Piaggio, Matías; Padilla, Emilio. «CO2 emissions and economic activity : heterogeneity across countries and non-stationary series». Energy Policy, Vol. 46 (2012), p. 370-381. DOI 10.1016/j.enpol.2012.03.074

This is the postprint version of the article:

Piaggio, M., Padilla, E. (2012) "CO_2 Emissions and Economic Activity: heterogeneity across countries and non-stationary series", *Energy Policy*, Vol. 46, pp. 370–381.
https://doi.org/10.1016/j.enpol.2012.03.074

CO_2 EMISSIONS AND ECONOMIC ACTIVITY:

HETEROGENEITY ACROSS COUNTRIES AND NON STATIONARY SERIES

Matías Piaggio and Emilio Padilla*

Department of Applied Economics, Univ. Autónoma de Barcelona, Edificio B, Campus de Bellaterra, 08193, Bellaterra, Spain

E-mails: matiasjose.piaggio@e-campus.uab.es; emilio.padilla@uab.es

Tel. : +(34) 935814572

Fax: + (34) 935812292

*Corresponding author

Abstract

This paper explores the relationship between CO_2 emissions and economic activity for 31 countries (28 OECD, Brazil, China, and India) during the period 1950 to 2006 using cointegration analysis. Single country long run relationships are estimated, and equality in the functional form, the parameters, and the turning point, when appropriate, are rejected. This confirms the relevance of considering the differences among countries in the relationship between air pollution and economic activity to avoid wrong estimations and conclusions.

Keywords: Bound test, carbon dioxide emissions, environmental Kuznets curve, economic growth, heterogeneity.

JEL codes: C32, O13, Q53, Q56.

1. Introduction

The Environmental Kuznets Curve (EKC) hypothesis suggests the existence of an inverted-U shaped relationship between environmental degradation and income level.

Grossman and Krueger (1991) argued that there are three channels that explain this path. In early stages of economic growth, the greater requirement of natural resources and waste generation increases environmental degradation (scale effect). This growing path might lead to changes in the economic structure towards less polluting activities (composition effect), which along with the increase in the capacity of higher income countries to face technological substitution towards less polluting processes (technological effect) would lead to a turning point in the relationship and to the decreasing section of the curve. Therefore, the transition from the increasing to the decreasing section of the curve in the relationship between environmental degradation and economic activity would arise when the composition and technological effects worked in the indicated direction and overcame the scale effect[1].

However, an EKC can be driven by different underlying factors, so that the relation behind the hypothesis can be generated by different structural models (Perman and Stern, 1999). The literature highlights the distribution of power (Torras and Boyce, 1998), income-elasticity of the demand for environmental quality (McConell, 1997; Dasgupta et al. 2002), environmental regulation and international agreements (de Bruyn, 1997) or structural transitions, like the oil price shocks in the 1970s (Moomaw

[1] The existence of composition and technological effects do not necessarily imply a result as the one suggested by the EKC hypothesis. For this to be the case, it is required that the composition effect involves a reduction of polluting sectors in absolute and not only in relative terms. As for the technological change, it might sometimes involve new processes with new (and sometimes unknown) pollutants or efficiency improvements leading to the increase of extractive or other environmentally damaging activities (Roca and Padilla, 2003). Therefore, it depends on the type of technological and composition change that these effects compensate or reinforce the scale effect for a specific pollutant.

and Unruh, 1997). Also, an EKC can be reached by individual countries through the displacement of polluting activities to other countries (the ‘pollution haven hypothesis’, Stern et al., 1996; Cole et al., 1997). In this way, although an inverted-U relationship can be empirically shown, this can be a statistical result stemming from other factors, which might imply that the observed relationship between environmental degradation and economic growth is spurious. Moreover, these factors might vary across countries and be different for different pollutants.

Earlier works ignored that the relationship between environmental degradation and income can be different across countries (or regions), both in the functional form as well as the parameters and the turning point (Grossman and Krueger, 1991 and 1994; Shafik and Bandyopadhyay, 1992; Selden and Song, 1994; Carson et al. 1997; Cole et al. 1997 and Vincent, 1997). This issue was first studied in the late 1990s and early 2000s (Perman and Stern, 1999 and 2003; List and Gallet, 1999; Dijkgraaf and Vollebergh, 2001; Martínez-Zarzoso and Bengochea-Morancho, 2003 and 2004 and Dijkgraaf et al., 2005). Following the same concerns, a series of analyses of the EKC at national level has emerged, (among them Vincent, 1997; de Bruyn et al., 1998; Moomaw and Unruh, 1998; Lekakis, 2000; Roca et al., 2001, Friedl and Getzner, 2003; Decon and Norman, 2004; Egli, 2004; Hung and Shawn, 2004; Shen, 2006; Halicioglu, 2008; Piaggio, 2008; Song et al., 2008; Wang, 2009, Menyah and Wolde-Rufael, 2010, and Jalil and Feridun, 2011).

Moreover, until the study of Perman and Stern (1999), the statistical properties of the data employed were not considered. The analysis using non-stationary series has to be carried out taking into account this characteristic.

The traditional EKC approach not only ignores that economies with the same level of activity might present different functional forms with respect to the relationship between income and environmental degradation, but also assumes the same parameters in this relationship across countries. However, there may be countries whose scale effect is still more important than the composition and technological effects (or other determinants which may lead to a decrease in emissions), while other countries with a similar economic activity level may show a decreasing relationship between pollution and income. While the first ones show a linear relation between pollution and economic activity level, the last ones show a quadratic relationship (an inverted-U). Finally, the scale effect can take relevance again after a decreasing path, giving place to a cubic, or N-shaped, path.

An EKC estimated from cross-section, or panel data when the series are hardly or not overlapped over time across countries, can simply reflect the juxtaposition of a positive relationship between environmental degradation and income in rich countries with a negative one in developing countries, and not a relationship operating for both kinds of countries (Vincent, 1997). This problem can be solved if the panel data set has overlapped observations for large periods (Egli, 2004). However, this would not solve the problem of assuming homogeneity in the functional form of the relationship between environmental degradation and income among countries.

In light of the above, the analyses that assume the same functional form and parameters across countries might in fact not reflect the behavior of the relationship between environmental degradation and income for these at the individual level. So, the conclusions that, after certain point, environmental degradation decreases with greater economic activity for the more developed countries might be wrong. Consequently, more attention should be paid to individual countries behavior in order to assess the possible benefits of the increase in economic activity on environmental quality for each country (de Bruyn et al., 1998). To impose *a priori* the constraint of homogeneity between countries in the functional form and the parameters might be a statistical device more than a model that appropriately approximates reality. Carson (2010) argues that the analysis should distinguish between a "weak" version of the EKC hypothesis, for a particular political jurisdiction, and a "strong" one, applying for the different political jurisdictions.

The objective of this paper is to analyze the assumption of identical functional form and parameters among countries in the long-run relationship between carbon dioxide emissions (CO_2) and economic activity. The analysis is carried out for 31 countries (28 OCDE countries, Brazil, China and India) over the period 1950–2006. The time period considered in this paper is longer than the one from previous studies. This is very important, because a longer period increases the degree of overlapping across the countries series that might have different functional forms. This is particularly relevant as a consequence of the important economic growth of the European countries in the post war period, and the exponential growth of several countries in the early XXI century. First, the functional form homogeneity will be tested through the estimation of the relation for each individual country. For those countries with the same functional forms the homogeneity in the parameters of the long run relationship would be tested, allowing variations among them in both short term adjustments and in the rate of convergence to the long run relationship. As a result, the functional form for each country will be determined. Also, unlike previous studies, homogeneity in the turning point among the countries that present one would be tested. This is a weaker restriction than the previous one, because it allows countries to reach the same threshold through different paths. This analysis will help the policy instruments design, because similar countries with different paths would require different tools. The use of cointegration techniques would avoid the possibility of a spurious relationship between CO_2 emissions and economic activity. The present paper will explicitly define the functional form of the apparent long run relationship for each country. This analysis is useful to guide the analysis of the determinants behind each country behavior, which would help to think over the policy instruments design involving countries with similar economic levels but different paths.

In the next section, the conceptual framework of the EKC hypothesis and the relationship between economic growth and environmental degradation adjusted to our analysis is presented. Section 3 presents the methodology and data used. Section 4 details the analysis results. Section 5 presents the final remarks.

2. Conceptual framework

The EKC hypothesis arises from a reduced model specification. Therefore, it can be the result of one or more different structural relationships, because it is an empirical phenomenon. So, this is in fact an apparent relation analysis between environmental degradation and economic activity. In line with previous works, the reduced form model relates environmental degradation level with economic activity for each country, which can follow a lineal, quadratic or cubic functional form:

$$(1) \quad E_{it} = \alpha_i + \beta_1 Y_{it} + \beta_2 Y_{it}^2 + \beta_3 Y_{it}^3 + \varepsilon_{it}$$

where E denotes the indicator of environmental degradation or pressure per capita and Y is income per capita. Subscript $i=1,\dots, N$ indicates countries, subscript $t = 1, \dots, T$ is the time period indicator, and ε is the error term normally distributed. The correct functional form for each country can be specified from the equation above.

Following Perman and Stern (1990 and 2000) and Carson (2010), a "weak" EKC would result if β_{1i}>0, β_{2i}<0, and β_{3i}=0 $\forall i$, but these parameter would have different values for different countries. A "strong" version would result if $\beta_{1i} = \beta_1$ *and* $\beta_{2i} = \beta_2 \ \forall i$.

In the same way, an N relation would result if β_{1i}>0, β_{2i}<0, y β_{3i}>0, where there would exist a second turning point. Finally, the relationship will be monotonous (increasing or decreasing) when $\beta_{2i} = \beta_{3i} = 0$. A "strong" version of a monotonous relationship would occur when $\beta_{1i} = \beta_1 \ \forall i$.

Empirically, any of the functional forms (lineal, quadratic or cubic) can be reached. Therefore, the functional form that best fits each country would be determined before the parameter homogeneity analysis.

When a quadratic or cubic functional form is determined, it is also relevant to study if the turning point is the same among countries. It is possible that countries with different reaction (elasticities) of emissions to economic activity reach the turning point for the same level of economic activity. This factor is relevant, because there could be support for directing policy making toward reaching the turning point, no matter what the path is. Therefore, the threshold from which environmental degradation is too high or irreversible would be a relevant piece of information to interpret the policy implications of supporting the EKC hypothesis for each country. It could be that from certain level of degradation it may not be feasible to revert environmental damage (Panayotou, 1993).

There are no theoretical foundations that support the functional form and parameters homogeneity restriction for different countries. Perman and Stern (1999 and 2003) reject parameters homogeneity in the case of SO_2 emissions for 74 countries between 1960 and 1990, assuming a quadratic functional form. Cole (2005) rejects the constant coefficients assumption across countries for SO_2 (110 countries between 1984 and 2000), NOx (26 countries, for 1975, 80, 85, and 90) and CO_2 emissions (110 countries, 1984-2000).

Martínez-Zarzoso and Bengochea-Morancho (2003 and 2004) reject functional form homogeneity in the case of CO_2 emissions between two groups of countries (19 Latin American and 22 OECD countries over 1975–1998). List and Gallet (1999) do not reject quadratic functional form homogeneity in the cases of NO_X and SO_2 emissions for 48 USA states over 1929–1994, while they find that the parameters are different among states. Dijkgraaf and Vollebergh (2001) and Dijkgraaf et al. (2005) reject parameters homogeneity in a cubic specification in the case of CO_2 emissions for a 24 OECD countries panel between 1960 and 2000. Finally, Musolesi et al. (2010) conclude that different dynamics are associated with the different sub-samples of countries considered for CO_2 emissions in a panel of 109 countries between 1959 and 2001.

Until the late 1990s the empirical literature ignored the analysis of the stationarity of the variables, which could have led to the estimation of spurious relations (Grossman and Krueger, 1991 and 1994; Shafik and Bandyopadhyay, 1992; Carson et al. 1997; Cole et al. 1997; Vincent, 1997 and de Bruyn et al., 1998). Both environmental degradation and income series use to be non-stationary (their parameters are not constant throughout time). Therefore, employing the variables in levels —without any stationary transformation— for the estimation of a long run relationship between environmental degradation and income would result in non robust estimators. This would make the application of inference tests impossible, and the relationship could be spurious, unless the series were cointegrated (Enders, 2004).

In the literature on the relationship between environment and economic activity, the time series stationarity analysis and cointegration analysis when the series are non stationary have been developed by various authors in the last decade, both for panel data and for individual countries studies (Perman and Stern, 1999 and 2003; Lekakis, 2000; Roca et al., 2001; Friedl and Getzner, 2003; Egli, 2004; Dinda and Coondoo, 2006; Wagner, 2008; Halicioglu, 2008; Piaggio, 2008; Song et al., 2008; Lee and Lee, 2009 and Wang, 2009).

3. Methodology and data

3.1. Empirical strategy

The EKC hypothesis refers to a long run phenomenon, and thus might be estimated via cointegration analysis. Pesaran et al. (2001) develops the bound testing (BT) for the cointegration analysis of the relationship of variables in levels. For this paper purpose, BT presents some advantages with respect to more frequent cointegration tests (Engle and Granger, 1987; Johansen and Juselius, 1990 and Johansen, 1991) because it can be applied when there is uncertainty about the degree of integration of the series involved, where all of them can be I(1), I(0) or a combination of both[2]. Long run economic series with integration order higher than one would be hard to believe, understand and interpret[3]. The BT approach will allow to determine the existence of a stationary linear combination of the variables involved that led to a long run relationship, dealing with the non linear transformation of non stationary series problem. This methodology has been previously employed by Perman and Stern (2003), Iwata et al. (2010a and 2010b), Menyah and Wolde-Rufael (2010) and Jalil and Feridun (2011).

Writing equation (1) as an Autoregressive Distributed Lag model, ADRL (p,p_1,p_2,p_3), for each single country in an Error Correction Model (ECM) form, BT allows to determine the existence of a long run relationship. The dynamic model allows to overcome the issue that deviations from the long run equilibrium are not instantaneously corrected (as suggests the static specification presented in equation (1)). This assumption is more plausible (and will be empirically tested), as it might be reasonable to expect that the adjustment between environmental degradation and economic activity to be slow (Perman and Stern, 1999).

In this way, once the existence of a long run relationship is tested, the following transformation of the ECM is estimated employing Non-Linear Least Squares (NLLS):

[2] I(q) indicates the degree of integration of the series, being the q^{th} difference of the series a stationary transformation.

[3] While Wagner (2008) argues theoretically that non linear transformations of series in general do not preserve the integration properties of variables and hence can change the stochastic behavior (which leads to the necessity of a different asymptotic theory for such regressions), Granger and Hallman (1991) show empirically that monotonous non linear transformations of I(1) series are also I(1).

$$(2)\Delta E_t = \sum_{m=1}^{p} \theta_m \Delta E_{t-m} + \sum_{n=0}^{p_1} \xi_n \Delta Y_{t-n} + \sum_{i=0}^{p_2} \delta_i \Delta Y_{t-i}^2 + \sum_{j=0}^{p_3} \gamma_j \Delta Y_{t-j}^3 + \alpha_0 [E_{t-1} - \mu^* - \beta_1 Y_t - \beta_2 Y_t^2 - \beta_3 Y_t^3] + \varepsilon_t$$

where the number of lags, p, p_1, p_2 and p_3 are independently chosen for each country, following from general to particular criteria (Hall, 1991)[4]. The term within brackets represents the error correction term (ECT). Besides the improvement in the consistence provided by the estimation method, this specification, presents three more advantages: i) it allows to identify the long run relationship, the short run dynamic and the coefficient of adjustment to the long run equilibrium relationship (α), ii) if the series in levels are cointegrated, the ECM is a linear combination of stationary variables. Then, estimations are robust, and conventional inference procedures can be applied, and iii) this specification allows testing different restrictions among individuals (Perman and Stern, 1999 and 2003).

Cointegration analysis and the estimation of the long run relationship by means of the ECM should be reiterated for the cubic, quadratic and linear specifications. In this way, the path that bests fits the long run relationship between CO_2 emissions and income level for each single country will be determined (if one exists). For those countries that do not satisfy the BT cointegration test, or that the model estimated is not satisfactory for the functional form that the BT indicates, a unit roots analysis through the Augmented Dickey-Fuller test (ADF) and the cointegration analysis through Engel-

[4] A general model for a given p, p_1, p_2 and p_3 value, large enough, is specified. Then, the lag is reduced, determining the value of each of them for the lag of greater degree statistically significant.

Granger test (1987) should be carried out (Enders, 2004). Then, when the series are I(1) and are cointegrated the ECM may be estimated for each specification[5].

A reduced form model captures the whole direct and indirect relationship between economic activity and environmental degradation, including the effects linked to the omitted (or unobserved) variables which are correlated with both economic activity and time (Mazzanti and Musolesi, 2011), so that the inclusion of additional variables would distort the analysis (List and Gallet, 1999). Therefore, it is not possible to assess what causes the relationship to exist. This kind of analysis allows for the study of apparent elasticities, not being an analysis of the determinants of environmental pollution. As it is a uniequational specification, it does neither solve the problem of a possible feedback between the variables. However, as it is developed through a cointegration analysis, the estimated parameters will be superconsistent, not being affected by the endogeneity bias of the variables (Veerbek, 2005).

The ECM specification is employed by Perman and Stern (1999 and 2003) for SO_2 emissions, and Martínez-Zarzoso and Bengochea-Morancho (2003 and 2004) and Dinda and Condoo (2006) for CO_2 emissions, all of them working with panel data. Egli (2004), for various contaminants, and Iwata et al. (2010a and 2010b), Menyah and Wolde-Rufael (2010) and Jalil and Feridun (2011), for CO_2 emissions, employed it for individual countries. Finally, Haciglou (2008) and Piaggio (2008) applied it to study CO_2 emissions for individual countries but in a multi equation specification.

[5] Engle-Granger cointegration test is seen as the most appropriate one for the present analysis, because a priori we explore the existence of only one cointegration relation. The test proposed by Johansen and Juselius (1990) and Johansen (1991) becomes complex in the presence of non linear transformations of one of the variables, as it allows for the existence of more than one cointegration relationship.

Once the correct functional form is specified and the long run relationship is estimated through the ECM, the homogeneity of parameters among countries with equal functional form is studied, allowing the short run coefficients and the quantity of lags to be different among countries. This will be tested computing confidence intervals (CI)[6] for the parameters of the long run relation. The same exercise is carried out with respect to the coefficient of adjustment of deviations from the long run relationship (α).

A similar strategy is followed for testing the turning point homogeneity. The turning point for countries with a quadratic functional form in equation (3) is given by $\hat{\theta} = -\frac{\widehat{\beta_1}}{2\widehat{\beta_2}}$. From this, the turning point CI will be computed for the turning point of those countries that show an inverted-U relationship[7]. A similar procedure might be developed with respect to those with cubic functional form.

3.2. Data

The analysis takes into account 31 countries (28 OECD countries[8], Brazil, China and India) between1950–2006[9]. This time period is longer than the one from previous

---

[6] IC: $\left[\hat{\beta} \pm z_{\alpha/2}\frac{s_{\hat{\beta}}}{\sqrt{n}}\right]$, where $s_{\hat{\beta}}$ is the standard deviation associated to the estimated parameter $\hat{\beta}$, (1-α) is the confidence level, n is the sample size, and *z* is the value of the standardized Normal distribution for $\alpha/2$ confidence level.

[7] $\hat{\theta} = -\frac{\widehat{\beta_1}}{2\widehat{\beta_2}} \sim \text{Normal}\left(\hat{\theta}, V(\hat{\theta})\right)$ given the distribution of parameters β_1 and β_2. Employing the Delta Method, following Hayashi (2000: pp. 93–94) and Greene (2003, p. 70), $\text{As.Var}\left(\hat{\theta}\right) = \begin{pmatrix} \frac{-1}{2\beta_2} & \frac{\beta_1}{2\beta_2^2} \end{pmatrix} \begin{pmatrix} \sigma_{\beta_1\beta_1} & \sigma_{\beta_1\beta_2} \\ \sigma_{\beta_2\beta_1} & \sigma_{\beta_2\beta_2} \end{pmatrix} \begin{pmatrix} \frac{-1}{2\beta_2} \\ \frac{\beta_1}{2\beta_2^2} \end{pmatrix}$

[8] Australia, Austria, Belgium, Canada, former Czechoslovakia (after 1992 the values for Czech Republic and Slovakia are added), Denmark, Finland, France, Germany (for the period 1950–1990 the information for the German Federal Republic and the German Democratic Republic are added), Greece, The Netherlands, Hungary, Ireland, Italy, Japan, South Korea, Mexico, Norway, New Zealand, Poland, Portugal, Spain, Sweden, Switzerland, Turkey, UK, USA, and former Soviet Union (from 1992 the values of Estonia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Russia, Tajikistan,

studies on the homogeneity of the parameters for CO_2 emissions, which increases the possibility of taking into account countries with overlapped income levels but heterogeneous paths. Moreover, the sample contains almost all countries (except Iceland and Luxembourg) committed to quantitative limits in CO_2 emissions through Annex B of the Kyoto Protocol (United Nations, 1998). Despite of the data for the countries that were members of the Council of Mutual Economic Assistance (COMECOM) until 1989 can be no reliable, we decided to keep these countries into the sample because of two reasons: first, we prefer to keep as much countries involved in the Kyoto protocol as possible; second, they are responsible of an important part of total emissions. In 2006 the countries of the former Soviet Union alone emitted 8.6% of total CO_2 emissions (Boden et al., 2009). Moreover, this is the best data available for this kind of analysis.

CO_2 emission data is published by the Carbon Dioxide Information Analysis Center (CDIAC) (Boden et al., 2009). It is consistent with the one of the World Bank (2005) for the period 1960–2005, allowing to take into account ten more years. CO_2 emissions are measured in metric tons of CO_2. Logarithmic transformation of emissions per capita (co2pc) is employed.

Economic activity at national level employed is estimated and transformed to 1990 Geary-Khamis dollars (which corrects by purchasing power parity, PPP) by Madison (2003), updated to 2006 by the same author for 155 countries[10]. The National Accounts System was set up in 1950 in various countries, which allows having reliable information. Logarithmic transformation of per capita growth domestic product for the

---

Turkmenistan, Ukraine and Uzbekistan are added). Two OECD countries, Iceland and Luxembourg, are excluded due to lack of information for the entire period.

[9] Except for Belgium, for which we took the period 1952–2006, as it presented atypical values for the two first years of the sample.

[10] http://www.ggdc.net/maddison/

variable in levels, and its quadratic and cubic transformation are used (gdppc, gdppc2, and gdppc3, respectively).

4. Results

4.1. Cointegration analysis

Following Pesaran et al. (2001) we will carry out the contrast several times, including up to four lags, due to the sensitiveness of the analysis to the quantity of lags included. Table I summarizes the results of the F-statistic of the Wald test for the linear, quadratic and cubic specification of equation (2).

Some countries of the sample allow for the existence of a long run relationship for the variables of interest for more than one functional form. This might result, for example, from quadratic forms that have not achieved the maximum, or that have just surpassed it, or from cubic forms with tiny decreasing sections, that might both be approached through linear models. Therefore, the adequate functional form for each country would be determined from the cointegration analysis jointly with the estimation of equation (2) for each one of the functional forms in the countries confirming the existence of a long run relationship[11]. Table I shows that BT is not conclusive for 24 cases, while it indicates that there is not a long run relationship for any functional form for France, United Kingdom, USA and Brazil. When the BT is inconclusive, Iwata et al. (2010a and 2010b) argue that the non existence of a cointegration relationship may be rejected or not according to the test of significance of the parameter of adjustment (α) of equation (2).

[11] For the choice of the functional form we employed different statistical and analytical tools, such as the *t-statistic* significance of the parameters, the Schwartz information Criteria, and taking into account if the turning point estimated is lower than the maximum level of income reached by each country.

From the analysis above, when BT does not reject the existence of a long run relationship equation (2) is estimated. Therefore, the preferred functional form for each country is determined. The results indicate the existence of a long run relationship between CO_2 emissions and economic activity, both in per capita terms, for 18 countries of the sample (1 cubic, 14 quadratic and 3 linear). From the 17 countries for which a quadratic specification is possible, 14 present the turning point within the sample, which confirms an inverted-U path. The other 3 are very close to achieving it. Sweden also presents the turning points within the values of the sample. Finally, there is no long run relationship between the variables involved for any functional form for 3 of them (former Czechoslovakia, Hungary, and former Soviet Union). Table II summarizes each country functional form. Table III of Annex A summarizes the ECT estimation of equation (2) for each one of the possible functional forms

Moreover, for those countries that BT did not indicate the existence of a cointegration relation (France, UK, USA and Brazil), and for those that BT did not reject it for at least one of the specifications but was not possible to estimate a satisfactory long run relationship (Germany, Mexico, New Zealand, Poland, Portugal, Spain and Turkey), a unit root analysis through the ADF statistic and a cointegration analysis through the Engle-Granger test are implemented. All the series for all the countries are I(1). Mexico is the only one for which a long run relationship does not exist for any functional form Again equation (2) is computed for those functional forms for which a long run relationship exists. Following previous criteria, there is a long run inverted-U relationship for France, Germany and USA, and linear for New Zealand, Portugal, Spain, Turkey and Brazil. Poland does not present any satisfactory specification.

	Table I - CO_2 emissions and economic activity bound testing cointegration test														
	Lineal[a]					Quadratic[b]					Cubic[c]				
Lags	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**	**0**	**1**	**2**	**3**	**4**
AUS	4.09[d]	7.66**	1.02	0.80	0.72	5.12**	4.93**	1.35	0.72	0.84	2.31	0.51	2.03	1.82	NA
AUT	1.50	0.86	1.17	1.25	0.78	4.25*	2.87	3.92[d]	2.15	1.62	3.31[d]	2.10	4.11*	3.86*	2.93[d]
BEL	4.91*	2.96	2.37	1.73	0.89	9.78***	3.20[d]	2.07	1.65	1.36	9.31***	1.70	2.17	1.14	0.93
CAN	0.65	0.49	0.78	1.50	2.14	2.57	3.08	1.54	1.88	3.53[d]	2.35	3.40[d]	2.19	1.54	2.81[d]
CZE	8.01***	3.37	3.12	3.96	5.1*	4.63*	2.87	2.08	1.96	1.99	3.14[d]	1.73	1.39	0.36	0.56
DEN	2.16	2.14	1.75	1.73	1.42	9.66***	5.53**	5.84**	7.23**	3.27[d]	7.05***	4.61**	4.98**	5.79***	3.58[d]
FIN	2.82	2.63	2.81	4.54[d]	3.71	3.22[d]	2.58	2.19	1.61	1.25	2.81[d]	2.46	2.95[d]	1.90	1.32
FRA	1.21	1.49	1.55	2.17	1.69	1.84	1.79	2.07	1.78	1.01	2.22	1.53	2.51	3.03[d]	2.75[d]
GER	1.39	0.36	0.54	0.62	0.75	1.33	1.92	1.67	1.23	1.26	3.89*	2.62	2.26	2.23	0.80
GRE	4.27[d]	5.07*	6.27**	7.58**	7.45**	5.64**	6.15**	6.35**	4.43**	5.30**	2.88d	2.69	2.18	1.37	1.16
HOL	1.23	0.63	0.55	0.85	0.93	3.16	2.45	3.50[d]	2.60	2.07	2.88[d]	2.01	2.92[d]	2.52	2.07
HUN	13.01**	8.69***	2.80	4.73[d]	4.43[d]	3.84[d]	3.29[d]	0.63	0.49	0.51	3.15[d]	3.87*	1.10	2.49	1.81
IRE	1.94	2.20	4.73[d]	5.73**	8.32**	7.12***	3.86[d]	2.75	1.87	3.25[d]	7.80***	5.14**	3.34[d]	2.08	1.90
ITA	6.50**	2.85	2.75	2.54	1.78	3.67[d]	5.38**	1.75	1.98	2.31	3.10[d]	4.82**	1.72	3.17[d]	3.36[d]
JAP	1.16	3.26	1.95	1.73	1.84	2.01	4.35**	2.65	1.10	1.79	1.54	2.85[d]	1.82	2.36	2.73[d]
KOR	24.53**	12.57***	19.36**	8.56**	3.97**	21.19***	8.41***	10.20**	7.06**	3.39[d]	15.58***	6.28**	9.75***	3.50[d]	1.95
MEX	1.09	0.67	0.13	0.49	0.66	1.67	1.50	2.36	1.49	1.52	1.67	1.53	3.48[d]	2.64	3.59[d]
NOR	2.20	1.60	1.51	1.89	2.53	3.54[d]	1.30	1.62	0.82	1.54	3.22[d]	1.86	2.77[d]	2.42	1.41
NZL	2.70	2.50	1.11	2.22	2.23	2.52	2.41	2.68	2.21	3.20[d]	3.12[d]	1.72	1.63	1.80	1.96
POL	5.23**	3.26	1.72	1.54	1.46	2.38	0.82	0.50	0.03	0.06	1.93	1.59	1.06	0.42	0.46
POR	0.04	0.13	0.11	0.06	0.06	6.68***	3.69[d]	2.50	2.82	3.73[d]	6.95***	3.75[d]	2.25	3.01[d]	4.59**
SPA	0.14	0.09	0.02	0.02	0.12	3.24[d]	1.19	1.62	1.00	1.20	2.25	1.06	1.17	0.91	1.27
SWE	4.41[d]	3.58	2.83	4.43[d]	3.60	1.48	0.74	0.89	0.83	1.23	2.12	2.46	2.55	3.26[d]	2.45
SWI	1.44	0.89	2.76	4.60[d]	6.42**	5.83**	8.05***	3.82[d]	3.37[d]	2.20	5.67***	7.02**	1.57	3.14[d]	1.67
TUR	0.64	1.16	2.65	2.31	1.65	7.51***	6.86***	3.28[d]	2.17	2.88	5.14**	4.62**	2.38	2.19	3.39[d]
UK	3.97	1.61	1.89	1.70	1.33	2.61	1.65	1.86	1.36	0.83	2.16	1.43	1.70	1.22	0.70
USA	0.53	0.90	1.71	1.74	3.10	1.14	1.11	0.78	0.96	1.17	1.98	1.26	0.54	0.71	0.47
USS	4.53[d]	2.21	3.27	2.33	1.06	4.57*	1.38	2.83	1.76	0.54	3.29[d]	0.92	2.58	2.04	1.76
BRA	3.75	3.48	2.18	3.63	0.81	2.50	1.93	1.61	1.46	1.57	2.65	1.83	1.70	1.65	1.25
CHN	6.70***	3.88	4.67[d]	7.22**	5.25*	2.64	2.99	2.49	3.46[d]	3.51[d]	3.63[d]	4.39**	2.86[d]	2.78[d]	3.80*
IND	0.10	0.58	2.59	1.71	1.66	4.25*	3.82*	1.16	1.14	0.75	2.50	2.39	0.59	0.86	0.37

[a] 1% CV (6.84;7.84), 5% CV (4.98;5.73) and 10% CV (4.04;4.78)
[b] 1% CV (5.15;6.36), 5% CV (3.79;4.85) and 10% CV (3.17;4.41)
[c] 1% CV (4.29;5.61), 5% CV (4.35;3.23) and 10% CV (3.77;2.72)
***, **,* significant at 1%, 5% and 10% respectively
[d] inconclusive at 1%

Finally, the United Kingdom shows an inverted linear relationship. This is an atypical result, but it can be interpreted as evidence in favor of the EKC. The UK is one of the more ancient industrialized economies. In this way, it is reasonable to assume that because its prior to 1950 industrial maturity stage, it has faced the post war economic growth stage through less polluting processes. In this way, the UK would be on the decreasing segment of the EKC during the period of analysis[12].

Table II summarizes results, 26 of the 31 countries of the sample do not reject the existence of a long run relationship between economic activity and CO_2 emissions between 1950 and 2006 (7 linear, 17 quadratic, 1 cubic, and 1 inverted linear). The result obtained confirms the existence of different relationships even among countries with similar activity levels. The fact that for some countries no long term relation was found can be consequence of data reliability, as may be the case of the countries that were members of the COMECON (former Czechoslovakia, Hungary, Poland and former Soviet Union), or because of an anomalous behavior at the end of the period in the case of Mexico, as a consequence of the crisis it experienced in 1994.

Comparing these results with other analyses for the same pollutant for individual countries, they are consistent with the ones of Iwata et al. (2010b) for France (for the period 1960–2003), Jalil and Feridun (2011) for China (1953 – 2006), and Iwata et al. (2010a) for Finland (1977–2003) and Japan (1966–2003). The last one tests —and obtains positive evidence of— the existence of a quadratic path for South Korea (1977–2003) and Spain (1968–2003), in contrast with the linear model supported by our results. Both works quoted take into account the share of nuclear power in total energy generation for each country. However, the linear specification for Spain is consistent with Roca and Padilla (2003) for the period 1980–2000, who also included factors referred to the energy sources structure.

[12] Individual countries charts distinguishing between short-run and long-run relationships and the results from the unit roots and cointegration tests are available from the authors upon request.

Table II - Summary of long term relationship estimation		
Model	**Country**	**Decision Method**
Linear	BRA	EG
	GRE	BT
	KOR	BT
	NZL	EG
	POR	EG
	SPA	EG
	TUR	EG
	UK*	EG
Quadratic	AUS	BT
	AUT	BT
	BEL	BT
	CAN	BT
	CHN	BT
	DEN	BT
	FIN	BT
	FRA	EG
	GER	EG
	HOL	BT
	IND	BT
	IRE	BT
	ITA	BT
	JAP	BT
	NOR	BT
	SWI	BT
	USA	EG
Cubic	SWE	BT
No relation	CZE	BT
	HUN	BT
	MEX	EG
	POL	EG
	USS	BT

* inverted linear

In contrast with our results, Friedl and Getzner (2003) found a cubic relationship for Austria (1960–1999), introducing the weight of imports and industry in total income. Haciloglu (2008) also found a different path from ours for Turkey (1960–2005), specifying a cubic functional form introducing the consumption of commercial energy and open grade, contrary to the linear one estimated here. However, analyzing the adjustment of Haciloglu’s model, it seems that it approaches a linear relation through a cubic path but with a tiny decreasing section. Egli (2004) specifies a linear functional form for Germany (1966–1999), including industry participation in product and open grade, in contrast with the quadratic form found by us. The differences in the results may be mainly due to the longer time period considered in our work, and to the fact that some of the above mentioned works include other independent variables that might be conditioning the functional form.

As mentioned above, different functional forms of the relationship between economic activity and carbon dioxide emissions for countries with similar economic activity levels mean that the various variables that modulate the relationship have different intensity in different countries. In those countries with a linear functional form the scale effect —the impact of production growth on emissions— is stronger, while there are countries with similar activity levels where the changes in the composition of production and technological improvements (or other variables, such as international trade, institutional factors, etc.) might have helped to diminish emissions while continued economic growth. This paper shed lights over which kind of relationship must be explained for each country, and is a kick off for analyzing the determinants of similar paths.

4.2. Homogeneity of the parameters and the turning point

Homogeneity of the parameters for models with linear and quadratic functional form is carried out separately. The homogeneity of the ECT parameter analysis can be done jointly for all the countries. CI overlaps are depicted in Figures 1 to 4. Table IV of Annex A presents the 95% CI[13].

The parameters of the long run relationship depict the reaction (elasticity) of carbon dioxide emissions to variations in economic activity (because the model specification is

[13] The results are similar constructing 90% and 99% CI.

in logarithms). In this way, heterogeneity in the long run parameters means that the emissions of the different countries do not respond in the same way to activity level variations. As we mentioned above, this is an apparent relation analysis, and a next step would be to study the real determinants that explain each coefficient and functional form. In any case, we can conclude from this research that similar levels of economic activity have dissimilar impact on carbon dioxide emissions in different countries.

For those countries that follow a linear functional form, the analysis rejects at 95% confidence the existence of groups of more than 2 countries with the same parameters (3 at 99%) (Figure 1). This means that while for all countries of this group economic growth has a direct impact on emissions, this impact —the elasticity of emissions to growth in economic activity— is not equal among them. For example, an increase in the economic activity level of Korea is associated to a lower increase in pollution than the same increase in Turkey. The factors that explain this difference must be explored avoiding the assumption that they are the same for all countries.

Figure 1: CI 95% - Linear Model

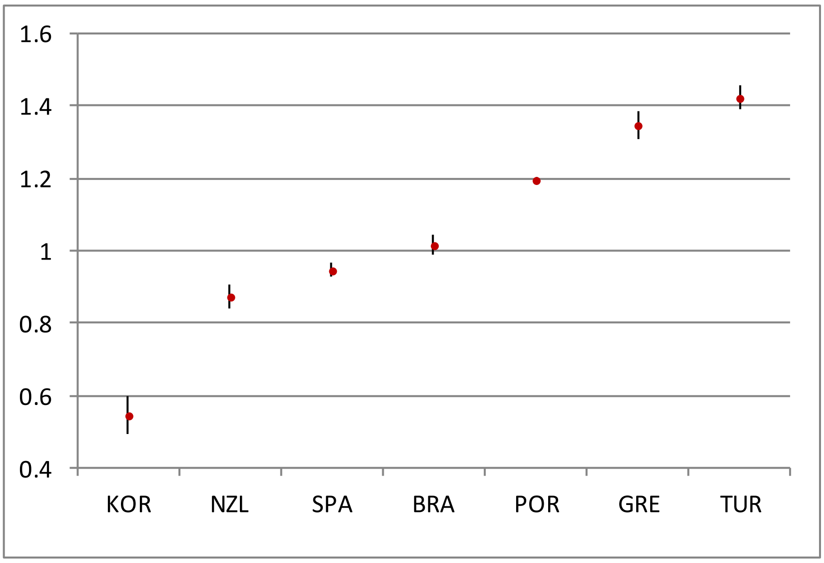
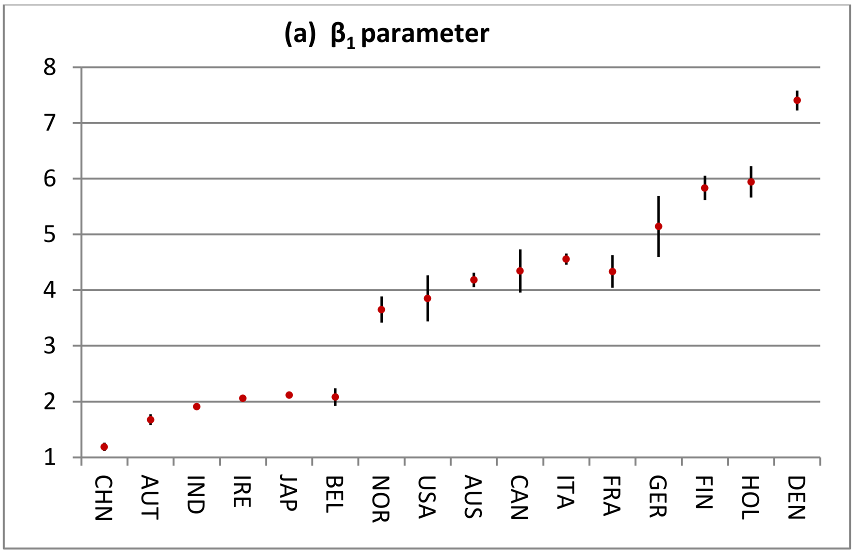


Figure 2: CI 95%- Quadratic Model



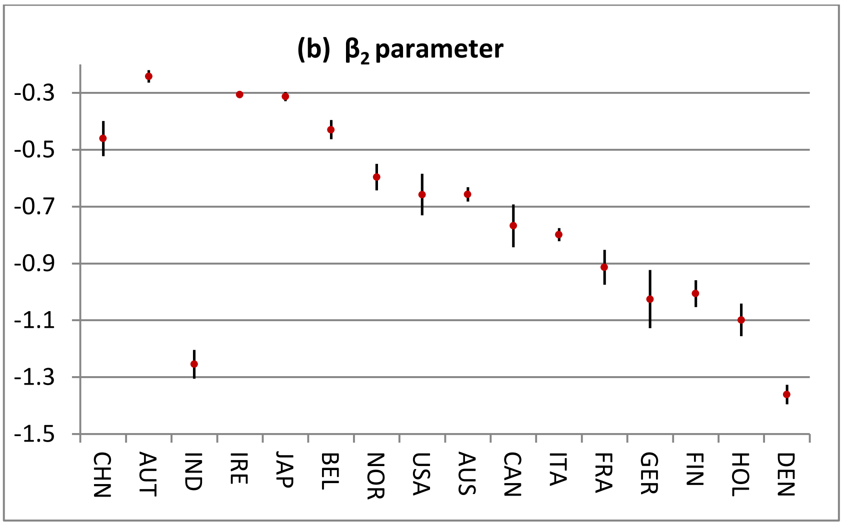


Figure 3: CI 95% - Long run relationship adjustment coefficient

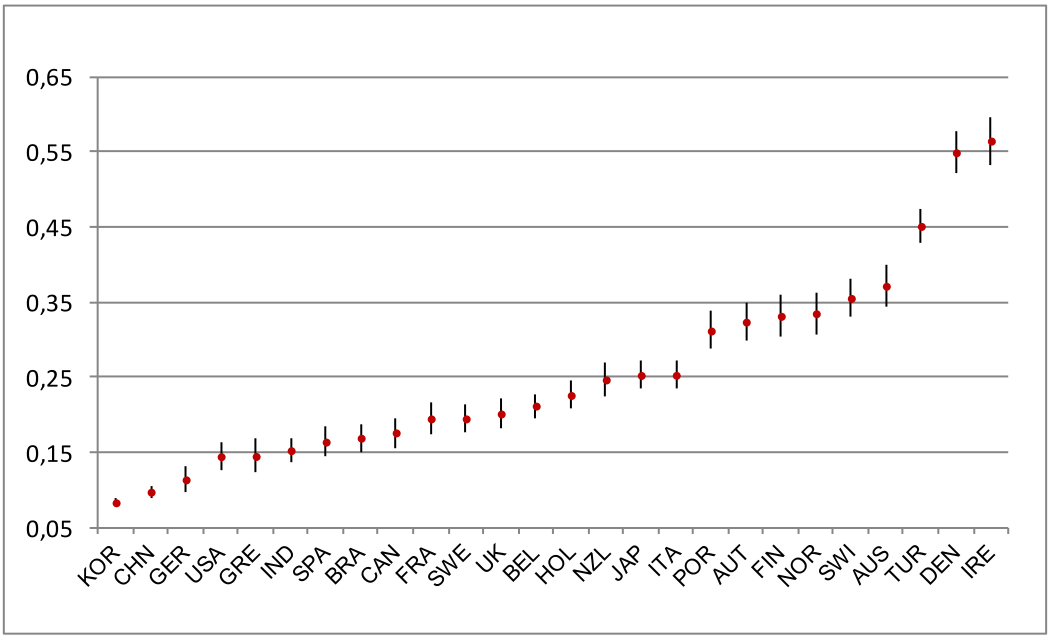
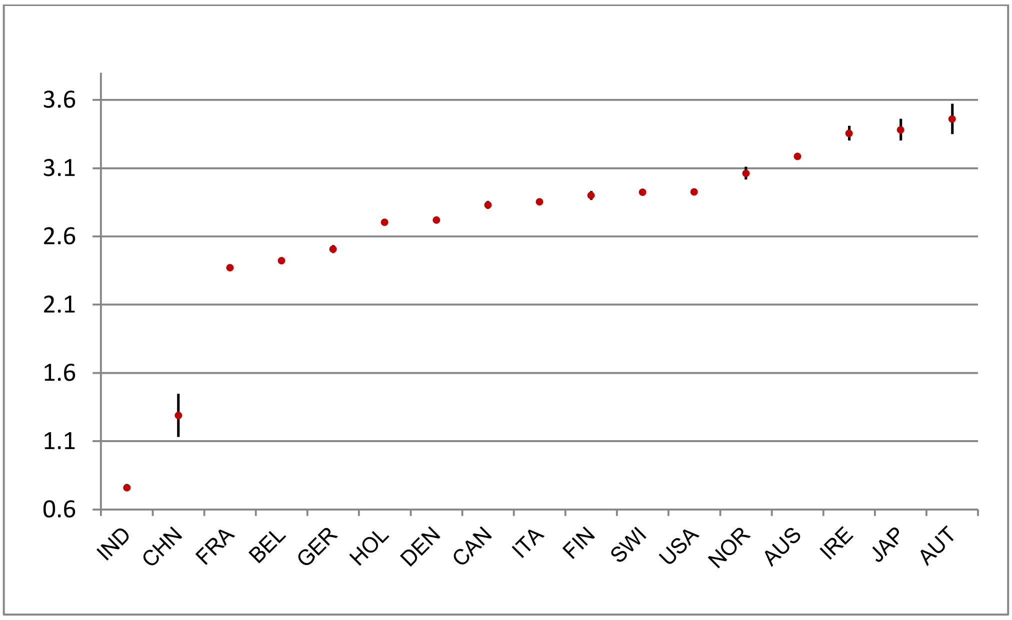


Figure 4: CI 95% - Turning Point



For those that the quadratic path fits better, different long run relationship parameters also means differences in emissions elasticity, but in this case, concavity of the curve is also considered. That is, variations of emissions in reference to variations in economic activity can be different among countries both in the increasing stage, as well as in the rate that they decrease when reaching the turning point. The β_1 parameter could be interpreted as the impact of the scale effect—direct relationship between the increase in the level of economic activity and emissions—while β_2 would indicate emissions deceleration due to other factors when the level of economic activity increases. For example, comparing the cases of China and Denmark, in the later case both estimated parameters are greater (in absolute terms). This indicates that the shape of the apparent relationship between emissions and GDP per capita in the case of Denmark would have a steeper slope and a faster deceleration, while in the case of China the inverted-U shape would be flatter. Parameter homogeneity of the long run quadratic relation is rejected for any possible group with more than 4 countries at 95% CI (5 at 99%) (Figure 2a and Figure 2b)[14]. This result is consistent with the ones of Dijkgraff and Vollebergh (2001), Martínez-Zarzoso and Bengochea-Morancho (2003 and 2004), Dijkgraff et al. (2005), Cole (2005) and Musolesi et al. (2010).

The ECT can be interpreted as the change in pollution that is attributed to the disequilibrium between the actual and the equilibrium models. That is, ECT differences between countries means that they react different to last period deviations from the long run relationship and some countries will take more periods than others to adjust to it. In the light of the above estimates, for example, when China (α=-0.10) deviates from the long run equilibrium relationship, it would take ten years to return to it, while Denmark (α=-0.55) only would need a little bit less than two years. Equality in the ECT adjustment parameter among countries is rejected for any group of countries with more than 8 countries at 95% confidence (10 at 99%) (Figure 3). This means that short-run deviations from their respectively long run relationships take different time periods to adjust among countries.

[14] Switzerland was excluded from the figure because it presents atypical values, while Sweden and UK are not included because their functional form is unique.

In summary, the relation between economic activity and carbon dioxide emissions is different among countries, both in functional form and the parameters of the long run relation of countries with same functional form. In no cases have we found any group of countries with more than five members with homogeneous parameters.

In spite of this, it is interesting to study if the turning points occur for the same level of economic activity, since it could be that some countries achieved it for the same level despite presenting different paths. This test is run for those countries showing an inverted-U form. Figure 4 shows that turning point equality for all the countries is clearly rejected, and there are no groups with more than 4 countries at 95% confidence (5 at 99%).

This means that countries that experienced an inverted-U path reached the maximum level of emissions for different economic activity levels. It must be highlighted that, despite the results reject an identical turning point for the whole sample of countries, there are some groups of countries for which this hypothesis is not rejected, even though the long run relation parameters were different among them. For example, Canada, USA, Finland, Italy and Switzerland are countries with different paths, but present statistically homogeneous turning points (they achieved it at the same threshold). If it were possible to generalize this result to the all countries, this would mean that policies must focus on avoiding high environmental non reversible damages. Other cases are Ireland, Japan and Austria, and Denmark and The Netherlands.

Therefore, the questions to beg here are first, what are the factors explaining paths homogeneity for some countries, and second, what are the determinants that make countries with heterogeneous paths achieve the maximum level of emissions for the same activity level.

5. Conclusions

The present paper supports the existence of a long run relationship between CO_2 emissions and GDP per capita for 26 of the 31 countries over the period 1950–2006. However, the functional form specification of these relationships is not homogeneous, being 7 linear, 17 quadratic, 1 cubic and 1 inverted linear. Moreover, the equality of the elasticities of the long run relationship for different countries is not supported, independently of the functional form. Finally, the assumption of an equal turning point for countries showing an inverted-U relationship is also rejected. Nonetheless, it might be noted that there are cases in which countries with different paths achieve the turning point for a similar GDP per capita level.

The contribution of the present paper is three fold. First, it reinforces that we must be cautious about studies that carry out the estimations of the relation between CO_2 emissions and economic activity without considering that the series are non stationary (Grossman and Krueger, 1991 and 1994; Shafik and Bandyopadhyay, 1992; Carson et al. 1997; Cole et al. 1997; Vincent, 1997; de Bruyn et al., 1998; and Hung and Shawn, 2004). We reject the existence of a long run relationship between CO_2 emissions and economic activity level for some countries (former Czechoslovakia, Hungary, Mexico, Poland, and former Soviet Union). Not considering this problem, above quoted works might include countries for which the relation is a spurious one.

Second, we rejected the assumption of equal functional form and parameters among countries (or regions). This is not tested in most studies (Grossman and Krueger, 1991 and 1994; Shafik and Bandyopadhyay, 1992; Selden and Song, 1994; Carson et al. 1997; Cole et al. 1997 and Vincent, 1997; Hung and Shawn, 2004 and Song et al., 2008). Therefore, panel data of countries (or regions) works that do not test for differences in the relationship among countries should be taken with a grain of salt, because assuming this restriction may lead to consider countries with the same GDP per capita level but different paths in the same way, or to wrongly assume that they will reach the turning point for the same GDP per capita level. In this way, we support the argument stated by de Bruyn et al. (1998) stipulating that in order to distinguish possible benefits stemming from economic activity growth in environmental quality, the study should focus on the analysis of the relationship between these factors at single country level. In this way, the functional form homogeneity analysis helps to identify countries with similar paths, and can give clues about which are their determinants.

The results of the present research are consistent with previous related literature (Dijkgraff and Vollebergh, 2001; Martínez-Zarzoso and Bengochea-Morancho, 2003 and 2004; Cole, 2005; and Musolesi et al., 2010) on the problematic assumption of parameters and functional form homogeneity of the long run relation between CO_2 emissions and economic activity level, both per capita, employing a longer period sample, and estimating single country relationships for each relevant functional form. The greater degree of overlapping is an important improvement, specially for analyzing functional forms homogeneity, because it extends the overlap between more and less developed countries. This is highlighted by the fact that different functional forms are found for countries with similar level of economic activity.

Following Carson (2010), this result rejects the optimistic view of the EKC, where developing countries might ignore environmental problems until they become developed. Developed countries can and have to consider this problem, since nothing guarantees a path as the one of the EKC for all countries (and neither the existence of a common path for them) (Dasgupta et al., 2002). Example of this is the case of France and Spain, which for similar levels of economic activity show a different relationship.

Finally, the assumption that the different countries showing an inverted-U relationship have the same turning point is rejected. However, there are groups of countries with different elasticities but similar turning points (but the level of emissions achieved in this point might be different). Moreover, there are some emergent countries, like China and India, which show a long run inverted-U relationship with lower turning points than the ones of the developed countries showing inverted-U relationships. This may lead to a less pessimistic interpretation of the results, in the sense that the long term relationship between emissions and economic activity can start decreasing from lower levels of economic activity (and environmental degradation) than the ones reached by developed countries. Although this is not strong evidence in favor of the optimistic view of the EKC, it suggests that it would be interesting to analyze the determinants for these countries.

In any case, results above clearly deny that economic growth will automatically drive to an EKC. Even less that the turning point will be achieved for reasonable pollution levels. This would depend on the real determinants behind the relationship, where energy and environmental policies, institutions, and trade play an important role. We explicitly define the functional form of the apparent long run relation for each country. This would help to think over the policy instruments design involving countries with similar economic levels but different paths.

Acknowledgments

We are deeply grateful to Prof. J.L. Raymond, for his advice, patience, and generosity in sharing his knowledge. We are also very grateful to the anonymous reviewers for their helpful comments. M. Piaggio wants to thank to the Agencia Española de Cooperación Internacional from the Ministerio de Asuntos Exteriories for the financial support provided. The authors also acknowledge support from projects ECO2009-10003 (Ministerio de Ciencia e Innovación), 2009SGR-600 and XREPP (DGR).

References

Boden, T.A., Marland, G., Andres, R.J. (2009) *Global, Regional, and National Fossil-Fuel CO_2 Emissions,* Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tenn., U.S.A. doi 10.3334/CDIAC/00001

Carson, R. (2010) "The Environmental Kuznets Curve: seeking empirical regularity and theoretical structure", *Review of Environmental Economics and Policy,* Vol. 4:1, pp. 3–23.

Carson, R, Jeon, Y., Mccubbin, D. (1997) "The relationship between air pollution emissions and income: US Data", *Environment and Development Economics*, Nº 2, pp. 433–450.

Cole, M.A, Rayner, A.J., Bates, J.M. (1997) "The environmental Kuznets curve: an empirical analysis", *Environment and Development Economics,* Nº 2, pp. 401–416.

Cole, M. (2005) "Re−examining the pollution−income relationship: a random coefficients approach", *Economics Bulletin*, Vol. 14, No. 1 pp. 1−7.

Dasugpta, S., Laplante, B., Wang, H., Wheeler, D. (2002) “Confronting the environmental Kuznets curve”, *Journal of Economic Perspectives*, Vol. 16, pp. 147–168.

de Bruyn, S.M., van den Bergh, J.C., Opschoor, J.B. (1998) *“Economic growth and emissions: reconsidering the empirical basis of environmental Kuznets curves”, Ecological Economics*, Vol. 25, pp 161–75.

Dijkgraaf, E., Melenberg, B., Vollebergh,H. (2005) “Environmental Kuznets Curves for CO_2: heterogeneity versus homogeneity”, *Environmental and Resource Economics*, Vol. 32, pp. 229–239.

Dijkgraaf, E., Vollebergh, H. (2005), “A Test on parameter heterogeneity in CO_2 panel EKC estimations”, *Environmental and Resource Economics*, Vol. 32, pp. 229–239

Dinda, S., Coondoo, D. (2006) “Income and emission: A panel data-based cointegration analysis”, *Ecological Economics*, Vol. 57, pp. 167–181.

Egli, H. (2004) “The Environmental Kuznets Curve – Evidence from Time Series Data for Germany”, ETH Zurich, Http://ideas.repec.org/p/eth/wpswif/03-28.html.

Enders, W. (2004) *Applied Econometric Time Series*, Wiley, 2nd Edition.

Engle, R. F., Granger, C. W. J. (1987) “Co-integration and Error Correction: Representation, Estimation, and Testing”, *Econometrica*, Vol. 55, pp. 251–276.

Friedl, B., Getzner (2003) “Determinants of CO_2 emissions in a small open economy”, *Ecological Economics*, Vol. 45, pp. 133–148.

Granger, C.W., Hallman, J. (1991) “Nonlinear transformations of integrated time series”, *Journal of Time Series Analysis*, Vol. 12, pp. 207–224.

Greene, W. (2003) *Econometric Analysis*, Prentice Hall.

Grossman, G., Krueger, A. (1991) "Environmental impacts of a North American free trade agreement", NBER working paper, Nº 3914.

Halicioglu, F. (2009) "An econometric study of CO_2 emissions, energy consumption, income and foreign trade in Turkey", *Energy Policy*, Vol. 37, pp. 1156–1164.

Hall, A. (1991) "Testing for a Unit Root in Time Series with Pretest Data Based Model Selection", Department of Economics, North Carolina State University. Mimeo.

Hayashi, F. (2000) *Econometrics*, Princeton University Press.

Hung, M.F., Shaw, D. (2004) *"Economic Growth and the Environmental Kuznets Curve in Taiwan: a simultaneity model analysis",* en in Boldrin, M., Chen, B.L. y Wang, P. (eds.), *Human Capital, Trade and Public Policy in Rapidly Growing Economies: From Theory to Empirics*, pp. 269–290.

Iwata, H., Okada, K., Samreth, S. (2010a) "Empirical study on the determinants of CO_2 emissions: evidence from OECD countries", Munich Personal RePEc Archive, paper nº 21520.

Iwata, H., Okada, K., Samreth, S. (2010b) "Empirical study on the Environmental Kuznets Curve for CO_2 in France: the role of nuclear energy", *Energy Policy*, Vol. 38, pp. 4057 - 4063.

Jalil, A. and Feridun, M. (2011) "The impact of growth, energy and financial development on the environment in China: a cointegration analysis", *Energy Economics*, Vol. 33, pp. 284 – 291.

Johansen, S. (1991) "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models", *Econometrica*, Vol. 59, pp. 1551–1580.

Johansen, S., Joselius, K. (1990) "Maximum Likelihood Estimation and Inferences on Cointegration— with applications to the demand for money", *Oxford Bulletin of Economics and Statistics*, Vol. 52, pp. 169–210.

Lee, C., Lee, J. (2009) "Income and CO_2 emissions: evidence from panel unit root and cointegration tests", *Energy Policy*, Vol. 37, pp. 413–423.

Lekakis, J. (2000) "Environment and Development in a southern European country: which Environmental Kuznets Curves?", *Journal of Environmental Planning and Management*, Vol. 43, pp. 139–153.

List, J., Gallet, C. (1999) "The Environmental Kuznets Curve: does one fits all?", *Ecological Economics*, Vol. 31, pp. 409–423.

McConnell, K. (1997) "Income and demand for environmental quality", *Environment and Development Economics*, Vol. 2, pp. 383–399.

Maddison, A. (2003) *The World Economy: Historical Statistics*, OECD.

Martínez-Zarzoso, I., Bengochea-Morancho, A. (2004) "Pooled mean group estimation of an environmental Kuznets curve for CO_2", *Economics Letters*, Vol. 82, pp. 121–126.

Martinez-Zarzoso, I., Bengochea-Morancho, A. (2003) "Testing for an Environmental Kuznets Curve in latin-american countries", *Revista de Análisis Económico*, Vol. 18, pp. 3–26.

Mazzanti, M., Musolesi, A. (2011) "Income and time related effects in EKC", Università degli studi di Ferrara, Dipartimento di Economia Instituzioni Territorio, Quadderno n. 5/2011.

Menyah, K., Wolde-Rufael, Y. (2010) "Energy consumption, pollutant emissions and economic growth in South Africa", *Energy Economics*, Vol. 32, pp. 1374 – 1382.

Moomaw, W., Unruh, G. (1997) "Are environmental Kuznets curves misleading us? The case of CO_2 emissions", *Environment and Development Economics*, Vol. 2, pp. 451–463.

Musolesi, A., Mazzanti, M., Zoboli, R. (2010) "A panel data heterogeneous Bayesian estimation of environmental Kuznets curves for CO2 emissions", *Applied Economics*, 42: 18, 2275 — 2287

Perman, R., Stern, D. (2003) "Evidence from panel unit root and cointegration test that the Environmental Kuznets Curves dows not exist", *The Australian Journal of Aricultural and Resource Economics*, Vol. 47, pp. 325–347.

Perman, R, Stern, D. (1999) "The Environmental Kuznets Curve: implications of non-stationarity", The Australian National University, Centre for Resource and Environmental Studies, Working Paper in Ecological Economics Nº 9901.

Pesaran, M.H., Shin, Y. Smith, R. (2001) "Bounds Testing approaches to the analysis of level relationships", *Journal of Applied Econometrics*, Vol. 16, pp. 289–326.

Piaggio, M. (2008) "Relación entre la Contaminación Atmosférica y la Calidad del Aire con el Crecimiento Económico y otros Determinantes: Uruguay a lo largo del Siglo XX", *Quantum*, Vol. III, Nº 1, pp. 35–54.

Roca, J., Padilla, E. (2003) "Emisiones atmosféricas y crecimiento económico en España", *Economía Industrial*, Vol. 351, pp. 73–86.

Roca, J., Padilla, E., Farré, M., Galletto, V. (2001) "Economic growth and atmospheric pollution in Spain: discussing the environmental Kuznets curve hypothesis", *Ecological Economics*, Vol. 39, pp. 85–99.

Selden, T., Song, D. (1994) "Environmental quality and development: Is there a Kuznets curve for air pollution emissions?", *Journal of Environmental Economics and Management*, Vol. 27, pp. 147–162.

Shafik, N., Bandyopadhyay, S. (1992) "Economic growth and environmental quality: time-series and cross-country evidence", Policy research working papers, Background paper for the World Development Report.

Shen, J. (2006) "A simultaneous estimation of Environmental Kuznets Curve: Evidence from China", *China Economic Review*, Vol. 17, pp. 383–394.

Song, T., Zheng, T., Tong, L. (2008) "An empirical test of the environmental Kuznets curve in China: A panel cointegration approach", *China Economic Review*, Vol. 19, pp. 381–392.

Stern, D., Common, M., Barbier, E. (1996) "Economic growth and environmental degradation: the environmental Kuznets curve and sustainable development", *World Development*, Vol. 24, pp. 1151–1160.

Torras, M., Boyce, K. (1998) "Income, inequality, and pollution: a reassessment of the environmental Kuznets Curve", *Ecological Economics*, Vol. 25, pp. 147–160.

United Nations (1998) Kyoto Protocol of the Framework Convention of the United Nation on Climate Change, United Nations.

Veerbeek, M. (2004) *A Guide to Modern Econometrics*, Wiley.

Vincent, J. (1997) "Testing for environmental Kuznets curves within a developing country", *Environment and Development Economics*, Vol. 2, pp. 417–431.

Wagner, M. (2008) *"The Carbon Kuznets Curve: a cloudy picture emitted by bad econometrics?", Resource and Energy Economics*, Vol. 30, pp. 388–408

Wang, Y. (2009) "Testing the EKC hypothesis: some econometric pitfalls and solutions", School of Economics, Arndt Building 25a, The Australian National University.

World Bank (2005) "World development indicators", Washington, D.C.

Annex A

Table III - Error Correction Term - ECM cubic, quadratic and linear model

	AUS			AUT			BEL			CAN			CZE			DEN		
	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear
ADRL	(0,0,0,0)	(0,0,0)	(1,1)	(0,2,2,2)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(0,3)	(1,0,0,0)	(0,0,0)	(1,1)	(0,0,0,0)	(0,0,0)	(0,1)
alfa	-0.45	-0.37	-0.07	-0.30	-0.32	-0.04	-0.19	-0.21	-0.13	-0.16	-0.18	-0.09	0.01	-0.02	0.01	-0.53	-0.55	-0.11
t-statistic	*-3.47*	*-3.38*	*-1.92*	*-2.73*	*-3.32*	*-1.29*	*-2.59*	*-3.52*	*-1.89*	*-2.10*	*-2.30*	*-1.73*	*0.27*	*-0.79*	*0.42*	*-4.52*	*-4.96*	*-1.84*
C	-9.40	-3.13	-9.43	-9.89	-6.08	0.37	-6.48	-6.75	-9.19	21.29	-3.60	-8.52	11.21	-8.60	0.01	5.14	0.69	-8.48
t-statistic	*-1.95*	*-5.01*	*2.04*	*-3.11*	*-14.14*	*1.31*	*-6.04*	*-9.22*	*-39.02*	*0.99*	*-1.92*	*-19.24*	*2.99*	*-0.88*	*0.00*	*0.63*	*0.81*	*-9.23*
GDPPC(-1)	3.26	-4.18	0.00	1.84	-1.68	0.00	-2.59	-2.08	-0.06	-33.57	-4.35	-0.32	-7.11	-5.03	-5.60	-12.75	-7.40	-0.19
t-statistic	*0.57*	*-8.43*	*0.08*	*0.45*	*-4.37*	*0.00*	*-1.82*	*-3.49*	*-0.65*	*-1.34*	*-2.91*	*-1.90*	*-1.11*	*-0.59*	*-0.47*	*-1.29*	*-10.84*	*-0.55*
GDPPC^2(-1)	-2.25	0.66		-0.72	0.24		0.72	0.43		12.07	0.77		5.81	2.26		3.47	1.36	
t-statistic	*-1.01*	*6.77*		*-0.41*	*2.88*		*1.01*	*3.40*		*1.26*	*2.64*		*1.63*	*0.90*		*0.89*	*10.18*	
GDPPC^3(-1)	0.37			0.07			-0.05			-1.44			-1.34			-0.27		
t-statistic	*1.31*			*0.27*			*-0.43*			*-1.19*			*-2.07*			*-0.54*		
Interventions																		
Step															1970			
Impulse																		
Turning Point	3.07	3.19		5.36	3.46		2.39	2.42		2.61	2.83		0.88	1.11		2.70	2.72	
	0.95			1.68			7.15			2.97			2.01			5.75		
Schwartz iC	-3.84	-4.03	-3.86	-2.68	-3.10	-3.86	-3.14	-3.21	-2.97	-3.43	-3.46	-3.49	-3.51	-3.81	-3.71	-2.15	-2.21	-1.86
JB	1.08	0.83	0.58	0.45	0.75	0.75	0.10	0.32	0.72	2.07	1.97	4.72	4.78	5.44	7.56	1.16	0.85	1.13
p-value	*0.58*	*0.66*	*0.75*	*0.80*	*0.69*	*0.69*	*0.95*	*0.85*	*0.70*	*0.36*	*0.37*	*0.09*	*0.09*	*0.07*	*0.02*	*0.56*	*0.66*	*0.57*
BG (4 lags)	0.03	0.18	0.18	1.82	2.02	2.08	1.08	0.76	0.38	0.34	0.90	1.07	0.89	2.07	1.95	2.44	2.09	2.34
p-value	*1.00*	*0.95*	*0.95*	*0.14*	*0.11*	*0.10*	*0.38*	*0.56*	*0.82*	*0.85*	*0.47*	*0.39*	*0.48*	*0.10*	*0.12*	*0.06*	*0.10*	*0.07*
TP in the sample		YES			NO			YES			YES			YES			YES	

	FIN			FRA			GER			GRE			HOL			HUN		
	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear
ADRL	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(3,3)
alfa	-0.33	-0.33	-0.09	-0.31	-0.20	-0.06	-0.26	-0.11	-0.04	-0.26	-0.19	-0.14	-0.20	-0.23	-0.02	-0.16	-0.11	0.01
t-statistic	*-3.02*	*-3.02*	*-1.68*	*-2.71*	*-2.47*	*-1.60*	*-2.49*	*-1.75*	*-1.16*	*-2.44*	*-2.41*	*-1.68*	*-2.43*	*-3.10*	*-0.48*	*-2.10*	*-1.90*	*0.26*
C	2.92	-0.90	-7.44	4.10	-3.90	-7.46	-1.64	-2.88	-9.80	-5.28	-4.69	-5.78	-20.04	-1.36	-10.55	21.29	-8.24	6.09
t-statistic	*0.60*	*-0.93*	*-6.48*	*0.72*	*-2.92*	*-7.07*	*-0.20*	*-1.01*	*-7.94*	*-6.94*	*-12.62*	*-15.05*	*-1.86*	*-1.05*	*-1.59*	*0.99*	*-3.43*	*0.12*
GDPPC(-1)	-11.44	-5.84	-0.64	-13.61	-4.34	-0.26	-6.55	-5.14	0.36	-1.73	-2.72	-1.35	14.98	-5.94	0.54	-33.57	-1.10	-9.03
t-statistic	*-1.70*	*-6.94*	*-1.44*	*-1.73*	*-3.81*	*-0.86*	*-0.67*	*-2.44*	*0.67*	*-1.05*	*-4.68*	*-9.18*	*1.16*	*-5.48*	*0.21*	*-1.34*	*-0.42*	*-0.28*
GDPPC^2(-1)	3.65	1.01		4.64	0.91		1.37	1.03		-0.14	0.39		-6.40	1.10		12.07	0.44	
t-statistic	*1.21*	*5.57*		*1.32*	*3.86*		*0.35*	*2.60*		*-0.14*	*2.13*		*-1.26*	*4.96*		*1.26*	*0.60*	
GDPPC^3(-1)	-0.40			-0.53			0.00			0.09			0.87			-1.44		
t-statistic	*-0.92*			*-1.05*			*0.00*			*0.49*			*1.32*			*-1.19*		
Interventions																		
Step														1982	1982			
Impulse																	1956	
Turning Point	imag.	2.90		imag.	2.37		2.40	2.51		3.11	3.45		3.00	2.70		2.61	1.26	
	imag.			imag.			1147.68			-2.08			1.92			2.97		
Schwartz iC	-1.61	-1.67	-1.59	-1.57	-2.83	-3.02	-3.80	-3.85	-3.91	-2.82	-2.92	-2.81	-2.82	-3.09	-2.77	-3.43	-2.98	-2.84
JB	2.01	1.25	1.13	3.36	1.56	0.34	1.47	0.26	0.48	0.48	1.91	0.45	4.96	7.87	9.06	2.07	7.00	0.26
p-value	*0.37*	*0.53*	*0.57*	*0.19*	*0.46*	*0.84*	*0.48*	*0.88*	*0.79*	*0.78*	*0.39*	*0.80*	*0.08*	*0.02*	*0.01*	*0.36*	*0.03*	*0.88*
BG (4 lags)	0.29	0.07	2.34	2.11	0.49	2.37	1.46	1.26	1.37	1.09	2.19	0.36	1.22	0.87	0.88	0.34	2.59	0.28
p-value	*0.88*	*0.99*	*0.07*	*0.09*	*0.74*	*0.07*	*0.23*	*0.30*	*0.26*	*0.37*	*0.08*	*0.84*	*0.32*	*0.49*	*0.48*	*0.85*	*0.05*	*0.89*
TP in the sample		YES			YES			YES			NO			YES			YES	

Table III - Error Correction Term - ECM cubic, quadratic and linear model

	IRE			ITA			JAP			KOR			MEX			NOR		
	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear
ADRL	(0,1,1,0)	(0,0,0)	(3,2)	(0,0,0,0)	(1,0,0)	(0,0)	(4,3,3,3)	(0,1,0)	(1,1,0)	(3,3,0,0)	(0,0,0)	(2,2)	(2,1,1,1)	(2,0,0)	(2,0)	(0,2,2,2)	(0,0,0)	(0,1)
alfa	-0.70	-0.57	-0.04	-0.15	-0.25	-0.04	-0.37	-0.25	-0.09	0.02	-0.10	-0.08	-0.24	-0.17	-0.12	-0.48	-0.34	-0.11
t-statistic	*-5.56*	*-4.58*	*-0.50*	*-1.96*	*-3.68*	*-1.32*	*-4.33*	*-3.64*	*-2.48*	*0.32*	*-2.54*	*-3.59*	*-3.30*	*-2.83*	*-2.14*	*-4.34*	*-3.19*	*-1.64*
C	-2.84	-5.94	-11.10	0.00	-2.45	-8.63	-6.96	-5.61	-5.58	7.50	-7.18	-7.44	-12.31	-3.87	-5.80	3.11	-3.49	-7.32
t-statistic	*-3.51*	*-28.65*	*-1.52*	*0.00*	*-5.51*	*-3.29*	*-7.82*	*-24.90*	*-10.14*	*0.19*	*-11.31*	*-17.48*	*-4.73*	*-3.28*	*-20.82*	*0.51*	*-3.14*	*-11.98*
GDPPC(-1)	-6.52	-2.06	1.44	-9.33	-4.56	-0.04	-1.21	-2.12	-1.13	-23.64	-1.45	-0.54	13.45	-4.34	-1.34	-12.86	-3.65	-0.66
t-statistic	*-5.52*	*-10.62*	*0.34*	*-1.43*	*-11.70*	*-0.04*	*-0.87*	*-8.50*	*-7.29*	*-0.38*	*-3.16*	*-2.80*	*2.35*	*-2.51*	*-8.18*	*-1.82*	*-4.03*	*-3.09*
GDPPC^2(-1)	2.29	0.31		3.30	0.80		0.20	0.31		13.01	0.24		-11.06	1.05		4.78	0.60	
t-statistic	*4.18*	*6.79*		*1.04*	*9.10*		*0.29*	*4.91*		*0.37*	*1.93*		*-2.72*	*1.77*		*1.76*	*3.32*	
GDPPC^3(-1)	-0.27			-0.40			-0.02			-2.48			2.67			-0.62		
t-statistic	*-3.35*			*-0.81*			*-0.14*			*-0.36*			*2.84*			*-1.80*		
Interventions																		
Step																		
Impulse																		2006
Turning Point	imag.	3.36		imag.	2.85		imag.	3.38		imag.	3.05		1.85	2.07		imag.	3.06	
	imag.			imag.			imag.			imag.			0.91			imag.		
Schwartz iC	-2.44	-2.36	-2.15	-3.52	-3.65	-3.66	-3.10	-3.12	-3.59	-2.75	-2.59	-3.16	-2.83	-2.89	-2.98	-1.62	-1.72	-1.69
JB	1.95	4.18	0.18	2.72	1.37	2.05	0.74	0.39	7.21	0.13	1.94	1.09	5.53	6.38	4.27	0.95	7.80	0.59
p-value	*0.38*	*0.12*	*0.92*	*0.26*	*0.50*	*0.36*	*0.69*	*0.82*	*0.03*	*0.94*	*0.38*	*0.58*	*0.06*	*0.04*	*0.12*	*0.62*	*0.02*	*0.75*
BG (4 lags)	0.85	0.76	1.63	0.60	0.53	0.63	3.11	2.32	1.88	1.31	0.89	0.53	1.79	0.49	1.21	0.88	2.69	2.30
p-value	*0.50*	*0.56*	*0.19*	*0.67*	*0.71*	*0.64*	*0.03*	*0.07*	*0.13*	*0.28*	*0.48*	*0.71*	*0.15*	*0.74*	*0.32*	*0.48*	*0.04*	*0.07*
TP in the sample		NO			YES			YES			NO			NO			YES	

	NZL			POL			POR			SPA			SWE			SWI		
	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear
ADRL	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(1,0)	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0)	(0,0)	(1,1,1,1)	(0,0,0)	(0,1)
alfa	-0.34	-0.26	-0.25	0.03	0.03	0.00	-0.57	-0.55	-0.31	-0.29	-0.31	-0.16	-0.20	-0.14	-0.06	-0.38	-0.36	-0.04
t-statistic	*-3.40*	*-2.66*	*-2.80*	*0.78*	*0.66*	*0.03*	*-3.82*	*-3.79*	*-3.21*	*-3.48*	*-3.93*	*-2.15*	*-2.62*	*-2.00*	*-1.57*	*-2.51*	*-3.80*	*-0.74*
C	-64.77	-7.07	-6.50	-2.18	-0.31	93.13	-5.58	-5.82	-5.58	-5.54	-5.94	-6.42	44.63	-0.58	-11.72	41.20	14.38	-8.87
t-statistic	*-2.64*	*-2.20*	*-20.50*	*-0.44*	*-0.04*	*0.02*	*-14.23*	*-46.03*	*-61.00*	*-6.34*	*-26.10*	*-34.58*	*2.00*	*-0.14*	*-4.90*	*0.85*	*5.29*	*-1.72*
GDPPC(-1)	70.12	-0.43	-0.87	-6.77	-8.76	-66.08	-1.37	-0.90	-1.20	-2.39	-1.63	-0.95	-61.52	-7.17	1.07	-42.33	-15.80	0.17
t-statistic	*2.33*	*-0.16*	*-6.91*	*-1.41*	*-1.14*	*-0.03*	*-1.77*	*-5.18*	*-30.44*	*-1.48*	*-6.08*	*-12.61*	*-2.26*	*-2.30*	*1.18*	*-0.81*	*-8.00*	*0.09*
GDPPC^2(-1)	-28.66	-0.09		1.63	2.19		0.21	-0.08		0.61	0.19		23.04	1.50		11.32	2.70	
t-statistic	*-2.34*	*-0.17*		*1.23*	*1.14*		*0.45*	*-1.65*		*0.69*	*2.63*		*2.11*	*2.48*		*0.61*	*7.56*	
GDPPC^3(-1)	3.83			0.33			-0.06			-0.07			-2.82			-0.92		
t-statistic	*2.32*			*0.60*			*-0.64*			*-0.48*			*-1.96*			*-0.42*		
Interventions																		
Step					1981, 1990	1981, 1990												
Impulse																		
Turning Point	2.83	-2.44		1.44	2.00		imag.			imag.	4.27		2.33	2.39		2.87	2.92	
	2.16			-4.72			imag.			imag.			3.12			5.36		
Schwartz iC	-2.83	-2.81	-2.87	-3.72	-3.80	-3.47	-2.66	-2.72	-2.84	-2.74	-2.81	-2.80	-2.23	-2.23	-2.26	-2.61	-2.74	-2.45
JB	3.94	1.55	0.95	4.60	3.76	1.54	1.30	1.67	0.43	2.40	2.22	0.41	0.72	1.01	0.69	0.64	0.67	0.64
p-value	*0.14*	*0.46*	*0.62*	*0.10*	*0.15*	*0.46*	*0.52*	*0.43*	*0.81*	*0.30*	*0.33*	*0.81*	*0.70*	*0.60*	*0.71*	*0.73*	*0.72*	*0.73*
BG (4 lags)	1.08	0.50	1.04	1.80	1.99	2.17	1.38	1.22	0.49	1.76	1.86	1.01	0.93	0.86	0.82	1.55	3.28	2.26
p-value	*0.38*	*0.74*	*0.40*	*0.15*	*0.11*	*0.09*	*0.25*	*0.31*	*0.74*	*0.15*	*0.13*	*0.41*	*0.45*	*0.50*	*0.52*	*0.21*	*0.02*	*0.08*
TP in the sample		YES			YES			YES			NO			YES			YES	

Table III - Error Correction Term - ECM cubic, quadratic and linear model

	TUR			UK			USA			USS			BRA			CHN			IND		
	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear	Cubic	Quad.	Linear
ADRL	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(0,0)	(0,0,0,0)	(0,0,0)	(0,0)	(1,2,2,2)	(1,0)	(1,0)	(0,0,0,0)	(4,4,0)	(0,0)	(1,1,0,0)	(1,1,1)	(1,1)	(0,0,0,0)	(0,0,0)	(0,0)
alfa	-0.24	-0.45	-0.16	-0.40	-0.22	-0.20	-0.17	-0.14	-0.05	0.03	-0.09	-0.06	-0.04	-0.07	-0.17	-0.16	-0.10	-0.06	-0.15	-0.15	0.01
t-statistic	*-1.51*	*-4.14*	*-1.79*	*-3.59*	*-2.18*	*-2.63*	*-2.37*	*-2.06*	*-1.47*	*0.43*	*-2.09*	*-1.56*	*-0.43*	*-0.77*	*-2.37*	*-4.13*	*-2.91*	*-2.45*	*-2.34*	*-2.38*	*0.24*
C	-5.14	-4.62	-5.52	-0.41	-9.47	-9.76	27.26	-4.31	-9.10	51.12	-7.45	-7.77	-9.85	-5.37	-5.70	-7.24	-6.94	-6.66	-6.57	-6.57	-0.13
t-statistic	*-4.80*	*-31.12*	*-26.46*	*-0.08*	*-7.67*	*-68.43*	*1.26*	*-1.94*	*-19.65*	*0.42*	*-4.35*	*-15.70*	*-0.71*	*-4.61*	*-35.68*	*-71.38*	*-41.36*	*-26.18*	*-55.43*	*-57.39*	*-0.01*
GDPPC(-1)	-1.92	-2.80	-1.42	-10.82	-0.01	0.24	-37.70	-3.85	-0.12	-127.59	-1.26	-0.85	9.15	-3.28	-1.02	-1.11	-1.19	-0.69	-1.90	-1.91	-2.29
t-statistic	*-0.65*	*-11.02*	*-11.40*	*-1.83*	*-0.01*	*3.95*	*-1.64*	*-2.42*	*-0.76*	*-0.48*	*-0.57*	*-2.86*	*0.26*	*-1.12*	*-9.67*	*-7.47*	*-4.23*	*-2.54*	*-15.05*	*-22.94*	*-0.64*
GDPPC^2(-1)	-0.17	0.51		4.27	0.05		12.65	0.66		89.47	0.12		-10.90	1.20		1.45	0.46		1.28	1.25	
t-statistic	*-0.07*	*5.15*		*1.81*	*0.24*		*1.56*	*2.33*		*0.47*	*0.17*		*-0.31*	*0.79*		*5.18*	*1.95*		*4.14*	*6.42*	
GDPPC^3(-1)	0.19			-0.55			-1.40			-20.65			3.75			-0.71			-0.06		
t-statistic	*0.30*			*-1.75*			*-1.49*			*-0.47*			*0.33*			*-3.91*			*-0.13*		
Interventions																					
Step									1970							1958	1958	1958			
Impulse																			1977	1977	1977
Turning Point	2.20	2.72		2.16	0.05		2.74	2.93		1.28	5.07		1.32	1.36		imag.	1.29		0.78	0.76	
	-1.58			3.06			3.26			1.60			0.62			imag.			13.18		
Schwartz iC	-2.44	-2.97	-2.79	-3.91	-4.03	-4.10	-3.91	-3.93	-4.69		-4.05	-4.15	-2.82	-2.88	-3.34	-2.40	-2.26	-2.33	-4.12	-4.19	-4.13
JB	1.32	0.21	0.63	0.02	0.35	0.43	0.68	1.30	1.73	4.12	0.74	0.43	0.46	0.75	1.31	3.41	7.79	3.57	2.44	2.29	1.42
p-value	*0.52*	*0.90*	*0.73*	*0.99*	*0.84*	*0.81*	*0.71*	*0.52*	*0.42*	*0.13*	*0.69*	*0.81*	*0.79*	*0.69*	*0.52*	*0.18*	*0.02*	*0.17*	*0.29*	*0.32*	*0.49*
BG (4 lags)	0.22	0.26	0.61	0.26	0.22	0.23	0.54	1.25	0.47	0.61	0.57	1.37	1.75	1.78	2.29	2.03	0.39	0.62	2.68	2.69	2.32
p-value	*0.93*	*0.90*	*0.66*	*0.90*	*0.93*	*0.92*	*0.71*	*0.30*	*0.75*	*0.66*	*0.69*	*0.26*	*0.16*	*0.15*	*0.07*	*0.11*	*0.82*	*0.65*	*0.04*	*0.04*	*0.07*
TP in the sample		NO			YES			YES			NO			YES			YES			YES	