Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.6, No.2, 2015

Economic Growth and Environmental Degradation in Saudi Arabia

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Abstract
This paper has for objective to examine the effects of the economic growth, energy use and trade openness on carbon dioxide (CO_2) emissions for the case of the Kingdom of Saudi Arabia by estimating what is called the environmental Kuznets curve (EKC) model over the period 1970-2012. Our findings infirm the existence of EKC whereas they indicate that Saudi Arabia would be in its ascending phase of the environmental Kuznets curve. We notice that the per capita GDP and the per capita energy use increase CO_2 emissions whereas trade openness does not have a significant effect on CO_2 emissions. Our results suggest that growth targets should be accompanied with the measures of adaptation and strategies of development which plan limits in energy use and CO_2 emissions in Saudi Arabia.
Keywords: Economic growth; Energy use, CO_2 emissions; environmental Kuznets curve; Saudi Arabia.

1. Introduction

The attention accorded to the environmental problems is more and more worrisome, and occupies very important research and media spaces worldwide (Alkhathlan and Javid, 2013). Indeed, the global warming, due to the accumulation of greenhouse gases (GHG), the main thing of which is the carbon dioxide (CO_2), constitutes the main threat for the humanity. It could cost to the global economy up to 550 billion US dollars (Stern, 2006) if the governments do not take radical measures.

Besides, a reheating of 2°C could lead to a reduction of 4 to 5 % of average annual consumption per capita in Africa and in Asia (Nordhaus and Boyer, 2000) while it would result from it small losses in high-income countries (Nordhaus, 2008). According to the World Bank (2010), climate change risks to invert the economic progress hardly realized; and developing countries will pay the most heavy toll, between 75 and 80 % of the costs of the damage caused by climate change (Hope, 2009).

The Intergovernmental Panel on Climate Change (IPCC) considers that the acceleration of the degradation of the environment is mainly due to human factors such as population growth, deforestation, industrialization, agriculture, trade (IPCC, 2007; 2013).

It is necessary to raise that the analysis of the determinants of the environmental degradation becomes a very fascinating subject in the economic literature. The majority of the previous studies tried to verify the hypothesis of the environmental Kuznets curve between the per capita income and the indicators of environmental degradation (Grossman and Krueger, 1993, 1995, 1996; Shafik and Bandyopadhyay, 1992; Shafik, 1994; Panayotou, 1993,1995; etc.)[1]. The EKC stipulates that at the early stages of economic growth, the degradation of the environment is accelerated, but beyond some level of development (or per capita income), the situation is reversed and the situation of the environment is improved due to the increased levels of per capita income (Alkhathlan and Javid, 2013). This logic is explained by the fact that at the early stages of development, countries move from the preliminary stage to the industrial stage where pollution increases rapidly due the extensive use of natural resources. In later stage of industrialization, incomes rise and people become more aware of the environment. Regulatory measures are taken and the pollution indicators are reduced (Dinda, 2004). The interest of the EKC is that it postulates the possibility for developing countries to improve the environmental quality as they develop, as the standard of living of the individuals improves and favors the hatching of an environmental consciousness (World Bank, 1992). Many authors proposed a detailed review of empirical works on the relation between income per capita and the quality of the environment (Dinda, 2004). The diversity of the studies confirms that the environmental problems are different from a region to the other one, making particular the solutions proposed to limit environmental degradation.

Considered as a taboo in developed and developing countries, the environmental problems take more and more scale since the holding of the first summit of Rio in 1992. Since that, the United Nations has been engaged in reducing GHG emissions by the adoption of the Kyoto Protocol in 1997 and its entering into force in 2005[2]. As of June 2013, there are 191 countries which ratified and signed the Kyoto Protocol including Saudi

[1] The EKC curve is so called in reference to the disparities - income curve revealed by Kuznets in 1955. It indicates that the disparities evolve and tend to be reduced as income increases, describing one relation in U inverted.
[2] "The Kyoto protocol attempts through political negotiations to guide participating industrialized countries' greenhouse gas

Arabia that signed it in 31 January 2005. This awareness is so relevant as the increase of CO_2 emissions was accelerated by the economic growth and fossil fuels use in many countries including Saudi Arabia. Therefore reducing GHGs emissions, mainly CO_2 emissions, becomes urgent in order to promote a sustainable development and mitigate climate changes.

Our choice of Saudi Arabia is motivated by the fact that it experiences an important increase of CO_2 emissions and a strong economic growth followed by a structural change and diversification of Saudi Arabian economy. Table 1 shows the Percent Distribution of Gross Domestic Product of Saudi Arabia by Economic Activities at constant prices.

So, explain and understand the relationships between the macroeconomic variables and the atmospheric pollution constitute the main centers of interest of this paper, which aims at testing the existence of the EKC for carbon dioxide emissions in the case of Saudi Arabia. Hence, we investigate the relation between the per capita CO2 emissions, per capita income, per capita energy use and trade openness in Saudi Arabia to propose compatible structural strategies of transformation with the objectives of sustainable development.

The rest of the paper is organized as follows. In section 2, we present an overview of environmental situation in Saudi Arabia. Section 3 presents a brief literature review, whereas section 4 presents the methodological approach. Section 5 is reserved for the analysis of the results. Finally, section 6 presents the conclusion and some recommendations of economic and environmental policy.

2. Overview of environmental situation in Saudi Arabia

The Saudi Arabian economy is based on oil resources. The different sectors of industry, building and transport are energy intensive (Alkhathlan and Javid, 2013). The evolution of carbon dioxide emissions is totally linked to the evolution of total primary energy consumption. Total primary energy consumption had increased by nine times between 1970 and 2012 in Saudi Arabia whereas worldwide total primary energy consumption had increased by only 1.5 times for the same period (BP Statistical Review of World Energy, 2013). In the same line, carbon dioxide emissions had increased by about 8.3 times between 1970 and 2012 in Saudi Arabia whereas worldwide carbon dioxide emissions had increased by only 1.29 times for the same period (BP Statistical Review of World Energy, 2013)[1]. Figures 1 and 2 show respectively the evolutions of total primary energy consumption and carbon dioxide emissions in Saudi Arabia over the period 1970-2012. Saudi Arabia's share of carbon dioxide emissions worldwide in 2012 was at the 8th place, or 1.8% share of worldwide emissions (BP Statistical Review of World Energy, 2013). During the decades 1970-1980, 1980-1990, 1990-2000, and 2000-2010, CO_2 emissions increased by 174%, 28%, 36% and 56%, respectively, in Saudi Arabia. These evolutions are detected by figure 2 which shows the evolution of carbon dioxide emissions in Saudi Arabia over the period 1970-2012. So, we notice a positive evolution of the carbon emissions in Saudi Arabia since the 1970s.

3. A brief literature review of the EKC hypothesis

The 1990s years mark the succession of the first works which aim at giving an empirical contents to the relation between the per capita income and the quality of the environment. The main objective of these works is to verify the hypothesis of the environmental Kuznets curve or of an inverted-U curve between the income and the indicators of environmental quality (CO_2, SO_2, deforestation, etc.). Instead of describing the economic growth as a threat for the environment and recommending to stop it, the hypothesis of the EKC supposes a certain compatibility between the environmental protection and the future economic growth.

To understand this mechanism, we use the decomposition of the total emissions proposed by Grossman and Krueger (1995) and Antweiller et al. (2001):

$$E_i = Y_i + \sum_{j=1}^{n} Y_{ij} + \sum_{j=1}^{n} \varepsilon_{ij} \tag{1}$$

Where E_i are the total emissions, i indexes the country, and j=1,2, …, n represent the diverse branches of industry, Y_i represents in general the GDP which captures the scale of the economy of the country i. The Y_{ij} represent the part of the added value of the sector j in the economy of the country i and indicates the composition of the economy. The ε_{ij} represent the intensity of pollution of the sector j in the economy of the country i.

Scale effect: The effect of scale refers to the increase of the environmental nuisances further to the

emissions from a positive growing trend, to reach a peak point (or turning point), and then be reduced to a negative growth. That means the relationship between decreasing GHG emissions and economic growth may be described by an inverted-U curve, which is consistent with the concept of the EKC hypothesis", (Huang et al., 2008).

[1] "The carbon emissions above reflect only those through consumption of oil, gas and coal, and are based on standard global average conversion factors. This does not allow for any carbon that is sequestered, for other sources of carbon emissions, or for emissions of other greenhouse gases. Our data is therefore not comparable to official national emissions data" (BP Statistical Review of World Energy, 2013).

increase of the production. By postulating that the state of the technology and the structure of the economy remain unchanged, any increase of the production will be translated by an increase of the nuisances of the same amount. The scale effect of production on environment results from the increasing production and the extraction of natural resources in the early stages of development when production shifts from primary production (agricultural production) to industrial production (Dinda, 2004).

Composition effect: The effect of composition captures the effect of a modification of the structure of production on the environment. The structural transformation of developed countries from essentially agricultural economy to an industrial economy was translated by an increase of the intensity of pollution, the technological level remaining unchanged.

Technical effect: The technical effect finally captures the impact of the technical progress on the quality of the environment. So, any improvement of the technical coefficient will be translated by a deceleration of the growth rate of the environmental damages. Furthermore, the implementation of a rigorous environmental regulations, due to the environmental awareness will also allow to reduce the environmental pressures (Neumayer, 1998).

All these effects act differently according to the level of development of countries. So, in low-income countries, the effect of scale combined with the effect of composition (due to the specialization in the polluting industries) dominate and accelerate the environmental degradation. However, as countries become more developed and rich, they release important incomes allowing to specialize in services and invest in the least polluting technologies, hence the improvement of the technical coefficient and a consequent reduction of the environmental damage (Kaika and Zervas, 2013).

The EKC hypothesis is the object of numerous works. Grossman and Krueger (1993), (1995), and (1996), Beckerman (1992), Panayotou (1993, 1995), Shafik and Bandyopadhyay (1992), Shafik (1994), and Selden and Song (1994) are the first authors to test empirically the effects of the per capita income on the environmental indicators (SO_2, NOx, CO_2, CO, municipal waste, airborne particles, etc.). Grossman and Krueger (1991) are the first ones to obtain an inverted-U curve in their working paper on the environmental effects of the North American Agreement of Free Exchange. They verify the relation of Kuznets for the air pollution and the water pollution. Panayotou (1993), Shafik and Bandyopadhyay (1992), Selden and Song (1994) also confirm the environmental Kuznets curve hypothesis for various environmental indicators and zones of studies. Many recent studies also confirm the existence of the EKC hypothesis (Jalil and Mahmud, 2009; Lamla, 2009; Pao and Tsai, 2011; Han et al., 2011; Lau et al., 2014).

Other investigations (Carson et al ., 1997; Cialani, 2007; Akbostanci et al., 2009; Halicioglu, 2009; Akpan et al. 2011; etc.) do not end in the inverted-U relationship. These authors obtain diverse alternative forms for the econometric model. Cialani (2007) tests the EKC hypothesis in the case of Italy over the period 1861-2002. His result does not confirm the inverted-U curve. Also, Akbostanci et al. (2009) do not confirm the EKC hypothesis for the case of Turkey during the period of 1968-2003. They find a monotonically increasing relationship between carbon dioxide emissions and per capita income. Kijima et al. (2010) argue that the relationship between environmental indicators and economic growth should be studied using various models that take into account policy designs. The manner by which economic growth affects environmental indicators is still controversial (Kijima et al., 2010).

Indeed, certain authors justify the absence of an inverted-U relation between the economic growth and the CO_2 emissions by the fact that there is no incentive in the reduction of discharges of pollutants, the cost of reduction of climate change being local and their global profits.

Various additional variables are introduced into the analysis of the determinants of the environmental quality. Studies of Shi (2003), Cole and Neumayer (2004), Halicioglu (2009), Shahbaz et al. (2010), Akpan et al. (2012), and Ismael and Mawar (2012) obtain a positive relation between CO_2 emissions and a set of macroeconomic variables such as trade openness or international trade, energy consumption, and population density or rate of urbanization.

Trade openness becomes an interesting variable in examining the relationship between environmental degradation and economic growth (Diwan and Shafik, 1992; Pearce and Warford, 1993; Ekins, 1997). Diwan and Shafik (1992) noted: “It is perfectly possible for a single nation to secure sustainable development-in the sense of not depleting its own stock of capital assets-at the cost of procuring unsustainable development in another country” (Pearce and Warford, 1993). “The availability of technologies that delink local and global pollution eliminated many of the automatic benefits for the global environment from addressing local concerns. Now, the North can achieve improvements in local environmental quality while continuing to impose negative externalities internationally” (Diwan and Shafik, 1992). These expressions explain what we call now the “pollution haven hypothesis”. Since these first works, many other authors support the role that can play trade openness in explaining the EKC hypothesis through the production of pollution-intensive goods by developing countries in order to expand their exports (Kaika and Zervas, 2013). Hence, higher production leads to more pollution. As the increase of production leads to a rise of incomes, this may result in more restrictive regulations toward pollution. Hence international trade increases pollution through the scale effect whereas it can improve environmental quality through the composition effect and/or the technical effect (Dinda, 2004).

The initial and standard EKC regression model, representing an inverted U relationship between environmental pollution and income, is as follows:

$$Ln(E_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 (\ln(Y_t))^2 + \mu_t \qquad (2)$$

Where ln is the natural logarithm, E is per capita emissions, and Y is the per capita income. The turning point or threshold level is given by $\pi = \exp(-\beta_1/2\beta_2)$. The general reduced-form of EKC model is as follows Dinda (2004):

$$Ln(E_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 (\ln(Y_t))^2 + \beta_3 (\ln(Y_t))^3 + \beta_4 Z_t + \mu_t \qquad (3)$$

Where Z_t represent some other variables (such as population density, trade openness, etc.) that may affect environmental degradation variable. The equation (3) reflects the model when we examine an N-shaped relationship between environmental pollution and economic growth. The estimation of this model can test the following cases (Kaika and Zervas, 2013):

a- If $\beta_1 = \beta_2 = \beta_3 = 0$, then absence of relationship between E and Y.
b- If $\beta_1 \neq 0$ and $= \beta_2 = \beta_3 = 0$, then a monotonic increasing or decreasing relationship between E and Y exists.
c- If $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 = 0$, then an inverted U relationship between E and Y exists.
d- If $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 = 0$, then a U-shaped relationship between E and Y exists.
e- If $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 > 0$, then an N-shaped relationship between E and Y exists.
f- If $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 > 0$, then an inverted N-shaped relationship between E and Y exists.

We observe that the third case implies an EKC-relationship. Recently, many empirical studies investigate the EKC hypothesis using time series econometric modelling. Fodha and Zaghdoud analyze the relationship between economic growth and pollutant emissions in the case of Tunisia over the period 1961-2004 using the Johansen multivariate cointegration approach. Their results confirm the inverted-U curve relationship between SO_2 emissions and income whereas a monotonically increasing relationship between CO_2 emissions and income. Ahmed and Long (2012) verify the hypothesis in the case of Pakistan using an ARDL cointegration approach and integrating beside economic growth, energy consumption, trade liberalization and population density in the model over the period 1971-2008. Their results support the inverted U-shaped relationship between carbon dioxide emissions and economic growth in both short and long runs. They find that energy consumption, population and economic growth affect negatively environment whereas trade has a positive effect on environment.

3. Methodology and data

3.1. Data and description of variables

In this study, we verify the EKC hypothesis in the case of Saudi Arabia using per capita CO_2 emissions as proxy of the environmental degradation as the dependent variable. The per capita GDP, the per capita energy use and trade openness are the independent variables.

This choice is justified by diverse manners:

- At first, the CO_2 is the main greenhouse gas responsible for climate change. It represents more than 60% of GHGs (Ozturk and Acaravci, 2010). Also the regulations of CO_2 become a very important intergovernmental question (Talukdar and Meisner, 2001). Such a study can thus result at the suggestion of a plan of convergence of CO_2 emissions for Saudi Arabia.
- Databases on CO_2 emissions are accessible, contrary to the other indicators for which there are only very few data, mainly in the case of developing countries.

As explained above, economic growth or income is the main driver of CO_2 emissions. Many previous studies prove that energy use is a driver of economic growth (Belloumi, 2009; Alshehry and Belloumi, 2014; etc.). Figure 3 shows the evolutions of per capita CO2 emissions and per capita GDP at constant prices of 2005. A country, such as Saudi Arabia, having a high level of energy use, has also a high level of per capita income. But a high level of energy use leads to a high level of CO_2 emissions. This explains and justifies our choice of including per capita energy use as an explanative variable in the model. Figure 4 shows the evolution of per capita CO2 emissions and per capita energy use in Saudi Arabia.

As explained above, trade openness is an interesting variable in explaining the environment situation. The summary statistics of the various variables are shown in Table 2. All the data of these variables are obtained from the World Development Indicators (2014) online database of the World Bank.

3.2. Econometric model

This work takes support on the following function, in which the explanatory variables are selected from a varied literature:

$$E = f(Y, EU, T) \qquad (4)$$

Where E is per capita CO_2 emissions. This variable is used as proxy of the environment pollution. The variable

Y is the per capita gross domestic product; EU is the per capita energy use; T is the trade openness (Exports + Imports / GDP).

Under its log-linear shape, the equation (4) can be rewritten under its N shape as follows:

$$Ln(E_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 (\ln(Y_t))^2 + \beta_3 (\ln(Y_t))^3 + \beta_4 \ln(EU_t) + \beta_5 \ln(T_t) + \mu_t \quad (5)$$

According to the EKC hypothesis, it is likely that β_1, β_3 and β_4 are positive, β_2 is negative whereas the sign of β_5 is not predictable. It can be positive or negative. The per capita GDP captures the impact of the level of development on the environment. In theory, the hypothesis of the EKC postulates that the degradation of the environment is accelerated in developing countries, whereas the inverse effect is observed when these countries reach certain level of income.

At the world level, the energy consumption constitutes the second source of greenhouse gas emissions. If the increase of the energy consumption is due to the good performances of the productive sector, the expected sign of the coefficient β_4 is positive.

The degree of trade openness captures the effects of the international trade on the environmental quality. In the developed countries, the imposition of a strong environmental regulations is generally translated by movements of relocation of the polluting industries towards countries with weak environmental regulations (it is about the hypothesis of the " haven pollution "). So, the sign of coefficient of international trade varies according to the level of development of countries (Grossman and Krueger, 1995; Halicioglu, 2009). In the developed countries, international trade reduces the environmental degradation, whereas the inverse effect is observed in developing countries. As Saudi Arabia is an emerging country with high per capita income, the sign of the coefficient of trade openness can be positive or negative.

4. Empirical results and discussion

Results of estimation of N-relationship given in equation (5) are presented in table 3. Also the results of the diagnostic tests (Jarque-Bera test for Normality of the errors, Breusch-Godfrey Serial Correlation LM test, White Heteroskedasticity test) are presented in the same table. The results show that the N-relationship between CO_2 emissions and per capita GDP is confirmed. Indeed, the three coefficients (β_1, β_2 and β_3) are statistically significant at a level of 5%. The first coefficient is positive, the second one is positive and the third is positive. The per capita energy use is significant and has a positive coefficient indicating that it affects negatively the environment. This result is highly expected for Saudi Arabia which uses intensively the fossil fuels. However, the results of Breusch-Godfrey Serial Correlation LM and White Heteroskedasticity tests indicate that the errors are correlated and heteroskedastic at 5% level. Hence we correct for autocorrelation and heteroskedasticity by using robust estimates. The results of robust estimates are shown in table 4. They show that the coefficients of per capita GDP, its squared form and its cubic form have alternate signs (positive, negative and positive) but they are not significant. Hence the N-relationship curve is rejected.

After presentation to the results of N-relationship, we estimate the inverted-U relationship between carbon dioxide emissions and per capita GDP but the estimation results infirm the existence of EKC for the case of Saudi Arabia. Indeed the coefficient of the squared variable of income is not significant. This allows us to estimate the model by considering, besides per capita energy use and trade openness, only per capita GDP as independent variable. The results of least squares estimates and robust estimates are shown in tables 5 and 6, respectively. As the estimates of least squares are biased due the correlation and heteroskedasticity of the errors, we consider and comment the results of robust estimates shown in table 6.

In this table 6, we notice that the economic growth has positive and significant effects on CO_2 emissions in Saudi Arabia, what indicates that Saudi Arabia would be in its ascending phase of the environmental Kuznets Curve. Figure 5 confirms this finding by the showing the relationship between economic growth and carbon dioxide emissions in Saudi Arabia over the period 1970-2012.

Besides, the energy consumption constitute the main determinant of the atmospheric pollution in the country of study. It has a significant and positive impact on CO_2 emissions. This impact is also stressed by the strong population growth which knows the country. This result is in accordance with that of Halicioglu (2009), Akpan et al. (2012) who notice that an increase of the energy consumption is translated by the increase of CO_2 emissions in Turkey and Nigeria respectively.

Finally, the coefficient of trade openness is positive but not significant. Hence, we notice that the international trade would not be a significant determinant of CO_2 emissions in Saudi Arabia. Unless, the improvement of the degree of opening of Saudi Arabia, this would not be translated by a significant increase of CO_2 emissions. This result indicates that the commercial liberalization is not manifested by the migration of the polluting industries of developed countries in direction to Saudi Arabia, less inflexible regarding environmental protection.

5. Conclusion

The objective of this paper is to examine the effects of the economic growth on CO_2 emissions in Saudi Arabia over the period 1970-2012. Globally, our findings indicate that economic growth and energy consumption would be the main determinants of CO_2 emissions in Saudi Arabia. Then, it is necessary to test the important role of trade openness in the incrimination of the pollution by the CO_2 emissions. Our results show that trade openness has a positive but insignificant impact on CO_2 emissions.

Previous studies on EKC have shown that economic growth could lead to improve the environmental quality if appropriate measures of regulations are taken (Dinda, 2004). In the political plan, our results suggest that growth targets should be accompanied with the measures of adaptation. In this case, it is necessary to incorporate programs of adaptation into the strategies of development which plan limits in energy use and CO_2 emissions in Saudi Arabia.

Besides, Saudi Arabia has to promote a Green Including Growth, which will cross inevitably by the raising awareness of the populations on the risks linked to environment.

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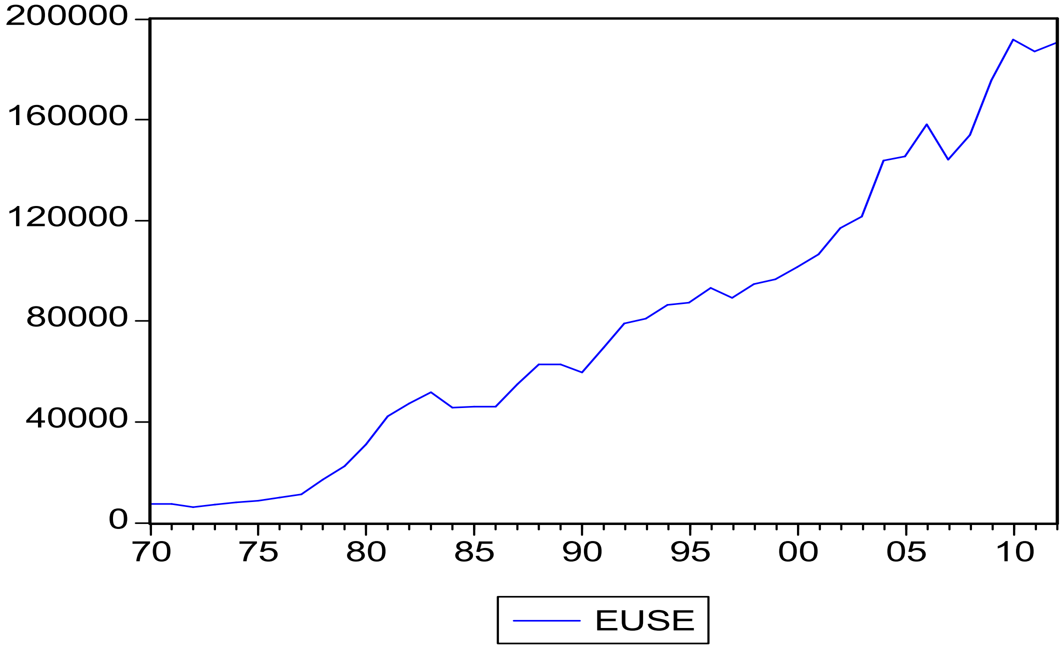

Figure 1. Evolutions of total primary energy consumption (Million tons oil equivalent)

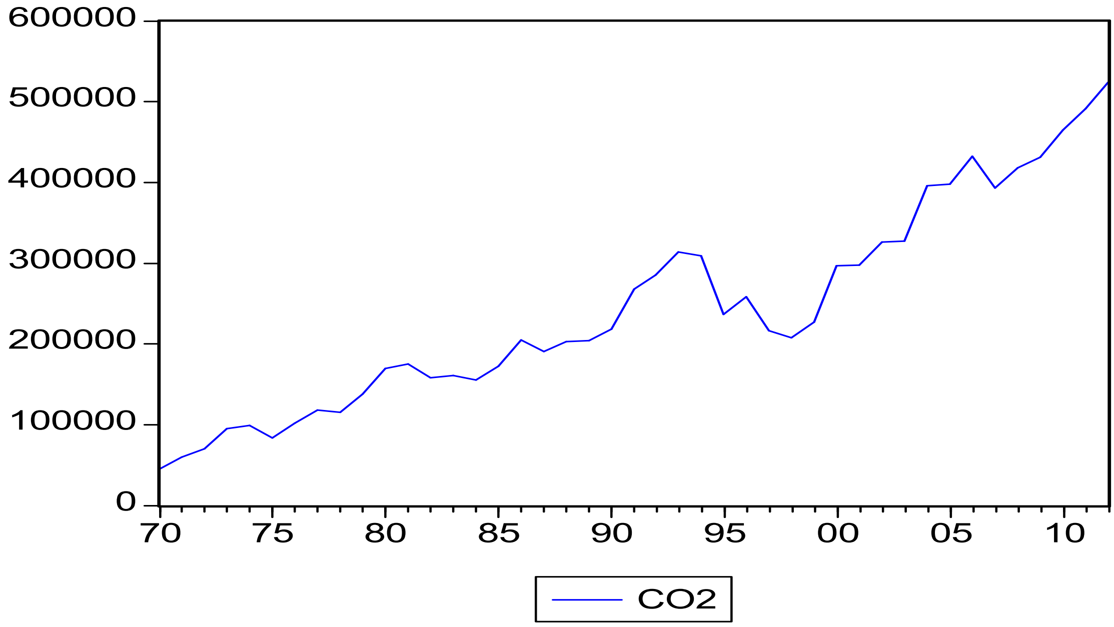

Figure 2. Evolutions of carbon dioxide emissions (Million tons)

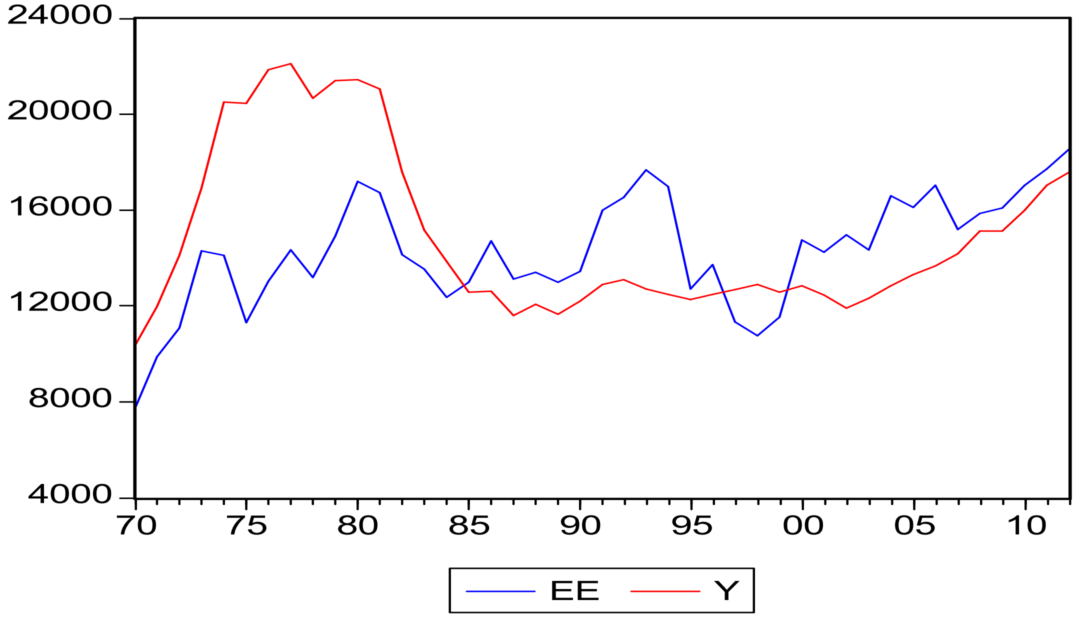

Figure 3. Evolutions of per capita CO_2 emissions and per capita GDP at constant prices of 2005

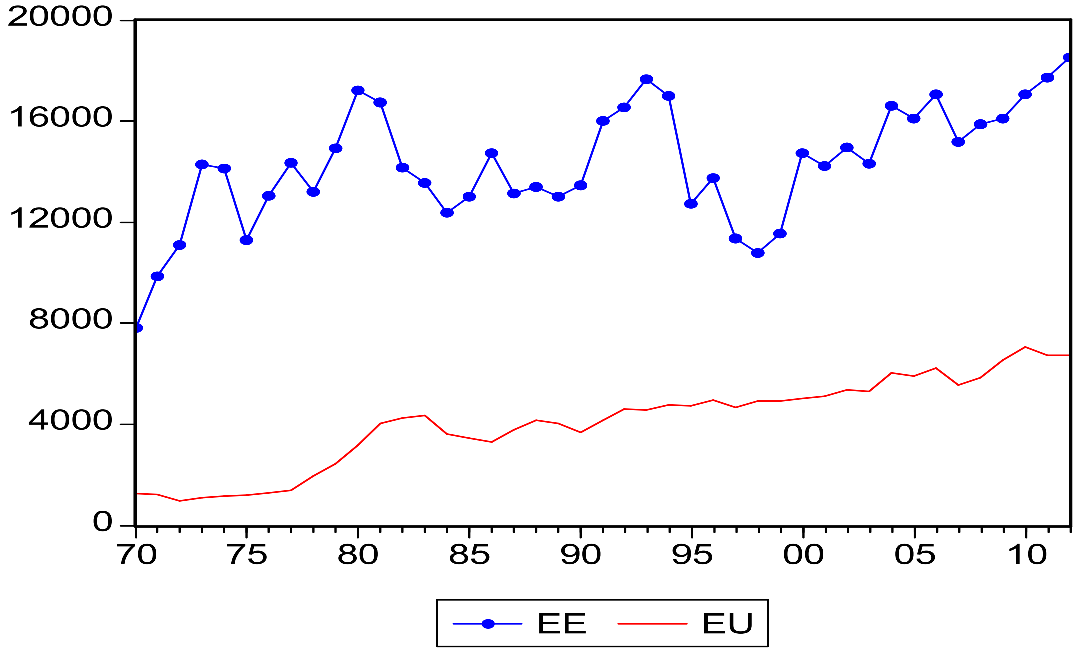

Figure 4. Evolutions of per capita CO_2 emissions and per capita energy use

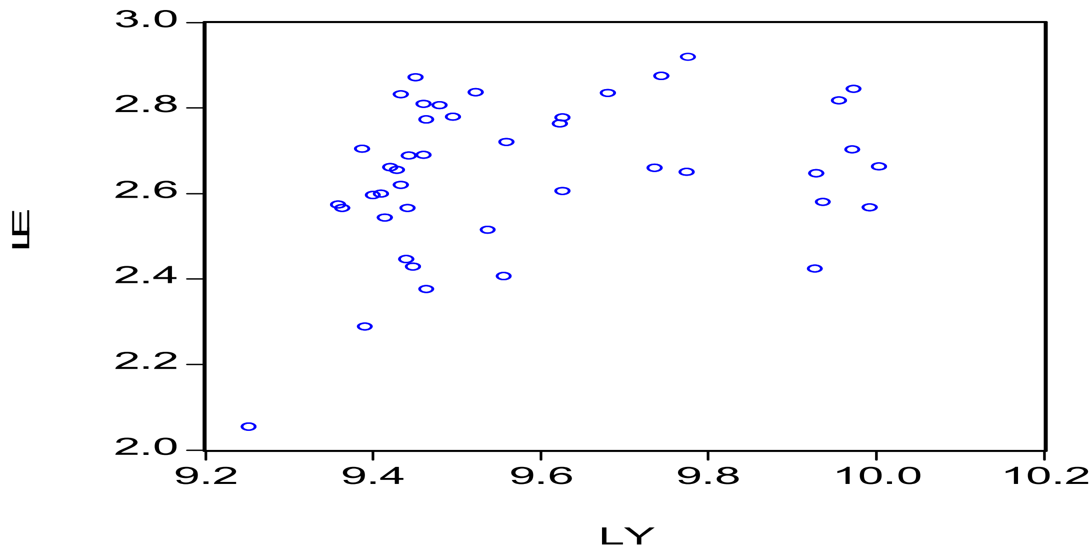

Figure 5. Relationship between per capita CO_2 emissions and per capita GDP

Table 1. Percent distribution of Gross Domestic Product of Saudi Arabia by economic activities at 1999 Constant Prices

Activities / Years	1970	1980	1990	2000	2010
Agriculture, Forestry & Fishing	3.15	2.01	6.02	5.65	3.76
Mining & Quarrying	50.07	44.30	30.65	29.74	19.13
Manufacturing	5.92	4.27	8.38	10.39	13.26
Electricity, Gas and Water	0.51	0.49	0.94	1.35	2.46
Construction	5.06	10.83	6.50	6.60	7.11
Wholesale and Retail Trade, Restaurants and hotels	2.41	5.00	6.51	7.61	12.53
Transport, Storage and Communication	3.51	3.15	4.44	4.58	9.04
Finance, Insurance, Real Estate and Business Services	9.55	14.56	12.16	9.97	13.17
Community, Social and Personal Services	2.82	2.39	3.65	3.55	3.29
Producers of Government Services	15.27	12.24	19.12	19.00	15.27
Import Duties	1.72	0.76	1.63	1.53	0.99

Source : Annual Statistics Book of Saudi Arabia

Table 2. Summary statistics of the data

Variables	Description	Mean	Median	Std.dev	Min	Max
Y	Per capita GDP (constant 2005 US$)	14902.4	13078.96	3450.92	10423.1	22109.7
E	Per capita carbon dioxide emissions (metric tons)	14.28	14.297	2.329	7.804	18.523
EU	Per capita energy use (kg of oil equivalent)	4081.15	4361.586	1767.63	985.59	7043.84
T	Trade openness (% of GDP)	78.48	76.852	13.365	56.47	124.84

Table 3. Least squares estimates of N-relationship model

Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
ln(Y)	1500.33**	715.91	2.095	0.04
$(\ln(Y))^2$	-155.37**	74.36	-2.089	0.04
$(\ln(Y))^3$	5.362**	2.57	2.083	0.04
ln(EU)	0.217*	0.037	5.738	0.00
ln(T)	0.307***	0.174	1.762	0.08
Constant	-4829.29**	2297.02	-2.102	0.04
Diagnostic tests	**Stat value**	**p-value**		
Fisher Test	13.85817*	0.000		
Durbin-Watson Test	0.939311			
Breusch-Godfrey Serial Correlation LM Test	12.232*	0.000		
White Heteroskedasticity Test	18.658*	0.009		
Jarque-Bera Test	0.027	0.986		

Note: *, * * and *** indicate significance of the coefficients at 1%, 5% and 10% levels, respectively.

Table 4. Robust estimation results of N-relationship model

Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
ln(Y)	1354.25	839.81	1.612571	0.11
$(\ln(Y))^2$	-140.32	87.079	-1.611	0.11
$(\ln(Y))^3$	4.84	3.009	1.610	0.11
ln(EU)	0.236*	0.075	3.133	0.003
ln(T)	0.182	0.157	1.160	0.25
Constant	-4356.8	2699.7	-1.613	0.11
Diagnostic tests	**Stat value**	**p-value**		
Fisher Test	11.671*	0.000		
Durbin-Watson Test	1.725			
Breusch-Godfrey Serial Correlation LM Test	2.213	0.136		
White Heteroskedasticity Test	7.298	0.398		
Jarque-Bera Test	2.156	0.341		

Note: *, * * and *** indicate significance of the coefficients at 1%, 5% and 10% levels, respectively.

Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.6, No.2, 2015

Table 5. Least squares estimates of linear model

Variable	**Coefficient**	**Std. error**	**t-stat**	**p-value**
ln(Y)	0.367*	0.113	3.234	0.002
ln(EU)	0.233*	0.032	7.193	0.00
ln(T)	0.194	0.1453	1.337	0.18
Constant	-3.632*	0.976	-3.720	0.00
Diagnostic tests	**Stat value**	**p-value**		
Fisher Test	19.97*	0.000		
Durbin-Watson Test	0.94			
Breusch-Godfrey Serial Correlation LM Test	9.86*	0.001		
White Heteroskedasticity Test	11.52***	0.073		
Jarque Bera Test	0.051	0.974		

Note: *, * * and *** indicate significance of the coefficients at 1%, 5% and 10% levels, respectively.

Table 6. Robust estimation results of linear model

Variable	**Coefficient**	**Std. Error**	**t-stat**	**p-value**
ln(Y)	0.373	0.158	2.361	0.02
ln(EU)	0.190	0.058	3.245	0.002
ln(T)	0.120	0.135	0.890	0.37
Constant	-3.002	1.663	-1.805	0.07
Diagnostic tests	**Stat value**	**p-value**		
Fisher Test	16.79267	0.000		
Durbin-Watson Test	1.713			
Breusch-Godfrey Serial Correlation LM Test	2.441	0.118		
White Heteroskedasticity Test	5.936	0.430		
Jarque-Bera Test	2.509	0.285		

Note: *, * * and *** indicate significance of the coefficients at 1%, 5% and 10% levels, respectively.