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Analysis of the Relationship Between Pollution and GDP in Selected OECD and OPEC Countries: A New Approach

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بررسی رابطه بین آلودگی محیط‌زیست و رشد اقتصادی در کشورهای منتخب عضو OECD و OPEC: با روشی جدید

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چکیده

بررسی تاثیر درآمد بر کیفیت زیست‌محیطی یکی از بحث‌های مهم در دهه ۱۹۹۰ بوده است. بسیاری از مطالعات شیوه‌های مختلفی را برای تحلیل رابطه این دو با استفاده از شیوه‌های مختلف سنجش آلودگی‌ها و درآمد بکار گرفته‌اند. آنچه که امروزه مورد تایید بیشتر مطالعات بوده رابطه عکس U شکل بین درآمد و انتشار آلودگی‌ها یا کاهش کیفیت زیست‌محیطی می‌باشد. با توجه به این امر، در این مقاله با استفاده از اصول اقتصاد خردی، ابتدا رابطه بین آلودگی و درآمد استخراج شده است در گام بعدی مقاله، رابطه عکس U شکل بین انتشار آلودگی (CO_2) و سرانه تولید ناخالص داخلی به ازای مصرف انرژی برای گروه کشورهای منتخب عضو *OECD* و کشورهای منتخب *OPEC* برای دوره‌های ۱۹۸۰-۲۰۰۳ و ۱۹۸۵-۲۰۰۳ مورد آزمون گرفته است. نتایج مقاله نشان می‌دهد که ساختار گروه کشورها و دوره زمانی مورد مطالعه نقش اساسی در رد و یا پذیرش فرضیه *EKC* برای کشورهای منتخب داشته است. همچنین نتایج مقاله، اندازه کشش بین انتشار آلودگی و سرانه تولید ناخالص داخلی به ازای مصرف انرژی برای کشورهای منتخب *OPEC* تقریبا دو برابر کشورهای منتخب عضو *OECD* را نشان می دهد.

کلمات کلیدی: کیفیت زیست‌محیطی، انتشار آلودگی‌ها، کشورهای OECD و OPEC.

Abstract

The analysis of income effect on environmental quality has been an important debate in the 1990. Several papers have used different approaches for an analysis of the relationship between income and environmental quality. Also, many of these papers have employed different measures of pollutants and income. The U inverse relationship between income and the level of pollution has been confirmed in many papers. In this paper, the relationship between pollution and income has been extracted by means of their microeconomic foundations. The U inverse relationship between the pollution generation (CO_2) and GDP per unit of energy use has been tested for selected OECD and OPEC countries in 1980-2003 and 1985-2003. The results of this paper show that the economic structure of the group of countries selected and the period of time had a major role to play in rejection or acceptance of the Environmental Kuznet's Curve hypothesis. Also, the elasticity of the problem of pollution and GDP per unit of energy use for selected OPEC countries is almost two times that of the OECD countries.

Keywords: Environmental Kuznet's Curve, Pollution, Microeconomic principles.

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Introduction

Increased income and its effect on pollution generation was one of the most important subjects of discussion during the 1990s. Extensive efforts have been made by economists to consider the relationship between income and pollution generation or reduction in environmental quality during this decade. Different methods have been put forward for considering the relationship between income, pollution and the reduction in environmental quality, among which one of the most important was through the use of a model in the shape of a square and a cube. Empirical results have not confirmed the cubic methods while most studies have confirmed use of the square methods. For this reason, square models have been used extensively in studies for considering the income/pollution relationship. Later this relationship (equation) became known as a reverse U shaped equation or Environmental Kuznets's Curve (EKC, 1991).

Consideration of the relationship between income and pollution generation in different countries has thrown up different results. In the most developed countries this reverse U shaped relationship has been confirmed, but in developing countries the results were variable. It seems, therefore, that the economic structure of the countries plays an important role in defining the relationship between the generation of pollution and their economic growth.

In contrast to other developing countries, the oil producing countries, and especially the OPEC member countries, are heavily dependent on their oil incomes. In other words, the economic growth of these countries increases when oil incomes increase and vice versa. According to this fact, the levels of investment in these countries in reducing the production of greenhouse gases are also dependent to the oil income stream. Furthermore, the economic dependency of these countries on oil incomes shows that their economies are heavily dependent on natural resources. In contrast, developed countries such as the OECD member states are quite different from OPEC member countries, and their economies are based on industrial products or knowledge. Therefore, the structural differences between these two sets of countries have a very important role to play in consideration of their environmental problems such as greenhouse gases.

In accordance with the structural differences between the two sets of OPEC and OECD member countries, the main questions addressed in this paper are: How could the flow of oil income into oil exporting countries, especially the OPEC member countries, affect the quality of the environment and or reduce generation of pollution? Does the relationship between income growth and pollution generation under the EKS model confirm this hypothesis for this set of countries? How can the structural differences of OPEC and OECD member countries affect valuation of the EKS model?

In order to answer the aforementioned questions four major oil exporting OPEC member countries, namely Iran, Saudi Arabia, United Arab Emirates and Venezuela, have been selected. Also, six OECD member countries, namely Australia, Canada, Finland, France, Germany and Japan have been selected for this study. The study has been organized in four parts with a theoretical discussion, presentation of empirical evidence, data and measuring methods. In the last part, following a brief review of the methods and different models that have been used in measuring the relationships between income and the generation of different forms of pollution, the final model has been designed in order to consider the results of the model estimations. The final part of this paper outlines the results of this study. In comparison with the previous studies in this field, this study has three distinguishing characteristics: firstly, it was based on microeconomic foundations and demonstrates the relationship between income and pollution. Secondly, in contrast to other previous studies that have mostly considered the relationship between income and the level of pollution generation, this study considers the relationship between income according to energy consumption and per capita pollution generation. From this perspective, the EKC test model has clearly shown the characteristics of OPEC member countries' economies. Thirdly, this study differs from previous studies in this field by comparing the effect of per capita income according to energy consumption and per capita pollution generation within the framework of the EKC model over two periods and the structural differences between OEPC and OECD member countries.

Materials and Method

Theoretical Framework

The relationship between economic growth and environmental quality has been a major subject of economic papers during recent decades. This discussion goes back to arguments about limits on growth in the end of 1960s. At one end of the spectrum, environmentalists such as the Club of Rome economists have suggested that limitation of environmental resources will prevent permanent economic growth. At the other end, some economists such as Beckerman (1992) believe that technological progress and environmental sustainability built on human capital can reduce dependency on natural resources and provide for permanent growth.

As Shafik (1994) pointed out during this discussion in the past, there was insufficient empirical evidence for supporting these two arguments and this discussion will therefore have a weak theoretical foundation for a long time. One of the reasons for this is related to the lack of environmental data for many years. The lack of any unified standard for measuring environmental quality has meant that few standards of environmental reduction have been used for measuring the impact of economic growth on the environment. The first report on environment and development (UN, 1992) was one of the first studies to place an emphasis on this discussion. As was shown in this report, in relation to the environmental quality reduction such as the generation of CO_2 gas, when income increases, CO_2 increases; some other standards used for measuring environmental quality with economic growth have also become worse. Other indices show that, with an increase in income, environmental quality will immediately be reduced. However, it should be emphasised that, in such situations, economic growth can later lead to an increase in the quality of the environment. Lastly, it should be pointed out that most measuring standards, such as the levels of SO_2 and NO gases, have shown an inverse relationship between the U curve and income. According to this, the quality of the environment at the early stages of growth becomes worse but, as it reaches its maximum level, it provides for an increase in the quality of the environment together with an increase in income (Figure 1). This inverse U shape is called the Environment Kuznets Curve (EKC) after a study by Simon Kuznets.

As Grossman *et al.* (1995) introduced for the first time, it is possible to separate out three main channels that cause an economic growth effect on environmental quality. First, growth has a scale effect on the environment: large scale economic activities in fact cause quality reduction to the environment. The reason is that any increase in production causes a need for more inputs and, as a result, more natural resources are used in the production process. Secondly, an income increase can have a positive effect on the environment through the integration effect: as soon as income increases, the economic structure will change and gradually the share of clean activities in gross domestic product will increase. In fact, as Panayotou (1993) has mentioned, reduction in environmental quality causes changes in the structure of the economy from an agriculture-based economy to an industrial-based one. However, a reduction in the quality of the environment will start from secondary structural changes in heavy industries whereby their special characteristic of using a lot of energy changes to becoming industries with the characteristic of using many services and pollution reducing technology. In the end,

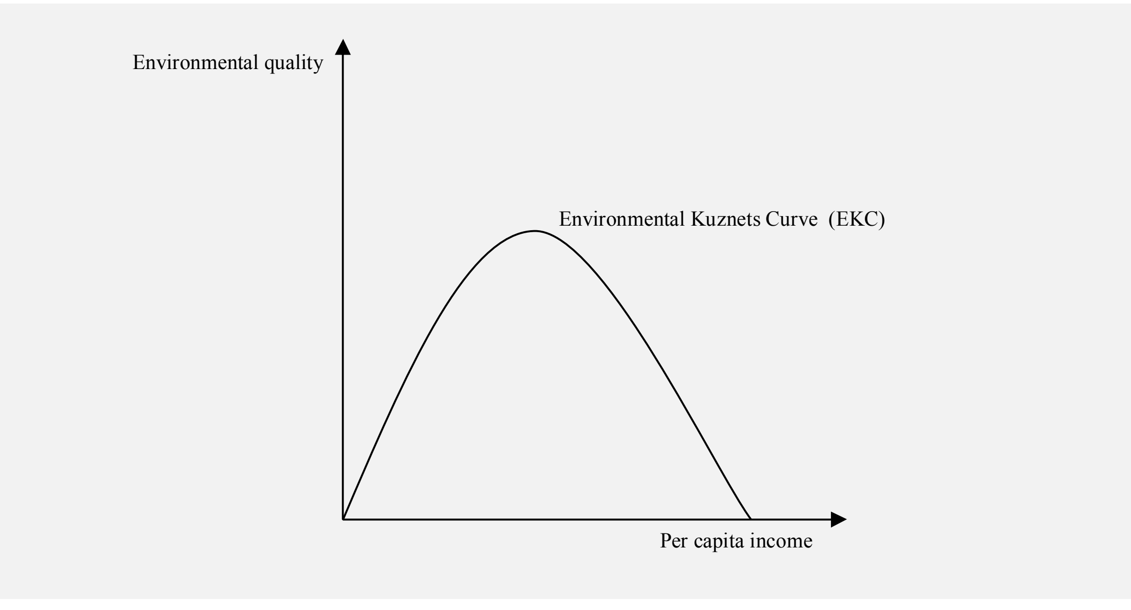

Figure 1. Reverse U curve of the second degree.

technological advances often occur with economic growth. Since rich economies are able withstand higher costs for research and development and, therefore, can substitute a lot of dirty technologies with clean technologies that provide a better foundation for environment. This issue is known as the "technological effect" of growth on the environment.

An inverse U equation between reduction of environmental quality and per capita income shows that the negative effect on the scale effect of environment cause dominates in the early stages of growth, but this effect is gradually reduced by the positive effect of integration and the technological effect of substitution that can lead to a reduction in the level of pollution. In most of the current literature, the income elasticity of environmental demands has been introduced as a main cause of this process. Immediately after the increase in income, people reach a high standard of living and take more notice of the quality of the living environment. Demand for a better environment after an income increase will result in structural changes in the economy and this will finally lead to a reduction in environmental pollution. On the one hand, a greater awareness of the environment and an increase in the demands of “green consumers” will result in the transfer of production and technologies towards environmentally friendly activities. From the other side, those can lead to the adoption of environmental policies by government with the aim of increasing environmental quality. In addition, government presence will result in a transfer of the economy towards cleaner technologies and other less polluting sectors. Hence, demand for a better environment and the policy response to that, are the main theoretical bases for this reduction in the EKC trend.

Another issue present in the recent literature on the gradient of the EKC curve is the endogenous self regulatory market mechanism. This discussion, presented by The UN Conference on Environment and Development (1992) and Moonaw and Unruh (1998), argues for the existence of an endogenous self regulatory market mechanism for natural resources that are traded in markets, together with income measures to prevent a reduction in environmental quality. In fact, in the early stages growth is usually involved with a huge exploitation of natural resources, because of the comparative importance of the agricultural sector. This can cause a reduction in natural capital capacity during this time. The continuous price increase of natural resources has a reverse result on their exploitation in the latter stage of growth which can have such results as a reduction in pollution of the environment. High prices of natural resources can cause a greater increase in economic transfer towards technologies characterised by using fewer natural resources. Therefore, political interference is not the only reason for the gradient of the EKC curve but market signals can explain also it.

Empirical Evidence

The recent discussion about the relationship between environment and income has been presented from a theoretical viewpoint. The question is, does the empirical evidence also support this model? Because of lack of time series data in relation to the environment, most studies have used an inter-country comparative method to respond to this question.

As was mentioned before, there is no unified standard for measuring environmental quality. On this basis, in order to consider the relationship between income and the environment, we need different standards to measure environmental quality. In general, by reviewing these studies they can be classified according to a division of measuring environmental standards into three groups: studies on air quality standards, studies on water quality standards and studies on other environmental quality standards.

According to air quality standards, there is strong evidence for the EKC equation. One of the important points in this group of studies regards the differences between pollution on the global and local levels. In accordance with the studies' results, measures of air quality at the city and local levels using SO_2, CO_2 and NO have a reverse U equation with income. These results have been confirmed by recent studies. Recent studies have also shown that pollution generation on the global level, such as CO_2, has increased steadily with increased income. Cole's *et al.* (1997) study shows that the CO_2 curve in this condition has bigger error standards and has a higher pick point than that of the local level.

Empirical evidence in relation to water quality standards is different. Measuring standards for water quality in these studies include concentration of contaminants in water, the amount of heavy and chemical materials introduced into the water by human activities and worsening indices of the oxygen system (saturated oxygen demand for biological and chemical oxygen). Some studies, such as that of Grossman and Kruger (1991), Shalik (1994), and Grossman and Kruger (1995), have provided evidence for an N shaped curve for some measuring indices. This suggests that, when income increases, water pollution first goes up then goes down and, in the end, increases again (Figure 2).

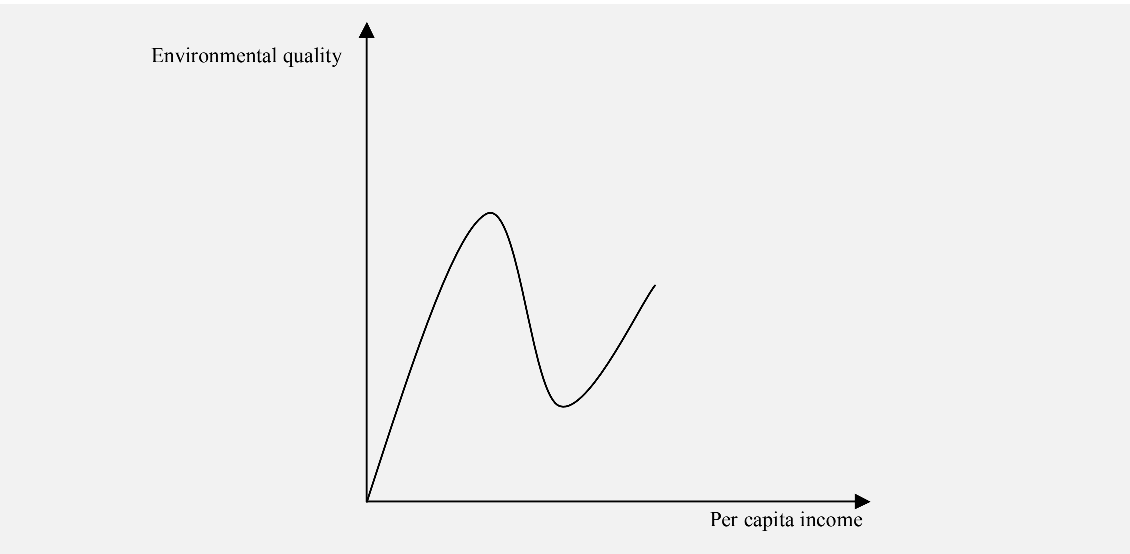

Figure 2. Reverse N-shaped EKC.

Those studies that have used other environmental standards have found little or no evidence concerning the Kuznets Curve. However, past studies and more recent studies by Shafik (1994) and Cole *et al.* (1998) have found that environmental problems have a direct effect on population achieving better living conditions, such as clean water together with access to a sewage system, when income increases. On the other hand, when environmental problems can be exogenous, the curve at the high income level never falls.

Recent studies by Cavlovic *et al.* (2002) and Stern (2004) have provided comprehensive surveys. Many of these studies found evidence of EKC relationships between per capita income and the toxic intensity of industrial production, national air quality, deforestation, various measures of water quality, solid wastes per capita, and hazardous waste sites; in the US, with automotive lead emissions and protected areas. McPherson *et al.* (2005) estimate an EKC for threatened bird and mammal species for 113 islands and found that endemic species are more threatened. They found that birds are threatened where political turmoil exists, while mammals are more threatened in countries under Muslim and Communist systems of law.

In addition to the above, other studies have examined the relationship between income and pollution levels. Some of the important ones include Grossman and Kruger (1991) who made the first EKC study as part of a study on the potential environment effects of NAFTA. Shafik and Bandy-Opandhy (1992) in their study confirm the results of the Find Report of UNCED (UN, 1992). They estimated EKC for 10 standard measures used in 31 different forms. Their study results have shown that lack of clean water and lack of a sewage system at first increases unsteadily with income growth. Regressions related to deforestation have shown that there is no relationship between income and cutting down forests, but that air quality gets worse when income increases. Finally, urban pollution and production of CO_2 directly increase with an increase in income.

Recent studies have been undertaken employing a small sample, and place an emphasis on the point that there is a steady relationship between CO_2 gas emissions and income. Dijkgraaf and Vollebergh (1998), using panel data from OECD countries, have achieved a reverse U equation for all the countries under study. Another study by Schmalensee *et al.* (1998) found this relationship in high income countries. However, the important point in all of these studies is that the selected samples have had a very significant role to play in the maximum points of these curves.

Besides the above mentioned studies, some other studies exist with the original EKS model introduced alongside other explanatory variables such as political freedom (Torras and Boyce, 1998) or the production structure (Suri and Chapman, 1997; Panapoto, 1998). The important point to be taken from these studies is that none of these studies has shown any relationship among the variables and, therefore, we cannot make any direct or clear interpretation in relation to the role of other variables in the equation with environment quality and income growth.

In addition to studies conducted overseas, some domestic Iranian studies have also been undertaken in this field. Sadeghi and Saadat (2004) demonstrated that there is a one-sided causal relationship between population and environmental destruction. Also, they showed that there is a mutual relationship between environmental destruction and economic growth. The results of Pajoyan and Morad Hasel's (2007) study showed that the EKC hypothesis was accepted for the 67 selected countries in their study, including Iran.

Poorkazemi and Ebrahimi (2008) have shown that there is an increasingly steady trend illustrating the relationship between income and pollution. Although the results were weak and the coefficients were not statistically significant, the EKC hypothesis was tested in this study and the outcome was to accept it.

The results of a study by Barghi Oskoie (2008) showed that an increase in business openness and an increase in per capita income in countries with a high per capita income and countries with a high average per capita income caused a reduction in pollution generation. However, in countries with a low average per capita income it led to an increase in pollution generation.

In general, by considering the studies under review it can be noted that, in all these studies, the relationship between income and pollution is demonstrated based either on statistical analysis or on data characteristics. The weak point of the reviewed studies appears to be that none of them was based on a microeconomic analysis of the relationship between income and pollution. Also, most of the studies reviewed considered the subject through an inter-country comparative method and the income characteristics of the countries provided the basis for the different outcomes (results). In this paper, we attempt to overcome the weaknesses of previous studies and consider the relationship between income and pollution by employing microeconomic analysis.

Empirical Methods of Measurement

Empirical analysis of the relationship between pollution and per capita income has been considered using an estimate reduced form model. These models can be described as having a parametric or semi-parametric form. Important characteristics of empirical models can point to their sensitivity to selected samples. Two parametric methods are usually used in empirical analysis. The first method that is used more frequently in the literature on this subject is the estimation of the fixed effects of two dimension model panel data using a model cubed in the form shown below:

$$P_{it} = \alpha_i + \varphi_t + Y_{it}\delta + \varepsilon_{it}$$

In this equation p_{it} is the production of pollution in a country or section *i* in time *t*, y_{it} is a vector of variables such as income, income square and income cubed of country or section *i* in time of *t* (i.e. $y_{it} = y_{it}\ y_{it}^2\ y_{it}^3$), δ a vector of coefficient gradient, α_t gives time effects and ε_{it} is the error term.

The second method that has been used in some of the empirical literature is the linear and cubed form of above equation. This method is known as a semi parametric model and is shown below in the following form:

$$P_{it} = \alpha_i + \varphi_t + g(y_{it}) + u_{it}$$

In this equation y_{it} is income, *g(o)* is the unknown function, u_{it} represents residuals with a zero mean and independent with *g(o)* and other variables that have been given. Different methods have been used for defining the *g (o)* function. The most commonly used method is the Kernal based method.

In this paper, in contrast to previous studies, we use a microeconomic model for measuring the relationship between income and pollution. Suppose, for example, a customer consumes some goods such as quality goods (C) and poor quality goods or pollution (P). Then the utility function is according to the equation below:

(1) $U = U(C, P)$ $U = U(C,P)$

In this equation $U_c > 0$ and $U_p < 0$ and we suppose *U* is semi concave to *C* and *P*. Then, we introduce the production technology of *P* into the model. It is natural to have pollution as an outcome of consumption. Suppose also that the consumer, with an improvement in their in resources, can reduce the amount of pollution or prevent the production of pollution. This resource is defined as the 'environmental effect' and is shown here as *E*. Therefore, pollution is a positive function of consumption and a negative function of the environmental effect:

(2) $P = P(C, E)$

In this equation we will see $P_c > 0$ and $P_e < 0$. Finally, we suppose that there is a limited amount of basic resources allocated to C and *E*. For simplification, the relative cost of *C* to *E* will be normalized. Therefore, the resource limitation will be as follows:

(3) $C + E = M$

Now we consider one example of the above mentioned equations:

(4) $U = C - zP$

$$P = C - C^{\alpha} E^{\beta}$$

In the above equations, *C* and *P* are linear and added functions and *z* is >0 and that shows the disutility of the pollution level. Pollution has two main segments; part C is impure pollution before reduction and part $C^{\alpha} E^{\beta}$ shows pollution after reduction. The pollution equation shows that consumption leads to increased pollution but that using resources for environmental actions can lead to a reduction in pollution.

By supposing *Z=1*, putting equation (4) in equation (3) and using the microeconomic base to look at consumer behaviour, meaning making maximizing utility *(U)* to endowment resources *(M)*. Finding the best consumer behaviour, consumption *(C)* and environmental effort *(E)* taking out Cobb-Douglas results we have the following:

(5) $$C^* = \frac{\alpha}{\alpha+\beta} M \quad , \quad E^* = \frac{\beta}{\alpha+\beta} M$$

According to equation (5), then, the optimal level of pollution is as follows:

(6) $$P^*(M) = \frac{\alpha}{\alpha+\beta} M - \left(\frac{\alpha}{\alpha+\beta}\right)^{\alpha} \left(\frac{\beta}{\alpha+\beta}\right)^{\beta} M^{\alpha+\beta}$$

Adding the differential of equation (6) to *M* provides the slope of the Environmental Kuznets Curve:

$$(7)\ \frac{\partial P^*}{\partial M} = \frac{\alpha}{\alpha+\beta} - (\alpha+\beta)\left(\frac{\alpha}{\alpha+\beta}\right)^{\alpha}\left(\frac{\beta}{\alpha+\beta}\right)^{\beta} M^{\alpha+\beta-1}$$

The sign of equation (7) is dependent on the α and β parameters; there are two probabilities:

(A) When is $\alpha+\beta=1$, meaning that environmental efforts for the reduction of pollution have a constant return to scale, then $\frac{\partial P^*}{\partial M}$ will be constant. Suppose that $0<\alpha$ and $\beta<1$, P^* increases with an increase in M and the income-pollution curve will have a positive slope (Figure 3-A).

(B) When is $\alpha+\beta\neq 1$, then the second differential of equation (6) will be as follows:

(8)

$$\frac{\partial^2 P^*}{\partial M^2} = -(\alpha+\beta-1)(\alpha+\beta)\left(\frac{\alpha}{\alpha+\beta}\right)^{\alpha}\left(\frac{\beta}{\alpha+\beta}\right)^{\beta} M^{\alpha+\beta-2}$$

If is $\alpha+\beta<1$, meaning a reduction in pollution as a result of technology has a decreasing return to scale, then $P^*(M)$ is convex (Figure 3-B). But, if $\alpha+\beta>1$, meaning that a reduction in pollution due to cleaner technologies has an increasing return to scale, then $P^*(M)$ will be concave (Figure 3-C). This situation is the same as that under the Environmental Kuznets Curve.

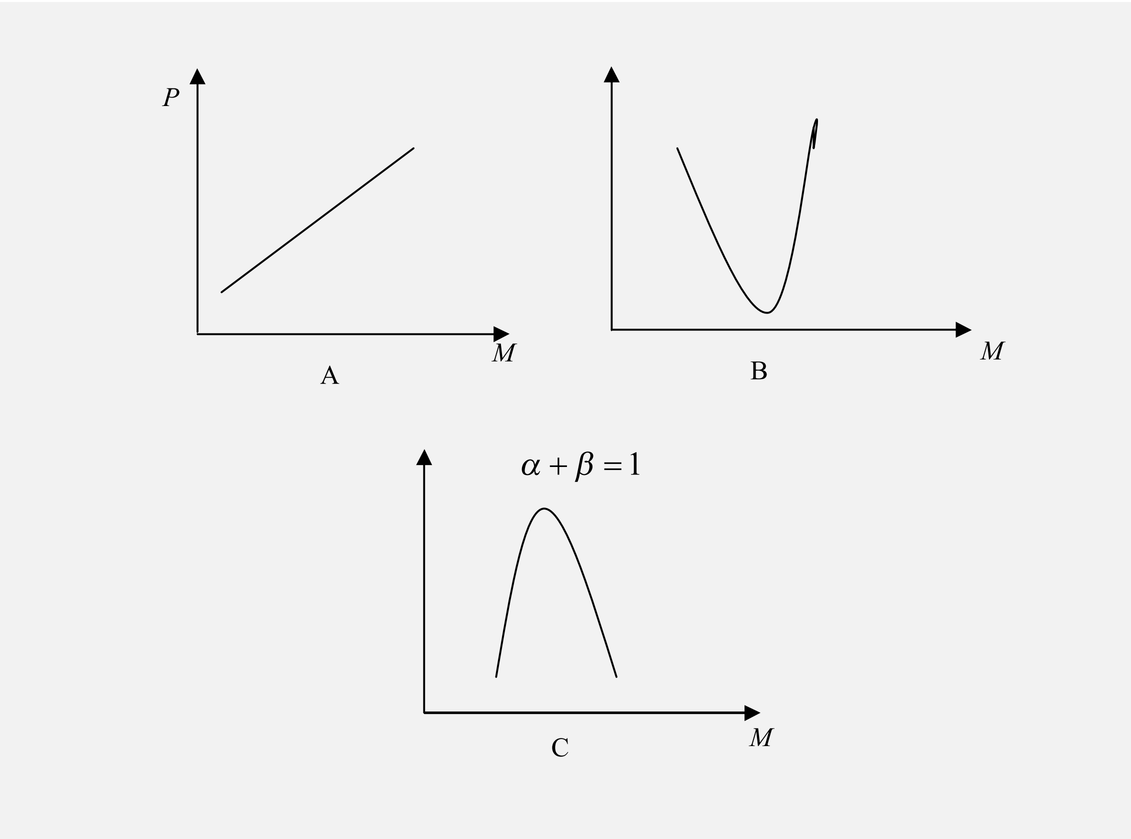

Figure 3. The relationship between pollution and income.

Therefore, if we employ a cleaner technology with an increasing return to scale, then the relationship between income and pollution is a kind of EKC. Can we suppose that the increasing return to scale of a cleaner technology is rational? In other words, if pollution and environmental efforts increase two times, does pollution decrease by more than two times? In response to this question, let us consider the following example.

Consider a technology for sweeping an area of ground. Suppose, then, the entries for this technology is (i) a piece of land with a one centimetre layer of dust and (ii) one hour of sweeping. Now, if the entries for this technology become two times, i.e. that the layer of dust and sweeping time become two times, and supposing that the sweeping speed before and after these changes in entries is the same, then the pollution of that area of land will decrease by more than two times. This means that in introduction of a cleaner technology will have the characteristics of an increasing return to scale.

Therefore, according to the aforementioned example and other examples, we can assert that technology pollution reduction in relation to pollution and environmental efforts will have an increasing return to scale. In accordance with this view, the following part of this paper will consider the relationship between income and pollution for two sets of countries-OECD and OPEC member States.

In this paper, according to microeconomic analysis based on the optimal behaviour of consumers that have the ability to reflect on all society, the following empirical model will be used for analysing the relationship between income and pollution:

$$\ln(P)_{it} = \alpha_i + \gamma_t + \beta_1 \ln(M)_{it} + \beta_2 (\ln(M)^2{}_{it} + \varepsilon_{it}$$

Where P is the pollution in country i at time t; M is income in country i at time t; and ε is the error term. The selected countries include oil producing OPEC members (Iran, Saudi Arabia, United Arab Emirates and Venezuela) and OECD members (Australia, Canada, Finland, France, Germany and Japan). The study periods are 1980-2003 and 1985-2003.

For empirical analysis of the relationship between pollution and income, we have used in this paper (as opposed to previous papers in this area) production data for CO_2 (kg per 2000 PPP \$ of GDP) as a proxy of pollution (production) and data for *GDP* per unit of energy use (constant 2000 PPP \$ per kg of oil equivalent) as a proxy for income. Data series have been used here for the periods of 1980-2003 and 1985-2003, derived from the World Development Indicators (WDI) 2007.

The unit root test has been used for each group of countries' data and the study shows that data related to pollution generation and income for each set of countries (unit root) panel data are at a meaningful level. In other words, the data that have been used are stationary at that level (see Table 1A and Table 2A in Appendix). After being satisfied that the data used are stationary, the empirical model has been estimated using the panel data method; the estimation for these results is shown in Table 1.

Results

The estimation results show that during the period 1980-2003 per capita elasticity of pollution (production) to consumption of energy compared with per capita income for energy consumption for selected OECD member countries is 0.23. This means that percentage changes in pollution increases at the start will increase in per capita income but, as can be seen, pollution generation elasticity to per capita income is insignificant. Percentage changes in per capita pollution generation to percentage changes in per capita income squared came to -0.32. This means that, after an increase in pollution (production) at the first stage of income generation, in the second stage pollution is reduced. In contrast with elasticity of pollution (production) to per capita income, elasticity of pollution (production) to per capita pollution squared is significant. Finally, for the period 1980-2003 we can mention for selected OPEC member countries that the EKC curve hypotheses between per capita pollution generation and per capita income are not accepted.

Results of the model for the period 1985-2003, show that elasticity per capita pollution (production) to per capita income is 1.77 and significant. This means that, with the increase in per capita income at the start, the per capita pollution (production) level for selected OPEC member countries also increases and this increase is opposite to that of the period 1980-2003 and is significant. The elasticity pollution (production) per capita to income squared for the period 1985-2003 is -1.97 and also significant. We can interpret this to mean that, with an increase in the per capita income of the selected countries at the second stage, the amount of pollution (production) per capita is reduced.

Discussion

The above results for selected OPEC member countries can demonstrate that, on the one hand, significant changes have occurred in relation between per capita income and per capita pollution generation with the passing of time. On the other hand, the EKC curve hypothesis in selected OPEC countries is supported over time. It seems that a change in attitude among the selected countries towards economic development has played a significant role in the meaningful changes in the significance of the results found for the periods under study.

Estimated results for selected OECD countries during the period 1980-2003 show that, on the one hand, per capita elasticity of pollution (production) to per capita income was –0.74 and significant. On the other hand, per capita elasticity of pollution (production) to per capita income squared was -0.28 and significant. These results show that the coefficient sign of per capita income is negative and is unpredicted. Therefore, we can state that the EKC curve hypothesis was not confirmed for selected OECD countries during the period 1980-2003.

Estimated results of the model for selected OECD countries for the period 1985-2003 show that, in contrast with the period 1980-2003, the estimated coefficient is significant and has the correct sign. Therefore, it can be mentioned that the EKC curve hypothesis for selected OECD countries for period 1980-2003 is confirmed.

Table 1. Results of the estimated model.

		C^a	Log(M)	Log(M)^2	R- square
OPEC countries	1980-2003	0.14	0.23	-0.32	R^2_w= 0.77[c]
		(0.64)[b]	(0.58)	(-1.97)	R^2_{uw}=0.72[d]
	1985-2003	-0.60	1.77	-1	R^2_w= 0.76
		(-2.33)	(3.54)	(-4.50)	R^2_{uw}=0.69
OECD countries	1980-2003	0.94	-0.74	-0.28	R^2_w=0.99
		(3.62)	(-2.14)	(-2.14)	R^2_{uw}=0.93
	1985-2003	-0.27	0.75	-0.69	R^2_w= 0.99
		(-0.91)	(2.01)	(-6.04)	R^2_{uw}=0.98

[a] fixed effects (Cross) [b] t- student [c] R^2- cross section weighted [d] R^2-unweighted

The estimated model results given in Table 1 show that the estimated coefficients for the period 1985-2003 for the selected OPEC countries are almost two times that of the estimated coefficients for the selected OECD countries. On the basis of this, the maximum level of pollution to per capita income level occurred less for the selected OPEC member countries than for selected OECD member countries. However, the maximum per capita pollution (production) in selected OPEC member countries is higher than the maximum per capita pollution generation in the selected OECD member countries during this period. Figure 4 shows the special character of the EKC curve for selected OPEC member countries and selected OECD member countries.

The EKC hypothesis test for the two sets of countries under study show that this hypothesis for both sets of countries is confirmed over time. For the selected OPEC member countries the EKC hypothesis during the period 1980-2003 has not been confirmed but the parameters have the expected signs. While the EKC hypothesis is not confirmed in this period for the selected OECD member countries, the parameters also do not have the expected sign. For the period 1985-2003

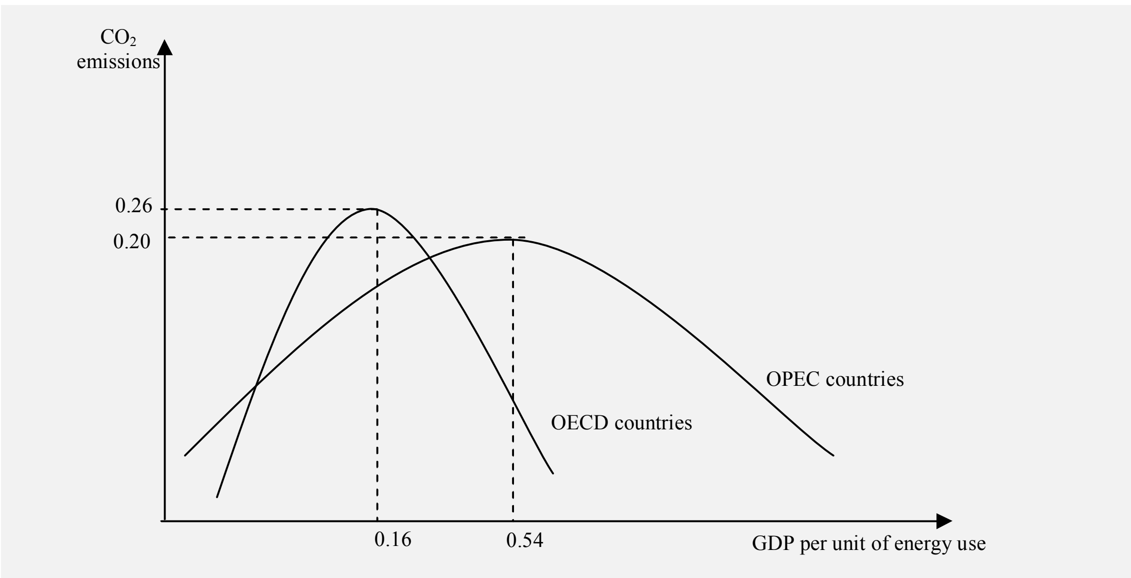

Figure 4. EKC for selected OPEC and OECD countries.

it is confirmed in both sets of the selected countries. In addition to this, the results of this paper show that the maximum point of EKC for the selected OECD member countries is higher in comparison with that for the selected OPEC member countries; it reaches its maximum point with a low income per capita level. This point to the fact that structural differences have an important role in EKC estimated characteristics.

Appendix

Table 1A. Results of the unit root test for OECD countries.

Pool unit root test: Summary
Series: GDP_AU, GDP_CA, GDP_FA, GDP_FR, GDP_GR, GDP_JA
Date: 11/25/11 Time: 20:25
Sample: 1980 2003
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 1
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.24887	0.1059	6	137
Breitung t-stat	-0.26954	0.3938	6	131
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.35743	0.0092	6	137
ADF - Fisher Chi-square	24.8778	0.0154	6	137
PP - Fisher Chi-square	24.7998	0.0158	6	138

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.
All other tests assume asymptotic normality.

Pool unit root test: Summary
Series: CO2_AU, CO2_CA, CO2_FA, CO2_FR, CO2_GR, CO2_JA
Date: 11/25/11 Time: 20:43
Sample: 1980 2003
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 1
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.91874	0.0275	6	137
Breitung t-stat	1.33695	0.9094	6	131
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.70735	0.0439	6	137
ADF - Fisher Chi-square	21.3263	0.0458	6	137
PP - Fisher Chi-square	21.3936	0.0449	6	138

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.
All other tests assume asymptotic normality.

Table 2A. Results of the unit root test for OPEC countries.

Pool unit root test: Summary
Series: CO2_IR, CO2_SA, CO2_UA, CO2_VE
Date: 11/25/11 Time: 20:39
Sample: 1980 2003
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 1
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-1.81838	0.0345	4	90
Breitung t-stat	-2.38663	0.0085	4	86
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-1.70108	0.0445	4	90
ADF - Fisher Chi-square	15.9227	0.0435	4	90
PP - Fisher Chi-square	10.7140	0.2184	4	92

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.
All other tests assume asymptotic normality.

Pool unit root test: Summary
Series: GDP_IR, GDP_SA, GDP_UA, GDP_VE
Date: 11/25/11 Time: 20:42
Sample: 1980 2003
Exogenous variables: Individual effects, individual linear trends
Automatic selection of maximum lags
Automatic selection of lags based on SIC: 0 to 4
Newey-West bandwidth selection using Bartlett kernel

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-9.22977	0.0000	4	88
Breitung t-stat	-0.12694	0.4495	4	84
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-7.91229	0.0000	4	88
ADF - Fisher Chi-square	57.7582	0.0000	4	88
PP - Fisher Chi-square	279.889	0.0000	4	92

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution.
All other tests assume asymptotic normality.

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