DEBT, STRUCTURAL ADJUSTMENT, AND ORGANIC WATER POLLUTION

A Cross-National Analysis

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This article presents cross-national models examining the determinants of organic water pollution per capita. The authors use lagged dependent variable panel regression models for a sample of 50 poor nations from 1990 to 2000. They find substantial support for dependency theory that debt, structural adjustment, and industrial exports increase water pollution. The authors also find support for world polity theory that international non-governmental organizations decrease water pollution. They conclude with a brief discussion of the findings, some policy implications, and directions for future research.

Keywords: *[PLS PROVIDE KEYWORDS]*

Only a few studies that examine the cross-national determinants of organic water pollution have been published (e.g., Jorgenson, 2006a, 2007; Li & Reuveny, 2006; Scruggs, 1998). The limited treatment of this issue is somewhat surprising given that water pollution is particularly important to study for a few reasons. First, water pollution is associated with a number of environmental problems, such as eutrophication and biodiversity loss in lakes, ponds, rivers, and streams (e.g., Hettige, Mani, & Wheeler, 2000). Second, it has the potential to adversely affect human health and well-being (e.g., Jorgenson & Burns, 2004). Third, water pollution is the result of human activities and thus can be modeled using cross-national data (e.g., Li & Reuveny, 2006).

These reasons underscore the importance for a better understanding of water pollution. In this article, we conduct the first cross-national study to examine dependency theory ideas that debt and structural adjustment increase organic water pollution. We also consider the world polity hypothesis that international non-governmental organizations decrease organic water pollution. We conclude with a brief discussion of the results, policy suggestions, and some directions for future research.

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The Importance of Studying Water Pollution

There are several important reasons why social scientists should examine the causes of organic water pollution from industry and manufacturing. First, water pollution from these sources contributes to other environmental problems. The chemicals and byproducts of manufacturing and industrial processes often end up as waste and are disposed of by being dumped into rivers, lakes, and streams (Clapp, 1998). They also leach into underground aquifers and contaminate drinking water (Eckenfelder, 2000). Many of the chemicals (e.g., mercury) that are dumped into waterways seep into aquifers are not only highly toxic but also take a long time to decompose (Eckenfelder, 2000). Consequently, there is a shift in the pH of water. This pH shift causes certain plants and animals to die off while allowing others to reproduce unchecked, thereby reducing biodiversity (Stanley, 1996). Some water pollutants also stimulate oxygen consumption by plants, algae, and bacteria (Hettige et al., 2000). This process reduces levels of dissolved oxygen creating a situation of chronic "stress" that lowers the body weight of aquatic animals and makes them less able to compete for food and habitat (Stanley, 1996). It also creates a situation that is toxic to some fish and other aquatic organisms, which die because of lack of oxygen (World Bank, 2003).

Second, water pollution from industrial and manufacturing activity has serious effects for humans (Jorgenson & Burns, 2004). The toxic chemicals found in water supplies affect people through the process of "bioaccumulation" or the building up of toxins in the fatty tissue of mammals (Czub & McLachlan, 2004). The long-term effects of bioaccumulation in adults include cancer, blood disorders, immunity suppression, and spontaneous abortions (Frey, 2003). The buildup of these pollutants has been linked to birth defects and mortality in infants (Burns, Kentor, & Jorgenson, 2003). Furthermore, women and children in poor nations are disproportionately and uniquely affected by polluted water (Rocheleau, Thomas-Slayter, & Wangari, 1996). As water becomes more polluted and, consequently, less accessible, women and children must travel farther and work harder to collect it. This extends work days for women and children and forces them to make tradeoffs regarding work, education, and health care (Norgaard & York, 2005).

Third, water pollution is largely the result of human activities and, thus, can be modeled using cross-national data. The industrial activities that contribute to it include manufacturing of glass, pesticides, medicines, plastics, ceramics, textiles, metals, pulp, and paper (Hettige et al., 2000). Some other activities that contribute to water pollution include food-processing facilities with inadequate disposal facilities and the dispersing of water used to cool coke during steel production (Miller, 2002). Several theories make predictions about the cross-national determinants of water pollution. We now turn to a discussion of dependency theory and world polity theory. We also consider insights from other perspectives.

Dependency Theory

Dependency theory contends that foreign debt is particularly harmful for the natural environment. The poor nations of the world are under constant pressure to service their debts (McMichael, 2004). As a result, governments attempt to increase export earnings to meet interest and principal obligations. However, organic water pollution from manufacturing and industry may well increase. This can arise from increased production of cheap industrial and manufactured goods for export (Jorgenson, 2007). The sectors that may be targeted include textiles, clothing, pharmaceuticals, and pesticides, which may all increase water pollution. For instance, firms making textiles and clothing for export use a variety of dyes and fixers, which end up in local rivers, lakes, and streams (Frey, 2003). Additionally, nations that extract primary products such as logs and minerals for export are often involved in the initial processing of these raw materials as well. These processes may increase organic water pollution in poor nations. For example, pulp and paper manufacturing yield starches, lost cellulose fibers, and carbohydrate as effluents (Stanley, 1996). Furthermore, processing of steel from iron ore increases organic water pollution by dispersing water used to cool coke after it has finished baking. Water pollution also results from the leaching of electric arch furnace dust into ground water when making steel (Andres & Irabien, 1994).

Although debt itself has the potential to increase water pollution, structural adjustment may also add to this problem. Beginning in the 1980s, the debt crisis highlighted an inability of many poor nations to generate enough revenue to make payments on foreign debt. As a result, the International Monetary Fund and World Bank provided structural adjustment loans designed to resolve the balance-of-payment issues by rescheduling payments, renegotiating loan terms, and providing new loans (George, 1992). However, the new loans required indebted nations to institute a variety of economic policy reforms in return for the money (Rich, 1994). These policy reforms include devaluing currency, reducing government spending, liberalizing trade, and privatizing government assets (Culas, 2006). The underlying logic attempts to stimulate economic growth to generate hard currency for debt repayment by increasing exports and decreasing spending. Although the "earn more" and "spend less" model may guarantee debt repayment, it also has the potential to increase organic water pollution (George, 1992). This may occur for several reasons.

First, structural adjustment loans require that governments increase exports (Peet, 2003). In this regard, cheap industrial and manufactured goods assume key roles in generating foreign currency to repay a loan. This often occurs by forcing a nation to devalue its currency (Mohan, 2001). The devaluation of currency creates a demand for a nation's exports on the world market. The poor nations meet demand by increasing production (Rich, 1994). Some of the sectors targeted for export that may increase organic water pollution include manufacturing of chemicals, metals, pulp, paper, glass, pesticides, pharmaceuticals, dyes, and textiles (see the discussion of debt for examples of how such processes may increase organic water pollution).

Second, structural adjustment loans require governments to liberalize trade by removing barriers for foreign investment (Karliner, 1997**[PLS PROVIDE REFERENCE]**; Shandra, London, & Ross, 2003). This often involves offering corporations a variety of regulatory concessions and financial incentives (Peet, 2003). The regulatory concessions include exemptions to environmental laws (e.g., proper disposal of toxic waste or treating waste water) and weak protections for labor (e.g., firing workers at will and outlawing strikes, protests, and unions) (Ross & Trachte, 1990). The most notable financial incentives for corporations are "tax holidays" that include exemptions of export duties, import duties, and income taxes (Leonard, 1988). The purpose of tax and regulatory policies of this sort is to stimulate investment largely in the export sector by lowering costs to generate exchange for repayment obligations (Ross & Trachte, 1990).

Again, such policies may well increase water pollution. Clapp (2001), Coote (1995), Clapp (1994), and Porter and Brown (1991) argue that the economic incentives and regulatory concessions tend to encourage the migration of "dirty" industries to poor nations. This has the potential to increase water pollution. Moreover, tax breaks, environmental law exemptions, and privatizing government assets yield reductions in spending because there is little new revenue being collected by the government (George, 1992). This hampers the regulatory capacity of governments to monitor and enforce environmental regulations, which are already limited by mandated budgetary cuts (see below). In other words, structural adjustment may contribute to organic water pollution by promoting unregulated industrialization (O'Meara, Mehlinger, & Krain, 2001).

Third, structural adjustment loans have usually required deep cuts in government spending to correct for budgetary imbalances (Barbosa, 2001). The nature of the cuts has varied from one nation to another, but a common trend has been the reduction in the budgets and staffs of environment and conservation departments (Bryant & Bailey, 1997). These cuts often hamper enforcement of environmental regulations and prevent the implementation of pollution abatement and monitoring efforts (Rich, 1994). Put differently, structural adjustment reduces the regulatory capacity of governments to monitor and enforce environmental regulations, which may increase water pollution (Deacon, 1994).

In recent years, Shandra (2007b), Culas (2006), Marquart-Pyatt (2004), Rudel and Roper (1997), and Kahn and McDonald (1994) among others considered the relationships between debt, structural adjustment, and deforestation. Shandra, London, Whooley, and Williamson (2004) consider if structural adjustments increase carbon dioxide emissions. Bradshaw and Schafer (2000) examined how debt and structural adjustment affect access to clean drinking water. However, this idea has not yet been applied to organic water pollution. Thus, we address this gap in the literature by examining if both debt service and structural adjustment increase organic water pollution.

World Polity Theory

The world polity perspective holds that international nongovernmental organizations play an important role in reinforcing world cultural norms, some of which have significant environmental implications (Boli & Thomas, 1999; Frank, 1999; Frank, Hironaka, & Schofer, 2000; Schofer & Hironaka, 2005; Shor, in press). First, they intervene in global political processes and help shape the language of environmental treaties, thereby influencing the normative content of global institutions (J. Smith, 1995). In this regard, treaties provide international nongovernmental organizations with an ideal way to highlight if governments do not sign treaties or meet their obligations once they sign (Clapp, 1994). In the absence of resources and formal mechanisms of enforcement, international nongovernmental organizations monitor adoption and compliance by governments with environmental agreements (Hafner-Burton & Tsutsui, 2005). Consequently, they point out embarrassing failures and hypocrisies of nations, putting pressure on governments to sign treaties or meet their treaty obligations (Finnemore & Sikkink, 1998).

Second, international nongovernmental organizations help mobilize support for problem-solving initiatives when national-level avenues are either inadequate or blocked (Keck & Sikkink, 1998). It has become increasingly common for these organizations to provide support for conservation efforts at subnational levels (Schofer & Hironaka, 2005). In doing so, many international nongovernmental organizations directly fund local environmental protection efforts. They also serve as intermediaries, bridging disparate community groups under the rubric of "grassroots" development (Clark, 1991; Schafer, 1999). This involves facilitating conservation efforts by integrating financial, technical, and organizational resources from abroad with local knowledge and community participation (Bradshaw & Schafer, 2000).

Third, international nongovernmental organizations support social movement activity at the local level (Keck & Sikkink, 1998). In fact, Frank et al. (2000) find that nations with more international nongovernmental organizations experience a growth in domestic environmental social movements (e.g., higher levels of domestic nongovernmental organizations). These ideas can be observed in practice when international nongovernmental organizations (e.g., Greenpeace, Sierra Club, and Conservation International) employ frames and discourses that encourage domestic social movement activity and, in turn, environmentalism within a nation. In such instances, Schofer and Hironaka (2005) argue, governments are "squeezed" from above and below to attend to environmental problems such as water pollution. Keck and Sikkink (1998) refer to this process as a "boomerang effect."

Shandra (2007b), Schofer and Hironaka (2005), and Shandra et al. (2004) found that international nongovernmental organizations reduce deforestation and carbon dioxide emissions. Bradshaw and Schafer (2000) found that international nongovernmental organizations increase access to safe drinking water. Thus, we hypothesize that international nongovernmental organizations decrease organic water pollution in poor nations.

Sample

We include all nations that are not classified as "high income" according to the income quartile scheme of the World Bank (2003). We exclude high-income nations because they do not receive structural adjustment loans. There is also no comparative data on debt service for high-income nations. We also do not include nations formed following the collapse of the Soviet Union because there are no data for these nations in 1990. This yields a sample of 52 nations for which complete data are available on all our variables.[1] We report and remove influential cases from the analysis.

Research Design

We use lagged dependent variable panel regression for our analysis. This approach is commonly used by sociologists in the analysis of cross-national data. For example, it has been used by Jorgenson and Burns (2007), Grimes and Kentor (2003), and Shandra, London, and Williamson (2003). In this sort of analysis, the dependent variable at one point in time is regressed on itself at an earlier point in time and the other independent variables at that same earlier time point. This method estimates the effects of the independent variables on change in the dependent variable between two time points. Our dependent variables are measured in

2000. The lagged dependent variable and independent variables are measured in 1990. This design is also referred to as the “conditional change score” model as shown in the mathematical notation:

$$Yt = B_0 Y_{t-1} + B_1 + B_2 X_{t-1} + E_t$$

The dependent variable (Y_t) is hypothesized to be determined by the lagged dependent variable ($B_0 Y_{t-1}$), the constant (B_1), the lagged value of the independent variable ($B_2 X_{t-1}$), and an error term (E_t).

There are several reasons for using lagged dependent variable panel regression rather than other modeling strategies. First, it improves on models that are cross-sectional in nature. By including the lagged dependent variable in the model, the design helps rule out reciprocal causality (Finkel, 1995). This also allows researchers to reduce the threat of “omitted variable bias” or spuriousness because of an apparent effect that can be accounted for by another factor causally prior to both the dependent and independent variables of concern (Menard, 2002**[PLS PROVIDE REFERENCE]**). Second, including the lagged dependent variable helps deal with one of the most pervasive phenomena in the analysis of change—the likely negative correlation between initial scores on a variable and subsequent change. This phenomenon, referred to as “regression to the mean,” may lead to biased regression estimates. See Finkel (1995) for a discussion of how including a lagged dependent variable partially controls for regression toward the mean. This issue is relevant to our analysis, as the water pollution in 1990 and change in organic water pollution from 1990 to 2000 are correlated at –.308.

Of course, researchers should be aware of potential limitations that may emerge when including a lagged dependent variable. First, there is the possibility of introducing serial correlation of errors. Nevertheless, with serial correlation of errors, the result would be a more conservative test of our hypotheses because the effect of the lagged dependent variable is inflated relative to the estimated effects of the independent variables (Timberlake & Kentor, 1983**[PLS PROVIDE REFERENCE]**). To address this issue empirically, we calculate Durbin-Watson statistics. The results of these tests indicate no potential problems with autocorrelation. Second, problems may arise with heteroskedasticity (Jackman, 1980**[PLS PROVIDE REFERENCE]**). We deal with this problem by transforming the dependent and lagged dependent variables using the natural logarithm. Additionally, we calculate Breusch-Pagan tests for our models to determine if heteroskedasticity is a problem (Menard, 2002). The results of these statistical tests indicate no potential problems with heteroskedasticity in our models.

Dependent Variable

Water pollution. The dependent variable includes total kilograms of organic water pollution released per day from manufacturing and industry per capita in 2000. The emissions are from processing and manufacturing of metals, paper, pulp, chemicals, food, beverages, stone, ceramics, glass, textiles, and wood (World Bank, 2003). This measure has been used previously by Jorgenson (2006a, 2007). The lagged dependent variable is measured in 1990. The organic water pollution and population data can be obtained from the World Bank (2003). Please note that all of the data below come from the World Bank unless otherwise noted. Organic water pollution is measured in terms of biochemical oxygen demand, which refers to the amount of oxygen that bacteria consume in the process of breaking down waste. This is a standard water treatment test for the presence of organic pollutants (World Bank, 2003). We log both the dependent variable and the lagged dependent variable to reduce problems that may arise with heteroskedasticity (London & Ross, 1995). We provide descriptive statistics and bivariate correlations in Table 1.

Independent Variables/International Variables

Nongovernmental organizations. We include the total number of international nongovernmental organizations in a nation for 1990. J. Smith (2004) collected information from The Yearbook of International Associations and coded those international nongovernmental organizations explicitly focusing on the environment. This variable has recently been used by Shandra (2007b) and J. Smith and Wiest (2005). We standardize this variable for comparison across nations by dividing it by a nation's population in millions for 1990. We log this variable because it has a skewed distribution. World polity theory suggests that more international nongovernmental organizations per capita should decrease water pollution.

Structural adjustment. To capture the effects of structural adjustment, pressure, and conditionality required by the International Monetary Fund and other multilateral lenders, Walton and Ragin (1990) developed a conditionality index. It has been used in various forms by Shandra, London, and Williamson (2003), Bradshaw and Schafer (2000), Schafer (1999), and Buchman (1996). This index is the sum of four variables, which include (a) the number of debt renegotiations between a country and an international financial body (e.g., private bank or multilateral lender), (b) the number of debt restructurings experienced by an indebted nation, (c) the number of times a country used the International Monetary Fund Extended Fund Facility, and (d) the total International Monetary Fund loans received by a country as a percentage of its allocated quota. The variables are measured in 1990. The four components of the index are converted to z scores and summed. The index effectively approximates structural adjustment because the International Monetary Fund imposes conditions in each of its negotiations and renegotiations with indebted nations. Furthermore, the International Monetary Fund is also involved with renegotiations with almost all other multilateral lenders (Buchman, 1996; see Bradshaw & Wahl, 1991; Walton & Ragin, 1990, for a more in depth discussion of the index). Dependency theory hypothesizes that structural adjustment should increase water pollution in poor nations.

Total debt service ratio. In addition to the pressure to adjust their economies, indebted nations must continually service their foreign debts. Therefore, it is also important to control for debt service. This approach has been used previously by Bradshaw and Schafer (2000), Schafer (1999), and Buchman (1996). As such, we also include the sum of principal and interest payments in foreign currency, goods, or services on long-term public and publicly guaranteed private debt with maturity of 1 year or longer as a percentage of goods and services exports. The data are available for 1990. We log this variable to deal with its skewed distribution.

Table 1: Descriptive Statistics and Listwise Correlation Matrix ($N = 56$)

	M	SD	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*	*(17)*	*(18)*
(1) Water pollution, 2000	7.825	1.041	1.000																	
(2) Water pollution, 1990	7.986	0.999	0.944	1.000																
(3) Gross domestic product, 1990	7.836	0.810	0.719	0.720	1.000															
(4) Economic growth, 1980-1990	2.972	4.750	–0.108	–0.277	–0.210	1.000														
(5) Service-based activity, 1990	46.169	10.442	0.141	0.041	0.371	0.206	1.000													
(6) Urbanization, 1990	46.740	20.094	0.452	0.475	0.760	–0.278	0.353	1.000												
(7) Polity IV democracy, 1990	1.280	7.149	0.545	0.518	0.601	–0.231	0.275	0.455	1.000											
(8) Freedom House democracy, 1990	3.951	4.063	0.482	–0.394	0.594	–0.024	0.496	0.530	0.835	1.000										
(9) Government expenditures, 1990	12.940	4.063	0.005	0.115	–0.192	–0.172	–0.266	–0.219	–0.208	–0.252	1.000									
(10) Total debt service, 1990	2.852	0.841	–0.101	–0.221	–0.184	0.288	0.236	0.063	0.067	0.282	–0.250	1.000								
(11) IMF and WB debt service, 1990	2.7352	0.867	–0.125	–0.245	–0.229	0.268	0.208	0.009	0.052	0.263	–0.206	0.984	1.000							
(12) Structural adjustment, 1990	2.201	4.572	–0.013	–0.092	–0.006	0.005	0.340	0.310	0.078	0.312	–0.009	0.275	0.285	1.000						
(13) Industrial exports, 1990	14.901	15.001	0.572	0.517	0.311	0.087	–0.074	0.025	0.195	0.058	0.129	–0.131	–0.128	–0.193	1.000					
(14) INGOs, 1990	0.912	1.386	0.160	0.157	0.121	0.098	0.294	–0.053	0.344	0.426	0.066	0.091	0.095	0.083	0.141	1.000				
(15) Latin America	0.300	0.463	0.186	0.156	0.447	–0.098	0.402	0.656	0.560	0.594	–0.435	0.286	0.244	0.396	–0.217	0.063	1.000			
(16) Asia	0.160	0.370	0.067	–0.032	–0.170	0.339	–0.176	–0.439	0.068	–0.095	–0.183	0.052	0.054	–0.294	0.386	–0.173	–0.286	1.000		
(17) Eastern Europe	0.080	0.274	0.334	0.459	0.279	–0.503	–0.335	0.141	0.197	0.079	0.279	–0.214	–0.188	–0.143	0.197	–0.094	–0.193	–0.129	1.000	
(18) Middle-East	0.080	0.274	–0.210	–0.231	–0.116	0.202	0.069	–0.041	–0.376	–0.274	0.096	–0.163	–0.145	–0.076	–0.144	–0.175	–0.193	–0.128	–0.087	1.000

Note: IMF = International Monetary Fund; WB = World Bank; INGOs = international nongovernmental organizations.

According to dependency theory, total debt service should also increase water pollution.

International Monetary Fund and World Bank debt service ratio. We also include a debt service ratio that covers long-term public debt and repayments to only the International Monetary Fund and World Bank. The data are measured as a percentage of exports of goods and services for 1990. This variable is logged to control for its skewed distribution. Like total debt service, this variable should also be associated with more organic water pollution.

Industrial exports. We also include industrial and manufacturing exports as a percentage of gross domestic product. The data are available for 1990. Industrial exports include (a) manufactured goods, (b) chemical products, (c) machinery and transport equipment, (d) textiles, (e) nonferrous metals, and (f) iron and steel. The data may be obtained from the Commodity Trade Statistics Database of the United Nations Web site. From above, dependency theory suggests that industrial exports should increase water pollution.

Independent Variables / Intranational and Control Variables

A fully specified model of the determinants of the cross-national variation in water pollution must also include a number of additional intranational economic, political, and demographic factors as well as some control variables (see Shandra, 2007a, 2007b).

Gross domestic product. As is standard in cross-national analyses, it is incumbent on us to take into account a nation's level of development to make sure that any effects discovered are independent of a nation's level of wealth. In this regard, we employ a measure of gross domestic product per capita at purchasing power parity for 1990. We log this measure because of its skewed distribution. We hypothesize that gross domestic product should decrease organic water pollution. This may occur for a couple of reasons. First, Burns, Kick, and Davis (2003)[PLS PROVIDE REFERENCE] find that gross domestic product per capita decreases deforestation. They attribute this finding to "recursive exploitation" in which richer nations externalize their deforestation by importing forest produces from poorer nations. A similar process may play out with water pollution as richer nations import industrial and manufactured goods from abroad. We note earlier that the processing of these goods has the potential to increase organic water pollution. Furthermore, nations with higher levels of gross domestic product may invest more money in environmentally sound technologies that help abate water pollution.

Economic growth rate. We also include the average annual economic growth rate from 1980 to 1990 in the analysis. According to the treadmill of production theory, economic growth should increase organic water pollution. To keep profits up, producers must constantly expand production, thereby boosting economic growth. Seeking to expand production while lowering costs, producers invest in economically efficient technologies that have higher yields per unit of labor. Consequently, there is a displacement of costly workers and an increase in unemployment. The only way to deal with the increased unemployment is to again expand production and growth. Governments also support increased production because it increases tax revenues, thereby providing the means to fund government programs. Through the continual expansion of production, the treadmill increases environmental degradation of various forms by placing more and more demands on resources and by increasing volumes of waste.

Service-based economic activity. We also include the value added from service-based economic activity as a percentage of gross domestic product for 1990. We include this variable because it has been suggested that the structure of the economy within a nation may be helpful in explaining deforestation (Ehrhardt-Martinez, Crenshaw, & Jenkins, 2002). Jorgenson (2006a, 2006b) argues that poor nations largely rely on export markets to stimulate economic growth. Similarly, organic water pollution may be mitigated to the extent that nations have something other than industrial and manufacturing exports to produce, such as services. Thus, we hypothesize that nations with high levels of value added in services should have less water pollution.

Urbanization. We also include the percentage of a population living in urban areas in the analysis. The data are measured in 1990. We log this variable to correct for its skewed distribution. It is hypothesized by some that urbanization may increase water pollution because many forms of production that generate water pollution are usually located in urban areas, especially in poor nations (D. A. Smith, 1996).

Polity IV Democracy Index. We also include the level of democracy or autocracy in a nation using data from the Polity IV Project (2005) in our models. This measure ranges from –10 (autocracy) to 10 (democracy). We anticipate that democracy should decrease water pollution because of political activism and electoral accountability (Murphy, 2000). In general, democratic nations have higher levels of political activism than repressive nations because democracies guarantee certain rights, including freedoms of speech, press, and assembly (Ehrhardt-Martinez et al., 2002). Leaders in a democracy must be responsive to such activism because of electoral accountability (Midlarsky, 1998). Furthermore, greater freedom of the press and assembly leads to wider diffusion of information, which in turn raises public awareness. Therefore, environmental groups are often more successful at informing people and organizing them to act in democratic rather than in repressive nations (Li & Reuveny, 2006).

Freedom House Democracy Index. We use the average of Freedom House's (1997) Political Rights and Civil Liberties Scale as another measure of democracy. Political rights reflect the degree to which a nation is governed by democratically elected representatives and has fair, open, and inclusive elections. Civil liberties reflect whether within a nation there is freedom of press, freedom of assembly, general personal freedom, freedom of private organizations, and freedom of private property (Freedom House, 1997). The variables are measured on 7-point scales with the following codes: free (1 to 2), partially free (3 to 5), and not free (6 to 7). We multiply our index by –1 so that high scores correspond with high democracy. We use this alternative indicator of democracy because Bollen and Paxton (2000) argue that nonrandom measurement error arising from the subjective perceptions of judges affect all cross-national measures of democracy to some degree. Such measurement error can bias coefficient estimators of effects and distort comparisons across nations, undermining the empirical results that ignore it. The sequential of two indicators of the same concept can help address this issue. Specifically, if similar findings are produced by each measure, then confidence in the results is enhanced. Like the Polity IV Project (2005) measure, we anticipate that this measure should decrease deforestation.

Government expenditures. We also include in our models total government expenditures as a percentage of gross domestic product in 1990. In a recent study, Shandra (2007b) finds that government spending contributes to deforestation because governments tend to invest in activities that degrade the environment to maximize economic growth. Thus, we hypothesize that government spending may also increase water pollution.

Geographical location. It is also important in cross-national research to account for findings that may arise out of geographical and historical circumstances of nations that cannot be accounted for by the other variables in the model (Firebaugh, 1979[PLS PROVIDE REFERENCE]). Therefore, we also include a series of dummy variables for the region in which a nation is located. We include a series of dummy variables, which identify a nation as being located in Latin America and the Caribbean, Eastern Europe, Asia, and the Middle East. The reference category includes nations located in Sub-Saharan Africa.

FINDINGS

In Table 2, we present the ordinary least squares estimates of organic water pollution. In every equation, we include a lagged dependent variable, gross domestic product per capita, economic growth, service-based economic activity, urbanization, government spending, industrial exports, international nongovernmental organizations, structural adjustment, and geographical dummy variables. We examine total debt service in Equations (2.1) and (2.2) and debt service to the International Monetary Fund and World Bank in Equations (2.3) and (2.4). We include the Polity IV Democracy Index in odd-numbered equations and the Freedom House Democracy Index in even-numbered equations.

We organize our analysis in this way for several important reasons. First, we want to avoid potential problems with multicollinearity. When we include both our democracy measures in the analysis together, for example, variance inflation factor scores are around 8. This is due to the high bivariate correlations between these variables. Second, multiple indicators help guard against potential problems associated with measurement error because one indicator may be imperfect but several measures are less likely to have the same error (Paxton, 2002). Third, the sequential use of “cognate” but “distinct” indicators of more than one independent variable should shed considerable light on the complexity of dynamics involving the issue under investigation (London & Ross, 1995). This line of reasoning also applies to our use of two different debt service measures.

Let us begin by focusing on the significant findings. First, the coefficients for structural adjustment are positive and significant in every equation of Table 2. Second, the coefficients for debt service are positive and significant in Equations (2.1), (2.3), and (2.4). Third, the coefficients for industrial exports are positive

Table 2: Estimates of Water Pollution Including Measures of Debt Service, Structural Adjustment, and Industrial Exports

	Equation 2.1a	*Equation 2.2a*	*Equation 2.3a*	*Equation 2.4a*
International variables				
Nongovernmental organizations, 1990	–.079*	–.094**	–.078*	–.093**
	–.106	–.126	–.104	–.124
	(–1.934)	(–2.327)	(–1.898)	(–2.299)
Total debt service ratio, 1990	.131**	.091		
	.106	.073		
	(2.111)	(1.471)		
International Monetary Fund and World Bank debt service, 1990			.123**	.084*
			.102	.070
			(2.080)	(1.694)
Structural adjustment, 1990	.030**	.023**	.039**	.022**
	.133	.099	.129	.097
	(2.720)	(2.070)	(2.628)	(2.018)
Industrial exports, 1990	.677*	.836**	.658*	.821**
	.097	.120	.095	.118
	(1.796)	(2.237)	(1.742)	(2.190)
Intranational variables				
Gross domestic product per capita, 1990	.231*	.172	.975*	.167
	.180	.133	.176	.130
	(1.762)	(1.315)	(1.731)	(1.286)
Economic growth rate, 1980-1990	.018	.022	.226	.012
	.083	.052	.087	.056
	(1.555)	(1.033)	(1.644)	(1.118)
Service-based economic activity, 1990	–.002	–.003	–.001	–.002
	–.016	–.026	–.014	–.024
	(–.280)	(–.479)	(–.248)	(–.451)
Urbanization, 1990	–.010*	–.020**	–.009*	–.009**
	.0184	–.191	–.172	–.183
	(–1.952)	(–2.099)	(–1.854)	(–2.031)
Polity IV Democracy Index, 1990	.021*		.021*	
	.146		.141	
	(1.957)		(1.890)	
Freedom House Democracy Index, 1990		.115**		.113**
		.186		.183
		(2.553)		(2.497)
Government expenditures, 1990	–.021	–.020	–.021	–.020
	–.081	–.077	–.082	–.079
	(–1.635)	(–1.623)	(–1.663)	(–1.649)
Control variables				
Europe (1 = *yes*)	–.380*	–.412*	–.382*	–.413*
	–.100	–.108	–.100	–.109
	(–1.700)	(–1.912)	(–1.702)	(–1.910)
Latin America (1 = *yes*)	–.237	–.173	–.233	–.173
	–.105	–.077	–.103	–.077
	(–1.367)	(–1.171)	(–1.344)	(–1.163)
Asia (1 = *yes*)	–.189	–.155	–.178	–.150
	–.067	–.055	–.063	–.053
	(–.982)	(–.908)	(–.930)	(–.876)
Middle East (1 = *yes*)	.191	.182	.175	.171
	.050	.048	.046	.045
	(1.113)	(1.103)	(1.030)	(1.043)
Water pollution per capita, 1990	.973**	.984**	.975**	.985**
	.933	.044	.935	.945
	(13.353)	(14.034)	(13.354)	(14.019)
Adjusted R^2	.932	.936	.931	.936
Number of cases	50	50	50	50
Mean variance inflation factor score	2.905	3.058	2.882	3.009
Highest variance inflation factor score	7.455	7.892	7.366	7.834

Note: Algeria and Angola are removed from the analysis because they are influential cases. The first number reported is the unstandardized regression coefficient, the second number is the standardized, regression coefficient, and the third number in parentheses is the *t* statistic.
$*p < .05$. $**p < .01$ (one-tailed).

and significant in every equation. Taken together, these results provide substantial support for dependency theory. Fourth, we also find support for the world policy hypothesis that international nongovernmental organizations reduce water pollution in poor nations. The coefficients for this variable are negative and significant in all four equations of Table 2. Fourth, we find that urbanization decreases water pollution. This finding is somewhat surprising and calls for additional research. Fifth, we find that democracy increases organic water pollution. The coefficients for the Polity IV Index are significant in Equations (2.1) and (2.3), whereas the coefficients for Freedom House Index are significant in Equations (2.2) and (2.4). Sixth, we find that nations in Eastern Europe have significantly less water pollution than Sub-Saharan Africa. This finding may partially be attributed to these nations having less debt burden and structural adjustment loans than nations in Sub-Saharan Africa.

There are some nonsignificant findings that should also be mentioned. First, we do not find that economic development or economic growth affect water pollution in most equations. However, gross domestic product per capita is positive and significant in two of four equations. This finding contradicts our hypothesis that as nations become richer they tend to "externalize" their environmental costs by shifting "dirty" industry abroad. Clearly, additional research should explore this contradictory finding. However, we speculate that it may have to do with most nations in the sample trying to increase the level of development by producing cheap industrial and manufactured goods for export. Second, we do not find support for the hypothesis that government spending affects water pollution. The coefficients for this variable are not significant in any of the equations.[2] Third, we do not find that service-based economic activity affects water pollution. The coefficients for this variable are not significant in any of the equations of Table 2.

A problem that commonly arises in cross-national research is that of missing data. Statistical procedures such as multivariate regression analysis generally assume that each country has complete data. However, for numerous reasons, countries may be missing values on one or more of the variables under investigation. When this is the case, questions emerge about the extent to which inferences about the parameters and tests of statistics are influenced by the presence of incomplete data. The most common method of dealing with missing data in cross-national research is listwise deletion. This is the method used in Table 2. However, serious problems may arise when using it for handling missing data.

When using listwise deletion, nations with any missing information are excluded from the analysis. An obvious advantage of this approach to missing data is its simplicity. However, Allison (1999) discusses three potential drawbacks. First, the effective sample size with listwise deletion only includes those nations with complete records, and consequently, this number can be substantially smaller than the original sample size if missing observations are scattered across many nations. Second, nations that are excluded will often be the poorer countries that have fewer resources to allocate toward record keeping. Thus, the final sample may not be representative of the poorest nations. Third, different models may be estimated with a different sample of nations in an attempt to maximize the use of data availability. In these instances, Allison concludes listwise deletion may result in biased estimates.

Therefore, we attempt to determine if our estimates are biased by listwise deletion by using Arbuckle's (1996) full information maximum likelihood estimation routine to handle incomplete data. This approach has been used by

Shandra (2007b), Jorgenson (2003), and Paxton (2002). Using this method, we create a likelihood for the entire sample by summing the likelihoods of each case using whatever information is available for it. This approach yields more consistent and efficient estimates than listwise deletion of missing data (Arbuckle, 1996).

The size and significance of the full information maximum likelihood estimates are remarkably similar to the listwise deletion estimates. For instance, we continue to find that debt service, structural adjustment, and industrial exports increase water pollution. We also find that international nongovernmental organizations decrease water pollution. Thus, there appears to be little evidence indicating that the listwise deletion results are biased. We do not present the full information maximum likelihood results for sake of space, but they are available on request from the authors.

DISCUSSION AND CONCLUSION

This study expands our understanding of variation in organic water pollution in poor nations. We find substantial support for dependency theory hypotheses that debt, structural adjustment, and industrial exports increase organic water pollution. The coefficients for these variables are positive and significant in almost every equation. We also find support for world polity theory claims that international nongovernmental organizations decrease water pollution. The results also suggest that democracy increases organic water pollution. This finding is somewhat surprising. However, Ehrhardt-Martinez et al. (2002) observe a similar finding in a cross-national study of deforestation. Midlarsky (1998) attributes such findings to freely elected leaders having to please competing interest groups to win as many votes as possible. This may be the case concerning water pollution. We increase the reliability of the findings by demonstrating their significance across alternative models specifications and various missing data techniques.

Some important policy implications originate from the main findings. First, international nongovernmental organizations may be well served by monitoring and exposing how operations in poor nations are polluting waterways on which people depend for survival and well-being. They may then be able to pressure governments and corporations to take action to clean up their operations. Second, international nongovernmental organizations may want to work with companies to install pollution abatement technology. Third, international nongovernmental organizations may want to direct their efforts toward the International Monetary Fund and World Bank for more debt forgiveness. This process could also involve lobbying leaders in rich nations to withhold funding form these multilateral lenders until such changes occur (Rich, 1994). Such debt forgiveness can reduce some of the pressure on poor nations to produce as many industrial exports, thereby reducing water pollution. Debt forgiveness may also free up desperately needed funds for government-sponsored environmental protection initiatives. Nevertheless, all these suggestions can be criticized for being "reformist" in nature. In other words, such solutions only incrementally alter the economic and political status quo. Thus, Bryant and Bailey (1997) may aptly conclude that "if the argument is that fundamental change is the only way in which to solve the environmental crisis," then nongovernmental organizations "may be part of the problem and not part of the solution" (p. 143). Accordingly, international nongovernmental organizations may need to push for the elimination of structural adjustment lending and total debt forgiveness for all poor nations.

We conclude with possible avenues for scholars interested in building on this work. We are concerned with water quality. Nevertheless, there are related topics that have received little attention in cross-national research. These include access to safe drinking water, access to adequate sanitation facilities, and water usage. Furthermore, we analyze organic water pollution that results from manufacturing and industry. However, water pollution also results from intensive agricultural practices involving pesticides and fertilizers. It may be that debt and structural adjustment increase the use of these products. Finally, comparative case studies could be used to illuminate the ways in which debt, structural adjustment, and international nongovernmental organizations affect water pollution across time and space.

NOTES

1. The following nations are included in the analysis: Albania, Argentina, Bolivia, Brazil, Bulgaria, Cameroon, Central African Republic, Chile, China, Columbia, Costa Rica, Ecuador, Egypt, Gabon, Gambia, Ghana, Guatemala, Honduras, Hungary, India, Indonesia, Iran, Jamaica, Kenya, Malawi, Malaysia, Mauritius, Mexico, Morocco, Nepal, Nigeria, Pakistan, Paraguay, Peru, Poland, Romania, Senegal, Sierra Leone, South Africa, Sri Lanka, Syria, Tanzania, Thailand, Trinidad, Tunisia, Uruguay, Venezuela, Yemen, Zambia, and Zimbabwe.

2. It may be important to examine not only total government spending but also how governments allocate their resources (Bradshaw & Schafer, 2000). Therefore, we replaced total government spending with (a) total government expenditures for health and (b) total government expenditures for education. These variables are measured as a percentage of gross domestic product for 1990. The coefficients for both variables were negative but failed to explain any significant variation in water pollution. We do not present these results for sake of space, but they are available from the authors on request.

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