The Political Economy of Environment-Development Relationships: A Preliminary Framework*

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1 Introduction

A growing body of empirical research indicates that several types of pollution seem first to increase as per capita income increases and then to decline. The resulting inverted-U relationship between income and pollution has been christened the 'environmental Kuznets curve.'[1] Research on this topic has largely ignored the fact that pollution control is a public good, provided by government.[2] Empirical models typically regress a measure of pollution on income, income squared, and other variables, but omit the form of government as a determinant. As a consequence, the profession can offer no credible insights on the kinds of political reforms that would foster environmental protection in the developing world or on the likely environmental effects of recent trends toward democratization.

Omitting the form of government as an explanatory variable in cross country empirical models can lead to biased results and incorrect inferences on the effect of economic growth on the environment. As argued later, the form of government belongs in the model because non-democratic regimes are likely to under provide public goods such as pollution control relative to democracies. Also, the form of government is strongly correlated with income, as recent macro economic research has shown repeatedly.[3] Omitting the form of government from empirical models of pollution generation and control is therefore a source of specification bias.

A mitigating factor is that most empirical studies have included fixed or random effects for countries or monitoring sites. There are several reasons why just including an additive

[1]Thompson and Strohm (1996) question the inverted-U generalization
[2]Exceptions are Lopez and Mitra (1997) and Barrett and Graddy (1997).
[3]See Barro (1991), Levine and Renelt (1992), Easterly and Rebelo (1993.)

country-specific constant does not remedy the problem, however. Most importantly, lumping the influence of government regime with other unexplained 'country effects' masks some of the potentially most interesting and important results and policy insights this line of research has to offer. It certainly begs the question of how democratization in the third world might affect the environment. Second, political regimes vary over time within countries and fixed or random effects will not capture this. Third, as Lopez and Mitra (1997) argue, there are reasons why the environmental Kuznets curve's functional form and turning point should be different for different forms of government. Country-specific constants cannot capture this possibility.[4]

Agencies responsible for promoting international aid, lending, and trade have shown keen interest in the environmental Kuznets curve, particularly its downward sloping portion. Commenting on the environmental implications of growth, GATT (1992) notes that: "Concentrations of SO_2 have risen with income at low levels of per capita GDP, fallen with income at higher levels of per capita GDP, and eventually leveled off in the most advanced economies. The estimated turning point comes at about $5,000. The conclusions for smoke pollution are much the same." The eventual decline is attributed to an income effect that operates through the policy process: "Countries near the top of the development ladder are likely to have different priorities from countries further down the ladder, and . . . . as a result they are likely to have and enforce stricter environmental standards. This appears to be borne out quite well in practical experience." The conclusion seems straightforward: income growth, possibly due to expanded trade, will eventually bring environmental benefits if carried past the turning point.

[4]Further, because different pollutants are generated by different processes, the same set of independent variables, with second or third degree polynomial terms in income, will not generally be appropriate for explaining concentrations of all pollutants. For SO_2 emissions, which generally result from burning fossil fuels, the determinants would logically include attributes of a nation's non-traded fuels, e.g., the size and sulfur content of its coal reserves and its hydropower potential. Some of these pollutant-specific factors probably vary within countries, over time, and others presumably are fixed. Items that vary, such as fuel reserves, metal production, population density, and the composition of output, cannot be captured by fixed country effects. Even factors that probably are fixed within countries may have effects that cannot be represented adequately by an additive constant. There is no reason why SO_2 pollution in countries that use different energy sources, e.g., high sulfur coal versus hydro, will differ by a fixed constant at all income levels.

The World Bank also drew a positive message from this research in its 1992 World Development Report. Commenting on how income growth affects environmental protection it reported that: “There are strong ‘win-win’ opportunities that remain unexploited. The most important of these relates to poverty reduction: not only is attacking poverty a moral imperative, but it is also essential for environmental stewardship.”

Whatever the factual merits of such reasoning may be, one possible consequence is a more relaxed attitude toward environmental protection in developing countries, particularly those that are growing rapidly. Policy makers might reason that the environmental protection problem eventually will take care of itself via an automatic policy response if growth proceeds far enough.[5] This could blunt progress toward adoption of sensible environmental policies. Significantly, the environmental Kuznets curve literature has provided very little evidence of actual policy responses. Further, while the idea of an ‘inverted U’ relationship between pollution and income is entirely plausible, the crucial question for policy is the income level at which the turning point occurs. To date this term has not been estimated as accurately as the data will allow.

Finally, and perhaps most importantly, the received literature might cause policy makers to focus on the wrong policy instrument. If the observed correlation between income and pollution mainly reflects political differences, fostering political reform may emerge as the key instrument for environmental improvement. The empirical evidence now available to policy makers provides no information on this possibility and it arguably confounds the effect of economic growth on the environment with the effect of differing political institutions.

The next section of this paper offers a brief intuitive explanation of the effect omitting the form of government might have on the turning point in estimated environmental Kuznets curves. Relevant literature on this subject is then surveyed and a preliminary model of pollution control

[5]While most economists have drawn guarded conclusions from these results, some have been less cautious. See Salinas-Leon (1993, p. 10) and Beckerman (1992). Bartlett (1994) uses these empirical results to put a perverse twist on the possible effects of environmental policy, claiming that “existing environmental regulation, by reducing economic growth, may actually be reducing environmental quality.”

and public goods provision by non-democratic governments is developed. The model allows for interaction between economic growth, environmental protection, and the composition of output, and recognizes that the composition of output can be affected by growth and by environmental policy. Preliminary empirical analysis is presented last and is confined to examining one aspect of the overall model, the effect of government regime type on the provision of environmental public goods.

2 Why Politics Matters

The essential reason why omitting the form of government from the determinants of environmental quality might cause biased results can be shown intuitively. Suppose the pollution that would result from production if no effort were spent on abatement is a monotone function of a country's total output as in Figure 1. Spending resources on abatement results in a lower level of 'net pollution.' Abatement is generally accomplished by adopting regulations on waste treatment and production processes.[6] Governments choose such regulations by balancing those environmental costs and benefits that are politically relevant, i.e., those that accrue to the group who controls the political process. In an ideal democracy the controlling group is the entire voting populace, and stylized models imply that the public good level equates marginal cost and marginal benefit to the median citizen.

Public choice theory has less to say about public goods provision by non-democratic governments. McGuire and Olson (1996) consider a model economy in which policies are controlled by an elite minority who can transfer funds from the public budget to themselves. Because public funds are fungible to the elite, the politically relevant opportunity cost of publicly

[6] The pollution generation curve is drawn to be concave, which is plausible if output shifts toward clean products as income grows. Figure 1 also shows net pollution to be monotonically increasing in income. These details are not essential.

produced goods is the full marginal cost of provision.[7] That is, spending an extra government dollar on, say, public sanitation reduces the elite's income by one dollar. On the benefit side, while pollution control is often a non-exclusive public good, only the benefit accruing to the political elite is policy relevant. In a nondemocratic country this is only a fraction of the benefit the entire population can enjoy. Since policy is set by balancing politically relevant marginal benefits with politically relevant marginal costs, the model implies that non-democratic governments will under provide public goods relative to democracies.

Figure 2 illustrates this simple message. It plots net pollution against output for three countries with different types of government: autocracy, A, democracy, D, and an intermediate type, Q, (quasi democracy) in which the elite group is relative large. Drawing the figure so that each regime abates a constant fraction of gross pollution makes the graph tidy, but is not essential. The figure reflects two crucial assumptions: (i) net pollution is greater under autocracy than democracy at each income level, as the argument in the preceding paragraph implies, and (ii) average income is lower under autocracy than democracy, i.e., $Y_A<Y_Q<Y_D$. The heavy line connecting income and pollution levels across the three countries now illustrates, in intentionally dramatic terms, a possible consequence of omitting the form of government in empirical studies of pollution and growth. Here, the heavy line plots out an inverted U relationship between pollution and income. The U shape is an artifact of the failure to control for the form of government, as pollution is assumed to be monotonically increasing with income for each form of government. More generally, omitting the form of government might bias the turning point either up or down.

This argument rests on two empirical propositions, that the form of government is systematically correlated with income and public good provision. Both propositions are examined empirically later in the paper.

[7] If pollution abatement takes place through regulations on production, its cost is felt in the prices of commodities. Here, the cost share borne by the elite should roughly equal their command of the nations spendable income.

3 Prior Research on the Growth-Environment Relationship

Most of the received research on the effect of economic growth on the environment is empirical. Shafik and Bandyopadhyay (1992) and Grossman and Krueger (1995) (SB and GK) both examined ambient concentrations of several air and water pollutants in a cross country panel of monitoring sites.[8] Both specified pollution to be second or third order polynomials in per capita income, linear in other variables, and allowed for fixed or random effects.[9] SB and GK both discuss structural factors, but neither postulates a structural framework. Both generally found inverted U relations for SO_2 and smoke in urban areas, with peaks in the range of $4-6,000 in GK and $3-4,000 in SB.[10] Selden and Song (1994) used the same basic approach to examine country level *emissions* of several air pollutants. They also found inverted U patterns. Selden and Holtz-Eakin (1995) examined carbon dioxide emissions in the same way and found that per capita emissions rise with per capita income up to extremely high income levels. Panayotou (1993) and Cropper and Griffiths (1994) have estimated such relationships for deforestation and other environmental outcomes. Reviewing this work, Thompson and Strohm (1996) and Stern, et al (1996) find that the lack of a theoretical structure robs these studies of clear policy implications.

Hilton and Levinson (1997) took a step toward identifying structural factors for lead emissions from gasoline. They broke down total emissions into pollution intensity, measured as lead per gallon of gasoline, and total gasoline consumption. Pollution intensity (lead per gallon), which reflects a policy response, was found to decline with income as several have conjectured.

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[8]Shafik and Bandyopadhyay (1992) also examined access to clean water and sanitation, deforestation, and solid waste generation.

[9]Other variables include investment shares of income, growth rates, trade intensity, debt, political rights and other variables in SB and population density plus climatic, topographical, and land use variables in GK.

[10]Results obtained for water pollutants and other environmental indicators are more varied, though single peaked curves for several forms of water pollution are obtained by GK. Another relevant empirical study is Lucas, Wheeler, and Hettige (1992) who examined changes in the industrial composition of output and implied changes in production of toxic materials across countries. Summarizing, their study found that production of toxics does decline at sufficiently high income levels, but that this is mainly due to shifts away from manufacturing at high incomes rather than to shifts within manufacturing toward less toxic outputs.

Total gasoline consumption rises with income. The product, lead emissions, follows an inverted U pattern. These results indicate, at least for lead emissions, that it is a policy response that causes the pollution curve to bend down at higher incomes. Further, because lead emissions result from consumption rather than production, the eventual decline is not due to a 'pollution haven' effect, whereby rich countries import pollution intensive goods from poor countries.

Barrett and Graddy (1997) revisited the GK data, extending the model to include measures of political and civil freedom. They found support for the proposition that more freedom is associated with lower levels of several pollutants. Since democracy and civil/political freedom tend to go together, this agrees with our basic premise. They also found, however, that this relationship does not apply to all pollutants. This seems to indicate that the downward sloping portion of environmental Kuznets curves for some pollutants is caused by something other than an induced policy response. (Shifts in the composition of output seems an obvious possibility.)[11]

In an important recent contribution Antweiler, Copeland, and Taylor (1997) (ACT) developed a rigorous structural framework. In their model countries set environmental policy endogenously by satisfying a Samuelson condition. Environmental policy, in turn, alters the relative prices of goods according to their pollution intensity. Countries trade, with comparative advantage determined both by environmental policy and factor abundance. A reduced form equation for pollution is then estimated with the same SO_2 data others have used, primarily to determine the environmental effects of trade liberalization.

Theoretical models of the growth-environment relationship are scarcer. Lopez (1994) models pollution as use of the environment as a productive input. He shows that an inverted U relationship is generally possible, though not if preferences are homothetic. He also shows that its form depends on the ease of substituting environmental and conventional factors. Lopez and Mitra (1997) extend this framework to examine the effect of government corruption. Corruption

[11]Congleton (1992) and Murdoch, Sandler, and Sargent (1997) correlated 'freedoms' measures with participation in international environmental agreements.

takes the form of payments from industry, the source of pollution, to government officials. Government officials are motivated by these payments and by the desire to retain office, which depends on the average citizen's welfare. They find that corrupt regimes may also follow an inverted U pattern, but with more pollution at each income level and a higher turning point than non corrupt regimes.

Overall, this review indicates the importance of basing empirical work on a structural framework to motivate policy inferences. It also describes suggestive evidence that the form of government is empirically related to pollution (Barrett and Graddy, 1997,)[12] and offers a set of relevant testable hypotheses (Lopez and Mitra, 1997.) Finally, ACT's structural framework seems adaptable to the present purpose, and a model sketched along these lines is presented next.

4 A Preliminary Framework

Consider of a small, open economy that consumes pollution, a public good, and two ordinary private goods. The analysis is static. Government policy concerning pollution control and public goods is endogenous, determined by income, the form of government, and other variables. The economy produces two private goods, X and Y, a public good Z, and a pollutant, W (waste.) Production of Y causes pollution, but production of X and Z does not. Thus pollution is partly determined by the composition of output. For simplicity, W is assumed proportional to Y

$$W = \alpha \cdot Y, \quad \alpha > 0. \qquad (4.1)$$

W can be reduced by reducing Y or by spending resources to reduce α, its pollution intensity.

The economy is endowed with a fixed primary input, R, which may be a vector. The production function for private goods and pollution control is

$$f(X, Y, \alpha, R, T) = 0 \qquad (4.2)$$

[12]GK and ACT both found pollution to be significantly higher in communist countries than other countries, and SB found a measure of 'political rights' to be significant in some regressions.

where T represents the production technology. $f(\cdot)$ is taken to be convex in X, Y, α, and R, increasing in X, Y, and α, and decreasing R. The private goods X and Y can either be consumed directly or used to produce the public good Z. Production of the public good is addressed shortly.

The country's economy is small and open, and trades both private goods at fixed world prices. Good X is numeraire and the price of Y is P. Production is competitive. The country's environmental policy takes the form of a tax on pollution, τ. Production of the public good is financed by a lump sum tax, Γ. Levels of both τ and Γ are determined later. The profit of a representative firm, net of the pollution tax and the tax to support public good production, is

$$P \cdot Y + X - c(X,Y,\alpha,R,T) - \tau \cdot \alpha \cdot Y - \Gamma, \tag{4.3}$$

where $c(\cdot)$ is the cost function for private goods. Profit maximizing output and pollution control choices are

$$Y = Y(P,\tau,R,T), \quad X = X(P,\tau,R,T), \quad \alpha = \alpha(P,\tau,R,T). \tag{4.4}$$

With an open economy, the composition of output is not affected by the income and preferences of domestic consumers except through environmental policy, as shown momentarily.[13] After-tax maximized profit, which is effectively the rent generated by R, is given by

$$\pi = \pi(P,\tau,R,T) - \Gamma. \tag{4.5}$$

Production of the public good Z is assumed to require only the private outputs X and Y, so

$$Z = Z(X,Y,T). \tag{4.6}$$

Public good production is assumed to take place at minimum cost. The resulting public good cost function, $g(Z,P,T)$, is convex and increasing in Z. Budget balance implies that

$$g(Z,P,T) = \Gamma. \tag{4.7}$$

The fixed number of individuals in the country is N. The country's government is controlled by an elite group numbering E=N. The limiting cases of pure democracy and singly

[13] This would of course be violated if some goods are not traded.

ruler dictatorship occur at E=N and E=1, respectively. Taking the form of government as given, the number of elite in the country is fixed. The utility of an elite member, i, is

$$u = u(X_i, Y_i, Z, W), \text{ where} \tag{4.8}$$

X_i and Y_i are i's consumption of the two private goods. Z and W are common to all individuals. u is assumed to be concave, increasing in X, Y, and Z, and decreasing in W.

Government policy regarding pollution control and public good provision are chosen by the elite to maximize their aggregate utility.[14] As a first step toward examining these choices, consider the aggregate budget constraint for the elite group. Let σ denote the share of the economy's income that the elite controls, and assume this share depends on the country's form of government. It is useful to define a 'form of government' variable that captures the concept of inclusiveness--the degree to which government policy incorporates, or fails to incorporate, the interests of the entire population. The most natural choice is E/N, the size of the elite relative to the entire population. A higher value of E/N corresponds to a more inclusive government. With 'pure democracy' E/N=1, the elite is the entire population. More generally, assume $\sigma = \sigma(E/N)$.

As a working hypothesis, it seems reasonable to specify that $\sigma(E/N) \geq E/N$, with equality holding only for E/N=1. This means that the elite captures a disproportionately large share of income in non-democratic governments. In a pure democracy, the share necessarily equals unity. Further, it seems reasonable to specify that σ is strictly increasing and concave in E/N. For σ to be increasing means that increasing the size of the elite for a given N, i.e., moving toward democracy, increases share of the economy's total income that the elite controls. This seems intuitively sensible. Concavity implies that $\sigma(E/N)/E$, the income share of an individual member of E, is decreasing in E. This means that an *individual* elite member's share of the economy's income is greater the smaller is the elite group, and is greatest under single ruler autocracy.

The economy's spendable income equals the rent generated by its resource endowment, $\pi(\cdot)$, plus the proceeds of the environmental tax, $\alpha \cdot \tau \cdot Y$, minus the cost of providing the public

[14]The elite's decision process could be characterized as maximizing the utility of the median elite member with little effect on the model.

good, g(·). The elite captures the share σ of this. Let e(P,W,Z,u) denote the expenditure function of a representative member of the elite. With this notation the elite group's budget constraint can be written

$$\sigma(E/N)\cdot[\pi(P,\tau,R,T) + \tau\cdot\alpha(P,\tau,R,T)\cdot Y(P,\tau,R,T) - g(P,Z,T)] = E\cdot e(P,W,Z,u). \qquad (4.9)$$

The elite group controls government and makes policy to maximize their collective welfare. The formal problem is to maximize E·u(·) subject to (4.9). Because E is fixed, this is no different than maximizing the utility of a typical elite member. The Lagrangian is

$$L = E\cdot u + \lambda\{\sigma\cdot[\pi(P,\tau,R,T) + \tau\cdot\alpha(P,\tau,R,T)\cdot Y(P,\tau,R,T) - g(P,Z,T)] - E\cdot e(P,W,Z,u)\}. \qquad (4.10)$$

The choice variables are u, τ, and Z and the first-order conditions are

$$\frac{?L}{?u} = E - \lambda\cdot E\frac{?e}{?u} = 0, \qquad (4.11)$$

$$\frac{?L}{?\tau} = \lambda\{\sigma\cdot[\frac{?\pi}{?\tau} + \alpha\cdot Y + \tau\cdot\alpha\frac{?Y}{?\tau} + \tau\cdot Y\frac{?\alpha}{?\tau}] - E\cdot\frac{?e}{?W}(\alpha\frac{?Y}{?\tau} + Y\frac{?\alpha}{?\tau})\} = 0, \qquad (4.12)$$

$$\frac{?L}{?Z} = -\lambda\{\sigma\frac{?g}{?Z} + E\frac{?e}{?Z}\} = 0, \qquad (4.13)$$

and the budget constraint (4.9). The solution is

$$\tau = \tau(P,R,E/\sigma,T), \quad Z = Z(P,R,E/\sigma,T), \quad u = u(P,R,E/\sigma,T). \qquad (4.14)$$

The first-order conditions have natural interpretations. Equation (4.11) identifies $1/\lambda$ as the marginal cost of utility. In order to interpret (4.12), notice that the envelope theorem implies $?\pi/?\tau = -\alpha\cdot Y$ (see (4.3).) Using this and canceling common terms, (4.12) can be written

$$\tau = (E/\sigma)\cdot\frac{?e}{?W}, \quad \text{or } \tau = \frac{E/N}{\sigma}\cdot[N\cdot\frac{?e}{?W}]. \qquad (4.15)$$

Condition (4.13) can be written

$$\frac{?g}{?Z} = -(E/\sigma)\cdot\frac{?e}{?Z}, \quad \text{or } \frac{?g}{?Z} = -\frac{E/N}{\sigma}\cdot[N\cdot\frac{?e}{?Z}]. \qquad (4.16)$$

In (4.15) and (4.16) the terms ?e/?W and -?e/?Z are an elite individual's marginal benefit of pollution control and the public good, respectively. Assume for a moment that all individuals in the country, elite and non-elite alike, have the same marginal benefit functions for pollution control and public good. In this case a Pareto efficient policy would equate the pollution tax to $N\frac{?e}{?W}$, the social marginal benefit of pollution control. In addition, it would equate the marginal cost of the public good to $-N\frac{?e}{?Z}$, the social marginal benefit of the public good. Recall that (E/N)/σ is below unity for non-democratic governments. The model therefore implies that non-democratic governments will under provide both pollution control and the public good, with the degree of under provision worse for less democratic regimes.

This formalizes a simple intuition. Because the elite captures a disproportionate share of the economy's net income, it will arguably bear a disproportionate share of the cost of any environmental regulation adopted or public good provided. If it captures all of the economy's rents, then it necessarily bears the entire cost. The elite captures only a proportionate share of the marginal benefit of pollution control and public good provision, however, because these goods are non-exclusive. Since the elite make the policy, public goods are therefore under provided relative to what is efficient.

This prediction must be amended if marginal pollution damages and marginal public good benefits increase with income. Members of the elite tend to be wealthier than the general population, so it is reasonable to expect each member's demand for public goods to be relatively high when E/N is small. Strictly speaking, this implies that the effect of the form of government on public goods provision is indeterminate in the model.

Two practical considerations mitigate this income effect, however. First, less democratic governments tend to experience poor economic performance, so concentrating the control of government among a smaller elite should reduce the size of the pie each member shares. Second, if E/N is small, members of the elite might find it advantageous to provide public goods, or substitutes for them, among themselves, even if the cost is high. An elite group may choose to live in a protected enclave, with their own systems for water, sanitation and education. They may even have clean air if enclaves are located away from urban centers. Dictators sometimes carry this to an extreme by maintaining villas in rich, pollution free, foreign countries. Such substitutes place a ceiling on the marginal damage the elite can suffer from general pollution.

It is instructive to consider the case of a public good, Z, that benefits industry rather than consumers, i.e., a public good input. A simple way to examine this is to drop pollution (W) from the model and to specify that Z enters the economy's profit function but not the elite's expenditure function. In this case the budget constraint (4.9) becomes

$$\sigma(E/N)\cdot[\pi(P,R,Z,T) - g(P,Z,T)] = E\cdot e(P,u). \qquad (4.17)$$

Solving the elite's utility maximization problem now requires that Z be chosen to maximize the country's rent, the term in brackets on the left hand side of (4.17). Since E/N does not appear in this expression, the solution is independent of the form of government. That is, the model implies that all forms of government provide *pure public inputs* efficiently.

Finally, a simple intuitive argument indicates that plotting pollution against income may well result in an inverted U relationship for *any* form of government, but that the exact shape is likely to be different for different forms of government. In the context of the present model, increasing income is equivalent to increasing the economy's resource endowment, R. Increasing R allows the economy to produce more of both private goods (X and Y) which, *ceteris paribus*, increases pollution. Increasing R also raises the demand for pollution control, however, resulting in a higher pollution tax. Raising the pollution tax lowers Y and its pollution intensity, α. The production and policy effects thus work in opposite directions, so the net effect on pollution is ambiguous. Intuitively, the pollution-income relationship is likely to have an inverted U-shape if the stringency of pollution control increases with the country's income at an increasing rate, so the policy effect tends to catch up to the production effect as income increases. From (4.15), however, the responsiveness of environmental policy to changes in total or percapita income tends to be small where σ/E is large, i.e., in non-democratic situations. Hence, if a turning point exists it should occur at a higher average income under non democratic government than democracy, which agrees with Lopez and Mitra (1997).

5 The Form of Government and the Provision of Public Goods: Empirical Results

One political economy aspect of the environment-development relationship is singled out for empirical examination, the effect of political regimes on public goods provision. The model captures this effect in two ways, in the demand function for public goods and the equilibrium environmental policy; see (4.14). Differences in political systems are captured by $E/\sigma(E/N)$, which can be written as a function of N and $(E/N)/\sigma(E/N)$. Recall that $(E/N)/\sigma(E/N)$ is higher in more democratic (more inclusive) regimes. The equilibrium public goods level is given by:

$$Z = Z(E/N,N,P,R,T).$$

Essentially the same effect is reflected in the pollution control tax, which is written:

$$\tau = \tau(E/N,N,P,R,T).$$

Given the duality between taxes and pollution control standards, $\tau(\cdot)$ can be considered a general measure of the stringency of a country's environmental policy. In these functions R represents the economy's capacity to produce, so GDP is an appropriate measure. P represents relative prices of goods with differing pollution intensities. In keeping with the open economy specification of the model, our empirical approach assumes that P is roughly the constant across countries and varies only over time. This is also assumed to be true for T, the technology variable. Variation in both is captured by temporal dummy variables or time trends.[15]

Defining Political Regimes

The obvious difficulty for empirical work is to capture the form of government, interpreted as the degree of inclusiveness, in an empirically tractible way. Here, we examine this problem from different perspectives to see if a single measure dominates and to see if robust

[15] The population level, N, also appears in $Z(\cdot)$ and $\tau(\cdot)$. This is because the public good and pollution control are assumed to be pure public goods, so increasing population should cause the benefits of public good provision and pollution control to rise proportionately. In estimation it is assumed that Z is linearly homogeneous in N, and therefore work with percapita measures of public good provision. Regarding τ, it is assumed that both the benefits and costs of pollution control are proportionate to N, so the standard is independent of population.

results emerge. Political scientists have compiled extensive data sets on the political attributes of countries. Two of these sources are relied upon in what follows. The first is the Cross-National Time Series Data Archive first compiled by Arthur Banks (19**) and now maintained by ***. This source lists objectively observed attributes of the governmental systems of virtually all countries, as explained below. The second is the Polity III data base maintained by Keith Jaggers and T. R. Gurr (1995) which gives information on the political systems of countries with populations greater than 500,000. It reports some objective attributes plus subjective judgements on the degree to which different institutions of government are democratic, or responsible to the populace. Both data bases cover the period from the late 1990s back into the 19th century. These two sources were used in different ways to classify governments into groups with similar political attributes. Membership in individual groups is then represented with dummy variables.[16]

The first classification scheme relies on data from Banks (19**). Banks reports: the effectiveness (and existence or nonexistence) of a country's legislature, competitiveness of the legislature's nominating process, the presence or absence of political coalitions, the degree to which parties are excluded from political participation, whether the government is controlled by civilian or military components of the population, the method of selecting the chief executive (e.g., elective or nonelective,) the method of selecting the legislature (elective or nonelective,) and the responsiveness of premier to the legislature in parliamentary systems.

Each attribute typically has several categories and each observation (country and year) is assigned to one. For example, for legislative effectiveness a legislature can be designated as nonexistent, ineffective, partially effective, and effective. A noneffective legislature is defined as one that canot implement legislation due to domestic turmoil, cannot meet because the executive prevents it, or is essentially a ‘rubber stamp’ body. A legislature is partially effective if the executive’s power substantially dominates, but does not completely dominate, it. A legislature is

[16]The widely used data base on political and civil freedoms sponsored by Freedom House and reported by Gastil was also considered, but was not used in part because of the common belief that it reflects a conservative bias.

effective if is has significant autonomy, including the power to tax, spend, and override executive vetoes. There clearly is an attempt to use objective criteria in assigning attributes.

None of these attributes can necessarily be considered decisive in indicating the degree of democracy or inclusiveness in a country's government. The presence of certain attributes does, however, generally indicate a presumptive absence of democracy. These are: ineffective or nonexistent legislature, noncompetitive nominating process for legislature, no opposition to party in power, significant exclusion of some political groups or parties, government controlled by military component of population, nonelective selection of chief executive, nonelective selection of legislature, and parliamentary government in which the premier is not responsible to legislature. Any country that possesses none of these nondemocratic attributes was presumed to be a Democracy.

A similar procedure was used to identify countries that, based on the attributes observed, appear to be dictatorial. Here, the presumption is that a country is democratic if it has: an effective legislature (possessing substantial power to tax, spend, and override executive vetoes,) direct popular election of the chief executive, and parliamentary governments in which the premier is fully responsible to the legislature. Any country that possesses none of these democratic attributes is considered a presumptive Dictatorship. Observations not falling into either group are labeled Indeterminate.

To obtain a finer division the possible democracies and dictatorships were then subdivided according other attributes. The Dictatorship group was split into two subgroups depending on whether or not a country has a popularly elected legislature. Those that do are placed in a group called Dictatorship 1, while those that do not are placed in Dictatorship 2. The Democracy group was also subdivided. An otherwise democratic country was placed in a group called Democracy 2 if it had an only partially effective legislature (so its power is substantially outweighed by the executive,) or if some minor or extremist political parties are excluded from the political process. The remaining members of Democracy were placed in Democracy 1, which is arguably the most democratic group.

In the sample examined, this resulted in the following percentage breakdown of observations by political designation: Democracy 1 19%, Democracy 2 21%, Dictatorship 1 16%, and Dictatorship 2 16%, Indeterminate 28%. This ordering from Democracy 1 to Dictatorship 2 is expected to coincide roughly with the ordering of inclusiveness of government regimes. The inclusiveness of the Indeterminate group is unclear.

The second method for defining regimes also relies on Banks, but combines attributes in different ways. Three basic attributes were used: the method of selecting the chief executive, the type of chief executive, and the existence or effectiveness of the legislature. Figure 3 shows how government regimes are defined and gives sample frequencies. A country with an effective or partially effective legislature and an elected chief executive is defined to be a Parliamentary Democracy or Presidential Democracy, depending on whether its chief executive is a premier or a president.[17] A regime with an elected chief executive (either president of premier) but an ineffective legislature or no legislature is called a Strong Executive system. When a country's chief executive is a nonelected member of the military, its regime is called a Military Dictatorship. When a country's chief executive is nonelected but not from the military, its regime is labeled Other. This group includes monarchies, protectorates, and countries in which no individual can be identified as wielding effective executive power, e.g., anarchies. The first two regimes appear most inclusive, followed by the strong executive and military dictatorships. The inclusiveness of the Other category is unclear. Military dictatorships and strong executive systems seem more likely than presidential and parliamentary systems to cater to an exclusive minority.

The third method for defining political regimes relies on the Polity III data base of Jaggers and Gurr (19**). Polity III reports a Democracy Score and Autocracy Score for each country and year. Each variable is a subjective assessment coded on a 0 to 10 point scale, with

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[17]Parliamentary democracy is distinguished from non-parliamentary democracy (presidential systems) because the legislature is arguably more powerful in the former.

higher numbers corresponding to 'more' of the named attribute.[18] These indexes were combined by subtracting 'Autocracy' from 'Democracy,' to obtain an overall democracy index that can take on 21 possible values, from -10 to 10, including 0. A country receiving a 0 on the Democracy scale and a top score on the Autocracy scale would receive an overall score of -10, while one with a top score on Democracy and 0 on Autocracy would score 10. Dummy variables were defined for country-year pairs falling into the different quintiles of this range. These regime variables are labelled Q1-Q5, ordered from most democratic to most autocratic.

Environmental and Public Goods Data and Empirical Specifications

Cross country data were collected for several measures of public goods provision, with emphasis on environmental public goods, and one measure of environmental policy. Two environmental public goods are examined, the percent of the rural population having access to <u>sanitation</u> facilities and <u>safe drinking water</u>. These data are collectected by the World Health Organization and are reported in the World Resources Institute database. Empirical analysis is based on data from a cross section of 118 countries for the year 19**. Since there is no time variation, temporal dummies are unnecessary. The only variables included on the right hand side are therefore percapita income and the political dummies. Each dependent variable has a natural truncation at 100%. When plotted against income, therefore, it should be increasing, roughly concave, and truncated at 100%. To capture this the dependent variable is expressed in levels in the two models, income is entered in logs, and tobit estimation is used.

The model does not just apply to environmental public goods, so it is of interest to examine other public goods for which data are available. Two are examined here, <u>roads</u> and <u>public education</u>. Data on the extent of paved and unpaved roads, available sporadically for about 120 countries over the period 1965-1995, were taken from the International Road

[18] Polity III also reports data on procedures for transferring executive power, the degree of competition in the electoral process, the openness of executive recruitment, the institutional independence of the chief executive, the openness of political expression, the general openness of competition for government office, and the degree of centralization of state authority.

Federation. To examine the hypothesized relationship, road density (kilometers of road per square kilometer of land) is specified to be a log-log function of population density, per capita income, and dummy variables for the form of government. A time variable was included to capture changes in technology and prices. This model was estimated with fixed effects for continents to allow for broad regional differences in climate and topography.[19]

To examine provision of public education, data on secondary school enrollments for approximately 120 countries over the period 1960-1995 were taken from Banks. The dependent variable is secondary school enrollment, divided by the population under age 15 to control for population age structure. Attention is focused on secondary public education because primary education is nearly ubiquitous across a large number of countries and hence does not exhibit much cross sectional variation. The independent variables are per capita income, population, time, and the political regime dummies. As with roads, the functional form is log-log and fixed effects for continents are included.

The environmental policy measure considered is the lead content of gasoline as reported by Octel Corp. This variable was examined for even years between 1972 and 1992 for a sample of 48 countries. Lead is a cheap source of octane in gasoline. When burned it collects in areas near roads and can eventually be ingested by humans. Lead ingestion leads to well known health problems, and the most common way to control its emission is to legislate an upper limit on lead concentrations in gasoline. By examining the actual lead concentration, rather than the legislated maximum, it is implicitly assumed that gasoline producers are effectively constrained by lead content regulations. Many countries have banned its use, imposing an effective zero limit on concentrations.

The empirical model for lead concentrations includes income and the political regime dummies as regressors. It also includes two additional variables. The first is a time trend. It reflects the fact that worldwide lead use in gasoline has been declining monotonically over the

[19] Fixed effects for countries would largely absorb the effects of political variation since regimes do not exhibit much variation within countries over time.

sample period, which may reflect increased knowedge of the health effects of lead in humans and development of technology for raising octane without using lead. Yearly dummies and a time trend yielded nearly identical results for other parameters and for overall fit. The linear trend specification is reported because it is simpler. The second new independent variable is the percent population living in urban areas. It is included to capture cross country differences in the human exposure and related health effects of emitting a given amount of lead into the environment. Intuitively, if a country's population is entirely rural then gasoline consumption and lead emissions will be dispersed, leading to low concentrations in the environment. The population is also dispersed, so exposure is relatively light. By contrast, in urban areas both gasoline consumption and human habitation are concentrated in the same areas. Lead concentrations are naturally truncted at zero. Accordingly, the its relationship with income are necessarily nonlinear. This was taken into account by expressing lead concentrations in levels, entering income in logs, and using tobit estimation.

Results

Table 1 presents variable mean income and public good levels, by political regime for the three different ways used to define political regimes. Incomes are clearly higher in democracies than in autocracies and the effect is roughly monotonic. One minor anomaly is the result obtained for the Q5 group in the Polity III regime set. This may be due to the influence of major oil producing countries, some of which are both autocratic and wealthy due to their natural resource base. A plausible reason why incomes are lower in less democratic regimes is that property rights are less secure where the rule of law is absent and this depresses investment incentives. A related explanation is that such regimes generally suffer from corruption, and the exercise of government power in this way can drain the economic surplus the private economy would otherwise produce. The observation that regimes and income are highly correlated confirms what was claimed earlier, that a failure to control for differences in political systems will tend to bias the estimated relationship between a country's income and its level of environmental quality or public good provision.

While there are exceptions, the measures of road provision, public schooling, and access to safe water and sanitation generally decline as democracy declines, while lead concentrations in gasoline generally increase. This is broadly true for all three ways of defining political regimes. It is consistent with the story told earlier, that autocracies do not include the benefits accruing to all citizens when deciding the levels at which such goods should be provided. Of course, the observed correlation between income and politics means that this effect could also be due to differences in incomes.

Tables 2-4 present regression results for the four public goods and lead concentrations, for the three different methods of defining political regimes. All three measures show fairly distinct differences between regimes for roads, school enrollment, and lead levels, and the dummy coefficients generally follow the expected pattern. The pattern is not as clear for safe water and sanitation, however. Here, the most democratic regime has significantly higher provision than the others in almost all cases, but there is generally little variation among the four less democratic regimes.

All three methods of defining political regimes give approximately the same fit to the data. There is one exception. The second method using the Banks data, with Parliamentary Democracy, Presidentialdemocracy, and so forth, does a poor job of fitting lead concentrations. The reason for this is not clear.

Most importantly, political regimes clearly matter for the provision of public goods and environmental protection, even after controlling for differences in income. Overall, the differences generally run in the expected direction. The differences between the most democratic regime and each of the other regimes is statistically significant in the vast majority of cases (56 out of 65) and all of the significant differences are of the expected sign. Differences among the less democratic regimes are less often significant, however. Generally, the differences between less democratic regimes are more likely to be significant for school enrollments and lead concentrations than for roads, safe water, and sanitation, though this is not a strong pattern.

The political regime effect on public good provision is generally large. Table 5 reports percent differences between public good and environmental policy levels under the most democratic regime and the 'worst,' in terms of underproviding public goods, of the less democratic regimes. In most cases the worst regime is also the least democratic, though this is not always the case. ***Comment on Table 5***.

6 Conclusions

These results should be viewed as preliminary. A more careful analysis may reveal a more illuminating way to use the data on political attributes to represent variations in democracy. Another consideration worth further study is that public good levels probably respond to changes in political conditions gradually. Roads are capital improvements, and can sensibly be augmented and depreciated only slowly. Similarly, provision of safe water, sanitation, and schools all require some capital investment, and hence are subject to the same consideration. This suggests that investigating a lag structure for political conditions may yield a clearer understanding of the effects of politics. ***What other conclusions could one reasonably draw?***

Though preliminary, the results do serve to demonstrate that these questions are empirically researchable and the pattern of correlations generally support the maintained hypothesis about the effect of governance on the provision of public goods. In addition, unreported results indicate differences in the income elasticities of public goods provision under different systems of governance. This implies that incorporating fixed effects for countries cannot capture the effects of differences in political systems, even when political systems tend to be relatively constant within countries.

Refining the model of political outcomes in nondemocratic governments is a logical next step. The model developed here relies entirely on the concept of inclusiveness to differentiate political systems. It is highly stylized and overlooks some of the more interesting attributes that autocracies seem to display, such as an apparent tendancy to spend heavily on military and police functions. Another obvious question to address is why countries end up with the political systems they have, i.e., what process leads to differences in political regimes?

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Table 1. Variable means by political regime

Regime type	GDP per cap	Road density	Sec. schl. enroll.	Safe water access	Sanit. access	Lead concent.
Banks 1:						
Democracy 1	7762.8	11.37	.177	96.05	97.30	1.48
Democracy 2	4030.5	7.13	.113	64.27	48.18	1.66
Dictatorship 1	2320.2	4.14	.056	56.53	41.70	2.27
Dictatorship 2	2857.6	.89	.052	52.16	30.24	2.41
Indeterminate	1855.4	1.74	.048	48.73	45.65	2.40
Banks 2:						
Parl. Democ.	5872.6	10.12	.159	88.03	83.81	1.77
Pres. Democ.	3991.5	5.41	.090	60.98	59.13	2.24
Strong Exec.	1508.9	2.51	.043	55.06	43.70	2.57
Milit. Dict.	1894.7	1.02	.053	44.91	32.90	2.44
Other	3523.6	3.59	.055	52.38	33.56	2.30
Polity III:						
Q1 (Democ.)	7908.7	12.07	.173	90.33	92.68	1.24
Q2	3385.5	3.73	.090	60.30	61.23	2.03
Q3	2128.6	3.88	.047	55.06	28.26	2.27
Q4	1703.5	3.08	.051	55.47	37.44	2.34
Q5 (Autoc.)	2831.4	1.29	.056	52.26	45.55	2.38

Table 2. Public good provision with Banks 1: Democracy 1 and 2, Dictatorship 1 and 2, and Indeterminate*

Indep. Vbl.	Road density	Sec. schl. enroll.	Safe water access	Sanit. access	Lead concent.
Income	.31008	.85377	14.6074	20.2495	-.12423
	(.0368)	(.0233)	(2.9984)	(3.3427)	(.0687)
Regimes:					
Democracy2-.47633	.08385	-29.6596	-44.5668	.41939	
	(.0760)	(.0582)	(9.0994)	(10.287)	(.1134)
Dictatorship1	-.63632	-.36659	-33.8072	-43.7200	.73066
	(.0865)	(.0576)	(9.1839)	(10.369)	(.1344)
Dictatorship2	-.78380	-.44292	-30.3396	-48.0567	.00137
	(.0948)	(.0561)	(10.369)	(11.641)	(.1193)
Indeterminate	-.45382	-.29838	-39.1696	-32.0175	.89888
	(.0845)	(.0538)	(9.2110)	(10.671)	(.1257)
Popul'n density	.73552				
	(.0194)				
Year					-.13427
					(.0109)
Percent urban					.00419
					(.0027)
Constant	-.73224	-9.3672	-20.9995	-68.1058	3.0817
	(.3182)	(.1939)	(27.7478)	(30.748)	(.5128)
R^2 (overall)	.8407	.5934			
X			88.47	98.97	229.31
Obs.	533	2742	118	110	504

*The default regime is Democracy 1. Equations for roads and school enrollments are log-log and include fixed effects for continents. In equations for safe water, sanitation, and lead, the dependent variable is in levels, income is in logs, and tobit estimation is used. Standard errors are in parentheses.

Table 3. Public good provision with Banks 2: Parliamentary Democracy, Presidential Democracy, Strong Executive, Military Dictatorship, and Other*

Indep. Vbl.	Road density	Sec. schl. enroll.	Safe water access	Sanit. access	Lead concent.
Income	.37160	.85490	17.891	24.330	-.05009
	(.0399)	(.0229)	(2.954)	(3.362)	(.0806)
Regimes:					
Pres. Democ.	-.10081	-.19015	-25.410	-19.793	.42591
	(.0919)	(.0498)	(9.508)	(9.126)	(.1108)
Strong Exec.	-.05219	-.29141	-19.088	-12.165	.61135
	(.0924)	(.0507)	(8.037)	(9.325)	(.1169)
Milit. Dict.	-.41266	-.35851	-25.127	-25.734	.46901
	(.1188)	(.0633)	(9.508)	(11.096)	(.1473)
Other	-.44744	-.51604	-23.289	-35.328	.33011
	(.0949)	(.0525)	(7.929)	(8.974)	(.1187)
Popul'n density	.72925				
	(.0198)				
Year					-.08557
					(.0141)
Percent urban					-.00114
					(.0030)
Constant	-1.4886	-9.3619	-57.813	-117.325	2.8021
	(.3443)	(.1856)	(25.895)	(29.428)	(.5714)
R^2(overall)	.8133	.5914			
X^2			82.20	93.25	91.64
Obs.	530	2689	117	109	412

*See notes to Table 2. Parliamentary democracy is the default regime.

Table 4. Public good provision with Polity III: Q1-Q5 regimes*

Indep. Vbl.	Road density	Sec. schl. enroll.	Safe water access	Sanit. access	Lead concent.
Income	.11201 (.0365)	.83730 (.0233)	21.088 (3.238)	23.104 (3.624)	-.0773 (.0708)
Regimes:					
Q2 (Democ.)	-.9298 (.0844)	-.06033 (.0548)	-25.047 (8.992)	-29.234 (10.566)	.6983 (.1143)
Q3	-1.2019 (.0938)	-.37396 (.0589)	-16.757 (10.094)	-49.531 (11.828)	.9681 (.1219)
Q4	-1.4426 (.1018)	-.09545 (.0609)	-7.855 (10.453)	-27.472 (12.199)	.8741 (.1459)
Q5 (Dict.)	-1.0823 (.0940)	-.39904 (.0568)	-24.036 (9.658)	-36.289 (11.395)	.9042 (.1310)
Popul'n density	.6827 (.0170)				
Year					-.1313 (.0107)
Percent urban					.0034 (.0026)
Constant	1.1826 (.3272)	-9.2619 (.1951)	-83.914 (29.370)	-95.419 (33.022)	2.613 (.5383)
R^2 (overall)	.8525	.5877			
X^2			76.71	90.88	241.16
Obs.	525	2590	109	101	496

*See notes to Table 2. Q1 is the default regime type.

Table 5. Percent differences in provision between the most and least democratic regimes.

Regime measure	Road density	Sec. schl. enroll.	Safe water access	Sanit. access	Lead concent.
Banks 1	xx%	yy%	etc.		
Banks 2	xx%	yy%	etc.		
Polity III	xx%	yy%	etc.		