Environment and economic development: determinants of an EKC hypothesis

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Environment and Economic Development: Determinants of an EKC

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Abstract

In this paper we examine the concept of an Environmental Kuznets Curve (EKC) hypothesis in a critical way aiming to justify its existence as well as to propose policies compatible with sustainable development. For this reason, we make use of a data set on CO_2 emissions for 32 countries over a 36 year time period. For this balanced panel database, we apply a number of econometric methods to estimate the income-environment relationship. Our results indicate the existence of N-shaped relationship between economic development and pollution. However we show that the turning points calculated by panel data analysis may not reveal the actual turning points valid for individual countries. In our case and using different countries from different geographical regions we found a mixture of monotonic or inverted U-shape or N-shape behaviour. Countries are heterogeneous with different stochastic regression coefficients. This implies that the use of the total N-shape income-environment relationship by policy makers may be misleading with serious policy ineffectiveness implications.

Keywords: Environmental Kuznets Curve; Panel Data; CO_2 emissions.

JEL Classification: Q56, O20, C23.

1. Introduction

Kuznets (1955) showed that during the various economic development stages, income disparities first rise and then begin to fall. Degradation tends to be higher in many middle income countries in comparison to less developed countries. The environmental Kuznets curve (hereafter EKC) hypothesis proposes that there is an inverted U-shape relation between environmental degradation and per-capita income. In this paper, we examine the concept of an environmental Kuznets curve in a critical way with an eye towards proposing policies compatible with sustainable development. Environmental damage seems to be lower in the most developed countries compared to many middle-income countries and higher in many middle-income countries compared to less developed countries.

A number of alternative theories of the economy-environment relationship exist and are presented in Everett et al. (2010). Namely, the *limits theory* defines the economy-environment relationship in terms of environmental damage hitting a threshold beyond which production is so badly affected that the economy gets smaller. The *new toxics view* relies on the idea that emissions of existing pollutants are decreasing with further economic growth but the new pollutants substituting for them increase. This view questions the existence of turning points and considers the possibility that environmental damage continues to increase as economies grow (Everett et al., 2010). Similarly the *race to bottom theory* states that international competition initially leads to increasing environmental damage, up to the point when developed countries start reducing their environmental impact but also export polluting activities to poorer countries. The net effect, in the best case scenario, is a non-improving situation. Finally, the *Porter's Hypothesis* refers to growth and environment as a false dichotomy and finds that well-designed environmental policy can increase R&D into resource efficient products and processes, resulting in improved business competitiveness and profitability (Everett et al., 2010).

Empirical formulations of the environment-income relationship and the exploration of the EKC hypothesis rely on the econometric specifications that consist of an environmental damage indicator as depending on an economic variable representing economic development like GDP/c in level, square and cubic values as independent variables. Due to lack of data different variables have been used so far in empirical modelling to approximate environmental damage like air pollutants (SO_X, NO_X, CO_2, PM10, CO, etc.), water pollutants (e.g. toxic chemicals discharged in water, etc.) and other environmental indicators (e.g. deforestation, municipal waste, energy use, urban sanitation and access to safe drinking water).

This paper is organised as follows. Section 2 discusses the existing theoretical and empirical work. Section 3 comments on the reasons for justifying an EKC, while section 4 presents the econometric models used in this study. The empirical evidence is presented in section 5. The final section concludes the paper.

2. Previous work

A number of authors have estimated econometrically the EKC using OLS analysis. The EKC estimates for any dependent variable (e.g. SO_2, NO_X, deforestation, etc.) peak at income levels, which are around the world's mean income per capita. Income as expected is not normally distributed but skewed (with a lot of countries below mean income per capita). Arrow *et al*. (1995), Ekins (1997) and Ansuategi *et al*. (1998) provide a number of reviews and critiques of the EKC studies. Stern *et al.* (1996) identified a number of problems with some of the main EKC estimators and their interpretation. They mention among other econometric problems, the mean-median income problems, the interpretation of particular EKCs in isolation from other environmental problems, the assumption of unidirectional causality from growth to environmental quality and the reversibility of environmental change and the asymptotic behaviour. Stern (1998) reviews these problems in detail and shows where progress has been made in empirical studies.

Cropper and Griffiths (1994) and Selten and Song (1994), conclude that the majority of countries in their analyses are below their estimated peak levels for air pollutants and thus economic growth may not reduce air pollution or deforestation. This implies that estimating the left part of EKC is easier than estimating the right hand part. Thus, use of OLS is not likely to yield accurate estimates of the peak levels.

The differences in the extracted relationships as well as in the estimated turning points may be attributed to the econometric models' functional form used and the adoption of static or dynamic analysis. Stern and Common (2001) find that sulfur emissions per capita are a monotonic function of income per capita, when they use a global sample and an inverted U-shape function of income when they use a sample of high-income countries only. They calculate a much larger in size turning point ($ 908178) compared with the total sample, again implying a monotonic EKC. Halkos (2003), using the same database but proposing a dynamic model formulation finds much lower turning points in the range of $2805-$6230 and inverted U-shape curves.

At the same time the inclusion of other independent variables in the model formulation, affects significantly the estimated relationship. Roca et al. (2001) claim that estimated EKC is weaker when more explanatory variables are used together with income. Empirical evidence is not clear and mixed results have been found (Galeotti et al., 2006; He and Richard, 2010; Chuku, 2011).

A number of studies found a linear and monotonic relationship between environmental damage and income per capita. Akbostanci et al. (2009) examined the income–environment relationship in the case of Turkey using time series and provincial panel data for the periods 1968-2003 and 1992-2001 respectively. They found a monotonically increasing relationship between carbon dioxide emissions and income in the case of times series analysis. Similarly, Fodha and Zaghdoud (2010) found a monotonically increasing relationship between CO_2 emissions and GDP for Tunisia and for the period 1961-2004.

Other researchers have found an inverted-U shaped relationship with turning points ranging from $823 to $79,000, implying a possible separation of environmental damage from economic development (Grossman and Krueger, 1995; Holtz-Eakin and Selden 1995; Cole et al., 1997; Stern and Common 2001; Halkos, 2003; Galeotti et al., 2006). Fodha and Zaghdoud (2010) found an inverted-U shaped relation with a turning point of $1,200 for SO2 for Tunisia and the period 1961-2004. Panayotou (1993; 1995; 1997) employed cross sectional data and GDP in nominal US $ (1985). The equations for the pollutants considered were logarithmic quadratics in income per capita. Deforestation was estimated against a translog function in income/c and population density. All the curves estimated were inverted U's with turning point for deforestation at $823 per capita. Finally, He and Richard (2010) using parametric, semi-parametric and non-linear models found weak evidence of the EKC hypothesis for the relationship between CO_2 emissions and GDP in the case of Canada and for the period 1948-2004.

Stern *et al.* (1996) claim that the mix of effluent has shifted from sulphur and NO_X to CO_2 and solid waste, in a way that aggregate waste is still high and even if per unit output waste has declined, per capita waste may not have declined. Regressing per capita energy consumption on income and temperature gave them an inverted U-shape relationship between energy and income. Energy consumption peaked at $14600. The authors claim that the results depend on the income measure used. If income in PPP is used, the coefficient on squared income was positive but small and insignificant. If income per capita was measured using official exchange rates, the fitted energy income relationship was an inverted U-shape with energy use peaking at income $23900.

Others have found an *N*-shape relationship (Friedl and Getzner, 2003; Martinez-Zarzoso and Bengochea-Marancho, 2004) which shows that the release of environmental damage from economic development may be temporary (He and Richard, 2010). Grossman and Krueger's (1991, 1995) and Shafik and Bandyopadhyay (1992) suggest that at high-income levels, material use increases in a way that the EKC is N-shape. Friedl and Getzner (2003) found an N-shaped relationship between CO_2 and GDP for Australia and for the time period 1960-1999. Akbostanci et al. (2009) found an *N*-shaped relationship in the case of SO_2 and PM10 emissions in their panel data analysis.

3. Reasons justifying the EKC

A number of recent EKC studies consider the factors, which cause an inverted U-shape pattern. A first reason is the improvement in environmental quality as the result of the change in the technological mode of production (de Bruyn, 1997; Han and Chatterjee, 1997) or of the exportation of "dirty industry" to less developed or developing countries (Rock, 1996; Suri and Chapman, 1998; Heerink *et al.*, 2001; Lieb, 2003).

Another reason is the role of preferences and regulation on the emissions profile of polluters. In the formalization of the transition to the low-pollution state there is a group of authors that provide significant analyses of the role of preferences and regulations on the emissions profile of polluters (Lopez, 1994; McConnell, 1997; Stokey, 1998). The better institutional set up in the form of credible property rights, regulations and good governance may create public awareness against environmental degradation (Dinda *et al.*, 2000). They claim that technological improvements, structural economic change and transition and increase in spending on environmental R & D accompanied with increasing per capital income are important in determining the nature of the relationship between economic growth and environmental quality.

The levels of several pollutants per unit of output in specific processes have declined in the developed countries over time with the use of strict environmental regulations. Pollution will stop increasing and start to decrease with economic growth because some constraints will become non-binding (Lieb, 2003). Stokey (1998) shows that pollution increases linearly with income until the threshold is passed and cleaner technologies can be used. The implied pollution-income path may be an inverse-V with a sharp peak taking place at the point where a continuum of cleaner technologies becomes available. Jaeger (1998), similarly to Stokey, finds that the pollution income relationship is an inversed-V. Jaeger relies on the assumption that at low levels of pollution consumers' taste for clean air is satisfied and marginal benefit of additional environmental quality is zero. Similarly, Jones and Manuelli (1995) using an overlapping generations model and determining economic growth by pollution regulations and market interactions show that depending on the decision making institution the pollution-income relationship may have an inverted V shape, but it could also be monotonically increasing or a "sideways-mirrored S".

Andreoni and Levinson (2001) suggest another explanation due to the technological link between consumption of a desired good and abatement of its undesirable byproducts (pollution). Torras and Boyce (1998) argue that the greater equality of incomes results in lower level of environmental degradation. This claim is challenged by Scruggs (1998). Demand for environmental quality increases with income implying environmental quality is a normal good. Poor people have little demand for environmental quality but as society gets richer its members intensify their demands for a healthier and cleaner environment (Lieb, 2003).

Natural progression of economic development goes from clean agricultural to polluting industrial and to clean service economies. Specifically, economic development is associated with environmental pollution and there are three different effects that may explain this relationship. Namely, the scale effect, the composition effect and the technical effect (Grossman and Krueger, 1995; Dinda, 2004; Everett *et al.*, 2010). The scale effect has a negative influence as more output results in more adverse effects for the environment. Simply higher quantities of output demand more natural resources in the production processes and lead to more emissions and by-products leading to environmental damage. At the same time the composition effect may have a positive influence on the environment offsetting (even partially) the adverse effects. The idea is that as economic output increases the structure of the economy tends to shift from agricultural activity to industrial economy which is pollution-intensive and then to service economy which are less damaging the environment. Figure 1 shows the mentioned effects graphically.

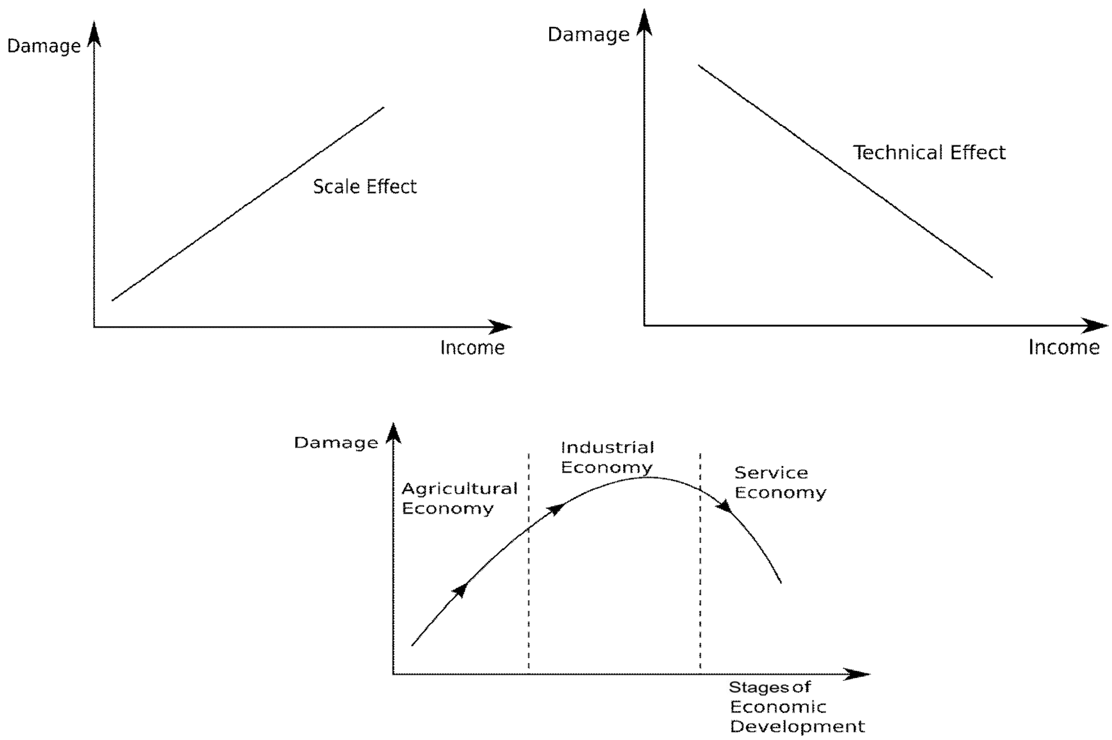

Figure 1: Scale, technical and composition effects

In analyzing long time-series, the three effects in continuation lead to an initial stage of economic development which has a negative effect on the environment due to scale effect followed up by changes in the structure of the economy as well as in the production methods that take place at the next stages of development which have positive effects on the environment and are due to composition and technical effects.

Similarly, environmental damage could enlarge through the scale effect as increasing volumes of exports increase the size of the economy. But trade can enrich environment through composition and/or technical effects. As income rises through trade, environmental regulation is becoming stricter encouraging pollution reducing innovations. According to Dinda (2004) the composition effect is attributed to two hypotheses. First *the displacement hypothesis* according to which the pollution intensive industries migrate from countries with stricter environmental standards to those with less strict standards. In this way rich countries are likely to be net importers of pollution intensive goods. The extracted inverted U-shape curve may be the result of changes in international specialization with that trade liberalization to lead to more pollution intensive industries in less developed economies as developed economies implement stronger environmental standards. Second *the pollution haven hypothesis* refers to the case where multinational firms (mainly involved in highly polluting activities) move to countries with less strict environmental regulations. This hypothesis states that low environmental regulations may be source of comparative advantage and may lead to changes in trade patterns (Dinda, 2004).

4. Econometric methods and Data used

The basic model to be estimated may be written as:

$$Y_{it} = \alpha + X_{it}\beta_{it} + \delta_i + \gamma_t + \varepsilon_{it} \qquad (1)$$

where Y_{it} is the dependent variable; X_{it} is a k-vector of explanatory variables; and ε_{it} are the disturbance terms for i = 1,2,…M cross-sectional units in periods t = 1,2,…T. The parameter α corresponds to the overall constant in the model while δ_i and γ_t represent cross-section and period specific effects (random or fixed) respectively.

Both fixed and random effects are inefficient in the presence of heteroskedasticity (Baltagi, 2001). In order to take into account heteroskedasticity and various patterns of correlation between the residuals, Generalized Least Squares (GLS) specifications may be used. For estimating β the GLS estimator is given as:

$$\hat{\beta} = (X'\Phi^{-1}X)^{-1}X'\Phi^{-1}Y \qquad (2)$$

We have applied panel data methods to estimate the above equation. The first method employed is the fixed effects (hereafter FE), which allows each individual country to have a different intercept treating the α_i and γ_i as regression parameters. This practically implies that the means of each variable for each country are subtracted from the data for that country and the mean for all countries in the sample in each individual time period is also deducted from the observations from that period. Then Ordinary Least Squares is used to estimate the regression with the transformed data.

The second model is the random effects (hereafter RE) in which the individual effects are treated as random. In this model the α_i and γ_i are treated as components of the random disturbances. The residual from an OLS estimate of the model with a single intercept are used to construct variances utilized in a GLS estimates (for further details see Hsiao, 1986). If the effects α_i and γ_i are correlated with the explanatory variables then the random effects model cannot be estimated consistently (Hsiao, 1986, Mundlak, 1978).

The orthogonality test for the RE and the independent variables is also examined. For this reason, a Hausman test is used in order to test for inconsistency in the RE estimate. This test compares the slope parameters estimated for FE and RE models. A significant difference indicates that the RE model is estimated inconsistently due to correlation between the independent variables and the error components. If there are no other statistical problems the FE model can be estimated consistently although the estimated parameters are conditional on the country and time effects in the selected sample of data (Hsiao, 1986). In the case of coefficient heterogeneity FE and RE estimates in a static formulation are consistent in the absence of other misspecification (Stern, 2010).

In our case, we analyze CO_2/c emissions in a sample of 32 countries for the period 1971-2006. We have performed Box-Cox tests in order to test the linear against the logarithmic functional form of the relationship between CO_2/c and GDP/c. The model proposed here is estimated as:

$$(CO_2/c)_{it} = \alpha_i + \gamma_t + \beta 1\ (GDP/c)_{it} + \beta 2\ (GDP/c))^2{}_{it} + \beta 3\ (GDP/c))^3{}_{it} + \varepsilon_{it} \qquad (3)$$

where the α_i's are country specific intercepts and the γ_i's are time specific intercepts and the countries are indexed by i and time periods by t. CO_2/c is carbon dioxide emissions per capita in tons and ε_{it} is a disturbance term. Our sample consists of the 32 countries with full record on CO_2 and GDP per capita information for the period 1971-2006[1]. The database used has 1152 observations per variable. GDP per capita has been used in international prices (2005 US dollars) and the data have been obtained from OECD (2008). The CO_2 data have been obtained from the IEA (2010).

5. Empirical evidence

Table 1a presents the results of a number of unit root tests on the variables of interest (i.e. CO_2/c and GDP/c). From this table it can be seen that there is evidence against non-stationarity in levels. Specifically, in all cases and according to the tests adopted, our variables are I(1). That is, they are stationary in first differences and non-stationary in levels in all levels of

[1] The countries used in our analysis are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland. Italy, Japan, Netherlands, New Zealand, Norway, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, UK, USA, Brazil, Chile, China, India, Indonesia, Israel, Russia, South Africa.

statistical significance. Similarly Table 1b presents the Pedroni Cointegration Tests. In seven of the eleven cases we reject the null hypothesis of no cointegration at the conventional statistical significance level of 0.05.

Table1a: Summary of panel unit root tests (P-values in brackets)

Levels	**Levin, Lin and Chu t***	**Breitung t-stat**	**Im, Pesaran and Shin W-stat**	**ADF- Fiscer Chi square**	**PP- Fiscer chi-square**
CO_2/c	-0.24013 [0.4051]	1.5615 [0.9408]	0.19409 [0.5769]	59.5051 [0.6360]	65.1873 [0.4352]
GDP/c	9.1413 [1.0000]	2.09624 [0.9820]	9.59097 [1.0000]	31.1598 [0.9998]	14.9650 [1.0000]
First Differences	**Levin, Lin and Chu t***	**Breitung t-stat**	**Im, Pesaran and Shin W-stat**	**ADF- Fiscer Chi square**	**PP- Fiscer chi-square**
Δ CO_2/c	-9.06847 [0.0000]	-5.7905 [0.0000]	-13.7486 [0.0000]	304.282 [0.0000]	870.216 [0.0000]
Δ GDP/c	-4.51879. [0.0000]	0.37198 [0.6450]	-6.7141 [0.0000]	162.935 [0.0000]	314.352 [0.0000]

Table 1b: Pedroni Residual Cointegration Test

	Statistic	**Prob.**	**Weighted Statistic**	**Prob.**
Panel v-Statistic	2.5056	0.0061	-0.5731	0.7170
Panel rho-Statistic	3.4835	0.9908	1.1007	0.8645
Panel PP-Statistic	-1.074	0.8585	-4.039	0.0000
Panel ADF-Statistic	-7.862	0.0000	-4.9215	0.0000
Group rho-Statistic	3.138	0.9991		
Group PP-Statistic	-3.1889	0.0007		
Group ADF-Statistic	-2.914	0.0018		

Next, Table 2 presents the panel data model results. Fixed and random effects were estimated first. These models were estimated also with time and country dummies but the results were insignificant. The diagnostic tests for the fixed and random effects models show a number of problems. As the Hausman test shows country intercepts and GDP/c are correlated in the global model. The test shows that the random effects formulation is consistently estimated. This suggests that there are omitted variables, which are correlated with GDP/c. Looking at the Breusch-Pagan Lagrange multiplier test for random effects we reject the null hypothesis in favour of the random effects model and we find significant differences across countries. Similarly, the Pesaran's test of cross sectional independence leads to rejection of the null hypothesis and there is cross-sectional dependence implying the estimation of the Driskoll-Kraay standards errors. Finally the modified Wald test for group-wise heteroskedassticity led to rejection of homoskedasticity.

We have estimated a number of other panel data analysis methods. As we face problem of heteroskedasticity, generalized least squares were estimated with panel specific AR(1) as well as generalized least squares with common AR(1) coefficients for all panels and heteroskedastic panels in both cases. Between the two estimations, the latter performed better. The results are presented in the last column of Table 2. The model passes the diagnostic tests and indicates the presence of an N-shaped curve, and parameter estimates as well as t-statistics are all statistically significant. The turning points are calculated at \$22175 and \$57231. Although the first is well within the sample the latter is above the maximum value of GDP/c in the sample (\$52152).

Table 2: Panel data model estimates (figures in parentheses are t statistics and in brackets P-values)

Model	**FE**	**FE Driskoll-Kraay s.e.**	**RE**	**FGLS RE Common AR(1)**
Constant	386.08 (12.243) [0.0000]	386.08 (4.30) [0.0000]	387.95 (2.3253) [0.0202]	177.115 (28.52) [0.0000]
GDPc	0.02174 (2.997) [0.0028]	0.02174 (5.18) [0.0000]	0.0213 (2.943) [0.0033]	0.01793 (58.55) [0.0000]
$GDPc^2$	-1.05E-06 (-2.7697) [0.0057]	-1.05E-06 (-4.72) [0.0000]	-1.03E-06 (-2.7224) [0.0066]	-5.61E-07 (-44.52) [0.0000]
$GDPc^3$	1.78E-11 (3.0458) [0.0024]	1.78E-11 (4.30) [0.0000]	1.76E-11 (3.0091) [0.0027]	4.71E-12 (28.52) [0.0000]
Adjusted R^2	0.942	0.942		
Modified Wald test	64000 [0.0000]			
Pesaran test	9.292 [0.0000]			
Breusch-Pagan LM			17010.81 [0.0000]	
Hausman Test			0.74 (P=0.3884)	
Turning Point				22171 and 57235
Heteroskedasticity		1.77 [0.077]	1.47 [0.141]	0.110 [0.91]
Heteroskedasticity		9.76 [0.000]	1.87 [0.062]	0.22 [0.828]
$RESET_1$		4.82 [0.0000]	4.88 [0.0000]	0.81 [0.418]
$RESET_2$		13.39 [0.0000]	13.61 [0.0000]	0.35 [0.7021]

In the same table four more diagnostic tests are presented in the last four rows. The first two are tests for heteroskedasticity while the last two for specification errors. The first test is a regression of the squared residuals on Xs while the second test is essentially a Glejser test. In most cases but the last there is heteroskedasticity problem. The last two tests refer to the specification error and are applied by regressing the residuals on the squared fitted values and on the cubic fitted values. The results of these RESET tests imply that the equations of our model are not misspecified only in the last case.

Moreover, an individual (country) time series analysis has been performed in order to see how much the total extracted relationship (N-shape) represents individual countries. First all the variables of the countries considered were tested for stationarity and were all I(1). Table 3 shows that the picture is unclear. Greece shows N-shape behaviour but at the same time South Africa, Australia and Finland show a monotonic relationship and Brazil an inverted U-shaped relationship. This raises the issue of heterogeneity as discussed analytically in Dijkgraaf and Vollebergh (2005).

Table 3: Individual time series analysis (figures in parentheses are t statistics and in brackets P-values)

Model	**Greece**	**South Africa**	**Australia**	**Finland**	**Brazil**
Constant	889.7 (26.98) [0.0000]	151.65 (14.03) [0.0000]	116.37 (39.65) [0.0000]	44.1323 (25.318) [0.0000]	31.94 (3.644) [0.0000]
GDPc	0.0375 (5.261) [0.0000]	0.03812 (9.82) [0.0000]	0.0083 (53.28) [0.0000]	0.00058 (5.928) [0.0000]	0.1014 (11.83) [0.0000]
$GDPc^2$	-2.75E-06 (-6.361) [0.0000]				-1.19E-05 (-7.7575) [0.0000]
$GDPc^3$	4.72E-11 (6.067) [0.0000]				
Adjusted R^2	0.93	0.74	0.99	0.51	0.65
Normality	0.38784 [0.8237]	2.175 [0.3371]	0.2825 [0.8683]	0.3031 [0.8585]	1.667 [0.4347]
RESET	0.6573 [0.4175]	0.1557 [0.6931]	0.1956 [0.6583]	0.2531 [0.6363]	1.3579 [0.2439]
ARCH effect	0.131994 [0.7164]	0.2039 [0.9031]	2.0288 [0.1543]	1.999 [0.1617]	1.91292 [0.1516]
Turning Point	8822 and 19240				4261
Comments	N-shaped	Monotonic increase	Monotonic increase	Monotonic Increase	Inverted U-shaped EKC

6. Conclusions and Policy Implications

Economic growth leads to higher pollution. This scale effect has several explanations. The demand for environmental quality is higher with higher income levels because of the potential damage irreversibility and higher demand for environmental quality requires stricter environmental regulations (Lieb, 2003). Our results indicate the existence of an N-shaped relationship between economic development and pollution in the form of CO_2 emissions as shown in Figure 2. The N-shape curve has the first turning point at $22171 and the next at $57235. The first is well within the sample while the second is outside the sample size maximum value ($52156). This implies that the reduction of environmental damage from economic development may be temporary and CO_2 emissions will increase indefinitely above the income level of $57235.

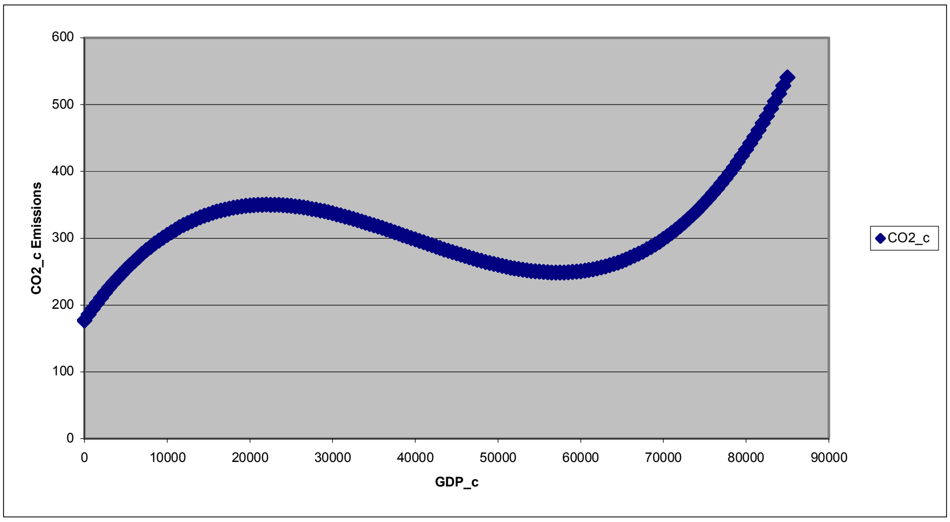

Figure 2: The extracted N-shape curve for the sampled countries

We also find that the turning points calculated by panel data analysis may not reveal the actual turning points (if any) that arise for individual countries. In our case and using different countries from different geographical regions we found a mixture of monotonic, or inverted U-shape or N-shape behaviour. This implies that the adaptation of the total N-shape income-environment relationship may be misleading with serious policy ineffectiveness implications.

Lieb (2003) claims that the downturn part of the N-shape may be due to a shock while the upturn part due to an equilibrium relationship. Lieb presents a thoughtful explanation for the final upturn of the extracted N-shape curve. This may be justified by the completion of the internalization of the pollution externality as well as that the abatement opportunities are exhausted. Lieb also claims that there is lower thermodynamics bound on material and energy use per unit of GDP as well as that at higher incomes the control methods applied exhibit decreasing and not anymore increasing returns to scale.

A number of policies may be followed. The need for technology transfer to help developing countries to achieve sustainability emerges. To reduce pollution levels many developing countries expect technology transfers in the form of foreign direct investment from developed countries. These clean and updated technologies will reduce environment damage by controlling emission levels. The main idea is that abatement technologies in developed countries are cleaner and more advanced. As developing countries have no financial resources to import and use these technologies at commercial cost this implies that developed countries should transfer or facilitate the transfer of these technologies to less developed or developing countries. The impact of this technology transfer depends on the type of industrial activity. That is, in the energy sector these transfers will be more beneficial for the environment compared to other industries such as textiles, etc. It should be emphasized that transfer of information must accompany these technology transfers on know-how and skills to enable countries to design or modify their own technologies.

Environmental policy may be a significant initiative for innovation. As air pollution is considered an externality, internalization of this externality requires relatively advanced institutions for collective decision making. This can be achieved only in developed economies (Vliamos and Tzeremes, 2011).

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