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Investigating the Environmental Kuznets Curve hypothesis using Environmental Performance Indices

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Abstract

This essay investigates the Environmental Kuznets Curve (EKC) hypothesis using the Environmental Performance Index (EPI). The index incorporates various environmental indicators related to human health as well as the human impact on ecosystem vitality. Therefore it assesses environmental quality better than separate environmental indicators, which are usually used to test the EKC hypothesis. We run OLS regression on cross-section data including developed and developing countries for the years 2006 and 2008. Our estimates confirm the EKC hypothesis: We find that the environmental quality initially worsens but eventually improves with an increasing level of per capita income. The impacts of income inequality and the level of political freedom on the environmental performance are also studied. The overall results suggest that there is a strong positive impact of the level of political freedom on the environmental performance, while income inequality appears to have an ambiguous impact.

Keywords: Environmental Kuznets Curve, Environmental Performance index, Income inequality

Course: NEKM02, Master Thesis in Economics, 15 ETCS

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1. Introduction

The promotion of economic growth has been a crucial part of development planning and policymaking in the second half of 20th century. In the last decades, this policy focus has been complemented by increased attention to sustainability and welfare issues, as a response to increasing recognition of the problems which modern nations, especially developing ones, encounter. These problems include, among others, income inequality, environmental decay and resource depletion.

In his classic paper, Kuznets (1955) presented the idea of an inverted U-shape relationship between income inequality and economic development. According to his hypothesis, at low levels of economic development, economic growth causes increased inequality, but after some turning point further economic development decreases income inequality. Recently the concept of the environmental Kuznets curve (EKC) has been studied in the scientific literature, investigating the inverted U-shape relationship between economic development and the level of environmental quality. According to the EKC hypothesis, environmental quality initially worsens but eventually improves with increasing level of economic development.

The amount of scientific articles dedicated to the EKC hypothesis is impressive: For example, one of the pioneering studies by Grossman and Krueger (1995) has been quoted more than 2150 times.[1] However, empirical estimations on the subject provide ambiguous results. To test the EKC hypothesis, most researchers use different proxies for environmental degradation, such as data on different pollutant emissions (sulphur or carbon dioxide), as well as organic water pollution, deforestation rates, percentage of land allotted to protected areas etc. A singular indicator can explain only some aspect of environment quality, but is unable to address the overall state of environment. Until recently, no composite indicator of environmental quality existed, which can be explained by the scarcity of the environmental data. Only a few studies tried to construct such an index: Färe et al (2004), Jha and Bhanu Murthy (2003), Xiaoyu et al (2011), but their approach is still fragmentary and does not access the environmental quality as a whole.

The recently launched Environmental Performance Index (EPI) offers a new comprehensive approach towards the measurement of environmental performance. This index, developed by Yale University and Colombia University in collaboration with the World Economic Forum and the Joint Research Centre of the European Commission, quantifies and

[1] According to Google Academy http://scholar.google.se

provides a benchmark for countries' environmental policies. As of May 2011 three EPI reports have been released, based on 2006, 2008 and 2010 data.

The aim of this essay is to assess the EKC hypothesis using Environmental Performance Indices. To our knowledge, there has been only one similar study deploying EPI in the EKC estimations (Yoshioka, 2010). While their study is based on the 2006 EPI, we perform our estimations on the cross-section data for the two EPI indices: the Pilot 2006 EPI, and the 2008 EPI. Moreover, we use improved methodology and account for other factors which may affect environmental performance apart from the income level.

Even though the EKC may hold, it doesn't automatically follow that economic growth is by itself a remedy to the environmental problems or that there is no space for policy interventions apart from supporting economic growth. Therefore, we test some additional hypotheses, developed in the EKC literature – namely, whether income inequality and the level of political freedom influence the shape of the EKC. It will allow us to provide some relevant policy recommendations: for example, whether inequality reduction policies can have a positive spillover effect on environmental quality or whether democratization may promote it.

The study will contribute to the existing literature on the relationship between per capita income and environmental quality, and will try to provide relevant policy advice. Therefore, it will be of interest for researchers, as well as practitioners and policy-makers.

The rest of the paper is organized as follows: Section 2 introduces the theoretical framework, section 3 discusses our methodology, the data used in our empirical investigation is presented in section 4. Section 5 presents and discusses the empirical results, and section 6 provides the main conclusions and policy implications of this study.

2. Theoretical Framework

This section provides the theoretical framework for our empirical analysis. It presents the conceptual background of the Environmental Kuznets Curve, theoretical explanations of its shape and additional factors which may affect it. We also summarize the existing empirical evidence on the subject.

2.1 The Kuznets Curve

In his classic paper, Kuznets (1955) presented the idea of the inverted U-shape relationship between income inequality and economic development, as measured by per capita income. According to his hypothesis, at low levels of economic development, economic growth causes increased inequality, but after some turning point with further economic development the distribution of income becomes more equal. Kuznets discussed the mechanisms underlying such a relationship and introduced empirical evidence based on time-series data for the UK, the US and Germany. The Kuznets hypothesis stimulated a large number of theoretical and empirical studies, which provided more solid theoretical grounds and empirical evidence on the existence of the Kuznets curve.[2]

2.2 The Environmental Kuznets Curve

In the 1990s, the Kuznets curve was reconsidered in a different context. Some empirical evidence showed that the level of environmental degradation and per capita income follow an inverted U-shaped pattern, just as income inequality and per capita income in the original Kuznets Curve. Therefore this pattern was named the Environmental Kuznets Curve (EKC). The first empirical EKC studies comprised three independent working papers by Grossman and Krueger (1993), Shafik and Bandyopadhyay (1992) and Panayotou (1993), all of which reached the same conclusion, namely, that relationship between some pollution indicators and per capita income can be described by an inverted-U curve.[3] Panayotou (1993) was the first one to use the ‘Environmental Kuznets Curve’ term and since then the EKC has become a standard tool to describe the relationship between the level of environmental quality and the level of per capita income. Figure 1a illustrates the original Kuznets Curve and Figure 1b presents the EKC. There are several arguments to explain the shape of EKC in the existing literature, which we review below.

[2] Kijima et al (2010), pp.1188–1189.
[3] Dinda (2004), p. 433

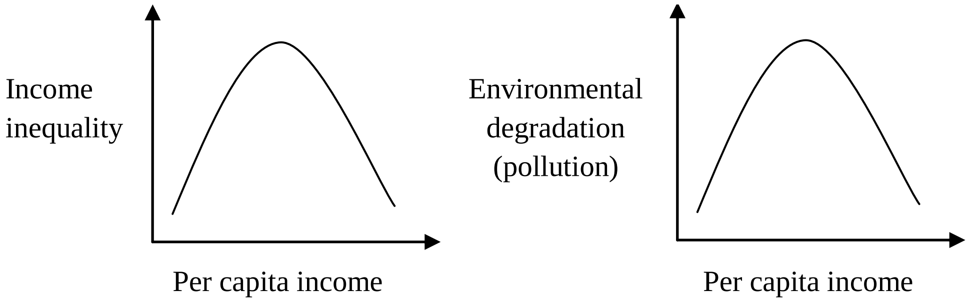


Figure 1a Original Kuznets Curve   Figure 1b Environmental Kuznets Curve

2.2.1 Income elasticity of the demand for environmental quality.

As people's income and standard of living increases, their priorities change and they care more for the quality of environment. Demand for a healthier and cleaner environment leads to structural changes in the economy and reduces environmental degradation: More is spent on cleaner technologies, people choose products which are less harmful for the environment, donate more to environmental organizations and create political pressure for environmental protection and regulations. This mechanism is called the "pure income effect" or the "abatement effect" in the literature.[4] An additional argument, presented by Dasgupta and Laplante (2002), states that as per capita income increases, the marginal propensity to consume should decline or at least be constant, which also helps explaining the shape of EKC.

2.2.2 Scale, technology and composition effects

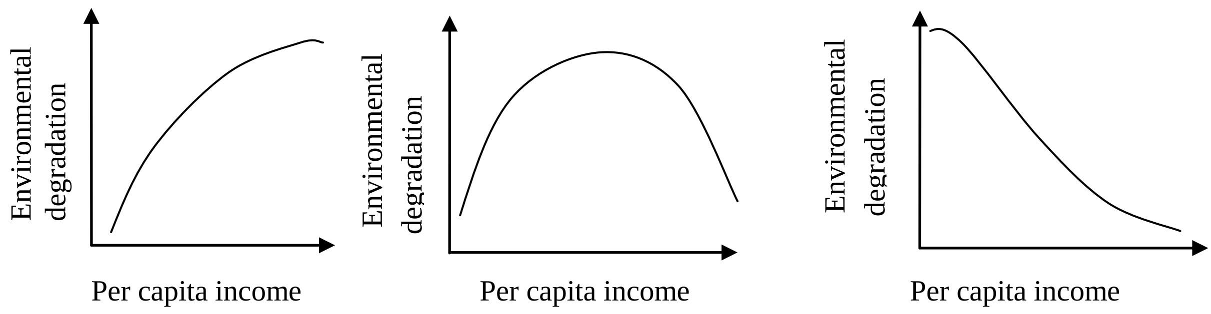
On the production side, economic growth affects the environment through scale, technology and composition effects (Grossman and Krueger, 1991). Scale effect implies that more resources are used as the output increases, which leads to more waste and harmful emissions. Through this effect economic growth has a negative impact on the environmental quality. The composition effect influences the state of environment in an opposite way: As income increases, the production structure changes towards less environmentally harmful activities. At earlier stages of economic development, environmental degradation tends to increase when the production structure changes from agricultural to industrial. However, it tends to fall as economy moves towards more services and knowledge-based technology-intensive industries. The technology effect of economic growth is essentially the same: As a nation becomes more affluent, more resources are spent on R&D and dirty technologies are replaced by cleaner ones, which improves the environmental quality. Figures 2a-c summarize and illustrate these different effects.

[4] Panayotou, (2003), p.52

Figure 2a
The scale effect

Figure 2b
The composition and technology effect

Figure 2c
The income effect



The EKC suggests that the scale effect dominates at the initial stages of an economy’s growth, but after some turning point the positive composition and technology effects, together with the income effect and the demand for pollution abatement prevail, and hence environmental quality improves (Vukina et al., 1999).

2.2.3 International trade

International trade can have offsetting environmental effects. On one hand, its impact can be negative through the scale effect: Trade often expands production possibilities of an economy, in which case the environmental degradation intensifies. On another hand, trade can have a positive impact on the environmental quality through the technology effect: As income rises with trade, more resources are directed to development of cleaner technologies. The impact of the composition effect is ambiguous: Though international trade pollution from the production of pollution-intensive goods decreases in some countries, it increases in others. The composition effect is further related to the hypotheses of displacement and pollution havens. Under the displacement hypothesis, EKC records a displacement of environmentally harmful industries to less developed economies. Therefore, the EKC reflects not the change in consumption patterns of certain nations, but the change in international specialization, where poorer countries specialize in more energy- and other resource-consuming activities, while developed countries specialize in services and production with cleaner technologies. The pollution haven hypothesis is quite similar and refers to the situation when low environmental standards become a comparative advantage and stimulate multinational firms to shift their environmentally harmful production to poorer countries where environmental regulation is less strict.[5]

[5] Dinda (2004), pp. 435-437

2.3 The use of environmental indices in the EKC estimations

There have been few studies in the EKC literature which focused not on the separate environmental indicators, but tried to assess the overall environmental performance.

Some studies have been trying to assess the production process and develop the index of environmental efficiency. Zaim and Taskin (2000) derive an environmental efficiency index based on a production approach that differentiates between environmentally desirable and undesirable outputs. The authors construct a frontier which represents the best-practice technology using data on inputs (aggregate labour and total capital stock), desirable output (real GDP) and undesirable output (represented by CO_2 emissions). Based on this approach, only the countries that use the most efficient technologies are located on the production frontier, while others are behind it. The authors' evidence supports the EKC: They conclude that environmental efficiency deteriorates with lower levels of income, but then improves after a turning point. The main limitation of the study is that it focuses only on OECD countries.

A similar methodology to construct an environmental performance index is adopted by Färe et al (2004). However, undesirable output in their estimations is represented by several pollutants: carbon dioxide, nitrogen and sulphur oxide emissions. Using data on OECD countries, they find no evidence of EKC. The implications of their study are very important: While the EKC may be found for separate pollutants as shown in a study by Zaim and Taskin (2000), there may be no clear-cut relationship between the overall environmental degradation and per capita income if one accounts for several pollutants simultaneously.

Jha and Bhanu Murthy (2003) develop a composite environmental degradation index using principal component analysis and data on six environmental variables (such as CO_2 emissions per capita, deforestation rate, annual per capita fresh water withdrawals etc.). While estimating the EKC hypothesis, they link the index not to the level of income, but to the Human Development index (HDI), which in the authors' view better reflects the level of economic development. Their empirical estimates show that the environmental degradation with respect to economic development doesn't follow an inverted U-path, but has an inverted N-shape, which means that environmental degradation first decreases with income, then slightly increases to start decreasing again at the highest levels of economic development.[6] Moreover, the authors conclude that there are large inequalities in the contribution to the

[6] Jha and Bhanu Murthy (2003), p.365

global environmental degradation across countries, with the small number of developed countries accounting for more than 50% of it.

Xiaoyu et al (2011) construct an environmental pollution index, taking into account 24 indicators within six dimensions of pollution: industrial wastewater, industrial waste gas, industrial solid waste, domestic wastes, air quality and energy consumption. Using panel data on thirty Chinese provinces, the authors test the EKC hypothesis and find empirical support for it.

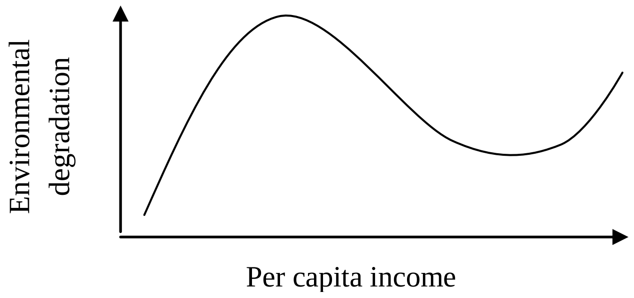
To our knowledge, Yoshioka (2010) is the only prior study using EPI in EKC estimations. He deploys the cross-section data for the 2006 EPI. The author doesn't confirm the EKC for the overall index, but only for several indicators within the index. Such results, however, may be driven by misspecification of the model and insufficient data transformation: For example, the author doesn't use the logarithmic values of variables in order to smooth the variables' distribution, which can substantially influence the estimation results.

2.4 Empirical evidence on the EKC hypothesis

Dinda (2004), He (2007) and Kijima (2010) review the existing EKC literature and provide critical surveys on the theoretical explanations and empirical evidence supporting the EKC hypothesis. They all conclude that the results of estimations are quite controversial and depend heavily on the choice of variables, sample and methodology. The EKC relationship typically holds for energy-related air pollutants, such as sulfur dioxide and particulate matter, which may be due to the fact that such pollutants are subject to more regulation. For other environmental indicators, such as water pollution, municipal waste, CO_2 or energy use, evidence of an EKC is quite inconsistent: These indicators either increase monotonically with per capita income or have turning points at very high levels of per capita income. Additionally, indicators that have a direct impact on human health (for example, access to drinking water and urban sanitation) tend to improve with increasing per capita income.[7] Some empirical findings suggest that certain pollutants follow an N-shaped relationship with income, which means that environmental degradation follows the inverted U-path initially, but beyond a certain level of income the relationship between the environmental degradation and income becomes positive again. This case is illustrated in Figure 3.1.

[7] Dinda (2004), p. 441-442

Figure 3.1 Cubic relationship between per capita income and the environmental degradation



Moreover, it may be that empirical evidence supporting the EKC hypothesis is applicable only for developed nations, since the studies that identify EKC relationship mostly are focused on OECD countries. For those studies that consider time-series or panel data on the developing nations, the empirical evidence is ambiguous, and the turning points of the EKC often don't exist or are found at substantially higher levels of per capita income than for developed nations.[8] Additionally, the EKC for developed nations may be confirmed because of the composition effect, which forces polluting industries out of the affluent countries to the poorer ones.

Besides the per capita income, other factors can also influence environmental change, such as the population density, the income inequality, the production structure of the economy, historical events, the degree of political freedom and democracy etc. If they do, this would imply that the environmental quality does not improve automatically as per capita income grows.[9] We will now analyze in more detail the factors that have been argued to have the strongest impact on the environmental quality apart from the level of income in the predominant part of these studies, namely income inequality and the level of political freedom.

2.5 Income inequality and the level of political freedom as additional factors influencing environmental quality

2.5.1 Income inequality

Combining the implications of the original Kuznets curve and the EKC, the decrease in income inequality could be expected to improve the state of environment. Boyce (1994) establishes a theoretical framework for the analysis of the relationship between income inequality and environmental quality. He argues that the scope of environmentally harmful economic activities depends on the balance of power between those who derive net benefits

[8] He (2007), p.10-11
[9] Gallagher and Thacker (2008)

from such activities and those who bear the net costs; greater inequalities and imbalances in power and wealth lead to more environmental degradation. In contrast to this political economy argument, Heerink et al (2001) argue that if an inverted U-shaped EKC holds on the household level, then lower income inequality increases the level of environmental degradation. This happens because richer households are located on the downward sloping part of the Environmental Kuznets curve and poorer households are located on the upward sloping part of the EKC, leaving more households closer to the peak of the environmental degradation with higher income equity. Magnani (2000) argues that the downward sloping segment of the Environmental Kuznets Curve emerges not only conditioned by the country's ability to pay for environmental quality, but also its willingness to do so. The willingness to pay for environmental quality depends on the relative income, or on how much a representative individual's income differs from the average income. Thus, greater income inequality negatively affects environmental policy decisions. Marsiliani and Renström (2002) derive conditions on individual preferences and technology that give rise to a negative correlation between income inequality and environmental quality. They present a model in which individuals have different levels of income, and where a representative, elected by the majority, decides on the level of pollution and redistribution taxes. The authors show that if income of the decisive individual is lower than the average income, then a higher redistributive tax and a lower pollution tax will be preferred.

Kempf and Rossignol (2007), Borissov et al (2010) use similar reasoning based on the median voter framework, and show that inequality can be harmful for the environment. They argue that there is a trade-off between the pollution-generating economic growth and environmental quality. They show that the poorer the median voter is relatively to the average individual, the fewer resources will be devoted to the environment, and economic growth will be preferred.

Besides the theoretical contributions mentioned above, there are a number of empirical studies that consider income inequality in EKC estimations. Hill and Magnani (2002) examine the conceptual and empirical basis of the EKC and argue that in estimating a simple EKC relationship, the omitted variables problem arises, and empirically show that income inequality is a key variable that needs to be included in EKC estimations.

Bimonte (2002) empirically tests the hypothesis of the EKC existence for the percentage of protected areas within the national territory, and stresses that the income distribution, among other variables such as education and information accessibility, may play a fundamental role in determining environmental quality.

Holland et al. (2009) use quite an unusual measure of environmental deterioration, investigating whether income inequality helps explaining biodiversity loss, and find that it indeed has a strong negative effect on the proportion of threatened species.

Clement and Meunie (2010) examine the relationship between social inequality and pollution, where social inequality incorporates both income inequality, as measured by the Gini coefficient, and political power inequality, as measured by the Freedom House political rights index. The authors provide a survey of theoretical approaches on the research topic, and empirically estimate the inequality impact on pollution, using panel data on 83 developing and transition countries. They confirm the EKC hypothesis for SO_2 emissions, but for water pollution the relationship with income follows an N-shaped curve. According to their findings, higher income inequality explains higher water pollution levels in developing countries, and higher levels of political freedom is associated with lower levels of pollution.

2.5.2 Political rights and democracy

Even though some empirical findings conclude that the relationship between environmental degradation and income has an inverted U-shape, it doesn't automatically follow that economic growth by itself can be regarded as a remedy to environmental problems or that there is no space for policy interventions apart from supporting continuous economic growth. On the contrary, as Grossman and Krueger (1995) argue, "the strongest link between income and pollution in fact is via an induced policy response. As nations or regions experience greater prosperity, they citizens demand more attention to be paid to the noneconomic aspects of their living conditions."[10]

The effect of political rights or democracy on the environmental quality is ambiguous. Li and Reuveny (2006) present the survey of the contradicting theoretical arguments, as well as empirical evidence on this issue. Democracy can improve environmental quality by raising public awareness and encouraging environmental legislation, because environmental interest groups are more successful at informing people and organizing them in a democracy than in an autocracy (autocratic regime can censor information flows). Moreover, democracies are better at representing environmental needs of the citizens through environmental political parties and groups, which can influence public policy. Gallagher and Thacker (2008) argue that democratic governments are more accountable for their actions and tend to cooperate more among themselves and sign international treaties to protect the environment.

[10] Grossman and Krueger (1995), p. 372

Democratic regimes can also have a negative impact on the state of environment through a number of other mechanisms. One of them is the so-called “Tragedy of Commons”, when free individuals and groups can overexploit common resources, ignoring the environmental damage of their economic actions. Moreover, democracies tend to be market economies, where business groups can have much more political power than environmentalists, because democratic leaders are accountable to business groups that support their coming to power. Since the interests of such groups prioritize profit-maximization to environmental concerns, this bears potential hazards for the quality of environment.[11]

Boyce and Torras (1998) include a measure of political rights and civil liberties in estimations of the EKC and find that such rights have positive, statistically significant impact on the environmental quality, as measured by different pollution variables. An especially strong effect is found for low-income countries, while for high-income countries the effect is weaker. The authors explain this finding by the implications of Kuznets’ original hypothesis: At lower levels of income, there is also more power inequality. Under high levels of power inequality those who benefit from pollution-generating activities tend to be more powerful than those who bear the costs, which results in higher pollution levels.

Li and Reuveny (2006) report that the existing empirical evidence on the EKC is mixed and present their own estimation. It is based on a broader sample size covering five main types of human-induced environmental degradation: carbon dioxide emissions, nitrogen oxide emissions, land degradation, deforestation, and organic pollution in water, as well as two composite environmental indicators. The authors find that a stronger democracy reduces environmental degradation, although the size of this effect varies with different environmental indicators.

Gallagher and Thacker (2008) treat democracy as a cumulative phenomenon and find a strong positive relationship between the long-term democracy (existing for a long time) and environmental quality. Buitenzorgy and Mol (2011) investigate the impact of democracy on deforestation rates and find evidence that an inverted U-shaped relationship exists between these variables. Their empirical findings suggest that countries in democratic transition experience much higher deforestation rates than non-democracies or mature democracies. Moreover, the authors show that democracy has a stronger explanatory power than per capita income in explaining deforestation rates.

[11] Li and Reuveny (2006), p.937-939

3. Methodology

This section provides a description of the model we are estimating. We describe the standard model estimated in the EKC literature, and provide a motivation for our alternative modifications of the model.

A reduced-form equation is typically used in the EKC estimations, where the level of environmental degradation or pollution is regressed upon the per capita income, the squared value of per capita income and additional determinants. This is done instead of modeling structural equations where environmental regulations, technology and industrial composition are related to GDP, and pollution is related to the regulations, technology and industrial composition. As Grossman and Krueger (1995) argue, the main advantage of the reduced-form approach is that it provides the net effect of per capita income on pollution, which in the case of structural approach would have to be estimated stage by stage and therefore would be more dependent upon the precision and bias at every stage. Moreover, under a reduced-form approach there's no need in collecting the data on pollution regulations and technology, which is important given the scarcity of such data.[12]

The following reduced form model is typically used to test EKC hypothesis:[13]

$$y_{it} = \alpha_i + \tau_t + \beta_1 x_{it} + \beta_2 {x_{it}}^2 + \beta_3 {x_{it}}^3 + Z'\gamma + \varepsilon_{it}$$

where the i and t subscripts denote the country and time, y is a certain environmental degradation indicator, α is a country-specific effect, τ is time-specific effect, x is per capita income and Z is a vector of additional explanatory variables which can influence environmental quality. Often logarithmic values of environmental indicators and income are used in the estimations. This is done in order to smooth the distribution of the data, and because the predicted y-variable only can take on positive values (some environmental damage is always expected to occur).[14]

The EKC hypothesis is confirmed if $\beta_1>0$, $\beta_2<0$ and $\beta_3=0$, where $\beta_1>0$ captures the linear increase of environmental degradation with income, and $\beta_2<0$ indicates the existence of the function's maximum, or "turning point". If $\beta_1>0$, $\beta_2<0$ and $\beta_3>0$, the relationship between the variables is cubic or N-shaped.

[12] Grossman and Krueger (1995), p.359
[13] Dinda (2004), p.440
[14] Stern (2003), p.3

The turning point of the EKC is estimated as $\tau = -\frac{\beta_1}{2\beta_2}$.[15]

In our study due to data limitations we can't use panel or time-series data, therefore we drop *t*-subscript from the equation provided above. We use a simple OLS regression on cross-section data that incorporates the following basic model:

$$\ln(Y_i) = \alpha + \beta_1 \log((GDP/P)_i) + \beta_2 (log(GDP/P)_i)^2 + \beta_3 (log(GDP/P)_i)^3 + \varepsilon_i \qquad (1)$$

where Y_i is the EPI and GDP/P is GDP per capita.

In order to account for heteroskedasticity, we use White's heteroscedasticity consistent covariance estimator. In the presence of heteroskedasticity of unknown form, which it likely to be the case for cross-sectional data, it provides consistent estimates of the coefficient covariances.[16]

Since the EPI is a measurement of environmental quality, and not of environmental degradation, the expected coefficients are reversed if the EKC hypothesis is valid: $\beta_1<0$, $\beta_2>0$ and $\beta_3=0$. In other words, environmental performance is expected first to decrease with an increasing level of per capita income, but then to improve after turning point.

Since we want to test for the impact of income inequality as well as the level of political freedom, we estimate different specifications of the basic models with additional explanatory variables:

$$\ln(EPI_i) = \alpha + \beta_1 \log((GDP/P)_i) + \beta_2 (log(GDP/P)_i)^2 + \beta_3 (log(GDP/P)_i)^3 + Z'\gamma + \varepsilon_i \ (2)$$

where Z is a vector of additional explanatory variables. We estimate regressions with each of the additional variables added separately, but also examine the joint effects and the interaction effects of the income inequality and the level of political freedoms. Moreover, we examine the difference in the impact of variables for different country groups in the sample.

[15] To find the turning point, we differentiate the estimated equation with respect to per capita income and set it to be equal to zero: $y'(x) = \beta_1 + 2\beta_2 x = 0$; $\quad 2\beta_2 x = -\beta_1$; $\quad x = -\frac{\beta_1}{2\beta_2}$

[16] Verbeek (2004), pp. 86-88

4. Data

In this section we introduce our data, and present our variable construction. We also present descriptive statistics.

4.1 The Environmental Performance Index

The Environmental Performance Index is constructed in collaboration between Yale University (Center for Environmental Law and Policy) and Columbia University (Center for International Earth Science Information Network), with support from the World Economic Forum and the Joint Research Centre of the European Commission. The index is based on proximity-to-target methodology, which is focused on a set of environmental outcomes linked to policy goals. By formulating specific targets and measuring how close each country comes to them, the EPI provides a basis for policy analysis and for evaluating environmental performance, and also facilitates cross-country comparisons.

The index contains two main categories: environmental health and ecosystem vitality. Each of the categories in turn consists of a number of subcategories, such as air quality, water resources, biodiversity and habitat, natural resources, climate and energy. Specific indicators within subcategories are the basic elements of the EPI. Each indicator, subcategory and category is assigned a certain weight in an overall index. Appropriate weights for each indicator are identified on the basis of the principle component analysis, with refinements and modifications suggested by the expert group of the EPI team.[17]

Relevant long-term public health or ecosystem sustainability goals are identified for each indicator. These targets are set as benchmarks, common for all the countries, and are based on international agreements, standards established by international organizations and authorities, or prevailing expert judgment.[18] To make indicators comparable, each is converted to a proximity-to-target measure with a range from 0 to 100. Extreme indicator values are winsorized to avoid skewed aggregations.[19]

Environmental Performance Index for years 2006 and 2008 is obtained from the index website, launched by the Yale Center for Environmental Law & Policy. The Pilot EPI 2006 uses 16 indicators and covers 133 countries. The 2008 EPI has similar structure to the 2006 EPI version, but deploys 25 indicators: some of the 2006 EPI indicators are removed, and some are added. EPI 2008 is estimated for 149 countries. The 2010 EPI ranks 163 countries

[17] Esty et al. (2008), pp. 22-23
[18] Esty et al (2006), p. 9
[19] Winsorization is a statistical technique, which adjusts extreme values in the sample by setting them to a specified percentile of the data.

on 25 indicators (also slightly modified compared to the 2008 version), but we don't use it in our estimations, since the data on additional variables is not available for year 2010 yet.[20]

Appendix A provides the composition of the 2006 and 2008 EPI. The methodology applied in 2008 has been substantially improved since the 2006 Pilot version, and since these indices aren't directly comparable, we need to perform individual estimations for the two years.

Where applicable, the EPI targets are population-based. For example, for the "Adequate sanitation" indicator, the target is set by "100% of population having access to adequate sanitation", and for the "Greenhouse gas emissions" the target is expressed in per capita values; but for such an indicator as the "Water stress", the target is set by "0% territory under water stress" and is rather territory- than population-based. Since the population size is already incorporated in the EPI structure, there is no need to account for the size of the population in our estimations.

As the index creators concede themselves, the main limitation of the EPI is the lack of time-series data and the inability to track change in environmental performance over time. However, it still allows us to perform cross-country analysis to explain the overall environmental performance.

4.2 Data on Per capita income, Political freedom and Income inequality

Original datasets on the EPI also include data on GDP per capita, but their data is not contemporaneous: the 2006 EPI and the 2008 EPI include data on 2005 GDP per capita. In our estimations we use data on income for years 2006 and 2008, taken from the World Development Indicators database: GDP per capita based on purchasing power parity (PPP), evaluated in constant 2005 international dollars. This way, our estimations capture long-run level effects in a way consistent with the theoretical EKC relationship.

As a measure of income inequality we use the Gini index obtained from the World Bank database. The Gini coefficient is a standard measure for the inequality of a distribution, and is commonly used to measure the inequality of income among individuals or households in an economy. It ranges from 0 to 1 (or from 0 to 100%), where zero value represents perfect equality, while 1 implies perfect inequality.[21] Since the available data on the Gini coefficient is very fragmentary, we use linear interpolation method for the period 1995-2009, as well as Eurostat and OECD statistical databases to fill in gaps in the data.

[20] Only data on the Freedom House index is available for year 2010 as to date.
[21] World Development Indicators: http://data.worldbank.org/

We deploy two different measures of the level of democracy. One of them is the Polity IV measure, obtained from The Center for Systemic Peace website. Polity IV is an indicator of the level of democracy, which is computed by subtracting 10-point AUTOC index measuring autocratic characteristics from the 10-point DEMOC index measuring democratic characteristics. Thus a composite indicator ranging between -10 and 10 is obtained. For those countries which are assigned "standardized authority scores": -66 standing for foreign interruption, -77 standing for interregnum or anarchy, and -88 standing for "transitions", the polity scores are treated in accordance with index manual. We follow Gurr et al (2010) and transform these data points as follows: -66 and -88 are transformed to missing values, and -77 score is set to be equal to zero.[22] This is done in order to avoid extreme outliers in the variable distribution.

Li and Reuveny (2006) argue that while continuous measures of democracy such as Polity IV are informative, the effect across a range of values along the scale may not be constant. For example, the effect of democracy rising from -10 to -5 may not be the same as the effect of it increasing from 0 to 5.[23] Therefore, following the authors, we use dichotomous measures of democracy and autocracy based on the Polity IV indicator. We create dummy variables for democratic and autocratic regimes, defining a country as democratic if Polity IV measure is above 5 and as autocratic if its score is below -5.[24]

Another measure used to assess the level of political freedom is Freedom House indicators of the state of civil and political rights. Each of the two indicators (Civil rights and Political rights) ranges from 1 to 7, where 1 indicates the most free and 7 indicates the least free country. Since the original Freedom House index depicts that higher values indicate lower levels of political freedom, but higher values correspond to higher levels of political freedom with Polity IV index, we perform a simple transformation to make the indices easier to compare and analyze. We take a simple average of the two Freedom House indicators, subtract this average from 7, and add 1, obtaining a 1-7 scale, where higher values of index reflect higher level of political freedom.

The two indices measure essentially the same thing: a simple correlation coefficient between these measures is very high and equals to 0,90 in 2006 and 0,87 in 2008.

[22] Gurr et al. (2010), p.17

[23] Li and Reuveny (2006), pp.941-942

[24] As Li and Reuveny (2006) point out, the thresholds are quite arbitrary in the sense that slightly higher or lower values of Polity IV index could also be chosen, but the values of 5 and -5 are the most common in scientific literature.

In our further estimations, test for the possibility that income inequality and the level of political freedom effects may differ depending on the country's level of development. Therefore, we subdivide our country sample into three income groups: low-, middle- and high-income countries. We deploy the World Bank definitions and use the following threshold values: less than 1000 dollars per capita for low-income countries; between 1000 and 12000 dollars per capita for middle-income countries; above 12000 for high-income countries. Using this definition, our sample for the year 2006 contains 15 low-income, 74 middle-income, and 39 high-income countries. For the year 2008, there are 13 low-income, 85 middle-income and 46 high-income countries. The list of these countries is provided in Appendix C. Appendix D contains the list of the countries for which the Gini coefficient is available, divided according to their level of income.

4.3 Descriptive statistics

Tables B1 and B2 in Appendix B present descriptive statistics for the variables entering our estimations. As already mentioned, the two indices are not directly comparable between each other due to the differences in methodology and sample sizes. We can observe the increase in the mean value for the EPI from 64,45 in 2006 to 71,87 in 2008, which may be partially explained by the change in the index methodology, but may also reflect improvement in the global environmental performance. Moreover, the 19 countries added to the 2008 EPI on average have quite high EPI scores.[25]

We can also look at the separate indicators within EPI that remain unchanged within index framework, to draw some conclusions on the dynamics of different aspects of environmental performance. Thus, we can see that such indicators as Adequate water sanitation, Access to drinking water, Indoor air pollution and Urban particulates improved from 2006 to 2008, while the Agricultural subsidies deteriorates; the rest of the indicators are not comparable through the two indices.

[25] These include Belarus, Belize, Bosnia and Herzegovina, Botswana, Croatia, Dijibouti, Eritrea, Estonia, Fiji, Guyana, Iraq, Kuwait, Latvia, Lithuania, Luxembourg, Macedonia, Mauritius, Solomon Islands and Uruguay (average EPI for these countries is 72,6); Gambia, Liberia and Suriname, present in the 2006 EPI, don't have the EPI score for year 2008.

5. Empirical analysis and results

In this section we report the empirical results of the methodology applied to our data and discuss them. We estimate different specifications of the basic model with additional explanatory variables for two years: 2006 and 2008. These are the two years for which cross-section data on all variables entering our model are available. Microsoft Excel was used to transform the data, and all the estimations are performed in E-Views 7.0.

5.1 Estimations of the EKC hypothesis for the year 2006

Table 5.1.1 presents the results of estimations for the year 2006. Specification I is our basic model as described by regression equation (1). Specification II includes the environmental effects of income inequality, as captured by the Gini coefficient. Specification III includes the Polity IV measure for the level of political freedom, while specification IV uses the Freedom House index. In specification V and VI we use the two dummy variables Autocracy and Democracy.

We confirm the EKC hypothesis for all model specifications, since $\beta_1<0$ and $\beta_2>0$, and these parameter estimates are statistically significant. In other words, environmental performance decreases with an increasing level of per capita income, but then to starts to improve after the turning point. Moreover, there is evidence of an N-shaped EKC, since the parameter estimate β_3 is positive and statistically significant, although the impact of this additional non-linear element is quite small. The model has high explanatory power, since it explains about 66% of the variation in the dependent variable.

Both the Polity IV and Freedom House measures of the level of political freedom are statistically significant and suggest that an increase in political freedom has a positive impact on the overall environmental performance. The magnitude of these effects is similar for both measures. Moreover, the dichotomous measures of autocracy and democracy are statistically significant, and suggest that if a country has a democratic regime, it is more likely to have better environmental performance, while if it is an autocracy, then it is more likely to have worse environmental performance. The size of the effects, however, is small compared to the income effects.

The model specification with the Gini coefficient, provides insignificant results for the income measures and thus for the EKC hypothesis. The only statistically significant coefficients in this specification are the intercept and the Gini coefficient. On one hand, this may call for a different model specification. Heenrik et al (2001) find similar effects for deforestation rates: when income inequality is included into the EKC model, income effects are not significant, while income inequality is. The authors provide the following explanation for this result: the EKC studies excluding income inequality may implicitly estimate the original Kuznets curve, i.e. the impact of income on income inequality, and hence on the environmental degradation.[26] Following the authors, we also estimate the original Kuznets curve for our data and find support for this proposition.[27]

Table 5.1.1 Estimations the EKC hypothesis with additional variables for the year 2006

	Model specification					
Explanatory variable	I	II	III	IV	V	VI
Constant	11,52***	6,21*	10,42***	9,61***	11,07***	11,01***
	(4,24)	(1,95)	(4,08)	(3,30)	(4,06)	(4,53)
ln GDP per capita	-3,04***	-1,15	-2,65***	-2,41**	-2,87***	-2,84***
	(-3,11)	(-0,98)	(-2,88)	(-2,32)	(-2,94)	(-3,23)
$(\ln \text{GDP per capita})^2$	0,38***	0,16	0,34***	0,32**	0,36***	0,36***
	(3,32)	(1,10)	(3,11)	(2,58)	(3,16)	(3,43)
$(\ln \text{GDP per capita})^3$	-0,02***	-0,01	-0,01***	-0,01***	-0,01***	-0,01***
	(-3,38)	(-1,08)	(-3,20)	(-2,71)	(-3,23)	(-3,47)
Gini coefficient	-	0,004***	-	-	-	-
		(2,75)				
Polity	-	-	0,007***	-	-	-
			(4,13)			
Freedom House	-	-	-	0,02***	-	-
				(3,15)		
Autocracy	-	-	-	-	-0,09***	-
					(-3,43)	
Democracy	-	-	-	-	-	0,07***
						(2,37)
R^2	0,66	0,71	0,68	0,68	0,66	0,67
Adjusted R^2	0,65	0,69	0,67	0,67	0,65	0,66
N	128	73	121	127	121	121

Values in parentheses indicate t-statistics.
***, ** and * denote that parameter estimates are statistically significant at 1, 5% and 10% level.

On the other hand, such results can be explained by the limited data sample, which doesn't allow us to account for all possible income levels. In our sample, countries which predominantly lack data on the Gini coefficient are the low-income countries: While there are 25 observations on high-income countries and 40 on middle-income countries, there are only 8 on the low-income countries for the year 2006 (Appendix D). Such a limitation may hinder us from observing the overall impact of income inequality on the environmental performance due to the small number of observations on the starting point of the curve. It should be mentioned that the average Gini coefficient is 41,72 for the low-income, 42,84 for the middle-income and 31,55 for the high-income countries.

[26] Heenrik et al (2001), p.365
[27] Estimations of the original Kuznets curve yield:

$Gini = 9{,}63 * \log(GDP/P) - 0{,}53 * (\log(GDP/P))^2$; parameters are statistically significant at 1% level

Table 5.1.2 Testing for the low- and high-income country effects for the year 2006

Explanatory variable	Model specification I	II	III	IV
Constant	6,25*	12,9***	8,14**	12,09***
	(1,93)	(4,59)	(1,99)	(4,38)
ln GDP per capita	-1,16	-3,47***	-1,92	-3,16***
	(-0,98)	(-3,43)	(-1,38)	(-3,18)
(ln GDP per capita)^2	0,16	0,43***	0,26	0,39***
	(1,10)	(3,58)	(1,66)	(3,31)
(ln GDP per capita)^3	-0,006	-0,02***	-0,01*	-0,02***
	(-1,07)	(-3,60)	(-1,83)	(-3,32)
Gini*low-income	0,004	-	-	-
	(1,49)			
Gini*middle-income	0,004**	-	-	-
	(2,63)			
Gini*high-income	0,004*	-	-	-
	(1,84)			
Polity*low-income	-	-0,01	-	-
		(-0,79)		
Polity*middle-income	-	0,009***	-	-
		(3,85)		
Polity*high-income	-	0,006***	-	-
		(4,14)		
FreedomHouse*low-income	-	-	0,03	-
			(1,14)	
FreedomHouse*middle-income	-	-	0,02***	-
			(2,69)	
FreedomHouse*high-income	-	-	0,02***	-
			(3,49)	
Democracy*low-income	-	-	-	-0,02
				(-0,19)
Democracy*middle-income	-	-	-	0,09***
				(2,74)
Democracy*high-income	-	-	-	0,07**
				(2,32)
R^2	0,71	0,69	0,68	0,68
Adjusted R^2	0,68	0,68	0,67	0,66
N	73	121	127	121

Values in parentheses indicate t-statistics.
***, ** and * denote that parameter estimates are statistically significant at 1, 5% and 10% level.

Following Boyce and Torras (1998), we also test for the possibility that income inequality and the level of political freedom effects may differ depending on the country's level of development. Since the level of development is associated with the level of income, we create three dummy variables for each of the income group defined in the Data section. We interact these dummies with the income inequality and political freedom variables; and present the estimation results in Table 5.1.2. Unfortunately, we were unable to estimate the impact of Autocracy for each of the income groups due to insufficient number of observations.

From these estimations we can conclude that the level of political freedom has the same level of impact on the environmental performance in middle- and high-income countries, since the coefficients of the interaction variables for these countries are statistically significant and have similar magnitudes for Polity IV, Freedom House, and Democracy indicators. In low-income countries we find no significant impact of neither income inequality nor the measures capturing political freedom. This contradicts Boyce and Torras (1998) findings, who conclude that political rights have a stronger effect on environmental degradation in low-income countries. This can be partially explained by our limited sample that contains only 15 observations for low-income countries. Another explanation is the difference in the methodology, since Boyce and Torras (1998) use a 5000 dollars per capita threshold to distinguish between the low- and high-income countries. However, such results can also suggest that on initial levels of economic development there is not much demand for the environmental quality in the first place. While there may be some rich and political influential interests in low-income countries, a predominant part of the population in low-income countries can barely satisfy their basic needs. Even with the higher levels of political freedom, there won't be any support for less environmental degradation until certain level of basic needs' satiation is reached, i.e., until the majority of people have the ability to pay for the environmental quality. Only then the ability to influence state policy becomes important in determining the environmental performance of a country.

The same type of argument applies to the income inequality, which according to our estimations has a strong positive impact on the environmental performance in middle- and high-income countries, but not in the low-income countries; income effects become insignificant. In low-income countries, the income groups that are rich enough to satisfy their basic needs and to care about the environmental quality, typically are closely connected to the business sector and to the politicians, and are more prone to favour profit-maximizing incentives that lead to environmental degradation. The results of other studies are also mixed in this respect: Boyce and Torras (1998) find contradicting impacts of income inequality in low-income countries for different environmental indicators; Clement and Meunie (2010) don't find any significant income inequality effects for SO_2 emissions, but conclude that increase in income inequality leads to more water pollution.

As a next step, we test for combined effects of income inequality and the level of political freedom, including several additional explanatory variables at a time. The estimation results are presented in Table 5.1.3. The Gini coefficient is included in each regression, and as in previous estimations, all the income effects lose their statistical significance, while income inequality effects are significant and positive. Once the Gini coefficient is taken into account, we find no significant effects of the level of political freedom. Among all these measures, only the Autocracy dummy has statistically significant effect, with a negative impact on the environmental performance. Following Clement and Meunie (2010), we also estimate model specifications that include interaction terms between income inequality and the Democracy/Autocracy dummies. The results are presented in specification V and VI in Table 5.1.3 The interaction terms between inequality and dummies for democracy and autocracy are insignificant, which suggests that the impact of income inequality does not depend on the political regime. These results are in line with Clement and Meunie (2010), who find no significant effect of the interaction terms when estimating the EKC for water pollutants.

Table 5.1.3 Combined effects of income inequality and political freedom on the environmental performance for the year 2006

Explanatory variable	Model specification					
	I	II	III	IV	V	VI
Constant	6,02*	6,28*	5,77*	6,26*	6,36*	5,97*
	(1,78)	(1,73)	(1,72)	(1,80)	(1,88)	(1,70)
ln GDP per capita	-1,08	-1,16	-1,00	-1,16	-1,23	-1,11
	(-0,86)	(-0,87)	(-0,81)	(-0,90)	(-0,98)	(-0,86)
$(\ln \text{GDP per capita})^2$	0,15	0,16	0,14	0,16	0,17	0,15
	(0,96)	(0,97)	(0,95)	(1,00)	(1,12)	(0,97)
$(\ln \text{GDP per capita})^3$	-0,006	-0,01	-0,01	-0,01	-0,007	-0,006
	(-0,95)	(-0,96)	(-0,98)	(-0,97)	(-1,15)	(-0,96)
Gini coefficient	0,004**	0,004***	0,003**	0,005**	0,003*	0,007*
	(2,57)	(2,65)	(2,01)	(2,63)	(1,74)	(1,82)
Polity	0,001	-	-	-	-	-
	(0,32)					
Freedom House	-	-0,004	-	-	-	-
		(-0,27)				
Autocracy	-	-	-0,10*	-	-1,03***	-
			(-1,87)		(-2,81)	
Democracy	-	-	-	-0,04	-	0,09
				(-0,74)		(0,47)
Gini*Autocracy	-	-	-	-	0,03	-
					(2,74)	
Gini*Democracy	-	-	-	-	-	-0,003
						(-0,72)
R^2	0,71	0,71	0,72	0,71	0,73	0,71
Adjusted R^2	0,68	0,69	0,70	0,69	0,79	0,68
N	70	72	70	70	70	70

Values in parentheses indicate t-statistics.
***, ** and * denote that parameter estimates are statistically significant at 1, 5% and 10% level.

5.2 Estimations of the EKC hypothesis for the year 2008

The estimation results for the year 2008 are presented in Tables 5.2.1 and 5.2.2.

Table 5.2.1 presents the results for the following model specifications: Specification I is our basic model, specification II includes the environmental effects of income inequality, specification III includes the Polity IV index and specification IV uses the Freedom House index. In specification V and VI we use the two dummy variables Autocracy and Democracy.

The EKC hypothesis is confirmed for all model specifications, except for the one including the Gini coefficient. The explanatory power for the alternative model specifications remains on the same high level. Both the Polity IV and Freedom House measures of the level of political freedom are statistically significant and indicate that the environmental quality improves with the increase in the level of political freedom. It should be also noted that while the size of the per capita income effects changes substantially from the year 2006 to the year 2008, the effect of the level of political freedom remains of the fairly same size. The Autocracy measure has the same negative sign as for the 2006 sample, but becomes statistically significant for the 2008 estimations. This may be partially explained by the increased number of observations in the sample. In general, we can conclude that the modifications of the EPI methodology don't significantly influence the relationship between the studied variables, compared to the year 2006.

We have 64 observations for the Gini coefficient, which contains only one low-income country (Mozambique), 25 middle-income countries and 37 high-income countries. The Gini coefficient is again on average 10 percentage points higher for the middle-income countries: The average value for middle-income and high-income countries is 40,95, and 32,46, respectively.

It may be the exclusion of all but one poor country and the small sample for middle-income countries that drives statistically insignificant results when we estimate the inequality effects on the environmental performance (Specification II in Table 5.2.1). Since almost all observations for the low per capita income countries are excluded in our estimations, the EKC relationship cannot be supported even if it prevails. The other explanation that we might be implicitly estimating the original Kuznets curve, may also explain the poor support of the EKC specification. Similarly to the year 2006, the original Kuznets curve for the year 2008 holds.[28]

[28]Estimations of the original Kuznets curve yield:
$Gini = 13{,}54 * \log(GDP/P) - 1{,}01 * (\log(GDP/P))^2$; parameters are statistically significant at 1% level

Table 5.2.1 Estimations of the EKC hypothesis with additional variables for the year 2008

Explanatory variable	Model specification					
	I	II	III	IV	V	VI
Constant	7,51***	-0,88	7,18***	7,12***	7,90***	7,43***
	(3,48)	(-0,30)	(3,12)	(3,51)	(3,24)	(3,36)
ln GDP per capita	-1,59**	1,37	-1,51*	-1,49**	-1,76**	-1,60*
	(-2,04)	(1,35)	(-1,80)	(-2,04)	(-1,98)	(-1,96)
(ln GDP per capita)^2	0,22**	-0,12	0,22**	0,21**	0,24**	0,23**
	(2,39)	(-1,04)	(2,16)	(2,45)	(2,30)	(2,29)
(ln GDP per capita)^3	-0,01**	0,004	-0,01**	-0,01***	-0,01**	-0,01**
	(-2,57)	(0,84)	(-2,37)	(-2,71)	(-2,46)	(-2,46)
Gini coefficient	-	0,001	-	-	-	-
		(1,47)				
Polity	-	-	0,005**	-	-	-
			(2,56)			
Freedom House	-	-	-	0,02***	-	-
				(2,63)		
Autocracy	-	-	-	-	-0,04	-
					(-1,38)	
Democracy	-	-	-	-	-	0,05*
						(1,89)
R^2	0,64	0,73	0,66	0,66	0,64	0,65
Adjusted R^2	0,63	0,71	0,65	0,65	0,63	0,64
N	144	63	138	144	138	138

Values in parentheses indicate t-statistics.
***, ** and * denote that parameter estimates are statistically significant at 1, 5% and 10% level.

Table 5.2.2 presents the estimation results of testing whether the effects of income inequality and the level of political freedom differ depending on the country's level of economic development. Similarly to the year 2006, we find that the level of political freedoms has a positive and a statistically significant effect of similar magnitude in both middle- and high-income countries: this is valid for the Polity IV index, the Freedom House index, and for the Democracy measure. The same measures have a negative effect in the low-income countries, which is statistically significant only for the Polity IV measure. Increased number of observations on the Autocracy measure, compared to the year 2006, allows us to estimate the impact of the autocratic regime on the environmental performance in countries with different level of income. While this impact appears to be significant for the low- and high-income countries, these results are hard to interpret, since most of the observations on the countries with autocratic regime in our sample belong to the middle-income countries, while there are only three for the high-income countries (Oman, Saudi Arabia and United Arab Emirates) and only one for the low-income country (Eritrea). The estimations including the Gini coefficient again don't provide any significant results. Moreover, since we only have one observation of the Gini coefficient for low-income countries, the results for this country group in model specifications including income inequality may not be representative for the low-income country group and only capture country-specific effects in Mozambique.

When testing for the joint impact of income inequality and the level of political freedom on the environmental performance, we don't obtain any statistically significant results for the year 2008. Given our data sample, we couldn't identify neither income nor income inequality or political rights effects. Therefore, we don't present our estimations here.

Table 5.2.2 Testing for the low- and high-income country effects for the year 2008

Explanatory variable	Model specification				
	I	II	III	IV	V
Constant	1,65 (0,42)	9,14*** (4,31)	8,81*** (4,07)	6,75*** (3,07)	8,95*** (3,33)
ln GDP per capita	0,55 (0,41)	-2,17*** (-2,78)	-2,02*** (-2,65)	-1,34* (-1,69)	-2,08** (-2,14)
$(\ln \text{GDP per capita})^2$	-0,03 (-0,22)	0,29*** (3,09)	0,27*** (3,00)	0,19** (2,06)	0,28** (2,40)
$(\ln \text{GDP per capita})^3$	0,0005 (0,09)	-0,01*** (-3,26)	-0,01*** (-3,20)	-0,008** (-2,26)	-0,01** (-2,54)
Gini*low-income	-0,0005 (-0,48)	-	-	-	-
Gini*middle-income	0,001 (1,47)	-	-	-	-
Gini*high-income	0,001 (1,53)	-	-	-	-
Polity*low-income	-	-0,02** (-2,45)	-	-	-
Polity*middle-income	-	0,005** (2,49)	-	-	-
Polity*high-income	-	0,007*** (4,29)	-	-	-
Freedom House*low-income	-	-	-0,003 (-0,17)	-	-
Freedom House*middle-income	-	-	0,02* (2,68)	-	-
FreedomHouse*high-income	-	-	0,02** (2,51)	-	-
Autocracy*low-income	-	-	-	0,16*** (4,22)	-
Autocracy*middle-income	-	-	-	-0,02 (-0,72)	-
Autocracy*high-income	-	-	-	-0,19*** (-6,24)	-
Democracy*low-income	-	-	-	-	-0,09 (-1,31)
Democracy*middle-income	-	-	-	-	0,07** (2,38)
Democracy*high-income	-	-	-	-	0,08** (2,36)
R^2	0,73	0,68	0,66	0,66	0,67
Adjusted R^2	0,70	0,67	0,65	0,65	0,66
N	63	138	144	138	138

Values in parentheses indicate t-statistics.

***, ** and * denote that parameter estimates are statistically significant at 1, 5% and 10% level.

Conclusions

The purpose of this essay was to assess the EKC hypothesis using the Environmental Performance Indices, as well as to investigate whether income inequalities and the difference in the level of political freedoms influence the EKC shape. We performed OLS estimations on cross-section data for the 2006 and 2008 EPI indices. We found strong support for the EKC hypothesis, which means that environmental performance initially worsens but eventually improves with an increasing level of per capita income. Moreover, our estimations confirm that higher level of political freedom improves environmental performance. However, this effect comes into power only once a certain income level is reached: we find no significant impact of political freedom on the environmental performance in the countries with the lowest income levels, but only for the middle- and higher-income countries.

Our study contributes to the EKC literature by using not a separate, but a composite indicator of environmental quality, which EPI represents. In contrast to the only study deploying the EPI by Yoshioka (2010), we find strong support of the EKC hypothesis, which can be explained by a better model specification.

The absence of time-series data for the Environmental Performance Index doesn't allow us to track the changes in the environmental performance over time. However, the data available still gives us a "snapshot" picture of the relationship between the environmental performance and per capita income around the world, and allows us to investigate some aspects of the EKC that have not, to our knowledge, been previously investigated.

Our estimation results suggests that, it is only after the initial stages of economic development and strong economic progress in terms of economic growth has already taken place, that democratization can help remedy environmental problems. Only at this stage, increased political rights and liberties, which provide better means for people to influence the environmental quality, are able to mitigate the negative environmental impacts of economic growth. This contradicts Boyce and Torras (1998) findings, who conclude that political rights have a stronger effect on environmental degradation in low-income countries, but may reflect that the authors of the mentioned study included both low-income and low middle-income countries in their definition of low-income countries. Thus, our findings may be more accurate in this respect.

We also conclude that including the measure of income inequality in the EKC model may distort the results of estimations, since such a specification may implicitly estimate the original Kuznets curve, i.e. the impact of income on income inequality, and hence on the environmental degradation. These findings are in line with Heenrik et al (2001).

The future access to better data availability will allow the further study of how the EKC develops over time and how income inequality affects its shape at all levels of economic development.

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http://www.oecd.org/ - OECD statistics

Appendix A EPI framework

Table A1. EPI 2006 Framework

Overal Performance	Broad Objectives	Policy Categories	Indicators
EPI	Environmental Health	Environmental Health	Child Mortality
			Indoor air pollution
			Outdoor air pollution
			Drinking water
			Adequate sanitation
	Ecosystem Vitality	Air quality	Urban particulates
			Regional Ozone
		Water resources	Nitrogen loading
			Water Consumption
		Biodiversity & Habitat	Wilderness Protection
			Ecoregion Protection
		Productive natural resources	Timber Harvest Rate
			Agricultural subsidies
			Overfishing
		Sustainble energy	Energy efficiency
			Renewable energy
			CO_2 per GDP

Source: EPI 2006

Table A2. EPI 2008 Framework

Index	Objectives	Objective Weight (% of EPI)	Policy Categories	Policy Category Weight (% of EPI)	Subcategories	Sub-category Weight (% of EPI)	Indicators	Indicator Weight in EPI %
EPI	Environmental Health	50	Environmental Health	50	Environmental burden of disease	25	Environmental burden of disease (DALYs)	25
					Water (effects on humans)	12,5	Adequate sanitation	6,25
							Drinking water	6,25
					Air Pollution (effects on humans)	12,5	Urban particulates	5
							Indoor air pollution	5
							Local ozone	2,5
	Ecosystem Vitality	50	Air Pollution (effects on nature)	2,5	Air Pollution (effects on nature)	2,5	Regional ozone	1,25
							Sulfur dioxide emissions	1,25
			Water (effects on nature)	7,5	Water (effects on nature)	7,5	Water quality	3,75
							Water stress	3,75
			Biodiversity & Habitat	7,5	Biodiversity & Habitat	7,5	Conservation risk index	7,5
							Effective conservation	
							Critical habitat protection	
							Marine Protected Areas	
			Productive Natural Resources	7,5	Forestry	2,5	Growing stock change	2,5
					Fisheries	2,5	Marine Trophic Index	1,25
							Trawling intensity	1,25
					Agriculture	2,5	Irrigation Stress	0,5
							Agricultural Subsidies	0,5
							Intensive cropland	0,5
							Burnt Land Area	0,5
							Pesticide Regulation	0,5
			Climate Change	25	Climate Change	25	Emissions per capita	8,333
							Emissions per electricity generation	8,333
							Industrial carbon intensity	8,333

Source: EPI 2008 http://epi.yale.edu:2008/Home

Appendix B Descriptive statistics

Table B1. EPI 2006 Descriptive statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	Obs
GDP per capita	11161,81	5781,00	51449,17	271,55	12514,53	128
log(GDP per capita)	8,59	8,66	10,85	5,60	1,31	128
GINI coefficient (extended)	38,75	37,72	58,49	23,7	9,45	73
Freedom House	4,58	5,00	7,00	1,00	1,91	132
Polity IV	3,84	7,00	10,00	-10,00	9,58	127
EPI	64,45	64,60	88,00	25,70	6,38	126
Environmental Health	**63,39**	**69,20**	**99,40**	**0,00**	**29,40**	**133**
Child Mortality	73,05	91,80	99,60	0,00	32,93	133
Indoor Air Pollution	52,51	52,00	100,00	0,00	40,14	133
Drinking Water	66,32	74,70	100,00	0,00	32,02	133
Adequate Sanitation	60,94	61,10	100,00	0,00	33,84	133
Air Quality	**54,38**	**55,50**	**98,00**	**6,90**	**18,96**	**133**
Urban Particulates	64,77	71,90	96,20	0,00	24,80	133
Regional Ozone	43,98	31,60	100,00	0,00	28,13	133
Water Resources	**81,91**	**91,70**	**100,00**	**6,50**	**21,77**	**133**
Nitrogen Loading	89,69	98,60	100,00	0,00	24,14	133
Water Consumption	74,13	84,00	100,00	0,00	30,40	133
Biodiversity and Habitat	**50,70**	**50,90**	**88,10**	**5,10**	**18,95**	**133**
Wilderness Protection	19,71	14,40	72,50	0,00	17,71	133
Ecoregion Protection	62,85	69,90	100,00	0,00	31,45	133
Productive Resource Management	**74,08**	**77,30**	**100,00**	**33,30**	**19,08**	**133**
Timber Harvest Rate	89,84	100,00	100,00	0,00	25,62	133
Agricultural Subsidies	82,92	100,00	100,00	0,00	32,64	133
Overfishing	37,75	33,30	83,30	0,00	22,11	102
Sustainable Energy	**66,52**	**74,80**	**92,40**	**0,00**	**22,77**	**133**
Energy Efficiency	72,51	80,20	100,00	0,00	27,09	133
Renewable Energy	16,81	9,20	100,00	0,00	20,98	133
C02 per GDP	71,96	82,50	98,10	0,00	26,09	133

Table B2. EPI 2008 Descriptive statistics

	Mean	Median	Max	Min	Std. Dev.	Obs
GDP per capita	11975,51	6951,24	73126,70	289,94	13287,00	144
log(GDP per capita)	8,70	8,85	11,20	5,67	1,29	144
GINI coefficient (extended)	36,04	34,21	54,46	23,40	8,74	63
Freedom House	4,63	4,75	7,00	1,00	1,90	148
Polity IV	4,04	7,00	10,00	-10,00	6,30	143
EPI	**71,87**	**74,10**	**95,51**	**39,05**	**12,74**	**149**
1. Environmental Health	**74,56**	**84,51**	**99,38**	**6,02**	**24,78**	**149**
Environmental Health	**74,56**	**84,51**	**99,38**	**6,02**	**24,78**	**149**
1.1 Environmental burden of disease (DALYs)	***79,86***	***92,79***	***99,82***	***0,00***	***27,24***	***149***
1.1.1 Environmental burden of disease (DALYs)	79,86	92,79	99,82	0,00	27,24	149
1.2 Water (effects on humans)	***67,96***	***75,72***	***100,00***	***0,00***	***29,95***	***149***
1.2.1 Adequate sanitation	64,76	73,10	100,00	0,00	32,32	149
1.2.2 Drinking water	71,16	83,02	100,00	0,00	30,25	149
1.3 Air Pollution (effects on humans)	***70,58***	***72,49***	***97,89***	***15,99***	***23,23***	***149***
1.3.1 Urban particulates	73,25	83,76	100,00	0,00	28,23	149
1.3.2 Indoor air pollution	57,31	68,42	100,00	0,00	37,95	149
1.3.3 Local ozone	91,76	99,78	100,00	0,00	21,62	149
2. Ecosystem Vitality	**69,18**	**71,30**	**92,81**	**37,09**	**10,76**	**149**
Air Pollution (effects on nature)	**90,72**	**96,14**	**99,97**	**43,99**	**13,36**	**149**
2.1 Air Pollution (effects on nature)	***90,72***	***96,14***	***99,97***	***43,99***	***13,36***	***149***
2.1.1 Regional ozone	90,26	99,86	100,00	0,00	22,87	149
2.1.2 Sulfur dioxide emissions	91,18	96,73	99,94	0,00	16,64	149
2.2 Water (effects on nature)	**66,58**	**67,64**	**98,98**	**0,00**	**18,49**	**149**
2.2.1 Water quality	48,86	49,55	99,02	0,00	26,14	149
2.2.2 Water stress	84,29	93,80	100,00	0,00	20,43	149
Biodiversity & Habitat	**46,36**	**46,48**	**100,00**	**0,23**	**27,56**	**149**
2.3. Biodiversity & Habitat	***46,36***	***46,48***	***100,00***	***0,23***	***27,56***	***149***
2.3.1 Conservation risk index	63,15	72,65	100,00	0,00	34,16	149
2.3.2 Effective conservation	45,77	42,11	100,00	0,00	34,51	149
2.3.3 Critical habitat protection	45,73	45,65	100,00	0,00	32,00	65
2.3.4 Marine Protected Areas	33,80	9,00	100,00	0,00	42,45	149
Productive Natural Resources	**79,82**	**82,29**	**98,97**	**44,39**	**10,86**	**149**
2.4. Forestry	***88,24***	***100,00***	***100,00***	***0,00***	***20,83***	***148***
2.4.1 Growing stock change	88,24	100,00	100,00	0,00	20,83	148
2.5 Fisheries	***70,29***	***77,23***	***99,53***	***0,00***	***22,61***	***113***
2.5.1 Marine Trophic Index	84,33	98,46	100,00	0,00	23,71	99
2.5.2 Trawling intensity	59,87	72,31	99,06	0,00	31,93	113
2.6 Agriculture	***77,72***	***77,98***	***99,14***	***46,49***	***10,55***	***140***
2.6.1 Irrigation Stress	88,56	99,88	100,00	0,00	21,01	142
2.6.2 Agricultural Subsidies	79,14	100,00	100,00	0,00	33,37	149
2.6.3 Intensive cropland	79,20	90,18	100,00	0,00	26,35	145
2.6.4 Burnt Land Area	82,85	93,03	99,98	0,00	23,15	143
2.6.5 Pesticide Regulation	59,95	77,27	100,00	0,00	38,93	149
Climate Change	**71,46**	**72,90**	**99,78**	**16,14**	**15,89**	**149**
2.7 Climate Change	***71,46***	***72,90***	***99,78***	***16,14***	***15,89***	***149***
2.7.1 GHG Emissions per capita	83,34	89,44	100,00	0,00	20,83	149
2.7.2 Emissions per electricity generation	52,25	50,52	100,00	0,00	27,48	149
2.7.3 Industrial carbon intensity	78,79	84,96	100,00	0,00	23,42	149

Appendix C Groups of countries according to their per capita income

Table C1 Groups of countries according to their per capita income for the year 2006

Low-income	Middle-income		High-income
Burundi	Albania	Laos	Australia
Central African Republic	Algeria	Lebanon	Austria
Dem. Rep. Congo	Angola	Mali	Belgium
Ethiopia	Argentina	Mauritania	Canada
Guinea	Armenia	Moldova	Chile
Guinea-Bissau	Azerbaijan	Mongolia	Cyprus
Madagascar	Bangladesh	Morocco	Czech Rep.
Malawi	Benin	Namibia	Denmark
Mozambique	Bolivia	Nicaragua	Finland
Nepal	Brazil	Nigeria	France
Niger	Bulgaria	Pakistan	Gabon
Rwanda	Burkina Faso	Panama	Germany
Sierra Leone	Cambodia	Papua New Guinea	Greece
Togo	Cameroon	Paraguay	Hungary
Uganda	Chad	Peru	Iceland
	China	Philippines	Ireland
	Colombia	Romania	Israel
	Congo	Senegal	Italy
	Costa Rica	South Africa	Japan
	Côte d'Ivoire	Sri Lanka	Malaysia
	Dominican Rep.	Sudan	Mexico
	Ecuador	Suriname	Netherlands
	Egypt	Swaziland	New Zealand
	El Salvador	Syria	Norway
	Gambia	Tajikistan	Oman
	Georgia	Tanzania	Poland
	Ghana	Thailand	Portugal
	Guatemala	Tunisia	Russia
	Haiti	Turkey	Saudi Arabia
	Honduras	Turkmenistan	Slovakia
	India	Ukraine	Slovenia
	Indonesia	Uzbekistan	South Korea
	Iran	Venezuela	Spain
	Jamaica	Viet Nam	Sweden
	Jordan	Yemen	Switzerland
	Kazakhstan	Zambia	Trinidad & Tobago
	Kenya		United Arab Emirates
	Kyrgyzstan		United Kingdom
			United States

Table C1 Groups of countries according to their per capita income for the year 2008

Low-income	Middle-income		High-income
Burundi	Albania	Laos	Argentina
Central African Republic	Algeria	Lebanon	Australia
Dem. Rep. Congo	Angola	Macedonia	Austria
Eritrea	Armenia	Mali	Belgium
Ethiopia	Azerbaijan	Mauritania	Botswana
Guinea	Bangladesh	Mauritius	Canada
Guinea-Bissau	Belarus	Moldova	Chile
Madagascar	Belize	Mongolia	Croatia
Malawi	Benin	Morocco	Cyprus
Mozambique	Bolivia	Namibia	Czech Rep.
Niger	Bosnia and Herzegovina	Nepal	Denmark
Sierra Leone	Brazil	Nicaragua	Estonia
Togo	Bulgaria	Nigeria	Finland
	Burkina Faso	Pakistan	France
	Cambodia	Panama	Gabon
	Cameroon	Papua New Guinea	Germany
	Chad	Paraguay	Greece
	China	Peru	Hungary
	Colombia	Philippines	Iceland
	Congo	Romania	Ireland
	Costa Rica	Rwanda	Israel
	Côte d'Ivoire	Senegal	Italy
	Djibouti	Solomon Islands	Japan
	Dominican Rep.	South Africa	Latvia
	Ecuador	Sri Lanka	Lithuania
	Egypt	Sudan	Luxembourg
	El Salvador	Swaziland	Malaysia
	Fiji	Syria	Mexico
	Georgia	Tajikistan	Netherlands
	Ghana	Tanzania	New Zealand
	Guatemala	Thailand	Norway
	Guyana	Tunisia	Oman
	Haiti	Turkey	Poland
	Honduras	Turkmenistan	Portugal
	India	Uganda	Russia
	Indonesia	Ukraine	Saudi Arabia
	Iran	Uruguay	Slovakia
	Iraq	Uzbekistan	Slovenia
	Jamaica	Venezuela	South Korea
	Jordan	Viet Nam	Spain
	Kazakhstan	Yemen	Sweden
	Kenya	Zambia	Switzerland
	Kyrgyzstan		Trinidad & Tobago
			United Arab Emirates
			United Kingdom
			United States

Appendix D Countries with the Gini coefficient available

Table D2. Year 2006

Low-income	Middle-income		High-income	
Burundi	Albania	Kazakhstan	Austria	Malaysia
Dem. Rep. Congo	Argentina	Kyrgyzstan	Belgium	Mexico
Guinea	Armenia	Laos	Chile	Netherlands
Mozambique	Azerbaijan	Mali	Cyprus	Norway
Niger	Bolivia	Moldova	Czech Rep.	Poland
Rwanda	Brazil	Mongolia	Denmark	Portugal
Togo	Bulgaria	Morocco	Finland	Russia
Uganda	Cambodia	Pakistan	France	Slovakia
	Colombia	Panama	Germany	Slovenia
	Costa Rica	Paraguay	Greece	Spain
	Côte d'Ivoire	Peru	Hungary	Sweden
	Dominican Rep.	Philippines	Ireland	United Kingdom
	Ecuador	Romania	Italy	
	El Salvador	Sri Lanka		
	Georgia	Tanzania		
	Ghana	Thailand		
	Guatemala	Turkey		
	Honduras	Ukraine		
	Indonesia	Venezuela		
	Jordan	Viet Nam		

Table D2. Year 2008

Low-income	Middle-income		High-income	
Mozambique	Albania	Laos	Argentina	Latvia
	Armenia	Macedonia	Australia	Lithuania
	Azerbaijan	Moldova	Austria	Luxembourg
	Belarus	Mongolia	Belgium	Malaysia
	Brazil	Panama	Chile	Mexico
	Bulgaria	Paraguay	Croatia	Netherlands
	Costa Rica	Peru	Cyprus	New Zealand
	Côte d'Ivoire	Romania	Czech Rep.	Norway
	Ecuador	Thailand	Denmark	Poland
	Georgia	Turkey	Estonia	Portugal
	Indonesia	Uganda	Finland	Russia
		Ukraine	France	Slovakia
		Uruguay	Germany	Slovenia
		Viet Nam	Greece	South Korea
			Hungary	Spain
			Iceland	Sweden
			Ireland	United States
			Israel	United Kingdom
			Italy	