Economic, Demographic and Political Determinants of Pollution Reassessed: A Sensitivity Analysis

Martin Gassebner[*], Michael Lamla[†]and Jan-Egbert Sturm[‡]

October 2004

Preliminary version; do not quote without permission

Abstract

Recent literature proposes many variables as significant determinants of pollution. This paper asks whether their estimated impact on both water and air pollution is robust to alterations of the conditioning information set. For that purpose, we apply so-called Extreme Bound Analysis (EBA) on a panel of 208 countries covering the period 1960–2001. Within our set of 21 explanatory variables, we in particularly focus upon the effect of economic and political freedom on pollution, demographic issues and the reassessment of the environmental Kuznets curve hypothesis.

We find supportive evidence on the existence of the environmental Kuznets curve. Furthermore, demographic variables and variables capture the economic structure of a country contribute in explaining air and water pollution. However, there does not appear to be a robust relationship between politico-institutional factors and environmental quality.

JEL classification: C52; F18; J18; O13; Q53

Keywords: pollution; sensitivity analysis; environmental Kuznets curve

1 Introduction

Facing a rapidly growing population and an ongoing industrialization over the last decades, pollution reduction started to play a steadily increasing role in the world economy. Hence, many authors joined the search for determinants of environmental degradation. In earlier studies researchers named production and production-specific variables in a high amount accountable for pollution. Among this type of variables per capita GDP is in the center of focus. Most authors today believe that its relationship to pollution is non-linear, in the sense that from a certain level of development onwards a higher degree of industrialization starts having a positive

---

[*] Department of Economics, University of Konstanz; `martin.gassebner@uni-konstanz.de`

[†] Department of Economics, University of Konstanz; `michael.lamla@uni-konstanz.de`

[‡] TWI – Thurgau Institute of Economics, Switzerland, Department of Economics, University of Konstanz and CESifo, Germany; `jan-egbert.sturm@uni-konstanz.de`

effect on the environment. Grossman and Krueger (1995) and Selden and Song (1994) were amongst the first to examine this particular relationship, which the latter labeled the *Environmental Kuznets Curve* (EKC).

Another line of literature discusses the impact of globalization on pollution. On the one hand, intensive trade patterns accelerate efficient allocations which in turn might lead to lower levels of pollution (see, e.g. Cole (2004)). On the other hand, the so-called *Pollution Haven Hypothesis* states that globalization causes dirty industrial sectors to be located in countries with low environmental standards (see, e.g. Birdsall and Wheeler (1993)).

Lately, political indicators are introduced into the discussion; the constitutional set-up of a country may explain different pollution levels. Especially economic and political freedom are used to indicate the conceptual differences between countries and the possible resulting effects (see, e.g. Neumayer (2003) and Carlsson and Lundström (2003)).

Authors like Klick (2004) also indicate that demographic factors induce different patterns in pollution levels.

The empirical literature on the determinants of pollution suffers from some drawbacks. First, a wide variety of variables has been suggested as determinants of environmental contamination and there is little consensus in the literature which variables really matter. Second, most authors do not carefully examine the sensitivity of their findings. Thus, it is hard to tell whether the variables reported to be significant in a particular regression are really robustly related to pollution. Third, the majority of papers only study a rather selective number of variables concentrating on mostly one particular hypothesis; no systematic analysis of the different hypotheses mentioned in the literature are offered. Hence, possible interdependencies with other variables and potential omitted variable biases are generally neglected. A final drawback of some studies is the limited data sample. Often estimations are done for only one country over several years, or for only one year over a cross section of countries.

The aim of this paper is to analyze to what extent various demographic, economic and political variables that have been suggested in the literature as affecting the level of pollution in a country are robust determinants of water and air emission. For this purpose, we estimate a panel model for 208 countries over the period 1960–2001 and use so-called Extreme Bounds Analysis (EBA) to examine to what extent variables are robust determinants of pollution in a particular year. To the best of our knowledge, this approach to check for the robustness of a relationship has not been used in this line of literature, although is has been widely employed in the economic growth literature (Levine and Renelt (1992), Sala-i-Martin (1997) and Sturm and de Haan (2004)). As pointed out by Temple (2000), presenting only the results of the model preferred by the author(s) of a particular paper can be misleading. Extreme Bounds Analysis is a fairly neutral means to check robustness and compare the validity of conflicting findings in empirical research.

This paper uses Biochemical Oxygen Demand (BOD)[1] and carbon dioxide (CO_2) exhaustion as measures of pollution. Both are widely accepted environmental proxies which have been well documented over longer periods of time for most countries in the world.

The reminder of this paper is structured as follows. Section 2 reviews the relevant literature and introduces the variables of our focus. The data are described in section 3. Section 4 introduces the methodological approach applied. The results are reported and interpreted in the section 5. The final section summarizes the conclusions.

2 Literature Overview

Table 7 in Appendix A summarizes those studies that have been published since the beginning of the 1990s dealing with the determinants of pollution. As we will point out below, previous studies have used a wide array of explanatory variables. Furthermore, the results for particular variables are rather mixed. On the basis of previous studies we have selected 21 variables for further empirical analysis.

From a theoretical point of view, the *Environmental Kuznets Curve* (EKC) is the most accredited hypothesis. Instead of an inverted U-shaped relationship between income inequality and per capita income – as suggested by Kuznets (1955) – the EKC presumes such a relationship between emissions and per capita income. Studies like Shafik (1994), Selden and Song (1994) and Grossman and Krueger (1995) report empirical evidence in favor of the EKC.[2] However, results presented by e.g. Arrow et al. (1995) point out that this finding is not necessarily robust.[3] We use various transformations of GDP per capita (in particular $LGDPPC$, $LGDPPC^2$) to test the EKC theory.

According to, e.g. Cole (2004) trade may reduce pollution emission due to greater competitive pressure or "greater access to 'greener' production technologies" (p. 79). For that reason we introduce the variable $TRADE$, representing trade intensity, in our analysis. Often the effect of trade is dis-aggregated into three components: a scale effect, a technique effect, and a composition effect.

The scale effect refers to the fact that trade enlarges the sales markets which presumably increases production which in turn increases pollution. The technique effect relates to the trade induced changes of the production technology. The composition effect stems from changes in production of an economy caused by specialization. Due to the different nature of these individual effects, the overall impact

---

[1] "BOD is a measure of how much dissolved oxygen is being consumed as microbes break down organic matter. A high demand, therefore, can indicate that levels of dissolved oxygen are falling, with potentially dangerous implications for the rivers biodiversity." (Definition by the European Environment Agency, `http://themes.eea.eu.int/Specific_media/water/indicators/bod/index_html`)

[2] For a review of empirical studies dealing with the EKC, we refer to Sahu (2002).

[3] Some authors propose an inverted N-shaped or even a N-shaped relationship. See for instance Holtz-Eakin and Selden (1995), Cole et al. (1997) or Moomaw and Unruh (1997). However, often the additional turning-point is out-of-sample.

of trade on the environment is ambiguous.[4]

In a similar vein, international capital transactions might also affect national pollution levels. Following Antweiler et al. (2001) we therefore include inward foreign direct investment (*FDIGDP*) in our analysis.

Another important concept is the *Pollution Haven Hypothesis* (PHH). The PHH claims that countries with a comparative advantage in 'dirty' production will specialize in pollution-intensive sectors. This concentration will be induced by outsourcing tendencies of these sectors in countries with stricter environmental regulations. Therefore, trade will increase between nations with different comparative advantages (Birdsall and Wheeler (1993), Mani and Wheeler (1998)). Overall the PHH is hard to verify. For instance, Jaffe et al. (1995) and Cole (2004) found no evidence for the existence of the PHH. As it is almost impossible to examine the PHH by including a single variable – as needed in our methodological set-up – we will not concentrate on this theory at this stage, but leave this for future research. Nevertheless, when discussing our trade variable one has to bear this theory in mind.

Real GDP growth (*GDPGR*) is included to control for business cycle fluctuations. It is originally proposed by Carlsson and Lundström (2003). The same authors also introduce the index of economic freedom (*ECFREE*) and the Political Freedom Index (*POLFREE*) in this line of literature. They claim that economic freedom leads to a more efficient allocation of resources and therefore to a lower level of emission. The intuitive reasoning behind *POLFREE* is that people can express their preferences for higher environmental standards better through a more democratic political system. Other politically motivated variables included in our analysis are a dummy variable measuring whether or not the party of the chief executive has a left-wing orientation (*LEFT*), the number of years the chief executive has been in office (*YRSOFFC*), a dictatorship dummy (*DICT*) and military expenditure as share of GDP (*MILEXPGDP*). The first is adapted from Neumayer (2003) who suggests a higher degree of sympathy toward environmental protection by left-wing governments. The second is suggested by Klick (2004), who argues that the longer a government is in power the less willing it is to enhance pollution controls. Furthermore, he claims that a dictator might take care of the environment to verify his leading position. In a similar vein, he introduces military expenditure to control for the regime type.

To check for the influence of the size of the economy many authors introduce a population measure in their models. Following e.g. Borghesi (2000) and Klick (2004), we opt for including population density (*LPOPDENS*). Besides population density other demographic factors might also play an important role (see, e.g. Antweiler et al. (2001) and Torras and Boyce (1998)). As a second demographic variable, we use the share of urban population in total population (*URBAN*).

Torras and Boyce (1998) argue that the distance to the coastline might be related

---

[4] For greater detail, see Grossman and Krueger (1991), Antweiler et al. (2001), Cole and Elliott (2003) and Cole (2004).

to in particular water pollution. On the one hand, the incentive to keep domestic water clean with an ocean or sea with its public good character nearby might be limited. On the other hand, water pollution from other countries without coastal area will eventually have to pass these regions. Therefore, we insert a variable measuring the percentage of land within 100 km of the sea or a navigable river with ocean access ($COAST$).

Neumayer (2003) points out that, given that the industry sector is usually regarded as more pollutive than at least services, the industry share might help explain the level of pollution.[5] We introduce such an industrialization measure both in terms of output ($INDSHGDP$) as well as in terms of labour input ($INDSHEMP$) in our analysis.

Besides the degree of the industrialization, the composition of a country's energy sector might play an important role. To check if it matters how energy is produced we include the share of electricity production from oil sources in total electricity production ($OILENERGY$), slightly adapting Neumayer (2003).[6]

Following Neumayer (2003) we also include $ENERGYGDP$ which stands for the amount of commercial energy used to produce one dollar of output. This intends to proxy for the level of efficiency in the production process. The more efficient an economy is, the less polluted it should be.

As a final economic structure variable, we take the use of fertilizer ($LFERT$) up in our list of potential explanatory variables. Cole and Elliott (2003) suggest that higher fertilizer consumption might increase the level of water pollution. We interpret this variable more in general as measuring the intensity of environmental pollution of the agricultural sector.

Pollution might also be related to the level of education in a country. This argument is brought forward by Klick (2004) and leads us to insert a measure of primary education ($PRIMEDU$) and the illiteracy rate among adults ($ILLIT$). It is hypothesized that the higher the level of education is, the higher will be the demand for a clean environment.

We focus upon two measures of pollution. For water pollution we take Biochemical Oxygen Demand (BOD), which is generally seen as endangering biodiversity under water. Air pollution is measured by CO_2 emissions. Both measures – scaled by the size of the population – are widely accepted by academic literature to capture the environmental standard in an economy.

3 Data

Our main data source is the World Development Indicators (WDI 2003) database. Series used cover up to 208 countries over the period 1960–2001. Indicators for economic and political freedom are retrieved from, respectively Gwartney et al.

---

[5] See also Torras and Boyce (1998), Borghesi (2000) and Carlsson and Lundström (2003).

[6] Obviously oil is not the only energy source used in electricity production. However, data limitations force us to restrict our attention to oil.

(2003) and Freedom House (1999). The variable *COAST* is taken from Gallup et al. (1999). Before taken logarithms, real GDP and our two dependent variables, i.e. CO_2 and *BOD*, are transformed into per capita terms. Logarithms are also taken for population density and fertilizer use. *POLFREE* is computed out of the equally weighted sum of the two Freedom House Indices, i.e. civil liberaties and political rights. The variable *DICT* is calculated out of the Executive Indices of Electoral Competitiveness (EIEC) included in the Database of Political Institutions as collected and described by Beck et al. (1999).

For a complete overview concerning source and specification of the variables we refer to Table 8 in Appendix B.

4 Model

We employ (variants) of the so-called Extreme Bounds Analysis (EBA) as suggested by Leamer (1983) and Levine and Renelt (1992) to examine which explanatory variables are robustly related to our dependent variables. To the best of our knowledge, this has never been done in this line of literature before, although there are some very good reasons to apply this methodology.

The EBA has been widely used in the economic growth literature. The central difficulty in this research – which also applies to the research topic of the present paper – is that several different models may all seem reasonable given the data, but yield different conclusions about the parameters of interest. Indeed, a glance at the studies summarized in Table 7 of Appendix A illustrates this point. The results of these studies sometimes differ substantially, while most authors do not offer a careful sensitivity analysis to examine how robust their conclusions are. As pointed out by Temple (2000), presenting only the results of the model preferred by the author can be misleading.

The EBA can be exemplified as follows. Equations of the following general form are estimated:

$$Y = \alpha M + \beta F + \gamma Z + u \tag{1}$$

where Y is the dependent variable; M is a vector of 'standard' explanatory variables; F is the variable of interest; Z is a vector of up to three possible additional explanatory variables (following Levine and Renelt (1992)), which according to the literature may be related to the dependent variable; and u is an error term. The extreme bounds test for variable F says that if the lower extreme bound for β – i.e. the lowest value for β minus two standard deviations – is negative, while the upper extreme bound for β – i.e. the highest value for β plus two standard deviations – is positive, the variable F is not robustly related to Y.

As argued by Temple (2000), it is rare in empirical research that we can say with certainty that some model dominates all other possibilities in all dimensions. In these circumstances, it makes sense to provide information about how sensitive the findings are to alternative modeling choices. Extreme bounds analysis provides a relatively simple means of doing exactly this. Still, the EBA has been criticized in the literature.

Sala-i-Martin (1997) rightly argues that the test applied in the extreme bounds analysis is too strong for any variable to really pass it. If the distribution of the parameter of interest has some positive and some negative support, then one is bound to find one regression for which the estimated coefficient changes sign if enough regressions are run. We will therefore not only report the extreme bounds, but also the percentage of the regressions in which the coefficient of the variable F is significantly different from zero at the 5%-level. Moreover, instead of analyzing just the extreme bounds of the estimates of the coefficient of a particular variable, we follow Sala-i-Martin's (1997) suggestion to analyze the entire distribution. We also report the unweighted parameter estimate of β and its standard deviation, as well as the unweighted cumulative distribution function (CDF(0)) test. The latter is based on the fraction of the cumulative distribution function lying on each side of zero. CDF(0) indicates the larger of the areas under the density function either above or below zero; in other words, regardless of whether this is CDF(0) or 1-CDF(0). So CDF(0) will always be a number between 0.5 and 1.0. However, in contrast to Sala-i-Martin, we use the unweighted instead of the weighted CDF(0).[7]

Another objection to EBA is that the initial partition of variables in the M and in the Z vector is likely to be rather arbitrary. Still, as pointed out by Temple (2000), there is no reason why standard model selection procedures (such as testing down from a general specification) cannot be used in advance to identify variables that seem to be particularly relevant. This is indeed what we have done. We started with 21 explanatory variables, which are all listed in Table 8 in Appendix B.

5 Results

As it is rather generally accepted that there exists a strong relationship between GDP and pollution, we first address the functional form of the EKC. Hence, we run panel regressions to check whether the relationship is linear, quadratic (U-shape relationship) or of an even higher order (inverted N-shape relationship). Our results clearly suggest the need of a quadratic term when describing the relationship between GDP and both water and air pollution. Hence, we are able to confirm an inverted U-shaped respectively an inverted N-shaped relationship. In the remaining, we leave out the cubic term due to a better fit to the data when using the squared specification.

After this initial step, we proceed by introducing the industry share of GDP

---

[7] Sala-i-Martin (1997) proposes using the (integrated) likelihood to construct a weighted CDF(0). However, the varying number of observations in the regressions due to missing observations in some of the variables poses a problem. Sturm and de Haan (2002) show that as a result this goodness of fit measure may not be a good indicator of the probability that a model is the true model and the weights constructed in this way are not equivariant for linear transformations in the dependent variable. Hence, changing scales will result in rather different outcomes and conclusions. We therefore restrict our attention to the unweighted version.

Table 1: Hausman and F-tests

Test, dependent variable	*BOD*	CO_2
Hausman (χ^2)	5.41	4.85
(fixed vs. random)	(0.25)	(0.30)
F-test	61.75	109.84
(random vs. constant)	(0.00)	(0.00)

Note: p-values are within parentheses.

Table 2: Extreme Bounds Analysis for the baseline model – *BOD*

Variable	**Lower Bound**	**Upper Bound**	**%Sign.**	**Unwght. CDF(0)**	**Unwght.** β	**Standard Error**
LGDPPC	−0.708	4.850	99.04	1.00	2.622	0.326
LGDPPC^2	−0.265	0.067	98.68	1.00	−0.130	0.020
INDSHGDP	0.001	0.067	100.00	1.00	0.019	0.003
ENERGYGDP	−0.188	1.376	97.24	1.00	0.487	0.071

Note: %Sign. refers to the percentage of regressions in which the respective variable is significant at a 5% significance level. The results are based on 833 regressions.

(*INDSHGDP*) and energy use per unit of production (*ENERGYGDP*). These variables have been selected using both a general-to-specific approach and because both forms of pollutions appear to be affected by these variables. Together with the two GDP variables capturing the EKC, these variables form our baseline model, i.e. the F variables mentioned in equation (1).

Throughout we conduct specification tests to decide whether or not, and if yes, how to correct for country-specific effects. Table 1 shows that for this baseline model a random effects model has to be preferred on statistical grounds. In general, this conclusions also holds for the other models we have estimated and present in this paper.

Tables 2 and 3 apply EBA to this baseline model, i.e. all combinations of up to three variables out of the remaining 17 variables are added to this model to check its robustness with respect to model specification. Evaluating 833 combinations for each of the two dependent variables shows that these baseline models work extremely well. All four variables are highly significant according to the CDF(0) criterion of Sala-i-Martin (1997) in both tables. *INSHGDP* and *ENERGYGDP* even pass the extreme EBA version of Levine and Renelt (1992) in, respectively the BOD and the CO_2 model.

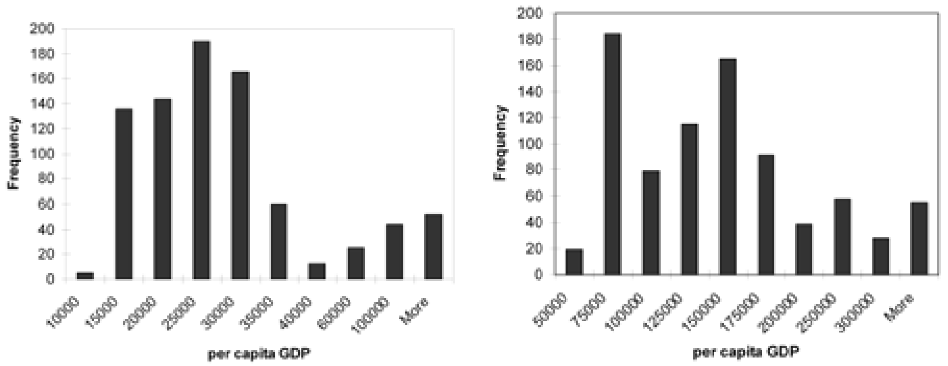
The EBA results for the baseline model further strengthen the hypothesis of the existence of an EKC. The negative coefficient of squared GDP per capita implies that there indeed exists an inverted U-shape relationship between per capita GDP and both pollution variables. All in all, we conclude that this relationship is robust to changes in model specifications.

Table 3: Extreme Bounds Analysis for the baseline model – CO_2

Variable	**Lower Bound**	**Upper Bound**	**%Sign.**	**Unwght. CDF(0)**	**Unwght. β**	**Standard Error**
LGDPPC	0.899	5.475	100.00	1.00	2.887	0.237
LGDPPC^2	−0.269	0.003	99.88	1.00	−0.124	0.015
INDSHGDP	−0.021	0.023	82.11	0.97	0.008	0.002
ENERGYGDP	0.304	1.507	100.00	1.00	0.607	0.051

Note: %Sign. refers to the percentage of regressions in which the respective variable is significant at a 5% significance level. Results are based on 833 Regressions.

Figure 1: Histogram of turning points



BOD

CO_2

It is interesting to see from which point onwards the relationship between GDP per capita and our two measures of pollution changes sign. Hence, we calculate the turning points of the EKC by taking the coefficients of the 833 regressions of both baseline models. Figure 1 show the implied histograms of these turning points; Table 4 reports some descriptive statistics. To control for outliers we cut off 2.5% at the upper and lower ends when calculating the descriptive statistics. Our results are in line with Cole (2004) who finds the turning points for *BOD* to be in-sample (in our case around 32,000 1995 US dollar per capita) while the CO_2 turning points are out-of-sample (136,000 1995 US dollar per capita). It seems that, since water pollution has somewhat less of an international public good character and becomes more apparent much sooner than air pollution, actions against water pollution are taken at an earlier state of development.

When looking at the signs of the other two variables in our extended basic model no surprises arise. *INDSHGDP* is positively correlated with both pollution proxies, i.e. the higher the manufacturing value added in an economy the higher is the pollution level of both air and water. The positive sign of *ENERGYGDP* is as expected and shows that a production technique that is energy inefficient leads to more pollution.

In the next step, each of the remaining 17 variables is included in the baseline

Table 4: Descriptive statistics of the turning points

	CO_2	BOD
Sample Mean	32,245	136,541
Standard Error of Sample Mean	1,256	2,486
Median	23,266	128,837
Sample Standard Error	35,343	69,929
Kurtosis	19.33	1.78
Skewness	4.18	1.28
Jarque-Bera	14,447	319

Note: The lower and upper 2.5% of the observed turning points are not included, which leaves 791 out of 833 observations.

model one at a time to take the function of the F variable in equation (1). The other 16 variables are used in 696 combinations to check the robustness of the coefficient estimates of the F variable. The results are presented in Tables 5 and 6.

Besides the four variables in the baseline model, these tables show that two additional variable appear to be related to both water and air pollution: industry share measured by employment (*INDSHEMP*) and fertilizer usage (*LFERT*). Both come somewhat as a surprise for different reasons. The first, because industry share measured by production (*INSHGDP*) is already included in the baseline model. From theory both variables appear to measure something rather similar. These results combined with their low correlation reported in Table 10 of Appendix B reveals that in practice this is not the case. As projected fertilizer usage (*LFERT*) increases the level of water pollution. However, we did not expect it to be this robustly related to air pollution as well. One can interpret this result as such that the use of fertilizer proxies a general attitude toward environmental protection in a society.

Other similarities between water and air pollution are that many variables like economic growth (*GDPGR*) and the illiteracy rate (*ILLIT*) feature no robust relationship with respect to the dependent variables.

In recent literature special attention is given to politico-institutional variables like political and economic freedom. Our results show that especially economic freedom (*ECFREE*) has no robust impact on either air pollution or water pollution. In the case of political freedom (*POLFREE*), we have to note that in slightly over 40% of our regressions we do find a significant negative relationship with air pollution, implying that countries with less political freedom (i.e. a higher value of *POLFREE*) have *lower* levels of CO_2 emission per capita. Given an estimated CDF(0) of only 0.82, we do not judge this relationship to be really robust to specification changes.

Also not robust and with a perhaps surprising sign is our left-wing dummy (*LEFT*). Interpreting the estimated cumulative distribution function suggests that it is rather positively related to both pollution measures. This would imply that left-wing government rule in countries characterized by lower levels of environmen-

Table 5: Extreme Bounds Analysis for the remaining variables – *BOD*

Variable	**Lower Bound**	**Upper Bound**	**%Sign.**	**Unwght. CDF(0)**	**Unwght.** β	**Standard Error**
INDSHEMP	−0.012	0.052	98.99	1.00	0.019	0.003
COAST	−0.002	0.023	96.26	1.00	0.007	0.002
LFERT	−0.206	0.236	72.13	0.95	0.055	0.025
LEFT	−0.191	0.334	38.94	0.87	0.042	0.030
MILEXPGDP	−0.078	0.123	20.32	0.87	0.014	0.011
ECFREE	−0.254	0.173	12.55	0.83	0.032	0.030
FDIGDP	−0.046	0.044	7.18	0.80	0.004	0.005
GDPGR	−0.055	0.006	18.25	0.77	−0.003	0.002
OILENERGY	−0.011	0.004	12.07	0.77	0.001	0.001
URBAN	−0.028	0.011	2.88	0.75	−0.002	0.003
YRSOFFC	−0.015	0.022	41.24	0.74	0.002	0.002
PRIMEDU	−0.008	0.024	20.29	0.67	0.002	0.001
POLFREE	−0.128	0.069	6.32	0.59	0.002	0.012
ILLIT	−0.046	0.021	34.82	0.59	0.001	0.003
DICT	−0.610	0.153	2.16	0.55	−0.016	0.043
LPOPDENS	−0.506	0.384	18.39	0.54	−0.012	0.060
TRADE	−0.006	0.004	1.01	0.51	−0.000	0.001

Note: %Sign. refers to the percentage of regressions in which the respective variable is significant at a 5% significance level. Results based on 696 regressions.

tal quality. In a similar vein dictatorships (*DICT*), if anything, are negatively correlated with air pollution. The remaining politico-institutional variables, i.e. the duration of the executive being in office (*YRSOFFC*) and military expenditure share (*MILEXPGDP*) do not seem to affect either pollution variable.

Interesting are the striking differences between the two pollution variables. International trade (*TRADE*) is almost never significantly related to water pollution, whereas it is significant in close to 92% of the regressions describing air pollution and has a CDF(0) close to 1. Its highly significant and positive relationship with air pollution seems to reject the hypothesis made by, e.g. Cole (2004) that increased international competition and easier access to 'greener' technologies would reduce pollution levels. Distinghuishing between the scale, technique and composition effects of globalization leads us to conclude that the technique effect – which basically refer to the increased availability of 'greener' technologies – is not dominant. Our result with respect to *TRADE* might also be interpreted as indirect evidence in favour of the Pollution Haven Hypothesis. International trade based upon comparitive advantages would – according to this theory – indeed increases the worldwide level of pollution. [8] This, however, does not explain as of why we are not able to report similar effects when looking at water pollution. Like *TRADE*, the positive relationship of foreign direct investment (*FDIGDP*) appears to be more significant when it comes to air as compared to water pollution. Its results, however, are clearly less robust.

---

[8] Some individual (especially developed) countries should see some improvement due to trade. However, this would not outweigh the increased pollution levels in the remaining countries.

Table 6: Extreme Bounds Analysis for the remaining variables – CO_2

Variable	**Lower Bound**	**Upper Bound**	**%Sign.**	**Unwght. CDF(0)**	**Unwght.** β	**Standard Error**
INDSHEMP	−0.015	0.038	88.79	0.99	0.009	0.003
TRADE	−0.002	0.005	91.95	0.99	0.002	0.001
LFERT	−0.053	0.215	80.32	0.98	0.060	0.017
LPOPDENS	−0.147	0.884	82.33	0.95	0.162	0.051
OILENERGY	−0.004	0.008	71.55	0.94	0.002	0.001
URBAN	−0.007	0.029	65.23	0.93	0.007	0.002
LEFT	−0.129	0.292	38.36	0.92	0.037	0.024
FDIGDP	−0.048	0.050	60.78	0.88	0.006	0.004
PRIMEDU	−0.013	0.006	29.45	0.86	−0.002	0.001
DICT	−0.287	0.326	53.45	0.84	−0.045	0.033
POLFREE	−0.107	0.070	40.66	0.82	−0.012	0.009
MILEXPGDP	−0.059	0.083	39.22	0.82	0.011	0.008
ILLIT	−0.029	0.019	13.79	0.70	−0.002	0.002
GDPGR	−0.010	0.019	4.31	0.65	−0.000	0.001
YRSOFFC	−0.011	0.015	22.13	0.64	−0.000	0.002
COAST	−0.024	0.010	3.30	0.62	0.001	0.002
ECFREE	−0.095	0.183	1.15	0.50	0.002	0.025

Note: %Sign. refers to the percentage of regressions in which the respective variable is significant at a 5% significance level. Results based on 696 regressions.

Population density (*LPOPDENS*) is also robustly related to air pollution, but not at all to water pollution. More inhabitants per square kilometer lowers a country's air quality. Urbanization has – although somewhat less pronounced – a similar effect on air pollution, and again no effect on water. The demographic factor significantly explaining large parts of water pollution is a country's share of land close to a sea or ocean or near a large river (*COAST*). As to be expected, this variable bears no relationship whatsoever with air pollution.

In line with our intuition, the extend to which an economy produces its energy by means of oil appears to affect the level of air pollution more significant than the level of water pollution.

To test the robustness of our conclusions, we conducted further sensitivity analysis. First, we split the overall sample along the time dimension. Arguably, the world has changed considerably since the 1960s and this may also have affected the overall attitude toward pollution. Broadly speaking, our general conclusions are similar in the pre-1973 and the post-1973 subsamples. Second, we have dropped countries with extreme pollution levels from the analysis. It turns out that the results reported above hardly change. Furthermore, we have experimented with different baseline models. Neither significance nor coefficient values differ highly from the results discussed above.

Finally, for a last backup of our findings we take the variables that fulfill the criterion of the EBA and estimate three models for water and air pollution. In the *BOD* model, seven variables meet the criterion. In case of CO_2 we present two variants since there are three variables that are close to being significant. The results of the three models, which can be seen in Table 9, reflect the findings of the EBA. With the exception of *LFERT* in the $> .92$ model all variables are significant.

6 Conclusion

Environmental quality continues to draw attention both in the public sphere and among economists. Recently, in the academic literature the discussion has started to focus on politico-institutional factors possibly determining pollution levels. However, despite empirical research investigating the interaction of various economic, demographic and politico-institutional factors and pollution, there is hardly not much of a consensus which of these forces might matter, casting doubt on the general robustness of these results. The present paper provides an overview and a thorough robustness analysis of these determinants of pollution.

A first result – in line with the literature – is that we endorse the existence of an Environmental Kuznet Curve. Using various specifications, a quadratic set-up appears dominant suggesting an inverted U-shaped relationship between prosperity and pollution. Especially in the case of air pollution, the non-linearity of this relationship seems to matter; our estimated turning point of around 32,000 US $ GDP per capita has already been reached by several countries within our sample. With an estimated turning point of around 136,000 US $ GDP per capita this is clearly not the case for water pollution.

Secondly, and as expected, a number of variables related to the economic structure of a country matter for its environmental quality. Both our production- and employment-based indicators of industrialization are highly significant and have the expected (positive) sign. Furthermore, a variable measuring agricultural intensity, i.e. fertilizer consumption per hectare of arable land, also explains a substantial degree of both air and water pollution levels around the world. A final variable which describes the economic structure of a country is the amount of commercial energy used to produce one unit of GDP. Again both air and water pollution are highly correlated with this structural variable.

Thirdly, openness – as measured by the ratio of trade or foreign direct investment over GDP – is only related to the amount of air pollution in an economy. The more open an economy is, the higher the level of CO_2 emission turns out to be. Apparently, the claim that access to 'greener' technologies caused by globalization would lead to an improvement of environmental quality is difficult to hold, at least in the rather general set-up chosen here.

Fourthly, short-term economic fluctuations do not seem to produce significant short-term fluctuations in environmental impact. The same holds for the level of education in an economy.

Fifthly, the type of demographic factors influencing air and water pollution differ substantially. Air pollution depends on the population density and to a somewhat lesser extend the degree of urbanization. The only demographic factor which helps explain water pollution is its proximity to a sea or an ocean.

Finally, despite recent interests in more politically motivated explanations of environmental quality, our results show that such factors at best play a minor role in practice. In fact, many of the political variables reported in the empirical literature to influence environmental quality are not significantly related to either air or water pollution. Furthermore, looking at the cumulative distribution function reveals that – if anything – the empirics regularly produce opposite effects of what recent theories propose. For instance, left-wing governments rather appear to exists in societies with low environmental standards.

References

Antweiler, W., Copeland, B. R., and Taylor, M. S. (2001). Is free trade good for the environment? *American Economic Review*, 91(4):877–908.

Arrow, K., Bolin, B., Constanza, R., Dasgupta, P., Folke, C., Holling, C. S., Jansson, B.-O., Levin, S., Maler, K.-G., Perrings, C., and Pimental, D. (1995). Economic growth, carrying capacity and the environment. *Ecological Economics*, 15(2):91–95.

Beck, T., Clarke, G., Groff, A., and Keefer, P. (1999). *The Database of Political Institutions.* World Bank, Development Research Group.

Birdsall, N. and Wheeler, D. (1993). Trade policy and industrial pollution in Latin America: Where are the pollution havens? *Journal of Environment and Development*, 2(1):137–149.

Borghesi, S. (2000). Income inequality and the environmental Kuznets curve. *Fondazione Eni Enrico Mattei, Nota di Lavoro 83.2000.*

Carlsson, F. and Lundström, S. (2003). The effects of economic and political freedom on CO_2 emissions. *Working Paper.*

Cole, M. A. (2004). Trade, the pollution haven hypothesis and the environmental Kuznets curve: Examining the linkages. *Ecological Economics*, 48:71–81.

Cole, M. A. and Elliott, R. J. R. (2003). Determining the trade-environment composition effect: The role of capital, labor and environmental regulations. *Journal of Environmental Economics and Management*, 46:363–383.

Cole, M. A., Rayner, A. J., and Bates, J. M. (1997). The environmental Kuznets curve: An empirical analysis. *Environment and Development Economics*, 2:401–416.

Freedom House (1999). *Annual Survey of Freedom Country Scores 1972-1973 to 1998-1999.* The Freedom House, Washington, D.C.

Gallup, J. L., Sachs, J. D., and Mellinger, A. (1999). Geography and economic development. *CID Working Paper*, 1.

Grossman, G. M. and Krueger, A. B. (1991). Environmental impacts of a North American free trade agreement. *NBER Working Paper*, 3914.

Grossman, G. M. and Krueger, A. B. (1995). Economic growth and the environment. *Quaterly Journal of Economics*, 110(2):353–377.

Gwartney, J., Lawson, R., and Samida, D. (2003). *Economic Freedom in the World: 2003 Annual Report.* The Fraser Institute, Vancouver.

Holtz-Eakin, D. and Selden, T. (1995). Stoking the fires? CO_2 emissions and economic growth. *Journal of Public Economics*, 57:85–101.

Jaffe, A. B., Peterson, S. R., Portney, P. R., and Stavins, R. N. (1995). Environmental regulation and the competitiveness of us manufacturing: What does the evidence tell us? *Journal of Economic Literature*, 33:132–163.

Klick, J. (2004). Autocrats and the environment or it's easy being green. *Working Paper.*

Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review*, 1:1–28.

Leamer, E. E. (1983). Let's take the con out of econometrics. *American Economic Review*, 73:31–43.

Levine, R. and Renelt, D. (1992). A sensitivity analysis of cross-country growth regressions. *American Economic Review*, 82(4):942–963.

Mani, M. and Wheeler, D. (1998). In search of pollution havens? Dirty industry in the world economy, 1960-1995. *Journal of Environment and Development*, 7(3):215–247.

Moomaw, W. and Unruh, G. (1997). Are environmental Kuznets curves misleading us? The case of CO_2 emissions. *Environment and Development Economics*, 2:451–464.

Neumayer, E. (2003). Are left-wing party strength and corporatism good for the environment? Evidence from panel analysis of air pollution in OECD countries. *Ecological Economics*, 45:203–220.

Sahu, N. C. (2002). The environmental Kuznets curve: A critique in the indian perspective. In Rajalakshmi, N., editor, *Environmental Costs of Economic Evaluation.*, chapter 8, pages 80–99. Manak, New Delhi.

Sala-i-Martin, X. (1997). I just ran two millions regressions. *American Economic Review*, 87(2):178–183.

Selden, T. M. and Song, D. (1994). Environmental quality and development: Is there a Kuznets curve for air pollution emissions? *Journal of Environmental Economics and Management*, 27(2):147–162.

Shafik, N. (1994). Economic development and environmental quality: An econometric analysis. *Oxford Economic Papers*, 46:757–773.

Sturm, J.-E. and de Haan, J. (2002). How robust is Sala-i-Martin's robustness analysis? mimeo.

Sturm, J.-E. and de Haan, J. (2004). Determinants of long-term growth: New results applying robust estimation and extreme bounds analysis. *Empirical Economics*. forthcoming.

Temple, J. (2000). Growth regressions and what the textbooks don't tell you. *Bulletin of Economic Research*, 52(3):181–205.

Torras, M. and Boyce, J. K. (1998). Income, inequality, and pollution: A reassessment of the environmental Kuznets curve. *Ecological Economics*, 25:147–160.

World Bank (2003). *World Development Indicators.* The World Bank, Washington D.C.

A Literature

Table 7: Overview of recent studies

Author	**Period**	**Countries**	**Obs.**	**Dependent Variable**	**Explanatory Variable**	**Effect**	**Sign.**
Congelton (1992)	1989	118	118	Methan	Capitalist country	-	-
				CFC	Democratic country	+	++
				Methan/GNP	Reserves of OIL	-	-
					Reserves of GAS	+	-
					Reserves of COAL	+	-
					Area	$\sim$	$\sim$
					GNP	+	+
					Population	-	-
Grossman and Krueger (1995)	1979-1990	10-42	488-1352	SO_2	Income	$\sim$	+
				Smoke	$Income^2$	$\sim$	+
				Heavy Particles	$Income^3$	$\sim$	+
			850-1599	Dissolved Oxygen	lagged income	$\sim$	+
				BOD	lagged $income^2$	$\sim$	+
				COD	lagged $income^3$	$\sim$	+
				Nitrates	Mean temperature	$\sim$	$\sim$
			1261	Fecal Coliforms	Year	$\sim$	$\sim$
				Total Coliforms			
			350-610	Lead			
				Cadmium			
				Mecury			
				Nickel			
Ravallion et al. (1997)	1975-1992	42	783	CO_2	GDP p.c.	+	+
					GDP^2 p.c.	-	+
					GDP^3 p.c.	+	$\sim$
					log(GDP p.c.)	+	++
					log(GDP^2 p.c.)	-	+
					Population	+	+
					log(population)	+	+
					GINI	+	+
					Time trend	+	+
					log(GDP $\cdot$ GINI)	+	-
					log(GDP^2 $\cdot$ GINI)	+	$\sim$
					log(population $\cdot$ GINI)	-	+
					Time trend $\cdot$ GINI	+	-

continued...

Table 7: Overview of recent studies *(continued)*

Author	**Period**	**Countries**	**Obs.**	**Dependent Variable**	**Explanatory Variable**	**Effect**	**Sign.**
Torras and Boyce (1998)	1977-1991	19-58	1188	SO_2	Income	~	++
			405	Smoke	Income^2	~	++
			854	Heavy Particles	Income^3	~	++
			1931	Dissolved O_2	Coast	-	++
			1484	Fecal Coliform	Central city	+	++
			82	%Access Save water	Industrial	+	~
			79	%Access Sanitation	Residential	-	-
					Year	~	~
					Mean water temp	~	++
					GINI ratio low income	~	++
					GINI ratio high income	~	~
					%Literate low income	~	~
					%Literate high income	~	~
					Political rights and civil liberties low income	~	~
					Political rights and civil liberties high income	~	~
					%Urbanized	+	~
Borghesi (2000)	1988-1995	126	N/A	CO_2	GDP p.c.	+	++
		GINI:37			GDP^2 p.c.	~	+
					GDP^3 p.c.	~	~
					Population density	~	~
					Industry share of GDP	+	~
					GINI	~	-

continued...

Table 7: Overview of recent studies *(continued)*

Author	**Period**	**Countries**	**Obs.**	**Dependent Variable**	**Explanatory Variable**	**Effect**	**Sign.**
Antweiler et al. (2001)	1971-1996	43 108 Cities	2555	log(SO_2) concentration	Hard coal reserves	~	-
					Soft coal reserves	+	~
					City economic intensity	+	++
					(City economic intensity)^2/1,000	-	-
					Capital abundance (K/L)	~	~
					(K/L)^2	~	~
					lagged income p.c. (INC)	-	~
					INC^2	+	++
					(K/L) · (I)	-	++
					Trade intensity (TI)	-	~
					TI · rel.K/L	~	~
					TI · (rel. K/L)^2	~	~
					TI · rel. INC	+	+
					TI · (rel. INC)^2	~	~
					TI · rel. K/L · rel. INC)	~	~
					Inward FDI stock/capital stock (FDI/K)	+	~
					FDI/K · poor countries	+	-
					FDI/K · rich countries	-	-
					Suburban	-	~
					Rural	-	-
					Communist country (C.C.)	~	-
					C.C. · INC	~	+
					C.C. · INC^2	-	++
					Average temperature	-	+
					Precipitation coefficient of variation	+	~
					Helsinki Protocol	~	-

continued...

Table 7: Overview of recent studies *(continued)*

Author	**Period**	**Countries**	**Obs.**	**Dependent Variable**	**Explanatory Variable**	**Effect**	**Sign.**
Carlsson and Lundstoem (2003)	1975-1995	75	319	CO_2	GDP	+	++
					GDP^2	-	++
					GDP^3	+	++
					log(GDP)	∼	∼
					$\log(GDP^2)$	∼	∼
					$\log(GDP^3)$	+	∼
					GDP Growth	-	-
					Economic structure and use of the marktes (ESUM)	+	-
					Freedom to trade with foreigners (FTF)	-	-
					Price stability and legal security (PSLD)	-	-
					Political freedom	-	-
					Industry share (IS)	+	++
					ESUM · IS	-	+
					FTF · IS	-	-
					PSLD · IS	+	+
Cole and Elliot (2003)	1975-1995	26	104	NO_x	Capital-labor ratio (K/L)	∼	∼pc +in
				SO_2	$(K/L)^2$	∼	∼pc -in
modeled both per capita emissions (pc)				CO_2	lagged income (INC)	∼pc -in	++pc ∼in
and pollution intensity (in)				BOD	INC^2	∼	∼pc +in
					K/L · INC	∼	-pc +in
					Trade intensity (TI)	∼pc -in	+
					TI · rel. K/L	∼	++
					TI · $(\text{rel. } K/L)^2$	∼	+
					TI · rel. INC	∼	+pc -in
					TI · $(\text{rel. } INC)^2$	-	∼
					TI · rel. K/L · rel. INC	+pc ∼in	-pc +in
					Linear time trend	∼pc -in	++pc ∼in

continued...

Table 7: Overview of recent studies *(continued)*

Author	**Period**	**Countries**	**Obs.**	**Dependent Variable**	**Explanatory Variable**	**Effect**	**Sign.**
Neumayer (2003)	1980-1999	21	420	CO_2	log(GDP)	+	++
	1990-1999		360	SO_2	log(vehilces)	+	++
			360	NO_x	Share of GDP from manufacturing	+	~
			180	CO	Share of fossil fuel among primary energy consumption	+	+
			180	VOC	GDP per unit of energy used	-	++
					Share of left seats in legislature	~	~
					Share of green seats in legislature	-	++
					Share of left and green cabinet members	~	-
					Siaroff indicator for corporatism	+	~
Cole (2004)	1980-1997	17	234	NO_x	log(income)	+	++
		18	247	SO_2	$(\log(\text{income}))^2$	-	++
		16	221	CO	$(\log(\text{income}))^3$	-	+
		8	117	SPM	Trade intensity	-	+
		15	208	VOC	Share of dirty exports	-air	+
		21	286	CO_2	to non-OECD countries	+water	
		17 (44 rivers)	416	BOD	Share of dirty imports	-air	+
		17 (42 rivers)	494	Dissolved Oxygen	from non-OECD countries	+water	
		11 (31 rivers)	585	Nitrates			
		14 (37 rivers)	559	Phosphorous			

continued...

Table 7: Overview of recent studies *(continued)*

Author	**Period**	**Countries**	**Obs.**	**Dependent Variable**	**Explanatory Variable**	**Effect**	**Sign.**
Klick (2004)	1986-1996	114	690/822	CO_2	Autocracy	-	++
				BOD	Autocrats tax share	+	$\sim$
					Non-Auto Tax Share	+	-
					Durable	+	+
					Inflation	$\sim$	-
					Male 15-64	$\sim$	$\sim$
					Population density	$\sim$	$\sim$
					Primary education	-	-
					Income	+	++
					Income^2	-	++
					Income^3	+	++
					Military	$\sim$	-
					Population	$\sim$	$\sim$
Markandya et al. (2004)	1870-1999	12	1561	SO_2	GDP	+	N/A
					GDP^2	-	N/A
					GDP^3	+	N/A
					GDP^4	-	N/A
					Dummy variable for air regulations	$\sim$	$\sim$

Note: *Effect* denotes the sign of the estimated coefficient: + stands for positive, - for negative and $\sim$ for changing

B Variables

Table 8: List of variables and their sources

Variable	**Sign**	**Description**	**Source**
LCO_2PC		Log of CO_2 Emissions in kt per capita	WDI (2003)
LBODPC		Log of BOD in kg per day per capita	WDI (2003)
LGDPPC	?	Log of real GDP per capita (in constant 1995 US $)	WDI (2003)
LGDPPC^2	?	Squared log of real GDP per capita	WDI (2003)
LGDPPCCB	?	Cubic log of real GDP per capita	WDI (2003)
GDPGR	?	GDP growth rate (annual %)	WDI (2003)
TRADE	?	Trade intensity ((import + export)/GDP)	WDI (2003)
POLFREE	-	Equally weighted sum of the Freedom House Indices	FHI (1999)
ECFREE	-	Fraser Economic Freedom Index	Gwartney et al. (2003)
YRSOFFC	+	Number of years chief executive in office	Beck et al. (1999)
INDSHGDP	+	Manufacturing value added (% of GDP)	WDI (2003)
INDSHEMP	+	Employment in industry (% of total employment)	WDI (2003)
LPOPDENS	+	Log of population per hectar	WDI (2003)
PRIMEDU	-	Gross primary school enrollment (in %)	WDI (2003)
MILEXGDP	?	Military expenditure (% of GDP)	WDI (2003)
ILLIT	+	Adult illiteracy rate (% of people ages 15 and above)	WDI (2003)
URBAN	+	Urban population (% of total)	WDI (2003)
FDIGDP	?	Net inflows of foreign direct investment (% of GDP)	WDI (2003)
OILENERGY	+	Electricity production from oil sources (% of total)	WDI (2003)
ENERGYGDP	+	Commercial energy use times 1,000,000 (kt of oil equivalent)/GDP	WDI (2003)
DICT	-	Dummy variable for dictatorship (executive index of electoral competitiveness < 3)	Beck et al. (1999)
LEFT	-	Dummy variable for the party of the chief executive being left-wing	Beck et al. (1999)
LFERT	+	Log of fertilizer use in 100g per ha of arable land	WDI (2003)
COAST^*	+	Percentage of land within 100 km of ocean or navigable river with ocean access	Gallup et al. (1999)

Note: Sign refers to the expected sign. See main text for further explanation.
*The data for the variable COAST covers only 1995. We assume this variable to be constant over our estimation period 1960–2001.

Table 9: Final Models

		BOD	CO_2	
	CDF(0)	$> .95$	$> .95$	$> .92$
	Variable			
1	**CONSTANT**	-8.4622	-11.8852	-12.7744
	T-Stat	-8.6262	-14.0322	-13.7152
	Signif	0.0000	0.0000	0.0000
2	**LGDPPC**	1.9277	2.2459	2.3250
	T-Stat	8.0668	10.7520	10.2280
	Signif	0.0000	0.0000	0.0000
3	**LGDPPCSQ**	-0.1030	-0.0875	-0.0922
	T-Stat	-7.3960	-6.9851	-6.7816
	Signif	0.0000	0.0000	0.0000
4	**INDSHGDP**	0.0106	0.0024	0.0037
	T-Stat	4.51276	1.3611	1.7677
	Signif	0.0000	0.1735	0.0771
5	**ENERGYGDP**	0.2057	0.4565	0.4619
	T-Stat	4.0337	11.2911	10.3054
	Signif	0.0001	0.0000	0.0000
6	**INDSHEMP**	0.0202	0.0063	0.0057
	T-Stat	9.1049	3.4180	3.0891
	Signif	0.0000	0.0006	0.0020
7	**LFERT**	0.0346	0.0362	0.0084
	T-Stat	1.7775	2.6783	0.5422
	Signif	0.0755	0.0074	0.5877
8	**COAST**	0.0057		
	T-Stat	3.4689		
	Signif	0.0005		
9	**TRADE**		0.0013	0.0018
	T-Stat		3.5568	4.3116
	Signif		0.0004	0.0000
10	**LPOPDENS**		0.2483	0.1200
	T-Stat		4.7367	2.0117
	Signif		0.0000	0.0442
11	**URBAN**			0.0097
	T-Stat			4.7955
	Signif			0.0000
12	**OILENERGY**			0.0015
	T-Stat			2.9450
	Signif			0.0032
13	**LEFT**			0.0256
	T-Stat			1.7369
	Signif			0.0824

Table 10: Variable statistics and correlation coefficients

	Mean	Std.Error	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)
(1) LBODPC	1.51	1.12	2024	0.76	0.74	0.73	0.53	-0.34	-0.04	0.29	-0.57	0.61	-0.15	-0.13	0.22	0.31	-0.72	0.64	0.08	-0.15	0.06	-0.47	0.66	0.48	0.48
(2) LCO_2PC	0.17	1.85	1911	6528	0.85	0.84	0.40	-0.37	0.00	0.32	-0.40	0.59	0.00	0.08	0.10	0.47	-0.62	0.78	0.09	-0.08	-0.04	-0.22	0.70	0.53	0.41
(3) LGDPPC	7.51	1.55	1902	5239	5961	1.00	0.35	-0.65	0.02	0.25	-0.62	0.49	-0.13	-0.05	0.16	0.44	-0.65	0.81	0.10	-0.15	-0.07	-0.25	0.68	0.65	0.45
(4) $LGDPPC^2$	58.77	23.87	1902	5239	5961	5961	0.33	-0.62	0.02	0.24	-0.61	0.47	-0.14	-0.05	0.17	0.40	-0.63	0.80	0.09	-0.17	-0.06	-0.24	0.66	0.66	0.44
(5) INDSHGDP	14.85	8.28	1541	3790	4070	4070	4232	-0.15	-0.04	-0.02	-0.24	0.37	-0.18	-0.17	0.25	0.35	-0.53	0.42	-0.03	-0.06	0.07	-0.29	0.47	0.18	0.29
(6) ENERGYGDP	0.66	0.72	1559	3131	3300	3300	2336	3300	-0.16	-0.08	0.44	-0.19	0.07	0.05	-0.05	-0.30	0.23	-0.46	0.00	-0.07	0.19	0.09	-0.37	-0.44	-0.40
(7) GDPGR	3.72	6.98	1908	5270	5780	5780	4112	3253	6020	0.05	0.02	-0.01	0.03	-0.02	0.02	0.06	0.03	-0.05	0.09	0.09	-0.05	0.02	0.03	0.05	0.02
(8) TRADE	71.47	43.93	1869	5062	5336	5336	4049	3177	5332	5599	-0.17	0.22	0.10	0.06	0.22	0.17	-0.31	0.23	0.38	0.18	-0.06	-0.03	0.29	0.40	0.25
(9) POLFREE	4.07	2.06	1845	4214	3799	3799	3087	2690	3857	3731	4348	-0.24	0.37	0.27	-0.19	-0.32	0.42	-0.43	-0.08	0.26	0.03	0.50	-0.49	-0.50	-0.41
(10) INDSHEMP	26.07	9.70	1159	1469	1470	1470	1158	1229	1497	1428	1376	1616	0.09	0.08	0.23	0.23	-0.43	0.48	-0.03	-0.09	-0.01	-0.15	0.44	0.26	0.29
(11) YRSOFFC	7.80	7.95	1707	3435	3116	3116	2513	2297	3165	3054	3481	1236	3509	0.20	-0.01	-0.10	0.06	-0.01	-0.01	0.17	0.03	0.12	-0.06	-0.07	-0.05
(12) MILEXPGDP	3.15	4.36	976	1498	1744	1744	1463	1286	1754	1694	1500	861	1229	1775	-0.04	-0.23	0.05	0.06	-0.02	0.22	-0.07	0.27	0.02	-0.09	-0.01
(13) LPOPDENS	-0.91	1.67	1917	6304	5424	5424	3985	3205	5547	5207	4246	1482	3462	1627	6813	0.18	-0.29	0.17	0.07	0.15	0.00	-0.17	0.45	0.19	0.59
(14) PRIMEDU	93.50	24.08	1087	2044	2101	2101	1731	1481	2113	2036	1875	1054	1588	1318	2187	2307	-0.64	0.37	0.18	-0.09	0.12	-0.25	0.46	0.23	0.23
(15) ILLIT	31.32	25.89	1538	3634	3593	3593	2971	2372	3632	3401	3222	1110	2762	1399	3837	1813	4352	-0.58	-0.15	0.08	-0.04	0.36	-0.59	-0.37	-0.38
(16) URBAN	46.68	25.02	2024	6488	5911	5911	4205	3270	5972	5550	4321	1612	3486	1775	6773	2295	4320	8610	0.08	-0.05	-0.10	-0.21	0.62	0.53	0.38
(17) FDIGDP	2.01	4.90	1728	3785	4116	4116	3275	2746	4124	3963	3508	1307	2917	1645	3992	1885	3197	4171	4203	0.01	-0.01	-0.08	0.16	0.31	0.09
(18) OILENERGY	32.53	33.38	1611	3334	3270	3270	2329	3166	3297	3152	2859	1297	2439	1237	3425	1538	2774	3816	2676	3846	-0.08	0.17	-0.08	-0.05	0.04
(19) LEFT	0.36	0.48	1618	3219	2924	2924	2381	2164	2976	2860	3268	1157	3292	1151	3247	1482	2583	3270	2727	2306	3293	-0.19	-0.01	-0.10	0.03
(20) DICT	0.27	0.44	1703	3429	3110	3110	2508	2292	3159	3050	3475	1231	3501	1225	3456	1581	2754	3479	2913	2436	3286	3502	-0.32	-0.17	-0.27
(21) LFERT	5.75	2.13	1820	5406	4899	4899	3653	3148	5040	4786	3889	1392	3247	1575	5785	2033	3512	5748	3713	3360	3061	3241	5787	0.52	0.59
(22) ECFREE	5.71	1.27	368	556	786	786	603	551	787	764	500	310	502	394	676	651	637	800	727	546	469	502	666	808	0.36
(23) COAST	45.57	37.34	1781	4997	4846	4846	3529	3115	4863	4655	3535	1360	2962	1612	5228	1988	3712	6216	3515	3627	2798	2955	5002	743	6258

Note: the first two columns report the mean and the standard deviation of each series; the upper-right of the remaining part of the table report correlation coefficients, whereas the lower-left shows the number of observations used to calculate the correlation coefficients.