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Democracy and Environmental Degradation

Quan Li

The Pennsylvania State University

Rafael Reuveny

Indiana University

In a relatively small but growing body of literature in political science and environmental studies, scholars debate the effect of democracy on environmental degradation. Some theorists claim that democracy reduces environmental degradation. Others argue that democracy may not reduce environmental degradation or may even harm the environment. Empirical evidence thus far has been limited and conflicting. This article seeks to address the democracy–environment debate. We focus on the effect of political regime type on human activities that directly damage the environment. Our discussion of the theoretical literature identifies different causal mechanisms through which democracy could affect environmental degradation. The empirical analysis focuses on the net effect of these competing mechanisms. We examine statistically the effect of democracy on five aspects of human-induced environmental degradation—carbon dioxide emissions, nitrogen dioxide emissions, deforestation, land degradation, and organic pollution in water. We find that democracy reduces all five types of environmental degradation. While the substantive effect of democracy is considerable, it varies in size across different types of environmental degradation. We also find nonmonotonic effects of democracy that vary across the environmental indicators.

Scholars debate the effect of democracy on environmental degradation both theoretically and empirically. Some theorists claim that democracy reduces environmental degradation; others argue that democracy may not reduce environmental degradation or may even harm the environment. Despite the obvious importance of this issue, existing empirical evidence is relatively scant and mixed, particularly in terms of large-N statistical analysis. Extant empirical studies may be categorized according to the nature of their dependent variables. One set of studies examines government commitment to environmental quality in terms of signing international agreements that protect the environment (e.g., Congleton 1992; Neumayer 2002). A second set of studies investigates resource scarcity and access to environmental

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amenities such as safe water or sanitation (e.g., Shafik 1994; Torras and Boyce 1998). A third set of studies explores human activities harmful to the environment, such as greenhouse gas emissions (e.g., Midlarsky 1998; Gleditsch and Sverdrup 2003). While it is important to study resource scarcity, access to environmental amenities, and commitment to environmental protection, we believe it is also important to study human actions that directly damage the environment. After all, the best way to protect the environment is to minimize the damage to the environment in the first place.

The various causal mechanisms in the theoretical literature on the effect of democracy on environmental degradation, although often conflicting, are all plausible given their theoretical assumptions. In other words, it is not possible to distinguish among them based on the theoretical arguments alone. As these causal mechanisms may operate at the same time, it is important to study their overall or net effect empirically. This is the focus of our analysis.

The dependent variable in our empirical/statistical model, environmental degradation, is measured with five salient types of human-induced degradation: carbon dioxide (CO_2) emissions, nitrogen oxide (NO_x) emissions, land degradation, deforestation, and organic pollution in water. For each type of degradation, we estimate several regression-based statistical models using various measures of democracy/autocracy. Depending on data availability for the environmental indicators, the number of countries included in the empirical sample varies from 105 for the land degradation analysis to 143 for the CO_2 emissions per capita analysis.

Our empirical analysis differs from previous studies in a number of ways. We focus on human activities that directly affect environmental quality. The sample size is generally larger than previous studies. The empirical results for the effect of democracy on the environment are consistent across all the above types of human-induced degradation: a rise in democracy reduces environmental degradation and improves environmental performance. The substantive effect of democracy on the environment is considerable, but it varies in size across different aspects of environmental degradation. We also find nonmonotonic effects of democracy that vary across the environmental indicators.

The remainder of this article proceeds as follows: the second section discusses the theoretical channels linking democracy to environmental degradation; the third section presents our empirical model in terms of the variables, data, measures, and expected effects; the fourth section discusses several technical design issues pertaining to the empirical analysis; the fifth section presents and discusses our empirical results; and the final section summarizes our findings and discusses their implications for public policy.

Effect of Democracy on the Environment

This section discusses the two opposing views regarding the effect of democracy on the environment and the associated empirical evidence. The debate turns on institutional attributes of political regimes: the role of public opinion in policy making, interest groups aggregation and representation, state autonomy, social movement mobilization, and the flow of information on environmental problems. Scholars take positions in the debate by emphasizing some of these regime characteristics.

Democracy Improves Environmental Quality

According to Schultz and Crockett (1990) and Payne (1995), political rights and freedom of information promote the cause of environmental interest groups, which in turn raise public awareness and encourage environmental legislation. This effect works through environmental groups and public opinion at large. Information on environmental issues flows more freely, and political rights are more numerous and better protected in a democracy than in an autocracy. Environmental groups, therefore, are often more successful at informing people and organizing them to act on environmental problems in a democracy than in an autocracy. While the elite in an autocracy may be more educated than the public (as education tends to rise with income), the autocratic regime censors information flows, and its decision making is more autonomous than that of a democratic government. Environmental degradation may not be reported by the media to the people. In contrast, as democracy allows for free media, environmental problems are more likely to be reported in the news. People in a democracy, therefore, are more likely to be informed about the environment than are members of the elite in an autocracy. Better informed actors, in turn, are more likely to act on environmental problems, raising environmental quality.

A second argument is that democracies are more responsive to the environmental needs of the public than are autocracies (Kotov and Nikitina 1995). This argument works through electoral accountability and the ability of groups to mobilize socially, achieve political representation, and influence public policy making. Democracies hold regular and free elections, which can bring to power new parties, including those friendly to the environment (e.g., the Green Party in Germany). In an autocracy, the distribution of political power is concentrated, reducing the likelihood that environmentalists will come to power. Thus, environmentalists stand a greater chance of affecting policy making in a democracy than they do in an autocracy. Of course, this logic implies that people can also freely elect extreme anti-environmental parties. Casual observation, however, suggests that such situations do not occur frequently in reality.

A third argument focuses on institutional and ideational features of democracy. According to this argument, democracies are more likely to comply with environmental agreements because they respect the rule of law. This in turn raises environmental quality (Weiss and Jacobsen 1999). Berge (1994) argues that democracies respect economic freedom and, therefore, have market economies. The market, in turn, promotes environmental quality. Gleditsch and Sverdrup (2003) suggest that as democracies respect human life more than autocracies, they are more responsive to life-threatening environmental degradation. They also reason that to the extent that democracies engage in fewer wars, they should have a higher level of environmental quality because wars destroy the environment. Sen (1994) argues that famines promote environmental degradation because they divert attention away from long-run environmental concerns. Famines tend not to occur in democracies because democratic governments are more responsive to the needs of the people. Hence, environmental degradation will be higher in autocracies than in democracies.

A fourth argument expects that the elite in an autocracy will be less pro-environment than the masses or the public at large in a democracy (Congleton 1992). The logic of this argument relies on environmental regulation that curtails pollution and waste. With the prevailing technologies and materials, environmental regulation lowers production and consumption, which, in turn, imposes a higher cost on the elite in an autocracy than on the masses in a democracy. This is because the ruling elite in an autocracy hold a much larger share of national income than most people in a democracy. They are therefore relatively less pro-environment than the masses in a democracy.

A fifth argument observes that environmental degradation develops slowly. Hence, the discount rate and the time horizon of the government are important. Congleton (1992) argues that the masses in a democracy should have less at stake over regime change than the elite in an autocracy. In an autocracy, the elite are tightly linked to the leader. If the leader loses power, the elite may suffer heavy losses or even lose their lives. Facing this possibility, the elite may wish to prevent regime change by force, and to this end, they allocate more resources to oppression. The elite may also think that the change is inevitable, becoming hedonic. Both actions raise the discount rate and reduce the time horizon of the autocratic government. As a result, the ruling elite in an autocracy will ignore environmental damage expected in the future. If they invest more today to suppress real or potential rebels, they will allocate resources away from environmental issues. If they consume more today, they will ignore environmental degradation that takes a long time to rectify or current activities that will cause damages in the future. In both cases, environmental quality will decline.

Democracy May Worsen Environmental Degradation

The view that democracy may not reduce environmental degradation or may even increase it relies on several mechanisms. First, Hardin (1968) warns about the impending hazards of unchecked natural resource exploitation and environmental mismanagement by self-interested individuals and groups. When private property rights of natural resources are not well defined, as is often the case with "the commons" (e.g., clean air, oceans, forests), free individuals or interest groups tend to over exploit such resources and ignore the damage that their economic actions inflict on the environment. Gleditsch and Sverdrup (2003:70) note that Hardin's "Tragedy of the Commons" does not encourage confidence in the effect of economic and political freedom on environmental quality.

Second, Paehlke (1996:28) argues that "the great danger for both democracy and the environment is that, while economy and environment are now global in character, democracy functions on only national and local decision levels." Thus, global environmental problems may not necessarily be attended to in a timely manner. Heilbronner (1974) argues that global population growth threatens global environmental quality. Being autonomous decision makers, autocracies can curtail human reproduction, but democracies are held accountable by the public and therefore respect citizen rights, including those involving human procreation.

Third, Dryzek (1987) notes that democracies tend to be market economies, where business interest groups have considerable clout. His argument highlights the asymmetric influence of profit-oriented corporate interests in capitalist democracies. Dryzek (1987:121) lists countries in which democracy is systematically skewed in favor of corporate interests, while "environmental groups have a hard time getting a foot in the door." Corporate interests, in turn, seek to maximize profit, not necessarily to better environmental quality. Thus, democratic leaders accountable to business interests that support their coming to power may not necessarily value environmental quality. "Polyarchy," Dryzek argues, "will normally yield to the imperatives of the market, if not always to the interests of large corporations . . . At their corporatist worst, polyarchies degenerate into caricatures of the ideal, with some dire consequences for ecological rationality" (Dryzek 1987:125).[1]

Fourth, Midlarsky (1998) argues that democracies often experience public policy inaction where environmental degradation is concerned. Democratic leaders have the tendency to please competing interest groups in the public in order to win as many votes as possible. "Corporations and environmental groups can fight each other to a standstill, leaving a decision making vacuum instead of a direct impact of democracy on the environment. As a result of budget constraints, democracies may not be responsive to environmental imperatives but to more pressing issues of the

[1] A reviewer argues that Dryzek's argument is not about democracy, but rather is about the effects of wealth in a democracy. Our reading of Dryzek differs somewhat: his argument focuses on the ability of business to affect government policies through the democratic process and hence is about democracy.

economic subsistence of major portions of the voting public" (Midlarsky 1998:159). In addition, democracy may be reluctant to alleviate environmental degradation because some groups are expected to benefit (or lose) from environmental policies more than others (Midlarsky 1998:159).

Previous Empirical Studies

As noted, previous empirical analyses studied the effect of democracy on the signing of international environmental agreements, resource scarcity, and access to environmental amenities, and human actions that directly harm the environment. Focusing on international agreements assumes (implicitly or explicitly) that they promote environmental quality. These agreements, however, also reflect international negotiations and bargaining. The end-product may not necessarily address the specific problems of any particular country. At times, these agreements also include "cheap talk" intended to appease environmentalists. Resource scarcity and access to environmental amenities can reflect non-environmental and structural conditions concerning wealth and resource endowment, which are not directly related to environmental quality. We seek to study the effect of democracy on human actions that directly degrade the environment. Before we proceed, a word of caution is necessary. While the distinction between signing agreements and human actions that hurt the environment is clear, the distinction between conditions of resource scarcity and actions that cause environmental degradation may be blurred. For example, land degradation can suggest soil pollution by humans, but it may also indicate the scarcity of productive land that forces humans to over exploit land already in use.

The empirical literature pertaining to our focus on human actions that directly damage the environment is relatively small. In a sample of 118 countries for the year 1989, Congleton (1992) finds that democracies have higher levels of methane and CFC emissions per capita than autocracies. Midlarsky (1998) reports several findings. A rise in the level of democracy increases CO_2 emissions per capita in a sample of 98 countries in the year 1990, increases soil erosion by water in a sample of 97 countries for the 1980s, and increases the percentage of annual deforestation between 1981 and 1990 in a sample of 77 countries. The level of biodiversity, as measured by the percentage of protected land area, rises with democracy for a sample of 100 countries in 1993. But democracy does not affect freshwater availability in a sample of 97 countries in 1990 and the level of soil erosion by chemicals in a sample of 97 countries during the 1980s. Barrett and Graddy (2000) find that a rise in democracy lowers per capita sulfur dioxide (SO_2) emissions in a pooled sample of countries for about 33 years and particulate emissions in a sample of 27 countries for about 38 years. The effect of democracy on water pollution is not statistically significant in a sample of 45 countries for about 29 years. Torras and Boyce (1998) find that a rise in the level of democracy, measured by the 1995 values of the Freedom House indicators of political rights and civil liberties, reduces air pollution (SO_2, smoke, particulate emissions) in pooled samples of 19–42 countries from 1977 to 1991, and decreases water pollution (dissolved oxygen, fecal coliform, access to safe water, and access to sanitation) from 1977 to 1991 in pooled samples of about 58 countries. These results, however, do not appear to be robust across samples. Based on a sample of the 148–185 sites in 24 countries across three different periods (1979–1982, 1983–1986, and 1987–1990), Scruggs (1998) finds that democracy does not affect water pollution and particulate emissions, but reduces SO_2 emissions. Gleditsch and Sverdrup (2003) report that a rise in democracy reduces CO_2 emissions per capita for a sample of 108 countries in 1990.

It is safe to say that extant empirical evidence on human actions that directly degrade the environment is mixed. Some studies used relatively small samples in terms of country or year coverage, or both. Previous studies also differ in terms of model specification. For example, many empirical analyses do not control for the Kuznets curve effect, and none of the studies cited here considers the effect of military conflict (except for Midlarsky 1998) or the effect of trade openness. In addition, these studies focus on different aspects of environmental degradation and their number of indicators ranges between one and seven. Some of the indicators used measure environmental amenities, as opposed to our focus on human actions that damage the environment. In short, there is room for additional systematic empirical analyses that investigate multiple indicators of environmental degradation in samples that are as large as possible while controlling for the Kuznets curve effect, trade openness, and military conflict.

Empirical Model

This section presents our empirical model for evaluating the effect of democracy on environmental degradation. Because the competing causal mechanisms discussed above may operate simultaneously, the purpose of our analysis is to assess the net effect of these forces, finding out whether overall, democracy is good or bad for the environment.

Dependent Variables

The focus of our empirical analysis, environmental degradation, is a multidimensional concept. Accordingly, we focus on five specific human activities that directly harm the environment: greenhouse gas emissions, air pollution, water pollution, deforestation, and land degradation. We analyze separately one representative, salient indicator for each area, with the exception of deforestation, for which we use two measures.[2] While these indicators are not exhaustive, they collectively provide a comprehensive picture of environmental degradation. They also have relatively more comprehensive data coverage than previous studies.

We conduct six different empirical tests. Each of these tests uses several measures of democracy to be discussed later. The first empirical test focuses on CO_2 emissions as this gas constitutes about 60% of greenhouse emissions. CO_2 emissions are generated by energy-related activities and sources, including industry, burning of solid fuels (e.g., coal), liquid fuels (e.g., petroleum), gaseous fuels (e.g., natural gas), gas flaring (burning of gas released in petroleum extraction), cement manufacturing, and bunker fuels (stored fuels). We use per capita CO_2 emissions in order to adjust for country-size differences. Data are from the World Development Indicators (2002).

The second test analyzes NO_x because this gas is a major health hazard and an important source of smog in urban areas. NO_x emissions are generated primarily from fossil fuel combustion in motor vehicle engines, as well as other processes including bio-fuel combustion, oil and gas production, solvent use in industry and other sectors, and waste burning. We use the logged NO_x emissions per capita. Data come from the GEO Data Portal (United Nations Environment Programm 2006).

The third test examines a major form of water pollution. The level of organic pollution in water is measured in terms of the amount of oxygen in kilogram that bacteria living in the water consume when breaking down organic matter (typically denoted as biochemical oxygen demand [BOD]). This standard measure is comparable across countries. Our measure is the logged ratio of BOD to the amount of internal renewable water resources in a country. Data on organic pollution in water come from the World Development Indicators (2002), and data on internal renewable water resources in a country come from the World Resources Institute (2001).

[2] Virtually all statistical studies in this area adopt this approach.

The fourth and fifth tests focus on deforestation because forests are important drivers of ecosystem health. Deforestation has been identified as one of the primary agents of climate change (IPCC 2001). Deforestation is measured here in two ways. One measure is the rate of deforestation. Available data measure deforestation in terms of permanent man-made conversion of natural forests into other uses (e.g., mining, ranching, agriculture). Areas logged with the intent of regeneration and areas degraded by acid rain and by forest fires are not included. Data on average annual deforestation rates per decade are collected from the World Resources Institute (1999) and the State of the World's Forests, 2001 (Food and Agriculture Organization of the United Nations 2006). A second measure is a country's land area that is forested. The deforestation rate allows us to evaluate the effect of democracy on the change in forests. This change does not necessarily reflect the size of forest area in a country.[3] Hence, we also assess the effect of democracy on the size of the forested area. To this end, we use the logged percentage share of the forested area in total land area. Data come from the Food and Agriculture Organization (Terrastat 2003).

The sixth test looks at severe land degradation, which greatly harms agricultural activities. Data come from the Food and Agriculture Organization (Terrastat 2003). As discussed in FAO (2000), this is the only available uniform global source of human-induced land degradation data. These data measure land degradation from water erosion (e.g., loss of topsoil, deformation, sedimentation), wind erosion (e.g., loss of topsoil, deformation, over blowing), chemical deterioration (e.g., loss of nutrients, salinization, acidification), and physical deterioration (e.g., compaction, crusting, lowered water table). Data are from the late 1980s, reported as the share of degraded land out of total land at five levels: not degraded, light degradation (reduced agricultural suitability), moderate degradation (greatly reduced productivity), severe degradation (largely destroyed, unreclaimable at farm level), and very severe degradation (fully destroyed biotic functions, unreclaimable). Our indicator is the logged share of severely and very severely degraded land out of total land area.

Independent Variable

The independent variable is regime type. We use two measures for this concept: one continuous and the other dichotomous. The continuous or interval measure of regime type is the widely used composite indicator of the level of democracy from the POLITY IV data (Marshall and Jaggers 2002). It is computed as the difference between the 10-point DEMOC index and the 10-point AUTOC index. The 10-point DEMOC measures democratic characteristics, while the 10-point AUTOC measures autocratic characteristics. The composite indicator, which ranges between -10 (most autocratic) and 10 (most democratic), is widely used in the literature (e.g., Londregan and Poole 1996; Li and Reuveny 2003).[4]

While the continuous measure of democracy is informative, one may question whether the effect is constant across a range of values along the scale. For example, the effect when the democracy score rises from -10 to -5 may not be the same as the effect when the score rises from 0 to 5. Some scholars (e.g., Dixon 1994; Fearon and Laitin 2003) often use dichotomous measures of democracy and autocracy coded based on the continuous indicator. In these studies, a country is often defined as a democracy if the continuous measure of democracy is greater than or equal to 6, and as an autocracy if its score is less than or equal to -6. The

[3] For example, a country that has destroyed cosiderable forest area before the sample period may have a low deforestation rate in the sample period, but may have only a small forest area. We thank an anonymous reviewer for bringing this issue to our attention.

[4] Despite the popularity of this measure of democracy, one may question whether the POLITY IV score needs to be treated as interval or dichotomous. We thank an anonymous reviewer for this comment.

dichotomous variables democracy and autocracy are coded 1 or 0 if a country is democratic or autocratic, respectively.[5]

Control Variables

The control variables we include are those used in a number of empirical studies in environmental economics and environmental politics. The first two variables are real income per capita and its squared term. A large literature argues that economic growth has competing effects on environmental quality. A larger economy generates more output and, therefore, more pollution and waste. Some types of technological progress, which are associated with growth, also may damage the environment (e.g., greenhouse gases). The effect is typically referred to as the *scale effect*. As income per capita rises above some threshold, the importance of environmental quality for people is said to rise, and they begin to use cleaner production techniques and fewer natural resources, thereby increasing investment in environmental regulation. This behavior is referred to as the *income effect*. The combined operation of the scale and income effects generates an inverted U figure when environmental degradation is plotted against income per capita.

The inverted U shape is known in environmental economics and environmental politics as the environmental Kuznets curve (EKC).[6] Its empirical existence, however, is debated, an issue to which we will return. Relevant to our analysis, one may also frame the Kuznets curve debate in terms of whether this is an economic effect (environmental quality as a luxury good that is affordable at higher per capita incomes) or a political effect (the emerging middle class as a byproduct of industrialization asserts itself politically on issues of air and water quality). As the economic effect would occur independent of the level of democracy but the political effect arguably would not, it is important to include in the Kuznets curve analyses both democracy and income per capita on the right-hand side of the statistical model, as we do.[7]

While the empirical existence of the Kuznets curve is debated, most studies allow for it in statistical models by including income per capita and its squared term. If the environmental Kuznets curve exists, the coefficient of income per capita will be positive, the coefficient of income per capita squared will be negative, and the coefficient of income per capita will be larger than the absolute value of the coefficient of income per capita squared. Gross domestic product (GDP) per capita, in purchasing power parity (PPP) adjusted, constant 1996 international dollars, is from the Penn World Table 6.1 (Heston, Summers, and Aten 2002).[8]

The third control variable is a country's level of trade openness. The trade and environment literature argues that trade can affect the environment in two broadly defined ways. In one way, the pattern of domestic production and consumption, and the methods of production, change under trade openness as countries follow their comparative advantages and/or adopt certain more efficient, cleaner or not, technologies to produce for other countries. For example, a country that trades environmentally clean goods will see its environmental quality rise, and vice versa. This channel also involves changes to environmental regulation, as some international trade treaties countries sign may require regulatory changes at home. In

[5] The chosen threshold of six is, of course, to some extent arbitrary in the sense that seven or five could also be used (but probably not -7 or -1, etc.). Nevertheless, the threshold of six has been used in many studies. To maintain compatibility with this norm, we use the threshold level of six.

[6] The name EKC is used in the literature, as the original Kuznets curve hypothesizes the existence of a inverted U curve for income inequality as a function of income per capita. For a review of these arguments, see Dinda (2004) and Panayotou (2000).

[7] We thank an anonymous reviewer for suggesting this interpretation to us.

[8] An alternative indicator of technology and knowledge is GDP per worker. But GDP per capita and GDP per worker are correlated very highly (correlation coefficient = 0.98).

addition, trade may also affect the environment by promoting economic growth, and hence, altering people's behaviors over time. While the combined empirical effect of trade on the environment is debated, it needs to be included in the model.[9] We use a popular measure of the importance of trade openness to a national economy, which is the sum of national exports and imports divided by GDP. Data are from the Penn World Table 6.1.

The fourth control variable is population density (population divided by land area).[10] The effect of population density on environmental degradation may change across indicators. A rise in population density is expected to generate more CO_2 emissions, as a larger population consumes and produces more. But it may generate less NO_x emissions, as denser areas tend to use more public transportation and fewer cars (the primary generator of this type of emissions). Water pollution is expected to rise with population density. As more people engage in consumption and production, organic water pollution will rise. Many densely populated nations tend to be more urbanized and depend less on the environment for livelihood (e.g., consider West European countries such as the Netherlands or Belgium). As such, they may clear fewer forests. A greater population implies more pressure to use agricultural land for food and industry and, therefore, more land degradation. Data are from the World Development Indicators (2002).

Finally, as discussed in Reuveny (2002), for example, military conflict can also affect the environment. Military conflict, however, may generate competing effects on environmental degradation. We set our conflict dichotomous indicator to 1 if a country is involved in an interstate or intrastate war in a given period, and 0 otherwise. Data are from Gleditsch et al. (2002).

Empirical Design Issues

This section discusses several design issues related to the empirical analysis. The first issue is whether to conduct cross-sectional analyses or cross-sectional time series (pooled) analyses. This choice is dictated by data availability. For the CO_2 emissions and water pollution, we have time-series cross-sectional data. For NO_x emissions, deforestation rate, forested land, and land degradation, we have cross-sectional data. Thus, we conduct pooled analyses for the first two indicators, and cross-sectional analyses for the latter six indicators. Given the various data structures in these indicators, we ensure that the time periods of the right-hand side variables match the time period of the dependent variable observations. For clarity, we discuss the sample and the unit of analysis for each dependent variable in the results section.[11]

The second design issue concerns the possibility of endogeneity for our right-hand side variables, an issue that concerns most if not all of the single equation studies in the social sciences. Our empirical framework treats democracy, income per capita (and income per capita squared), population density, conflict, and trade as exogenous variables. One may argue that environmental degradation can affect these variables. For example, land degradation may reduce the exports from an agrarian economy. Or, environmental degradation may lead to conflict, a hotly debated issue in the literature. To mitigate the potential risk of simultaneity, the

[9] For a review of these arguments see, e.g., OECD (1994), Harris (2002: chapter 19), and Pugel (2003: chapter 12).

[10] For examples of studies using this indicator, see Panayotou (2000).

[11] In principle, it is possible that cross-sectional data may not be all measured in the same time period, particularly for our decade data. Our data source does not specify when exactly a measurement was taken for a country. We assume that these possible measurement problems are absorbed into the error term. We thank an anonymous reviewer for this comment.

right-hand side variables are lagged 1 year, as is done in many studies (e.g., Oneal and Russett 1999; Li and Reuveny 2003).[12]

Third, national structural variables (e.g., climate, education) and global or local biophysical attributes (e.g., atmospheric integrity, existing damage) may also affect environmental degradation. Because these factors tend to change slowly, environmental degradation is likely to exhibit inertia. This is modeled empirically through the inclusion of the lagged-dependent variable on the right-hand side for the pooled analysis. We further guard against the potential risk of missing structural variables in our pooled analyses by using the two-way fixed-effects estimator. This estimator includes separate intercepts for each country and each year. In addition, the lagged-dependent variable and the fixed-effects country and year dummies also help to control for the fact that different types of environmental degradation may have different causal determinants. Hence, including these controls is important for ensuring that the comparison of the effect of democracy across different types of environmental degradation is plausible. Unfortunately, due to data availability, we could only do so for CO_2 emissions and organic water pollution, but not for NO_x emissions, deforestation, forest area, and land degradation. The use of the lagged-dependent variable and the two-way fixed-effects estimator, however, does not come without any cost. It is well known that they soak up the variations in the dependent variable that could otherwise be explained by other right-hand side variables. This should make it harder for us to find statistically significant results. Hence, this approach to empirical modeling can be considered conservative.[13]

Fourth, we consider the risks of heteroskedasticity and serial correlation. When error terms are not spherical, the estimated regression coefficients are consistent, but their standard errors are inefficient and biased. To deal with the risk of heteroskedasticity, we estimate Huber–White robust standard errors (White 1980). Both the year dummies and, as Beck and Katz (1995a, 1995b) suggest, the lagged-dependent variable capture the temporal dynamics in the pooled data, controlling for possible serial correlation.

Fifth, we need to consider the issue of multicollinearity. This potential problem is a cause of concern when the effects of key variables are statistically insignificant in models of good fit (high R^2). In this case, statistical insignificance may be an artifact of multicollinearity that increases the standard errors of the coefficient estimates. We will assess the extent of this possible problem using the variance inflation factor (VIF) diagnostic.

Sixth, there is the issue of which statistical significance level to use when one interprets the results. In evaluating the effect of democracy on the environment, we have discussed two types of theories. One type expects that democracy will promote environmental quality, while the other type expects the opposite. As noted, it is not possible to reject either set of theories based on theoretical grounds a priori. Given their assumptions, both types of theories appear correct concerning the expected sign of the net effect. In each model, we will therefore test the sign of this net effect of democracy on the environment against the null hypothesis of no effect—or rather the two competing effects are equal in size—using the one-tailed test in reporting the results. Many other studies have used this approach (see, e.g., Morrow, Siverson, and Tabares 1998; Oneal and Russett 1999; Li and Reuveny 2003; Reuveny and Li 2003).[14]

[12] This popular practice is sufficient for addressing the possibility of endogeneity under the weak exogeneity assumption (Wooldridge 2002).

[13] As a caveat, this suggests that statistical results and inferences for CO_2 emissions and organic water pollution are likely to be more reliable than those for the other indicators with less data. Future research with more data for the other indicators is certainly in order.

[14] In the interpretation of the results, we use the 10% significance level in addition to the 1% and 5% levels. We adopt this approach as some of our samples are relatively small due to limits on data availability. Our approach is also justifiable for our pooled models as we include fixed effects and the lagged-depended variables, which soak up the variations in the dependent variable.

Finally, we need to measure the size of democracy's effect on the environment. We will discuss the size of the estimated coefficient of democracy in our models, provided that the coefficient is statistically significant. If the coefficient is statistically insignificant, the size of the effect is so small that it is statistically 0. For the size of change in the independent variable (in our case democracy), we follow other studies by using its 1 SD change in the sample. We proceed by first computing a base value for the dependent variable, holding all the continuous right-hand side variables at their sample mean and setting the dichotomous war variable at 0, and then computing a new value for the dependent variable when the continuous democracy variable is increased by 1 SD in the sample. The two values are then compared with each other, and the difference is expressed in terms of percent change.

This practice is most appropriate for cross-sectional analyses. However, it does not tell the full story when the lagged-dependent variable is included on the right-hand side in the pooled analysis. This is so because it only captures the immediate impact of democracy; it does not take into account the fact that the impact of democracy on the environment from previous periods is absorbed into the effect of the lagged environmental degradation variable, which is also on the right-hand side. Democracy affects the current environment via its direct effect, and continues to affect the environment in the next period via the lagged environmental degradation. These effects accumulate over time. The long-run impact of a change in democracy produces the following change in environmental quality: [coefficient of democracy/(1 − coefficient of lagged environmental degradation)] × (change in democracy). We will compute the long-run effect in the pooled analyses of CO_2 and water pollution.[15]

Empirical Results

Table 1 presents the results for the net effect of the level of democracy on environmental degradation. The unit of analysis is the country year. Column 1 presents the results for CO_2 emissions per capita. The sample includes 143 countries from 1961 to 1997. Column 2 presents the results for NO_x emissions. The sample includes 118 countries in 1990. Column 3 presents the results for organic pollution in water. The sample includes 112 countries from 1980 to 1998. Column 4 presents the results for the rate of deforestation, and Column 5 the results for the forest areas. The sample covers 134 countries. For each country, the data include two average annual deforestation rates: one rate for the 1980s and the other for the 1990s. The annual rates during a decade are computed based on the total forest areas for 1980, 1990, and 2000. The right-hand side variables take on their decade-average values to represent their values during the decade, capturing the cross-sectional patterns. Column 5 presents the results for the forested area as a percentage of total land area in a country. In this case, we have three data points for each country (1980, 1990, and 2000). Column 6 presents the results for land degradation. The sample includes 105 countries in the 1980s.

Across the six columns in Table 1, the net effect of democracy on six different environmental indicators is always statistically significant, albeit at varying significance levels, and consistently in the direction of reducing environmental degradation. Relative to their less democratic counterparts, more democratic countries produce less CO_2 emissions per capita, less NO_x emissions per capita, and less organic pollution in water, experience lower deforestation rates and less land degradation, but enjoy higher percentages of forested land. It is worth noting that the effects of democracy on CO_2 emissions and the level of organic pollution in water

[15] For the long-run effect, see e.g., Londregan and Poole (1996).

TABLE 1. Effect of Level of Democracy on Environmental Degradation

	(1) CO_2 Per Capita	(2) NO_x Per Capita	(3) Organic Water Pollutants Per km^3	(4) Annual Deforestation Rate	(5) Forest Area Share of Land Area	(6) Degraded Area Share of Land Area
Level of democracy	– 0.0021**	– 0.0198*	– 0.0033*	– 0.1187***	0.0807***	– 0.0281*
	(0.0011)	(0.0140)	(0.0021)	(0.0362)	(0.0236)	(0.0219)
Trade	– 0.0006	0.0043**	0.0005	0.0144**	– 0.0030	– 0.3661*
	(0.0011)	(0.0025)	(0.0004)	(0.0070)	(0.0035)	(0.2692)
Conflict	– 0.0539***	0.1102	0.0063	0.4832*	– 0.3983**	0.3917*
	(0.0189)	(0.1891)	(0.0282)	(0.3418)	(0.1749)	(0.3004)
Real GDP per capita	0.00009***	0.00014***	0.00001	0.0004***	– 7.2033e-05	6.3722***
	(0.00002)	(0.00004)	(0.00001)	(0.0001)	(6.8775e-05)	(2.3470)
Real GDP per capita squared	– 2.80e-09***	– 2.39e-09*	– 4.83e-10*	– 1.09e-08***	9.96e-10	– 0.384***
	(5.33e-10)	(1.53e-09)	(3.13e-10)	(3.57e-09)	(2.49e-09)	(0.145e-09)
Population	0.0007***	– 0.0005**	0.0001***	– 0.0011**	– 0.00005	0.2854***
	(0.0002)	(0.0002)	(0.0000)	(0.0006)	(0.0002)	(0.0966)
Lagged level$_{t-1}$	0.8658***		0.7895***			
	(0.0228)		(0.0832)			
Constant	0.1247*	1.9067***	1.4091***	– 2.8402***	3.4046***	– 22.6986**
	(0.0643)	(0.1815)	(0.5286)	(0.5745)	(0.2879)	(9.4663)
Observations	3,833	108	1,344	204	255	105
R^2	0.99	0.41	0.99	0.28	0.13	0.20

Robust standard errors in parentheses.
*Significant at 10%, **Significant at 5%, ***Significant at 1%.
Pooled analysis for CO_2 and organic water pollutants; cross-sectional analysis for NO_x, deforestation, and land degradation.
Coefficients for year and country dummy variables not shown for models of CO_2 and organic water pollutants.
GDP, gross domestic product.

are statistically significant in the two-way fixed-effects models, despite the inclusion of taxing country and year dummies.[16]

Next, we turn to the substantive effect of democracy on these environmental indicators. In this computation, we raise the POLITY score of democracy 1 SD above its mean within each sample, while we consistently hold other continuous variables constant at their sample means, and the conflict variable at 0. As noted, because of the differences in research design and data availability, we can show both the immediate and the long-run effects of democracy (accumulated via the lagged-dependent variable) for CO_2 emissions and organic water pollution. For the other indicators, we are only able to show the immediate effect of democracy.

Based on Table 1, a 1 SD increase in democracy (7.6) above its sample mean (0.84) causes CO_2 emissions per capita to fall by 0.47%. The immediate effect of democracy on CO_2 emissions per capita appears small. The effect that cumulates over time through the lagged-dependent variable is 0.12 metric tons per capita, which is about 7.5 times the size of the immediate effect. This amounts to a decline of about 4% in CO_2 emissions. It should be noted that these numbers pertain to per capita carbon emissions. Hence, as its democracy level rises 1 SD above its sample mean, a country such as China, whose population is about 1.3 billion people, will see a decline of 156 million metric tons per year in the long run. This is a large decline that can make a difference for the global environment, considering that in 1998 the total carbon emissions of Asia and the Pacific region (2.5 billion people) were 2,167 million metric tons per year (United Nations Environment Programme 2003:215).

Moving to column 2, the direct effect of democracy on NO_x emissions per capita is much larger. An in-sample 1 SD increase in democracy (7.60) above its sample mean (1.3) causes NO_x emissions per capita to decline by 14%. This effect is larger than the long-run effect of democracy on CO_2 discussed above, which in and of itself is not small. In column 3, an in-sample 1 SD increase in democracy (7.26) above its sample mean (3.44) causes the level of organic pollution in water to decline by about 2.4%. The long-run net effect of a 1 SD increase in democracy is much larger, reaching 11%.

In column 4, an in-sample 1 SD increase in democracy (6.6) above its sample mean (1.25) causes the average annual deforestation rate to fall by about 271%. This is obviously a very large effect. In column 5, an in-sample 1 SD increase in democracy (6.9) above its mean (1.86) raises the percentage of forested land in a country by 75%. This also is a very large effect. Finally, in column 6, a 1 SD increase in democracy (7.8) above its mean (0.2) causes the share of severely and very severely degraded land out of total land area to decline by 20%. This still is a relatively large effect.

Turning to the control variables, trade has no effect on CO_2 emissions per capita, on organic water pollution, or on forested area. But the effect of trade on NO_x emissions per capita and on the rate of deforestation is positive and statistically significant. And its effect on land degradation is negative and statistically significant. Trade is not necessarily a boon for the environment.

The effect of military conflict on CO_2 emissions per capita is statistically significant and negative, reflecting the net effect of competing forces. CO_2 emissions may

[16] For the CO_2 model, the average VIF is 5.7. Hence, multicollinearity is not a concern. For the NO_x model, the average VIF is 8.7, suggesting that multicollinearity may be a concern. Using the matrix of variance decomposition, we find that the multicollinearity is caused by the high correlation between real income per capita and its squared term. The VIFs for other variables are smaller than 2.5, indicating that multicollinearity for them is not a concern. For the organic pollution in water model, the average VIF is 4.8, suggesting that multicollinearity is not a concern. For the deforestation model, the average VIF is 4.9, suggesting that multicollinearity is not a concern. For the land degradation model, the average VIF is 95. Hence, multicollinearity is a concern. However, using the matrix of variance decomposition, we find that the source of the collinearity is the correlation between real income per capita and its squared term. The VIFs for other variables are all smaller than 2, indicating that multicollinearity is not a concern for them.

rise during wars due to greater production and operation of weaponry. But they may also fall during wars due to the reduced normal economic activity that generates emissions, as the labor force is drafted and/or parts of the economy are destroyed. This logic applies to all of our environmental indicators. For CO_2, the emission-reducing effect of conflict is larger than the increasing effect. The net effects of conflict on NO_x emissions per capita and organic pollution in water are statistically insignificant. In these cases, the competing effects of conflict are of about the same size. In contrast, military conflict significantly raises the rate of deforestation, reduces the size of the forested area, and raises land degradation.

The effects of the lagged CO_2 emissions per capita and the lagged organic pollution in water on the contemporary values of these indicators, respectively, are both positive and statistically significant. Hence, these indicators exhibit inertia. As noted, population density also may exhibit competing effects on the environment. We find that the net effects of population density on CO_2 per capita, organic pollution in water, and land degradation are statistically significant and positive. In these cases, a larger population density leads to more environmental damage. In contrast, the effects of population density on NO_x emissions per capita and on the rate of deforestation are negative and statistically significant, while the effect on the forested area is not statistically significant.

Our findings for the signs and significance levels of real income per capita and real income per capita squared suggest that CO_2 emissions per capita, NO_x emissions per capita, the average annual rate of deforestation, and land degradation exhibit an environmental Kuznets curve, while organic water pollution and forested land do not. Stated in real 1996 international dollars, the turning points are 16,071 for CO_2; 25,951 for NO_x; 18,486 for the rate of deforestation; and 4,012 for land degradation.[17] It is apparent that our results support both the economic and the political effects discussed earlier. The income variables, though, largely capture the economic effect, as the political effect via the middle class is controlled for by the democracy variable. To the extent that Seymour Lipset is right about the modernization thesis of democracy, part of democracy's effect of the Kuznets curve also traces to economic development, which is present in the model.

Tables 2 and 3 present the results for the dichotomous measures of democracy and autocracy, respectively. While these measures lose information contained in the level variable, they provide a sharper contrast of the difference in effect between democracy and nondemocracy (a group including anocracies and autocracies), or between autocracy and nonautocracy (a group including anocracies and democracies). We therefore view the dichotomous measures of democracy and autocracy as complementary to, rather than substitutes for, the level of democracy measure.

Table 2 presents the results for the dichotomous measure of democracy. We find that the net effect of transition from a nondemocratic to a democratic regime is not consistently significant across the five dimensions of environmental degradation. Democratic regimes do not appear to be different from nondemocratic regimes in terms of CO_2 emissions per capita, NO_x emissions per capita, or the level of organic pollution in water. But they do have statistically significantly lower deforestation rates, larger forested land area, and lower levels of land degradation.

[17] For land degradation, income is logged. The Kuznets literature is very large. The location of the turning point and whether the Kuznets curve exists are empirical issues. Results vary among studies, depending on model specification, data, indicators, and estimators. For example, Cole, Rayner, and Bates (1997) find turning points of 25,100 dollars for CO_2 and 15,100 for NO_x. Moomaw and Unruh (1997) find 18,333 dollars for CO_2. de Bruyn, Van Den Bergh, and Opschoor (1998) do not find Kuznets curves for CO_2 and NO_x. Many studies do not find a Kuznets curve for water pollution (Panayotou 2000). For forests, Shafik and Bandyopadhyay (1992) and Barbier (2001) do not find a Kuznets curve, while Bhattarai and Hamming (2001) find a turning point of 6,800 dollars. We did not find any studies of the Kuznets curve for land degradation. Investigating the sources for differences in the Kuznets curve literature is a very large task that is beyond the scope of this article.

TABLE 2. Effect of Democracy on Environmental Degradation

	(1) CO_2 Per Capita	*(2) NO_x Per Capita*	*(3) Organic Water Pollutants Per km^3*	*(4) Annual Deforestation Rate*	*(5) Forest Area Share of Land Area*	*(6) Degraded Area Share of Land Area*
Democracy	0.0119	– 0.1651	– 0.0235	– 0.8832**	0.8884***	– 0.6729**
	(0.0153)	(0.1785)	(0.0282)	(0.4409)	(0.2907)	(0.3475)
Trade	– 0.0006	0.0044**	0.0005	0.0146**	– 0.0028	– 0.3785*
	(0.0011)	(0.0025)	(0.0004)	(0.0074)	(0.0037)	(0.2672)
Conflict	– 0.0541***	1.03e-01	0.0069	0.4943*	– 0.3827**	0.3272
	(0.0189)	(2.02e-01)	(0.0275)	(0.3595)	(0.1845)	(0.2994)
Real GDP per capita	8.37e-05***	1.17e-04***	7.10e-06	0.0004***	– 5.05e-05	6.1217***
	(1.78e-05)	(3.72e-05)	(8.92e-06)	(0.0001)	(6.75e-05)	(2.3207)
Real GDP per capita squared	– 2.71e-09***	– 1.64e-09	– 4.47e-10*	– 8.96e-09***	3.78e-10	– 3.65e-01***
	(5.37e-10)	(1.46e-09)	(3.09e-10)	(3.68e-09)	(2.49e-09)	(1.43e-01)
Population	0.00072***	– 0.0005**	0.00011***	– 0.0010*	– 0.0001	0.2794***
	(0.00020)	(0.0002)	(0.00004)	(0.0006)	(0.0002)	(0.0971)
Lagged level$_{t-1}$	0.8660***		0.7907***			
	(0.0228)		(0.0832)			
Constant	0.1251*	2.0430***	1.3918***	– 2.4500***	3.0809***	– 21.6105**
	(0.0650)	(0.1765)	(0.5254)	(0.5281)	(0.2658)	(9.4136)
Observations	3,833	108	1,344	204	255	105
R^2	0.99	0.40	0.99	0.22	0.09	0.21

Robust standard errors in parentheses.
*Significant at 10%, **Significant at 5%, ***Significant at 1%.
Pooled analysis for CO_2 and organic water pollutants; cross-sectional analysis for NO_x, deforestation, and land degradation.
Coefficients for year and country dummy variables not shown for models of CO_2 and organic water pollutants.
GDP, gross domestic product.

TABLE 3. Effect of Autocracy on Environmental Degradation

	(1) CO_2 Per Capita	*(2) NO_x Per Capita*	*(3) Organic Water Pollutants Per km^3*	*(4) Annual Deforestation Rate*	*(5) Forest Area Share of Land Area*	*(6) Degraded Area Share of Land Area*
Autocracy	0.0363***	0.4211***	0.0498**	1.5445***	– 0.6237**	0.3654†
	(0.0138)	(0.1727)	(0.0296)	(0.5144)	(0.3113)	(0.2894)
Trade	– 0.0006	0.0043**	0.0005	0.0147**	– 0.0032	– 0.3802*
	(0.0011)	(0.0025)	(0.0004)	(0.0069)	(0.0035)	(0.2736)
Conflict	– 0.0544***	9.09e-02	0.0070	0.6424**	– 0.4663***	0.4269*
	(0.0188)	(1.81e-01)	(0.0284)	(0.3607)	(0.1972)	(0.3091)
Real GDP per capita	8.62e-05***	1.58e-04***	6.41e-06	0.0004***	– 2.27e-06	6.6709***
	(1.77e-05)	(3.59e-05)	(9.02e-06)	(0.0001)	(6.03e-05)	(2.2913)
Real GDP per capita squared	– 2.80e-09***	– 3.11e-09**	– 4.57e-10*	– 9.50e-09***	– 5.19e-10	– 4.05e-01***
	(5.31e-10)	(1.48e-09)	(3.12e-10)	(3.31e-09)	(2.36e-09)	(1.40e-01)
Population	0.00071***	– 0.0005**	0.00012***	– 0.0008*	– 0.0002	0.2891***
	(0.00020)	(0.0002)	(0.00004)	(0.0006)	(0.0002)	(0.0967)
Lagged Level$_{t-1}$	0.8659***		0.7932***			
	(0.0228)		(0.0840)			
Constant	0.1102*	1.6855***	1.3578**	– 3.1578***	3.4179***	– 23.8747**
	(0.0640)	(0.1867)	(0.5390)	(0.6532)	(0.3434)	(9.2644)
Observations	3,833	108	1,344	204	255	105
R^2	0.99	0.43	1.00	0.27	0.06	0.19

Robust standard errors in parentheses.
*Significant at 10%, **Significant at 5%, ***Significant at 1%.
†Significant at 10.5%. Pooled analysis for CO_2 and organic water pollutants; cross-sectional analysis for NO_x, deforestation, and land degradation. Coefficients for year and country dummy variables not shown for models of CO_2 and organic water pollutants.
GDP, gross domestic product.

Table 3 presents the results for the dichotomous measure of autocracy. As shown, autocratic regimes experience higher CO_2 emissions per capita, higher NO_x emissions per capita, higher levels of organic pollution in water, higher deforestation rates, and smaller forested land area. They also tend to exhibit more land degradation, but this effect is weaker, statistically significant only at 10.5%.

Taken together, Tables 1–3 demonstrate the patterns in the effects of political regime type on different dimensions of environmental degradation. As Table 1 shows, the continuous democracy measure exhibits consistent and statistically significant effects on the five dimensions of environmental degradation. Tables 2 and 3 suggest that this effect is not monotonic across various segments of the continuous democracy measure. For CO_2, NO_x emissions, and organic pollution in water, the significant effect of the continuous measures are to some extent driven by the difference between autocratic and nonautocratic regimes. For land degradation, the effect of the continuous democracy measure is driven by the difference between democracy and nondemocracy. For forests, the effect appears to be monotonic, as it is statistically significant in all the three tables.

Finally, while it is useful to study the effect of democracy on different dimensions of environmental degradation separately, one may wonder what the effect of democracy on the composite environmental indicator is. Recently, the World Economic Forum (WEF) (2002) has embarked on a large-scale effort to construct composite environmental measures. The project aggregates environmental indicators by computing the average of their *Z* scores in their respective distribution.[18] It is worth reiterating that these composites lump together different environmental indicators, just as gross domestic product does for the economy. But the environmental story is much more complex than the economic story. For one thing, while money value provides a common metric to aggregate economic activities, environmental forces do not have a similar, readily available common metric (i.e., they are each measured in specific physical, chemical, or geographical units). Thus, one should interpret the composite measure-based results with caution.

With this in mind, we use two core composite contributors to the environmental sustainability index (ESI), put together by the WEF. The Environmental Systems Quality composite aggregates measures in the areas of air quality, water quantity, water quality, biodiversity, and terrestrial degradation. The Reducing Environmental Stresses composite aggregates measures in the areas of reducing air pollution, reducing water stress, reducing ecosystem stress, and reducing waste, consumption, and population pressures on the environment. The data come from the WEF (2002), available for the year 2002.[19]

Table 4 includes six columns. The first three columns focus on the environmental systems quality composite. The next three columns concern the reducing environmental stress composite. In each case, we report results using the three measures of political regime type. Among the control variables, only the effect of population is consistently significant across the six columns; its sign is negative. This is not surprising given that the control variables often have different effects on the various dimensions of environmental degradation, as shown in Tables 1–3 and in the literature. This should caution us against being overly confident about the results based on any composite environmental indicator.

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[18] The Z score transformation subtracts the variable's sample mean from its value in the sample, and divides the result by its standard deviation. For details, see Appendix A at http://www.yale.edu/esi/. We thank an anonymous reviewer for suggesting the analysis for the composite indicators.

[19] The ESI aggregates five core composites, of which we use two. The other three core contributors involve economic, social, and political indicators, in areas such as science and technology, capacity for public debate, private sector responsiveness to environmental issues, and governance. Given our focus on human actions that harm the environment, we do not use these core areas or the ESI. In addition, WEF has released data for 2005. We do not use them as we do not have data on other variables for 2005.

TABLE 4. Effect of Political Regime Type on Environmental Composites

	Environmental Systems Quality	*Environmental Systems Quality*	*Environmental Systems Quality*	*Reducing Environmental Stress*	*Reducing Environmental Stress*	*Reducing Environmental Stress*
Level of Democracy	0.1474			0.1530		
	(0.2753)			(0.1518)		
Democracy		2.5670			3.1022**	
		(2.9863)			(1.8368)	
Autocracy			– 6.8081**			– 2.4238
			(3.4276)			(2.6298)
Trade	– 0.0226	– 0.0212	– 0.0286	– 0.0304	– 0.0287	– 0.0327
	(0.0324)	(0.0324)	(0.0325)	(0.0265)	(0.0259)	(0.0269)
Conflict	1.0001	0.9833	0.6373	0.7810	0.8037	0.4803
	(4.5546)	(4.4603)	(4.4805)	(2.7258)	(2.6394)	(2.8041)
Real GDP per capita	0.0004	0.0003	0.0004	– 0.0000	– 0.0002	0.0001
	(0.0006)	(0.0006)	(0.0005)	(0.0004)	(0.0004)	(0.0004)
Real GDP per capita squared	– 3.23e-10	2.54e-09	– 2.63e-09	– 3.04e-08**	– 2.65e-08**	– 3.29e-08***
	(1.93e-08)	(2.02e-08)	(1.81e-08)	(1.44e-08)	(1.44e-08)	(1.39e-08)
Population	– 0.0511***	– 0.0518***	– 0.0507***	– 0.0260*	– 0.0269*	– 0.0254*
	(0.0208)	(0.0205)	(0.0203)	(0.0174)	(0.0171)	(0.0172)
Constant	53.9768***	53.3760***	55.2909***	61.0057***	60.2561***	61.5675***
	(2.8579)	(2.8392)	(2.9870)	(2.5402)	(2.5593)	(2.6550)
Observations	108	108	108	108	108	108
R^2	0.28	0.28	0.29	0.45	0.46	0.45

Robust standard errors in parentheses.
*Significant at 10%, **Significant at 5%, ***Significant at 1%.
GDP, gross domestic product.

Limitations not withstanding, the results in Table 4 are in the spirit of those reported in Tables 1–3. Table 4 shows that the effects of the level of democracy on both the environmental systems quality composite and the reducing environmental stress composite are positive, as in Table 1, but they are weak or statistically insignificant. A transition from nondemocracy to democracy raises environmental system quality, but the effect is insignificant. On the other hand, this transition raises the reducing environmental stress composite, and the effect is statistically significant. Hence, democratic transition is good for reducing the environmental stress composite. A transition from nonautocracy to autocracy reduces environmental systems quality, and the effect is statistically significant, implying, once again, that democracy is good for the environment. This transition also lowers the reducing environmental stress composite, but this particular effect is weak.

Conclusion

Theoretically, scholars debate the effect of democracy on the environment. Existing empirical evidence in the literature is mixed and relatively scant. Seeking to contribute to this literature, we focus on human activities that directly damage the environment. The empirical analysis focuses on five important types of human activities that degrade the environment: CO_2 emissions, NO_x emissions, organic pollution in water, deforestation, and land degradation. We also study the effect of democracy on two composite environmental measures.

Our analysis contributes to the democracy–environment literature by empirically testing the net effect of democracy on environmental degradation. We use a wide array of empirical measures of environmental degradation. We also use a continuous measure of the level of democracy/autocracy and two dichotomous measures of democracy and autocracy. The empirical scope of our data analysis is generally wider than in previous studies.

The empirical results we report are consistent across the different types of environmental degradation. We find that a higher level of democracy leads to less CO_2 emissions per capita, less NO_x emissions per capita, less organic pollution in water, lower deforestation rates, and less land degradation. But such an effect appears discontinuous along the continuous scale of political regime types. We find that the difference between autocracy and nonautocracy significantly influences CO_2 emissions, NO_x emissions, and organic pollution in water, while the difference between democracy and nondemocracy significantly affects land degradation. But the effect of democracy on the deforestation rate and the forested land area appears to be monotonic along the democracy scale. In sum, democracy reduces the extent of human activities that directly degrade the environment, and the nonmonotonic effects of democracy vary across the environmental indicators.

We also find that the effect of democracy on environmental degradation varies in size across degradation types. But in all cases, a rise in democracy produces a noticeable effect on environmental degradation. This also applies to CO_2 and organic water pollution when we take into account the long-run effect of democracy via the lagged-dependent variable. The sizes of effects are considerable for the rate of deforestation, the size of forested land, NO_x emissions per capita, and land degradation. The immediate (annual) effects of a rise in democracy on organic pollution in water and CO_2 emissions per capita appear to be small, but the cumulative effects of this rise in democracy over time are much larger. Yet, these two effects are still smaller than the effects of democracy on NO_x emissions, rate of deforestation, forested land, and land degradation. Hence, democracy reduces some types of environmental degradation more than other types.

Our results also suggest that democratization could indirectly promote environmental degradation through its effect on national income. This effect is subtle and works through the environmental Kuznets curve. Across the five aspects of environmental degradation, we find evidence supporting the existence of an environmental Kuznets curve for CO_2 emissions per capita, NO_x emissions per capita, the rate of deforestation, and the level of land degradation. When income per capita is low, a rise in income per capita causes more degradation; once passing a threshold, a rise in income per capita reduces degradation. Although existing evidence on the effect of democracy on economic growth is inconclusive, to the extent that a rise in democracy promotes economic growth, the environmental Kuznets curves that we find suggest that democracy could indirectly cause more environmental degradation for the above-mentioned indicators at the initial stage of development, and only later help to reduce it.

Because we focus on the net effect of democracy on different dimensions of environmental degradation, testing how specific mechanisms and processes of democracy influence environmental degradation is beyond the scope of this paper. Future research may benefit from testing more refined hypotheses with respect to the exact sources of the effect of democracy on the environment. This may help identify whether the benign net effect of democracy on the environment results from the dominance of the benign effect of democracy over its malignant effect, or whether it is because the malignant effect of democracy on the environment simply does not exist. Future research may also help explain the nonmonotonic effect of democracy on different types of environmental degradation. We hope our empirical analysis here provides some impetus for moving scholarship in that direction.

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