The Effects of Economic Growth on Environment: An Application of Environmental Kuznets Curve in United Arab Emirates

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Abstract: The correlation between economic growth and environmental degradation is becoming important as a result of the concerns for environment and sustainable development. The correlation has been empirically modeled through CO_2 emissions and per capita income relationship by many researchers. The results of such researches have been formulated by environmental Kuznets curve (EKC) hypothesis. According to EKC hypothesis there is an inverted U-shape relationship between environmental degradation and income per capita so that, eventually, growth reduces the environmental impact of economic activity. Having such trend in a country is thought to be one of the most important indicators of sustainable economic development. The main objective of this study is to analyze the effect of economic growth on environment by applying EKC approach to UAE economy. The long-run EKC relationship for CO_2 emission and UAE's per capita income over the 1970- 2010 period was analyzed. An autoregressive distributed lag (ARDL) model was used to determine the effects of per capita income, openness ratio of UAE economy, and human development index (HDI) on CO_2 emission. According to the results there was a inverted-U shape relationship between CO_2 emission and per capita income of UAE. In addition to that even though there were expected significant negative effects of energy consumption, opening ratio and HDI on CO_2 emission, their effects were not statistically significant. According to results of the analysis one can conclude that the economic growth in UAE is leading a decent environment, which is supporting the EKC hypothesis.

Keywords: Environmental Kuznet Curve, Environmental Degradation, CO_2 Emission, Economic Growth

Introduction

The correlation between economic growth and environmental degradation has been an important topic as a result of the concerns for environment and sustainable development. The correlation has been empirically modeled through CO_2 emissions per capita, as an indicator of environmental pollution, and per capita gross domestic products (GDP), as an indicator of income growth. The results of such researches have been formulated by environmental Kuznets curve (EKC) hypothesis. According to EKC hypothesis there is an inverted U-shape relationship between environmental degradation and income per capita so that, eventually, growth reduces the environmental impact of economic activity (Grossman & Krueger, 1991). Having such trend in a country is thought to be one of the most important indicators of sustainable economic development.

According to Kuznets (1955) income inequality and per capita income increases together at the first stage of development. After some turning points of development the inequality starts to decline. So the inequality of income is more in early stages of economic development but later the distribution of income move toward equality. There is a bell shaped curve relationship between per capita income and income inequality known as Kuznets Curve. Grossman and Krueger (1991, 1994) are among the first researchers who realized a systematic relationship between income growth and environmental pollution. According to their research there was an inverted U-shaped relationship between per capita income and environmental degradation as realized in original Kuznets Curve.

There has been great studies on effects and sustainable economic growth and environmental protection on each other. The main question is: is it possible to have economic development with a clean

environment at the same time? In contrast to having negative effect of economic development on environment, if one can prove that sustainable economic development can help a decent environment the countries can easily implement the necessary policies regarding the issue. The systematic relationship between income of a country and its environmental quality was first indicated by Kuznets (1955), known as Environmental Kuznets Curve and believed to have a "U" shape relationship.

Following Grossman and Krueger (1991, 1994) some other researchers have analyzed the possible relationship between the economic growth and environmental quality in different countries of the world. While some of them used panel data (Aslanidis & Xepapadeas, 2006; Grossman & Krueger, 1991, 1994; Moomaw & Unruh, 1997; Shafik & Bandyopadhyay, 1992; Tucker, 1995) some others used time series data (Cole, Rayner, & Bates, 1997; De Bruyn, van den Bergh, & Opschoor, 1998; Friedl & Getzner, 2003; Lantz & Feng, 2006; Roca, Padilla, Farré, & Galletto, 2001) to analyze the relationship.

Following, there are some studies that analyzed the relationship between economic growth and environmental quality. While some used the simple relationship between the two; some others added more variables such as the openness ratio, energy consumption and etc. to analyze the relationship.

Esteve and Tamarit (2012) modeled long-run relationship between per capita CO_2 and per capita income for the Spanish economy over the period 1857 – 2007 by using threshold cointegration techniques. According to their results there was non-linearity relationship between CO_2 and per capita income, which determines the existence of an EKC for the Spain.

Arouri et al. (2012) analyzed the relationship between CO_2 emissions, energy consumption, and real GDP for 12 Middle East and North African Countries (MENA) over 1981 – 2005 period. According to their results, energy consumption has a positive significant impact on CO_2 emissions in the long run. There was a quadratic relationship between real GDP and CO_2 emissions for the region.

Al –Mulali (2012) investigated the major factors that influence the CO_2 emission in 12 Middle Eastern countries by using panel model for 1990-2009 period. According to his results energy consumption, foreign direct investment net inflows, GDP, and total trade were important factors in increasing CO_2 emission in the countries.

He and Richard (2010) used semi parametric and flexible nonlinear parametric modeling methods to analyze and provide more robust inferences for the relationship between EKC and CO_2 in Canada. Their results show evidence in favor of the EKC hypothesis. In addition to that, they realized that the oil shock of the 1970s has had an important impact on progress towards less polluting technology and production in Canada.

Akbostanci et al. (2009) investigated the relationship between income and environmental quality for Turkey by checking the relationship between the CO_2 emissions and per capita income via time series covering 1992 – 2001 period using cointegration techniques. According to their results there was a monotonically increasing relationship between CO_2 and income in the long run. As for the second part of the study they used panel data analysis for SO_2 and PM_{10} emissions. Their results indicated an N-shape relationship between such pollutants and income.

Jalil and Mahmud (2009) examined the long-run relationship between CO_2 emissions and energy consumption, income and foreign trade for China by using 1975–2005 time series data. By using auto regressive distributed lag (ARDL) methodology they found a quadratic relationship between income and CO_2 emission, which supports EKC relationship. Their results for Granger causality tests indicate one-way causality running from economic growth to CO_2 emissions. In addition to that income and energy consumption were determinant of CO_2 emissions in the long run.

Soytas et al. (2007) tried to examine a dynamic causal relationships between carbon emissions, energy consumption, income, and foreign trade in Turkey using the time-series data covering 1960 –2005 period. By using augmented Granger causality analysis they found that the income was the most significant variable in explaining the carbon emissions in Turkey followed by energy consumption and foreign trade.

As indicated above, many studies has searched the validity of Environmental Kuznets Curve between CO_2 and some other indicators such as income per capita, energy consumption, openness ratio, foreign direct investment and etc. while some of them found a relationship that improve the validity of the curve; some other could not found such relationship to support the hypothesis of the curve. The main objective of this study is to analyze the effect of economic growth, on environment by applying EKC

approach to UAE economy.

Methodology

Annual time series data for UAE from 1970 to 2010 were taken from world development indicator database, the World Bank (2012). The real GDP was taken in US dollars according to year 2000 constant prices and converted to the per capita real GDP. Then, per capita real GDP was used as an indicator for economic growth of UAE. As for the environmental pollution, CO_2 was taken as the proxy and calculated as metric tons per capita. Per capita energy consumption was measured as kilogram of oil equivalent. The openness ratio measured as the summation of real exports and imports over real gross national product in USA dollars. The base year for monetary values was 2000=100. The human development index (HDI) is "a new way of measuring development by combining indicators of life expectancy, educational attainment and income into a composite human development index" (UNDP, 2011)

The data were organized and stationary and/or unit root statistical test procedures were utilized prior to econometric analysis. Nonstationary variables can easily be converted to stationary by simple differentiating them from their previous values. If there is a spurious problem nonstationary time-series variables should not be used in regression analysis with an exception of cointegration (Hill, Griffiths, Lim, & Adkins, 2008). The Augmented Dickey-Fuller test was conducted for both variables and differenced variables.

The long-run EKC relationship for CO_2 emission and UAE's per capita income over the 1970- 2010 period was analyzed. A log linear quadratic equation is utilized to test the long run relationship between CO_2 emission and energy consumption, economic growth, openness ratio, and human development index.

$$CO_{2_t} = \beta_0 + \beta_1 lnINC_t + \beta_2 lnINC_t^2 + \beta_3 lnE_t + \beta_4 lnOR_t + \beta_5 lnHDI_t \quad (1)$$

Where $CO_{2_t}$is CO_2 emission per capita in time t, INC_t is income per capita in time t; INC_t^2 is square of income per capita in time t; $E_t$is energy consumption per capita in time t; $OR_t$is opening ratio in time t, and HDI_t is human development index in time t.

In recent decades several different cointegration model was utilized to analyze the relationship between diffrerent economic indicators and environmental pollution. There are many examples of both univariate and multivariate cointegration approaches used to analyze the relationships. Engle and Granger (1987), Ghosh (2010) are two well known examples of such studies. Recently, a single cointegration approach was developed by Pesaran et, al. (2001) and called autoregressive-distributed lag (ARDL) model. The model has become popular among the researchers. The cointegration approach, also known as bounds testing, has certain econometric advantages in comparison to other single cointegration procedures. As indicated by Pesaran et al., (2001) The advantages are: "(i) endogeneity problems and inability to test hypotheses on the estimated coefficients in the long run associated with the Engle-Granger method are avoided; (ii) the long- and short-run parameters of the model in question are estimated simultaneously; (iii) the ARDL approach to testing for the existence of a long-run relationship between the variables in levels is applicable irrespective of whether the underlying regressors are purely I(0), purely I(1), or fractionally integrated; (iv) the small sample properties of the bounds testing approach are far superior to that of multivariate cointegration.

The ARDL approach recently has been used by researchers such as Jalil and Mahmud (2009), Akbostanci et al (2009), Halicioglu (2009) and etc. the basic formulation of the model is as follows;

$$\begin{aligned}\Delta CO_2 &= \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta\, CO_{2_{t-i}} + \sum_{i=1}^{p} \alpha_2 \Delta INC_{t-i} + \sum_{i=1}^{p} \alpha_3 \Delta INC_{t-i}^2 + \sum_{i=1}^{p} \alpha_4 \Delta\, OP_{t-i} + \sum_{i=1}^{p} \alpha_5 \Delta\, EN_{t-i} \\ &+ \sum_{i=1}^{p} \alpha_6 \Delta\, HDI_{t-i} + \gamma_1 CO_{2_{t-1}} + \gamma_2 INC_{t-1} + \gamma_3 INC_{t-1}^2 + \gamma_4 OP_{t-1} + \gamma_5 EN_{t-1} + \gamma_6 HDI_{t-1} \\ &+ e_t \end{aligned} \quad (2)$$

Where α_0 is drift component and e_t is white noise. The terms with the summation signs represent the error correction dynamics and the second part of the equation with γ indicate the long run relationship between independent variables and CO_2 emission per capita.

The cointegration approach of Pesaran et al., (2001) is recent development in time series econometrics literature. The bound testing procedure is basically based on the Fisher (F) and/or Wald- statistics and is the beginning stage of the ARDL cointegration methodology. The joint significance test that implies no cointegration hypothesis, (H0: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = 0$), and the alternative hypothesis, (H0: $\gamma_1 \neq \gamma_2 \neq \gamma_3 \neq \gamma_4 \neq \gamma_5 \neq \gamma_6 \neq 0$) should be conducted for Eq. (2). The ARDL methodology was used to analyze the long run effects of income per capita, income per capita square, opening ratio, energy consumption per capita and human development index on CO_2, which is a proxy for environmental pollution.

Results and Discussion

The descriptive statistics of the variables are given on Table 1. According to the table CO_2 emission per capita is ranged between 27.00 and 45.17 with an average value of 80. The average income per capita, opening ratio, energy consumption per capita, and human development index are $ 40906.37, 76.46, 8941.95, and 0.69, respectively.

Table 1. Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
CO_2 per Capita	27.00	80.00	45.17	13.43
Income per Capita	21087.00	61375.00	40906.37	11739.26
Opening Ratio	39.00	132.00	76.46	24.96
Energy Consumption per Capita	2081.00	12608.00	8941.95	3276.86
Human Development Index (HDI)	0.53	0.85	0.69	0.09

The time trend of the variables and their first differences are given in the following figures. According to the figures both CO_2 per capita and real incomes are in decreasing trend from 1970 to 2010 period. On the other hand, opening ratio and human development index are in the increasing trend in the same period. The shape of energy consumption per capita is concave to the origin. This situation clearly shows efficient energy conservation policies of UAE government in 2000s.

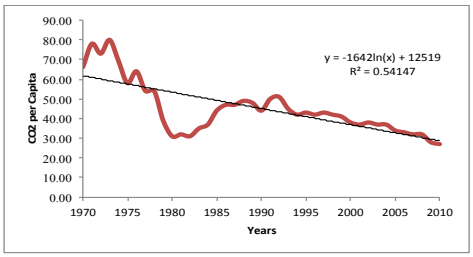

Figure 1. CO_2 per Capita (1970 – 2010)

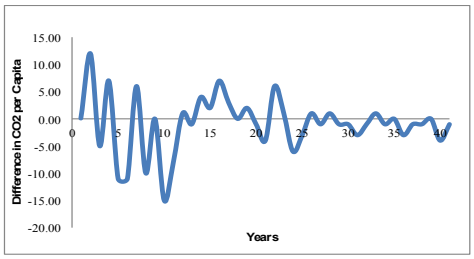

Figure 2. Difference in CO_2 per Capita (1970 – 2010)

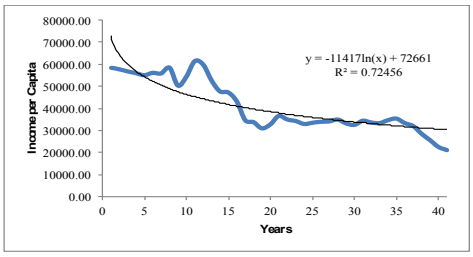

Figure 3. Income per Capita (1970 – 2010)

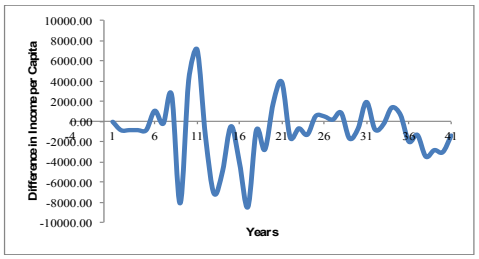

Figure 4. Difference in Income per Capita (1970-2010)

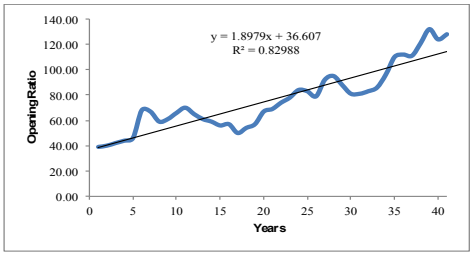

Figure 5. Opening Ratio (1970 – 2010)

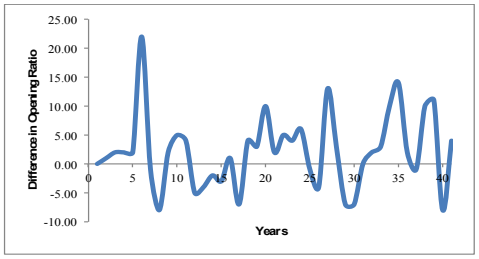

Figure 6. Difference in Opening Ratio (1970 – 2010)

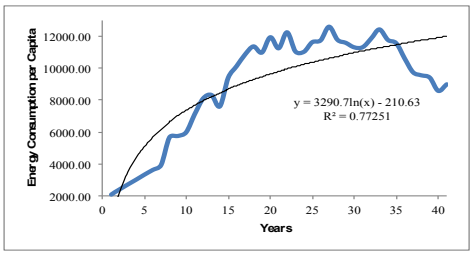

Figure 7. Energy Consumption per Capita (1970 – 2010)

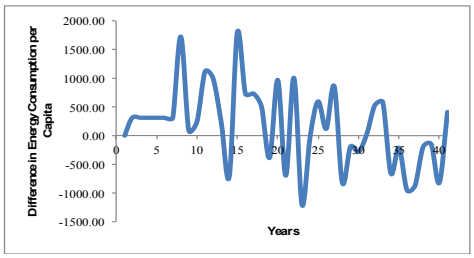

Figure 8. Difference in Energy Consumption per Capita (1970 – 2010)

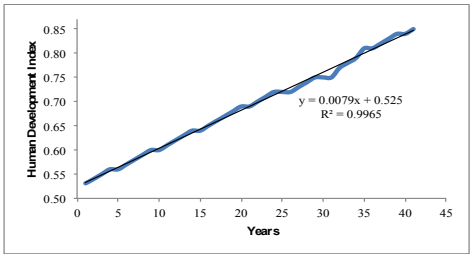

Figure 9. Human Development Index (1970 – 2010)

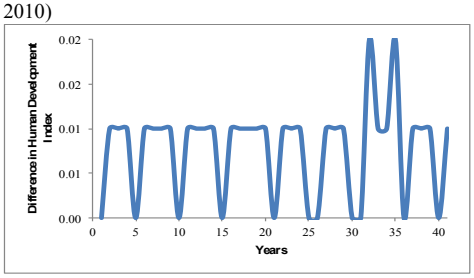

Figure 10. Difference in Human Development Index (1970 – 2010)

Unit root test for the variables were checked vie augmented Dickey-Fuller unit root statistics. According to the statistics only energy variable is stationary and all others are non-stationary. After taking the first differences of the variables, as can be seen in Table 2, all variables have become stationary at 1% significance level.

Table 2. Unit Root Test

Variables	ADF	Differenced Variables	ADF
Log of CO_2	-0.109	Δ Log of CO_2	-0.865*
Log of Income	-0.011	Δ Log of Income	-0.674*
Log of Income Square	-0.013	Δ Log of Income Square	-0.686*
Log of Opening Ratio	-0.060	Δ Log of Opening Ratio	-5.165*
Log of Energy	-0.118*	Δ Log of Energy	-4.700*
Log of Human Development Index	-0.014	Δ Log of Human Development Index	-2.790*

*, represent 1% level of significance

The results of Autoregressive distributed lag model are given in Table 3. According to results only lag of CO_2 has significant negative effect on the level of CO_2 per capita. Since income has a positive effect and square of income has negative effects on the CO_2 level one can easily say that the inverted U-shape hypothesis of EKC has been detected, however the effect of the variables are not significant. All the other three variables, (opening ratio, energy consumption, and human development index) have expected negative effects on CO_2 emission. However the effect

are statistically insignificant. International trade requires environmental friendly products. That is why as import and export of the countries increases the environmental pollution is supposed to decrease. In addition that, almost all countries of the world have started to implement clean and efficient energy policies. As such policies progressed successfully then the effect of energy use on environmental degradation decreases.

Table 3. Autoregressive Distributed Lag Model Long Run Estimates

Dependent Variable LCO2		
Regressors	Coefficients	*t*-Values
Lag of ln CO_2	-0.52	-2.38**
Lag of ln Income	18.33	1.31
Lag of ln Income Square	-0.89	-1.32
Lag of ln Opening Ratio	-0.18	-1.25
Lag of ln Energy	-0.17	-0.85
Lag of ln Human Development Index	-0.44	-0.47

**, represent 5% level of significance

In addition to the variables mentioned above, human development index is a good indicator of the development of the countries in education, income per capita and food safety. That is why; progress in HDI is expected to cause a decent environment for sustainable development purposes.

Conclusions

In this study we examined the relationship between income and environmental quality for UAE in order to analyze the validity of Environmental Kuznets Curve. In addition to income per capita, the square of income per capita, energy consumption per capita, opening ratio, and human development index were added to the econometric mode to see their effects on the CO_2 emission in UAE. According to the results there was an insignificant inverted-U shape relationship between CO_2 emission and per capita income. In addition to that, the lagged values of CO_2 had negative significant effect on the level of current CO_2 emission per capita. One can easily see that the level of the gas in the atmosphere of UAE is decreasing from year to year. Even though their effects on the emission are insignificant, energy consumption per capita, opening ratio, and human development index had expected negative effect on the emission level. As a result we can conclude that the economic growth, energy consumption per capita, trade and human development index in UAE are leading a decent environment, which is supporting the EKC hypothesis.

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