF-statistic:

$$\tilde{Z}_t^{*} = \sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{s}_i^{*2}\,\hat{\varepsilon}_{it-1}^{*2}\right)^{-1/2}\sum_{i=1}^{N}\left(\hat{\varepsilon}_{it-1}^{*}\,\Delta\hat{\varepsilon}_{it}^{*}\right)$$

Where $\hat{\varepsilon}_{it}$ is the estimated residual from Eq. (3) and L_{11i} is nuisance parameter corresponds to the number specific long-run conditional variance for the residuals. Similarly, $\hat{\sigma}_i^2$ and $\hat{s}_i^2$ ($\hat{s}_{it}^{*2}$) are, respectively, long-run and contemporaneous variances for individual *i*. The other terms are also defined by (Pedroni, 1999) with appropriate lag length using Kernel estimator such as Newey- West method. The panel v-statistics is a one-sided test for which greater positive values reject the null of no cointegration. For the rest of the statistics divergence to negativity is sufficiently high, which means that large negative values reject the null hypothesis. The critical values are also computed and tabulated by (Pedroni, 1999) using standard assumptions regarding the data.

5.4 Panel FMOLS and DOLS Estimates

Subsequently estimating the cointegration, the study estimated the long-run relationship among economic growth, urbanization, energy consumption and CO_2 emission by applying Fully Modified Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) technique (see Pedroni1999, 2001; Kao & Chiang 2001). This is mainly because it is always a case that in case of panel data, the OLS estimator is biased and inconsistent especially when it is applied to co-integrated panel series. In this regard, the FMOLS method not only produces consistent estimates in small samples but also controls for the likely endogeneity of the regressors and auto correlation .Our models in general form are as follows as suggested in (Pedroni, 2001);

$$Y_{it} = \alpha_i + \beta_i X_{it} + u_{it} \quad , i= 1, 2 \text{-----}N, t= 1, 2, \text{----}, T, \tag{4}$$

Where Y_{it} is dependent variable and X_{it} independent variable. All variables are in natural log. The variables Y_{it} and X_{it} are cointegrated with slopes β_i , which may or may not be homogeneous across *i*.

$$Y_{it} = \alpha_i + \beta_i X_{it} + u_{it} + \sum_{k=-ki}^{ki} \tau_{ik} \Delta X_{it-k} + u_{it} \quad , i= 1,2 \text{-----}N, t= 1,2, \text{----},T, \tag{5}$$

In case of strong relationship, null hypothesis be $H_0 : \beta_i = 1$ for all i. Let ξ_{it} = ($u\hat{}_1 it, \Delta X_1 it)$ be a stationary vector including the estimated residuals and difference

$$\Omega_{it} = lim_{T\to\infty} E\left[T^{-1}\left(\sum_{t=1}^{T}\xi_{iT}\right)\left(\sum_{t=1}^{T}\xi_{iT}\right)'\right]$$

in X_{it} . Let be the long run covariance related to vector process which can be disintegrated into $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i$ where Ω_i^0 is the contemporary covariance and Γ_i is a weighted sum of auto covariances. The panel FMOLS estimator for the co-efficient β is given as follows:

$$\hat{\beta}_{NT} = N^{-1}\sum_{i=1}^{N}\left(\sum_{i=1}^{T}(X_{it} - \bar{X}_i)^2\right)^{-1}\left(\sum_{i=1}^{n}(X_{it} - \bar{X}_i)Y_{it}^* - T\hat{\tau}\right) \tag{6}$$

Where $Y_{it}^* = (Y_{it} - \bar{Y}_i) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}\Delta X_{it}$ and $\hat{\tau} = \hat{\Gamma}_{21i} + \hat{\Omega}^0_{21i} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}}(\hat{L}_{22i} + \hat{\Omega}^0_{22i})$. The associated *t*-statistics follow normal distribution.

We can also construct the group mean panel dynamic ordinary least square (DOLS) estimator as $\hat{\beta}^*_{GMD}$ = $N^{-1}\sum_{1}^{N}\left[\sum_{t=1}^{T} Z_{it}Z'_{it}\right]^{-1}\left[\sum_{t=1}^{T} Z_{it}\tilde{Y}_{it}\right]$ where Z_{it} is a 2(k+1) x 1 vector of regressors $Z_{it} = X_{it} - \bar{X}_{it}$, ΔX_{it-k} , ……, ΔX_{it+k} and $\tilde{Y}_{it}$ = $Y_{it} - \bar{Y}_{it}$.

5.5 Causality Analysis

After analyzing the long-run coefficients, we now establish the causal relationship among sample variables. For this, the study applies the panel Granger causality test of Dumitrescu and Hurlin (2012). Before applying this model, the study analyses the order of integration by applying panel unit root tests. As shown in Table (1), the results indicate that there is unit root at level and all the sample variables achieve stationarity at first difference. Dumitrescu and Hurlin (2012) proposed a panel causality test based on the individual Wald statistic of Granger non-causality averaged across the cross-section units. The testing procedure considers the heterogeneity of causative relationships and the heterogeneity of the regression model used for testing Granger causality. The linear panel regression model followed by Dumitrescu and Hurlin (2012) is as follows:

$$\Delta EM_{i,t} = \phi_i + \sum_{i=1}^{l} \alpha_i^j \Delta EM_{i,t-i} + \sum_{i=1}^{l} \beta_i^j \Delta X_{i,t-i} + \varepsilon_{i,t} \tag{7}$$

$$\Delta ENC_{i,t} = \phi_i + \sum_{i=1}^{l} \alpha_i^j \Delta ENC_{i,t-i} + \sum_{i=1}^{l} \beta_i^j \Delta X_{i,t-i} + \varepsilon_{i,t} \tag{8}$$

$$\Delta GDP_{i,t} = \phi_i + \sum_{i=1}^{l} \alpha_i^j \Delta GDP_{i,t-i} + \sum_{i=1}^{l} \beta_i^j \Delta X_{i,t-i} + \varepsilon_{i,t} \tag{9}$$

Where ΔEM appears as first difference of carbon emission variable which is explained by first difference of explanatory variables (ΔX) as URBAN, ENC and GDP. Similarly in equations (8) and (9), the dependent variables are first difference of ENC and GDP with explanatory variables as URBAN, EM and interchange of ENC and GDP. According to Dumitrescu and Hurlin (2012) the contruction of a model based on homogenous panel assumption does not provide adequate causal evidence between two variables if there is presence of any kind of heterogeneity across individuals in the data. Thus, in order to take this into account, the causality model proposed an average Wald statistics that has the null of no causal relation for any of the cross section units (*Ho*: $\beta_i = 0$ (*i* = 1……..N)), against the alternative hypothesis that causal relationships occur for at least one sub-group of panel. (H_1: $\beta_i = 0$ (*i* = 1……..N_1)); $\beta_i \neq 0$, (i = N_1+1, N_1+2……N)). The rejection of null hypothesis with N_1= 0 indicates that X Granger causes EM for all *I* in equation (7). While, rejection of the null hypothesis that N_1> 0 suggests that causal relations vary from one individual sample to another. In this situation, the average of Wald statistics given by Dumitrescu and Hurlin (2012) assumes the following.

$$W_{N,T}^{HNC} = \frac{1}{N} \sum_{i=1}^{N} W_{i,T} \tag{10}$$

Where $W_{i,T}$ is the individual Wald statistics for the ith-cross section unit.

6. Empirical Results

In this section, the study discusses the empirical results for GCC countries. A precondition for applying the Pedroni panel cointegration test is to prove that variables contain a panel unit root. At first stage, the study applies three unit root tests viz., Im-Pesaran-Shin (IPS), ADF-Fisherand PP-Fisher tests. The results of unit root are shown in Table (1), the results overwhelmingly reject the present of unit root at first difference. However, all the variables achieve stationarity at their first differences. The results suggest that cointegration can be applied to examine the long-run relationship.

Table 1. Panel unit root test results

Variable	Im.Pesaran and Shin (IPS)		ADF - Fisher Chi-square		PP - Fisher Chi-square	
	Level	First difference	Level	First difference	Level	First difference
LEM	2.091	-5.444**	2.508	43.818**	4.871	79.581**
LENC	0.730	-6.167**	4.354	51.119**	12.557	120.93**
GDP	3.479	-4.613**	2.572	37.512**	9.097	43.276**
URBAN	2.804	-5.610**	1.167	46.811**	9.402	26.137**

Note: ** shows the level of significance at 5% level of significance.

6.1 Panel Cointegration Tests Results

After proving that all variables under study are stationary at first difference, we move to test whether there is a long- run relationship between the variables through the cointegration test.

Table 2. Panel cointegration test results

Test statistics	Model 1	Model 2	Model 3
Panel v-Statistic	-1.849	1.079	0.813
	[0.967]	[0.140]	[0.208]
Panel rho-Statistic	-1.583	-4.287	0.668
	[0.056]**	[0.000]**	[0.748]
Panel PP-Statistic	-6.707	-9.018	-1.340
	[0.000]**	[0.000]**	[0.090]*
Panel ADF-Statistic	-2.903	-9.252	-1.612
	[0.001]**	[0.000]**	[0.054]**
Group rho-Statistic	-0.804	-2.912	1.296
	[0.210]	[0.001]	[0.903]
Group PP-Statistic	-8.944	-9.475	-1.307
	[0.000]**	[0.000]**	[0.096]*
Group ADF-Statistic	-3.142	-9.603	-1.444
	[0.000]**	[0.000]**	[0.074]*

Note: Values in parentheses are p-values. ** and * denote the level of significance at 5% and 10% and better, respectively.

Therefore, in order to establish the long-run relationship, the study applies the Pedroni cointegration test. As mentioned above, we have applied panel cointegration test on three models. The results of models (1, 2 & 3) in Table (2) suggest that the cointegration results vary among cointegration statistics. More specifically, five out of seven statistics reject the null of no cointegration in case of all models, implying that there is long-run relationship among the variables to be examined.

6.2 Fully Modified OLS (FMOLS) and Dynamic OLS (DOLS) Test Results

After examining the cointegration relationship, the study now analyses the results of long-run coefficients by applying FMOLS and DOL Son three different models. In the first model, the study estimates the long-run coefficients of CO_2 emissions (LEM in this case) with respect to LURBAN, LGDP and LENC (see Table 3). Analyzing the FMOLS results, it appears that all the variables like LURBAN, LGDP and LENC show direct and positive relationship with LEM. The results suggest that in case of GCC countries, there is positive and significant impact of LURBAN on LEM, as the FMOLS results reveal, a 1% increase in urbanization rate leads to 0.09% increase in energy emission. Similarly, a 1% increase in LGDP and LENC leads to about 0.16% and 0.72% increase in LEM, respectively. Accordingly, DOLS results demonstrate that LGDP and LENC have positive and statistically significant sign. LURBAN has negative and statistically significant sign. The results imply that in case of GCC countries, the prominent factors like LURBAN drives the LEM (Carbon emission), indicating an urgent need to undertake policy measures. As expected, the results of LGDP and LENC are not surprising as these variables reveal positive relationship with LEM. Analyzing these results individually, the results suggest that with the exception of Bahrain in GCC countries, Oman, Saudi Arabia and UAE exhibit direct and positive relationship between LURBAN and LEM. Considering the magnitude of coefficient of LURBAN, UAE appears have the highest magnitude followed by Saudi Arabia and Oman. The coefficients reveal that among four GCC countries, a 1% increase in urbanization leads to more than 0.20% increase in emission in case of UAE. Similarly, Saudi Arabia and Oman exhibit0.09% and 0.07% increase in emission cause by 1% increase in urbanization in FMOLS model. In case of DOLS model coefficients of LURBAN, LGDP and LENC are statistically significant in sample countries except UAE. Only LENC is positive and significant in case of UAE. Notably, in FMOLS model, the coefficients of Urbanization (LURBAN) in case of Saudi Arabia, Bahrain and Oman are not statistically significant, implying that the Urbanization is not the significant and only factor of increase in emission. Analyzing the LGDP as a proxy of affluence and growth, the results reveal that in case of GDP augments the carbon emission in case of all sample GCC countries except UAE. A 1% increase in GDP leads to 0.05% increase in emission in Bahrain, 0.22% in Oman, 0.48% increase in Saudi Arabia and 0.09% decrease in UAE in FMOLS model. In DOLS model coefficients of GDP are significant and positive except in UAE. Seemingly, energy consumption also increases the emission in case of all GCC countries in FMOLS model as well as DOLS models except in Oman where it has negative relationship in DOLS. A 1% increase in energy consumption leads to0.93% increase in carbon emission in case of Bahrain followed by 0.80% in Oman, 0.68% in UAE and 0.42% in Saudi Arabia, while 1% increase in energy consumption leads to a 0.87% increase in emission in Bahrain, 1.47% in Saudi Arabia and 0.67% in UAE but 1.47% decrease in Oman according to

DOLS. The results imply that in case of GCC countries, the highest carbon emitting factor is high energy consumption followed by GDP and Urbanization. Therefore, it can be concluded that urbanization alone should not be considered as the only factor for rise in carbon emission.

Considering the case of energy consumption in GCC, it appears that on the whole, urbanization does not significantly affect the energy consumption, though the result is insignificant in FMOLS model but statistically significant in DOLS model. There is negative and insignificant relationship between energy consumption and GDP in FMOLS but negative and statistically significant. However, energy consumption impacts significantly the increase in carbon emissions in FMOLS as well as DOLS model. Analyzing individually, it appears that among sample countries, urbanization significantly impacts the energy consumption in case of Oman, Saudi Arabia and UAE, while in case of Bahrain it is not significant according to FMOLS model. Notably, in case of Oman and UAE, a high rate of urbanization leads to reduction in energy consumption. Like for example, a 1% increase in urbanization leads to 0.27% and 0.17% decrease in energy consumption in case of UAE and Oman, respectively in FMOLS. This result is consistent except for UAE in DOLS model. The possible explanation in this regard could be because of energy efficient use of technology and design and development of energy saving urban infrastructure. However, the results of Urbanization in case of Saudi Arabia and Bahrain appears to be positive. A 1% increase in urbanization leads to 0.46% and about 0.02% increase energy consumption in Saudi Arabia and Bahrain, respectively in FMOLS. Results are not consistent in DOLS. Considering the energy-growth framework, it appears that there is positive relationship between energy consumption and economic growth in case Oman and UAE and negative relationship between energy consumption and economic growth in Bahrain and Saudi Arabia in FMOLS model. But these variables are negatively related in all countries in case of DOLS model. The results reveal that in case of Bahrain, Saudi Arabia, a 1% increase in GDP leads to about 0.036%, and 0.36% decrease in energy consumption, respectively but for Oman and UAE, 1% increase in GDP leads to about 0.10% and 0.12% increase in energy consumption respectively. These relationships are well established and are in line with large number of studies. Carbon emission exhibits the positive and significant impact in case of all sample GCC countries both in FMOLS and DOLS models.

Considering the third model in which economic growth (LGDP) is dependent variable, the FMOLS and DOLS model results suggest that the group statistics of GCC countries indicate positive and significant relationship between urbanization and economic growth. The results of FMOLS model reveal that a 1% increase in urbanization leads to 0.53% increase in GDP and 0.80% increase in GDP in DOLS model, which is quite attractive and concern policy suggestions. The magnitude appears to be true because most of sample GCC countries are highly urbanized. Particularly countries like UAE, Bahrain and Oman, urban amenities play significant role in driving the economy. Similarly, carbon emission exhibits positive and significant relationship between carbon emission and GDP in both the models. The results reveal that a 1% increase in carbon emission leads to 0.05% increase in economic growth in FMOLS model and 0.08% increase in economic growth in DOLS model. It may be noted that the result is complementary to the model 1 (in which carbon emission is considered as dependent variable) which suggested that 1% increase in GDP leads to about 0.17% increase in emission. The results imply that in case of GCC countries, there is bi-directional and positive relationship between carbon emission and economic growth.

Analyzing individually, the results in FMOLS suggest that there is positive impact of urbanization on economic growth in case of Bahrain, Oman and UAE. Whereas, Saudi Arabia exhibits negative relationship. Interpreting the coefficients individually, the results indicate that given the small size of economies like Bahrain, Oman and UAE, a 1% increase in urbanization leads to 0.72%, 0.41% and more than 1.24% increase in economic growth of Bahrain, Oman and UAE, respectively. In case of DOLS model there is positive impact of urbanization on economic growth in Bahrain and UAE and negative relationship in Oman and Saudi Arabia. This is not surprising because the economic prospect of most these three economies rely on the development of tourism and highly concentrated urban development. Especially in case of UAE, the result is not surprising as rapid pace of urbanization has yielded positively as far as economic growth is concerned. In case of Saudi Arabia, the result appears to be surprising as it indicates that there is inverse relationship between high urbanization and economic growth. The statistically insignificant result of FMOLS indicates that a 1% increase urbanization leads to 0.25% decrease in economic growth. The possible explanation could be because Saudi Arabia is the largest country by geography and its economy is mainly driven by booming oil sector and enormous domestic demand of good and services.

Analysing the variables such as energy consumption and economic growth, there is no statistically significant relationship between these variables. Analysing individual y, the result suggests that there is positive impact of energy consumption on economic growth in case of UAE where as in other countries, the relation is not statistically significant as per FMOLS. But in case of DOLS model the result is different. Energy consumption has positive relationship with economic growth in Oman and UAE and but inverse for Bahrain and Saudi Arabia.

To summarize, the results suggest that in case of sample GCC countries, factors like urbanization and economic growth impact significantly the emission of Greenhouse gases.

6.3 Causality Results

The estimated results of causality are shown in Table (5) which indicates that in case of Bahrain there is one way casuality moving from urbanization to carbon emission, implying that rapid growth in urbanization causes the carbon emission issue in case of Bahrain. While, in case of Oman it is quite opposite, emission appears to cause the urbanization, implying that high rate of growth of carbon emission may thwart the urbanization activities. However, in case of Saudi Arabia, feedback hypothesis appears to be applicable. As the results indicate the directional causality between carbon emission and urbanization. This means that there is need to tradeoff between urbnization and carbon emission. In case of UAE, it appears that there is no causal relationship between carbon emission and urbanization. This is surpsirisng and it is in contrast with the results of FMOLS. Considering urbanization and energy consumption, it appears that out of four countries of GCC, there is only one way causality moving from energy consumption to urbanization in case of Oman and from urbanization to energy consumption in case of Saudi Arabia. While, UAE and Bahrain exhibit no relationship. This is again in contrast with the findings of FMOLS. Analyzing the causal relaitonship between energy consumption and GDP growth, the results indicate that among sample countries, Bahrain exhibits uni-directional causality moving from GDP growth to energy consumption, Oman exhibits bidirectional causal relationship, Saudi Arabia exhibits unidrectional moving from energy consumption to GDP growth and UAE shows the bilateral causal relationship. These results imply that there exists causal relaitonship between energy consumption and economic growth. Hence, it can be said that energy-growth framework is applicable in case of sample GCC countries. Lastly, we analyze the relationship between carbon emission and GDP growth, the results indicate that among GCC countries, it is the GDP growth that causes carbon emission in case of Bahrain and Oman. While, UAE exhibits unidrectional causal relaitonship moving from carbon emission to GDP growth, implying that in case of UAE, high carbon emission may cuase its high economic growth trajectory. Surprisingly, Saudi Arabia exhibits no causal relaitonship between carbon emission and economic growth. The result appears to be in contrast with the findings of FMOLS.

Table 3. Panel long-run estimators

LEM as Dependent variable			***LENC as Dependent variable***			***LGDP as Dependent variable***		
	FMOLS	**DOLS**		**FMOLS**	**DOLS**		**FMOLS**	**DOLS**
	BAHRAIN			**BAHRAIN**			**BAHRAIN**	
LURBAN	-0.017	-0.570**	LURBAN	0.029	0.613**	LURBAN	0.727**	1.685**
LGDP	0.051	0.457**	LGDP	-0.036	-0.432**	LENC	-0.782	-3.753**
LENC	0.934**	0.873**	LEM	1.034**	1.054**	LEM	1.307	3.631**
	OMAN			**OMAN**			**OMAN**	
LURBAN	0.073	0.754**	LURBAN	-0.173*	-0.479**	LURBAN	0.418**	-0.432**
LGDP	0.228	4.087**	LGDP	0.109	-1.572**	LENC	0.190	0.186
LENC	0.808**	-1.778**	LEM	1.030**	2.183**	LEM	0.239	0.621
	SAUDI ARABIA			**SAUDI ARABIA**			**SAUDI ARABIA**	
LURBAN	0.097	-1.127**	LURBAN	0.461**	0.479	LURBAN	-0.255	-0.122
LGDP	0.486**	0.257**	LGDP	-0.360**	-1.890**	LENC	-0.466	-1.052**
LENC	0.423**	1.479**	LEM	1.065**	2.389**	LEM	1.641**	2.110**
	UAE			**UAE**			**UAE**	
LURBAN	0.206**	0.098	LURBAN	-0.271**	0.189**	LURBAN	1.244**	2.080**
LGDP	-0.093**	0.035	LGDP	0.122**	-0.261**	LENC	1.796**	3.716**
LENC	0.684**	0.679**	LEM	1.427**	1.202**	LEM	-2.975**	-6.022**
	GROUP			**GROUP**			**GROUP**	
LURBAN	0.090**	-0.211**	LURBAN	0.012	0.201**	LURBAN	0.533**	0.803**
LGDP	0.168**	1.209**	LGDP	-0.041	-1.039**	LENC	0.185	-0.226**
LENC	0.712**	0.313**	LEM	1.139**	1.707**	LEM	0.053**	0.085**

Note: ** and * indicate the level of significance at 5% and 10% and better, respectively.

Pesaran's test of cross sectional independence = -1.140, Pr = 1.7456

To summarize, it can be said that in case of sample of GCC countries, there are two factors that are of major concerns i.e. urbanization and carbon emission and energy-growth relationship. These two frameworks need to be futher investigated considering the increasing concern of climate change and economic development of this particular countries. Though the empirical exercise conducted in this study needs further investigation as the results of FMOLS and causality results differ from each other in some cases.

Table 4. Panel causality test results

Null hypothesis			Cross section units			
			Bahrain	**Oman**	**Saudi Arabia**	**UAE**
LEM	↛	LURBAN	1.326	6.806**	7.764***	3.164
LURBAN	↛	LEM	7.914***	2.294	10.284***	2.239
LENC	↛	LURBAN	0.856	9.054***	1.919	2.063
LURBAN	↛	LENC	5.039	3.797	6.499**	0.977
LENC	↛	LGDP	0.152	3.248**	4.051***	7.449***
LGDP	↛	LENC	6.125***	4.013***	2.329	2.521*
LEM	↛	LGDP	0.011	0.451	0.013	4.295***
LGDP	↛	LEM	9.717**	4.587**	0.426	0.087

Note: denote the null hypothesis of no causality between variables. ***, ** and * denote rejection of the null hypothesis at the 1%, 5% and 10% and better, respectively.

Table 5. Summary of causality results

Null hypothesis			Cross section units			
			Bahrain	**Oman**	**Saudi Arabia**	**UAE**
LEM	↛	LURBAN	No	Yes	Yes	No
LURBAN	↛	LEM	Yes	No	Yes	No
LENC	↛	LURBAN	No	Yes	No	No
LURBAN	↛	LENC	No	No	Yes	No
LENC	↛	LGDP	No	Yes	Yes	Yes
LGDP	↛	LENC	Yes	Yes	No	Yes
LEM	↛	LGDP	No	No	No	Yes
LGDP	↛	LEM	Yes	Yes	No	No

Note: denote the null hypothesis of no causality between variables.

7. Conclusion and Discussion

In this study we use the panel data of carbon emission, energy consumption, urbanization and economic growth of four GCC countries namely Bahrain, Oman, Saudi Arabia and UAE. This study finds a long-run relationship between energy consumption, carbon emission, urbanization and economic growth with varying degree for a panel data in GCC countries over the period 1980-2011. Urbanization, economic growth and energy consumption have a positive and statistically significant impact on carbon emissions for the group of countries. Since, the fact is that increase in urbanization and real economic growth requires more energy consumption leading to high generation of carbon emission and greenhouse effect. In case of GCC countries, the prominent factor like urbanization drive the carbon emission. There is urgent need of policy measures in this regard. From the further finding, it has been inferred that the highest carbon emitting factor is high energy consumptions followed by GDP growth and urbanization. In case of energy –growth framework, there is positive relationship between energy consumption and economic growth. This result corroborates the large number of studies. Similarly, there is positive and significant relationship between urbanization and economic growth, probably, most of GCC countries are highly urbanized. Further it has been found that there is bi-directional and positive relationship between carbon emission and economic growth in case of GCC countries. If we see the causal relationship, Saudi Arabia has bidirectional relationship between carbon emission and urbanization. This bidirectional relationship is also found between economic growth and energy consumption in case of Oman.

The findings of this study will provide policymakers some understanding about the relationship between the carbon emission, energy consumption, urbanization and economic growth and designing of policies to tackle the environmental problems without creating hindrance for the growth of urbanization and economic growth. Further study is required to know the impact of different stages development on energy use and carbon emission.

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Notes

Note 1. The GCC is comprised of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates.

Note 2. Occasional Paper Series, no-92, July 2008 European Central Bank.