Contributions to Economic Analysis & Policy

Volume 3, *Issue* 1 2004 *Article* 2

Willingness to Pay for Environmental Quality: Testable Empirical Implications of the Growth and Environment Literature

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Abstract

Several different theoretical models of economic growth and environmental quality each generate inverse-U-shaped pollution-income paths, or "environmental Kuznets curves." They rely on different assumptions to generate the reversal of pollution trends, with correspondingly different policy implications. While the empirical implications for pollution are indistinguishable (by design), the models have distinct implications for the pattern of people's marginal willingness to pay (MWTP) for environmental improvements as a function of income. In this paper we demonstrate those different implications theoretically, and test for them empirically using data from the World Value Survey (WVS). We find strong relationships between MWTP and individual characteristics, such as age, income, and education, but little evidence that MWTP varies systematically with economic growth.

KEYWORDS: World Values Survey, environmental Kuznets curve, environmental preferences

*The authors are grateful to Eli Berman, David Bloom, William Jack, John List, Gib Metcalf, Kerry Smith, and anonymous referees for helpful comments, to Sjamsu Rahardja for excellent research assistance, to the NBER for hosting and financing the conference, and to the NSF for financial support (grant #SES-9905576).

1. Introduction

Recent empirical evidence has documented some forms of local pollution (airborne lead, sulfur) that have declined significantly in industrialized countries despite robust economic growth. Poor countries appear relatively unpolluted, middle-income countries more polluted, and rich countries clean again.[1] Because this evidence comes from reduced-form, country-level regressions of pollution on per-capita GDP, the cause of this inverse-U pattern is uncertain and the policy implications are ambiguous. Some have inferred that poor countries are not efficiently regulating externalities. Others have concluded that environmental progress eventually becomes an automatic consequence of economic growth.[2] If nothing else, these disparate claims highlight the need for a causal explanation of the relationship between economic growth and environmental quality.

In very recent years, several theoretical explanations have circulated. Because these theories were designed to generate inverse-U-shaped pollution-income patterns, they cannot be distinguished empirically on the basis of those patterns. However, the theories have different implications for people's marginal "willingness to pay" for environmental cleanup, and therefore may have testable empirical predictions using international surveys of environmental priorities.

We begin by noting that the inverse-U-shaped pollution-income relationship may be based entirely on individual preferences. This "individual preferences" explanation demonstrates that the observed pattern of pollution and income is not sufficient evidence that low-income countries set either Pareto-efficient or inefficient policies. Without any institutional barriers to accommodating individual preferences, this explanation has no implications for policy. Moreover, the stark prediction of this explanation is that people's marginal willingness to pay (MWTP) for environmental quality will be the same at different income levels, *ceteris paribus*.

We then identify three theoretical explanations that depend on institutional differences between countries with varying levels of per-capita GDP. These include constraints on technologies, constraints on government institutions, and returns to scale in pollution abatement. Some of the models predict that MWTP increases with income, some predict increasing and then decreasing MWTP, while still others have no implications for the pattern of MWTP and income. Furthermore, because the models rely on different mechanisms to generate the inverse-U-shaped pollution-income path, they have different policy implications.

In what follows we examine patterns of willingness to pay across households with different incomes and countries with different levels of GDP, using household-level data from the third wave of the World Values Survey (WVS), a poll of about 70,000 respondents in 48 countries. Among other questions, the survey asked "would you be

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[1]This pattern has come to be called an "environmental Kuznets curve," after Simon Kuznets' observation that income inequality appears follow a similar pattern, increasing and then decreasing with countries' incomes.
[2]Bartlett (1994) wrote in the *Wall Street Journal* that "existing environmental regulation, by reducing economic growth, may actually be reducing environmental quality."

willing to pay 20 percent higher prices to protect the environment?" and "which is more important: environmental quality or economic growth?" While these do not conform to standard contingent valuation protocols, we are not seeking specific dollar measures of willingness to pay. Instead, we only wish to see whether the patterns of marginal willingness to pay conform to those predicted by the models. For this purpose the WVS provides a reasonable first look at these previously unstudied empirical implications of the growth and environment theories.[3]

2. Theories of growth and environmental quality

One commonly heard explanation for the observed inverse-U-shaped pollution-income path is that it reflects the natural progression of economic development, from clean agrarian economies to dirty industrial economies to clean service economies. This explanation has no normative implications for the future pattern of pollution and economic growth, since we cannot forecast the nature of the next phase of economic development after service economies. A related explanation is that rich countries become cleaner by importing those products whose manufacture creates the most pollution. This suggests that the pattern cannot be repeated indefinitely, because the poorest countries will never have poorer countries from which they can import their polluting goods.

Alternatively, the entire curve may be explained by individual preferences. Perhaps the inverse-U-shaped pollution-income path merely represents non-monotonic income expansion paths, or Engel curves, as pictured in figure 1. No economic theory implies that goods must be normal or inferior in all ranges of income, and cannot switch back and forth. While it may seem improbable that given the same prices, poor people choose clean environments, middle-income people prefer to trade clean environments for other goods, and rich people prefer clean environments, no economic fundamentals would be violated by such a pattern.[4] And, this explanation predicts that MWTP for improvements in the environment will be constant with respect to income.

In contrast, three recent theoretical explanations for the observed inverse-U-shaped pollution-income path rely on institutional characteristics of economies, rather than individual preferences. We have labeled these explanations "technology constraints," "institutional constraints," and "returns to scale." The technology constraint explanation,

[3]While a number of CV studies have examined how stated willingness to pay for environmental quality varies by household income within a country, both in industrialized and developing countries (Flores and Carson, 1997; Whittington, 1998), and some studies compare aggregate summaries of stated willingness to pay or support for the environment across countries (Bloom, 1995), our project will be one of the first to use individual survey responses to compare how willingness to pay varies both across and within countries. (See Israel (2004) for a similar examination of these issues using a different data set with 15 countries.)

[4]A second problem with the individual preferences explanation, and with figure 1, is that it is not clear what the origin of the graph represents. If the linear "frontiers" in figure 1 represent tradeoffs between environmental quality and consumption, then a poor country is endowed with both low consumption and high pollution. A more realistic model would endow poor countries with clean environments, along with the ability to trade environmental quality for consumption.

represented by Stokey (1998), and John and Pecchenino (1994), is that poor countries are as polluting as they can possibly be, given available resources and technologies. In these papers, there is some most polluting form of production. Poor countries would like to use even dirtier and cheaper technologies, but none exist. As poor economies expand, they become both dirtier and richer. Once a country is sufficiently wealthy and polluted, the marginal cost of abating pollution becomes worthwhile, and pollution begins to decrease gradually with economic growth as less polluting, more expensive technologies are employed. The normative implication of this explanation is that the observed inverse-U shape can represent a Pareto-optimal response to technological constraints. If we were to relax those constraints somehow, poor countries would only become more polluted faster. In these models, the only efficient way to become less polluted is to grow.

The institutional constraint explanation is that some obstacle prevents poor countries from establishing the social institutions necessary to regulate pollution. An example would be the political-economic barriers in Jones and Manuelli (2001). Once a country is wealthy enough, these fixed costs become worth incurring, environmental agencies are established, and pollution begins to decline with economic growth. A normative implication of this explanation is that the welfare in developing countries might be improved by assistance in overcoming the fixed costs of establishing environmental agencies.

The returns-to-scale explanation, represented by Andreoni and Levinson (2001), is that as economies become larger, abating the marginal unit of pollution becomes cheaper, and larger economies therefore abate more. In this case, the empirical observation of an inverse-U pattern has no normative policy implications. With only one agent, all decisions are by definition Pareto-optimal. With multiple agents, both the decentralized (sub-optimal) and centralized equilibria exhibit inverse-U-shapes, with the difference being that the decentralized pattern reaches a peak pollution level at higher income and with more pollution. Merely observing an inverse-U is therefore neither necessary nor sufficient evidence that the underlying pattern is efficient or inefficient.

Each of these three explanations predicts that pollution levels will rise and then fall with economic growth. They are, therefore, indistinguishable empirically using only data on countries' incomes and pollution levels. Each has, however, a different prediction about the pattern of households' marginal willingness to pay (MWTP) for environmental improvements as a function of national income.

In the technology constraint explanation, poor countries start with low MWTP (they would trade worse environmental quality for more income). But no technology exists that can reduce pollution at such low marginal cost, and so poor countries do no abatement. As they become richer and more polluted, they become more willing to trade income for environmental improvements. At some point a country is rich and polluted enough that it becomes worthwhile investing in a marginal amount of abatement technology, and pollution begins to decline gradually with economic growth. MWTP increases with income up to the point where the technological constraint is relaxed. Beyond that point, the pattern of MWTP and income depends other factors. Under the functional form and parameters in Stokey (1998), MWTP continues to increase with income.

In the institutional constraints explanation, poor countries cannot afford the fixed costs of developing environmental protection agencies. As their economies grow, they become richer and more polluted until it becomes worthwhile incurring those fixed costs. At that point an environmental agency is established, externalities are internalized, pollution declines, and MWTP stops increasing and declines. After the externalities are internalized, the pattern of MWTP is indeterminate.

In the returns-to-scale explanation, as countries become richer abatement becomes cheaper. At the same time, if clean air is a normal good, as people are richer they will have higher MWTP. The pattern of MWTP and incomes thus depends on whether, as incomes rise, abatement costs fall faster or slower than preferences for abating pollution rise.

Together, these theoretical explanations for the observed inverse-U-shaped pollution-income path generate separate predictions for the patterns of MWTP and national income. If the observed path is due to individual preferences, or to the returns-to-scale story of Andreoni and Levinson (2001), MWTP need not exhibit any particular pattern with respect to national income. If the path is due to technological constraints, as in Stokey (1988), MWTP will increase with national income, at least for poor countries. And if the path is due to institutional constraints as in Jones and Manuelli (2001), MWTP will rise and then fall with national income.

Before turning to international survey data to look for evidence of these patterns of MWTP, we first demonstrate the theoretical arguments in more detail. First we derive the MWTP in the technology constraint model. We then depict MWTP in both the technology constraint and institutional constraint models graphically, using standard indifference curves and budget constraints. Finally, we generalize both models to incorporate the returns-to-scale story.

2.1 Technology constraint

Stokey (1998) describes a static model with a choice of production technologies with varying degrees of pollution. John and Pecchenino (1994) present an overlapping generations model in which environmental quality is a stock resource that degrades over time unless maintained by investment. Both models yield pollution-income relationships that are inverse-V-shaped, peaking when the equilibria switch from corner solutions with zero environmental investment to interior optima with positive investment.

Each of these stories involves the conclusion that at low levels of income, countries are somehow endowed with an *excess* of environmental quality. Stokey's producers would like to use an even more polluting but cheaper technology, were one available. Since it is not, they use the dirtiest available technology and pollution increases steadily with production until such time as they begin to value the environment and switch to cleaner technologies. Similarly, John and Pecchenino's citizens would like to trade environmental quality for other goods, but cannot, so they slowly degrade their environment with polluting production until they reach an income threshold beyond which they care about pollution and begin to invest in environmental quality.

Stokey starts with a representative agent's utility function:

$$U(C,P) = V(C) - h(P) \tag{1}$$

where C is consumption and P is pollution, and $V()$ and $h()$ are subutility functions. Stokey assumes that consumption is produced from potential income (M) using some technology, indexed by $\theta \in (0,1]$, where $\theta=1$ is the dirtiest possible technology. Consumption is equal to θM, and pollution generated is $P=\phi(\theta)M$, where $\phi(0)=0$, $\phi'(0)=0$, $\phi(1)=1$, $\phi'(1)=1$, and $\phi''(0)>0$. The government's role is to choose θ to maximize **(1)** subject to these constraints, yielding the first order condition

$$\frac{h'}{V'} \leq \frac{1}{\phi'} \tag{2}$$

The left-hand side of **(2)** is the MWTP for a decrease in pollution.

Stokey then defines M^* as the threshold level of potential income (the economy's endowment) below which it will always be optimal to choose $\theta^*(M)=1$ for all $M<M^*$. Above M^*, $\theta^*(M)<1$, which means that some pollution abatement takes place in the form of cleaner technologies employed.

Figure 2 depicts this setup.[5] The downward sloping concave lines represent the available tradeoffs between pollution and consumption, defined by the function $\phi(\theta)$. For $M<M^*$, preferences are such that the marginal willingness to pay for abatement is less than the marginal rate of technical substitution implied (assumed to be $\phi(1)=1$), and no abatement takes place. In figure 2 when the economy is small, with endowment of potential income M_1, the indifference curve is steeper than the consumption possibility frontier, and we are at a corner solution where consumption is M_1 and pollution is P_1.

As the economy grows, so long as $M<M^*$, $\theta=1$, the dirtiest technology is employed, pollution increases, and the MWTP increases (the slopes of the indifference curves at corner solutions like 1 and 2 become flatter). At some point, the economy grows sufficiently and becomes sufficiently polluted that the slope of the indifference curve equals the slope of the technology frontier, and we move to an interior solution. Such an interior is depicted at point 3. Notice that pollution increases and then decreases as income grows.

Algebraically, MWTP is $h'(M\phi(\theta))/V'(\theta M)$ in equation **(2)**. So long as $M<M^*$, this is equal to $h'(M)/V'(M)$. And, so long as environmental quality is a normal good, and the marginal utility of consumption is diminishing, MWTP increases with income.

When $M>M^*$, and cleaner technologies become optimal, the pattern of MWTP with respect to income is less clear. Stokey uses the following functional forms as an example:

[5] Figure 2 is a reinterpretation of figure 1 from Stokey (1998).

$$\phi(\theta) = \theta^{\beta}$$
$$V(C) = \frac{C^{1-\sigma} - 1}{1-\sigma} \qquad (3)$$
$$h(P) = \frac{bP^{\gamma}}{\gamma}$$

where $\beta>1$, $\sigma>0$, $\gamma>1$, $b>0$. In this case, the marginal willingness to pay is

$$MWTP = b\theta^{\beta(\gamma-1)+\sigma} M^{\gamma+\sigma-1} \qquad (4)$$

and $\partial MWTP/\partial M > 1$, so MWTP increases with income even after the technology threshold is passed, though this is not necessarily the case for all values of the parameters.

The empirical implication of this technology constraint explanation is that all else equal, richer countries will have *higher* MWTP than poor countries, at least up until the point where pollution starts to improve with income. This implication is in theory testable using international survey data. Before describing the test however, we derive contrasting implications from competing theoretical explanations for the inverse-U-shaped pollution-income pattern.

2.2 Institutional constraints

A second explanation is that some institutional constraints block poor countries from enacting legislation to clean up their economies. Jones and Manuelli's (2001) model consists of two overlapping generations in which the younger generation sets pollution regulations. Depending on the voting mechanism, the pollution-income relationship can be an inverted-U, monotonically increasing, or even a "sideways-mirrored-S" (what others have called "N-shaped"). In their model, all of the dynamics come from the political economy. Pollution is a flow, lasting only one period, and is only suffered by the older generation. Consequently, much of the intuition in their model can be described in a static framework along the lines of the technology constraint discussion.

Figure 3 depicts this model graphically. Begin with the smallest endowment economy, the rectangle bordered by M_1. The resource constraint faced by a representative consumer is the kinked thick line. The short segment along the bottom right corner of the box represents the fixed costs of enacting regulation (political-economic costs in Jones and Manuelli). Once these fixed costs are incurred, the economy can abate pollution at some cost of foregone consumption. The highest indifference curve this small economy can attain is in the lower right corner of the endowment box, where no abatement takes place. As the economy expands, and M grows, MWTP increases until at some point the optimum will jump from the corner solution of no abatement (sucn as point 2 in the graph) to an interior solution with abatement (such as point 2a).

The pattern of MWTP here is distinct. So long as the economy is at the corner solution, where no abatement takes place, as M increases MWTP increases, just as in the Stokey model when $M<M^*$. At the threshold where abatement takes place, however, in this scenario there is a discrete jump from the corner to an interior solution. Pollution falls suddenly, and MWTP falls, from point 2 to point 2a in figure 3. Beyond this threshold, the pattern of MWTP with respect to income depends on other things.

Note that depicted this way, the institutional constraint explanation of Jones and Manuelli is a special case of the technology constraint explanation of Stokey. In both stories, poor economies are stuck at the corner solution of no abatement -- the southeast corner of their endowment boxes in figures 2 and 3. As the economies grow, marginal willingness to pay increases. The difference is that in figure 2, the possibility frontier is concave, so when the economy moves off the corner it does so gradually, and pollution is gradually abated. In figure 3, the frontier is convex, and so the economy jumps discretely from the corner to some interior solution.

2.3 Returns to scale

A third model relies on returns to scale in the technology for abating pollution. Andreoni and Levinson (2001) describe a one-agent, one-good, consumption model, with no technological or institutional constraints on consumption or pollution abatement, in which returns to scale in the abatement technology generates an inverse-U-shaped pollution-income path. They start with a general version of Stokey's utility function from equation **(1)**:

$$U = U(C, P) \tag{5}$$

where $U_C>0$ and $U_P<0$. Next, they assume that gross pollution is created as a byproduct of consumption, but that pollution can be abated by devoting effort to cleanup.

$$P = C - A(C, E) \tag{6}$$

where $A()$ is the abatement function, E is cleanup effort, and $A_C>0$ and $A_E>0$. The single agent is endowed with resources (M) that can be divided among consumption (C) and abatement effort (E).

$$M = C + E \tag{7}$$

Maximizing **(5)** subject to **(6)** and **(7)**, and rearranging terms, yields the first order condition

$$\frac{-U_P}{U_C} = \frac{1}{1-(A_C - A_E)} \tag{8}$$

The left-hand side of **(8)** is the marginal willingness to pay for environmental improvement. It is the slope of an indifference curve, plotted with consumption on the bottom axis and pollution on the left axis, and it will always be positive in the optimum.[6]

To find what happens to MWTP as income (M) increases, note that the derivative of **(8)** with respect to M will have the same sign as the derivative of (A_C-A_E) with respect to M:

$$\Big[\underset{+}{A_{CE}} - \underset{-}{A_{EE}}\Big] + \Big[\underset{-}{A_{CC}} - 2\underset{+}{A_{CE}} + \underset{-}{A_{EE}}\Big]\underset{+}{\frac{\partial C}{\partial M}} \tag{9}$$

As long as the abatement function has diminishing marginal product of C and E (A_{CC}<0, A_{EE}<0), and the marginal product of E is increasing in C (A_{CE}>0), and C is a normal good ($\partial C/\partial M > 0$), then the sign of **(9)** is ambiguous. The left bracketed term is positive, the right bracketed term is negative, and $\partial C/\partial M$ is positive.

Figure 4 depicts what is happening graphically. The smallest rectangle represents the endowment (M_1) of a small economy. If the agent consumes nothing, no pollution is created. If the agent consumes the entire endowment M_1, devoting nothing to abatement, P_1 units of pollution are generated. The consumption possibility frontier, derived from A(), depicts the tradeoff between pollution and consumption facing the economy. Given convex indifference curves, the agent will optimize at some point as depicted. The MWTP in this case is the inverse of the slope of the indifference curve at that tangency point.

Richer economies, with successively larger endowments M_2 and M_3 , are represented by increasingly larger rectangles. Andreoni and Levinson show that if the abatement function A() has increasing returns to scale and environmental quality is a normal good, the new point of tangency will at some point begin to have higher consumption and lower pollution levels. As depicted, pollution increases and then decreases with the wealth of the economy.

Unlike the technology or institutional constraint explanations, this returns-to-scale story is consistent with *any* pattern of MWTP. Thus, although we can never rule out returns to scale using MWTP data, if we do find evidence against the technology or institutional constraints, we now have a substitute explanation for the inverse-U-shaped pollution pattern.

[6]Note that if we switch one unit of resources (M) from abatement effort (E) to consumption (C), the change in pollution is (1-A_C+A_E). In the optimum, this has to be positive, otherwise we could get both more consumption and less pollution by making the switch, and the original situation could not have been optimal.

All of these institutional explanations have different implications for the pattern of MWTP and national income per capita. Under the technology constraint story, MWTP will increase with income until the point that the threshold is passed and less polluting technologies are chosen. After that point MWTP is uncertain, but with Stokey's functional form and parameters it continues rising. Under the institutional constraints explanation, MWTP rises until the point where environmental agencies are established, falls once the externalities are internalized, and is indeterminate beyond that point. Finally, the returns-to-scale explanation has no prediction for the pattern of MWTP and income.

To look for support for these models, we turn to international survey data on environmental valuations from the World Values Survey, and examine the empirical patterns of people's expressed willingness to pay for environmental improvement as a function of household and national incomes.

3. Empirics

Perhaps the ideal way to examine the empirical relationship between MWTP and national income would be to conduct an international contingent valuation (CV) study.[7] One could survey individuals' marginal willingness to pay for an extra unit of some local air pollutant that has been shown to increase and then decrease with national income, following established CV protocol, asking people to vote yes or no for a well defined environmental benefit, with a well defined payment mechanism. In the absence of such an internationally comparable survey, we turn to what is arguably the next best alternative: the World Values Survey (WVS).

The WVS is designed to be a representative survey carried out using consistent methodologies across numerous countries. We focus on the third wave of the survey, carried out predominantly from 1995-96, with some countries surveyed in 1997 or 1998.[8] The appendix contains some of the key income and environment questions. We combine the WVS with national income data from the World Bank (2002). Thirty-three countries had consistent data on the environmental questions, national income, and associated household characteristics. The countries are listed, along with some descriptive statistics, in the appendix.

While none of the WVS environment questions listed in the appendix conform to standard contingent valuation protocols, some come close enough to make comparisons of responses across households and countries worthwhile. For example, one question asks "would you be willing to pay 20 percent higher prices to protect the environment." (See the appendix for the exact format and wording.) Respondents are asked to pick from

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[7]We are aware of the numerous critiques of the CV methodology. (See Diamond and Hausman, 1994.) However, compared with alternative methodologies for calculating willingness to pay, such as travel costs, hedonics, or averting behavior, CV seems at least as likely to generate comparable values across countries. See Carson *et al.*(2000), and Smith (1997 and 2001), for defenses of CV methods.

[8]The first wave of the data was conducted only for European countries. The last wave is not yet available. The third wave is the only wave currently available with numerous environmental questions.

among four choices, "strongly agree," "agree," "disagree," and "strongly disagree."[9] Though the question is not a referendum, we can group the first two and last two responses to simulate what a yes/no question would have yielded. The question does seem to ask about *marginal* willingness to pay, as opposed to *total*, and the pattern of responses across incomes supports that interpretation.[10]

A larger problem with the "higher prices" question is that it does not ask about a specific environmental problem. If we find that MWTP does not follow a pattern predicted by a particular theory, that could be because the theory is wrong, or because the question is about an environmental problem that does not follow an inverse-U-shaped pollution-income path, or because different countries face different environmental problems and interpret the question differently. Moreover, by asking about a price increase, the question implicitly imposes a higher absolute cost on high-income respondents than on low-income respondents. Though this concern will be partially mitigated to the extent we can control for household income, as we will describe, that control turns out to be problematic. For these reasons, we will compare the responses to this price question to the other environmental questions asked by the WVS.

In sum, if our goal were to place a precise dollar value on people's willingness to pay, we would be concerned about a number of features of these questions. However our goal is not to identify people's MWTP precisely. Rather, we merely wish to establish the relationships among people's MWTP, their individual household incomes, and the national incomes of the countries in which they reside.

Table 1 presents some descriptive statistics. Of the 36375 observations, a little less than half (48 percent) said "yes" they would be willing to pay higher prices to protect the environment. (This is the sum of those who "agreed" and "strongly agreed.") Not surprisingly, this is highly correlated with respondents' opinions about the importance of environmental protection relative to economic growth, and with respondents' propensity to choose environmental products and to contribute to environmental organizations.

The per-capita GDP of people who said "yes" they would pay higher prices for the environment is lower than that of people who said "no." While the GDP difference is statistically insignificant, people who support the environmental improvement are significantly more likely to be female and younger.

The household income variable is a ranking of ten income categories for each country. Households with higher relative incomes (categories 5 through 10) are more likely to respond "yes" to the environmental questions (although this difference is statistically significant only for the top income category). Households with low relative incomes (categories 2 through 4) are less likely to respond "yes," as would be expected if

[9]In theory, this leaves the survey open to strategic manipulation, with respondents concealing their true preferences in order to influence the ultimate outcome. In practice, we doubt this concern is relevant for these descriptive analyses.

[10]Controlling for household income and other demographics, the proportion of respondents answering "yes" is *lower* for richer countries. If environmental quality is normal, this pattern only makes sense if the question is interpreted as a marginal increase in quality, and richer countries have cleaner environments.

environmental quality is a normal good. However, for some reason, households in the lowest category of incomes are more likely to respond "yes," although the difference in responses is small (half of a percentage point) and only marginally significant. Respondents with at least some university education and those living in bigger cities were more likely to respond "yes" to paying for environmental improvements.

The models outlined in section 2 all describe a single representative agent. In the WVS, of course, respondents are heterogenous. There are rich respondents in poor countries and vice versa. Hence, our goal is to describe how marginal willingness to pay changes with national income, controlling for household characteristics. Our strategy is to estimate a set of linear probability models, where the dependent variables are equal to one if the respondent agrees with the environmental question posed, and zero otherwise. We control for the respondent's age, sex, income, education, and city size, and we include a set of country-specific dummy variables, or fixed effects.

The key role played by the country dummies is that we can plot their coefficients against GDP per capita to see whether, in relative terms, rich countries' citizens have higher or lower propensities to answer "yes" to the environmental questions. Under the technology constraint story, the country dummy coefficients should increase with income for low-income countries. Under the institutional constraint story, the coefficients should increase and then decrease.

Before turning to the results, one final problem with the data needs to be addressed. For household income, respondents were asked to place themselves in one of 10 income brackets, defined by specific monetary ranges (e.g. $0-$10000, $10000-$20000, etc.). These brackets were different for each country, and were meant to correspond to the income deciles for each country. However, it is clear from the survey responses that the categories rarely matched income deciles. As a consequence, we have only a rough idea of the relative income of households in each country. A person in income category 5 in a poor country may be poorer in absolute terms than a person in income category 5 in a rich country. The income categories are *relative* rankings of income, and differ by country. If we were to ignore this problem and simply regress MWTP on household income bracket dummies and country dummies, the country dummies would pick up both country-level income per capita and individual respondents' incomes. If the country fixed effect for a rich country were higher than for poor country, we would not be able to say for certain whether that was due to individual preferences of richer people, or the institutional characteristics of richer societies. Absolute household income would be an important omitted variable that is correlated with GDP per capita.

We deal with this concern in three ways. First, we include in the regressions demographic characteristics associated with human capital: age, sex, education, and city size. To the extent that these capture absolute household income, the omitted variable bias is mitigated. (We must interpret carefully those ancillary coefficients, as they reflect both the direct effect of the demographics on MWTP, and the indirect effect via income.) Second, we interact the 10 income categories with the per-capita GDP of the respondents' country. This means that the regressions include relative income (the income categories), per-capita GDP (embodied in the fixed effects), and the interaction between the two, which we interpret as absolute household income.

As a third means of controlling for absolute household income, we use the coding of the original income category questions, and assume that everybody in each income category earns the midpoint of the relevant range. For example, respondents in the United States in category 5 ($30,000 to $39,999) would be assigned a household income of $35,000. Unfortunately only 9 countries in the data had complete enough documentation available to assign absolute household incomes in comparable international dollars (compared with 33 countries with complete answers to the other demographic questions).

Table 2 presents linear probability models for four of the environmental questions in the WVS. The table reports the coefficients on age, a female dummy, and income, education and city size dummies. Not reported are coefficients on the interactions between per-capita GDP and the income dummies, and a set of country fixed effects. In column (1) the dependent variable is a 1 if the respondent answered "agree" or "strongly agree" to the question about willingness to pay higher prices, and zero otherwise. Older respondents are significantly less likely to support protecting the environment. All else equal, a person 10 years older will be 1.7 percent less likely to agree to pay higher prices to protect the environment. Female respondents are about 2.5 percent more likely to support the environment. Support for the environment is generally greater for the higher income respondents, though the trend in the income category coefficients is not uniformly positive. The negative coefficients imply that those in the top income category are more likely to agree to higher prices than those in the other income categories. And, support for the environment is consistently increasing with education, with respondents with a formal education more likely to support protecting the environment than those with no education. The coefficients on per-capita GDP interacted with household income categories (not reported) are small, mostly statistically insignificant, and do not seem to follow any particular pattern.[11]

Figure 5 plots some country characteristics and regression coefficients against per-capita GDP. Panel A of figure 5 plots the average percent willing to pay higher prices to protect the environment, by country. Low-income countries display no particular pattern, while among mid to high-income countries there may be a downward trend in the percent supporting the environment. Panel B of figure 5 plots the fixed-effects coefficients from the first regression in Table 2. After controlling for age, sex, household income, education, and city size, the same pattern persists: low income countries display no pattern with respect to GDP, while willingness to pay appears to decline for high-income countries. This decline in MWTP for high-income countries is not inconsistent with any of the theoretical models, and is consistent with the "institutional constraints" story.

One reason MWTP may decline is that this first question asks about a 20 percent increase in prices, obviously a relatively larger cost to high-spending households. If we

[11]We have also estimated the models in table 2 without the interactive terms, with no significant effects on the other coefficients or on the pattern of country fixed-effects coefficients.

have not successfully accounted for income with our demographic covariates and with the interactions between relative income categories and GDP, then the country fixed effects reflect in part the incomes of the respondents. Higher-income countries may exhibit lower MWTP because respondents are being asked to bear larger costs.

To account for this concern, we have explored the other environmental questions in the WVS. Column 2 of table 2 asks whether people agree that "protecting the environment should be given priority, even if it causes slower economic growth." The dependent variable is one if the environment is the priority and zero if economic growth is the priority. The pattern of coefficients parallels those in column 1. Younger people, women, richer people, and more educated people are more likely to agree that the environment should be a priority above growth. Panel C of figure 5 plots the average responses to this question against per-capita GDP. Here there is no apparent downward trend among mid to high-income countries. Panel D plots the country fixed effects, from column 2 of table 2, again with no apparent downward trend. This is open to (at least) two interpretations. It may be that the downward trend in MWTP in response to the price question is a spurious result of the fact that a price increase will cost higher-spending households more. Or, it may be that the question about the environment being a priority is not interpreted by respondents as anything like a *marginal* willingness to pay.

For comparison, consider the last two questions we explore: "have you chosen household products you think are better for the environment?" and "have you contributed to an environmental organization?" We believe that these last two questions reflect *total* rather than *marginal* willingness to pay. They do not ask about willingness to pay extra for an incremental improvement in environmental quality, but about whether the respondent already contributes in some way towards existing environmental quality. Furthermore, both poor households and rich households can purchase green products and contribute to green organizations at any level and still respond "yes" to this question. There is no sense in which this costs rich households more. In fact, if households buy products and contribute in proportion to their incomes, then poor households are paying *less* for the positive response to this question than are rich households. Panels E and G of figure 5 plot the raw responses to these questions, and panels F and H plot the country fixed-effects coefficients. All exhibit an upward trend in the proportion saying "yes". This is consistent with the questions being interpreted as *total* willingness to pay, giving us confidence in the survey results, but suggesting that these last two questions are inappropriate for examining the theoretical patterns of *marginal* willingness to pay described in section 2.

As one final means of addressing our concern that we may not have controlled for household income appropriately, and that the country fixed effects may be picking up individual income differences, we estimated these models using estimates of actual annual household incomes, rather than relative income categories. For the 9 countries where the survey documentation listed the complete income ranges, we assigned each respondent the midpoint of the appropriate range, after converting the income ranges to US dollars using purchasing power parity.[12]

Table 3 presents the results of linear probability models using these estimates of household income. The first column contains the results for answers to the question about willingness to pay higher prices to protect the environment. As in table 2, each 10 years of age subtracts about 2 percent from the probability that a respondent agrees. Women are about 3 percent more likely to support the environment. Each $10000 of household income adds about 1.7 percent to the probability that a respondent expresses willingness to pay higher prices. And, more educated respondents are generally more willing to pay higher prices than are respondents with less formal education. Figure 6 plots the country fixed effects from the regressions in table 3. These follow roughly the same pattern as when income categories are included, though of course there are many fewer countries.

Columns 2 through 4 of table 3 present the results for the other three environment questions, again using actual household incomes rather than relative categories. Again the results are similar. Figure 6 plots the country fixed-effects coefficients. It is hard to discern any pattern in the fraction of respondents listing the environment as a priority over growth in panel B, and the fraction of respondents choosing environmental products and contributing to environmental organizations increases with per-capita GDP in panels C and D.

While MWTP does not appear either to increase or decrease with per-capita GDP among the low-income countries, the country fixed effects do explain much of the variation in MWTP, and the estimated coefficients for the individual countries are generally statistically significant. This suggests that there may be country characteristics other than per-capita GDP that affect the MWTP of respondents. In some cases there appear to be similarities among the MWTP of respondents in the same region. Among the Latin American countries, Venezuela, Brazil, Uruguay and Mexico have similar estimated coefficients when examining the willingness to pay higher prices (although Chile, Peru, and the Dominican Republic are not very similar). However, there do not seem to be general patterns distinguishing the MWTP of low-income countries of one region from another.

The estimation technique presented here places no structure on the pattern of willingness to pay across countries. We have merely estimated linear probability models of the probability that people say "yes" in response to a question about the environment, and then plotted the coefficients on a set of country fixed effects. In addition to these results, we have also estimated linear probability models in the spline of per-capita GDP, probit models and splines, and linear probabilities and probits of quadratic functions of per-capita GDP. In those cases, we have included country characteristics including Gini coefficients, air pollution readings, and dummy variables for former Soviet bloc countries

[12] The midpoint is not available for the top income category, so the minimum income for that category is assigned instead. Actual household income, rather than income categories, is available and utilized for Macedonia.

(transitional economies) and other low-income developing countries.[13] We have also estimated these models with and without the sampling weights provided in the WVS. For none of the specifications, however, does a consistent pattern emerge for the low-income countries. Looking at the data in figure 5, it is easy to see why.

4. Conclusions

The various theories described in section 2 all aim to explain the observation that some pollutants worsen and then improve as countries' economies grow. Each theory has a different implication for the patterns of people's marginal willingness to pay (MWTP) for improvements in environmental quality. Stokey's technological constraint explanation predicts that MWTP will increase with per-capita GDP for countries with incomes below the level where their environments begin to improve. Jones and Manuelli's institutional constraint story predicts that MWTP will increase and then decrease with per-capita GDP, with a peak at the point where countries' environments begin improving. And theories based on individual preferences, as well as the returns-to-scale explanation of Andreoni and Levinson, have no prediction about how MWTP will change as per-capita GDP increases.

Using data from the WVS we do not find strong evidence that people's MWTP increases with per-capita GDP among low-income countries. This may be because the technological and institutional constraint stories do not explain the inverse-U-shaped pollution-income path. Or, it may be because we have a poor measure of MWTP, from a deficient contingent valuation question, because we have poor controls for households' incomes, or because respondents are thinking about some environmental problem that does not follow an inverse-U or different environmental problems in different countries.

Finally, although we have not been able to discern a pattern in the relationship between MWTP for environmental improvements and national income, that is not to say that country-specific institutional explanations are not important. To the contrary, even though we have included ample demographic characteristics of respondents, the country fixed effects explain a large fraction of the variation in the responses. This suggests that country characteristics matter, though perhaps not in the stylized way suggested by the models in section 2.

[13]We do not include air pollution as a separate control variable in the estimation results presented in this paper primarily because we include country fixed effects. In addition, the theoretical models predict the relationship of MWTP to income, without assuming that pollution is held constant.

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Table 1. Descriptive statistics from the World Values Survey

Variable	Willing to pay higher prices to protect the environment? Yes	No
Environment a priority over growth.[a]	0.64	0.46 *
Choose environmental products.[a]	0.50	0.41 *
Contribute to environmental organization.[a]	0.17	0.11 *
Per capita GDP using purchasing power parity exchange rates ($1000)	8.60 (8.11)	8.65 (8.45)
Age	39.79 (15.36)	42.51 * (16.22)
Female	0.52	0.50 *
Income category 1	0.119	0.113 †
Income category 2	0.127	0.145 *
Income category 3	0.136	0.143 †
Income category 4	0.124	0.129
Income category 5	0.124	0.120
Income category 6	0.091	0.089
Income category 7	0.086	0.084
Income category 8	0.075	0.073
Income category 9	0.062	0.058
Income category 10	0.057	0.045 *
Education: none	0.026	0.036 *
Education: some primary	0.054	0.064 *
Education: complete primary	0.120	0.132 *
Education: some secondary	0.145	0.149
Education: complete secondary	0.394	0.404 †
Education: some university	0.079	0.068 *
Education: university degree	0.181	0.148 *
City size: < 2000	0.109	0.140 *
City size: 2-5000	0.130	0.135
City size: 5-10000	0.073	0.083 *
City size: 10-20000	0.076	0.072
City size: 20-50000	0.113	0.115
City size: 50-100000	0.087	0.075 *
City size: 100-500000	0.177	0.163 *
City size: > 500000	0.234	0.217 *
Observations	17435	18940

Sample standard deviations for continuous variables in parentheses. * Differences statistically significant at 5 percent. † Differences statistically significant at 10 percent.
[a] These environmental questions had slightly fewer responses: 30809, 30401, and 34338, respectively.

Table 2. Linear probability models of yes/no responses to WVS questions.
Uses household income categories, and interactions with GDP per capita.

	WTP higher prices	Environment a priority over growth	Choose environmental products	Contribute to environmental organization
	(1)	(2)	(3)	(4)
Age	-0.0017*	-0.0011*	-0.00012	-0.000014
	(0.0002)	(0.0002)	(0.00018)	(0.00012)
Female	0.025*	0.018*	0.053*	-0.005
	(0.005)	(0.006)	(0.005)	(0.004)
Income category 1	-0.046*	-0.070*	-0.110*	-0.054*
	(0.022)	(0.024)	(0.023)	(0.015)
Income category 2	-0.113*	-0.083*	-0.110*	-0.048*
	(0.022)	(0.023)	(0.022)	(0.015)
Income category 3	-0.077*	-0.086*	-0.105*	-0.057*
	(0.021)	(0.023)	(0.021)	(0.014)
Income category 4	-0.073*	-0.055*	-0.109*	-0.039*
	(0.021)	(0.023)	(0.021)	(0.015)
Income category 5	-0.045*	-0.057*	-0.097*	-0.054*
	(0.021)	(0.023)	(0.021)	(0.014)
Income category 6	-0.033	-0.073*	-0.081*	-0.039*
	(0.022)	(0.024)	(0.022)	(0.015)
Income category 7	-0.052*	-0.079*	-0.074*	-0.058*
	(0.022)	(0.024)	(0.022)	(0.015)
Income category 8	-0.061*	-0.050*	-0.067*	-0.054*
	(0.022)	(0.024)	(0.022)	(0.015)
Income category 9	-0.015	-0.026	-0.055*	-0.046*
	(0.024)	(0.026)	(0.023)	(0.016)
Education: some primary	0.031†	-0.015	0.036*	0.028*
	(0.018)	(0.020)	(0.018)	(0.013)
Education: complete primary	0.068*	0.015	0.078*	0.020†
	(0.017)	(0.019)	(0.016)	(0.012)
Education: some secondary	0.086*	0.015	0.112*	0.027*
	(0.017)	(0.019)	(0.017)	(0.012)
Education: complete secondary	0.103*	0.049*	0.135*	0.037*
	(0.017)	(0.019)	(0.016)	(0.012)

(continued)

(Table 2, continued)

Education: some university	0.120* (0.019)	0.087* (0.021)	0.161* (0.018)	0.058* (0.013)
Education: university degree	0.155* (0.017)	0.090* (0.020)	0.188* (0.017)	0.070* (0.012)
City size: 2-5000	0.021† (0.011)	-0.0059 (0.012)	-0.0053 (0.011)	-0.003 (0.007)
City size: 5-10000	-0.010 (0.012)	-0.022† (0.013)	-0.0005 (0.012)	-0.002 (0.009)
City size: 10-20000	0.042* (0.012)	-0.0045 (0.013)	0.030* (0.012)	0.002 (0.008)
City size: 20-50000	0.016 (0.011)	-0.016 (0.012)	0.022† (0.011)	0.012 (0.008)
City size: 50-100000	0.053* (0.012)	0.0038 (0.013)	0.005 (0.012)	-0.003 (0.008)
City size: 100-500000	0.035* (0.010)	0.0134 (0.011)	0.024* (0.011)	0.015* (0.007)
City size: > 500000	0.021* (0.010)	-0.017 (0.011)	0.009 (0.010)	0.005 (0.007)
N	36375	30809	30401	34338
Countries	33	33	29	32
Share of variance explained by country fixed effects.	0.72	0.78	0.44	0.70

Notes:
* Statistically significant at 5 percent.
† Statistically significant at 10 percent.
Each regression includes country fixed effects and a set of interaction terms between GDP per capita and the 10 household income categories.

Table 3. Linear probability models of responses to WVS environment questions. Uses actual household incomes.

	WTP higher prices	Environment a priority over growth	Choose environmental products	Contribute
	(1)	(2)	(3)	(4)
Age	-0.0022*	-0.0009*	-0.0006*	-0.0001
	(0.0003)	(0.0004)	(0.0003)	(0.0002)
Female	0.030*	0.034*	0.052*	-0.021*
	(0.010)	(0.011)	(0.010)	(0.006)
Annual household income ($1000, ppp)	0.0017*	0.0008*	0.0012*	0.0010*
	(0.0003)	(0.0003)	(0.0003)	(0.0002)
Education: some primary	0.036	0.054	0.216*	0.013
	(0.030)	(0.035)	(0.029)	(0.019)
Education: complete primary	0.073*	0.140*	0.275*	-0.004
	(0.031)	(0.036)	(0.030)	(0.020)
Education: some secondary	0.096*	0.140*	0.304*	0.017
	(0.035)	(0.040)	(0.034)	(0.023)
Education: complete secondary	0.109*	0.191*	0.312*	0.007
	(0.033)	(0.038)	(0.032)	(0.022)
Education: some university	0.084*	0.199*	0.334*	-0.007
	(0.038)	(0.043)	(0.036)	(0.024)
Education: university degree	0.139*	0.204*	0.363*	0.036
	(0.035)	(0.040)	(0.034)	(0.023)
N	9737	8158	8392	8692
Countries	9	9	8	8
Share of variance explained by country fixed effects.	0.69	0.64	0.62	0.46

Notes:
* Statistically significant at 5 percent.
† Statistically significant at 10 percent.
Each regression includes country fixed effects and a set of city size dummies, as in table 2.

Figure 1. Individual preferences explanation

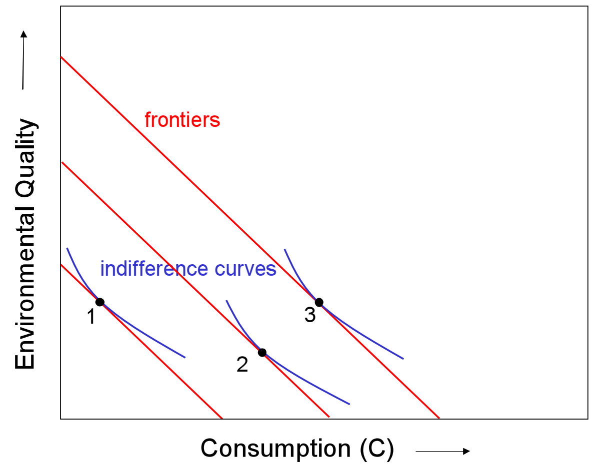


Figure 2. Dirtiest technology explanation

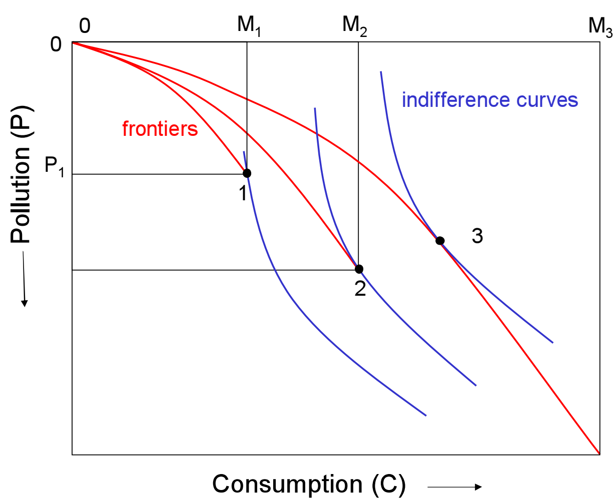


Figure 3. Institutional cost explanation

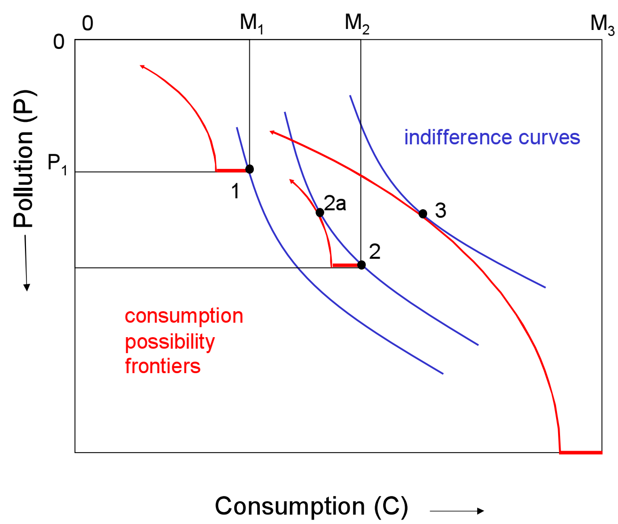


Figure 4. Returns to scale explanation

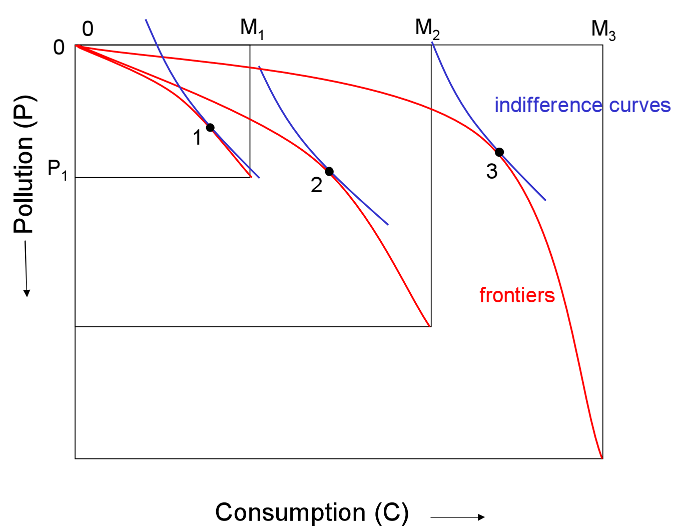


Figure 5. Country coefficients from Table 2.

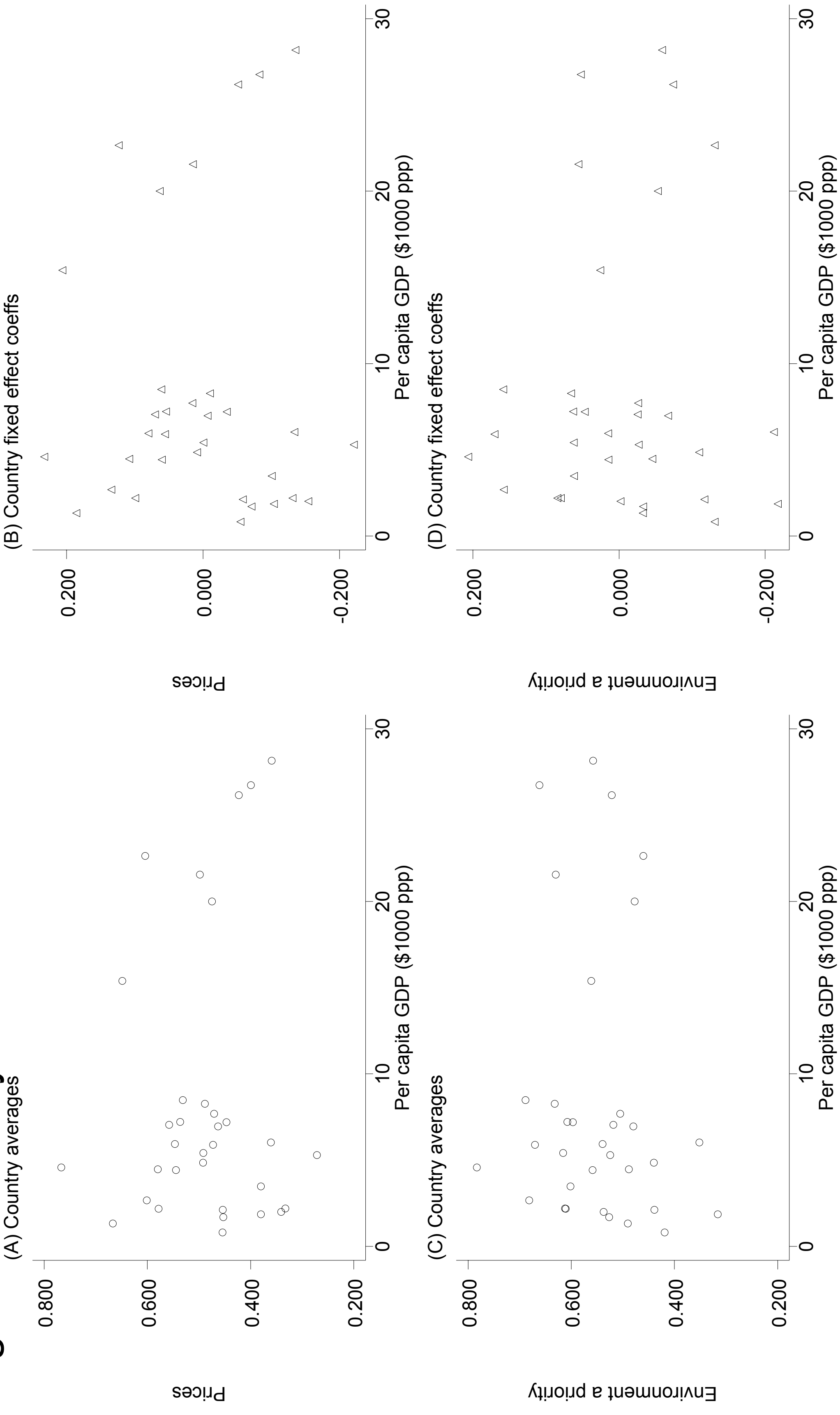


Figure 5 continued.

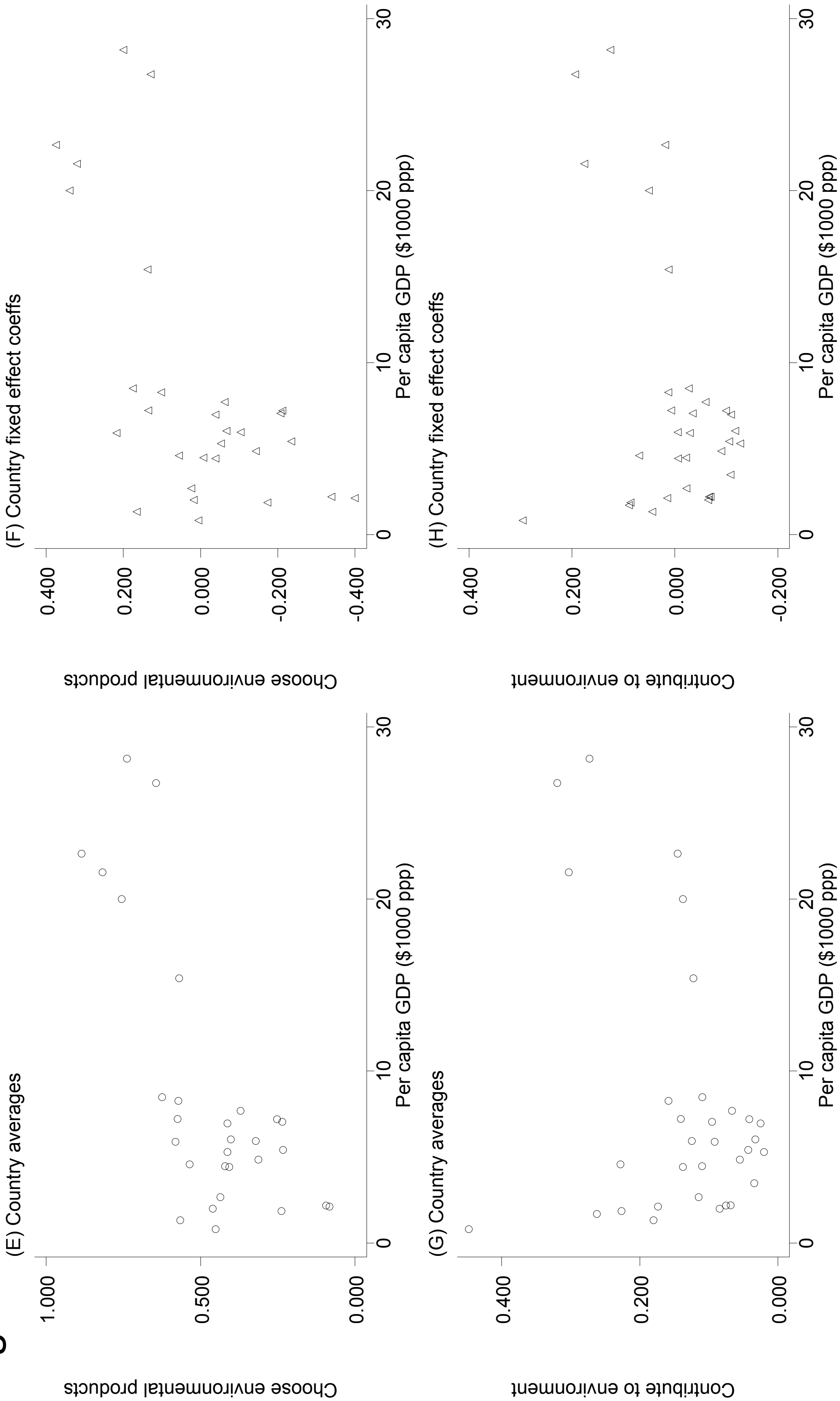
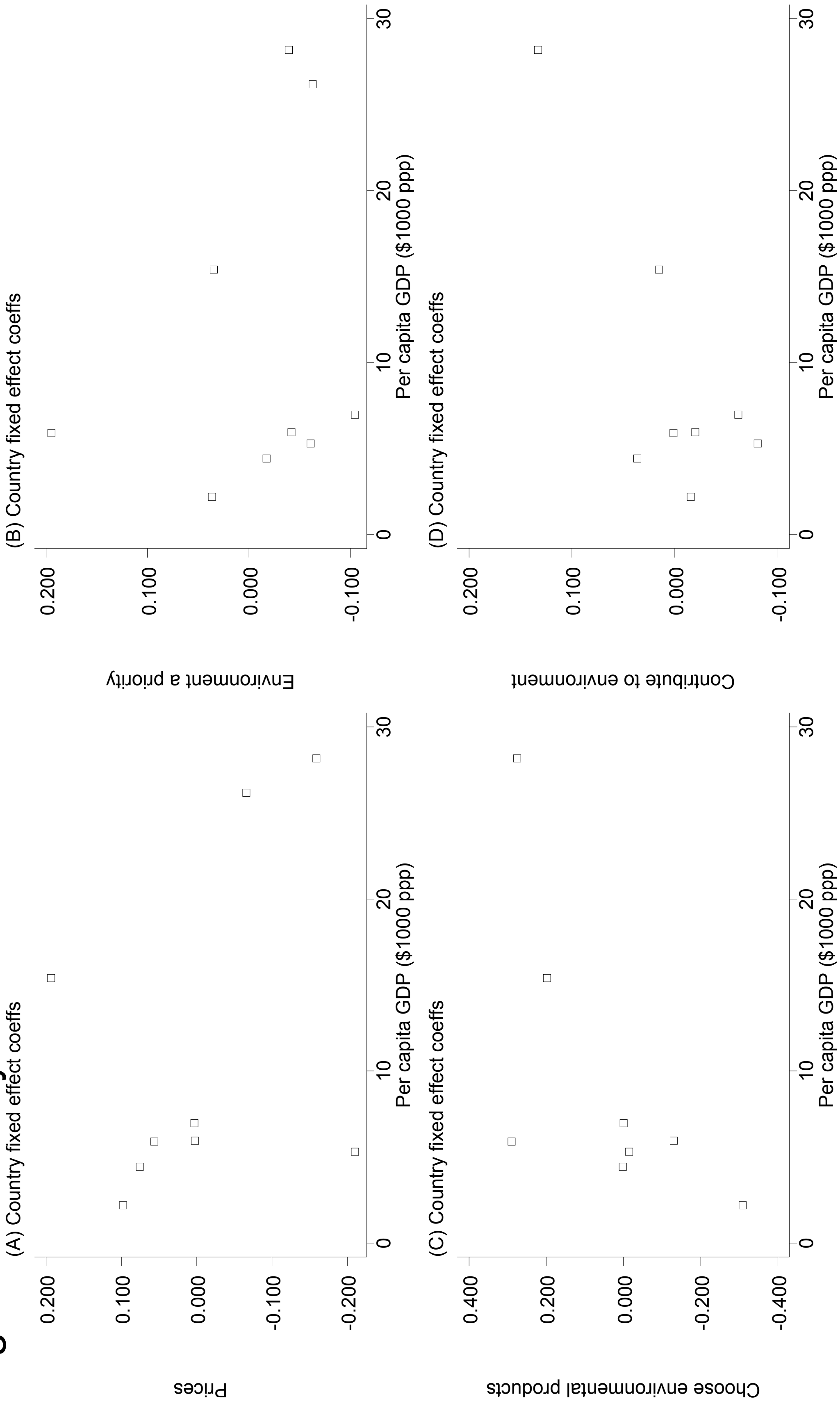


Figure 6. Country coefficients from Table 3.



Appendix: Some sample questions from the 3rd Wave of the World Values Survey

1) The key income question:

V227. Here is a scale of incomes. We would like to know in what group your household is, counting all wages, salaries, pensions and other incomes that come in.

2) Environment questions:

V39 I would buy things at 20% higher than usual prices if it would help protect the environment.

a. agree strongly,
b. agree,
c. disagree or
d. disagree strongly?

V41 Here are two statements people sometimes make when discussing the environment and economic growth. Which of them comes closer to your own point of view?

1. Protecting the environment should be given priority, even if it causes slower economic growth and some loss of jobs.

2. Economic growth and creating jobs should be the top priority, even if the environment suffers to some extent.

3. Other answer (volunteered).

Which, if any, of these things have you done in the last 12 months, out of concern for the environment?

V42 Have you chosen household products that you think are better for the environment?

V45 Have you attended a meeting or signed a letter or petition aimed at protecting the environment?

V46 Have you contributed to an environmental organization?

Appendix Table 1. Country averages from the World Values Survey.

Countries ranked by per capita GDP	Willing to pay higher prices to protect environment[1]	Per capita GDP (US$ for survey year)[2]	Number of observations
Nigeria	0.454	0.82	1604
Bangladesh	0.667	1.34	1173
Ghana	0.452	1.71	42
India	0.379	1.87	1260
Azerbaijan	0.340	2.02	1561
Armenia	0.453	2.12	1621
Georgia*	0.578	2.20	2073
Moldova	0.332	2.20	900
China	0.600	2.68	1274
Ukraine	0.379	3.49	1687
Macedonia*	0.544	4.43	588
Peru	0.579	4.48	321
Dominic Rep	0.767	4.59	317
Bulgaria	0.492	4.86	653
Latvia*	0.271	5.30	1034
Belarus	0.491	5.42	1704
Croatia*	0.472	5.91	1084
Venezuela*	0.546	5.95	1069
Lithuania	0.360	6.03	753
Estonia*	0.463	6.98	947
Brazil	0.557	7.06	1084
Russia	0.446	7.21	1690
Mexico	0.536	7.22	1022
Poland	0.470	7.71	976
Chile	0.488	8.28	897
Uruguay	0.531	8.49	880
Spain*	0.648	15.41	815
Finland	0.474	20.01	837
Australia	0.498	21.56	1712
Germany	0.604	22.65	1636
Switzerland*	0.422	26.18	909
Norway	0.399	26.76	1033
USA*	0.358	28.17	1219

1 Source: Authors’ calculations from World Values Survey, Wave 3.
2 Source: World Bank (2002), adjusted using purchasing power parity.
* Documentation available for household income brackets, used in table 3 and figure 5.