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Original article

Environmental Kuznets Curve for CO_2 emissions: An analysis for developing, Middle East, OECD and OPEC countries

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ABSTRACT

The purpose of this study was to determine the relevance of the Environmental Kuznets Curve, which shows that there is an inverted-U shaped relationship between environmental pollution and economic growth. We investigated the relationship between per capita income and the carbon dioxide emissions as indicators of environmental pollution in Developing Countries, OECD, Middle East and OPEC countries for the period of 1970-2016. The contribution of our study is the evaluation and comparison of Developing Countries, OECD, Middle East and OPEC countries together in the context of EKC. We employ the fixed effect and GMM techniques in this study and results obtained from cubic models indicate that the N-shaped relationship for Developing, Middle East countries and OECD countries and inverted N-shaped relationship for OPEC countries exist. Considering these conclusions, we draw some serious policy implications for the policy makers in these countries. Governments should closely follow the industries that generate CO_2 emissions as after some point environmental degradation increases again as income increases. In addition adopting clean energies including wind and solar systems and making these technologies widespread across countries might reduce CO_2 emissions. Another alternative way to reduce CO_2 emissions might be a carbon tax which should be implemented for polluters.

KEY WORDS: Environmental Kuznets Curve, economic growth, CO_2 emissions, GMM estimation

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1. Introduction

Economic growth is defined as an increase in the production capacity of a country. However, the total demand for the actual production of goods and services must also increase. Sources can cause different growth rates in proportion to the amounts allocated to production of consumption and investment goods every year (KEISER, 1964).

The environment, on the other hand, offers a wide variety of benefits to people. The environment also provides us with raw materials that can be recycled. Today, as in the past, the economic well-being of individuals and nations depends on the protection of the environment and natural resources. As a result, the importance of the environment for economic growth is enormous. The creation of environmental pollution to serve the purpose of economic growth has created a situation in the long run which acts against nations and individuals (WARD, 2006).

Carbon dioxide (CO_2) emissions, which we consider to be indicative of environmental pollution in our study, consist of a combination of natural resources and human activities. The most important source of CO_2 from human activities is the release of fossil fuels during consumption. Since the industrial period, fossil fuel consumption has increased dramatically (BODEN ET AL., 2011).

While economic growth has taken place, pollution of the environment has risen. Therefore the relationship between environmental pollution and economic growth has been empirically studied by many authors. The results of these studies have been linked to the Environmental Kuznets Curve (EKC). While the EKC is the main concept explaining the relationship between environmental pollution and economic growth, there are studies that show favourable and unfavourable views for EKC. These views will be discussed in detail in the literature review of our study.

Detecting whether a country has an EKC relationship or a N-shaped relationship between economic growth and pollution is important. For instance, if there is an inverted U-shaped relationship between economic growth and pollution, this means that in the first stage of economic development, environmental damage increases and after some level, economic degradation decreases thanks to the environmental technologies adopted. Hence, concerns for environmental degradation might disappear. However, the existence of a N-shaped relationship between income and environment leads to different conclusions in terms of policy recommendations. A N-shaped relationship implies that a decline in environmental pollution occurs when income is rising, but only up to a certain level, then there will be again, an increase of pollution at higher incomes. In other words, concern for environmental issues is continuing. Economic growth is likely to cause environmental pollution. Therefore, policy implications in the case of a N-shaped relationship should differ compared to an inverted U-shaped relationship.

In terms of country classification in the work presented below; Developing Countries, OECD Countries, OPEC (Organization of The Petroleum Exporting) Countries and countries of the Middle East have been analysed. The relationship between per capita incomes of the relevant country groups and CO_2 emissions, which are indicative of environmental pollution, has been assessed in the context of the EKC.

At the end of the study, we have justified the N-shaped relationship rather than EKC hypothesis by using panel GMM regression models as well as environmental pollution increases again after a certain level of per capita income. We have also seen that the level of environmental pollution in Middle-East Countries is higher than Developing, OECD and OPEC Countries.

Our work consists of six parts. After the introduction, in the second part, the EKC hypothesis is examined theoretically. In the third part, a literature review on the subject is presented. The data, analysis and results obtained are discussed in the fourth and fifth parts respectively. In the sixth part, we conclude and evaluate the findings reached as the result of the analysis.

2. EKC hypothesis

The EKC hypothesis (KUZNETS, 1955) was mainly rooted in Simon Kuznets's work, entitled "Economic Growth and Income Inequality", which revealed an inverted-U shaped relationship between per capita income and income inequality. This hypothesis reveals that income inequality increases in the first stages of economic growth, but income inequality decreases in later stages of economic growth after a turning point. As a result, the relationship between per capita income and income inequality reveals the existence of an inverted U-shaped relationship.

The same kind of analysis has also been applied to the relationship between pollution and economic growth. The logic behind the EKC is quite simple. In the early stages of economic growth, countries do not produce enough to generate serious pollution. As production increases and per capita income rises, environmental pollution starts to increase. Nevertheless, individuals struggle to reduce environmental pollution when they earn enough to care for environmental pollution. From a microeconomic point of view, a clean environment becomes more important as people earn more income (WEIL, 2005).

The EKC hypothesizes that there is an inverted U-shaped relationship between per capita income and environmental pollution. The EKC has argued that economic growth in developing countries has increased environmental pollution in the first stages and that environmental degradation has diminished by continuing economic growth after a turning point.

Income elasticity of demand for environmental quality is one of the indicators used to explain the EKC. According to this indicator, a property causing environmental pollution is considered as a normal property at the levels of low income, but it becomes inferior goods at high levels of income. When the per capita income is low, the demand for the increase in the environmental quality is low as well. However, as per capita income increases, the demand for a healthy and clean environment increases. The EKC emphasized the role of the demand elasticity for increasing the environmental quality for the inverted-U shaped relationship between per capita income and environmental pollution (MCCONNELL, 1997).

Economic development could be achieved by making efforts to preserve the environment in order to sustain its utility for future generations. Renewable energy sources such as geothermal, hydropower, biomass, wind and solar systems have contributed to obtain a clean environment while income per capita increases. Therefore in the context of the EKC hypothesis, in the later stages of economic growth, implementing stricter environmental regulations and technological improvements cause air pollution to fall (Lorente & Álvarez-Herranz, 2016).

Financial development can also affect CO_2 emissions in different ways. First, financial development attracts foreign direct investment to a country and contributes economic growth. Enhanced stock and credit markets allow investors and consumers to access credit easily (Zhang, 2011). More energy consumption due to higher economic growth contributes to CO_2 emissions. On the other hand, firms access more funds via financial development and invest in environmentally friendly technology that reduces CO_2 emissions. According to the pollution haven hypothesis which can be explained as developed countries moving polluting industries to developing countries where there are lower environmental standards (Cole, 2004).

3. Literature review

One of the main studies that examines the relationship between environmental pollution and economic growth in the context of EKC is the study of Grossman & Krueger (1995). In this study, there are four elements which are indicative of environmental pollution. These elements are urban air pollution, oxygen regime in river basins, contamination by fish populations and heavy metals, and pathogenic contamination in sewage. They found that environmental pollution increases in the first stage of economic growth and then the air and water quality is improved by economic growth. They have expressed their views in favour of the Environmental Kuznets Curve with the results of the analysis included in their study. The reason why the downward sloping curve emerges is because the country has ceased to produce pollution-intensive goods as the country's economic growth accelerates and these products are derived from other less developed countries. In the study dealing with the relationship between trade, EKC and the pollution heaven hypothesis; the difference in environmental quality between developed and developing countries suggests that developed countries may cease to produce pollution-intensive goods and may cause developing countries to become distracted in the most pollution-intensive production areas. For this reason, Cole (2004) stated that after a certain number of points in the developed countries, the quality of the environment improved and the reason for the inverted-U shape of the EKC was because the developed countries were exporting the impurities to the developing countries.

Shafik & Bandyopadhyay (1992) examined forest areas, annual deforestation, dissolved oxygen and fresh water deficiency in rivers, municipal waste per capita and CO_2 emissions per capita in the study between 1961-1986 in 149 countries. As a sign of environmental pollution, they found an inverted-U shaped relationship between deforestation and per capita income and concluded that competition among countries and investments made in new technologies will contribute to reducing environmental pollution. Panayotou (1993) studied thirty countries and proved the existence of the EKC, explaining the relationship between income and environmental pollution between the years 1982-1994. Stern & Common (2001) studied 73 countries between 1960 and 1990 and they confirmed the existence of the EKC.

Apergis & Ozturk (2015) use four variables; population density, land, industrial shares in total GDP, and CO_2 emissions for 14 Asian countries between 1990 and 2011 to test the relationship between CO_2 emissions and per capita GDP in the context of the EKC. They confirmed the existence of the EKC hypothesis. They argued that environmental pollution could be reduced with some importance such as a reduction of greenhouse gas caused by industrial transportation and heating and an increase in the use of biodiesel fuel without sacrificing economic growth. The causality relationship between short and long term has been examined in a study of 1980-2010 to test the validity of EKC among 25 OECD countries' per capita CO_2 emissions, GDP, renewable and non-renewable energy consumption and international trade. The inverted-U shaped hypothesis between GDP and per capita CO_2 emissions was supported. They point out that OECD countries need to increase their use of renewable energy to reduce CO_2 emissions and combat global warming and thus reduce energy dependence (Jebli et al., 2016).

Galeotti et al. (2006) conducted research to test the EKC using two sets of data, the International Energy Agency (IEA) and the Carbon Dioxide Information Analysis Centre (CDIAC) data sets for OECD countries. The CDIAC is based on a single set of data on CO_2 emission estimates, a single coefficient estimate for fossil fuel, gas and oil burning. In the IEA dataset, more specific results arise because specific emission coefficients are used for different energy products. According to the IEA dataset, EKC has basically an increasing structure. The relationship between CO_2 and sulphur dioxide (SO_2) emissions was examined for economic growth and environmental pollution for the developing country of Tunisia between 1961 and 2004. The relationship between SO_2 emissions and GDP is an inverted-U shape and a monotonically increasing relationship between CO_2 emissions and GDP was found (FODHA & ZAGHDOUD, 2010).

ARROW ET AL. (1996) emphasize the importance of EKC in developing ways to reduce environmental pollution. With economic growth it means that the pollution increases with the level of income and decreases after a turning point. They pointed out that some solutions for environmental pollution in the first stages of economic growth can be found within autonomous processes specific to each country. They mention that free trade will contribute to economic growth and therefore reduce environmental pollution. They also stated that the EKC is less applicable for CO_2 emissions since the environmental pollution will continue even at very high levels of income as these emissions are causing problems on a global scale. MOOMAW & UNRUH (1997) found that the causes of the inverted-U shaped EKC's turning points between environmental pollution and economic growth are not the increase in per capita income, but are directly related to all historical events and the shocks affecting countries.

In the study of the relationship between per capita incomes and CO_2 emissions in Austria between 1960 and 1999, it was found that there was a break due to the oil shock that took place in the middle of the 1970s and that oil shock led to an increase in the quality of the environment and a shift to technology-based production. For this reason, it has been argued that there is an N-shaped relationship between per capita income and CO_2 emissions, which is an environmental indicator, not an inverted-U shape (FRIEDL & GETZNER, 2003).

TORRAS & BOYCE (1998) concluded that their study had an N-shaped relationship between economic growth and SO_2 emissions. LANTZ & FENG (2006) pointed out that CO_2 emissions, which are indicative of environmental pollution, will increase, or decrease, depending on population and technology, not per capita income. LINDMARK (2002) examined the relationship between CO_2 emissions and economic growth as indicators of environmental pollution in Sweden in three stages. In the first stage, technological and structural changes in the period from 1870 to World War I contributed to a reduction in emissions. In the second stage, he dealt with the period from World War I to 1960. In the third phase there was an increase of emissions from 1960 to 1997. The increase in fuel prices caused by the oil shock in 1973 led to significant structural and technological changes, contributing to the reduction of emissions, and in particular the development of nuclear energy, contributed positively to the process.

SURI & CHAPMAN (1998) examined the EKC hypothesis according to the commercial energy regime that constitutes the source of environmental problems. They pointed out that exports of goods manufactured by industrialized countries played an important role in forming the upward sloping part of the EKC. Imports in industrialized countries have also contributed to the downward trend. Although the study conducted for the Middle East and North African (MENA) countries in the long run supported the EKC hypothesis, it was concluded that the EKC hypothesis was not fully supported, except in Jordan, because the turning points were very low and very high in some cases (AROURI ET AL., 2012). In the study of 8 selected OPEC countries (Algeria, Ecuador, Iran, Kuwait, Nigeria, Saudi Arabia, UAE and Venezuela) between 1971 and 2008, the causal relationship between energy consumption, pollution and economic growth was empirically investigated. Results suggested a N-shaped relationship between economic growth and CO_2 emissions. For this reason, the results of the analysis do not support the inverted-U shaped EKC (DEHNAVI & HAGHNEJAD, 2012).

A co-integration analysis was conducted to test the EKC hypothesis, and took into account the relationship between SO_2 emissions and per capita income for 74 countries between 1960 and 1990. As a result, for the SO_2 emissions, the EKC curve is not completely valid, i.e. it is a problematic concept (PERMAN & STERN, 2003). Some authors have shown that the EKC curve is not valid and that there is a monotonically increasing, or decreasing, relationship between environmental pollution and GDP (HOLTZ-EAKIN & SELDEN, 1995).

OZATAC ET AL. (2017) investigated the EKC hypothesis for Turkey from 1960 to 2013 by taking into account energy consumption, trade, urbanization and financial development. The results of the bounds test and the error correction model under autoregressive distributed lag mechanism showed long-run relationships among the variables as well as proof of the EKC. They found causal relationships among the variables and propose a "polluter pays" mechanism to sustain the awareness of a clean environment.

ASLAN ET AL. (2018) aimed to examine the validity of an inverted U-shaped Environmental Kuznets Curve by investigating the relationship between economic growth and environmental pollution for the period from 1966 to 2013 in the USA. They use the bootstrap rolling window estimation method in order to detect the possible changes in causal relations. They found an increasing trend of economic growth in the 1982-1996 sub-sample periods and a decreasing trend in the 1996-2013 sub-sample periods. Therefore, the existence of an inverted U-shaped Environmental Kuznets Curve was validated in the USA.

BILGILI ET AL. (2016) studied 17 OECD countries from 1977 to 2010 benefitting panel FMOLS (Fully Modified Ordinary Least Squares) and panel DOLS (Dynamic Ordinary Least Squares) estimations. They found that the EKC hypothesis was valid and renewable energy consumption has a negative impact on CO_2 emissions. SUGIAVAN & MANAGI (2016) estimated the EKC in the case of Indonesia for the period of 1971–2010 by considering the role of renewable energy in electricity production, and using the autoregressive distributed lag (ARDL) approach to cointegration as the estimation method. They found an inverted U-shaped EKC relationship between economic growth and CO_2 emissions in the long run. DOGAN & SEKER (2016) conducted panel Pedroni, Kao, and Lagrange multiplier (LM) co-integration tests and FMOLS and DOLS estimators on the data of 40 countries for the period between 1985 and 2011 and confirmed the validity of the EKC hypothesis. They also reported that per capita renewable energy consumption reduced per capita CO_2 emissions. LACHEHEB ET AL. (2015) study the EKC hypothesis in Algeria for the period 1971-2009 using the autoregressive distributed lag cointegration method. They find that the EKC does not exist in Algeria.

4. Data and methodology

We obtained the data used in our study from the database of the World Bank which are GDP per capita (constant US dollar) and Carbon Dioxide Damage (% of Gross Domestic Product, GDP) covering the period from 1970 to 2016. Table 1 presents a list of countries as categorized. We will follow the panel data estimation procedure as an empirical methodology as we have a time series and county level data. We only use two variables in our study in order to focus on the exact relationship between economic growth and environmental damage. Our aim was not to find the determinants of environmental pollution around the world. Therefore we only include GDP per capita and CO_2 variables in our model.

Table 1. List of Countries, World Bank

Developing Countries	Angola, United Arab Emirates, Argentina, Burundi, Benin, Burkina Faso, Bangladesh, Bahrain, Bolivia, Barbados, Brunei, Botswana, Central African Republic, Chile, China, Cote d'lvoire, Cameroon, Congo, Colombia, Comoros, Cabo Verde, Costa Rica, Cuba, Djibouti, Dominican Republic, Algeria, Ecuador, Egypt, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Gambia, The, Guinea-Bissau, Equatorial Guinea, Guatemala, Guyana, Hong Kong SAR, Honduras, Haiti, Indonesia, India, Iran, Iraq, Israel, Jamaica, Jordan, Kenya, Korea, Kuwait, Lebanon, Liberia, Libya, Sri Lanka, Lesotho, Morocco, Madagascar, Mexico, Mali, Myanmar, Mozambique, Mauritania, Mauritius, Malawi, Malaysia, Namibia, Niger, Nigeria, Nicaragua, Nepal, Oman, Pakistan, Panama, Peru, Philippines, Papua New Guinea, Paraguay, Qatar, Rwanda, Saudi Arabia, Sudan, Senegal, Singapore, Sierra Leone, El Salvador, Somalia, Sao Tome and Principe, Syrian Arab Republic, Chad, Togo, Thailand, Trinidad and Tobago, Tunisia, Turkey, Tanzania, Uganda, Uruguay, Venezuela, RB, Vietnam, Yemen, Rep., South Africa, Zambia, Zimbabwe.
OECD Countries	Australia, Belgium, Canada, Switzerland, Chile, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, United Kingdom, Greece, Hungary, Ireland, Iceland, Israel, Italy, Japan, Korea, REP., Luxembourg, Mexico, Netherland, Norway, New Zealand, Poland, Portugal, Slovak Republic, Slovenia, Sweden, Turkey, United States.
OPEC Countries	Angola, United Arab Emirates, Algeria, Ecuador, Gabon, Equatorial Guinea, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, Venezuela, RB.
Middle-East Countries	Afghanistan, Arab World, United Arab Emirates, Armenia, Bahrain, Algeria, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, Tunisia, Turkey, Yemen.

5. Study design and econometrics method

Firstly, the fixed and random effects models, which are two types of panel estimator approaches, will be utilized in this work. The fixed effects model portions are controlled for using orthogonal forecasts. These forecasts of projections eliminate the specific means from the cross-sections and the period from the dependent variables and the exogenous regressors and then employs the quantified regression using the demeaned data (BALTAGI, 2008). The fixed effects model has an important benefit which enables us to remove the bias problems emerging from the omitted variables that do not change over time. At the same time, the random effects model assumes that the equivalent effects of the cross-section effect vectors and the time period effect vectors are essentially uncorrelated. In other words, it is accepted by the random effects model that the effects are uncorrelated with the residuals. We used the HAUSMAN (1978) test to decide the more suitable model. The Hausman test contrasts the random and fixed effects estimates of coefficients. The Hausman test is built on Chi-square statistics; if the Chi-square statistic is significant, the random effects model is not decent, and the fixed effects model should be employed. Since the fixed and random effects are weak in controlling the correlation and the heterogeneity between the instruments' variables, the generalized method of moments (GMM) is also employed in the study.

The GMM is a commonly used method to estimate parameters in an econometrics model. It is usually practiced in the setting of semi-parametric models in which the parameter of interest is finite dimensional. The maximum likelihood estimation is not appropriate because the full shape of the distribution function of the data may not be known. The GMM belongs to a number of estimators, known as M-estimators, which can be identified by minimizing the number of the functions of a criterion. The model is essentially a robust estimator that does not require information about the precise distribution of the disturbances. It supplies a number of estimates that can remove the correlation and the heterogeneity between the instrumental variables and disturbance (AL-MULALI ET AL., 2015). We use the lagged differences of variables and the constant for the variables as instruments to control multi-collinearity. Since the lagged dependent variable creates an endogeneity problem, the other dynamic estimators such as Mean Group and Pooled Mean Group can be misleading. For instance, time invariant unobserved effects, which are included in the error term will be correlated with the lagged dependent variable causing a dynamic panel bias. Hence, Arellano Bond's (1991) GMM technique is convenient for dynamic panels, see ROODMAN (2006). A GMM estimator is also efficient and consistent when T (time) is short and N (countries) is large. Furthermore, the validity of the instrumental variables for the GMM models is controlled with the help of the Sargan test. This test is actually a Chi-square test which determines whether the residuals are correlated with the instrumental variables. We conclude that the instruments are valid and thus there is no indication of instrument mis-specification when we cannot reject the null hypothesis of the Sargan test (ARELLANO & BOND, 1991).

5.1. Empirical evidence for EKC

Various studies have found the empirical evidence for the existence of an EKC. The data mostly used in these studies are panel hosting cross-sectional and time series data. Therefore, we use the following reduced form model to test the various possible relationships between environmental damage and income:

$$y_{it} = \alpha_i + \theta_t + \beta_1 x_{it} + \beta_2 x_{it}^2 + \beta_3 x_{it}^3 + \varepsilon_{it} \quad (1)$$

where: y is environmental damage as a percentage of GDP, x is income. Here, the subscript i and t stands for the countries and the time periods, respectively. α is constant and β_k is the coefficient of the polynomials of income variable. The country specific terms α_i capture all fixed factors inherent to each country, which are not considered in the model, such as geographical, social, cultural or not directly observable. The parameter θ_t denotes a time-varying intercept. All variables in regressions are in logarithmic forms.

$$y_{it} = \alpha_i + \theta_t + \beta_1 x_{it} + \beta_2 x_{it}^2 + \beta_3 x_{it}^3 + \varphi y_{(it-1)} + \varepsilon_{it} \quad (2)$$

The second equation is the GMM equation, which is essentially a dynamic panel equation that accommodates additionally dynamic effects of the dependent variable, $y_{(it-1)}$.

The econometric model we construct above enables us to test several forms of hypothesis between environment and economic development (DINDA, 2004):

i. $\beta_1 = \beta_2 = \beta_3 = 0$
   A flat pattern or no relationship between x and y.
ii. $\beta_1 > 0$ and $\beta_2 = \beta_3 = 0$
   A monotonic increasing relationship or a linear relationship between x and y.
iii. $\beta_1 < 0$ and $\beta_2 = \beta_3 = 0$
   A monotonic decreasing relationship between x and y.
iv. $\beta_1 > 0, \beta_2 < 0$ and $\beta_3 = 0$
   An inverted-U-shaped relationship, i.e., EKC.
v. $\beta_1 < 0,\ \beta_2 > 0$ and $\beta_3 = 0$
   U-shaped relationship.
vi. $\beta_1 > 0,\ \beta_2 < 0$ and $\beta_3 > 0$
   A cubic polynomial or N-shaped curve.
vii. $\beta_1 < 0,\ \beta_2 > 0$ and $\beta_3 < 0$
   An inverted N-shaped curve.

Considering seven different variations, we try to figure out which hypothesis is valid for which countries. In this paper we firstly run the regressions for all countries in the world and then distinguish them in their characteristics and properties such as developing or developed, Middle East or OPEC countries which export oil. We aim to observe different EKC relationships among countries by doing this separation. Summary statistics for all countries used are given in Table 2.

Table 2. Summary statistics

All Countries					
VARIABLES	Observation	Mean	Std. Dev.	Min	Max
Carbon dioxide	7,834	1.159	1.532	0.0105	21.420
GDP (per capita)	10.097	7.971	14.913	57.64	192.989
Developing Countries					
VARIABLES	Observation	Mean	Std. Dev.	Min	Max
Carbon dioxide	4.237	1.036	0.959	0.0125	10.92
GDP (per capita)	4.495	3.708	7.710	57.640	88.565
Middle East Countries					
VARIABLES	Observation	Mean	Std. Dev.	Min	Max
Carbon dioxide	861	1.500	1.023	0.124	5.891
GDP (per capita)	984	7.686	12.127	100.3	88.565
OECD Countries					
VARIABLES	Observation	Mean	Std. Dev.	Min	Max
Carbon dioxide	1.351	0.698	0.506	0.129	4.184
GDP (per capita)	1.409	20.989	18.991	279.1	119.225
OPEC Countries					
VARIABLES	Observation	Mean	Std. Dev.	Min	Max
Carbon dioxide	525	1.529	1.167	0.0756	10.920
GDP (per capita)	591	9.817	14.136	136.0	88.565

Table 3 reports the results of the panel regression for all countries, developing countries, Middle East countries, OECD and OPEC countries. The organization for Economic Cooperation and Development (OECD) is an intergovernmental organization with 35 mostly developed countries to stimulate economic progress and world trade. OPEC is a permanent inter-governmental organization of 14 oil-exporting developing nations that coordinates and unifies the petroleum policies of its Member Countries. We use a different group of countries for analysis to observe whether there exists an EKC in order to distinct its impact on several countries.

We perform the Hausman test to ratify whether the fixed effects, or the random effects, model is the optimal for our panel regression. Chi-square is significant at the 1% level for all groups of countries; therefore we decide that the fixed effect model is the optimal model for the analysis. It is well known that the fixed effect model is weak in controlling serial correlation and heterogeneity, for that reason, we compute standard errors that are robust to serial correlation and heterogeneity to make the fixed effects model robust (Arellano, 1987; White, 1980).

Estimation results of CO_2 for all countries presented in Table 3 column I reveal that the coefficients of income and income-square variables are significant and their signs are positive and negative, respectively. The coefficients of the model are: $\beta_1 > 0, \beta_2 < 0 \; and \; \beta_3 = 0$, that is hypothesis (iv) above is accepted. Therefore, our findings support the EKC hypothesis of inverted U shape when we include all countries into consideration. If the income level of countries increases, environmental damage first increases but then after some point it begins to decrease.

Table 3. Fixed effect regression results

VARIABLES	All countries CO_2	Developing countries CO_2	Middle East countries CO_2	OECD countries CO_2	OPEC countries CO_2
GDP	2.322*** (0.838)	1.282*** (0.408)	5.482*** (1.123)	0.332 (0.946)	-1.121 (1.812)
GDP^2	-0.205* (0.104)	-0.0682 (0.0540)	-0.584*** (0.140)	0.0134 (0.104)	0.174 (0.216)
GDP^3	0.00558 (0.00421)	2.43e-05 (0.00234)	0.0209*** (0.00572)	-0.00224 (0.00376)	-0.00805 (0.00839)
Constant	-8.389*** (2.193)	-5.844*** (1.008)	-16.81*** (2.922)	-2.921 (2.851)	2.169 (4.923)
Observations	7,733	4,194	858	1,34	522
Adj R-squared	0.745	0.661	0.479	0.832	0.138
Country FE	YES	YES	YES	YES	YES
Number of Countries	210	105	23	33	14
Observation	7733	4194	858	1340	522
F statistics	27.78	210.44	58.22	30.52	2.89
Prob>F	0.000	0.000	0.000	0.000	0.034
Hausman Chi-square	43.67 (0.000)	32.31 (0.000)	21.85 (0.000)	20.31 (0.000)	12.31 (0.000)

Note: Robust standard errors in parentheses, significant levels *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Results of the panel data model for the developing countries are shown in column II of Table 3. When we analyse the effect of income on environmental damage clustering the countries regarding of their properties, we obtain different results. We accept the second hypothesis, that is $\beta_1 > 0 \text{ and } \beta_2 = \beta_3 = 0$. This reveals that a monotonic increasing relationship or a linear relationship between income and CO_2. As income level in developing countries increases, the amount of CO_2 also increases. It is an expected result in the sense that developing countries are generally more focused on economic growth rather than the environment.

The fixed effect results for the Middle East countries reveal the existence of a N-shaped relationship between income and CO_2, implying income firstly damages the environment in Middle East countries and after some point of income environmental interests become more important and then finally income causes environmental degradation. We did not find any significant relationship between income and environmental damage in OECD and OPEC countries.

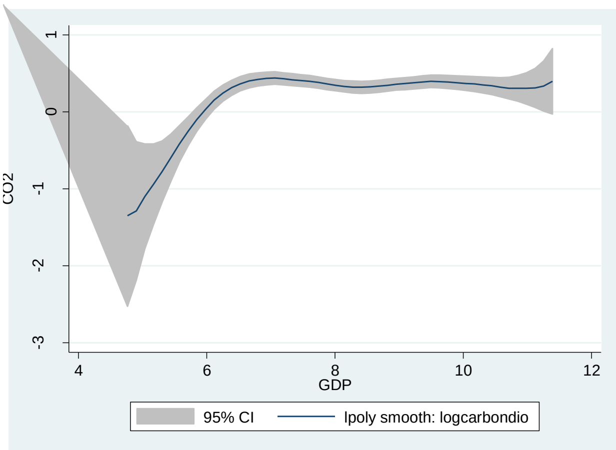
In order to have more robust results we utilize the GMM model. Before interpreting the empirical results, we report the Sargan test to investigate the validity of the GMM instruments. As seen in Table 4, the Sargan test declares that the instruments used in the GMM model are valid for all income groups. The coefficients of income at level, in quadratic form and cubic form, are statistically significant at 1% and their signs positive, negative and positive, respectively. Only OPEC countries have opposite signs opposed to the general EKC theory. This means that the GMM estimation method shows the N-shaped relationship between income and environmental degradation when we classify the countries as developing, Middle East and OPEC. These findings might be interpreted such that any beneficial effects economic growth may have on environmental pollution is transitory (He & Richard, 2010). Our findings are in the same line with some other studies (Martínez-Zarzoso & Bengochea-Morancho, 2004; Sengupta, 1996).

We also illustrate the relationship between income and CO_2 emissions in Fig. 1. They clearly reflect the findings in regression results.

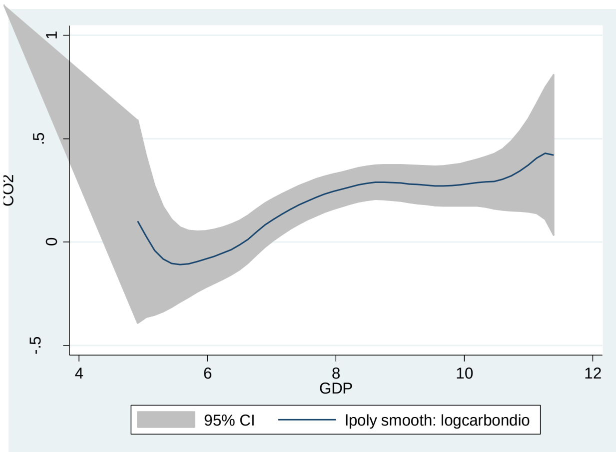
Table 4. GMM regression results

VARIABLES	All countries	Developing countries	Middle East countries	OECD countries	OPEC countries
	CO_2	CO_2	CO_2	CO_2	CO_2
GDPpc	8.362*** (0.189)	4.487*** (0.303)	6.245*** (0.458)	5.725*** (0.392)	-3.079*** (0.631)
GDPpc^2	-1.090*** (0.0247)	-0.452*** (0.0426)	-0.691*** (0.0587)	-0.558*** (0.0430)	0.466*** (0.0811)
GDPpc^3	0.0472*** (0.00105)	0.0147*** (0.00194)	0.0254*** (0.00247)	0.0178*** (0.00156)	-0.0227*** (0.00341)
Constant	-21.60*** (0.470)	-14.39*** (0.702)	-18.44*** (1.170)	-19.74*** (1.177)	6.802*** (1.605)
Observations	7,733	4,194	858	1,34	522
Number of Countries	210	105	23	33	14
Sargan Test p-value	0.3356	0.1678	0.4562	0.6784	0.5467

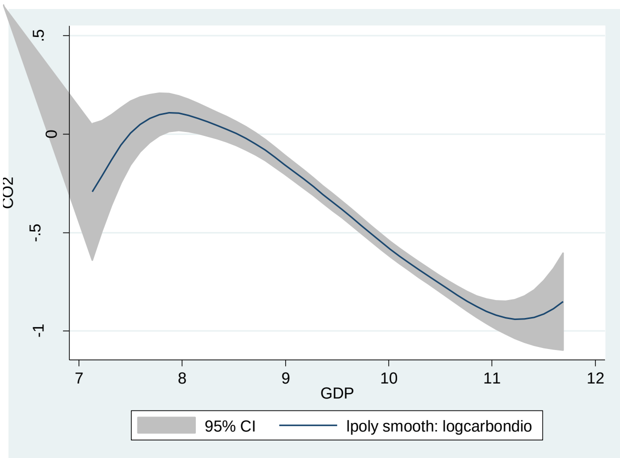
Note: Robust standard errors in parentheses, Significant levels *** p<0.01, ** p<0.05, * p<0.1



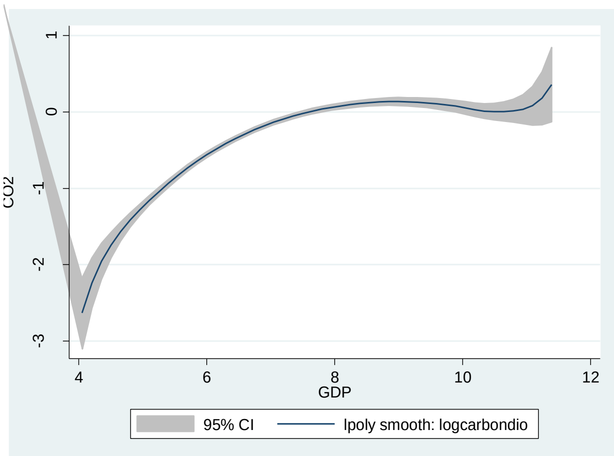
Middle-East Countries



OPEC Countries



OECD Countries



Developing Countries

Note: Grey area illustrates the 95% confidence intervals

Fig. 1. Shapes of the relationship between Income and CO_2

6. Conclusion

We investigated the existence of an environmental Kuznets curve for CO_2 emissions in Developing, Middle East, OECD and OPEC countries over a period of 47 years. The aim of doing this separation was to understand whether income growth has a different impact on the environment. We applied the fixed effect and GMM estimation methods in this study. Results obtained from cubic models indicated that a N-shaped relationship mostly exists. We found a N-shaped relationship between income per capita and CO_2 emissions in the developing, OECD and the Middle East Countries whereas there is an inverse N-shaped relationship for the OPEC countries, meaning that while the income per capita increases it firstly decreases the CO_2 emissions and after some time it increases and then it begins to decrease again. This finding is in accordance with PERMAN & STERN (2003) and MARTÍNEZ-ZARZOSO & BENGOCHEA-MORANCHO (2004) since they also explore a N-shaped relationship for the majority of countries.

Particularly we assumed that per-capita GDP is non-linearly related to CO_2 emissions, it is found that the relationship between the two variables is monotonically increasing but the slope of this function changes over time. In the EKC literature, it is generally interpreted as an adjustment towards less polluting technology in response to more expensive fuel after oil shocks in the 1970s. To conclude, the cubic function we utilized suggests that we should anticipate a reduction in CO_2 emissions when income is increasing, however, after a certain level the higher income levels will begin to increase environmental pollution.

The findings highlight some serious policy implications. Governments should closely follow the industries causing CO_2 emissions since after some point environmental degradation increases again as income increases. This fact could be explained in such a way that increasing competition among firms in the globalised world leads them to re-use less environmentally-friendly technology, hence in the later stages of economic growth pollution increases. In addition adopting clean energies including wind and solar systems and making these technologies widespread across countries might reduce CO_2 emissions. Another alternative way to reduce CO_2 emissions might be a carbon tax which will be implemented for polluters.

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