

Carbon Dioxide Emissions, Energy Consumption and Economic Growth in Saudi Arabia: A Multivariate Cointegration Analysis

Abstract

This paper applied the ARDL and VECM test techniques on economic growth, CO₂ emissions, energy consumption and the employment ratio to establish the long- and the short-run relationships between these variables in Saudi Arabia. The results show that there is a long-run relationship between the variables in the model. The estimated elasticity coefficient of CO₂ emissions is positive and significant, implying that an increase in GDP will increase the country's CO₂ emissions. The estimated elasticity coefficient of energy consumption is positive and significant. However, the magnitude of the CO₂ emissions elasticity coefficient is higher than the energy consumption elasticity coefficient. The estimated elasticity coefficient of the employment ratio shows that a significant increase in GDP will increase employment in the country. The application of the ECM based Granger Causality test of the long-run relationship between the variables is found to be consistent with the outcome of the ARDL test. The result shows that GDP does not Granger-Cause CO₂ emissions and indicates that in a logarithmic model, the EKC hypothesis does not hold in the case of Saudi Arabia. There is evidence of bidirectional causality running from energy consumption to economic growth and unidirectional causality running from the employment ratio to economic growth.

Keyword: *GDP, CO₂, Energy, Causality, ARDL, VECM*

1. Introduction

Climate change and global warming have attracted considerable worldwide attention. Many studies have focused on the relationships between growth and carbon dioxide (CO₂) emissions and growth and energy over the last two decades. It has been observed that higher economic growth causes environmental degradation and threatens the sustainability of the environment. It has been found that higher economic growth requires a higher level of energy consumption and is responsible for higher levels of

CO₂ emissions. This notion attracted the world's attention during the 1990s because of the potential threats to the ecosystem. It became the general consensus that higher economic growth should not be pursued at the expense of the environment and this issue raised the question of how economic growth can be made more sustainable. Brundtland (1987) defines sustainable development as development that meets the needs of the present without compromising the ability of future generations to meet their own needs.¹ International organizations around the world continuously attempt to reduce the adverse impacts of global warming. One such attempt is the Kyoto Protocol agreement, titled the United Nations Framework Convention on Climate Change (UNFCCC), made in 1997 as an attempt to reduce the adverse impacts of global warming. Among the variety of polluting substances, CO₂ is a major one and represents 58.8 percent of green house gas emissions (World Bank, 2007).

The choice of studying Saudi Arabia is motivated by the fact that the country is the 4th largest producer of oil and one of the largest consumers of energy in the world. Saudi Arabia also produced the 13th largest volume of CO₂ emissions in the world in 2008. Growth theory predicts that in the initial stages of development, the pressure on the environment is high because the use of energy is crucial to economic growth and development. Thus, Saudi Arabia became one of the highest energy consuming and CO₂ emitting countries in the world (World Bank, 2011).

1. This is consistent with the Neo-classical definition of income that proposes that technological progress is necessary to sustain positive growth in the long-run. Hicks, 1946, defines it as "a person's income is what he can consume during the week and still be as well-off at the end of the week as was at the beginning". Similarly, Medow, 1972, in a study on the "limits to growth" observed that if the present levels of consumption of non-renewable resources continue then it will exhaust the resources for future generations.

Saudi Arabia has revised its General Environmental Laws and the rules for their implementation (2001), in line with Article (32) of the constitution and under the responsibility of the Presidency of Meteorology and Environment (PME), to conserve and protect the natural resources and environment of the country.² To that end, this study seeks to empirically examine the long-run and causal relationships between economic growth, CO₂ emissions and energy consumption in a multivariate framework for Saudi Arabia during the 1980-2008 period. The study employed an Auto Regressive Distributed Lag (ARDL) model and Vector Error Correction Model (VECM) techniques to

establish the long- and short-run relationships between the variables in the model. In addition, the study applied an error correction model (ECM) based Granger causality test to evaluate the possible causal relationship between the variables in the model.

The remainder of the study is organized as follows. The second section outlines the brief literature about the relationships between economic growth, CO₂ emissions and energy consumption. The third section presents the model specifications, data and methodology. The fourth section presents the empirical results, and the last section includes important findings and valuable suggestions.

II. Literature Review

The links between economic growth and CO₂ emissions have been primary concerns of the empirical research, particularly since the 1990s. A number of empirical studies have enumerated the possible risks of CO₂ emissions and impediments to sustainable development.³ Theory suggests that a preference for environmental considerations will cause economic growth and prosperity. The available literature can be categorized into that on the growth CO₂ emissions nexus and that on the growth energy consumption nexus. The previous studies have found a variety of relationships between economic growth and environmental quality. In empirical studies, Shafiq and Banhyopadhyay (1992), Shafiq (1994), Bruyn et al. (1998) and Fodha and Zahdoud (2010) found a linear relationship between economic growth and environmental quality.

2. Presidency of Meteorology and Environment, Ministry of Environment, Government of Saudi Arabia.

3. Sustainable development refers to resolving the conflicting issues of economic prosperity, environmental quality and social equity. Environmental degradation comes in the form of various types of pollution and the depletion of ozone layer that degrades the eco-systems necessary for the sustainability of living organisms.

Studies by Friedl and Getzner (2003), Zarzoso and Maranco (2004), Hye and Richard (2010) established an N-shaped relationship. Studies by Grossman and Krueger (1999), Shafiq and Bandyopadhyay (1992), Panayotou (1993) and Galeotti et al. (2006) have instead found an inverse U-shaped relationship and challenged the Environmental Kuznets Curve (EKC). The EKC was popularized by Grossman and Krueger (1991) and based on a hypothesis made by Simon Kuznets (1955). The theory states that in the early stages of economic growth, environmental quality decreases with increases in per

capita income, but after a certain level, it starts decreasing with the increase in the level of per capita income, thus resulting in an inverted U-shaped curve.

Many empirical studies have considered CO₂ emissions and observed that CO₂ accounted for 60 percent of the greenhouse effect (Ozturk and Acaravci, 2010). Grossmann and Krueger (1993) used sulfur dioxide (SO₂) per capita, Panayatou (1993) included a trade component, Panayatou (1997) included population and Paul and Bhattacharya (2004) included energy consumption to show the direction of the relationship between economic growth and environmental quality. Ratnayake and Kim (1999) used air pollution, water pollution, administrative strictness and registered vehicles per capita. Perman and Stern (2003) and Stern (2004) observed that the available econometric literature on the EKC is weak. Narayan and Narayan (2010) noted that studies using income-squared and cubic variables suffer from the problems of colinearity or multicollinearity. They also observed that defining the turning point for the relevance of the EKC hypothesis suffers from model misspecification problems. They proposed that environmental quality can be judged by comparing the short-run income elasticity and the long-run income elasticity. They argue that if the long-run income elasticity is less than the short-run income elasticity, then it can be inferred that over time, increased income leads to decreased carbon dioxide emissions.

The links between economic growth and energy consumption have been examined by a number of empirical studies, and most of these studies have found that energy consumption has a direct impact on environmental quality. Economic theory predicts that higher economic growth requires higher energy consumption and is responsible for higher emissions. Kraft and Kraft (1978) observed that a unidirectional causality flows from output to energy consumption. Hye and Mashkoor (2010) observed bidirectional causality between economic growth and environmental sustainability. In a study on economic growth and energy consumption in four Asian developing economies, Adjay (2010) found a combination of unidirectional and bidirectional causality. Oh and Lee (2004) observed a unidirectional causality between economic growth and energy consumption in the short-run and found a bidirectional causality in the long-run. Erdal "et al.", (2008) observed bidirectional causality between energy consumption and economic growth in Turkey. Paul and Bhattacharya (2004) observed

bidirectional causality between economic growth, energy consumption and environmental quality. Tsani (2010) found a unidirectional causality that runs from energy consumption to economic growth in the case of Greece. Rufael (2010) observed a unidirectional relationship between energy consumption and economic growth in which causality runs from energy consumption to economic growth, in the case of South Africa. Lee and Chein (2010) found a unidirectional causality running from energy consumption to economic growth in their study of G-7 countries.

Saudi Arabia, alone of the largest consumers of energy, is also one of the largest countries in terms of global CO₂ emissions. There has been no systematic investigation to analyze the relationships among economic growth, CO₂ emissions and energy consumption in Saudi Arabia. The proposed study is an attempt to fill this gap.

III. Model and Econometric Methodology

The study applied multivariate model analysis techniques to examine the long-run relationships among economic growth, CO₂ emissions, energy consumption and the employment ratio in Saudi Arabia. The country has the world's largest oil reserves and is expected to have high levels of energy consumption and CO₂ emissions. The study is based on the assumption that economic growth is driven by high energy consumption that is likely to produce CO₂ driven economic growth in the country (Ozturk and Acaavci, 2010). The basic form of the relationship between the variables can be expressed as:

$$Y_t = f(COP_t, ENP_t, LAP_t)$$

where, (Y) represents GDP, (COP) represents CO₂ emissions, (ENP) represents energy consumption and (LAP) represents the employment ratio. The relationship can be expressed in as an equation as follows:

$$Y_t = \alpha + \beta COP_t + \delta ENP_t + \theta LAP_t + \varepsilon_t \dots \dots \dots \text{eq. (i)}$$

The study employed a log-linear model specification, and is thus likely to give more definitive results, as supported by Elrich (1977), Lays (1983) and Elrich (1996). The equation (i) can be modified in a logarithmic form:

$$\ln Y_t = \alpha + \beta \ln COP_t + \delta \ln ENP_t + \theta \ln LAP_t + \varepsilon_t \dots \dots \dots \text{eq. (ii)}$$

The coefficients β , δ and θ represent their respective elasticities, and ε_t is the disturbance term.

Where, Y_t = GDP Per capita ($GDPT/N_t$)
 COP_t = Carbon Dioxide per capita (COP_t/N_t)
 ENP_t = Energy consumption per capita (ENP_t/N_t)
 LAP_t = Employment Ratio ($LAP_t \times 100/N_t$)

III.I Bounds Testing Approach

This section outlines the application of ARDL techniques for cointegration developed by Pesaran et al. (2001) to establish the long-run relationship among economic growth, CO2 emissions, energy consumption and the employment ratio in Saudi Arabia. Econometric theory suggests that if the variables are cointegrated, there will be at least one linear combination of variables in the model. One implication is that most of the time, series data are non-stationary in nature, and the application of OLS techniques will result in spurious outcomes. These data requires that before the application of ordinary least squares (OLS) to estimate the relationship, it is necessary to establish the order of their integration: 1(0) or 1(1). The ARDL test technique requires endogenous variables to be non-stationary with respect to level, and the variables should not be integrated of order 1(2). For this purpose, the study applied a unit root test based on the Dicky-Fuller (1979) and the Augmented Dicky-Fuller (1981) tests to examine the time series properties of the data. The Dicky-Fuller (1979) test is employed in the model as follows:

$$Y_t = \beta_1 + \beta_2 t + \mu_t \dots \dots \dots \text{eq. (i)}$$

Where, $\mu_t = \alpha \mu_t + \varepsilon_t$ and ε_t represents a zero mean covariance stationarity in the model. The reduced form of the equation can be written as

$$Y_t = \beta_1 + \beta_2 t + \alpha(Y_{t-1}) + \varepsilon_t \dots \dots \dots \text{eq. (ii)}$$

$$\text{Where } \beta_1 = \beta_1(1 - \alpha) \text{ and } \beta_2 = \beta_2(1 - \alpha)$$

The test assumes a null hypothesis of a Unit root ($\alpha = 1$) and the alternative hypothesis $\alpha < 1$. One implication of the Dicky-Fuller test is that it is applicable under autoregressive processes of order one, AR(1), and in case of a higher autoregressive order, it will yield a spurious results. This inconsistency can be resolved by the application of the Augmented Dickey-Fuller (1981) test, which includes the higher order lagged differences. It is a more standard unit root test to check the stationarity of a series.

$$\Delta Y_t = \beta_1 + \beta_2 t + \alpha Y_{t-1} + \delta \sum_{i=1}^n \Delta Y_{t-i} + \varepsilon_t \dots \dots \dots \text{eq. (iii)}$$

Where Δ represents the first difference and nis lag length in the model

$$\Delta Y_{t-1} = (Y_{t-1} - Y_{t-2})$$

$$\text{and } \Delta Y_{t-2} = (Y_{t-2} - Y_{t-3})$$

After testing the non-stationary properties of the data, the study applied ARDL model techniques to establish the long-run relationships between the variables in the model. This is based on the estimates of the Unrestricted Error Correction Model (UECM), and OLS techniques will then be applied to estimate the model. The model for economic growth, CO₂ emissions, energy consumption and the employment ratio in the long- and short-run can be stated as follows:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{n-1} \alpha_{1i} \Delta Y_{t-i} + \sum_{i=0}^{n-1} \alpha_{2i} \Delta ICOP_{t-i} + \sum_{i=0}^{n-1} \alpha_{3i} \Delta IENP_{t-i} + \sum_{i=0}^{n-1} \alpha_{4i} \Delta ILAP_{t-i} + \beta_1 Y_{t-1} + \beta_2 ICOP_{t-1} + \beta_3 IENP_{t-1} + \beta_4 ILAP_{t-1} + \varepsilon_t \dots \text{eq. (iv)}$$

Where, Δ represents the first difference and ε_t is a disturbance term. The above equation indicates that economic growth is influenced by its past values. The null hypothesis that there is no cointegration relationship among the variables in the model such that

$$H_0: \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0 \text{ Whereas the alternative hypothesis that a long-run relationship exists is } H_1: \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq 0$$

The results of the ARDL test establish the acceptance or rejection of the null hypothesis. If the values of F-statistics are greater than the upper bound critical values, we reject the null hypothesis of no cointegration among the variables in the model. If the values of the F-statistics are lower than the lower bound critical values, we accept the null hypothesis of no cointegrating vector among the variables in the model. If the values of the F-statistics lie within the two critical values, the results will be inconclusive. When the results of the bounds test establish the long-run relationship, the long-run estimation of output growth (Y_t) can be calculated after considering the appropriate lag length in the model using the Shahbaz Bayesian Criteria (SBC) or Akaike Information Criteria (AIC).

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 ICOP_{t-1} + \beta_3 IENP_{t-1} + \beta_4 ILAP_{t-1} + \varepsilon_t \dots \text{eq. (v)}$$

III.II Application of the ECM Technique

The study also applied the ECM technique to trace the causal relationship for the dependent variables in the model in the short-run as follows:

$$\Delta IY_t = \alpha_0 + \sum_{i=1}^{n-1} \alpha_{1i} \Delta IY_{t-i} + \sum_{i=0}^{n-1} \alpha_{2i} \Delta ICOP_{t-i} + \sum_{i=0}^{n-1} \alpha_{3i} \Delta IENP_{t-i} + \sum_{i=0}^{n-1} \alpha_{4i} \Delta ILAP_{t-i} + \delta_{ii} ECM_i + \varepsilon_t \dots \dots eq.(vi)$$

Where, the respective elasticity coefficients are the short-run dynamic coefficients to the long-run equilibrium, and the δ coefficients are expected to have negative signs and reflect the speed of adjustment in the model.

IV.III Granger Causality

The application of the ARDL technique establishes the existence of the long-and short-run relationships between the variables in the model. The Engel Granger (1987) test reveals whether Granger Causality exists at least in one direction provided that the variables are integrated of order (1). One implication is that applying the Granger Causality test based on the Vector Auto Regressive (VAR) model in the first difference in the long-run relationship in equation (v) may yield inconsistent results in the presence of cointegration. Therefore, to capture the long-run relationship, an additional variable, the Error Correction Term (ECT), is incorporated in the model. The error correction term based on the Granger Causality test in a multivariate framework of the p th order can be formulated as:

$$(1-L) \begin{pmatrix} \Delta IY_t \\ \Delta ICOP_t \\ \Delta IENP_t \\ \Delta ILAP_t \end{pmatrix} = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ \beta_4 \end{pmatrix} + \sum_{i=1}^p (1-L) \begin{pmatrix} \mu_{11i} & \mu_{12i} & \mu_{13i} & \mu_{14i} \\ \mu_{21i} & \mu_{22i} & \mu_{23i} & \mu_{24i} \\ \mu_{31i} & \mu_{32i} & \mu_{33i} & \mu_{34i} \\ \mu_{41i} & \mu_{42i} & \mu_{43i} & \mu_{44i} \end{pmatrix} \begin{pmatrix} \Delta IY_{t-i} \\ \Delta ICOP_{t-i} \\ \Delta IENP_{t-i} \\ \Delta ILAP_{t-i} \end{pmatrix} + \dots \dots \dots$$

$$\dots \dots + \begin{pmatrix} \mu_{11k} & \mu_{12k} & \mu_{13k} & \mu_{14k} \\ \mu_{22k} & \mu_{22k} & \mu_{23k} & \mu_{24k} \\ \mu_{31k} & \mu_{32k} & \mu_{33k} & \mu_{34k} \\ \mu_{41k} & \mu_{42k} & \mu_{43k} & \mu_{44k} \end{pmatrix} \begin{pmatrix} \Delta IY_{t-k} \\ \Delta ICOP_{t-k} \\ \Delta IENP_{t-k} \\ \Delta ILAP_{t-k} \end{pmatrix} + \begin{pmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \end{pmatrix} ECT_{t-1} + \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \end{pmatrix} \dots \dots \dots equ (vii)$$

V. Empirical Results

The study applied the Dicky-Fuller (1979) test and the Augmented Dicky-Fuller (1981) test, and the results are presented in table 2. The results reveal that the dependent variables are integrated of order 1(1), while the exogenous variables are a mixture of orders 1(0) and 1(1).⁴

Table 2. Unit Root Test for Stationarity

Variables	DF Test		Significance Level			ADF Test		Significance Level		
	Level	First Difference	1 %	5%	10%	Level	First Difference	1 %	5%	10%
IY	0.344	-3.051	-2.653	-1.954	-1.610	-0.216	-4.621	-3.700	-2.976	-2.627
IENP	0.966	-1.030	-2.665	-1.956	-1.610	-1.743	-6.146	-3.724	-2.986	-2.633
ICOP	-2.176	-5.206	-2.653	-1.954	-1.610	-2.548	-5.111	-3.700	-2.976	-2.627
ILAP	-0.444	-1.623	-2.653	-1.954	-1.610	-1.153	-1.755	-3.700	-2.976	-2.627

Note: * indicates significance at the 1%, 5% and 10% levels respectively.

The results of the test indicate that we can reject the null hypothesis of no cointegration vectors and apply the ARDL technique to examine the long-run relationship among the variables in the model.

The application of the ARDL test based on Pesaran et al. (2001) on the basis of SBC lag criteria are presented in table 3. The ARDL test accounts for the existence of long-run relationship between the variables in the model. The computed F-statistics are greater than the upper bound critical values based on Pesaran et al. (2001) and Narayan (2005) at the 10%, 5% and 1% significance levels.

Table 3 Bounds Test Results of Long - run relationship

F-Statistics	9.189			
Significance Level				
	Pesaran et.al (2001)		Narayan (2005)	
	Lower Bounds	Upper Bound	Lower Bounds	Upper Bound
10%	4.13	5.0	6.19	4.42
5%	3.10	3.87	4.19	5.34
1%	2.63	3.35	3.39	7.88

Note. Based on Pesaran et al (2001), Table CI (iii) Case III. Narayan (2005) is taken from Hye and Ma

4. Pesaran et.al (2001) proposed that ARDL techniques can be applied whether the exogenous variables are integrated of order 1(0) or 1(1). shkoor (2010).

Table 3 presents the results of the long-run relationships between variables IY, ICOP, IENP and ILAP for the selected ARDL model. The results indicate that along-run relationship between the variables in the model exists. The estimated long-run

coefficients of CO₂ emissions percapita are positive and significant and indicate that an increase in GDP will increase CO₂ emissions per capita. The estimated coefficients of energy consumption are positive and significant by 0.34 percent, implying that a one percent increase in energy consumption will increase GDP by 34 percent

. The CO₂ emissions per capita intensity in Saudi Arabia is higher than the energy consumption intensity elasticity coefficient. The estimated elasticity coefficient of the employment ratio is positive and significant and indicates that an increase in the employment ration has an effect on the GDP growth rate in the country.

Table 3. Estimated Long-run Coefficients for the Selected ARDL
Dependent Variable (IY)

Variables	Coefficients	t-statistics
Constant	-1.910	[-2.330]
ICOP	0.340	[1.719]
IENP	0.417	[2.427]
ILAP	2.693	[4.076]
Diagnostics Test		
Adjusted R-square	0.645	
Jarque-Bera Normality test	1.490(0.475)	
Breusch-Godfrey Serial Correlation test	0.594(0.568)	
ARCH Test	0.294(0.748)	
Ramsay Reset Test	0.360(0.783)	
Durbin Watson Test	1.913	

The diagnostic tests reported at the bottom of the table indicate that the model satisfies the statistical requirements. The adjusted R-square indicates that 65 percent of the variation in the dependent variable is explained by the independent variables. The CUSUM and CUSUM squared tests, as depicted in Figure.1 (Appendix.1), indicate that the residual lines fall within the 5 percent critical bound values.

The results of the ECM-based application are presented in table 4. The results indicate that the ECM is negative and significant at a 5 percent significance level. This implies that 91 percent of the deviation in the long-run can be corrected in the next period. The estimated elasticity coefficients indicate that CO₂ emissions per capita are positive and significant in the short-run. The results also present positive coefficients for the impact of energy consumption on GDP in the short-run.

Table 4. Results of the ECM for the Selected ARDL model
Dependent Variable: GDP (IY) Per capita

Variables	Coefficients	t-statistics
Constant	-1.124	-4.532
$\Delta IY(-1)$	0.601	4.697
$\Delta IY(-2)$	0.514	3.744
$\Delta ICOP$	0.379	3.210
$\Delta ICOP(-2)$	-0.452	-3.931
$\Delta IENP$	0.122	0.672
$\Delta IENP(-1)$	-0.688	-3.669
$\Delta ILAP(-2)$	3.094	2.107
ECM(-1)	-0.910	-6.680
Diagnostics Test		
Adjusted R-square	0.708	
Jarque-Bera Normality Test	1.490(0.475)	
Breusch-Godfrey Serial Correlation Test	0.450(1.471)	
ARCH Test	0.294(0.653)	
Ramsay Reset Test	0.115(0.892)	
Durbin Watson Test	1.913	

The study also applied an error correction based on the Granger causality test to establish the direction of causal relationships between the variables in the model in the short- and long run. The results of the application of these techniques are presented in table 5. The results indicate that the coefficient of the lagged error correction term is negative and significant and make it possible for a long-run relationship to exist. The results of the ECM-based Granger Causality test for the long-run relationship are negative and significant and are found to be consistent with the results of the ARDL test. The results show that ICOP and IENP do not Granger-cause output in the short-run, but ILAP does. It can also be inferred that GDP does not cause CO₂ emissions, energy consumption and the employment ratio. The results establish that GDP does not cause CO₂ emissions and indicate that in a logarithmic model, the EKC hypothesis does not hold for Saudi Arabia. It can also be observed that IENP Granger-causes neither GDP nor CO₂ emissions but does cause the employment ratio in the country. There is evidence of a bidirectional causality running for energy consumption to the employment ratio and unidirectional causality running from the employment ratio to economic growth.

Table 5. Results of the Granger Causality Test

	F-statistics				
Dependents	ΔIY	$\Delta ICOP$	$\Delta IENP$	$\Delta ILAP$	EC_{t-1}
ΔIY		0.358(0.703)	3.233(0.587)	3.813(0.038)*	0.851[-4.630]*
$\Delta ICOP$	1.730(0.201)		0.249(0.782)	0.949(0.403)	-
$\Delta IENP$	0.612(0.551)	0.641(0.536)		2.636(0.094)*	-
$\Delta ILAP$	2.422(0.112)	2.084(0.148)	4.275(0.027)*		-

Notes: * denotes the 5% & 1% levels of significance. The numerals in the brackets depict t-values and those in parenthesis are p-values.

The results of the study are consistent with the findings of Soytaş and Sari (2009) and Ozturk and Acaravci (2010). The results of the test are also consistent with the proposed findings of Narayan and Narayan (2010) and found that long-run income elasticity, in the case of Saudi Arabia, is larger than the short-run income elasticity. Thus, the results indicate that an additional increase in GDP will increase per capita CO₂ emissions. The above analysis reveals that energy consumption policies will not increase the GDP growth rate, and it demands that the use of alternative means to conserve the country's oil resources be emphasized. A long-run relationship between economic growth, energy consumption and the employment ratio is present in Saudi Arabia. This scenario means that energy consumption is crucial for development, but the rapid pace of CO₂ emissions requires the adoption of alternative sources of energy and approaches to development.

V. Conclusion&Suggestions

This paper examines the relationships among economic growth, CO₂ emissions, energy consumption and the employment ratio in Saudi Arabia during the 1980-2008 period. The study applied the ARDL test and VECM-based test techniques to establish the short- and long-run relationships between the variables in the model. The results indicate that a long-run relationship between the variables in the model exists. The long-run estimated elasticity coefficient of CO₂ emissions is positive and significant, implying that an increase in GDP will increase per capita CO₂ emissions in the country. The estimated elasticity coefficient of energy consumption is positive and significant, implying that a one percent increase in per capita energy consumption will increase GDP by 34 percent in the long-run. The results indicate that the elasticity of CO₂ emissions intensity is higher than that of energy consumption in Saudi Arabia. The

estimated elasticity coefficient of the employment ratio reflects a significant increase in the GDP over a possible change in the employment ratio in the country. The results for the ECM-based, short-run relationship establish a positive and significant impact of CO₂ emissions and the employment ratio on economic growth. The results also establish a positive relationship between economic growth and energy consumption in the short-run.

The application of the ECM-based Granger Causality test is found to be consistent with the outcomes of the ARDL test. The results indicate that GDP does not Granger-Cause CO₂ emissions and demonstrate that in a logarithmic model, the EKC hypothesis does not hold in the case of Saudi Arabia. There is evidence of a bidirectional causality running from energy consumption and unidirectional causality running from the employment ratio to economic growth in Saudi Arabia. The results are consistent with the proposed findings of Narayan and Narayan (2010) that the long-run income elasticity is greater than the short-run income elasticity. Thus, it exhibits the results demonstrate that maintaining a high level of energy consumption will aggravate CO₂ emissions given an increase in GDP. The above analysis reveals that energy conservation policies will not increase the GDP growth rate. The analysis demands an emphasis on the use of alternative means to conserve oil and other natural resources of the country.

References:

- Akinlo, A.E 2008, 'Energy consumption and economic growth: Evidence from 11 Sub-Sahara African countries', *Energy Economics*, vol. 30, no. 5, pp. 2391-2400
- Albania, Bulgaria, Hungary and Romania: Evidence from ARDL bound testing approach', *Applied Energy*, vol. 87, no. 6, pp. 1938-1943.
- Asafu-Adjaye, J 2000, 'The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries', *Energy Economics*, vol. 22, no. 6, pp. 615-625.
- Brundtland, G.H (1987), 'Our Common Future'. Report of World Commission on Environment and Development, United Nations.
- Cordero, Paula., Sepulveda, Sergio and Rodriguez, Adrian (2008), Trade and Environment issues. Inter-American Institute for Cooperation on Agriculture (IICA). San Jose, Costa Rica
- Erdal, G, Erdal, H.&Esengun K 2008, 'The causality between energy consumption and economic growth in Turkey', *Energy Policy*, vol. 36, no. 10, pp. 3838-3842.
- Friedl, B & Getzner, M (2003). Determinants of CO₂ Emissions in a Small Open Economy. *Ecological Economics*, 45, 133-148.
- Fodha, M & Zaghoud, O (2010). Economic Growth and Pollution Emissions in Tunisia: AN empirical analysis of the environmental Kuznets curve. *Energy Policy*, 38, 1150-1156.
- Galeotti, M, L. Alessandro & F. Pauli (2006), Reassessing the environmental Kuznets Curve for

407 Co2 emissions: A robustness exercise, *Ecological Economics*, 57:152-163.
 408 Grossman, G.M & Krueger, A.B (1995). Economic Growth and the Environment. Quarterly Journal of,
 409 Economics 110(2): 353-377.
 410 Hye and Mashkoo (2010) Growth and Energy Nexus: An Empirical Analysis of Bangladesh Economy.
 411 Volume, 15, number 2 (2010).
 412 Johansen, S & Juselius K, 1990, 'Maximum likelihood estimation and inference on cointegration with
 413 application to the demand for money', Oxford Bulletin of Economics and Statistics, vol. 52, no. 2,
 414 pp.169-210.
 415 Kraft, J & Kraft, A 1978. 'On the relationship between energy and GNP', Journal of Energy and
 416 Development, vol. 3, no. 2, pp. 401-403.
 417 Lee, CC & Chien M 2010, 'Dynamic modeling of energy consumption, capital stock, and real income in
 418 G-7 countries', Energy Economics, vol.32, no. 3, pp. 564-581.
 419 Masih, AMM & Masih, R 1996, 'Energy consumption, real income and temporal causality: Results from a
 420 multi-country study based on co-integration and error-correction modelling techniques', Energy
 421 Economics, vol. 18, no. 3, pp. 165-183.
 422 Odhiambo, NM 2010, 'Energy consumption, prices and economic growth in three SSA countries: A
 423 comparative study', Energy Policy, vol. 38, no. 5, pp. 2463-2469.
 424 Oh, W & Lee, K 2004, 'Causal relationship between energy consumption and GDP revisited: The case of
 425 Korea 1970–1999', Energy Economics, vol. 26, no. 1, pp. 51-59.
 426 Martinez-Zarzoso, I. And Bengochea-Morancho, A. (2004). Pooled mean estimation for an environmental
 427 Kuznets curve for CO2. Economics Letters, 82, 121-12, OI:10.1016/j.enpol.2008.11.012
 428 Paresh Kumar Narayan and Seema Narayan, 2010. Carbon Dioxide Emissions and Economic
 429 Growth: Panel Data Evidence from Developing Countries. Energy Policy. 38(1), 661-666.
 430 Ozturk, I & Acaravci, A 2010, 'The causal relationship between energy consumption and GDP in
 431 Albania, Bulgaria, Hungary and Romania: Evidence from ARDL bound testing approach', Applied
 432 Energy, vol. 87, no. 6, pp. 1938-1943.
 433 Paul, S. (2004). Causality between Energy Consumption and Economic Growth in India: A Note on
 434 Conflicting Results. Energy Economics 26: 997-983.
 435 Panayotou, T., (1993) Empirical Tests and Policy Analysis of Environmental Degradation at
 436 Different Stages of Economic Development, Working Paper WP238 Technology and
 437 employment Programme, Geneva: International Labor Office
 438 Panayotou, T. 1997. Demystifying the environmental Kuznets curve: Turning a black box into a
 439 policy tool. *Environment and Development Economics* 2:465– 484.
 440 Paul, S & Bhattacharya, RN 2004, 'Causality between energy consumption and economic growth in
 441 India: A note on conflicting results', Energy Economics, vol. 26, no. 6, pp. 977-983.
 442 Ratanake, Ravi & Woo-Young Kim (1999). Economic Growth and The Environment in High
 443 Performing East Asian Countries: Lessons from South Korea. Department of Economics, University of
 444 Auckland. Economic Growth and Environmental Degradation in Nigeria: Beyond the Environmental
 445 Kuznets Curve
 446 Perman, R. and Stern, D. I., 2003. Evidence from panel unit root and cointegration tests that the
 447 environmental Kuznets curve does not exist. Australian Journal of Agricultural and Resource Economics,
 448 Vol. 47.
 449 Saudi Arabia Monetary Authority (SAMA), Annual Report, 2011
 450 Shafik, Nemat & Sushenjit Bandyopadhyay, 1992. 'Economic Growth and Environmental Quality: Time
 451 Series and Cross-Country Evidence.' *Background Paper for the World Development Report*. The
 452 World Bank, Washington D.C.
 453 Soytaş, U., Sari, R., 2009. Energy consumption, economic growth, and carbon emissions: challenges
 454 faced by an EU candidate member. *Ecological Economics* 68, 1667–1675.
 455 Stern, DI & Cleveland, CJ 2004, Energy and economic growth, Rensselaer Working Papers in Economics
 456 edn, Rensselaer Polytechnic Institute, Department of Economics.

Simon Kuznets (1955), Economic Growth and Income Inequality. The American Economic Review, Volume XLV, number One, March, 1955

Tsani, S.Z 2010, 'Energy consumption and economic growth: A causality analysis for Greece', Energy Economics, vol. 32, no. 3, pp. 582-590.

UNCTAD, 2011, UNCTADstat, UNCTAD, 2011.

Wolde, Rufael. (2005). Energy Demand and Economic Growth: The African Experience. Journal of Policy Modeling, 27: 891-903.

World Bank (2007), Growth and Co2 emissions: How do different countries fare. Environment department, Washington, D.C

World Bank, (2011), World Development Indicators on line statistics, World Bank, (2011

Appendix.1

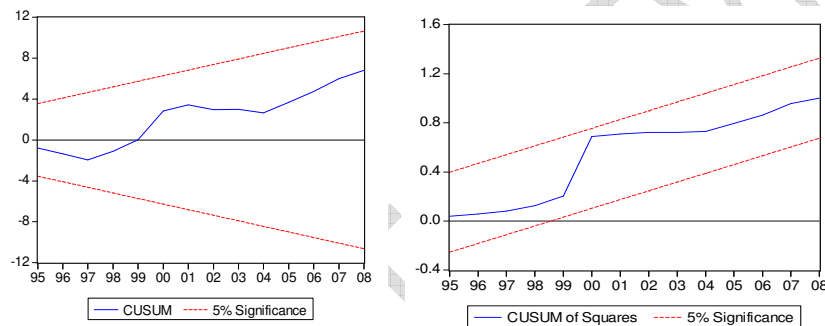


Fig. 2 Plot of both the CUSUM and CUSUM Squared tests for the dependent Variable IY