Debt, Democratization, and Development in Latin America: How Policy Can Affect Global Warming

René W. Aubourg
David H. Good
Kerry Krutilla

Abstract

The environmental Kuznets curve (EKC) hypothesis conjectures a nonlinear relationship between pollution and economic growth, such that pollution per capita initially increases as countries economically develop, but then reaches a maximum point before ultimately declining. Much of the EKC literature has focused on testing this basic hypothesis and, in studies that find evidence of an EKC, estimating the "turning point" level of development at which the per capita pollution-growth relationship changes sign. This approach has not emphasized the policy relevance of specification issues or the potential role of policy variables. This research explores a modified EKC specification which conditions the pollution-growth relationship on a country's level of debt and degree of democratization. These variables turn out to be significant, implying that different political and economic contexts can shift EKCs and their turning points. These findings suggest that policies to relieve debt burdens and institute political reform, in addition to their usual justifications, also could be used as a strategy to reduce carbon emissions from developing countries.

INTRODUCTION

The environmental Kuznets curve (EKC) hypothesis conjectures a nonlinear relationship between economic growth and pollution in which pollution per capita initially worsens as countries develop but ultimately improves with economic advance. The possibility that economic growth is ultimately associated with declining pollution has the strong implication that growth and environmental policy objectives may not be necessarily conflicting, or at least that the environmental impact of growth could become relatively diminished in the longer term. Applied to carbon emissions, the EKC hypothesis implies the possibility of lower global warming risks than current forecasts based on the monotonic extrapolation of existing carbon emissions trends.

The implication that economic growth is ultimately associated with lower per capita environmental damages is quite controversial, of course, and has led to an extensive literature. This literature has treated the EKC as an empirical hypothesis to be tested, with empirical models largely specified as reduced-form "black-box" relationships between per capita emissions and income. The focal point of this research has been to assess whether the data support the identification of a per capita income threshold at which emissions begin to decline, and what the threshold income level might be, and how a variety of specification issues affect conclusions about the presence or absence of EKCs. Modeling issues such as functional form, the treatment of country-specific effects (fixed or random), possible cross-country

Journal of Policy Analysis and Management, Vol. 27, No. 1, 7–19 (2008)

Published by Wiley Periodicals, Inc. Published online in Wiley InterScience (www.interscience.wiley.com)
DOI: 10.1002/pam.20304

or -region EKC heterogeneity, and whether or not the data are nonstationary have played a prominent role in this research agenda (see Dasgupta, Laplante, Wang, & Wheeler, 2002; Dinda, 2004; Stern, 2004).

Although the EKC literature has yielded much interesting insight, it has lacked empirical study to explain why different income thresholds for the declining pollution per capita phase have been observed in different countries or regions, or considered how policy interventions might influence these thresholds. The objective of this study is to begin to explain such differences for developing countries, and to consider how policy might influence them. We develop a specification for country-level per capita carbon emissions that is context-specific, reflecting cross-country differences in foreign debt servicing obligations and a country's degree of political and civil freedom. As a country alters its level of foreign debt service obligations and/or undertakes democratic reforms, the income threshold for declining per capita emissions (hereafter, the "EKC turning point") shifts, implying that at least part of the differences observed in EKCs in different developing countries can be explained by cross-country differences in these variables. The conditionality of EKCs on debt service obligations and the degree of a country's democratization opens the door for policy intervention, because these variables can be influenced by domestic policy and/or foreign assistance programs.

The region for our empirical application is Latin America and the Caribbean. The level of foreign debt service obligations and degree of democratization are relevant contextual factors for this region, as they are for many developing areas of the world. Four of the countries in the sample—Mexico, Argentina, Brazil, and Venezuela—were heavily indebted for at least part of the period of the study (1973–1999). Other countries such as Haiti, Nicaragua, Guatemala, Bolivia, Ecuador, and Peru have had periods of political and institutional instability during the study time-frame.

Our application to carbon emissions is also particularly policy-relevant given the emerging consensus about impending climate change (Dowdeswell, 2006; Osborn & Briffa, 2006). Policymakers in advanced countries need to understand the structural factors in developing countries that can be leveraged through aid or other incentives as part of a global effort to reduce carbon emissions. Because the conditioning variables in our empirical analysis turn out to be significant, our results suggest that policies to relieve debt burdens and institute political reform, in addition to their usual justifications, also could have the effect of reducing EKC turning points in developing countries, or at least the level of carbon emissions generated during the course of development. Leveraging such policy reforms through foreign assistance could be part of a joint global strategy to reduce carbon emissions, helping developing countries, which are likely to resist more coercive policy measures such as binding emissions limits, to lower their economy's carbon output per capita while at the same time achieving their own domestic objectives for economic development and political advance.

BACKGROUND

The EKC literature is quite large, and thorough reviews are available elsewhere (for example, Dasgupta et al., 2002; Dinda, 2004). In general, the literature suggests that the pollution-growth relationship reflects the relative strength of three structural elements: the scale of the economy, the composition of the economy's output, and the composition of the economy's inputs (the latter referred to as the "technique effect" in the Kuznets literature; for example, Grossman & Krueger, 1995; Panayotou, 1997). As the scale of the economy expands, more pollution will be produced absent offsetting economic changes. This scale effect can be further decomposed into increases in population size and increases in the level of per capita consumption. However, as income increases, the composition of this consumption can change from more- to less-pollution-intensive goods (for example, a shift from manufactures to services) and/or production techniques can become less pollution-intensive (for example, more energy-efficient production processes, less-polluting fuels, more technologically advanced pollution control). Whether or not an EKC materializes depends on the degree to which the factors that lower pollution per unit of output come to dominate the scale effect of economic activity.[1] Furthermore, absolute pollution declines will be achieved only when per capita declines are larger than population growth rates. In the remainder of this paper, as with the bulk of the EKC literature, we focus on the relationship between per capita consumption and per capita emissions, and assume that a decline in per capita emissions implies a decline in absolute emissions conditioned on population size.

The Kuznets literature contains much theorizing about why the pollution-lowering aspects of economic growth could ultimately come to override the pollution augmentation associated with economic scale. Plant modernization, energy efficient conservation investment, output shifts from more- to less-energy-intensive final goods, and fuel switching from coal and oil to natural gas and renewables are all channels that could lower the output of CO2 per capita with additional economic growth. Cost-effective "no regrets" energy conservation investment offers one avenue for lowering the energy intensity of output per capita (Boyd, Krutilla, & Viscusi, 1995). Micro-data suggests that individuals consume more energy-efficient appliances as incomes rise (Roca, 2003). The general shift from lower- to higher-quality energy-using services and appliances appears to be a ubiquitous feature of the so called "energy transition" exhibited in developing countries throughout the world (Barnes, Krutilla, & Hyde, 2005).

Notwithstanding the theoretical possibility of an EKC for carbon emissions and suggestive evidence from micro-level data, the structure and form of the economic growth-carbon emissions relationship must be empirically studied at the macro level to draw reasonable conclusions about the relationship between aggregate economic growth and carbon output. In this context, the evidence from the Kuznets literature is decidedly mixed. Some studies have found that CO2 emissions monotonically increase with income and fail to find any turning point (for example, Shafik 1994; Cole, Rayner, & Bates, 1997; Holtz-Eakin & Selden, 1995). Others have found emissions turning points within the sample range but at income levels at or above $10,000—out of reach, at least in the near term, of most developing countries (Galeotti & Lanza, 1999; Galeotti, Lanza, & Pauli, 2001; Schamlensee, Stoker, & Judson, 1998; Dijgraaf & Volleberg, 2001). More recent research provides mixed evidence of an EKC for carbon emissions; namely, an EKC relationship was found to exist only for OECD countries, with non-OECD nations showing a positive relationship between carbon emissions and income (Galeotti, Lanza, & Pauli, 2006; Richmond & Kaufmann, 2006).

This empirical literature can be critiqued on a number of grounds. The most relevant issue for this paper is that the common approach assumes that countries share the same EKC turning-points; that is, the slope coefficients in estimating equations are assumed to be the same across countries, with cross-country differences only reflected in fixed or random effects intercept terms. This homogeneity assumption is quite problematic, because countries can vary widely in terms of socio-economic, political, cultural, and demographic factors that might affect CO2 emissions. In fact, the studies which have separately estimated EKCs for different

[1] In an open economy setting, the relocation of pollution-intensive industry abroad also can lower domestically produced emissions per capita.

subsamples in the data find different EKCs across sample subsets; for example, for developing countries and developed countries, or for individual countries (for example, Carlsson & Lundström, 2000; Hill & Magnani, 2002). These results beg for an explanation: What are the excluded variables that explain such differences? This is particularly important if the EKC is to be used to draw policy conclusions.

In the context of CO2 emissions, candidates for excluded variables are those that affect the ability of individuals to invest in new plant and equipment, to flexibly shift resources between sectors, and to have unrestricted consumer choice among alternative fuel types and energy-efficient services and appliances. The development and environment literatures have arrived at some conclusions about variables that fit these requirements. The macro proxy variables we choose to represent them are the level of foreign debt servicing obligations and the degree of a country's democratic development.

Foreign borrowing can play a crucial role in complementing domestic savings that are insufficient to finance plant modernization and energy efficiency. As such, the level of a country's indebtedness could result from an optimal investment program. In that case, we might hypothesize an inverse relationship between a country's level of indebtedness and level of carbon emissions. However, the history of debt financing in developing countries has been far from optimal, and the excess level of debt accumulated has imposed severe investment constraints (Sachs, 1989). Given that foreign creditors appropriate some of the returns on local investments as debt service payments, external debt acts as an implicit tax on domestic resources (Krugman, 1988). Servicing a high external debt while maintaining consumption also can crowd out competing investment outlays. In an empirical study, Cohen (1993) showed that transferring one percent of GDP abroad to service debt reduced domestic investment by a third of a percentage point. This transfer may displace domestic investments in efficient energy-using technology required for modernizing capital in existing sectors, as well as inhibit the startup and expansion of new, more energy-efficient, economic sectors.

There is also an established literature documenting the relationship between political instability and suboptimal investment due to property rights insecurity and the risk of asset expropriation. In the environmental context, Deacon (1999) demonstrates in a theoretical study that non-democratic regimes are more likely to underinvest in pollution control than democratic ones. Lopez and Mitra (2000) use a theoretical model to show how rent-seeking in a corrupt society dissipates resources, leading to higher levels of pollution at all income levels and EKC turning points above the socially optimal level.

Relatively few studies in the Kuznets literature have added variables to the specification related to the strength of policymaking processes or democratic institutions. For example, Panayotou (1997), in a decomposition model of the structural determinants of sulfur dioxide emission, uses an explicit policy variable for the quality of institutions as reflected by five indicators (the stringency of contract enforcement, the level of bureaucratic efficiency, the efficacy of the rule of law, the extent of government corruption, and the risk of asset appropriation). He finds that better institutions/policies have a greater impact on environmental quality at higher income levels than at lower ones. Torras and Boyce (1998) examined the impact of power inequality measured in three different ways (Gini coefficients, the literacy rate, and an index of political and civil liberties) on seven air and water quality indicators. They found that all seven environmental indicators were adversely affected by at least one of the three measures of power inequality. Barrett and Grady (2000) tested the impact of the political environment as measured by an index of political and civil liberties on the comprehensive data set for air and water quality indicators.

They found that an improvement in civil and political freedom significantly improves air quality indicators and has mixed effects on some water quality pollutants, but has no effect on water oxygen regime indicators. Carlsson and Lundström (2000) investigated how political and economic freedoms affect CO2 emissions in subsamples of developed and less developed countries. They measured political freedom in terms of an index of political and civil liberties, and used different measures of economic freedom to account for four effects (regulation, efficiency, stability, and credit) through which they hypothesized economic freedom affects environmental quality. They found that political freedom had no effect on CO2 emission in either subsample, whereas economic freedom had positive effects on environmental quality in developed countries and a negative effect in the less developed ones.

Although these empirical studies are suggestive of the potential for political and institutional factors to affect the economic-growth pollution relationship, crucial to the rationale for this study is that the specifications in all of them capture the impact of political-institutional variables as dummy variables that can only affect intercept terms. In such specifications, the omitted variables can affect the amplitude of the EKC but not its turning point. Hence, these studies cannot address the possibility of different EKC turning points as suggested in theoretical literature (Brock & Taylor, 2004; Volleberg, Dijkgraaf, & Melenberg, 2005) or observed in the empirical EKC studies of separate countries or regions.

In contrast, the model developed in the following section expands the specification of the economic growth-CO2 emissions relationship by entering the omitted variables interactively with the income term. In this specification the EKC and its turning point become context specific, depending on a country's foreign debt burden and level of democratic development. This modeling approach, used in Aubourg (2003), provides a way to represent the empirical observation of multiple EKC turning points, as well the means to evaluate the impact of such policy interventions as debt relief and political reform on a country's level of carbon emissions.

THE DATA AND MODEL

The data, developed in Aubourg (2003), comprise a total of 29 Latin American and Caribbean countries with the exception of American, British, Dutch, and French territories. Cuba, Aruba, Surinam, and the Bahamas were not considered because of insufficient data availability for most of the variables selected. The remaining countries included Antigua and Barbuda, Argentina, Barbados, Belize, Bolivia, Brazil, Costa Rica, Chile, Columbia, Dominica, Dominican Republic, El Salvador, Ecuador, Grenada, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nevis and St. Kitts, Nicaragua, Panama, Paraguay, Peru, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, Uruguay, and Venezuela.

Economic data that form the basis for our sample (1973–1999) are taken from the 2001 World Bank Development Indicators CDROM. As is usual in the EKC literature, the measures for emissions and income are expressed in per capita terms to make the values comparable across countries of varying sizes. We measure income (GDP) in thousands of constant 1995 dollars of gross domestic product per person. The measure for emissions (CO2) is metric tons of CO2 emitted per capita and is derived not only from manufacturing energy consumption but also from the use of solid, liquid, and gaseous fuels in transportation, cement manufacturing and gas flaring. An exception is bunker fuels used for international shipping because it is difficult to allocate consumption to individual countries.

The measure of debt (DEBT) used in the analysis is the "debt service to export ratio." The numerator is measured as the value of foreign exchange a country forgoes

Table 1. Descriptive statistics of the sample.

	CO2	GDP (000)	LowF	HighF	DEBT %
Mean	2.22	2.66	0.29	0.28	20.82
Median	1.38	2.24	0.00	0.00	18.09
Maximum	17.75	8.47	1.00	1.00	70.06
Minimum	0.05	0.36	0.00	0.00	0.38
Observations	667	667	667	667	667

each year to service its foreign debt obligations, whereas the denominator is measured as the value of foreign exchange the country earns through annual exports. If this ratio is greater than 1, the country is losing more foreign exchange through debt repayment than it is earning through exports. The "debt service to export ratio" is a commonly used indicator of debt sustainability in the academic development literature (for example, Cohen, 1993), and is also used in assessment reports by financial institutions such as the International Monetary Fund and the Asian Development Bank (for example, Thomas, 2006; Asian Development Bank, 2003).

Missing values and other minor inconsistencies in the data were corrected by going back to the original data sources and making adjustments. In some cases, this process entailed talking to desk economists at specific central banks or directly using the data published by a given central bank such as Haiti's Central Bank, checking the data compiled by the Caribbean Center for Monetary Studies (CCMS) at the University of the West Indies in Trinidad and Tobago for English-speaking Caribbean central banks, and the data from the Center for Latin American Monetary Studies (CEMLA) based in Mexico City on Latin American central banks.[2]

Dummy variables representing the institutional strength of democratic processes (LowF, MedF, and HighF) were constructed from indices of political and civil freedoms compiled by Freedom House and constructed by Gastil (1989). The political freedom index reflects whether a government came into power by election or by the gun, whether elections are fair and free, and whether an opposition exists and has the opportunity to take power by the consent of the electorate. The civil freedoms index measures constraints on the freedom of the press, and on the rights of individuals to debate, to assemble, to demonstrate, and to form organizations, including political parties and pressure groups. Both indices run on a scale of 1 to 7, where 7 is the lowest level of freedom.

Following Barro (1996) and Barrett and Grady (2000), we convert these indices into a scale of 0 to 1, where 0 corresponds to the lowest level of freedom and 1 the highest one. We then create a composite index, which is the average of the political and civil indices, and apply the classification used by Barro (1996) and Barrett and Grady (2000) to group countries according to their degree of political and civil liberties. Low freedom countries (LowF) are defined as countries whose political and civil liberties indexes range between 0 and 0.33, medium freedom countries (MedF) as countries with indexes between 0.33 and 0.67, and high freedom (HighF) countries as countries whose indexes are between 0.67 and 1. Summary statistics for the variables used in our study are presented in Table 1.

[2] We wish to thank those governments and researchers at CEMLA and CCMS that helped to fill in much of the missing information in the World Bank data set.

To allow the debt and freedom variables to alter the impact of economic growth on carbon emissions, our reduced form model[3] for estimation is quadratic in GDP with multiplicative interaction terms:

$$CO2_{it} = \alpha_i + \beta_1 GDP_{it} + \beta_2 GDP^2_{it} + \beta_3 LowF_{it} + \beta_4 HighF_{it} + \beta_5 DEBT_{it} + \beta_6 GDP_{it} * LowF_{it} + \beta_7 GDP_{it} * HighF_{it} + \beta_8 GDB_{it} * DEBT_{it} + \beta_9 t + \varepsilon_{it} \quad (1)$$

where α_is are the country-specific effects. The country effects allow for the presence of other excluded country-specific but time invariant variables (for example, varying cultures and social norms). The time trend (t) is used as a proxy for technological change and to account perhaps for potential trend nonstationarity. As described earlier, a key feature of this model is that it also allows the EKC turning point to be context specific; only countries with similar political institutions and indebtedness have the same EKC turning points for carbon emissions. An added advantage of this model is that it allows the analysis of the joint effects of variables. This aspect of the specification is helpful for providing information about the possibility of deploying mutually reinforcing, complementary policy measures.

RESULTS

We estimated both fixed effects and random effects versions of the model. As one would expect, tests indicate that a fixed effects specification is supported over a random effects specification (Hausman test value $\chi^2 = 59.04$ with df = 9 and $p < .0001$). Variables in this model are slow to change over time and it was reasonable to estimate a model which accounted for both serial correlation and heteroskedasticity. We used a first-order Markov model for serial correlation with FGLS (feasible generalized least square) estimation to correct this problem. We also used White standard errors to account for any potential heteroskedasticity. Table 2 presents the results for two different models.[4] The first model (labeled "Basic Model") is offered as a reference case. It is the standard quadratic model in the EKC literature, which omits any explanatory variables other than per capita income; that is, the independent variables are per capita GDP alone and per capita GDP squared. The second model is the expanded model described in Equation 1 (labeled "Augmented Model"). Note that although not statistically significant, the coefficient estimates for the basic model are of the right sign for a downward bending relationship between development and emissions. Comparing the two models, the results indicate a clear rejection of the basic model in favor of the augmented model (F = 64.692, p-value < .0001).

[3] Like most of the EKC literature, our model can be viewed as a reduced form in which the multiple pathways by which our variables affect emissions though the scale, composition, and technique effects need not be specified. In particular, we consider policies that might have direct effects on pollution, such as environmental regulation, to be endogenously determined by both the people's demand for it and the government's willingness and capacity to supply it. Attempting to incorporate these mechanisms explicitly leaves us with two insurmountable problems. First, as a vague construct, environmental regulation is at best measurable by a weak proxy, especially given our need in a cross national panel. Even then, given its endogeneity, consistent estimation requires that we identify credible instruments.

[4] The EKC literature is not instructive about functional form, and many forms other than quadratic have been estimated in the literature. In our investigation we also considered generalizing our second-order Taylor series approximation by including elements from cubic and quartic functional forms as well as interactions between GDP squared and our debt and freedom variables. The Akaike, Schwartz, and Amemiya information criteria (AIC, BIC, and PC) provide ways to balance parsimony and fit among these models. All measures suggested a preference for simpler functional forms. The interaction terms with GDP squared added little to model fit (F = 0.34, p-value = 0.80) and lead to substantively similar findings for GDP/CO2 growth paths. Collinearity also became a problem in these more complex models and only the linear term on GDP as well as some of the interaction terms remained statistically significant.

Table 2. Estimation results for CO2 emissions.

Variables	Basic Model FGLS Estimates[2]	Augmented Model FGLS Estimates[2]
29 Country fixed effects	–	–
GDP	0.5682*	0.4395*
	(0.1358)	(0.0685)
GDP^2	−.0406	−0.0443**
	(0.0306)	(0.0181)
DEBT	–	−0.0090*
		(0.0033)
HighF	–	−0.0275§
		(0.1575)
LowF	–	−0.1546*§
		(0.0462)
GDP*DEBT	–	0.0094*
		(0.0029)
GDP*HighF	–	−0.1716§
		(0.1203)
GDP*LowF	–	0.1199*§
		(0.0360)
T	–	0.0178*
		(0.0059)
R-squared[1]	0.8444	0.9349
Adjusted R-squared[1]	0.8382	0.9310
BFN statistic[3]	1.8574	2.0122
ρ	0.7007	0.6321

* significant at the 1% level, ** significant at the 5 % level; § joint hypothesis significant at the 1% level. HighF and LowF are most appropriately tested jointly. For testing if the coefficient on HighF and LowF both equal zero, the F value is 7.54. For testing if these variables interact with GDP, the F value is 7.24.
[1]Values are reported for the original model (CO2 per capita) using FGLS estimates.
[2]Results are reported using White heteroskedasticity-consistent standard errors and covariance.
[3]Bhargava-Franzini-Narendranathan (1982) test uses a Durbin-Watson–like statistic for serial correlation in panel data models. The test, applied to the transformed model, is not significant in either model, suggesting little serial correlation beyond a first order Markov process.

Substantively, the results for the augmented model provide evidence of EKCs for CO2 emissions from countries in the Latin American and the Caribbean regions, with the coefficients of GDP and GDP^2 being statistically significant at conventional levels (1 and 5 percent, respectively). Table 2 also shows that coefficients for both the DEBT and LowF variables are statistically significant at the 1 percent level. To ascertain the statistical significance of joint effects in the model, a Wald test was applied for zero restrictions on the parameters of the interaction terms involving the debt-service variable and the variable for political and civil freedoms. In both cases, the Wald test rejected the hypothesis of zero restrictions and confirms that the interaction terms matter.

As a benchmark, the turning point derived from the basic model is a constant: $6,998 per capita. In contrast, the derivation of the EKC turning point from the augmented model is an equation, as follows:

$$\textit{EKC Turning Point} = 4.96 + 0.11\ \textit{DEBT} + 1.35\ \textit{LowF} - 1.94\textit{HighF} \qquad (2)$$

For the basic model the constant turning point is obviously context-independent, whereas the turning point for the augmented model is a function of the three variables in Equation 2, which vary across countries. Countries in the region will have different EKC turning points, depending on their level of indebtedness and the degree of their democratic development. Based on the range of independent variable values found in the sample, EKC turning points in Latin America and the Caribbean can range from a low of \$3,054 per capita to a high of \$13,735 per capita. Given this range, it is not surprising that researchers who have estimated samples separately have found widely varying EKC turning points from one sample to another. And it is not surprising that estimating a basic EKC model without relevant conditioning variables could easily lead to false inferences about the nonexistence of EKCs.

Figure 1 provides the graphical results of a simulation to better illustrate the magnitude of effects of the variables for the debt burden and degree of democratization on the EKC turning point for CO2 emissions. The basic model from Table 2 is also simulated to allow for a comparison of the standard specification to the augmented model.

It is clear that higher levels of democracy will decrease the per capita income threshold for the EKC turning point, while lower levels of democratic development will increase the threshold income level for the EKC turning point (see Figure 1). Moreover, the height of the peak of the EKC increases in the latter case. Thus, economic growth produces less CO2 emissions in countries with greater levels of democratic development than those with less, reducing growth-associated environmental damages at every observed income level.

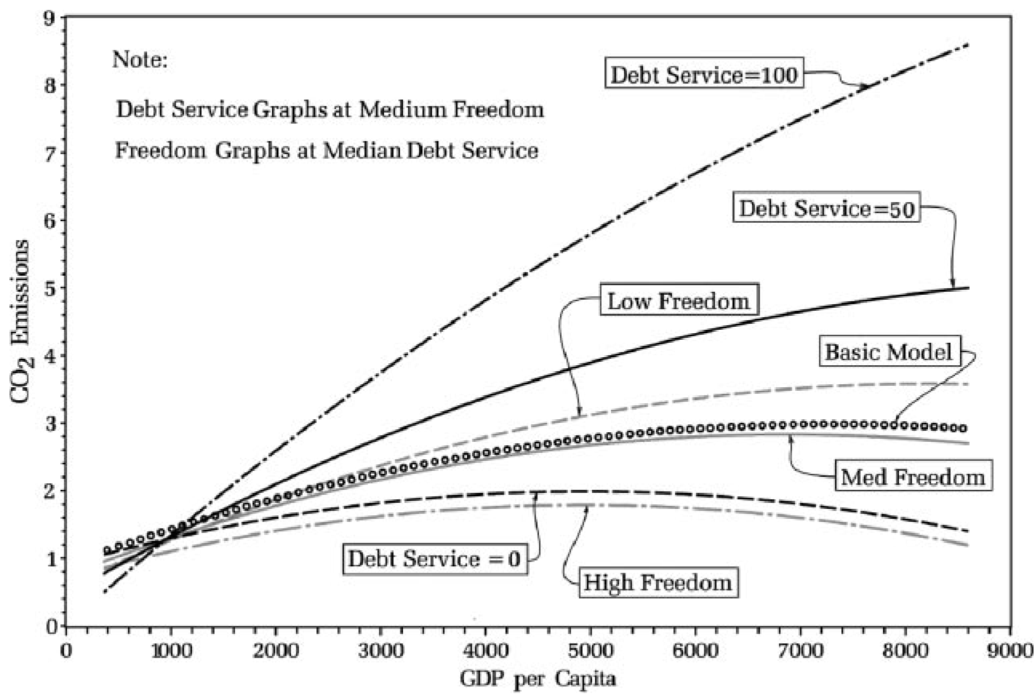

Figure 1. The impact of freedom and debt on the EKC.

A similar pattern holds for a country's level of indebtedness. The higher the debt servicing burden, the greater the CO2 emissions at every income level and the greater the threshold income at which the EKC turning point occurs.

It is interesting to observe the impact of the variables for the degree of democratic development and the level of debt service with reference to the standard model. Higher debt levels and lower levels of democratic development cause the amplitude of the EKC to rise above the peak emissions level of the basic model, whereas low levels of debt servicing and higher levels of democratization cause the EKC to undershoot the peak of the basic EKC model. These outcomes are consistent with findings in the Kuznets literature in which an inverted-U relationship is more likely in developed countries (low debt and high freedom) than for less developed countries. This pattern also illustrates the possibility labeled by Munasinghe (1999) as "tunneling through" the EKC; namely, that the emissions peak of the standard EKC model can be undershot in the course of development by using policies intelligently to reduce CO2 emissions along the development path. In the present case, the policy scenarios to "tunnel through" the Kuznets curve would be to minimize debt servicing obligations and to undertake democratic reforms.

Turning to the direct and indirect impacts of variables on CO2 emissions, these effects reinforce each other to reduce CO2 emissions for countries with higher levels of democracy, as can be seen by looking at the negative coefficient signs of HighF and GDP*HighF in Table 2. In contrast, for countries with a lesser degree of democratization, direct and indirect effects go in opposite directions, with the consequence that one effect to some extent counterbalances the other.

POLICY IMPLICATIONS AND CONCLUDING REMARKS

We believe that a significant contribution of our research is to integrate EKC modeling with the development literature, rather than viewing the EKC as the sole mechanism linking growth policy to the environment. Rather than the all-or-nothing view of previous EKC work, which left little room for political and economic context, we find that such variables can influence the relationship between economic growth and CO2 emissions. Furthermore, rather than the curvature of the relationship and the EKC turning point being the central concern, the impact of variables on the initial slope and magnitude of emissions is also seen to be important.

Our results imply that countries in Latin America and the Caribbean will have different EKC turning points for CO2 emissions, reflecting a country's level of indebtedness and degree of democratization. We can conjecture that these results are attributable to the negative effects of debt and political constraints on the availability and mobility of resources, and the incentives and means for economic agents to allocate them efficiently—for example, to have the resources and incentives to make investments in cost-effective energy-efficient technologies, to have the ability to shift resources between sectors, to make new investments, or to have relatively unrestrained consumer choices, such as the ability to purchase energy-efficient services and appliances. Literatures drawn from a variety of fields suggest a negative relationship between burdensome debt and political constraints on energy efficiency and/or pollution control.

Because our methodology is not based on a fully specified structural model, however, there is still some uncertainty about the causal pathways affecting CO2 emissions. The causal mechanisms behind our findings deserve further theoretical assessment and empirical testing.

The finding that institutional, political, and economic context influence CO2 emissions has policy implications for structuring foreign assistance programs. Policy reforms to encourage debt cancellation or reduction could reduce CO2 emissions associated with future economic growth. Because the level of democratization also influences CO2 emissions, it is possible that political reform also could be employed as a strategy to help reduce future emissions trajectories. In fact, a logical assistance strategy would be to condition debt relief on a country's agreement to undertake political reform. That kind of complementary aid package would provide the right kinds of incentives for policy reform, and also help minimize the future trade-off among economic growth, carbon emissions, and global climate effects.

A complementary combination of debt relief and policy reform might also be considered as a mechanism for joint implementation, a strategy associated with the United Nations Framework Convention on Global Climate Change (UNFCCC, 2006). In traditional joint implementation scenarios, developed countries finance energy conservation programs in the developing world, or transfer energy-efficient technologies (UNFCCC, 2006; Martin, 2000). Such strategies allow advanced countries to cost-effectively reduce carbon emissions, while offering wealth transfers to developing countries justifiable on equity grounds. Our results suggest that a combination of political reform and debt relief offers an additional mechanism for a joint strategy to reduce global warming risks, by using these policies to help developing countries reduce their carbon emissions.

The international development community is coming to recognize the linkage among political, institutional, and economic reforms as critical for sustainable development. Within that context, the Millennium Challenge Act of 2003 establishes criteria for U.S. foreign assistance conditioned on a country's commitments to political and economic reform, economic freedom, controlling corruption, social investment, and civil liberties and the rule of law (Millennium Challenge Corporation, 2006). Similarly, the U.N. millennium development goals put human development, social and economic progress, and environmental sustainability at the forefront of policy objectives. The results of this study suggest that such holistic approaches to development, in addition to their commonly perceived local economic and environmental benefits, could offer ancillary benefits to donors and aid recipients alike by reducing CO2 emissions and global warming risks.

RENÉ W. AUBOURG is Assistant Professor at the School of Public Affairs, American University.

DAVID H. GOOD is Associate Professor at the School of Public and Environmental Affairs, Indiana University.

KERRY KRUTILLA is Associate Professor at the School of Public and Environmental Affairs, Indiana University.

REFERENCES

Asian Development Bank. (2003). Sri Lanka, borrowing capacity assessment. Manila: Asian Development Bank.

Aubourg, R. W. (2003). Two essays on the relationship between economic growth and carbon dioxide emissions using multivariate contingency approach and panel cointegration analysis. Ph.D. Thesis. School of Public and Environmental Affairs, Indiana University.

Barnes, D., Krutilla, K., & Hyde, W. F. (2005). The urban household energy transition: Social and environmental impacts in the developing world. Washington, DC: Resources for the Future Press.

Barrett, S., & Grady, K. (2000). Freedom, growth, and the environment. Environment and Development Economics, 5, 433–456.

Barro, R. (1996). Democracy and growth. Journal of Economic Growth, 1, 1–27.

Bhargava, A., Franzini, L., & Narendranathan, W. (1982). Serial correlation and the fixed effects model. Review of Economic Studies, 49, 533–49.

Boyd, R. G., Krutilla, K., & Viscusi, W. K. (1995). Energy taxation as a policy instrument to reduce CO2 emissions: A net benefit analysis. Journal of Environmental Economics and Management, 29, 1–24.

Brock, W. A., & Taylor, S. (2004). The green Solow model. NBER Working Paper 10557. Cambridge, MA: National Bureau of Economic Research.

Carlsson, F., & Lundström, S. (2000). Political and economic freedom and the environment: The case of CO2 emissions. Working Paper in Economics No. 29. Department of Economics, Göteborg University, Sweden.

Cohen, D. (1993). Low investment and large LDC debt in the 1980's. American Economic Review, 83, 437–449.

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

Dasgupta, S., Laplante, B., Wang, H., & Wheeler, D. (2002). Confronting the environmental Kuznets curve. Journal of Economic Perspectives, 16, 147–168.

Deacon, R. T. (1999). The political economy of environment-development relationships: A preliminary framework. Working Paper. Department of Economics, University of California, Santa Barbara.

Dijkgraaf, E., &.Vollebergh, H. R. J. (2001). A note on testing for environmental Kuznets curves with panel data. Nota di Lavoro 63.2001. Climate Change Modeling Policy. Fondazione Eni Enrico Mattei. Milan, Italy.

Dinda, S. (2004). Environmental Kuznets curve hypothesis: A survey. Ecological Economics, 49, 431–435.

Dowdeswell, J. A. (2006). The Greenland ice sheet and global sea-level rise. Science, 311, 963–964.

Galeotti, M., Lanza, A., & Pauli, F. (2006). Reassessing the environmental Kuznets curve for CO2 emissions: A robustness exercise. Ecological Economics, 57, 152–163.

Galeotti, M., Lanza, A., & Pauli, F. (2001). Desperately seeking (environmental) Kuznets: A new look at the evidence. Nota Di Lavoro. 67.2001. Climate Change Modeling and Policy. Fondazione Eni Enrico Mattei. Milan, Italy.

Galeotti, M., & Lanza, A. (1999). Desperately seeking (environmental) Kuznets. Working Paper. Fondazione Eni Enrico Mattei. Milan, Italy.

Gastil R. D. (1989). Freedom in the world: Political rights and civil liberties 1988–1989. Washington, DC: Freedom House.

Grossman, G. M., & Krueger, A. (1995). Economic growth and the environment. Quarterly Journal of Economics, 110, 353–377.

Hill, R. J., & Magnani, E. (2002). An exploration of the conceptual and empirical basis of the environmental Kuznets curve. Australian Economic Papers, 41, 239–254.

Holtz-Eakin, D., & Selden, T. M. (1995). Stoking the fires. CO2 emissions and economic growth. Journal of Public Economics, 57, 85–101.

Krugman, P. (1988). Financing vs. forgetting a debt overhang. Journal of Development Economics, 110, 1127–1170.

Lopez, R., & Mitra, S. (2000). Corruption, pollution, and the environmental Kuznets curve. Journal of Environmental Economics and Management, 40, 137–150.

Martin, W. (2000). Reducing carbon dioxide emissions through joint implementation of projects. World Bank Policy Research Working Paper No. 2359.

Millennium Challenge Corporation. (2006). Millennium Challenge Corporation adopts environmental and land access criteria for selection of eligible countries. Press Release, September 11.

Munasinghe, M. (1999). Is environmental degradation an inevitable consequence of economic growth: Tunneling through the environmental Kuznets curve. Ecological Economics, 15, 121–124.

Osborn, T. J., & Briffa, K. R. (2006). The spatial extent of 20th-century warmth in the context of the past 1200 years. Science, 311, 841–844.

Panayotou, T. (1997). Demystifying the environmental Kuznets curve: Turning a black box into a policy tool. Environmental and Development Economics, 2, 465–484.

Richmond, A. K., & Kaufmann R. K. (2006). Is there a turning point in the relationship between income and energy use and/or carbon emissions? Ecological Economics, 56, 176–189.

Roca, J., (2003). Do individual preferences explain the environmental Kuznets curve? Ecological Economics, 45, 3–10.

Sachs, J. (1989). The debt overhang of developing countries. In G. A. Calvo, R. Findlay, P. Kouri, & J. B. de Macedo (Eds.), Debt stabilization and development: Essay in memory of Carlos Dias Alejandro (pp. 80–102). Oxford: Basil Blackwell.

Schmalensee, R., Stoker, T. M., & Judson, R. A. (1998). World carbon dioxide emissions: 1950–2050. Review of Economics and Statistics, 80(1), 15–27.

Shafik, N. (1994). Economic development and environmental quality: An econometric analysis. Oxford Economic Papers, 46, 75–773.

Stern D. I. (2004). The rise and fall of the environmental Kuznets curve. World Development, 32, 1419–1439.

Thomas, A. (2006) Do debt-service savings and grants boost social expenditures? International Monetary Fund Working Paper 06/180. Washington, DC: International Monetary Fund.

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

United Nations Framework Convention on Global Climate Change. (2006). Joint implementation. Accessed December, 1, 2006, at http://unfccc.int/kyoto_mechanisms/ji/items/1674.php.

Volleberg, H. R. J., Dijkgraaf, E., & Melenberg, B. (2005). Environmental Kuznets curve for CO2: Heterogeneity versus homogeneity. Discussion Paper No. 2005–25. Department of Economics, Tilburg University.