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Freedom from Pollution?
The State, the People,
and the Environmental Kuznets Curve

By

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Abstract

We develop and estimate an econometric model of the relationship between several local and global air and water pollutants and economic development while allowing for critical aspects of the socio-political-economic regime of a State. We obtain empirical support for our hypothesis that democracy and its associated freedoms provide the conduit through which agents can exercise their preferences for environmental quality more effectively than under an autocratic regime, thus leading to decreased concentrations or emissions of pollution. However, additional factors such as income inequality, age distribution, and urbanization may mitigate or exacerbate the net effect of the type of political regime on pollution, depending on the underlying societal preferences and the weights assigned to those preferences by the State.

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1. Introduction

The examination of the relationship between national income and environmental quality has become of great interest to economists, policy-makers, and the public at large. This interest is not only expressed within national boundaries but also is reflected by growing conflicts between global environmental concerns and global economic development policy, as seen by uprisings at recent WTO meetings. Previous literature has focused on the so-called Environmental Kuznets Curve (EKC), which hypothesizes an inverted-U shape when pollution indicators are plotted against income per capita. Explanations for this hypothesis generally focus on several primary factors that interact to produce the shape. Among these are (1) changes in the composition of aggregate output as economies evolve from agricultural to industrial to service-based goods and services, (2) technological progress, and (3) increases in demand for environmental quality as income grows (Anderson and Cavendish, 2001; Ansuategi and Escapa, 2002; Grossman and Kruger, 1995; Heerink, et. al., 2001; Panatoyou, 1997).

However, as most authors tend to agree, the relationship between environmental quality and economic development is not formed in isolation from political institutions that govern the process of policy making in a particular country. Thus, for example, Dasgupta and Mäler (1995, P. 2412) have aptly emphasized: "*The connection between environmental protection and civil and political rights is a close one. As a general rule, political and civil liberties are instrumentally powerful in protecting the environmental resource-base, at least when compared with the absence of such liberties in countries run* *by authoritarian regimes*". This observation raises several important questions: How does pubic policy towards environmental quality influence the relationship between per capita income and pollution, and how does that public policy represent the citizens' preferences for environmental quality? In other words, can we identify demand-side characteristics that influence the State's environmental policy regime, and can we explain the mechanism(s) through which these preferences are manifested?

Several authors have included explanatory variables to explicitly account for the role of political institutions in the income-environment relationship. For example, in their study of the causes of deforestation in Latin America, Africa, and Asia, Bhattarai and Hammig (2001) use a measurement of institutional quality, measured by an index of political rights and civil liberties, to account for the role of different policy regimes. Torras and Boyce (1998) use a similar technique for a panel data survey of a variety of air and water pollution indicators measured as ambient concentrations of toxins. However, these studies did not explicitly decompose the demand for environmental policy based on heterogeneous population characteristics, nor did they address the potential for distortions of the environmental quality preferences by the political regime.

This paper proposes an empirical econometric model of the relation between several local and global air and water pollutants and economic development, measured by national income per capita. The model explicitly accounts for critical aspects of the socio-political-economic regime of a State. Specifically, we develop a model that directly incorporates the relationship between societal preferences and provision of public pollution abatement, utilizing a measure of quality of governance as a proxy for weights on those preferences. We hypothesize that democracy and its associated freedoms provide the conduit through which agents can exercise their preferences for environmental goods more effectively than under an autocratic regime, thus resulting in reduced concentrations and/or emissions of pollution. However, additional variables such as income inequality, age distribution, and urbanization may mitigate or exacerbate the net effect of the type of governance on pollution, depending on the underlying preferences of the population at large and the weights assigned to those preferences by the State.

Section 2 provides a simple representation of the relationship between demand-side preferences of the population and realized environmental policy. Section 3 describes the structure and key variables included in the empirical models. Section 4 describes the data used in the analysis and the estimation issues that arise. Section 5 presents and discusses the results. Section 6 concludes.

2. Relationship between Environmental Policy, Governance, and Preferences

One of the major determinants of environmental policy is the socio-political regime of a particular country, or "governance" as phrased by Rivera-Batiz (2002). Specifically, Lopez and Mitra (2000) argue that corruption and rent-seeking behavior can influence the relationship between income and the environment. In general, they provide a theoretical model that shows corruption causes the turning points of an EKC to rise above the social optimum. They suggest that corruption manifests itself as rent-seeking behavior by the State. Additionally, Magnani (2000) suggests that well-defined property rights, democratic voting systems, and respect of human rights can create synergies that lead to increased levels and efficacy of environmental policy.

We propose a simple explanation of this argument, based on the relationship between the demand and supply of environmental quality. Because environmental quality is, in most cases, a public good, and in many cases the capital costs of the required infrastructures to abate pollution are huge, individuals or groups within a society are unable to effectively provide them.[1] As such, provision of these goods usually comes from the State, and the realized environmental policy is a function of the preferences of society. The correlation between preferred and actual levels of environmental quality will depend on the weights placed on the various heterogeneous societal preferences by the policy makers, which can be generally characterized as the policy regime.

To illustrate, consider the following simple model. Assume that the N individuals in society can be aggregated into two non-intersecting groups, i = 1,2. Each group is represented by a certain representative consumer with a different intensity of preferences for environmental quality. The preferences are assumed to be reflected by each representative consumer's propensity for abatement efforts to be undertaken by the State, and are denoted by $e_i(\gamma_i), i = 1,2$, where γ_i is a measure of the distinguishing characteristic of the ith group. The categorical distinctions can be made along any number of characteristics that are likely to affect environmental preferences, such as "rich vs. poor", "educated vs. non-educated", or "young vs. old". In the case of the former, γ_i may represent total income of the ith group, while in the latter cases, it represents the number of individuals in each category. Suppose further that for any $\gamma_i > 0$, the first group's preference for environmental quality and hence abatement efforts is more

[1] As opposed to private environmental quality, say, in the home as a result of inadequate ventilation.

intensive than the second group's, i.e., $1 \geq e_1(\gamma_1) > e_2(\gamma_2) \geq 0$. For example, the rich consumers typically demand more pollution abatement than the poor ones.

It is reasonable to think that in deciding how much abatement efforts to undertake, the State may take the preferences of different citizen groups into account, but the extent to which it does so depends on the structure of political institutions and hence the authoritative power of the State. Formally, letting the *preferred* abatement level for each citizens group be $E_i(\gamma_i) = e_i(\gamma_i)\gamma_i$, and the State's own preferred (autocratic/discretionary) abatement level be E_d, then the *realized* (or actual) abatement level provided through the State (denoted by $\hat{E}$) may be expressed as a function of the three preferred abatement levels (by the two citizen groups and by the State) and the State's degree of democratic representation of the citizen's preferences, i.e.

$$\hat{E} = E\left(E_1(\gamma_1), E_2(\gamma_2), E_d; \boldsymbol{\alpha}\right). \tag{1}$$

Here the vector of parameters $\boldsymbol{\alpha} = (\alpha_1, \alpha_2, \alpha_3)$ can be viewed to reflect the type of the existing political structures and processes that determine the weight of each agent (representatives of the two citizens groups and the State itself) in deciding about the actual level of abatement. Accordingly, α_1 and α_2 represent the weight of preferences of citizens groups in the final decision (reflecting the degree of democratic representation of citizens' preferences), while α_3 may be interpreted as the State's own preferences for the level of abatement independently of those preferences (reflecting the degree of State's autocracy). Thus, for example, at one extreme, a political structure may be so corrupt that it leads to a capture of the State by one group or the other (α_1=1 and $\alpha_2 = \alpha_3 = 0$, or $\alpha_2 = 1$ and $\alpha_2 = \alpha_3$=0). At other extreme, the existing political structure and institutions may be purely democratic so that only the citizens' preferences count in the state's decision ($\alpha_3 = 0$). In reality, of course, a wide range of other alternatives lying in between these two extremes are possible, implying different values of the parameters. Technically speaking, the parameters α_1, α_2, and α_3 determine, at the margin, the rate at which the State trades off one citizen group's preferred abatement level for that of the other group and of its own preferred level when deciding to provide a target level of abatement expenditure.

A simple linear functional form for the model results in the specification

$$\hat{E} = E\left(E_1(\gamma_1), E_2(\gamma_2), E_d; \boldsymbol{\alpha}\right) = \alpha_1\left[e_1(\gamma_1)\gamma_1\right] + \alpha_2\left[e_2(\gamma_2)\gamma_2\right] + (1-\alpha_1-\alpha_2)E_d. \qquad (2)$$

That is, the actual public abatement level is a weighted average of the preferred abatement levels by each category and the State. Notice that in a purely egalitarian democratic political setting $\alpha_1 = \alpha_2 = \frac{1}{2}$ while in a completely autocratic political regime $\alpha_1 = \alpha_2 = 0$.

Expressing equation (2) as a function of the aggregate characteristic $\gamma = \gamma_1 + \gamma_2$, we obtain

$$\hat{E} = \alpha_1[e_1(\gamma_1)]\gamma_1 + \alpha_2[e_2(\gamma_2)][\gamma - \gamma_1] + (1-\alpha_1-\alpha_2)E_d \qquad (3)$$

or

$$\frac{\hat{E}(\cdot)}{\gamma} = [\alpha_1 e_1(\gamma_1) - \alpha_2 e_2(\gamma_2)]\frac{\gamma_1}{\gamma} + \alpha_2 e_2(\gamma_2) + (1-\alpha_1-\alpha_2)\frac{E_d}{\gamma} \qquad (4)$$

The left-hand side of equation (4) can be interpreted as abatement per unit of characteristic, such as abatement expenditure per dollar of income in the case of an income measure, or abatement expenditure per person in the case of a personal characteristic. The change in abatement per unit as society develops along a particular attribute is given by

$$\frac{\partial\left(\hat{E}/\gamma\right)}{\partial\left(\gamma_1/\gamma\right)} = \alpha_1 e_1\left(\gamma_1\right) - \alpha_2 e_2\left(\gamma_2\right), \tag{5}$$

the sign of which is determined both by preferences intensities *and* the weights given to each preference group by the State.

For example, assume that γ represents education level and a particular society has an equal number of "educated" and "non-educated" citizens (i.e. $\gamma_E = \gamma_N = \frac{1}{2}\gamma$), with those in the educated bracket having a greater propensity to prefer environmental quality, $e_E\left(\gamma_E\right) > e_N\left(\gamma_N\right)$. In a purely egalitarian democracy, $\alpha_1 = \alpha_2 = \frac{1}{2}$, and equation (5) predicts that increased education levels ($\frac{\gamma_E}{\gamma}$) will increase the aggregate propensity to spend on abatement efforts, and hence lead to higher environmental quality. If, however, there were a greater percentage of those in the "non-educated" category ($\gamma_N > \frac{1}{2} > \gamma_E$), or due to distortions in the political system (such as a "pro" non-educated bias of the government), the government placed a much larger weight on the preferences of those without education ($\alpha_2 > \frac{1}{2} > \alpha_1$), then it is possible that the government's abatement efforts (and hence environmental quality) would *decrease* as the education level of the populace increases (in this case, $\alpha_1 e_1\left(\gamma_1\right) - \alpha_2 e_2\left(\gamma_2\right) < 0$ in (5)).

While highly stylized, this model of environmental quality provision highlights the importance of the political regime on the relationship between economic development and environmental quality. Specifically, it suggests that environmental quality expenditures are, in part, a function of the preferences of society, but these preferences are subject to distortion (for example, under political pressure from interest groups), interpretation, and neglect by the State. The more open and democratic the society, however, the more likely it is that the preferences of society will be reflected in actual policy decisions.

3. Preference Shifters and the Empirical Models

Despite the potential complications from the assumption of unidirectional causality between economic growth and the environment, the econometric models use a reduced-form parametric approach that implies no feedback from environment to economy, with the structure allowing for flexibility via higher-order terms in GNP per capita and population density (Grossman and Kruger, 1995; Coondoo and Dinda, 2002). As such, the coefficient estimates represent the net effect of each shifter on pollution concentrations, but should not be interpreted as a causal relationship (Grossman and Kruger, 1995).

Following Panayotou (1997), we begin the decomposition by assuming that policy can be instrumented solely by the democratic/autocratic structure of political institutions of the country, resulting in the following model:

$$X_{it} = \alpha_{\mathrm{i}} + \sum_{j=1}^{3} \beta_j Y_{it}^j + \sum_{k=1}^{3} \beta_{k+3} P_{it}^k + \beta_7 D_{it} + \beta_8 D_{it} Y_{it} + \delta t + \varepsilon_{it}, \qquad (6)$$

where X_{it} denotes the pollutant measure in country i at year t, Y_{it} is GDP per capita in year t for the country in which i is located, P_{it} is population density in year t for country i, D_{it} is the democracy measure in year t for country i, t is a linear time trend to account for technological change over time, β_j and δ are regression coefficients, α_i's are country-level fixed effects and ε_{it} is an error term. Note that the policy variable enters both additively and multiplicatively, allowing for both intercept and slope shifts of the estimated relationship between national income and the pollution indicator. Equation (6) is utilized as a benchmark in the analysis, and is used to test the EKC hypothesis and the effect of political institutions on environmental quality.

Equation (6) is then expanded to include variables expected to be correlated with the heterogeneous preferences of society at large, thus explicitly incorporating the demand for environmental quality into the specification. It is assumed that these preferences can be exercised only through the political system of the state, and as such the democracy variable is used to interact with each shifter. This specification implies that strongly autocratic regimes will be unresponsive to societal preferences relative to more democratic societies, with the actual weights ($\boldsymbol{\alpha}$) implied by the magnitude of the coefficients.

One preference shifter discussed in the literature is inequality, both in political power and economic power. The former is addressed through the interactions with the democracy variable. There is little agreement as to the causal relationship through which the latter, as represented by income inequality, is manifested. One hypothesis suggests that there is evidence of a positive correlation between preferences for environmental degradation and individual's income and/or power due to ownership and consumption patterns (Torras and Boyce, 1998). This hypothesis is further advocated empirically by Bimonte (2002) with respect to public lands, and by Magnani (2000) who finds that reduced income equality decreases public expenditure on pollution abatement. It is, however, disputed by Scruggs (1998), who argues that higher levels of education and wealth are often associated with “pro environment” preferences, so that movements in these directions (implying greater income inequality) within a country may result in better environmental quality.

Heerink, et. al. (2001) use individual household models in which agents at the micro level are assumed to both consume and produce. They conclude that convexity and concavity properties of the individual household EKC determine the marginal effects of income redistribution when aggregated to the macro level, so generalizations are inaccurate. While our model cannot distinguish between these competing theories, we can empirically test if and how income (and political) inequality significantly affects pollution indicators, implying a certain weighting structure by the State.

The remaining variables used to explain policy preferences are the demographic distribution of the population, particularly with respect to the overall youth of the population, the education level of the population, and the degree of urbanization within a society. There is surprisingly little in the literature regarding the age distribution, and yet, as alluded to in the introductory remarks, the recent demonstrations at WTO meetings in part to protest the environmental consequences of globalization have been largely organized and led by the young environmentalist groups. One notable exception in this regard is the work of Ono and Maeda (2001), who study the effects of an aging population on environmental quality. They conclude, based on the interaction of income and substitution effects from a change in longevity, that the marginal impact of age distribution on environmental quality depends on the risk-aversion properties of individual agents’ preferences. Particularly, if relative risk aversion with respect to consumption is less then one (i.e. implying that the population is not avert to intergenerational inequality in consumption), then aging may be beneficial to the environment. Further complicating the matter, the authors indicate that technological change and growth in income can either mitigate or exacerbate the uncertain effects of age distribution on environmental quality, given different assumptions about the state of preferences and economic growth. Based primarily on casual observation, we hypothesize that a younger population tends to demonstrate a larger propensity to demand environmental quality.

The education level of the population is addressed in Bimonte (2002), who argues that increases in education are often accompanied by increases in preferences that favor a higher level of environmental amenities. At the same time, the education level may affect the governance of a nation as well, since a more educated workforce contributes to a more educated (and possibly democratic-minded) public sector (Rivera-Batiz, 2002). The net result of this preference shifter is thus expected to be reduced pollution with greater education levels, as the two effects complement each other in sign.

Finally, urbanization is included to account for preference differences between rural and urban populations, as well as the potential economies of scale effects with regards to pollution abatement (Torras and Boyce, 1998). Increased urbanization may also improve the quality of governance, as costs of transportation and other communication means are lowered with increased urbanization, thereby increasing the weights of citizen groups' preferences in the State's decision (Rivera-Batiz, 2002). Of course, high degrees of urbanization may result in increased pollution concentrations as well, as fossil fuel consumption per capita and per unit area increase (Panayotou, 1997).

Formally decomposing equation (6) to account for these preference shifters results in the following model:

$$X_{it} = \alpha_{\text{i}} + \sum_{j=1}^{3} \beta_j Y_{it}^j + \sum_{k=1}^{3} \beta_{k+3} P_{it}^k + \beta_7 D_{it} + \beta_8 D_{it} Y_{it} + \beta_9 U_{it} + D_{it} \left(\beta_{10} G_{it} + \beta_{11} A_{it} + \beta_{12} U_{it} + \beta_{13} I_{it} \right) + D_{it} Y_{it} \left(\beta_{14} G_{it} + \beta_{15} A_{it} + \beta_{16} U_{it} + \beta_{17} I_{it} \right) + \delta t + \varepsilon_{it}, \quad (7)$$

where U_{it} is a measure of urbanization, G_{it} is the GINI coefficient measuring inequality, A_{it} is the proportion of the population 14 years of age and under, I_{it} is the illiteracy rate of the adult population as a proxy for the education level, and all other variables are as previously defined. We maintain the assumption that the regime and preference shifters can affect both the intercept and slope of the income-environment quality curve, resulting in a significantly flexible functional form with marginal effects that may depend on the current state of development.

4. Data and Estimation Issues

We estimate the regression models for a number of diverse environmental quality indicators for air and water quality, using data from several sources. Anthropogenic CO_2 is a greenhouse gas emitted from the burning of fossil fuels and cement production, and emissions data is collected by the United Nations for over two hundred countries for the period 1980-1998 (UN, 2003; World Bank, 2003, EPA, 2003). The World Bank world development indicators (WDI) report biochemical oxygen demand (BOD) for over one hundred countries over the period 1980-1999. BOD is a measure of the amount of oxygen that bacteria in water will consume in breaking down wastes, and is a measure of the *lack* of organic water pollution (World Bank, 2003; EPA, 2003). The World Resources Institute (WRI) collects a number of data series from the “Tables of Anthropogenic

Emissions in the Economic Commission for Europe (ECE) region by the Programme for Monitoring and Evaluation of the Long-Range Transmission of Air Pollutants in Europe (EMEP), including emissions of nitrogen oxides (NO_X), non-methane volatile organic compounds (VOC), and sulfur dioxide (SO_2) from 1980 through 1996 for primarily European and North American nations. These chemicals contribute to ground level ozone (smog) from industrial and transportation sources, with SO_2 concentrations deriving from primarily fixed-point industrial sources and also contributing to acid rain. Finally, ambient SO_2 concentration data, as opposed to SO_2 emissions data, from the Global Environmental Monitoring System/Urban Air Pollution Monitoring and Assessment Programme (GEMS/AIR) is used in the analysis. The data series contains an unbalanced panel data set for mean ambient concentrations of SO_2 for different monitoring stations in forty-five countries over the period 1972 – 1994. We use the median concentration for each country in each year, as in Panayotou (1997), for comparability with the other pollutants, as well as minimizing bias due to the relatively larger number of stations in high-income countries.

The political regime variables are taken directly from the Polity IV Database, a project of the Integrated Network for Societal Conflict Research Program, Center for International Development and Conflict Management, University of Maryland.[2] Polity IV contains, amongst many other variables, yearly composite indicators measuring both "institutionalized democracy" and "autocracy" for just about every independent nation with a population over 500,000 on an additive eleven-point scale. Institutionalized democracy is defined on the basis of weighted measures of political participation, openness and competitiveness of executive recruitment, and constraints on the chief executive, while autocracy is a similarly weighted measure of those variables plus regulation of participation. A summary "polity" measure is then defined as the difference between the democracy and autocracy scores, with 10 indicating "strongly democratic" and –10 indicating "strongly autocratic". As such, this paper uses the polity measure plus ten as an explanatory variable indicating the political regime, with increasing values indicating greater levels of democratic freedom over both time and between nations.

The World Bank provides the balance of the data used in the analysis, including the WDI for GDP, population density, illiteracy, urbanization, and share of the total population under the age of 15 years of age. The income measure is defined as gross domestic product per capita in current dollars, adjusted into PPP terms to account for relative purchasing power in each nation. The illiteracy rate is used as an (inverse) proxy for the education level of the general populace, and the share of total population under the age of fifteen years captures differences in preferences as a result of the demographic structure of the population. Finally, income inequality is proxied by the updated estimates of Gini coefficients compiled by Deininger and Squire (1996)[3]. Summary measures of the variables, as they enter the empirical model, are provided in Table 1.

Issues with regard to specification, estimation, and generalizations abound, as evidenced by the special issue of Ecological Economics (1998) dedicated to the EKC. Empirically, Stern and Common (2001) argue that evidence supporting the EKC hypothesis may be sample-specific and dependent on estimation methods, some of which may lead to omitted variable bias in the parameter estimates. Significant differences have

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[2] See www.bsos.umd.edu/cidcm/inscr/polity.
[3] As this dataset is incomplete, a variety of techniques were applied to fill in the missing data, including truncated linear interpolations and regression of the included GINI values on the rest of the exogenous variables in the system. The results are quite robust to both methods.

also been found between cross-section studies and those that focus on individual countries (Roca, et. al., 2001; Vincent, 1997).

In addition, there are several methodological issues that must be addressed in the estimation procedure, including regressor endogeneity due to parameter heterogeneity, measurement error as result of missing observations, and multicollinearity amongst regressors. Given that we are lucky enough to have a panel data set, the endogeneity and omitted variable problem is handled through estimation of a fixed-effects (or within) model, in which the models described by equations (6) and (7) are estimated via ordinary least squares on deviations from the mean data values for dependent and independent variables (Greene, 2000). The parameter estimates are thus calculated from variance within groups, rather than between groups, and assumes that group-specific intercept terms are fixed parameters to be estimated.

Measurement error is most severe for the Gini coefficients, which are relatively incomplete in a time-series sense in relation to the dependent pollutant data. Ideally, one would like to instrument the inequality variables to avoid potential correlation with the error term in the parametric regression. However, data limitations here prevent such an exercise. Instead, assuming that inequality admits a small variance over time and the series are relatively smooth over time, linear interpolation is used between interior years to complete the series, while incomplete years on either end of the time scale are held constant to the closest year's actual value. The latter technique is employed in order to minimize the introduction of arbitrary trends outside of the original data set.[4]

[4] Of course, any procedure to fill in missing values may introduce either bias or inefficiency into the coefficient values or standard errors. However, the results reported below are robust to alternative techniques, such as regression of the known GINI values on the exogenous variables of the system. Nevertheless, the reader is advised to be cautious.

Finally, multicollinearity is a problem resulting from the introduction of the power terms in the parametric regression and the interaction terms between the income variables and other shifters, leading to inflated standard errors on the highly collinear terms. Unfortunately, there is little in the way of a correction that can be performed, as the flexibility of the functional form is essential to the analysis of the EKC, and is, in fact, the goal of the exercise. Nevertheless, the reader should be cautious in interpreting the econometric results.

5. Results

We begin by examining the results of equation (6), as reported in Table 2 and Table 4. As in Panayotou (1997), this specification assumes that environmental policy can be represented solely by the polity variable, which captures the quality of institutions and openness of the state to the environmental preferences of the populace. This allows us to test the hypothesis of an inverted-U shaped relationship between national income per capita and pollution indicators conditional on the institutional regime, as well as the marginal effect of increasing the quality of the public institutions on environmental quality.

For each of the six pollutants used as dependent variables, the unrestricted fixed-effects model was estimated using the full cubic polynomials in GDP per capita and population density, plus the two policy shifters and a time trend. Individual and joint hypothesis tests were then employed to test for the statistical significance of each of the variables, and those restrictions that were not rejected by the data were imposed. In all cases, a significant relationship between income per capita and pollution was identified in the restricted model, and at least one of the policy shifters appears at the 99% level of confidence.

Of the six regressions, only two support the EKC hypothesis once the proxy for environmental policy is included: biochemical oxygen demand and emissions of non-methane volatile organic compounds, with the latter admitting a turning point outside of the sample range of GDP per capita.[5] Emissions of the ozone-causing NO_X and SO_2 exhibit a cubic relationship with large, positive slopes at low and high levels of income, but smaller marginal effects at moderate levels, possibly turning negative for SO_2 for highly democratic societies. The income and CO_2 emissions relationship is unambiguously positive and linear, while the curve for ambient SO_2 concentrations is U-shaped, with the turning point depending on the level of GDP per capita and polity. These results support the findings of the previous literature; namely, growth in income per capita is *not* sufficient for increases in pollution abatement as nations develop. As emphasized in the statement by Dasgupta and Mäler (1995) quoted in the introduction, conscious choices of environmental policy emanating from civil rights to express preferences are the key to understanding the relationship between economic development and environmental quality.

Testing the effects of the policy proxy on the estimated relationship corroborates this hypothesis. In all cases, the marginal effect of the polity variable with respect to the pollutant is negative for the majority of the income range under consideration, suggesting that more democratic institutions have a greater tendency to reduce pollution. For those measures for which the effect changes sign (BOD, VOC, and SO_2 emissions), it does so

[5] As opposed to the other pollutants, BOD is a measure of the health of a body of water, and as such the EKC relationship is U-shaped, rather than inverted U-shaped.

at relatively low levels of income (less than the 40th percentile of the sample data). It is interesting to note that the level of income corresponding to initial marginal benefits of improved political institutions is lower for the pollutants that more immediately and perhaps more drastically harm the general population than for those with indirect, or latent adverse affects. Thus, the benefits of improved institutions tend to occur at lower levels for water pollution (BOD) than for emissions related to fixed-source industrial pollution (SO_2). It appears that for most policy regimes, the State recognizes the trade-off between industrial development and environmental quality, and for any given level of income is less concerned about abating air pollution from fossil fuel use than water pollution, which more immediately affects the population.

With the recognition that environmental policy considerations are of paramount importance in describing the relationship between economic development and the environment, we turn now to the results of the model described by equation (7). This model decomposes the environmental policy indicator variable in order to account for both the heterogeneous preferences of the society *and* the mechanism through which these preferences are translated into realized pollution abatement. As with the previous model, the unrestricted full specification was estimated first, with subsequent restrictions imposed given the results of individual and joint significance tests. Results of the restricted model are reported in Table 3, while qualitative characterizations of the effects of the preference and governance variables are reported in Table 5.

Overall, the proportion of the variance in each dependent variable explained by the decomposition model increases with the expanded specification, and each preference shifter is statistically significant in at least four of the six regressions. As expected, the relationship between GDP per capita and the pollution measures is similar to that estimated in the basic model, although the CO_2 model now includes second and third degree polynomial terms, while the SO_2 emissions model excludes them. Nevertheless, the similarity in conditional results suggests that the decomposition is valid, and that demand considerations based on heterogeneous societal preferences are an important determinant of overall environmental quality.

The last row of Table 5 shows that marginal impacts of increased democracy on five of the six indicators are negative when evaluated at the sample means, as in the basic model. This again confirms that increased institutional quality tends to increase environmental quality. The exception is the estimated positive effect of increased democracy on water pollution when evaluated at the mean of the sample. Examination of the BOD coefficients in Table 3 suggests that this relationship is reversed for relatively literate or relatively young societies. In conjunction with the a priori expectations regarding the environmental preferences of these groups, this result supports the hypothesis that the institutional structure is the conduit through which environmental preferences are exercised. From a policy standpoint, strengthening the quality of institutions through democratization appears to be positively correlated with environmental quality, while degrading such institutions erodes the responsiveness to societal preferences, resulting in greater levels of pollution.

We now turn to the effects of the individual preference shifters on the pollution indicators, conditional on the state of the institutions in a given society. As seen in Table 3 (and repeated in Table 5), urbanization has an unambiguous net positive effect on BOD, and this relationship is unaffected by levels of polity or GDP per capita. On the other hand, urbanization is positively correlated with both the emissions and ambient concentrations of the air pollution measures, suggesting that the effects of increased fossil fuel use in urban societies dominates any economies of scale or preference effects. However, preference effects are evident through the significant negative interaction terms in Table 3, as the positive effects of urbanization on ambient concentrations of SO_2 and emissions of NO_X are mitigated through increased democracy (and in the case of NO_X, income). However, the positive marginal effects of urbanization are exacerbated by increases in polity and/or income for SO_2, VOC, and CO_2 emissions, as seen in the first row of Table 5. While the reasons behind these findings are plausible in the light of the theoretical model above, they are not intuitively obvious. It may be that individuals in urban areas are more sensitive to ambient concentrations than emissions, or that urban societies are more tolerant of some types of air pollution than are rural societies. Indeed, the nature of the urbanization variable makes it extremely difficult to disaggregate the potential effects, and the reduced-form equation worsens the situation, as we are only able to identify net effects of the shifter.

Another abatement demand shifter widely discussed (and disputed) in the literature is income inequality, as it is hypothesized that the distribution of income may play a role in the income/environment relationship. In this application, the proxy for income inequality, the GINI coefficient, is found to be statistically significant in four of the six regressions, as indicated in Tables 3 and 5. In the case of ambient SO_2 concentrations, the estimated coefficient of the interaction term between income inequality and polity is positive, implying that increased inequality increases pollution levels, and the effect is stronger the more democratic the societal institutions. In terms of the theoretical model presented by equation (5), we have $\frac{\partial\left(\hat{E}/\gamma\right)}{\partial\left(\gamma_1/\gamma\right)} = \alpha_1 e_1\left(\gamma_1\right) - \alpha_2 e_2\left(\gamma_2\right) < 0$; so that, interpreting $\frac{\gamma_1}{\gamma}$ as the national income share of the wealthy and assuming that the wealthy have a higher propensity to demand environmental quality ($e_1(\gamma_1) > e_2(\gamma_2)$), this result suggests that the weight given to the privileged few in democratic societies (α_1) is small relative to that assigned to the less advantaged group (α_2). We find similar results for emissions of two of the three ozone-creating chemicals (see the last three columns of the second row of Table 5), although the relationship is conditional on a fairly high level of aggregate income per capita. At lower levels of income, it may be that the extremely wealthy are given much higher consideration and/or are considerably more powerful in poorer nations.

On the other hand, Table 5 shows that emissions of CO_2 exhibit the opposite relationship, as increased inequality for levels of income slightly greater than $5,000 PPP is associated with decreased CO_2 emissions. Interestingly, a distinction can be made here between greenhouse gasses (such as CO_2) and the ozone and acid rain generating chemicals (such as SO_2, VOC, and NO_x). The latter pollutants most often exhibit an EKC relationship due to the nature of the damage (primarily local), as opposed to carbon compounds which are global in nature (Stern and Common, 2001; Shafik, 1994; Ansuategi and Escapa, 2001). One explanation for this intriguing result, then, may be that governments weight particular interest groups differently depending on the particular effects of the pollutant and the length of run under consideration. In this case, the State places a higher weight on those with high propensities to prefer environmental quality (the rich), perhaps due to lobbying activities or the lack of interest in the issue shown by the poorer members of society.

A similar pattern manifests itself in terms of the age distribution of the society, as measured by the percentage of the population less than fifteen years of age. A priori, it is expected that “younger” societies would prefer a cleaner environment and be willing to invest in pollution abatement for longer-run improved quality than would those societies that would be considered “older”. As seen on the “Youth” row of Table 5, this expectation is confirmed for the NO_x and VOC emissions regressions, in that the percentage of children as a proxy for age distribution is negatively correlated with emissions for these chemicals. The relationship is reversed only for SO_2 emissions with very high GDP per capita at levels (achieved by only 5% of the observations in the sample). A similar result holds for water pollution, and the relationship for three out of these four pollutants is exacerbated by increases in the democracy measure. Again, however, CO_2 emissions are predicted to increase with the category presumed to have a relative preference towards environmental quality, and this marginal effect is intensified with increases in GDP per capita. It thus appears that the nature of the pollutant may affect the weights, and thus the rate, at which preferred environmental policy is translated to realized environmental policy.

The last preference shifter under consideration is the education of the populace, as proxied by the illiteracy rate for adults greater than fourteen years of age. As seen in Table 3, at least one education term is significant in all of the emissions regressions, though no significant correlation could be determined for ambient SO_2. However, the sign of the marginal effects of illiteracy on environmental quality, as qualitatively reported in Table 5, may require additional explanation. First, note that for income per capita levels generally *less* than the mean of the sample, illiteracy enters the model with the expected sign (a negative correlation between illiteracy and environmental policy). While in four cases the marginal effect changes sign at relatively higher income levels, this result has little economic meaning. Specifically, it is difficult to imagine a scenario of high per capita income and high illiteracy rates, nor there exist data points in the sample consistent with this pattern. We conclude that in the relevant range of per capita income levels, more education, as proxied by a decline in the illiteracy rate, results in a *greater* demand for environmental quality, but does so at a decreasing rate.

6. Conclusions

This paper has investigated the link between income per capita and environmental quality. Recognizing that the often- cited "inverted U-shaped" relationship or EKC is not an inevitable result of growth in income, a structural model was developed that specifically accounted for different environmental policy regimes. The regime was identified as a function of governance and preference variables, with preferences for environmental policy exercised through interactions with the political system.

Results of the exercise do not support the basic EKC hypothesis that suggests growth in the economy alone is sufficient for increases in environmental quality. Instead, it was shown that in addition to the state of development in general, the qualities of political institutions and several indicators of societal preference interact with each other to create the inverted-U shape, which is frequently cited in the environment-development literature. Estimates of individual effects for each of the included preference shifters support the hypothesis that more democratic governments respond favorably to environmental demands by the populace. Further research, especially with regard to mechanisms through which preferred policy is related to actual policy, is needed to determine the extent of these linkages. Furthermore, the assumption of an exogenous political system and income distribution themselves may need to be relaxed. Finally, direct estimation of a structural system that accounts for feedbacks between the economy, environment, and institutions, while fairly complex, would be valuable in formulation of future environmental policy.

Table 1: Summary Statistics of Primary Explanatory Variables

Variable	*Units*	*# Obs.*	*Mean*	*Std. Dev.*	*Min*	*Max*
CO_2 [a]	emissions, kg per capita	622	2,680.34	3,670.19	29.05	19,336.53
BOD [a]	emissions, kg/day/worker, organic water pollution	694	187.52	44.75	90.00	380.00
NOx [a]	emissions, '000 metric tons per million persons	225	39.90	20.29	6.04	97.66
VOC [a]	non-methane emissions, '000 metric tons per million persons	151	49.60	51.39	0.64	251.90
SO_2 [a]	emissions, '000 metric tons per million persons	226	58.13	49.66	3.98	309.27
$GEMSSO_2$ [b]	ambient concentration, parts per million	275	15.55	12.47	0.30	78.00
GDP [b]	000 Current PPP$	275	7.47	5.36	0.44	23.63
Popden [b]	00,000 persons / sq. km.	275	0.11	0.12	0.00	0.43
Polity [b]	index, 0 (autocratic) - 20 (democratic)	275	15.79	6.63	1.00	20.00
Urban [b]	% population	275	61.71	23.64	14.18	96.10
Gini [b]	index, 0 (equal) - 100 (unequal)	275	36.10	8.16	19.90	59.00
Youth [b]	% population 14 yrs or under	275	0.29	0.08	0.18	0.50
Illit [b]	% population 15 yrs and above	275	12.38	16.42	0.00	72.85
Year [b]		275	1982.55	4.37	1975	1992

[a] CO_2, BOD, NOx, VOC, and SO_2 emissions statistics for full sample.

[b] Remaining statistics summarized for $GEMSSO_2$ observations.

Table 2: Basic EKC Model using Polity as Policy Proxy, Fixed Effects

	Dependent Variable					
	CO_2	*BOD*	*NOx*	*VOC*	SO_2	$GEMSSO_2$
GDP	472.8**	-15.62**	9.877**	14.70**	25.23*	--
	(42.09)[a]	(2.072)	(1.610)	(2.878)	(10.63)	
GDP^2	--	0.781**	-0.400**	-0.125**	-1.037	0.118**
		(0.158)	(0.103)	(0.043)	(0.573)	(0.030)
GDP^3	--	0.017**	0.006*	--	0.026*	--
		(0.004)	(0.002)		(0.013)	
Popden	49.55**	--	--	-68.86**	-103.75**	423.00**
	(17.80)			(20.78)	(29.38)	(114.67)
$Popden^2$	-0.090**	--	--	2.032**	3.684**	--
	(0.021)			(0.709)	(1.010)	
$Popden^3$	--	--	--	0.020**	-0.037**	--
				(0.008)	(0.011)	
Polity	--	-0.498**	-0.192**	1.975**	3.235**	--
		(0.222)	(0.099)	(0.796)	(1.680)	
*Polity*GDP*	-8.30**	0.177**		-0.506**	-0.585**	-0.175**
	(1.30)	(0.047)		(0.140)	(0.306)	(0.279)
Year	-31.00**	0.910**	-1.690**	-0.259**	-3.405**	-0.471**
	(7.65)	(0.21)	(0.24)	(0.60)	(1.10)	(0.28)
R^2	0.232	0.106	0.440	0.313	0.439	0.140
$Prob > F^b$	0.24	0.34	0.67	0.31	--	0.93
N	586	670	205	138	206	275
M	92	81	30	25	30	32

* denotes significance at the 5% level, ** at the 1% level.

[a] Standard errors in parentheses.

[b] Joint p-value for imposed zero restrictions.

Table 3: Extended EKC Model, Policy Regime Decomposition

	Depdendent Variable					
	CO_2	*BOD*	*NOx*	*VOC*	SO_2	$GEMSSO_2$
GDP	728.31**	-14.54**	6.608**	14.193**	14.046*	--
	(114.84)[a]	(2.19)	(1.627)	(2.036)	(6.323)	
GDP^2	-51.99**	0.856**	-0.345**	-0.089*	--	-0.090
	(13.73)	(0.160)	(0.117)	(0.035)		(0.047)
GDP^3	1.438**	-0.018**	0.006*	--	--	0.004*
	(0.495)	(0.004)	(0.003)			(0.002)
Popden	143.85**	--	-23.410**	--	-121.77**	3.803**
	(35.06)		(5.486)		(31.649)	(1.187)
$Popden^2$	-0.753**	--	1.595**	--	4.475**	--
	(0.227)		(0.285)		(1.101)	
$Popden^3$	0.0009**	--	-0.020**	--	-0.048**	--
	(0.0003)		(0.003)		(0.011)	
Polity	-380.35**	--	--	-12.819**	16.850**	--
	(42.89)			(2.120)	(4.064)	
Urban	--	0.643*	2.460**		7.985**	1.553**
		(0.303)	(0.284)		(1.218)	(0.527)
*Gini*Polity*	1.779**	--	--	-0.070*	-0.269**	0.022*
	(0.535)			(0.030)	(0.055)	(0.009)
*Youth*Polity*	350.64**	--	-5.185**	-22.969**	-31.324**	--
	(90.17)		(0.825)	(4.363)	(10.817)	
*Urban*Polity*	1.463**	--	--	0.359**	--	-0.053*
	(0.386)			(0.037)		(0.025)
*Illit*Polity*	2.028**	--	0.073**	0.359**	0.572**	--
	(0.454)		(0.015)	(0.117)	(0.105)	
*Polity*GDP*	--	--	0.263**	-0.648**	-1.801**	--
			(0.038)	(0.106)	(0.405)	
*Gini*Polity*GDP*	-0.351**	--	--	0.007**	0.020**	--
	(0.126)			(0.002)	(0.004)	
*Youth*Polity*GDP*	84.96**	0.511*	--	--	1.794**	--
	(21.04)	(0.099)			(0.410)	
*Urban*Polity*GDP*	--	--	-0.002**	--	0.005*	--
			(0.000)		(0.002)	
*Illit*Polity*GDP*	-0.484*	-0.013*	-0.011**	-0.057**	-0.075**	--
	(0.192)	(0.00)	(0.003)	(0.009)	(0.018)	
Year	-37.26**	0.652*	-2.334**	-3.042**	-6.006**	-0.835**
	(9.233)	(0.240)	(0.196)	(0.465)	(1.220)	(0.308)
R^2	0.354	0.136	0.684	0.659	0.585	0.171
Prob > F	0.25	0.40	0.54	0.93	0.36	0.70
N	585	669	204	139	206	275
M	92	81	29	26	30	32

* denotes significance at the 5% level, ** at the 1% level.

[a] Standard errors in parentheses.

[b] Joint p-value for imposed zero restrictions.

Table 4: Qualitative Characterization of Basic Models
Existence of EKC and Effect of Polity

	Dependent Variable					
	CO_2	*BOD*[a]	*NOx*	*VOC*	*SO_2*	*$GEMSSO_2$*
EKC Relationship?	No	Yes	No	Yes	No	No
Turning Point	linear	6.731	increasing cubic	26.79	cubic, decreasing section w/ large polity	U-shaped quadratic
Slope varies with	Polity	GDP, Polity	GDP	GDP, Polity	GDP, Polity	GDP, Polity
Slope at Means	341.8	1.696	4.843	4.842	4.883	-1.001
Change w.r.t. Polity[b]	- slope only	+ for GDP>2.812	- intercept only	- for GDP>3.906	- for GDP>5.527	- slope only

[a] BOD is a measure of the health of a body of water, therefore EKC is U-shaped.

[b] Net effect of intercept and slope shifters

Table 5: Qualitative Characterization of Regime Decomposition Models
Effect of Preference Shifters on Pollutant Measures

	Dependent Variable					
	CO_2	BOD[a]	*NOx*	*VOC*	SO_2	$GEMSSO_2$
Urban	+	+	+	+	+	+
	incr. in Pol	constant	decr. in GDP or Pol	incr. in Pol	incr. in GDP or Pol	decr. in Pol
Gini	+	n/a	n/a	+	+	+
	for GDP<5.068			for GDP>10.000	for GDP>13.450	incr. in Pol
Youth	+	+	-	-	-	n/a
	incr. in GDP	incr. in GDP or Pol	decr. in Pol	decr. in Pol	for GDP<17.460	
Illit	+	-	+	+	+	n/a
	for GDP<4.190	decr. in GDP or Pol	for GDP<6.636	for GDP<6.298	for GDP<7.626	
Polity[b]	-	-	-	-	-	-

[a] BOD is a measure of the health of a body of water, therefore EKC is U-shaped.

[b] Evaluated at sample mean values.

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