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Democracy, Income, and Environmental Quality

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Democracy, Income, and Environmental Quality

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Abstract

This paper considers the role of democracy in environmental quality and the Environmental Kuznets Curve (EKC). Some studies in the EKC literature have examined the extent to which democratic nations are more or less apt to have improving environmental conditions, but they have drawn from static measures of a nation's current regime. In this paper we examine panel data from 1960 to 2001 and analyze the extent to which both the current level and the stock of a country's democracy have significant and independent effects on a nation's sulfur and carbon dioxide emissions. While we find no evidence for the short-run effect of the current level of democracy, we find strong evidence that long-term democracy stock helps lower sulfur and carbon dioxide emissions.

Keywords: Environmental Kuznets Curve; political economy of environment; sulfur emissions; carbon dioxide emissions; democracy; democracy stock; democracy and environment

1. Introduction

Why do some countries pollute more than others? Why and how do countries' pollution levels change over time? A great deal of both scholarly and policy work has paid increasing attention in recent years to the relationship between rising incomes and environmental quality. A hypothesis has emerged in this burgeoning literature that initial increases in a nation's income may have an adverse effect on environmental quality, but that environmental conditions will subsequently improve as income increases over time (the Environmental Kuznets Curve, or EKC). A handful of new studies have presented an alternative hypothesis that the level of a nation's democracy is also an important determinant of environmental quality. In democracies, these scholars argue, those affected by and concerned with the environment will have a greater voice in political decision making and will put pressure on governments and businesses to clean up their act—and the environment.

This paper reassesses the EKC relationship and considers it in conjunction with the hypothesis that democracy may improve environmental quality. More specifically, we introduce the concept of “democracy stock” to that literature. Democracy stock refers to the accumulation and evolution of democratic institutions over time. A few studies in the EKC literature have examined the extent to which democratic nations are more or less apt to have improving environmental conditions. However, such studies have typically drawn from static measures of the level of a nation's democracy at a given point in time to perform their analyses. This paper is the first that we are aware of in the EKC literature to analyze the concept of democracy stock. Within political science, we believe it to be the first to consider the impact of democracy stock on the environment. This paper examines panel data from 1960 to 2000 to analyze the extent to which both the current level and stock of a country's democratic history—the accumulation and strength of democracy over time—have had significant and independent effects on nations' sulfur and carbon dioxide emissions.

We find little evidence to support the argument that the current level of democracy is associated with environmental improvement, but substantial evidence that a long history of strong democracy can help reduce pollution emissions. In short, democracy matters, but only in the long run.

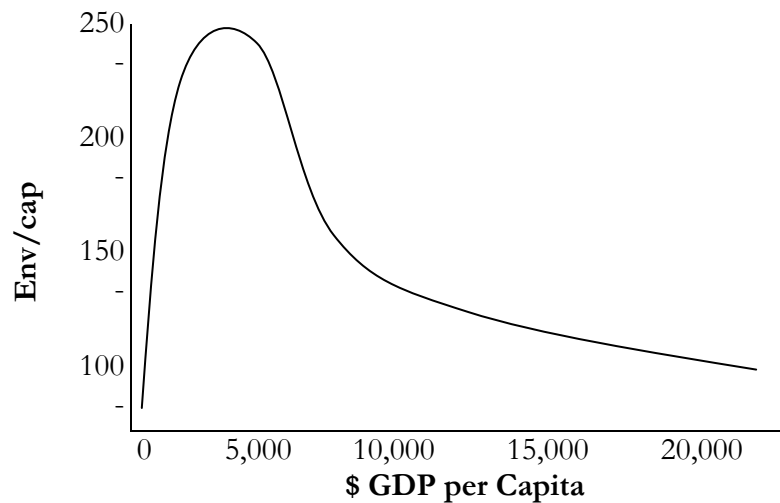
Following this brief introduction the next section of the paper provides a short overview of the EKC literature and is followed by a section on the relatively smaller subset of works that deal with the democracy and environment question. The fourth section of the paper introduces our methodology and data, while the fifth discusses our results. The final section of the paper summarizes our findings and draws out lessons for future research and policy.

2. The Determinants of Environmental Quality

Any contemporary empirical investigation that aims to identify the cross-national determinants of environmental quality must first situate itself within the EKC literature. The EKC invokes the landmark work of Simon Kuznets (1963). Kuznets published a highly influential study implying that growth in per capita income over time first increases inequality, then later decreases it. Development policymakers evoked this theory for decades to argue that inequality could be ignored in the short term.

In a now-classic study attempting to estimate the environmental impacts of the North American Free Trade Agreement (NAFTA) in Mexico, Grossman and Krueger (1995) reported a similar relationship between environmental degradation and levels of income—hence the term Environmental Kuznets Curve. As countries begin to raise their incomes, rates of natural resource depletion and environmental pollution should proceed rapidly. As incomes reach higher levels later in time, they are able to lower their levels of environmental degradation. Figure 1 depicts this relationship graphically.

Figure 1. The Environmental Kuznets Curve



Perhaps even more illuminating than the empirical findings are the theoretical insights these authors postulated to explain this inverted-U relationship between environment and growth. They identified three mechanisms by which rising incomes could affect the environment: scale, composition, and technique effects. Scale effects occur when liberalization causes an expansion of economic activity. If the nature of that activity is unchanged but its scale is growing, then pollution and resource depletion will increase along with output.

Composition effects occur when increased trade leads nations to specialize in the sectors where they enjoy a comparative advantage. When comparative advantage derives from differences in environmental stringency, the composition effect of trade will exacerbate existing environmental problems in the countries with relatively lax regulations. Race-to-the-bottom discussions are perfectly plausible in this vein of economic theory. The Heckscher-Ohlin (H-O) theory in trade economics postulates that nations will enjoy a comparative advantage in those industries that use their abundant factors intensively. Applying the H-O theory to pollution, it could be argued that a country with less stringent environmental standards would be factor-abundant in the ability to pollute. Therefore, trade liberalization between a country with more stringent regulations and one

with more lenient rules may lead to an expansion in pollution-intensive economic activity in the nation with the lesser regulations. The country with the less stringent regulations, often a developing nation, becomes a “pollution haven” for pollution intensive economic activity (Copeland and Taylor, 2003).

Technique effects, or changes in resource extraction and production technologies, can potentially lead to a decline in pollution per unit of output over time for two reasons. First, multinational corporations may transfer cleaner technologies to developing countries. Second, if income levels increase, newly affluent citizens may demand (and be able to afford) a cleaner environment. (Of course, such an argument implies a heretofore poorly understood or substantiated political mechanism for the transmission of such demands.) These three effects interact together to form an inverted U: while growth (scale) will increase pollution, composition and technique effects will counteract those effects.

A wide literature has developed around the notion of the EKC, and it is not well understood in policy circles. Early EKC studies predicted the “turning point” (the peak of the inverted U depicted in Figure 1) at which environmental degradation may begin to decline to fall between \$3,000 to \$5,000 GDP per capita in 1985 PPP terms. The first EKC study, by Grossman and Krueger, examined ambient concentrations of sulfur, smoke, and particulate matter. They found turning points between \$4,000 and \$5,000 for sulfur and smoke, and an even lower turning point for particulates. Early EKC analyses were also published as part of the World Bank’s *World Development Report* (1992). In that volume, the turning points for ambient concentrations of sulfur and particulate matter ranged from \$3,000 to \$4,000 GDP per capita. Such levels are quite close to mean global income.

The standard EKC structural model has become:

(1)

$$POL = f(Y, Z)$$

where POL is the level of pollution, Y is the level of income per capita, and Z is a vector of non-economic determinants of pollution levels. The regression models that examine these relationships more often than not use panel data and fixed effects models that are usually some variation of:

(2)

$$\ln(POL / P)_{it} = x_{it} + \beta_1 \ln(Y / P)_{it} + \beta_2 (\ln(Y / P))_{it}^2 + \varepsilon_{it},$$

Where P is population, \ln is the natural logarithm, i are countries, t are years. Numerous control variables and non-economic factors (Z) are also added as independent variables. The formula to calculate the turning point incomes where pollution per capita begins to decline with income is:

(3)

$$\tau = \exp(-\beta_1 / (2\beta_2)).$$

Many policy advocates and policymakers have generalized from the EKC to argue that the environment can wait, because economic growth will eventually (and naturally) result in environmental improvements. According to the academic literature, such claims are often misconstrued. Five qualifications characterize the empirical evidence on the EKC (for comprehensive reviews see Stern, 2004):

- **Evidence for an EKC is limited to a small number of pollutants.** Thus far, evidence for an EKC relationship has been consistently found for ambient concentrations of localized air pollutants in OECD countries. In particular, EKC's have been identified for pollutants such as sulfur and particulate matter. The EKC relationship may exist for such (criteria) pollutants because their effects are more localized and subject to regulation. For many other environmental problems, such as water pollution, municipal waste, carbon dioxide, and energy use, evidence of an EKC relationship has been questionable.

- **Evidence for the EKC may be limited to the experience of developed nations.** Most of the studies that have found an inverted-U relationship have datasets dominated by or exclusive to OECD countries. In the smaller number of studies representative of the developing nations, evidence for an inverted-U relationship has been ambiguous. There is also a fallacy of composition insofar as the exit of polluting industries drives the composition effect in the OECD. The ability of rich countries to lower pollution through this mechanism does not imply that all countries can do the same, or that global emissions are falling with OECD growth.
- **The range of turning point estimates is now significantly higher than original estimates.** Although some of the original studies had turning points in the \$3,000 to \$5,000 range, a number of studies have predicted much higher turning points. For example, studies have found turning points of \$14,730 and \$22,675 for sulfur, \$9,800 for particulate matter, and \$35,000 for carbon dioxide. In some cases, a second wave of environmental degradation occurred at higher levels of income. Grossman and Krueger found that at income levels between \$10,000 and \$15,000 that levels of environmental degradation began to increase again. These studies suggest that environmental degradation could rise for decades before “turning around”—if it ever does.
- **Other significant factors, aside from national income, are important drivers of environmental change.** Variables such as population density, income inequality, economic structure, historical events (such as the oil price shocks of the 1970s), and the degree of political freedom and democracy in a nation have been found to be significantly correlated with levels of environmental degradation, in addition to or more importantly than income. These findings imply that environmental degradation, if it does decline, will not decline automatically as economic growth proceeds.

It is to one these “other” determinants of environmental quality—political democracy—that we now turn.

3. Democracy and Environmental Quality

As discussed in the previous section, recent EKC studies have paid increasing attention to determinants of environmental quality other than national income. A small but important number of these studies have examined the extent to which a nation’s level of democracy has a significant and independent effect on environmental quality. This section of the paper reviews theoretical and empirical contributions to this element of the environmental quality debate and generates the working hypotheses tested in the empirical analysis to follow.

It has become almost commonplace among policymakers to assert a positive, fruitful relationship between democracy and the environment. Indeed, Albert Gore, the 2007 Nobel Peace

Prize winner and perhaps the most well known public official advocate of environmental protection, has said that “an essential prerequisite for saving the environment is the spread of democratic government to more nations of the world” (Gore 1992, 179).

While such assertions alone do not provide the basis for a plausible theory of democracy and the environment, the theoretical literature generally does lend them some support. The most direct treatment of the subject from the political science literature comes from Payne (1995), who argues four essential reasons why more democratic governments will yield better environmental outcomes:

- 1) *Accountability*. Democratic governments are more accountable. Thus, the environmental concerns of constituents cannot be ignored.
- 2) *Information*. Democracies tend to facilitate greater access to information. Free presses and other forms of information will enable citizens to be more informed about environmental issues and discoveries.
- 3) *Civil society*. Environmentalists are more apt to associate in democracies. Where freedom of speech and association exist, citizens are more likely to organize on environmental issues and pressure governments.
- 4) *International cooperation*. Democratic governments cooperate more amongst themselves and are therefore more likely to collaborate on international treaties to protect the environment.

Other work has stressed the importance of institutional development, especially over time (Gerring, Thacker and Alfaro 2007). According to this line of thought, democracy tends to generate wider-reaching, more effective political institutions. To the extent that strong institutions are a necessary prerequisite for governmental environmental protection initiatives, long-standing democracies would appear to hold distinct advantages over newer, less institutionalized democracies and personalistic dictatorships.

These advantages of democratic rule do not necessarily accrue immediately. It takes time, and democratic depth, for the mechanisms of accountability to be established; for freedom of information and the press to generate a culture of an informed, inquisitive society; for the freedom of association to help generate a strong civil society environmental movement; for democracies to develop compatible, cooperative foreign policies that might generate international agreements to

protect the environment; and for democratic institutions to stabilize, develop, grow and take on added responsibilities in the environmental arena. Given such constraints, we surmise that democracy is best considered as a cumulative stock rather than as a level at a given moment in time. Both the history and degree of democracy in a country must be jointly considered if we are to capture its full causal impact.

Other scholars claim that democracies will be more apt to have degraded environments. Desai (1998, 11) has argued that “as democracy is dependent on economic development, and since economic growth and prosperity generally result in environmental pollution and ecological destruction, democracy would not necessarily be protective of the environment.” This argument, however, says little about the independent effects of democracy, separate and apart from income.

Over the past decade a small number of scholars have begun to test empirically the relationship between democracy and environmental quality in an EKC framework. By and large, all of them support the view that democratic countries tend to have lower levels of environmental degradation, but none considers democracy as an historical phenomenon. The majority of these studies econometrically examine cross-sectional or panel data in an EKC framework and add a contemporaneous measure of democracy as an independent variable. These studies hypothesize and find (with a few exceptions) a statistically significant and positive correlation between democracy and environmental quality. In other words, in any given year a democracy will experience decreasing (or less) pollution than non-democracies. But none of these studies controls for a country’s history with democracy when testing the impact of its current level of democracy on the environment, and many are quite limited in their geographic scope and time frame.

Three of the earliest studies examining the relationship between democracy and the environment came up with results that differed with respect to the type of environmental medium under analysis. Torras and Boyce (1998) examined the effect of democracy on levels of sulfur

dioxide, smoke, heavy particles, water pollution, and the percentage of the population with access to safe drinking water. They found that their democracy variable (taken from Freedom House) was statistically significant and associated with environmental improvement in the majority of cases for low-income countries. Scruggs (1998) used similar data to examine fecal coliform, particulate emissions, and dissolved oxygen and came to similar findings. On a different set of pollutants, however, Midlarsky (1998), using a variety of indices, found that democratic countries tend to protect a higher percentage of their land area, but also have higher carbon dioxide emissions and deforestation rates.

Barrett and Graddy (2000) find that countries that are more democratic tend to have lower levels of sulfur dioxide emissions, smoke, particulates, arsenic, and lead. Harbaugh and colleagues (2002) identified a statistically significant relationship between democracy and reduced sulfur dioxide, smoke, and particulates. Neumayer (2002) essentially tests Payne's hypothesis that democratic governments will be more apt to collaborate with each other on environmental issues. Using a number of indices of democracy, he found that democracies sign and ratify more multilateral environmental agreements and participate more in various international environmental forums. A more recent paper by Farzin and Bond (2006) finds democracy associated with lower levels of carbon dioxide, nitrogen oxides, volatile organic compounds, and sulfur dioxide.

4. Data and Method

This section of the paper describes our approach to investigating the extent to which democracy affects the level of environmental quality. First, we discuss the limitations of existing analyses on this topic. We then present a rationale for introducing measures of a country's "stock" of democracy in addition to using the type of measures employed in previous studies. Third, we introduce the model we will be testing and the data used for our empirical analysis.

Consensus seems to be growing around the notion that politics is closely linked to the level of environmental quality that countries enjoy, but such arguments are still relatively underdeveloped compared to the EKC and other findings. Our analysis builds on and deepens this previous work by introducing a cross-national measure of the stock of a democracy over time.

To measure democracy, we employ the Polity2 measure from the latest Polity IV dataset (see Marshall and Jaggers 2000). This variable measures the extent to which democratic or authoritarian “authority patterns” are institutionalized in a given country. It takes into account how the executive is selected, the degree of checks on executive power, and the form of political competition. The Polity2 ranking combines each country’s Authoritarianism and Democracy scores and ranges from -10 to 10, with 10 being the most democratic (a fuller discussion of the Polity methodology can be found at www.cidcm.umd.edu/polity).¹ Along with the Freedom House measures of democracy, the Polity variable is the most commonly used in the literature. Though not perfect, it correlates highly with other existing measures of democracy and appears therefore to have a high degree of external validity.²

To create our stock measure of democracy we sum each country’s Polity2 score from 1900 to the observation year, applying a one percent annual depreciation rate going back in time. This means that a country’s regime stock stretches back over the course of the entire twentieth century, but that more distant years receive less weight than recent ones. Our expectation is that the causal

¹ To facilitate time-series analysis, the Polity2 measure fills in scaled Polity scores for observations that occur during political interregnums and transitions, which would otherwise be treated as missing values. See <http://www.cidcm.umd.edu/polity/data/> for details. To correct for Polity2’s exclusion of micro-states, an omission that might bias our sample, we impute democracy scores for these excluded cases using other democracy indices that are conceptually and empirically close to the Polity2 measure. These measures include: a) the Freedom House Political Rights indicator (http://freedomhouse.org/template.cfm?page=351&ana_page=333&year=2007), b) Ken Bollen’s Liberal Democracy variable (Bollen 1993), c) Tatu Vanhanen’s Competition variable (Vanhanen 1990), d) Arthur Banks’s Legislative Effectiveness variable, and e) Banks’s Party Legitimacy variable (Banks 1994). These measures of democracy take into account the degree to which citizens can participate freely in the political process, the extent of suffrage, the competitiveness of national-level elections, the degree of party competitiveness, and the degree to which the legislature affects public policy.

² Correlations between Polity2 and other common democracy indices are as follows: “Political Rights” (Freedom House) = -0.85; “Liberal Democracy” (Bollen) = 0.92; “Democracy index” (Vanhanen) = 0.85.

effect of democracy, like other capital stocks, cumulates but depreciates over time. We choose the year 1900 as a threshold period that ushered in a period in which mass democracy becomes a world-historical phenomenon (no longer restricted to the U.S. and a few European states). We choose a one percent depreciation rate because it seems a reasonable estimation of how a long-run historical effect might play out, but the use of different rates of depreciation has little effect on results (not reported).

Because the historical component of this index weighs heavily on our understanding of the concept and because the Polity dataset ignores non-sovereign states in its coding procedures, we supplement the Polity2 coding with our own coding of several nation-states that were previously part of contiguous empires. This procedure assigns values to currently sovereign countries that were not independent during prior periods included in the calculation of the democracy stock variable. The procedure is as follows. For each year that a nation-state belonged to a contiguous imperial power it receives the same Polity2 score as its imperial ruler; e.g., Estonia receives the same score as the Soviet Union from 1941 through 1990. We use this procedure only for nation-states contiguous with the empire to which they previously belonged. We assume that contiguous colonies are likely to be governed in the same manner as the imperial power itself, a dynamic less likely to be true for overseas colonies.³

Other studies have found a much more robust relationship between democracy stock and development than between democracy level and development. Examples include Gerring et al.

³ This re-coding affects the following countries: Albania (1900-1912, Ottoman Empire), Andorra (1900-present, France), Armenia (1900-1990, Russia/USSR), Azerbaijan (Russia/USSR 1900-1990), Belarus (Russia/USSR, 1900-1990), Bosnia-Herzegovina (1908-1917, Austria-Hungary; Yugoslavia 1929-1991), Croatia (1900-1917, Austria-Hungary; Yugoslavia 1929-1991), Czech Republic (1900-1917, Austria-Hungary), Slovakia (1900-1917, Austria-Hungary), Estonia (1900-1916 and 1941-1990, Russia/USSR), Finland (1900-1916, Russia), Georgia (1900-1990, Russia/USSR), Iraq (1900-1917, Ottoman Empire), Israel (1900-1917, Ottoman Empire), Kazakhstan (1900-1990, Russia/USSR), Kyrgyzstan (1900-1990, Russia/USSR), Latvia (1900-1917 and 1941-1990, Russia/USSR), Lithuania (1900-1917 and 1941-1990, Russia/USSR), Macedonia (1922-1990, Yugoslavia), Moldova (1900-1945, Romania; 1946-1990, USSR), Mongolia (1900-1920, China), Bangladesh (1947-1971, Pakistan), Slovenia (1900-1917, Austria-Hungary; Yugoslavia 1929-1991), Syria (1900-1917, Ottoman Empire), Tajikistan (Russia/USSR, 1900-1990), Turkmenistan (1900-1990, Russia/USSR), Ukraine (1900-1917 and 1920-1990, Russia/USSR), Uzbekistan (1900-1990, Russia/USSR), and East Timor (1976-1999, Indonesia).

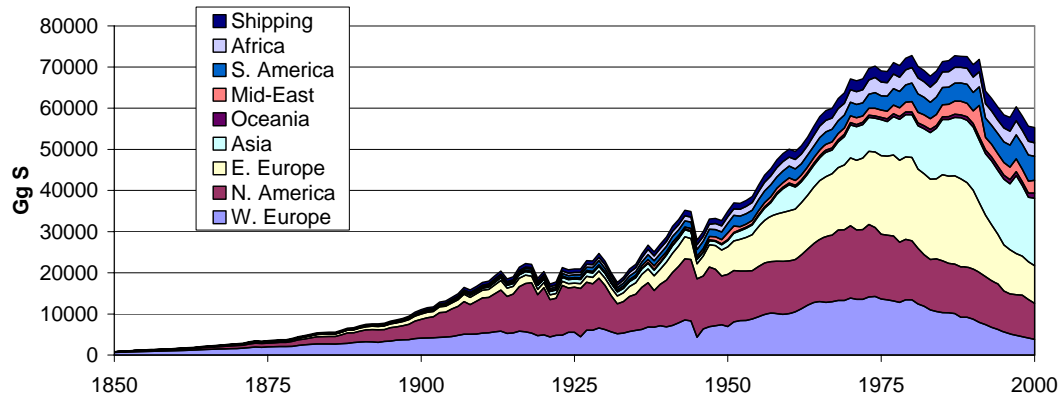
(2005), who find that democracy stock increases the rate of economic growth. Gerring, Thacker and Alfaro (2007) find similar results in the case of human development, with democracy stock effectively lower infant mortality rates. Beer (2007) finds that democracy stock is associated with improved gender equality, and Brown (2007) links democracy stock to human capital and education. Finally, Thacker (2007) finds a strong relationship between democracy stock and market-oriented economic policies.

We build upon these recent advances in the political science literature by applying the democracy stock hypothesis to the environment. To what extent does the stock of democracy in a given country affect its environmental quality over time? How does this effect compare to that of the level of democracy at a given moment in time? Does democracy yield environmental benefits immediately, or are these salutary effects more likely to emerge as a result of the accumulation of strong democratic rule over time?

The environmental quality variables that we analyze are sulfur and carbon dioxide emissions. Sulfur is emitted from the combustion of coal and petroleum and contributes to smog and localized air pollution, acid rain, and global climate change. We choose sulfur because of its characteristics as both a global and localized problem, and because of the availability of data. As shown in Figure 2, global sulfur emissions have peaked in the world and are now on the decline.

Figure 2:

Global Sulfur Emissions 1850-2000

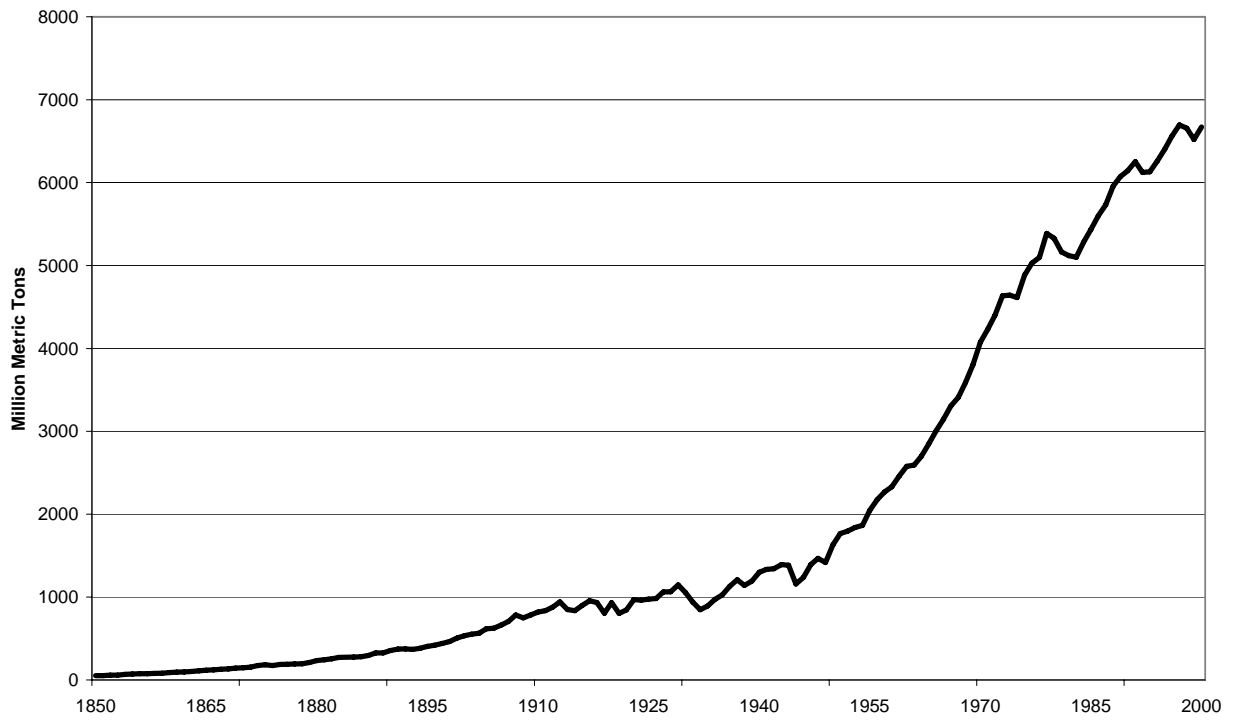


Source: Stern, 2005

Figure 3 presents global carbon dioxide emissions during the same period, in millions of metric tons. Unlike sulfur, carbon dioxide emissions continue to increase. Indeed, over 300 billion tons of carbon have been released to the atmosphere since 1750, with half of these emissions occurring since the mid-1970s. Carbon dioxide is emitted chiefly from fossil fuels combustion (96 percent), cement production, and gas flaring (Marland et al, 2006). Though emissions continue to rise, patterns in Figure 3 suggest that they may have begun to do so at a decreasing rate.

Figure 3:

Global Carbon Dioxide Emissions, 1850 to 2000



Source: Marland et al, 2006

The underlying model for our analysis is:

(4)

$$\ln(S/P)_{it} = x_{it} + \beta_1 \ln(Y/P)_{it} + \beta_2 (\ln(Y/P)_{it})^2 + \beta_3 (\ln(Y/P)_{it})^3 + \beta_4 DEMLEVEL_{it} + \beta_5 DEMSTOCK_{it} + \varepsilon_{it},$$

Where S is sulfur; Y is per capita income; $DEMLEVEL$ and $DEMSTOCK$ are the level and stock democracy variables described above; P is population and i are countries in t years. (We use an equivalent model to estimate carbon emissions.) Betas are the coefficients to be estimated. We measure the level and stock democracy variables using the Polity2 indicator described above to examine the extent to which democracy level and stock have significant, independent effects on sulfur and CO2 emissions. We also include vector of other covariates, or control variables.

Consistent with previous studies, we control for urban population (as a percent of total population) and illiteracy rates.⁴ We also include a time trend variable to control for the possibly spurious correlation between heavily trended dependent and independent variables. Finally, we introduce a cubed income term into the equation. This has become common in most EKC studies. Some have found that environmental quality initially increases with income, then declines, but increases again as incomes continue to grow (Torras and Boyce, 1998). All independent variables are lagged by one year, except for democracy stock, which is lagged by two years (to separate it from the stock variable).

Controlling for these factors, including democracy level, we expect that the stock of democracy will be associated with lower sulfur and CO2 emissions. In other words, the sign on B_5

⁴ The World Bank (2005) does not report illiteracy statistics for certain countries that have near 100% literacy rates. For these cases, we hand-code a 0.5% illiteracy rate. Illiteracy data for other countries are also somewhat limited. We impute missing data using the following technique. First, we fill in missing years between observed years of total adult illiteracy rates using linear interpolation. Second, we use annual regional averages to fill in missing data in the new interpolated illiteracy variable.

should be negative and significant, indicating that as the stock of democracy increases in a particular nation over time, levels of sulfur and CO2 emissions decrease, all else being equal.

If the income variables are statistically significant we will also calculate the turning point(s) for an EKC in our full sample estimations. The formula to calculate the first turning point is:

(5)

$$\tau = \exp\left(\frac{-\beta_2 + \sqrt{\beta_2^2 - 4\beta_1\beta_3}}{-2\beta_1}\right)$$

The second turning point can be calculated as:

(6)

$$\tau = \exp\left(\frac{-\beta_2 - \sqrt{\beta_2^2 - 4\beta_1\beta_3}}{-2\beta_1}\right)$$

To perform these analyses we employ a time-series—cross-section (TSCS) data set from 1960 to 2000 (2001 for CO2) for our analyses. Data for sulfur are logged and come from a new database of global sulfur emissions from 1850 to 2000 constructed by David Stern at the Rensselaer Polytechnic Institute (for a full description, see Stern 2005). Data for carbon dioxide, measured in metric tons per capita (and also logged), are from the World Bank (2005). Data for other independent variables not defined above are also from the World Bank (2005). Analyses employ a country fixed-effects format and Newey-West standard errors, which assume a heteroskedastic error distribution and apply a TSCS equivalent of Huber/White/sandwich, or “robust,” standard errors (Newey and West 1987). We also include a one-period (AR1) correction for autocorrelation.

5. Results

To reiterate our research question, we examine the extent to which the stock of a nation’s democracy affects its levels of sulfur and carbon dioxide emissions. We find that democracy stock

has a significant effect on the level of emissions of both substances in our sample, while the effect of the contemporaneous level of democracy is weak and inconsistent. Interestingly, in relation to income and emissions, we find an *S*-shaped relationship for both pollutants. In the early stages of income growth there is a decrease in sulfur and carbon dioxide emissions that is followed by an acceleration of such emissions when income continues to grow, ending with another decrease in emissions when a nation becomes fairly developed.

Tables 1 and 2 exhibit our results. For comparative purposes we first estimated the equation with only the income and conditioning variables, excluding the democracy variables. The results of that exercise are shown in the first columns of Tables 1 and 2 and labeled “EKC.” We then estimated separate equations for the level and stock of democracy, and another that includes both level and stock. Columns two through four present these results. Because our goal is to examine the independent effects of level and stock, we consider model four, which includes the level and stock variables together, the best test of our hypothesis. Finally, we estimate equation (4) separately for members and non-members of the Development Assistance Committee of the OECD; these results appear in columns five and six.

Results for the current level of democracy do not suggest that democracy today has any noticeable impact on environmental quality for the world as a whole. Tested alone and in conjunction with democracy stock, democracy level shows no significant relationship with emissions of sulfur and carbon. (It emerges significant only in the case of developing countries’ sulfur emissions.) In contrast, a country’s democracy stock has a strong, robust relationship to improved environmental conditions. The more democracy stock a country accumulates, the lower will be its emissions of sulfur and carbon, all else being equal. This result is robust to a wide variety of tests, many not reported here, and holds both when democratic level is included and when it is not. (The only exception to this pattern is the finding for CO₂ emissions in the wealthy countries, where

neither democracy nor income seem to exert much of an effect. This non-finding may be due in part to the lack of variation across both the dependent and independent variables for this small group of countries.)

We find an *S*-shaped EKC for sulfur and carbon dioxide, with two key turning points. The signs indicate that in the very early stages of economic development, per capita sulfur emissions decline with income until a nation reaches about \$132 to \$135 per capita. Then, sulfur emissions grow with income until they reach approximately \$10,500 to \$15,700, when they begin to decrease again.

For CO₂, the curve is longer, with the initial rise kicking in at about \$31-33 and the later decrease not arriving until over \$38,000, and at \$41,153 for our “full” model (in 1995 dollars). Numerous studies have found no EKC relationship for CO₂. Those that have indicate a range of turning points from \$15,000 to \$99,000 (Perman and Stern, 2003; Galeotti et al., 2006; Neumayer, 2002). Recent work has shown that introducing energy prices into the estimation eliminates an EKC for CO₂ in OECD countries (Richmond and Kaufman, 2006). We, too, find that to be the case for the OECD DAC (not reported); however, results presented in Model 7 in Table 2 show that an EKC relationship still holds for the entire sample when the crude oil price variable is included.⁵

The results for sulfur are plausible from a scientific perspective. At extremely low levels of income people are more apt to burn highly polluting, biomass fuel wood. But as they become more skilled and their incomes rise, they begin to burn it more efficiently and also switch over to relatively cleaner coal and petroleum, leading to a decline in emissions up until the first turning point. When a nation begins to industrialize, its use of fossil fuels becomes much more intensive, thus causing

⁵ The coefficient for the energy price variable is oddly positive. Reassuringly for our purposes, coefficients on the democracy and income variables in the full model are remarkably robust to the inclusion or exclusion of the oil price variable.

increases in emissions between the first and second turning points. When a nation passes the second turning point—somewhere between \$10,000 and \$16,000 GDP per capita, according to our results—a nation will be more likely to adopt pollution control technologies that reduce emissions.

Table 1: Determinants of Global Sulfur Emissions, 1960-2000

<i>Model</i>	1	2	3	4	5	6
<i>Variable</i>	<i>EKC</i>	<i>Level</i>	<i>Stock</i>	<i>Full</i>	<i>OECD DAC</i>	<i>Non-OECD DAC</i>
Democracy Level		-0.002 (0.003)		-0.001 (0.003)	-0.003 (0.006)	-0.007** (0.003)
Democracy Stock			-0.002*** (0.0003)	-0.002*** (0.0003)	-0.003*** (0.001)	-0.001*** (0.0004)
Income	-13.596*** (1.581)	-14.040*** (1.577)	-13.669*** (1.592)	-13.683*** (1.592)	18.674 (25.691)	-9.749*** (1.719)
Income squared	2.105*** (0.220)	2.190*** (0.219)	2.123*** (0.222)	2.125*** (0.222)	-0.951 (2.757)	1.536*** (0.243)
Income cubed	-0.098*** (0.010)	-0.103*** (0.010)	-0.099*** (0.010)	-0.099*** (0.010)	-0.002 (0.098)	-0.071*** (0.011)
Illiteracy	0.144** (0.065)	0.160** (0.065)	0.139** (0.065)	0.139** (0.065)	-0.653*** (0.120)	0.208*** (0.070)
Urban population	0.020*** (0.004)	0.021*** (0.004)	0.016*** (0.004)	0.016*** (0.004)	0.031*** (0.006)	0.015*** (0.005)
Trend	-0.019*** (0.003)	-0.018*** (0.003)	-0.018*** (0.003)	-0.018*** (0.003)	-0.045*** (0.006)	-0.011*** (0.003)
Constant	19.196*** (3.641)	19.983*** (3.635)	19.366*** (3.645)	19.390*** (3.648)	-93.112 (79.489)	10.877*** (3.959)
<i>Turning Points</i>						
	1	\$135	\$134	\$132	\$132	
	2	\$12,852	\$10,577	\$12,699	\$15,691	
<i>Observations</i>	4899	4789	4753	4752	790	3962
<i>Countries</i>	150	147	147	147	21	126
<i>R-squared</i>	0.17	0.19	0.21	0.21	0.77	0.15
<i>Prob >F</i>	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Newey-West standard errors in parentheses. All independent variables lagged by one year, except for Democracy Stock, which is lagged by two years.

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2: Determinants of Global Carbon Dioxide Emissions, 1960-2001

<i>Model</i>	1	2	3	4	5	6	7
<i>Variable</i>	<i>EKC</i>	<i>Level</i>	<i>Stock</i>	<i>Full</i>	<i>OECD DAC</i>	<i>Non-OECD DAC</i>	<i>Full w/ oil prices</i>
Democracy Level		0.0001 (0.0018)		0.0005 (0.0017)	-0.0031 (0.0041)	-0.002 (0.0019)	0.001 (0.0018)
Democracy Stock			-0.0004** (0.0002)	-0.0004** (0.0002)	-0.0003 (0.0006)	-0.0004** (0.0002)	-0.0003* (0.0002)
Income	-2.4615*** (0.7005)	-2.5465*** (0.7054)	-2.5418*** (0.7055)	-2.5270*** (0.7073)	-21.852 (19.4490)	-0.779 (0.7965)	-2.5021*** (0.7051)
Income squared	0.4762*** (0.0961)	0.4850*** (0.0971)	0.4828*** (0.0972)	0.4807*** (0.0974)	2.7501 (2.0396)	0.2211** (0.1125)	0.4770*** (0.0971)
Income cubed	-0.0227*** (0.0042)	-0.0230*** (0.0043)	-0.0228*** (0.0043)	-0.0227*** (0.0043)	-0.1102 (0.0711)	-0.0103** (0.0051)	-0.0225*** (0.0043)
Illiteracy	-0.0061*** (0.0019)	-0.0055*** (0.0019)	-0.0040* (0.0021)	-0.0040* (0.0021)	-0.0236** (0.0104)	-0.0019 (0.0022)	-0.0041* (0.0021)
Urban population	0.0092*** (0.0029)	0.0109*** (0.0030)	0.0105*** (0.0029)	0.0104*** (0.0029)	0.0129*** (0.0050)	0.0100*** (0.0031)	0.0104*** (0.0029)
Oil prices							0.0255** (0.0130)
Trend	0.0004 (0.0017)	0.0004 (0.0017)	0.0014 (0.0018)	0.0014 (0.0018)	-0.0038 (0.0037)	0.0044** (0.0021)	0.0008 (0.0018)
Constant	1.3691 (1.6668)	1.545 (1.6748)	1.4505 (1.6759)	1.4167 (1.6795)	55.4482 (61.7677)	-2.4977 (1.8610)	1.3168 (1.6722)
<i>Turning Points</i>							
	1	\$31	\$33	\$33	\$33		
	2	\$38,702	\$38,740	\$40,813	\$41,153		
<i>Observations</i>	5211	5093	5094	5093	809	4284	5093
<i>Countries</i>	159	156	156	156	21	135	156
<i>R-squared</i>	0.39	0.39	0.4	0.4	0.62	0.39	0.4
<i>Prob >F</i>	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Newey-West standard errors in parentheses. All independent variables lagged by one year, except for Democracy Stock, which is lagged by two years.

* significant at 10%; ** significant at 5%; *** significant at 1%

The results for CO₂ are deeply troubling from a scientific and policy perspective. The results follow a similar logic as those for sulfur, but the first turning point comes earlier in the development process and the second later. As in the case of sulfur, one would look at these results and hypothesize that at the outset, countries are apt to reduce their per capita emissions as they substitute coal and petroleum for biomass fuel wood. But very soon (at less than \$35 in per capita income in 1995 prices), emissions begin to rise and continue to do so as the use of coal and petroleum becomes more intense. The next turning point does not occur until per capita incomes reach somewhere in the \$38,000-42,000 range, where a nation will be more likely to adopt pollution control technologies to reduce per capita emissions. If one estimated a generous 2.5 percent GDP per capita average annual world growth rate looking forward, it would take at least seven decades for world CO₂ emissions to “turn around” under this model. The Intergovernmental Panel on Climate Change argues that the world must begin to reduce emissions by 2020.

6. Discussion

Contrary to earlier studies on this topic, this paper argues that, for the most part, there is no strong relationship between a country’s current regime type (democracy level) and environmental quality. Instead, we find that a causal relationship between democracy and environmental quality is more likely to emerge when we view democracy a long-run, cumulative phenomenon. We believe that this result makes sense not only empirically, but also theoretically. It takes time for the machinations of democracy to yield tangible instrumental gains (outside of their own intrinsic benefits). Democratic history is typically replete with tales of intermittent progress, punctuated by occasional setbacks but more characterized by incremental advances that build upon each other to promote social welfare over the long run. Democracy can help improve the environment, but only if given time to promote mechanisms of accountability, facilitate information, foster associational life, spur international cooperation, and promote institutional development.

These findings have important implications for both theory and policy. From a theoretical perspective, Payne's initial and landmark insights into the relationship between democracy and the environment should be broadened. Indeed, as Payne indicates, in democracies citizens are better informed about the environment, can better express their concerns about the environment, can organize amongst each other around those concerns, and finally put pressure on governments to improve environmental conditions. However, our results imply that these factors are not likely to exert their effects overnight, that they are likely to take some time to develop. A nation with a longer history of freedom of the press, freedom of speech, freedom of association and freedom to vote will be more apt to make significant improvements in environmental quality than a nation that has just undergone a transition.

If citizens can witness that their predecessors have raised demands concerning environmental problems, organized around those problems, and successfully pressured policymakers to make change, they will be more apt to build on the movement of the past. Civil societies need to build momentum over time, norms need to be developed to support greater demands for environmental quality, political competition needs to be routinized, and government institutions need capacity strengthening before we should expect to witness significant and lasting reversals of environmental degradation.

There are two major policy implications of this study. First, we must underscore the fact that factors beyond the level of a nation's income determine environmental quality. This paper adds to the growing number of studies that have shown that growth in per capita income alone will not automatically improve the environment. Put simply, the world cannot afford to wait for the problem to fix itself (more precisely, for economic development to generate the ability and incentive to clean up the environment), especially in the case of carbon dioxide. We must find other levers to

bring to bear on the problem, especially political levers. In this particular case, we find that democracy matters, and that it matters in a particular (time-dependent) manner.

On the other hand, this paper implies that simply transitioning into a democracy will not automatically change environmental problems overnight. Our results indicate that it may be unreasonable to expect a brand new, fledgling democracy to have the capacity to reverse what may be decades or more of environmental degradation. But with concentrated effort on the part of democratic and international actors to allow the press and civil society to flourish, and to establish the most appropriate government institutions, laws, and social norms that go along with respecting the environment, substantial progress can be made over time.

7. References

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