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Revisiting Environmental Kuznets Curves through the energy Price lenses

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Abstract

The goal of this paper is to provide new insights to make clear cut on the ambiguous evidence in favour of the Environmental Kuznets Curve (EKC) hypothesis. We contribute with an original explanation to dismiss the EKC based on relative energy prices. For the first time in the empirical literature, the econometric analysis includes the prices for coal, oil products and natural gas. We may conclude that there is evidence for a decoupling process between GDP and CO_2 but without reaching any turning point on that relationship. Accordingly, the presence of relative energy price changes in the econometric specification confirms a monotonic and positive relationship between CO_2 and GDP. Otherwise, we will eventually end up with distorted empirical evidence for EKC in our database, as long as we neglect energy substitution effects from price changes. The policy implications are straightforward: any international climate change agreement that eventually includes restrictions on developing countries might abate their legitimate ambitions for further economic development.

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1. Introduction

There is an important strand of the literature searching for the relationship between CO_2 emissions and Gross Domestic Product (GDP), population growth, or both variables simultaneously. The underlying idea behind most papers is the Environmental Kuznets Curve (EKC)[1] hypothesis: a sort of inverted U-shape relationship relating pollution to economic development. It suggest that per capita CO_2 emissions may rise as a response to per capita income growth at early stages of economic development up to a threshold level, after which emissions begin to decline.

The EKC hypothesis seems to beg the question if income growth beyond a turning point (threshold level) might serve as a solution to environmental degradation instead of the source of the problem (Kaika and Zervas, 2013a, includes a very interesting literature review on this issue). Many papers has questioned whether the empirical data accommodates to the EKC hypothesis and if so, whether or not the turning point is located within the sample income levels.

From our point of view, the search for a turning point is central in the EKC literature. Some papers might be supportive of the EKC hypothesis but their estimated turning point is beyond sample income levels (for a survey of papers reporting turning points see for instance Galeotti and Lanza, 1999; He, 2007). Strictly speaking, they only provide evidence of a decreasing marginal propensity to emit. Nevertheless, there are also papers that estimate turning points within sample income levels. We do not pretend to be exhaustive, but some recent examples are provided in Ang (2007), Coondoo and Dinda (2008), Apergis and Payne (2009), Dutt (2009), Hsiao and Chung (2010). Therefore, our search in the empirical literature leads us to inconclusive results about the validity of EKC on CO_2.

There are important policy implications from those papers providing evidence in favor of the EKC for CO_2 and turning points within sample income levels: further increases of income beyond the turning point leads to unambiguous reductions in CO_2 emissions.

[1]See also Dinda and Coondoo (2006), Dinda (2004), Kaika and Zervas (2013a) and Verbeke and De Clercq (2006) for discussions about the EKC topic.

Consequently, favorable evidence in the EKC literature might legitimate lax political responses against climate change as long as it offers a solution to the medium and long term. That kind of statement is explicit or implicit in messages from some papers, (for recent examples, see for instance[2] Richmond and Kaufmann 2006b, Apergis and Payne, 2009; Hsiao and Chung, 2010; Niu et al., 2011). To our knowledge, only Dutt (2009) makes an important point with regard to that statement: "Based on all the findings so far, this [increases in income will automatically result in lower emissions] does not seem to be the case. […] Policies, combined with better institutions and public awareness could have helped reduce emissions, and in this study these happen to be associated with high-income countries". Nevertheless, according to the EKC hypothesis, enhanced environmental policies together with better institutions and public awareness might be endogenously determined by the income level.

The main objective of this piece of research is to provide additional evidence on the important role of energy prices in the EKC debate. Substitution and income effects in response to energy price changes exert a major influence on CO_2 emissions. Authors such as Agras and Chapman (1999) or Richmond and Kaufmann (2006a) have included the oil prices attempting to capture the energy effect. However, using just one price to identify the effect of the energy consumption on CO_2 could lead us to misleading results since we are not accounting for substitution effects among energies with different levels of pollution.

This paper contributes to the literature by including relative energy prices for the first time in an empirical exercise. Thus emphasising the need for accounting for relative energy prices in order to avoid biased conclusions. The paper develops through the following sections. Section 2 summarize a review of the literature on the EKC hypothesis. Section 3 presents the methods and tools (database, econometric methodology). Section 4 provides the econometric results and some further discussion. And finally section 5 summarizes conclusions and the main policy implications.

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[2] In some cases, authors seem to agree with this view; in some others, they just mention that may be the conclusion behind any eventual support to the EKC hypothesis and/or within-sample turning points.

2. A survey of the literature

Three effects are the main pillars of the theoretical explanations for the EKC hypothesis: the income effect, the structural effect and the abatement effect (see for instance, Grossman and Krueger, 1995; Islam et al., 1999; and more recently Kijima et al.; 2010; Vishal, 2011; Kaika and Zervas, 2013a). We may summarize the main insights from this hypothesis as follows. Economic development (greater income per capita) rises the consumption of goods and services and therefore per capita CO_2 emissions. Simultaneously, national economies experience structural changes: from agricultural based economies to industrial (thus increasing per capita CO_2 emissions) and later on knowledge based economies leading to less energy and natural resources intensive nations (thus reducing per capita CO_2 emissions). Finally, those economies that achieve the greatest economic development will be able to invest more resources (both private and public) on environmental protection and efficient technologies (thus reducing per capita CO_2 emissions); regarding their increasing interest in environmental problems (affecting consuming and voting behavior). As a result of these three effects, the intensity of environmental degradation (per capita CO_2 emissions) decreases beyond a threshold level of income per capita (referred as the turning point) in such a way that the interaction of these three effects will depict the CO_2 to GDP per capita relationship as an inverted-U-shaped curve.

Some literature surveys questioned the validity of this hypothesis because of inconclusive results. Some authors point out there are technical weakness in some analysis as well as the presence of omitted variables bias (for an exposition on these issues see for instance the surveys in Stern 1998, 2004; Dinda 2004; He 2007; Kaika and Zervas 2013ab). A complete presentation of the multiple forces (variables) behind the income, structure and abatement effects is beyond this paper objective. In addition to the surveys we mention previously, the reader may found some updated literature revisions in the latest publications[3]. Consequently, Borghesi and Vercelli

[3] See for instance, Marrero (2010), Hsiao and Chung (2010), Narayan and Narayan (2010), Miah et al. (2010), Stern (2010), Niu et al. (2011), Vishal (2011), Esteve and Tamarit (2012), Saboori and Sulaiman (2013b), Liau and Cao (2013), Shahbaz et al. (2013b).

(2003) and Stern (2004) concluded that the EKC hypothesis might not be generally accepted for the case of carbon emissions whereas it may be correct for those studies based on local emissions.

As we mention in the introduction of this paper, the main purpose of this piece of research is to emphasise the relevance of energy prices in the empirical research. There are two main motivations. First, nearly all of the studies surveyed omit energy prices. Second, there are multiple channels energy prices impact on CO_2. On the one hand, an increase on energy prices may produce substitution effects (among different energy sources; between energy and other final goods; between energy and other intermediate inputs or primary factors; etc.). On the other hand, it may boost investments on energy efficiency (by households; by firms on their production processes; by firms on the energy efficiency incorporated to the final goods offered to the households or any other economic agent; etc.). Additionally, an increase on energy prices may reduce energy consumption and CO_2 emissions because of a reduction on real income.

In whatever way any price increase takes place, it will move downwards the EKC. Figure 1 shows a hypothetical representation of a positive and monotonic GDP-CO_2 relationship for a particular country before (blue line) and after (red line) a significant rise on energy prices. Let us assume that along the price change there is a reduction in energy consumption and CO_2 emissions together with a sustained rise on per capita GDP[4]. Thus, an empirical assessment on the data generated by this graphical representation (black line) might provide evidence in favour of the EKC despite each single coloured line represent the true relationship between GDP and CO_2 emissions. With this simple example, we want to emphasise that researches lacking to include energy prices may be jeopardizing the robustness of their empirical results in favor of the EKC hypothesis.

[insert Figure 1 here]

[4] There is not truncation on the development process. So point A takes place earlier in time than point B. Otherwise the final point will be C following a price increase without a rise on per capita GDP.

The first attempt to our knowledge to study EKC for CO_2 emissions including energy prices as an explicative variable is Agras and Chapman (1999). Their results may be subject to criticism as long as they use the same variable (real gasoline prices in the US) for all countries in the sample (i.e., prices may follow diverse patterns because of differences in policies and shocks between countries). They use the price of crude oil delivered to US refiners in each year measured in 1994 US dollars.

In the particular case of Richmond and Kaufmann (2006a), the authors use the price of light fuel oil for industry in sixteen OECD nations with observations for 1978 to 1997. Thus, they use end-user prices to take into account any differences in tax burdens or any other structural constraint affecting final prices. They arrive to quite interesting results. On the one hand, they found evidence in favor of the EKC type relationship but it vanishes when energy prices are included. On the second hand, the coefficients associated with GDP and quadratic GDP are not statistically different from zero when energy prices are included. That is indeed an unexpected result (at least for GDP).

Some drawbacks are worth mentioning from the Richmond and Kaufmann (2006a) paper. First, robustness of results should be checked by including additional energy prices. Authors acknowledged that electricity prices resulted an insignificant variable and no other energy price was studied to our knowledge. Second, the inclusion of energy shares (energy mix) may be subject to criticism. Certainly, that sort of fuel-mix regression model might maximize the goodness of fit to the data (higher r-square). However, that may be the result of some sort of accounting identity, which might bias the specification[5]. Finally, there are many examples in the literature were the inclusion of energy shares respond (in author's words) to the need for controlling on composition and structural changes along the economic development process. Nevertheless, as we mentioned in this survey, that is precisely the idea at the heart of the EKC hypothesis: structural changes are the natural outcome of economic development (and therefore it might arise an endogeneity misspecification problem).

[5] Richmond and Kaufmann (2006a) calculated carbon emissions as a weighted sum of fuel consumption, using fixed coefficients reflecting the carbon content of each type of energy "To ensure that carbon emissions are consistent with the IEA energy data". As a result, changes in energy shares may explain changes in CO_2 *ceteris paribus* energy per capita remains unchanged. If that is the case (minor changes in energy per capita), there is little explicative room left for GDP.

Therefore, we should not include those variables in the empirical exercise. Otherwise, we will jeopardize the impact of GDP on carbon emissions according to the EKC hypothesis. Instead, we include the share of domestic production for each source on total primary energy. Using these variables instead of energy shares (energy mix), we account for structural energy constrains such us shortage/excess on domestic endowments of energy resource. Consequently, these shares might be capturing to some extent the level of national energy independence and therefore energy security.

As we mentioned, the controversy on the empirical evidence deserves further research on this issue. In the next section, we contribute to the empirical literature by including relative energy prices for the first time. Besides, we avoid some of the drawbacks and criticism summarized in this survey.

3. Methodology and data

In this section we outline the econometric methodology and the database in order to validate the EKC hypothesis for CO_2 emissions. We express the model as following:

$$d_{it} = \beta_1 y_{it} + \beta_2 y_{it}^2 + \beta_3 P_{it} + \beta_4 X_{it} + u_{it}; \quad i = 1,\dots,N; t = 1,\dots,T$$

We will assume that the fixed effect u_{it} follows a one-way error component model[6],

$$u_{it} = \mu_i + \upsilon_{it}$$

where μ_i ~ IID $(0,\sigma_\mu^2)$ and υ_{it} ~ IID $(0,\sigma_\upsilon^2)$, independent of each other and among themselves.

In this model, d_{it} is CO_2 per capita discharged on the environment, y_{it} is the per capita Gross Domestic Product at purchasing power parity, P_{it} is the set of energy prices and X_{it} is the set of variables accounting for the national endowment on energy resources.

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[6] Within this class of models, the fixed effects specification is a common choice for macroeconomic analysis and it is believed to be more appropriate than a random effects model for two reasons. First, if the individual effect represents omitted variables, it is likely that these country-specific characteristics are correlated with the other regressors. Second, a typical macro panel is not likely to be a random sample from a larger universe of countries. Moreover, we have tested for fixed effects using Hausman test in all specifications and fixed effects are preferable to random effects.

As pointed out in the introduction to this paper, the aim of this piece of research is to incorporate several energy prices. As we acknowledge in previous sections, very few papers have included energy prices for explaining the EKC hypothesis (see for instance the last survey published by Kaika and Zervas 2013a). The reason may be the lack of data availability for some energy sources (i.e. coal) even for OECD countries. As a result, some authors use oil price as a proxy for energy prices. However, any researcher using this specification will be unable to take into account substitution effects driven by relative price changes. That might be the reason why some authors do not get significant price effects on carbon emissions (Richmond and Kaufmann, 2006b). Accordingly, prices of refined oil products, coal and gas have been included as additional explicative variables in our empirical model.

We have excluded electricity prices from the empirical model because of two main reasons. First, it is a tradition in developed countries that electricity prices have been highly regulated through public tariffs with minor inter year variations. That renders a low explicative value from electricity prices for any empirical purpose[7]. Second, other energies like coal, oil products and natural gas may act as fuels for the production of electricity. Thus, there would be a sort of double accounting channel for those prices that it should be avoid.

We perform different specifications in order to assess the robustness of our results. First of all, we estimate a basic Environmental Kuznet Curve (EKC) equation plus the set of energy prices but without year dummies and time trend variables. This specification will allow us to compare our results with similar econometric equations in previous studies (Richmond and Kaufman, 2006a). Furthermore, they will provide a reference point for comparison purposes with alternative specifications.

We also include in our empirical model the share of domestic production[8] of energy relative to total primary energy consumption that might be capturing to some extent the level of national energy independence and therefore energy security.

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[7] That is probably the reason for the insignificance of electricity prices in Richmond and Kaufmann (2006b).

[8] With destination to both domestic and international markets.

Finally, results reported by Holtz-Eakin and Selden (1995) disclose the importance for controlling for year and country effects. They emphasize the role of the former to account for time varying omitted variables and also stochastic shocks common to all countries which could be correlated with per capita GDP (i.e., the omission of these variables would bias the results). As regards to country effects, they may include not only permanent conditions but also population distribution (e.g., urban sprawl), access to low carbon electricity and national industrial structure (see Bataille et al 2007 for further discussion). These features may be better understood as somewhat inflexible national characteristics in our analysis time span (24 years) and therefore improbable to be dramatically modified by policy pressures or shocks in the short term. Definitely, they will be captured by the fixed effect econometric methods. Accordingly, we include year dummies and country-trends in order to account for common shocks and country-specific tendencies (e.g., technological developments).

The lack of data for many countries and sources (mainly energy prices) restrict our sample to a balanced panel for 15 OECD countries during the period 1980 to 2004 (similar constraints are reported in Richmond and Kaufmann, 2006ab). This data has been published by the "Energy Statistics of OECD countries, 2007 edition" and the "Energy Prices & Taxes 2nd Quarter 2007", both published by International Energy Agency (IEA) and OECD.[9] We have excluded previous years in order to avoid the structural changes taking place in the 70's in response to important oil market disruptions[10]. Similarly, we have excluded recent years in order to avoid economic shocks related to the financial crisis.

Accordingly, we managed to include in our empirical exercise the 20-year decline in oil prices and the last race in oil prices during the 2000s. During that period, nominal oil prices completed a full reversal or circle: from approximately 40US$ in 1980 to the same level in 2004 afterward the bottom 12US$ in 1986 and 1999. In real terms, our database includes an important decrease in oil prices for the whole period. Furthermore, our database includes several OECD countries at very different stages (i)

[9]More details about the variables definition are included in the Appendix.

[10]The OPEP oil embargo in 1973 and the Iranian Revolution in 1979.

on their development process and (ii) CO_2 per capita levels (some EU countries and former soviet federation European republics, USA, Australia, and Turkey). Table 1 summarise the main descriptive statistics.

[insert Table 1 here]

4. Results and discussion

As expected, results in Table 2 highlight the important role of energy prices in order to explain the path followed by per capita CO_2 emissions. In the first column, we show a specification closer to that provided in Richmond and Kaufmann (2006a) including the oil price. Instead of the energy mix (as Richmond and Kaufmann) we included the ratios of domestic production to total energy consumption (proxies for national energy independence). The purpose of energy independence variables is to discard any biased results from relevant omitted variables. In other words, we are not very much interested in the coefficients linked to energy independence variables but in the robustness of the empirical evidence with regard to the EKC hypothesis and the role played by energy prices. Certainly, these energy independence variables might be capturing some idiosyncratic element for some countries.

[insert Table 2 here]

Results from the first column are similar to that reported by Richmond and Kaufmann (2006a). We found a negative and significant effect from oil prices and for most of the energy independence shares as well. However, our results are in contradiction with Richmond and Kaufmann (2006a) who found GDP exert an insignificant impact on carbon emissions once the price for oil products was included in their econometric equation (at least for those specifications testing the EKC hypothesis).

As we mention in the introduction to this paper, we are considering important to account for the prices of different energies. As a result, the second column in table 2 includes several energy prices (oil, coal and natural gas) that resulted in significant coefficients for all of them. That represents the first contribution of this paper with respect to previous results in the literature. Besides, it provides evidence in favor of the EKC hypothesis and a turning point. However, Table 2 offers a counter intuitive result suggesting that a rise in the price of oil products may increase CO_2 emissions. We will expect that higher energy prices reduce energy use and carbon emissions as a result of substitution effects and energy efficiency investments. Perhaps the reason for that unexpected result is that a rise in the price for oil will increase the consumption of coal which is far more polluting.

We wonder whether these changes on coefficients for energy prices in Table 2 reflects the model inability to accurately account for substitution effects among energy sources and price elasticity (that is indeed the main motivation for including energy prices). The third column in Table 2 may corroborate that intuition. The inclusion of relative prices instead of absolute values provides significant coefficients to explain CO_2 emissions. In particular, an increase in the price of coal relative to oil would decrease per capita CO_2 emissions. This represents a step forward in the empirical literature; where there is not any search for the role of relative prices in the EKC hypothesis to our knowledge. Our results provides an additional finding: we are no longer able to get evidence in favor of the EKC hypothesis because the squared GDP term becomes insignificant once relative prices are included.

In order to check the robustness of that evidence we proceeded in the last two columns in Table 2 by including year dummies and country trends. Interestingly, the main conclusions we had got from the third column in Table 2 remain unchanged: (i) relative energy prices are significant variables to explain CO_2 emissions and (ii) they are responsible of model inability to get evidence in favor of the EKC hypothesis. Additionally, our preferred specification in the fifth column tell us that there is a positive relationship among GDP and CO_2 emissions. The elasticity or responsiveness of CO_2 emissions to GDP is smaller than one: around 0.5 to be more precise. Finally, we had got an insignificant coefficient for the price of natural gas relative to oil as it should be expected according to their similar carbon content.

Now we may proceed with the main insights from this piece of research. We have provided empirical evidence of a positive relationship among GDP and of CO_2 emissions (our empirical search was estimated on per capita terms in order to correct for the heterogeneity between countries). This conclusion is robust to the inclusion of year dummies and country trends in order to control for unexpected shocks (common for all countries) and particular technological developments (e.g., differences in the time frame for the adoption of new technologies). The elasticity of CO_2 emissions to GDP is around 0.5 and therefore there is indeed a decoupling process between both variables (a decreasing contribution of GDP to CO_2 growth). Nevertheless, there is no evidence of an eventual turning point. Therefore, we should not expect that once reached a high enough GDP level there will a reversal on that relationship where greater GDP might result in lower CO_2 emissions.

We may conclude then that GDP exert an important (but marginally decreasing) influence on the path followed by CO_2 emissions. Additionally, relative energy prices impact on the particular (national) level of CO_2 emissions as expected (once the econometric specifications had controlled for national fixed effects; e.g., nuclear power development, geography and climate, etc.). Those conclusions may rationalize the apparent contradiction of some results published in the empirical literature: empirical evidence in favor and against the EKC hypothesis. Our results corroborates the intuition we have presented in our survey and summarized by Figure 3: changes in relative prices might influence carbon emissions and, as a result, researches lacking to include energy prices may be jeopardizing the robustness of their empirical results in favor of the EKC hypothesis.

5. Conclusions.

This paper contributes to the literature by including relative energy prices for the first time in an empirical exercise. This piece of research provides important evidence on the role of energy prices in the EKC debate as suggested in our literature review. In particular, relative energy prices accounting for substitution effects (instead of absolutes values) invalidates the evidence in favor of the EKC hypothesis we might found otherwise in our database. As a result, we may account for a decarbonization process or decoupling between GDP and CO_2 but without reaching any turning point on that relationship.

Thus, the approach to the EKC followed in this paper will help us to rationalize some contradictory observations found in the literature, emphasising the need for accounting for relative energy prices in order to avoid biased conclusions.

Finally, we would like to highlight the role of renewable energy and relative energy prices on the reduction of carbon emission. Actually, policymakers could use energy prices to encourage the consumption and to promote the research on less pollutant energies. From a political point of view, the failure of the EKC hypothesis (in particular, the absence of turning points within reasonable income ranges) should raise some concerns about the distributional consequences of policies to fight against climate change. On the one hand, any policy aiming to control or even to reduce carbon emissions that eventually includes developing countries (and this is a precondition to get involved key countries like USA) might abate their legitimate aspirations for further economic development. On the second hand, less-developed and emerging countries will usually bear the highest cost whereas it will be moderate for developed countries (see Brechet and Tulkens (2013), Luderer et al. (2012), Edenhofer et al. (2010) and Giordano and Watanuki (2012), among others). The cause for that distributional impact is the high carbon intensities values (carbon emissions to GDP ratio) in less-developed and emerging countries. The paradox is that the moderate decarbonization process reported in this paper (without net reductions in emissions) results in lower carbon intensity values the grater the per capita GDP level (greater development) and therefore lower abatement cost. But any progress in per capita GDP level in less developed countries will increase global carbon emission and therefore global warming.

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Appendix: Variables definitions and calculations

- **CO_2 discharge on the environment:** CO_2 sectoral approach (mt of CO_2).

- **Gross domestic Product per capita** (expressed in thousands 2000 $ US using PPPs per person).

- **Total primary energy consumption** (it includes oil, coal, gas and renewable) (ktoe per person).

- **Weighted average price of oil products** (2000 $ US - using power purchase parity/kl): It is calculated as a weighted average of industry and household prices (we use the final consumption as weights). Industry prices include representative heavy fuel oil, light fuel oil and automotive diesel but not fuels used for electricity generation. The household index includes representative gasoline and light fuel oil.

- **Weighted average price of coal** (2000 $ US using power purchase parity/ton): It is calculated as a weighted average of industry and household prices (we use the final consumption as weights). For coal, the industry index includes representative steam coal and coking coal. The household index includes steam coal.

- **Weighted average price of gas** (2000 $ US using power purchase parity/m^3): It is calculated as a weighted average of industry and household prices (we use the final consumption as weights).

- **Oil, coal, gas or renewable energy independence** (ktoe): domestic production for each energy source before including imports and exports relative to total primary energy.

Table 1: Descriptive statistics

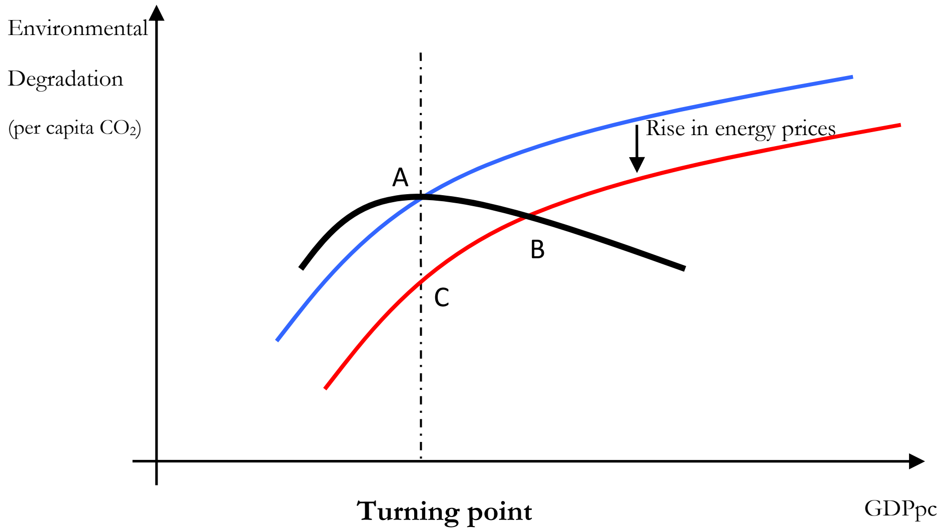
Variable	Obs	Mean	Std. Dev.	Min	Max
CO2pc	387	9.32	3.94	1.66	21.66
GDPpc (using ppp)	387	19.13	7.43	4.53	36.24
Oil prices ($/kl using ppp)	387	933.66	412.36	292.76	2465.90
Coal prices ($/t using ppp)	387	150.92	126.96	25.31	624.41
Gas prices ($/m^3 using ppp)	387	431.63	196.59	89.44	1147.46
Coal prices/oil prices	387	0.19	0.19	0.02	0.89
Gas prices/oil prices	387	0.54	0.33	0.11	1.65
Oil energy independence	387	9.73	18.44	0.12	98.98
Coal energy independence	387	17.92	26.75	0.00	103.12
Gas energy independence	387	7.02	9.86	0.00	42.49
Renewable energy independence	387	17.60	12.40	0.30	47.07

Table 1: Estimation results

	(1)	(2)	(3)	(4)	(5)
ln(GDPpc)	0.446**	0.816***	0.537***	0.625***	0.554*
$\ln(GDPpc)^2$	-0.038	-0.115***	-0.054	-0.037	-0.034
ln(Oil prices)	-0.055**	0.055*			
ln(Coal prices)		-0.117***			
ln(Gas prices)		-0.074***			
ln(coal/oil prices)			-0.095***	-0.089***	-0.053***
ln(gas/oil prices)			-0.056***	-0.066***	-0.017
ln(Oil energy independence)	-0.065***	-0.063***	-0.055***	-0.062***	-0.060***
ln(Coal energy independence)	-0.009	-0.007	-0.003	-0.009	-0.019**
ln(Gas energy independence)	0.012***	0.011***	0.007*	0.010***	0.004
ln(Renewable energy independence)	-0.157***	-0.135***	-0.146***	-0.136***	-0.055***
constant	2.016***	1.789***	1.240***	0.768**	1.073***
Observations	387	387	387	387	387
R2_within	0.52	0.6	0.573	0.651	0.845
Adjusted_R2	0.493	0.575	0.547	0.603	0.816
Country-trends Included	NO	NO	NO	NO	YES
Year-dummies included	NO	NO	NO	YES	YES
Turning point		34.70			

* p<.1, ** p<.05, *** p<.01

Figure 1: Per capita Carbon emissions and GDP



Source: own elaboration.