Property Rights and Environmental Quality: A Cross-Country Study

Carrie B. Kerekes

Public policy often regards pollution and other measures of poor environmental quality as public bads that result from market failure and require government intervention through regulatory policies and more stringent environmental standards. In this article, I argue that pollution and environmental quality should instead be regarded from a property rights perspective, in which institutions of clearly defined and enforced property rights create incentives that lead to reduced levels of pollution and an overall improvement in environmental quality. Using cross-country data, I examine the relationship between property rights and environmental quality.

This article shows that where property rights can be well defined and enforced, as with property rights pertaining to land and water, increases in the security of property rights lead to improvements in environmental quality. For instance, I find that as property rights become more secure, deforestation decreases and access to safe water and sanitation facilities improves. When property rights cannot be well defined, such as property rights over the air, increases in the overall security of property rights may erode environmental quality. For example, I find that more secure property rights are positively related to several indicators of air pollution.

The findings that more secure property rights are positively correlated with air pollution and negatively correlated with land and

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water pollution are not necessarily surprising given the nature of property rights over these resources. The adverse effect of property rights on air quality is also unsurprising due to the mechanisms through which property rights affect environmental quality. Property rights have both a direct and an indirect effect on environmental quality. The direct effect is that as property rights become more secure, individuals have incentives to maintain, conserve, and efficiently allocate resources. More secure property rights also lead to increases in production, exchange, and economic development. This process has an indirect impact on environmental quality: as more rapid industrialization occurs, firms may increase air pollution. Although the direct effect of more secure property rights on environmental quality is positive, the indirect effect may be negative. The net result will depend on the magnitudes of these direct and indirect effects. Several problems arise in defining and enforcing property rights over the air. Thus, it is likely that the direct effect of property rights on air quality will be small, while the indirect effect will be negative and larger in magnitude—so as overall property rights become more secure air quality may actually decrease because rights are not well defined and enforced.

Other articles have examined the impact of the level of a country's income and the inequality and distribution of power within a country on environmental quality (Grossman and Krueger 1995, Torras and Boyce 1998). However, those studies fail to take into account the importance of property rights. This article adds to the literature on environmental quality by focusing on the importance of secure, well-defined private property rights.

Environmental Quality

Environmental quality and its value have historically been difficult concepts to measure and evaluate. The term "environmental quality" itself has various meanings and interpretations. Air and water pollution are common indicators of environmental quality, as are deforestation and soil erosion.

Air pollution is particularly harmful to human health and is commonly measured by suspended particulate matter (including heavy particles and smoke), sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), chlorofluorocarbons (CFCs), carbon dioxide (CO_2), methane (CH_4), and lead (Pb). Air pollution is associated with a multitude of health problems, ranging from coughing and bronchitis to respiratory disease, miscarriages, birth defects, retardation, and mortality. Far from a recent phenomenon, air pollution has long plagued the global environment. Air pollution reached its maximum between 1700 and 1900, after which time it has declined steadily. Possible reasons for this reduction include decreases in the consumption of fossil fuels, improved technology and equipment that reduce harmful emissions, and increased energy efficiency (Lomborg 2001). Also, improved environmental quality as measured by air pollution is associated with higher levels of economic development. Therefore, as air quality continues to improve in many developed countries, it is expected that this trend will expand to developing countries as incomes rise.

Water pollution is another indicator of environmental quality. Measures of water quality include the level of dissolved oxygen, pathogenic contamination, and the concentration of heavy metals within a body of water. Water pollution can reduce the aesthetic and recreational quality of bodies of water and may pose hazards to health if individuals consume contaminated fish or other marine life. Pathogens pose a significant health problem by spreading serious, and sometimes fatal, diseases. Such diseases include dysentery, typhoid, cholera, and hepatitis. The literature uses concentrations of fecal coliform (bacteria found in human and animal feces) as a measure to indicate the presence of pathogens (Grossman and Krueger 1995). Heavy metals include lead, cadmium, arsenic, mercury, and nickel, and are associated with a large number of health risks. As with air pollution, water pollution is also decreasing over time, including concentrations of fecal bacteria. Similar to air pollution, fecal pollution in rivers increases with income to a certain point, after which it decreases with further economic development. Also, oxygen levels in water increase with improvements in economic development (Lomborg 2001).

In addition to air and water pollution, indicators of land pollution are also important for examining environmental quality. Land pollution can be measured by such factors as deforestation, soil degradation, industrial waste, and loss of biodiversity. Obviously, tropical forests are a valuable asset because of the timber they provide. In addition, deforestation occurs in the developing world as individuals use wood as a source of fuel. Forests are considered a valuable natural resource that provide timber for a multitude of products, offer recreation and aesthetic value, prevent soil erosion and reduce flooding, and increase biodiversity by acting as a home to animals. The theory then is that higher levels of deforestation are harmful to the environment and are less desirable. Soil degradation refers to erosion and the depletion of minerals and nutrients present in soil. Soil degradation reduces the biological and economic productivity of land, thus it is also undesirable.

Although pollution is declining in developed countries, air and water quality are still difficult to ensure due to problems arising from the assignment of liability for pollution. Primarily, it may not be easy to identify polluters, the rights to clean air and water are not vested in particular individuals, and the costs of pollution can easily be passed on to other individuals (Anderson and Leal 1991). Large numbers of individuals make it difficult to define and enforce property rights and to assign liability for pollution. As the number of parties affected by pollution increases, the damage each individual faces is likely to be small. Free-rider problems occur, with individuals having little incentive to take action against the polluter. Likewise, large numbers of polluters make it difficult to find the source of pollution and to assign liability. In summary, an increase in the number of individuals increases the cost of internalizing externalities (Demsetz 1967).

For these reasons, regulatory policies are often advocated to correct perceived market failures and to address the public good properties of environmental quality. The result is a second-best solution, which includes selecting a level of pollution to be attained at as low a cost as possible (Anderson and Leal 1991). There are problems with implementing this second-best solution, including informational asymmetries, knowledge of the lowest-cost technologies to reduce pollution, and political pressure from special interest groups to achieve specific outcomes. In light of these problems, this article maintains that secure property rights are still the preferable alternative to regulatory policies in order to promote environmental quality.

Property Rights

Recent literature illustrates the importance of the relationship between institutions and economic development. Douglass North (1990) argues that institutions are the “underlying determinant” of economic performance, and defines institutions as constraints created to reduce uncertainty in exchange by structuring political, economic, and social interaction. Property rights in particular are important for economic development. The important role of secure property rights for successful economic growth has long been emphasized by many economists (Montesquieu 1748, Hayek 1960, Smith 1776). More recently, Acemoglu and Johnson (2005) find evidence of a positive correlation between private property rights and economic growth, investment, and financial development. Several other studies also analyze the relationship between property rights and economic growth (Besley 1995; Knack and Keefer 1995; Leblang 1996; de Soto 1989, 2000; Acemoglu, Johnson, and Robinson 2001, 2002; Rodrik, Subramanian, and Trebbi 2004; Kerekes and Williamson 2008).

Recent literature also examines the impact of property rights on natural resources and the environment. Demsetz (1967) offers a theory of property rights and argues that one of the fundamental functions of these rights "is that of guiding incentives to achieve a greater internalization of externalities" (p. 348). He explains that property rights emerge when the costs of internalizing externalities are outweighed by the gains of internalization. In this manner, property rights can help internalize the costs of pollution and promote environmental quality.

Environmental quality may be undervalued and underprovided by the market when property rights are not effectively used to coordinate the incentives of individuals. Efficient property rights require that they are well defined (owners have exclusive use to their property), enforced, and transferable. Secure property rights underlie voluntary exchange and provide the foundation for markets. Private ownership of the factors of production leads to a price mechanism that enables the emergence of a system of profits and losses (Mises 1920). As such, prices serve as signals to owners about the most profitable uses of resources. Well-defined property rights hold individuals accountable and create incentives to maintain and allocate resources efficiently, because owners bear any losses from the mismanagement of their resources. In this manner, property rights affect the utilization and allocation of natural resources. The absence or uncertainty of property rights leads to more rapid land and natural resource use. Such exploitation erodes environmental quality

(Libecap 1989). For example, poorly defined property rights exacerbate the process of deforestation, representing an emphasis on the short-term use of a natural resource.

Property rights also improve environmental quality by their impact on entrepreneurship and technological innovation. Secure property rights enable firms and entrepreneurs to benefit from innovation. Innovation helps to protect the environment by introducing new technologies that reduce pollution and new production methods that require the use of fewer raw materials.

In the following sections I examine the relationship between property rights and environmental quality across countries. To do so, I employ variables measuring air, land, and water quality. Several problems arise when using measures of air pollution as indicators of environmental quality, particularly problems violating the exclusivity requirement of private property rights. Land and water pollution, however, create relatively fewer complications since land and water rights are more likely to be well defined and enforced. Therefore, in addition to investigating the relationship between property rights and environmental quality in general, the following analysis will also investigate the effect of property rights on indicators of air quality versus indicators of land and water quality.

Empirical Model and Data

To empirically examine the effect of the structure of property rights across countries on environmental quality, I implement cross-sectional regressions in order to maximize observations due to data limitations. For my analysis, I employ two alternative measures capturing the degree to which property rights are secure and well defined across countries. The first measure is an index measuring the average protection against risk of government expropriation compiled by Political Risk Services (2006). This index is based on a scale of 0 to 10, with a higher score indicating less risk and more protection against government expropriation. Due to data limitations, I use the average of this index from 1982 to 1997. My second measure of property rights is the Heritage Foundation's Index of Private Property (Holmes, Feulner, and O'Grady 2008). This variable is measured on a scale of 0 to 100, with a higher score indicating more protection of private property.[1] I use the average of this variable from 1995 to 2005.

As discussed earlier, there are several different indicators of environmental quality. However, many of these variables are difficult to measure and for many indicators (including soil degradation and loss of biodiversity) there is limited availability of comparable and reliable data across countries. Therefore, as with other studies that investigate environmental quality, my empirical analysis is limited to a small number of indicators. To examine air quality, I use the following indicators from the World Resources Institute (2008) that measure air pollution: sulfur dioxide emissions (SO_2), nitrogen oxides emissions (NOx), carbon dioxide emissions, and carbon monoxide (CO) emissions. To examine land quality, I use data on average annual deforestation and net forest depletion from the World Bank's *World Development Indicators* (2007); for water quality I use data on improved water source and improved sanitation facilities from the WHO/UNICEF Joint Monitoring Programme (2006).

Sulfur dioxide, nitrogen oxides, carbon dioxide, and carbon monoxide emissions are each measured in thousand metric tons of emissions per one million persons. I use the average of these variables from 1990 to 2005, with the exception of carbon dioxide emissions, which is averaged from 1990 to 2002. I have no prior expectation for the coefficients on the measures of property rights for the air pollution variables, because property rights over the air are less likely to be well defined and enforced. Therefore, improvements in air quality may not necessarily correspond to increases in our measures of property rights security.

Average annual deforestation refers to the permanent conversion of natural forest to alternative uses and is measured as a percentage. Negative numbers indicate an increase in forest area. Net forest depletion as a percentage of gross national income (GNI) is calculated as the product of resource rents and the excess of roundwood harvest over natural growth. For both average annual

[1]This measure of the strength of private property rights includes ranking a country for the independence of its judiciary, the transparency of its commercial code affecting contracts, the risk of expropriation of private property, the degree of corruption within the legal system, and the extent to which private ownership is protected by law (Beach and Kane 2008: 51–52). It is more likely to reflect the security of land and water rights than air rights, since the later are not well defined.

deforestation and net forest depletion I use the average of these variables from 1990 to 2005. I expect the coefficients on the measures of property rights to be negative and significant for the deforestation variables, indicating that deforestation decreases with increases in the security of property rights.

Improved water source and improved sanitation facilities are national-level pollution variables. Improved water source and improved sanitation facilities are the percentage of a country's population with access to safe water and sanitation, respectively. For these variables I use the average of the years for which data are available over the period 1990 to 2004. Pathogenic contamination is one indicator of water quality. Pathogens exist in sewage; therefore, increased access to sanitation facilities that aids in the prevention of human, animal, and insect contact with excreta indicates higher levels of environmental quality. I expect the coefficients on the measures of property rights to be positive and significant for these national-level pollution variables. In other words, countries for which property rights are more secure should experience increased access to safe water and sanitation.

Summary statistics are provided in Table 1. The sample includes all countries for which the variables are available, which differs slightly depending on which measure of property rights is employed in a regression.

The basic relationship between each measure of property rights and each indicator of environmental quality can be expressed as a univariate model. Tables 2 and 3 present the univariate regression results. Table 2 examines the relationships between the two measures of property rights security and the indicators of air quality, while Table 3 examines the effect of more secure property rights on the measures of land and water quality.

The coefficients on sulfur dioxide, nitrogen oxides, and carbon dioxide emissions are positive and highly significant using either measure of property rights. This result suggests that as overall property rights become more secure air pollution increases. The coefficients on carbon monoxide are negative and insignificant. The coefficients on average annual deforestation and net forest depletion are negative and significant, indicating that as property rights become more secure deforestation decreases. Lastly, the coefficients on improved water source and improved sanitation facilities are positive and highly significant, suggesting a positive

TABLE 1
Summary Statistics

	Obs.	Mean	Std. Dev.	Min.	Max
Average Protection against Risk of Expropriation	128	7.06	1.84	1.81	10
Heritage Index of Private Property	162	50.40	22.54	10	90
Sulfur Dioxide (SO_2) Emissions	207	30.73	49.99	0	461.64
Nitrogen Oxides (NO_x) Emissions	207	26.94	34.92	0	349.32
Carbon Dioxide (CO_2) Emissions	207	3,825.86	5,640.21	0	46,128.02
Carbon Monoxide (CO) Emissions	207	230.55	309.43	0	2,325.42
Average Annual Deforestation	150	0.04	1.36	−6.7	3.2
Net Forest Depletion (% of GNI)	167	0.48	1.24	0	8.37
Improved Water Source	181	80.50	19.85	21.5	100
Improved Sanitation Facilities	170	65.47	28.73	8	100
GDP per Capita, PPP	169	8,166.88	8,613.51	532.48	42,625.50
GDP per Capita Growth	191	1.81	3.00	−5.31	26.06
Manufacturing	180	14.64	7.74	0.91	40.62
Government Consumption (% of GDP)	180	17.07	7.39	4.74	53.47
Urban Population	207	4.02	24.60	8.03	100
GINI Index	129	40.47	9.75	22.65	74.33
Ethnolinguistic Fractionalization	153	0.33	0.30	0	1

TABLE 2
Property Rights and Air Quality: Univariate Regressions (OLS Estimation)

	Dependent Variable: Sulfur Dioxide (SO_2) Emissions	Dependent Variable: Nitrogen Oxides (NO_x) Emissions
Average Protection against Risk of Expropriation	9.830*** (5.29)	5.659*** (4.66)
R-squared	0.18	0.15
Observations	128	128
Heritage Index of Private Property	0.791*** (5.93)	0.498*** (5.94)
R-squared	0.18	0.18
Observations	162	162
	Dependent Variable: Carbon Dioxide (CO_2) Emissions	**Dependent Variable: Carbon Monoxide (CO) Emissions**
Average Protection against Risk of Expropriation	1,841.248*** (6.83)	−16.931 (1.15)
R-squared	0.27	0.01
Observations	128	128
Heritage Index of Private Property	127.72*** (6.94)	−0.280 (0.24)
R-squared	0.23	0.00
Observations	162	162

Note: Absolute t-statistics are in parentheses. Significance level: *** 1 percent, ** 5 percent, * 10 percent. Each coefficient represents a separate regression.

relationship between property rights and access to safe water and sanitation.

These results suggest that more secure property rights are negatively related to air quality and positively related to land and water quality. However, these initial results do not control for

TABLE 3
PROPERTY RIGHTS AND LAND AND WATER QUALITY:
UNIVARIATE REGRESSIONS (OLS ESTIMATION)

	Dependent Variable: Average Annual Deforestation	Dependent Variable: Net Forest Depletion
Average Protection against Risk of Expropriation	−0.244*** (3.68)	−0.133*** (3.11)
R-squared	0.11	0.08
Observations	116	121
Heritage Index of Private Property	−0.134*** (2.69)	−0.010** (2.44)
R-squared	0.05	0.04
Observations	144	153
	Dependent Variable Improved Water Source	Dependent Variable: Improved Water Source
Average Protection against Risk of Expropriation	6.817*** (8.72)	9.802*** (8.20)
R-squared	0.39	0.38
Observations	119	110
Heritage Index of Private Property	0.489*** (8.11)	0.688*** (7.47)
R-squared	0.31	0.28
Observations	151	143

NOTE: Absolute t-statistics are in parentheses. Significance level: *** 1 percent, ** 5 percent, * 10 percent. Each coefficient represents a separate regression.

other factors that may influence environmental quality. To do so, I construct a more complete model specification, as follows:

$$Y_i = \alpha X_i + Z`\delta + \varepsilon_i$$

where $Z`$ is a vector of control variables, including GDP per capita growth, manufacturing, urban population, government consumption, the GINI index, and ethnolinguistic fractionalization. GDP is highly correlated with institutional indexes and cannot be included in regressions with the property rights measures. Therefore, I include GDP per capita growth. Manufacturing is measured as the value added by industries in this sector as a percentage of GDP, and urban population is measured as the percentage of the total population in each country living in areas defined as urban. Increases in manufacturing and urbanization are generally associated with higher levels of pollution. However, these variables may also reflect a country that is at a higher level of economic development, which is positively related to environmental quality (Grossman and Krueger 1995, Torras and Boyce 1998, Lomborg 2001). Government consumption is real government consumption expenditure and is measured as a percentage of GDP. For GDP per capita growth, manufacturing, urban population, and government consumption I use the average of these variables from 1990–2005. All data are from the *World Development Indicators* (World Bank 2007).

In addition to the above control variables, I also include two additional control variables to capture inequality within each country. Torras and Boyce (1998) investigate the relationship between the distribution of power and income inequality on environmental quality. They predict that higher levels of inequality erode environmental quality as individuals that benefit from activities that generate pollution may be better able to further their interests versus those that bear the costs of pollution. To measure income inequality, I include the GINI index for each country. Data for this variable, obtained from the World Bank (2007), are averaged for all years for 1990 to 2005. The second variable that I use to proxy for inequality and to account for the possible effects of ethnic and linguistic diversity on environmental quality is ethnolinguistic fractionalization. This variable is an average of five different indices that capture ethnic and linguistic diversity in a country. A diverse population comprised of many different ethnic groups may experience more conflict and political instability as groups disagree over public policies and are less likely to overcome differences (Easterly and Levine 1997, La Porta et al. 1999, Easterly 2001, Leeson 2005). Therefore, a country that is more diverse may also experience difficulties in establishing and maintaining secure property rights. The transactions costs of defining and enforcing property rights may be higher in populations that are more heterogeneous.

Also, ethnolinguistic fractionalization may affect environmental quality through its possible effects on the distribution of power within a country. Torras and Boyce (1998) note that in addition to income distributions, other attributes such as race, ethnicity, gender, and the political framework may also affect the distribution of power.

Results

Using average protection against risk of expropriation as the property rights measure, Tables 4 and 5 show the impact of property rights on indicators of air quality In each table column (1) includes manufacturing as a control variable; column (2) includes government consumption as a control variable; column (3) includes urban population as a control variable; column (4) includes manufacturing, government consumption, and the GINI index as control variables; and column (5) includes manufacturing, government consumption, and ethnolinguistic fractionalization as control variables. All regressions include GDP per capita growth as a control variable.

The results indicate that secure property rights are positively correlated with indicators of air pollution (with the exception of carbon monoxide emissions). The coefficient on average protection against risk of expropriation is positive and highly significant with respect to sulfur dioxide, nitrogen oxides, and carbon dioxide emissions. It is significant (and negative) in only one of the five regressions on carbon monoxide emissions. The results are similar when using the Heritage Index of Private Property as the property rights measure.[2] The coefficient on the Heritage Index of Private Property is positive and highly significant on sulfur dioxide, nitrogen oxides, and carbon dioxide emissions. It is insignificant in all regressions for which carbon monoxide emissions is the dependent variable. In addition, the results indicate that government consumption and urban population are generally positively and significantly related to indicators of air pollution; however, manufacturing, when significant, is usually negatively related to air pollution. The coefficient on the GINI index is positive and significant on nitrogen oxides and carbon monoxide emissions. Ethnolinguistic fractionalization is significant

[2]The results using the Heritage Index of Private Property are not included as separate tables in the interest of space. However, these results are available from the author by request.

TABLE 4.1
The Impact of Average Protection against Risk of Expropriation on Sulfur Dioxide (SO_2) Emissions

	Dependent Variable: Sulfur Dioxide (SO_2) Emissions				
	(1)	(2)	(3)	(4)	(5)
Average Protection against Risk of Expropriation	9.720*** (4.43)	8.896*** (4.09)	5.843*** (2.83)	8.834** (2.39)	6.879** (2.59)
GDP per Capita Growth	0.848 (0.68)	0.472 (0.23)	0.424 (0.37)	0.743 (0.29)	−0.049 (0.02)
Manufacturing	0.320 (0.54)	—	—	1.161 (1.56)	0.639 (0.90)
Government Consumption	—	1.601*** (2.65)	—	2.428** (2.53)	1.513** (2.15)
Urban Population	—	—	0.650*** (4.03)	—	—
GINI index	—	—	—	0.549 (1.05)	—
Ethnolinguistic Fractionalization	—	—	—	—	−11.814 (0.83)
Constant	−40.412*** (2.82)	−53.844*** (3.53)	−44.514*** (3.36)	−108.457*** (2.81)	−44.969** (2.11)
R-squared	0.20	0.24	0.29	0.29	0.23
Observations	122	122	127	97	108

Notes: Absolute t-statistics are in parentheses. Significance level: *** at 1 percent, ** at 5 percent, * at 10 percent.

Emissions in thousand metric tons per million persons.

Column (1) includes manufacturing as a control variable; column (2) includes government consumption as a control variable; column (3) includes urban population as a control variable; column (4) includes manufacturing, government consumption, and GINI index as control variables; and column (5) includes manufacturing, government consumption, and ethnolinguistic fractionalization as control variables. All regressions include GDP per capita growth as a control variable.

and negatively correlated with carbon dioxide emissions, but positively correlated with carbon monoxide emissions.

Tables 6 and 7 show the impact of property rights on indicators of land and water quality, again using average protection against risk of expropriation as the property rights measure.

TABLE 4.2
THE IMPACT OF AVERAGE PROTECTION AGAINST RISK OF EXPROPRIATION ON NITROGEN OXIDE (NO_x) EMISSIONS

	Dependent Variable: Nitrogen Oxides (NO_x) Emissions				
	(1)	(2)	(3)	(4)	(5)
Average Protection against Risk of Expropriation	7.170*** (5.52)	4.226*** (3.09)	2.851** (2.10)	9.511*** (5.19)	5.486*** (3.33)
GDP per Capita Growth	0.401 (0.53)	−0.013 (0.01)	−0.096 (0.13)	1.568 (1.22)	0.178 (0.13)
Manufacturing	−0.563** (2.43)	—	—	−0.627* (1.70)	−0.609 (1.38)
Government Consumption	—	1.151*** (3.93)	—	1.138** (2.39)	1.3622*** (3.11)
Urban Population	—	—	0.431*** (4.07)	—	—
GINI index	—	—	—	1.002*** (3.88)	—
Ethnolinguistic Fractionalization	—	—	—	—	−1.458 (0.16)
Constant	−10.239 (1.18)	−24.609** (2.54)	−15.561* (1.79)	−93.890*** (4.90)	−22.274* (1.68)
R-squared	0.20	0.24	0.25	0.42	0.26
Observations	122	122	127	97	108

NOTES: Absolute t-statistics are in parentheses. Significance level: *** at 1 percent, ** at 5 percent, * at 10 percent.

Emissions in thousand metric tons per million persons.

Column (1) includes manufacturing as a control variable; column (2) includes government consumption as a control variable; column (3) includes urban population as a control variable; column (4) includes manufacturing, government consumption, and GINI index as control variables; and column (5) includes manufacturing, government consumption, and ethnolinguistic fractionalization as control variables. All regressions include GDP per capita growth as a control variable.

These results indicate that secure property rights are negatively correlated with deforestation and positively correlated with access to safe water and sanitation facilities. The coefficient on average protection against risk of expropriation is negative and significant in seven out of the ten regressions on deforestation. The results

TABLE 5.1
The Impact of Average Protection against Risk of Expropriation on Carbon Dioxide (CO_2) Emissions

	Dependent Variable: Carbon Dioxide (CO_2) Emissions				
	(1)	(2)	(3)	(4)	(5)
Average Protection against Risk of Expropriation	2058.078*** (8.62)	1583.569*** (5.14)	1124.892*** (3.88)	1890.308*** (6.03)	1680.727**** (6.70)
GDP per Capita Growth	187.660 (1.38)	152.383 (0.53)	100.058 (0.62)	14.781 (0.07)	−95.053 (0.45)
Manufacturing	−119.123* (1.86)	—	—	22.090 (0.35)	−34.387 (0.51)
Government Consumption	—	301.197*** (3.51)	—	101.787 (1.25)	110.311 (1.65)
Urban Population	—	—	113.436*** (5.01)	—	—
GINI index	—	—	—	−18.524 (0.42)	—
Ethnolinguistic Fractionalization	—	—	—	—	−3082.607** (2.28)
Constant	−84873154*** (5.44)	−11298.7*** (5.23)	−9618.071*** (5.16)	−10705.96*** (3.27)	−7779.098*** (2.28)
R-squared	0.41	0.34	0.40	0.54	0.51
Observations	122	122	127	97	108

Notes: Absolute t-statistics are in parentheses. Significance level: *** at 1 percent, ** at 5 percent, * at 10 percent.

Emissions in thousand metric tons per million persons.

Column (1) includes manufacturing as a control variable; column (2) includes government consumption as a control variable; column (3) includes urban population as a control variable; column (4) includes manufacturing, government consumption, and GINI index as control variables; and column (5) includes manufacturing, government consumption, and ethnolinguistic fractionalization as control variables. All regressions include GDP per capita growth as a control variable.

are much stronger for access to improved water sources and improved sanitation facilities. In these regressions both measures of property rights are positive and highly significant. Columns (1) through (3) indicate that manufacturing, government consumption, and urban population are generally positively and signifi-

TABLE 5.2
The Impact of Average Protection against Risk of Expropriation on Carbon Monoxide (CO) Emissions

	Dependent Variable: Carbon Monoxide (CO) Emissions				
	(1)	(2)	(3)	(4)	(5)
Average Protection against Risk of Expropriation	−5.939 (0.36)	−43.292** (2.62)	−20.307 (1.17)	28.515 (1.17)	−19.974 (1.03)
GDP per Capita Growth	−9.888 (1.04)	−11.876 (0.77)	−14.308 (1.47)	20.068 (1.18)	11.588 (0.71)
Manufacturing	−14.255*** (3.19)	—	—	−12.144** (2.48)	−9.480* (1.82)
Government Consumption	—	18.359*** (3.99)	—	18.774*** (2.98)	22.119*** (4.29)
Urban Population	—	—	0.192 (0.14)	—	—
GINI index	—	—	—	16.423*** (4.79)	—
Ethnolinguistic Fractionalization	—	—	—	—	283.954*** (2.71)
Constant	456.078*** (4.27)	314.219*** (2.71)	433.803*** (3.90)	−749.259*** (2.95)	120.662* (0.77)
R-squared	0.11	0.14	0.03	0.34	0.31
Observations	122	122	127	97	108

Notes: Absolute t-statistics are in parentheses. Significance level: *** at 1 percent, ** at 5 percent, * at 10 percent.

Emissions in thousand metric tons per million persons.

Column (1) includes manufacturing as a control variable; column (2) includes government consumption as a control variable; column (3) includes urban population as a control variable; column (4) includes manufacturing, government consumption, and GINI index as control variables; and column (5) includes manufacturing, government consumption, and ethnolinguistic fractionalization as control variables. All regressions include GDP per capita growth as a control variable.

cantly related to improvements in land and water quality. Ethnolinguistic fractionalization is significant in all regressions for which it enters and is negatively correlated with land and water quality. The GINI index is significant only on improved access to water and sanitation facilities when the Heritage Index of Private

TABLE 6.1
The Impact of Average Protection against Risk of Expropriation on Deforestation

	Dependent Variable: Average Annual Deforestation				
	(1)	(2)	(3)	(4)	(5)
Average Protection against Risk of Expropriation	−0.232*** (2.94)	−0.158** (2.03)	−0.131* (1.73)	−0.207* (1.86)	−0.136 (1.64)
GDP per Capita Growth	−0.82* (1.96)	−0.164** (2.41)	−0.68* (1.70)	−0.166** (2.20)	−0.108 (1.65)
Manufacturing	−0.008 (0.38)	—	—	−0.010 (0.46)	0.008 (0.35)
Government Consumption	—	−0.044** (2.04)	—	0.003 (0.11)	−0.009 (0.38)
Urban Population	—	—	−0.017*** (2.88)	—	—
GINI index	—	—	—	0.009 (0.59)	—
Ethnolinguistic Fractionalization	—	—	—	—	1.416*** (3.40)
Constant	1.917*** (3.81)	2.072*** (3.90)	2.006*** (4.20)	1.643 (1.48)	0.429 (1.17)
R-squared	0.14	0.17	0.19	0.22	0.17
Observations	112	112	115	94	109

Notes: Absoute t-statistics are in parentheses. Significance level: *** at 1 percent, ** at 5 percent, * at 10 percent.

Column (1) includes manufacturing as a control variable; column (2) includes government consumption as a control variable; column (3) includes urban population as a control variable; column (4) includes manufacturing, government consumption, and GINI index as control variables; and column (5) includes manufacturing, government consumption, and ethnolinguistic fractionalization as control variables. All regressions include GDP per capita growth as a control variable.

Property is included in the regression. In these regressions it enters with the expected, negative, sign.

According to the above results, an overall improvement in the security of property rights has different impacts on air quality as opposed to land and water quality. In general, increases in the security of property rights are associated with improvements in land and

TABLE 6.2
THE IMPACT OF AVERAGE PROTECTION AGAINST RISK OF EXPROPRIATION ON FOREST DEPLETION

	Dependent Variable: Net Forest Depletion				
	(1)	(2)	(3)	(4)	(5)
Average Protection against Risk of Expropriation	−0.109** (2.14)	−0.128** (2.56)	−0.43 (0.90)	−0.200** (2.61)	−0.059 (0.97)
GDP per Capita Growth	−0.023 (0.82)	−0.011 (0.22)	−0.012 (0.46)	0.066 (1.22)	0.048 (0.82)
Manufacturing	−0.014 (0.96)	—	—	−0.026 (1.66)	−0.023 (1.37)
Government Consumption	—	−0.24* (1.67)	—	−0.012 (0.60)	−0.033** (2.00)
Urban Population	—	—	−0.014*** (3.71)	—	—
GINI index	—	—	—	−0.019* (1.71)	—
Ethnolinguistic Fractionalization	—	—	—	—	0.812** (2.43)
Constant	1.366*** (4.20)	1.637*** (4.70)	1.452*** (4.79)	3.029*** (3.78)	1.266** (2.56)
R-squared	0.09	0.12	0.18	0.19	0.207
Observations	117	118	121	97	106

NOTES: Absoute t-statistics are in parentheses. Significance level: *** at 1 percent, ** at 5 percent, * at 10 percent.

Column (1) includes manufacturing as a control variable; column (2) includes government consumption as a control variable; column (3) includes urban population as a control variable; column (4) includes manufacturing, government consumption, and GINI index as control variables; and column (5) includes manufacturing, government consumption, and ethnolinguistic fractionalization as control variables. All regressions include GDP per capita growth as a control variable.

water quality. As property rights become more secure, deforestation decreases and access to safe water and sanitation facilities improves. However, there appears to be a negative relationship between increases in the overall security of property rights and air quality. As property rights become more secure sulfur dioxide, nitrogen oxides, and carbon dioxide emissions increase.

TABLE 7.1
The Impact of Average Protection against Risk of Expropriation on Improved Water Source

	Dependent Variable: Improved Water Source				
	(1)	(2)	(3)	(4)	(5)
Average Protection against Risk of Expropriation	5.943*** (7.39)	6.457*** (7.58)	4.211*** (5.99)	6.458*** (4.88)	4.062*** (4.52)
GDP per Capita Growth	1.643*** (3.67)	2.407*** (3.08)	1.337*** (3.58)	1.067 (1.16)	0.757 (1.00)
Manufacturing	0.714*** (3.31)	—	—	0.940*** (3.49)	0.629** (2.54)
Government Consumption	—	0.229 (0.96)	—	0.303 (0.89)	0.412* (1.72)
Urban Population	—	—	0.429*** (7.90)	—	—
GINI index	—	—	—	0.289 (1.58)	—
Ethnolinguistic Fractionalization	—	—	—	—	−23.172*** (4.79)
Constant	24.805*** (4.68)	25.572*** (4.61)	24.649*** (5.63)	0.654 (0.05)	42.748*** (5.91)
R-squared	0.53	0.47	0.67	0.55	0.62
Observations	113	113	118	91	102

Notes: Absoute t-statistics are in parentheses. Significance level: *** at 1 percent, ** at 5 percent, * at 10 percent.

Column (1) includes manufacturing as a control variable; column (2) includes government consumption as a control variable; column (3) includes urban population as a control variable; column (4) includes manufacturing, government consumption, and GINI index as control variables; and column (5) includes manufacturing, government consumption, and ethnolinguistic fractionalization as control variables. All regressions include GDP per capita growth as a control variable.

Conclusion

This article empirically investigates the relationship between property rights and environmental quality. I distinguish between indicators of air quality and indicators of land and water quality because property rights to the air are less likely to be well defined

TABLE 7.2
THE IMPACT OF AVERAGE PROTECTION AGAINST RISK OF EXPROPRIATION ON SANITATION

	Dependent Variable: Improved Sanitation Facilities				
	(1)	(2)	(3)	(4)	(5)
Average Protection against Risk of Expropriation	8.769** (6.97)	9.516*** (7.26)	5.850*** (5.49)	9.566*** (4.79)	6.904*** (5.19)
GDP per Capita Growth	2.319*** (3.47)	2.558** (2.16)	1.785*** (3.20)	0.005 (0.00)	−0.497 (0.04)
Manufacturing	0.861*** (2.55)	—	—	1.106*** (2.71)	0.755*** (2.03)
Government Consumption	—	0.701* (1.88)	—	0.348 (0.69)	0.754** (2.15)
Urban Population	—	—	0.656*** (7.93)	—	—
GINI index	—	—	—	−0.020 (0.07)	—
Ethnolinguistic Fractionalization	—	—	—	—	−35.124*** (5.03)
Constant	−11.740*** (1.45)	−14.576 (1.58)	−12.416* (1.86)	−23.498 (1.16)	7.800 (0.74)
R-squared	0.51	0.47	0.66	0.54	0.63
Observations	105	105	109	86	96

NOTES: Absoute t-statistics are in parentheses. Significance level: *** at 1 percent, ** at 5 percent, * at 10 percent.

Column (1) includes manufacturing as a control variable; column (2) includes government consumption as a control variable; column (3) includes urban population as a control variable; column (4) includes manufacturing, government consumption, and GINI index as control variables; and column (5) includes manufacturing, government consumption, and ethnolinguistic fractionalization as control variables. All regressions include GDP per capita growth as a control variable.

and enforced. I find that property rights are not related to some indicators of air pollution and are positively related to others. For land and water pollution, I find that more secure property rights institutions are negatively correlated with deforestation and positively correlated with improved access to safe water and sanitation facilities.

The reason for the different effects of property rights on air, land, and water quality arise due to the nature of defining property rights over these different types of resources and because of the *direct* and *indirect effects* of property rights on environmental quality. The air is not a resource over which property rights can be well defined and enforced. Therefore, it is not surprising that air pollution may actually increase as overall property rights become more secure. Increases in the security of private property lead to increases in capital formation and investment that spur economic development, which may then lead to increases in air pollution as the level of production in a country rises (the indirect effect). Grossman and Krueger (1995) show that economic development is associated with an initial phase of environmental deterioration that eventually improves past a certain level of income. Property rights over land and water resources, however, are more likely to be well defined and enforced. Therefore, as property rights become more secure, land and water quality will improve as individuals have more incentives to maintain, conserve, and protect these resources.

The results of this article suggest that more secure property rights improve environmental quality when property rights over a resource can be well defined and enforced, such as property rights pertaining to land and water. In these circumstances, the proper incentives exist to encourage good stewardship of natural resources and to protect the environment. These findings suggest that secure private property rights and market forces can provide environmental quality without increased government intervention through means of more stringent environmental standards and regulatory policies.

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