Subjective Well-Being Approach to Environmental Valuation: Evidence for Greenhouse Gas Emissions

Beja Jr., Edsel L.

Ateneo de Manila University

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EDSEL L. BEJA, JR.

Ateneo de Manila University, Philippines; Email: edsel.beja@gmail.com

Abstract

The subjective well-being approach to environmental valuation is applied to analyze the valuation of greenhouse gas emissions. Dimensions like population and income are then incorporated into the valuation to get the fairness-adjusted marginal value of emissions. The results indicate that the industrialized countries have high willingness-to-pay to reduce emissions with the United States and Japan reporting the largest figures. Developing countries differ in their valuations, albeit they are not subject to the mandatory reductions of emissions, but still the results indicate that poor countries like China and India indicate willingness to pay whereas Brazil and Mexico indicate willingness to accept payments to reduce emissions. The high willingness-to-pay indicated by the industrialized countries does not imply that they can pay off the developing countries to continue emitting as usual. However, the different modes of willingness-to-pay and willingness-to-accept of countries indicate possibilities toward the formation of an inter-group payments and transfers system to allow societies to contribute toward global reduction emissions reduction. Part of the payments from the industrial countries could be used to support global programs to change the patterns of production and consumption and accelerate the development of cleaner technologies.

Keywords: Subjective well-being, greenhouse gas emissions, environmental valuation

JEL Codes: D60; Q51

1. INTRODUCTION

In its fourth assessment report published in 2007, the *Intergovernmental Panel on Climate Change* (IPCC) said that indicators are unquestionably pointing that man-made climate change is taking place today. Evidence is strong that the cause of man-made climate change is the accumulation of greenhouse gases originating from the ever-expanding human activities that require increasing amounts of fossil fuel burning, greater deforestation and land conversion for agriculture, and so on. Policy action is urgent. The required effort is to reduce total emissions by 80 percent of their 1990 levels by 2050. If the task is not taken very soon and if the mitigation and adaptation measures are limited, the changes in sea levels, wind and rain patterns, and so on, would mean severe adverse impacts on the well-being of humans and ecosystems. The IPCC Synthesis Report noted that the "[c]hoices about the scale and timing of [greenhouse gases] mitigation involve balancing the economic costs of more rapid emission reductions now against the corresponding medium-term and long-term climate risks of delay" (IPCC 2007: 67).

Understanding what and how policies can influence behavior is a crucial step towards addressing the problem at hand. In the political economy of man-made climate change, the preferred option is to put monetary values on greenhouse gases in order that prices can reconfigure the incentive structures and, in turn, see changes in human behavior in favor of emissions reduction.

Environmental valuation is now a considerably advanced field. Johansson (1987) and Freeman (1993) are two important references in the area. However, there are questions on what meaning to attach to the imputed values especially when ordinary people are actually powerless to change the situation due to the dominance of corporate power, political expediency, and class interests. On a practical level, the primary obstacle with environmental method is its reliance on some surrogate or pseudo market setup and a hypothetical good for trade.

An emerging alternative technique is the subjective well-being (SWB) approach to environmental valuation. It uses the correlation between SWB and an external variable (in this case, greenhouse gases) and that between SWB and income to obtain the marginal rate of substitution between the external variable and income, which is taken as a monetary valuation of the external variable. In so doing, this procedure circumvents the need to use a surrogate or pseudo market or even a hypothetical good in the valuation exercise. But, more importantly, what it obtains is a monetary valuation that is not only associated with outcomes that the person cares about also a result that could help make policy making less complicated for all concerned.

Earlier studies using the SWB approach find that the value of improving air quality is $750 per capita for nitrogen dioxide and $1,400 per capita for lead (Welsch 2007), between $250 and $440 per capita for sulfur dioxide (Luechinger 2009), and $895 per capita for particulate matter (Levinson 2009). The SWP approach has also been applied to other environment-related issues like airport noise (van Praag and Baarsma 2005), climate (Frijters and van Praag 1998), drought (Carroll *et al.* 2009), flooding (Luechinger and Raschky 2009), and temperature (Ferreira and Moro 2010). The literature has recently been surveyed by Welsch and Kühling (2009) and Frey et al. (2010). Di Tella and MacCulloch (2006), Kahneman and Krueger (2006), and Frey and Stutzer (2010) survey the SWB researches in economics.

Here, the SWB approach is applied to the valuation of greenhouse gas emissions. The paper also incorporates self-reported attitudes toward "local air quality" and "global greenhouse effects" to proxy for: (i) unobserved personal characteristics that may influence environmental preferences (c.f., Ferrer-i-Carbonell and Gowdy 2007), (ii) belief systems toward man-made climate change that may influence the reported self-assessments of well-being (c.f., Alesina *et al.* 2004), and (iii) focusing illusion effects that may occur when people are asked to direct attention to a situation or scenario such as "local air quality" and "global greenhouse effects" (c.f., Schkade and Kahneman

1998). In addition, the paper improves the valuation exercise by incorporating weights like shares of emissions, populations, and incomes. Part 2 presents the conceptual framework then the empirical strategy. Part 3 contains the results, including the implications of the findings. The last part concludes the discussion.

2. SWB APPROACH TO ENVIRONMENTAL VALUATION

2.1. Conceptual Framework

Subjective well-being (SWB) refers to reported self-assessment of well-being. Such assessment is considered equivalent to the person-experienced utility (Kahneman and Sugden 2005). In fact, it approximates the true utility of the person (Di Tella and MacCulloch 2006). Moreover, SWB encompasses an affective component and an evaluative component. The former covers the positive and negative feelings of the person. Studies find that affect is measurable (Watson *et al.* 1988), and the ratio of positive to negative affect is deemed as a measure of overall hedonic well-being (Larsen and Prizmic 2008). The information collected in large-scale surveys like the World Values Survey is happiness. The evaluative component is a self-appraisal of the life of a person. It considers achievements relative to aspirations across relevant life domains. Like affect, studies suggest that life satisfaction is measurable (Cantril 1965; Diener *et al.* 1985).[1] The information collected in large-scale surveys like the World Values Survey is life satisfaction.

The aforementioned components are known to be separable from each other, yet each one is at least moderately correlated to the other (Diener 1984; Lucas *et al.* 1996; Diener and Emmons

[1] Happiness and life satisfaction are the common measures used in SWB studies. Andrews and Robinson (1991) discuss various measures of well-being.

1984). There is high validation of self-reports as supported by studies showing that happy people smile more (Ekman *et al.* 1990; Pavot *et al.* 1991), are rated happy by spouses, relatives, and friends (Costa and McRae 1988; Sandvik *et al.* 1993), and succeed more in many life domains (Lyubomirsky *et al.* 2005). So what is measured is actually being measured with considerable success. Recent studies also find that the measures of positive affect, negative affect, and life satisfaction correlate differently with variables such as income (Diener *et al.* 2010; Kahneman and Deaton 2010; Helliwell *et al.* 2010). Thus the findings tell us that one component of SWB may be more appropriate in some cases and another component in others. In any case, the SWB components have enough reliability using, say, test-retest approach, albeit the self-reports can change in time or in response to new conditions (Larsen and Frederickson 1999; Kahneman and Krueger 2006).

The true SWB (SWB*), however, remains latent because it remains internal to the person. As such, a SWB function is regarded as a positive monotonic transformation of SWB*; or formally, $SWB = h[U(\cdot)]$, where $U(\cdot)$ *is* SWB* and SWB is the self-report of well-being. Personality traits (Costa and McCrae 1980) and genes (Lykken 1999) can affect well-being, while the environment and new conditions can transform the nature of experience (Diener and Suh 1999; Inglehart and Klingemann 2000; Diener and Seligman 2004). But Helliwell (2006) finds that personality differences have little effect on demographics and socio-economic indicators as well as on macroeconomic indicators, implying that there is room for public policy.

The SWB function for environmental valuation can thus be expressed as $SWB = h(Z, Y, \boldsymbol{X})$, where Z is the environmental object of interest, Y is income, and $\boldsymbol{X}$ is a vector of relevant explanatory variables. Total differentiation obtains $dSWB = h_Y\, dY + h_Z\, dZ + h_{Xi}\, d\boldsymbol{X}$. Setting $dSWB$ and $d\boldsymbol{X}$ to zero and then rearranging terms obtains the marginal value (MV) of Z, which is the marginal rate of substitution between Z and Y. Or, algebraically, $MV = -\frac{dY}{dZ} = \frac{h_Z}{h_Y}$. With regards to income, $h_Y > 0$. So if Z is an environmental good, $h_Z > 0$; if it is an environmental bad, $h_Z < 0$. The signs of h_{Xi} depend on the indicators in $\boldsymbol{X}$.

The marginal value is a "pure" monetary valuation of the environmental object of interest. Other dimensions can be incorporated to get a more appropriate metric, which is here called "fairness-adjusted marginal value" (FMV), and calculated as follows: $FMV = \frac{h_Z}{h_Y} \Pi \theta_i$, where $\theta_i = \frac{D_i}{\Sigma D_i}$, D is a domain i, Π is the product operator, and i = 1…n. The domain needs to be measurable so it can be included in the analysis. As such, $FMV > 0$ is the fairness-adjusted willingness-to-accept for reduce environmental goods; $FMV < 0$ is the fairness-adjusted willingness-to-pay for reduced environmental bads.

2.2. Method and Data

The structural model for greenhouse gases can be specified as follows: $SWB^*(Z, Y, \boldsymbol{X}) = \alpha + \beta_i \cdot z_i + \gamma \cdot y + \delta \cdot \boldsymbol{X} + \lambda A + \varepsilon$ and $SWB = k \leftrightarrow u_k \leq SWB^* \leq u_{k+1}$, where z is the logarithm of emissions, y is the logarithm of income, X are the relevant demographic and socio-economic profile, A are the attitudinal indicators with respect to the environment, ε is the residual term, and k are discrete rank categories relevant to SWB. Further details about the indicators are discussed in turn.

Subjective Well-Being: The measure of subjective well-being is life satisfaction, which is obtained as the response to the question: *All things considered, how satisfied are you with your life as a whole these days?* The person responds by locating herself on a 10-point scale wherein 1 means "completely dissatisfied" and 10 means "completely satisfied." In the specification above, k is from 1 to 10. Life satisfaction data are from the World Values Survey 2005.

Environment: The emissions covered in this paper are the greenhouse gases covered by the Kyoto protocol, namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydroflourocarbons (HFC), and perflourocarbons (PFC). Studies suggest that CO_2, CH_4, N_2O comprise more than 70% of man-made climate change (e.g., Spash 2002).[2] Data for sulfur hexafluoride (SF_6), hydroflourocarbons (HFC), and perflourocarbons (PFC) are reported as "other greenhouse gases." Moreover, emissions data are reported as CO_2 equivalent emissions. It should be stressed that the unit of CO_2 equivalent emissions merely facilitates the aggregation of the calculated marginal values. While the different properties and impacts of greenhouse gases and the different characteristics of sources are very important, they are not covered in the paper because data are not available. Similarly, adaptation costs to man-made climate change, etc., are also not included in the analysis. Five-year average of million tons CO_2 equivalent emissions is the used in the regressions. Emissions data are available from the World Development Indicators.

Income: The World Values Survey does not report individual income, but gross domestic product (GDP) per capita is used as a suitable proxy. The five year average of GDP per capita is the unit used in the regression. Data are from the World Development Indicators.

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[2] The Earth's atmosphere is principally comprised of nitrogen (78%) and oxygen (21%). Argon (0.9%) is the third largest volume of gas in the atmosphere. The remainder of about 0.1 percent is a mixture of carbon dioxide, methane, nitrous oxide, chlorofluorocarbons, ozone, etc., listed in sequence of proportional shares. The volume of water favor, which contributes about two-thirds of global greenhouse effect, varies in terms of altitude. There is very little water favor in the stratosphere but plenty near the Earth's surface. Naturally occurring water vapor and carbon dioxide create greenhouse effect that sustains life on Earth. The problem is that the increased volumes of with greenhouse gases especially carbon dioxide have, as a consequence, intensified the greenhouse effect, which then leads to climate change.

Demographics and socio-economic profile: The indicators included in the regression are: (a) age of the person in years; (b) gender of the person with male = 1 and zero otherwise; (c) marital status of the person with ex-married (that is, divorced or separated) = 1 and zero otherwise; widowhood = 1 and zero otherwise; and single = 1 and zero otherwise; (d) highest educational attainment of the person with tertiary education = 1 and zero otherwise; secondary education = 1 and zero otherwise; and primary education = 1 and zero otherwise; (e) job status of the person with unemployed = 1 and zero otherwise; and (f) income class of the person with upper income (that is, deciles 10 to 8) = 1 and zero otherwise; middle income (that is, deciles 7 to 4) = 1 and zero otherwise, and low income (that is, deciles 3 to 1) = 1 and zero otherwise. Demographic and socio-economic data are taken from the World Values Survey 2005.

Environmental attitude: Two attitudinal questions are included in the regression. The first item is attitude towards local level air quality in response to the question: "I am going to read out a list of environmental problems facing many communities. Please, tell me how serious you consider each one to be *here in your own community* (emphasis mine): poor air quality?" The person responds using a 4-point scale with 1 for "very serious," 2 for "somewhat serious," 3 for "not very serious," and 4 for "not serious at all." The second item concerns attitude towards global-level air quality: "Now let's consider environmental problems in the world as a whole. Please, tell me how serious you consider each of the following to be *for the world as a whole* (emphasis mine): global warming or the greenhouse effect?" The person likewise responds using a 4-point scale with 1 for "very serious," 2 for "somewhat serious," 3 for "not very serious," and 4 for "not serious at all." Both "very serious" and "somewhat serious" are recoded as 1, whereas both "not very serious" and "not serious at all" are recoded as 0. In effect, the data are transformed into two yes-no items in the regression. Attitudinal data are available only in the World Values Survey 2005.

Thirty one countries (or G-31) have data for air quality attitudes and greenhouse gas emissions:

Argentina, Australia, Brazil, Burkina Faso, Chile, China, Ethiopia, Finland, Germany, Ghana, India, Indonesia, Italy, Japan, Mali, Mexico Norway, Peru, Poland, Romania, Rwanda, South Korea, Sweden, Switzerland, Thailand, Ukraine, United States, Uruguay, Vietnam, and Zambia. The countries are grouped into four to control for geography and culture-related differences: Europe and United States (10 countries), Asia and Pacific (9 countries), Latin America (6 countries), and Sub-Sahara Africa (6 countries). Regressions are performed for each region.

The ordered probit procedure is performed on cross-section pooled data given that reported well-being is an ordinal ranking. Simply put, people can rank what they consider as the best, second best, and so on, in a similar way regardless of personality traits, genes, and environmental setting, etc. That is, the amount that constitutes the "best", "second best", and so on, for person A need not be exactly the same magnitude for person B yet the sequence of ranking is the same for both persons. Country-dummies are used to control for idiosyncrasies within the country groupings. Person-level fixed effects are not possible with the pooled cross-section data. The residual term becomes a catch-all item. The size of the random error is not expected to distort the correlations or undermine the reliability between the right-hand side indicators and SWB.

The correlation between a right-hand side indicator and the dependent variable indicates the overall direction of relationship. There is, of course, the issue of causality. In terms of the model specification above, causality is not a concern with regards to the "external" indicators, namely: GDP per capita income (c.f., Easterlin 1974) and greenhouse gas emissions. There is perhaps a concern with the environmental attitudinal indicators. Do people who are more worried about the environment report lower well-being; or, are people with low well-being more worried about the environment?[3] Once again, the pooled cross-sectional dataset (with the data being "unique" to the

[3] Or, the results on environmental attitudes could reflect the effects of omitted variables. But Ferrer-i-

World Values Survey 2005) does not allow correction for possible endogeneity of environmental attitudes.

3. FINDINGS

3.1. Descriptive Analysis

The respective shares of each country to the regional totals and the G-31 totals of greenhouse gas emissions are show in Table 1. The figures show that, in the mid-2000s, at least 50% of the G-31 total emissions came from the United States (29.1%) and China (25.1%). Another eight countries contribute about 30% of G-31 total emissions: India (9.5%), Japan (5.8%), Germany (4.1%), Brazil (4.1%), Mexico (2.4%), Indonesia (2.4%), Italy (2.3%), and Australia (2.3%). Poland (1.6%), Ukraine (1.8%), Argentina (1.3%), and Thailand (1.4%) added another 6% to the G-31 total emissions. Crucial to the success of reducing global emissions is collective action among the identified countries. Because of the magnitude of their emissions and their productive capacities, the United States and China are expected to lead such efforts.[4] Without them at the helm of global initiatives, the breakdown of efforts toward reducing greenhouse gas emissions is easy to foresee.

[Insert Table 1 and 2 Here]

Table 2 juxtaposes information on total emissions, population, and average income. Again, the

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Carbonell and Gowdy (2007) find that introducing omitted variables do not even alter the results.

[4] Other countries with sizeable greenhouse gas emissions but not included in the paper because data on the attitudinal questions are not available in the World Values Survey 2005 include: Iran, Russian Federation, South Africa, Saudi Arabia, and United Kingdom.

respective shares to the regional and G-31 totals are indicated in the table. The table help explain why collective action is such a difficult goal to achieve. On the basis of the magnitude of their emissions, the United States would insist that, if it exerted effort at reducing emissions, China should also exert an equivalent or proportional amount of effort since both are great emitters.[5] Japan can join the United States in this argument given similar income standings. Meanwhile, China can make a counterargument that it should not be pushed to put up as much effort as the United States since it is a poor country. Shifting resources toward reducing emissions could mean reducing economic growth and put China on the path of underdevelopment. The same argument can be made by India and Indonesia.

Another position exploits relative population size dimension to global emissions. Take Australia, a major emitter and relatively well-off but definitely not a highly populated country, as example.[6] Argentina also shares similar characteristics, albeit it is less well-off than Australia. Using data in table 2, the annual per capita emission of Australia is 28 million tones, or five times the annual per capita emissions of China or ten times that of India. Annual per capita emissions could be a misleading indicator because the Australian emissions come to 2.3% of the G-31 total emissions compared to 25% of China. In fact, Italy and South Korea can make the same argument as Australia against China.

Naturally, there are unending arguments and counter-arguments. The determination of a solution

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[5] "Great emitter" means having a share of at least 4% of total CO_2 equivalent emissions; "major emitter," a share of 2% to 3.9% of total CO_2 equivalent emissions; and "large emitter," a share of 1% to 1.9% of total CO_2 equivalent emissions.

[6] "Extremely large population" means having a share of at least 4% of total population; "extra large population," a share of 2% to 3.9% of total population; and "large population," a share of 1% to 1.9% of total population.

is made difficult to reach in the process. Population and income are important dimensions, but countries must transcend these issues to reach a common ground for global collective action.

3.2 Regression Analysis

Details of the regressions are available in the Appendix. The results should be treated with caution given the limitations of the dataset. Suffice to say, though, that regression results on the standard correlates of well-being are consistent with the extant literature. They are discussed in turn.

The age of the person is positively correlated with subjective well-being (SWB), and it exhibits a quadratic relationship with SWB. This finding holds across groupings, although the magnitudes of the coefficients vary from 0.0001 for the Sub-Sahara Africa group to 0.0002 for the Latin America and the Asia and Pacific groups to 0.0004 for the Europe and United States group. So the minimum point for age varies with Asians at 40 years old, African at (an average of) 46 years old, Latinos at 48 years old, and Europeans-Americans at (an average of) 53 years old. Therefore, all things the same, younger Asians report lower well-being than the rest whereas older Asians report higher well-being than the rest.

The well-being of males is on average lower than that of females but not so in both Latin America and Sub-Sahara Africa groups. Perhaps, a Latino factor explains the Latin America findings. The result for Africans is just saying that gender is not a factor to the variations in well-being.

Third, marriage dissolution (i.e., divorce, separation, or widowhood) is negatively correlated with SWB. The pattern holds across the groupings except in Asia and Pacific, where the correlation of SWB with widowhood in weakly statistically significant (if p-value of 0.12 is acceptable), and in Sub-Sahara Africa, where the correlation of both ex-marriage and being single with SWB are not statistically significant (but the former has the expected sign). Perhaps, the support provided by family in the context of Asia and Pacific reduces the impact of bereavement or loss of a partner on well-being. For the Sub-Sahara Africa group, however, the correlation of widowhood with SWB is the only marital status that is statistically significant. Perhaps, this finding reflects the unique character of the region, wherein the death of a spouse or partner is likely to be associated with HIV/AIDS and other diseases (c.f., Deaton *et al.* 2010), ethnic conflicts and civil strife and war. All things the same, widowhood in western societies has the biggest impact on well-being relative to other areas.

Fourth, educational attainment is positively correlated with SWB across all regions except for the Latin American group. Across the regions, completing tertiary level education brings the largest gains in well-being; but, in Latin America, educational attainment is not an appropriate indicator of well-being. Perhaps, the finding is indicative of an educational treadmill for the Latinos (c.f., Graham 2010; Cardenas *et al.* 2009).

Unemployment is negatively correlated with SWB as expected. The same finding holds across the regions except in Sub-Sahara Africa, where the results are inconclusive. It is possible that social comparison is behind the result, especially when public discussions stress that Sub-Sahara Africa has been left behind on the economic development ladder.

Lastly, results for the income classes are consistent with the expectation that the upper income people have, on average, higher well-being than the middle income people; and, in turn, middle income people also have, on average, higher well-being than the low income people. This finding is consistent across the four regions.[7]

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[7] The sum of the absolute values of the coefficients of the upper and of the low income classes may point to

The next set of results is on the attitude questions. The correlation of “local air quality” attitude with SWB is not statistically significant except for the Latin American group, where it is found to be negatively correlated with SWB. Second, the correlation of “global air quality” attitude with SWB is positively and statistically significant, albeit the results for the Latin America group are only weakly significant (if a p-value of 0.12 is acceptable). These findings are counterintuitive to some extent because the conventional view is that attitudes toward local and global air quality should be negatively correlated with well-being if people are concerned about the environment. Do the results suggest that people do not care about greenhouse gas emissions?

Upon closer inspection, the results may indicate some detachment to the environmental issues. Perhaps, the findings confirm the presence of the so-called not-in-my-backyard syndrome. The transboundary nature of emissions implies that there is little direct perception of the effects of greenhouse gases on local air quality or greenhouse effect. That is, well-being is not directly adversely affected by the quality of the global environment because it is something external to the local environment. The findings on “local air quality” for the Latin America group, however, support the conjecture that well-being is adversely affected if people do feel strongly about the quality of their immediate surroundings.

The results on the valuation of greenhouse gases are interesting, especially because they enable us to determine how people actually perceive global emissions. For instance, for the Europe and United States group, all types of greenhouse gas emissions are seen as environmental bads. In the case of the Latin America group, emissions are environmental goods. Mixed results are found for

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income inequality with respect to well-being. For Europe and United States, income inequality is between 0.49 and 0.51; for Asia and Pacific, between 0.32 and 0.35; for Latin America, between 0.65 and 0.68; and for Sub-Sahara Africa, between 0.80 and 0.95.

both Asia and Pacific and Sub-Sahara Africa groups. Carbon dioxide and other greenhouse gases are environmental bads in Asia and Pacific but are environmental goods in Sub-Sahara Africa, whereas nitrous oxide and methane are environmental goods in the former but are environmental bads in the latter.

In western societies, greater preference for cleaner environments come with higher income status and explains why the emissions are environmental bads, a finding that is consistent with standard economic theory if environmental quality is considered a luxury good. In the same fashion, the differences in level and character of economic development explain the mixed results among the developing countries in the four groupings. Where economies are growing fast like those in the Asia and Pacific group, carbon dioxide emissions and other environment-related issues like urban congestion and overexploitation of resources are typical concomitant problems to progress. Such troubles bring costs and perceived as such. Economic progress of the Latin American group pales that of the Asia and Pacific group at least in the timeframe covered in the study, and thus carbon dioxide emissions are acceptable by-products of the catch up process. Not surprisingly, therefore, environmental problems are perceived to be acceptable conditions. Nitrous oxide and methane are environmental goods for the Asia and Pacific group but are environmental bads for the Latin America group. As the standards of living rise, there are also expanded usage of automobiles and other transportation and increased demand for cereals, dairy, and meat products, and so on. Such transformation in consumption patterns explain why nitrous oxide and methane emissions in both groups of countries emerge as environmental goods. Interestingly, nitrous oxide and methane are environmental bads in Sub-Sahara Africa. Perhaps, this finding reflects the adverse changes in the surroundings due to drought and others that have damaged both agriculture and grazing lands. In other words, it is the contraction of industrial activities and agricultural production in Sub-Sahara Africa that explains why the emissions turn out to be environmental bads.

3.3 Fair marginal value of greenhouse gas emissions

The fairness-adjusted marginal value (FMV) of the greenhouse gas emission is calculated next using population, income, and volume of emissions as weights for the adjustments (see Table 2). Incorporating the three domains means $FMV = \frac{\widehat{\beta} Y_i}{\widehat{\gamma} Z_i} \cdot \theta_1 \cdot \theta_2 \cdot \theta_3$, where $\theta_1 = \frac{Y_i}{\Sigma Y_i}$ is the income share of country i to the G-31 total income, $\theta_2 = \frac{POP_i}{\Sigma POP_i}$ is the population (POP) share of country i to G-31 total population, and $\theta_3 = \frac{Z_i}{\Sigma Z_i}$ is the greenhouse gas (Z) share of country i to G-31 total CO_2 equivalent emissions. Recall that $FMV > 0$ is the willingness-to-accept for reduced emissions and $FMV < 0$ is the willingness-to-pay for reduced emissions.

[Insert Tables 3 Here]

Table 3 indicates that the Europe and United States group is willing to pay for reduced emissions. The same can be said for the Asia and Pacific group, at least for carbon dioxide and for other greenhouse gases. Latin America and Sub-Sahara Africa groups are willing to accept payments for reduced emissions.

Moreover, all the industrialized countries in Table 3 indicate large willingness-to-pay for reduced emissions. The figures for the United States ($1,301) are particularly interesting result because they are contrary to the purported opposition for emissions charges. Other great emitters among the industrialized countries likewise indicate large willingness-to-pay for reduced emissions. In fact, the figures for Norway ($51), Switzerland ($49), Sweden ($40), and Finland ($19) are interesting because they appear to be within the range of emission charges in those countries (c.f., Baranzini et al. 2000). The figures for Australia reveal that people are actually willing to pay a reasonable amount of money to reduce emissions.

The variation in the amounts is expected given the differences in circumstances. Poland, Romania, and Ukraine, for example, have relatively low willingness-to-pay to reduce emissions not because there is less concern for man-made climate change but rather because the dissolution of the Soviet Union in 1991 meant that the former Eastern bloc countries are now below the emission target baselines as defined in the Kyoto protocol. Regardless of the differences in attributes, and given that the values in Table 3 are derived from a valuation exercise that utilized reported well-beings, it can be safely asserted that levying emissions charges or introducing emissions payments will not be economically and politically objectionable. Put another way, there seems to be disconnect between the large willingness-to-pay for reduced emissions at the person-level and the reluctance of governments to introduce emission charges. Thus existing policies in Europe can be considered to be heading in the right direction if emissions charges are in line with the willingness-to-pay for reduced emissions. If the charges are actually higher than willingness-to-pay, the differential is indication that there is enough room to fine tune policy so as to bring charges in line with behavior or preferences.

Even if mandatory reduction of emissions is not required from developing countries, the valuation exercise still reveals that there is actually readiness to undertake emission reductions. In fact, the payments to do so are quite reasonable. This finding indicates that there is openness to participate in global efforts to address the cause of man-made climate change. Indeed, even if the amounts for Sub-Sahara Africa are very small, they still do not imply that Africans care the least about emissions reduction or they are not disturbed about man-made climate change compared to other developing countries. The fact that the fairness-adjusted marginal values are still positive despite the valuation being done on very poor countries is enough indication that Africans care about the environment and would still participate in global initiatives to reduce emissions. What is perhaps needed is a system whereby revenues from emissions charges can be recycled in the developing countries to finance emission reductions, technology adoption, social adaptation, and similar initiatives to minimize the disruptions and impacts of man-made climate change.

Even so, the large willingness-to-pay of the industrialized countries does not actually suggest that it is alright to raise a fraction of the amounts, use the revenues to "payoff" the developing countries, and then keep on emitting the usual volume of greenhouse gases. Those with high capacity to pay should lead global efforts by demonstrating their commitment with payments for emissions. More importantly, a mechanism in the industrialized countries that parallels the setup suggested above for the developing countries is needed to support research and development, fund technology transfer and adaptation, and international assistance.

In the end, a vertically articulated mechanism of payments and transfers across regions can help break the impasse of the political economy of blame, which stresses that some countries are more responsible than others for man-made climate change and that others are not responsible for the problem. The point is that reducing global emissions should not be as difficult or as unappealing or as expensive as commonly portrayed in the public discourse.

The paper did not address the distributional impacts of introducing emission charges. Nonetheless, studies find that well-designed mechanisms for recycling revenues to help societies burdened with the resultant higher prices and to support production restructuring, technology development, etc., can offset distributional impacts associated with emissions charges (c.f., Boyce and Riddle 2007; Brenner *et al.* 2007). Efforts need to progress from payment schemes to working out alternatives to the conventional modes of production and consumption and thus wean societies away from carbon-intensive activities. The presumption that emission charges are economically unfeasible and emissions reduction is politically unattractive is not clearly supported by the findings of this paper that draw on subjective well-being.

4. CONCLUSION

This paper applied the subjective well-being (SWB) approach to the valuation of greenhouse gas emissions. The approach is a useful alternative because it does not rely on a surrogate or pseudo market setup or even a hypothesized good in the valuation exercise. Some interesting insights were found in the study. First, carbon dioxide, nitrous oxide, methane, and other greenhouse gases are environmental bads in Europe and United States but are environmental goods in Latin America. In Asia and Pacific, carbon dioxide and other greenhouse gases are environmental bads but nitrous oxide and methane are environmental goods. The reverse pattern applies in Sub-Sahara Africa.

Second, the corresponding payment schemes for emissions reflect the perception of a society with a greenhouse gas. Where an emission is found as an environmental bad, the valuation reflects the willingness-to-pay for reduced emissions. Where an emission is found as an environmental good, the valuation reflects the willingness-to-accept for reduced emissions. More importantly, the amounts for reducing emissions are reasonable and, in fact, affordable across all societies covered in the paper.

Even if the developing countries are not subject to mandatory reductions in greenhouse gas emissions, the findings suggest that they are actually ready to participate in global initiatives to reduce emissions. As argued in the paper, the findings for the industrialized countries do not mean that they can simply put up a fraction of the amounts then use them to “payoff” the developing countries in order to continue with the usual volume of emissions. It was also argued that collective action can be facilitated through the creation of payment and transfers systems to assist countries not only in efforts at reducing emissions but also in shifting to less carbon-intensive activities and adaptation yet still make everyone better off in the end. The final message of the paper is that reducing global emissions is not as expensive or as publicly unattractive as often understood or argued by opponents. Perhaps what is pricey is political will.

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Table 1: *Greenhouse gas emissions per type, including shares to group total and global total*

Europe and U.S.	**CO_2**	**%GRP**	**%GLB**	**N_2O**	**%GRP**	**%GLB**	**CH_4**	**%GRP**	**%GLB**	**Other**	**%GRP**	**%GLB**
Finland	61.3	0.77	0.25	5.3	0.82	0.02	6.4	0.55	0.03	0.8	0.42	0.00
Germany	822.5	10.37	3.36	65.3	10.11	0.27	76.3	6.56	0.31	37.6	21.24	0.15
Italy	460.9	5.81	1.88	36.8	5.70	0.15	41.6	3.57	0.17	22.4	12.68	0.09
Norway	44.3	0.56	0.18	4.8	0.75	0.02	12.6	1.08	0.05	1.9	1.06	0.01
Poland	305.2	3.85	1.25	27.7	4.28	0.11	67.0	5.76	0.27	0.9	0.49	0.00
Romania	92.4	1.17	0.38	13.9	2.15	0.06	24.4	2.10	0.10	1.7	0.93	0.01
Sweden	52.7	0.66	0.22	6.4	0.99	0.03	6.9	0.59	0.03	1.5	0.82	0.01
Switzerland	40.9	0.52	0.17	3.0	0.46	0.01	4.4	0.38	0.02	2.1	1.20	0.01
Ukraine	319.1	4.02	1.30	29.6	4.58	0.12	82.1	7.06	0.34	0.8	0.44	0.00
United States	5,730.8	72.27	23.38	453.3	70.16	1.85	841.4	72.34	3.43	107.4	60.71	0.44

Latin America	**CO_2**	**%GRP**	**%GLB**	**N_2O**	**%GRP**	**%GLB**	**CH_4**	**%GRP**	**%GLB**	**Other**	**%GRP**	**%GLB**
Argentina	149.5	15.14	0.61	75.2	15.67	0.31	90.8	14.32	0.37	0.9	7.99	0.00
Brazil	338.8	34.30	1.38	289.5	60.35	1.18	374.4	59.08	1.53	7.2	66.21	0.03
Chile	56.0	5.67	0.23	11.0	2.29	0.04	18.6	2.93	0.08	0.0	0.09	0.00
Mexico	406.3	41.13	1.66	71.9	14.98	0.29	114.1	18.01	0.47	2.7	24.79	0.01
Peru	31.7	3.20	0.13	16.1	3.36	0.07	20.3	3.21	0.08	0.1	0.73	0.00
Uruguay	5.5	0.55	0.02	16.1	3.35	0.07	15.6	2.46	0.06	0.0	0.18	0.00

Source of raw data: World Development Indicators online

Definitions:

1. CO_2 = million tons of carbon dioxide emissions; N_2O = nitrous oxide million tons of CO_2 equivalent emissions; CH_4 = methane million tons of CO_2 equivalent emissions; and Other = sulfur hexafluoride (SF_6), hydroflourocarbons (HFC), and perflourocarbons (PFC) million tons of CO_2 equivalent emissions.
2. %GRP is percentage share to group total, and %GLB is percentage share to 31 countries total.

Table 1 *Continued…*

Asia and Pacific	CO_2	%GRP	%GLB	N_2O	%GRP	%GLB	CH_4	%GRP	%GLB	Other	%GRP	%GLB
Australia	343.4	3.93	1.40	105.1	9.43	0.43	116.0	5.05	0.47	3.9	2.20	0.02
China	4,536.4	51.97	18.51	556.6	49.95	2.27	973.7	42.36	3.97	82.6	47.00	0.34
India	1,318.5	15.10	5.38	278.7	25.01	1.14	722.4	31.43	2.95	9.0	5.13	0.04
Indonesia	295.2	3.38	1.20	69.1	6.20	0.28	223.1	9.71	0.91	0.9	0.51	0.00
Japan	1,280.2	14.67	5.22	26.2	2.35	0.11	59.5	2.59	0.24	69.7	39.68	0.28
Malaysia	159.5	1.83	0.65	9.4	0.84	0.04	25.3	1.10	0.10	0.5	0.30	0.00
South Korea	471.7	5.40	1.92	16.2	1.45	0.07	29.9	1.30	0.12	8.2	4.64	0.03
Thailand	243.7	2.79	0.99	26.0	2.34	0.11	77.1	3.35	0.31	0.9	0.53	0.00
Vietnam	80.9	0.93	0.33	27.1	2.43	0.11	71.6	3.11	0.29	0.0	0.01	0.00

Sub-Sahara Africa	CO_2	%GRP	%GLB	N_2O	%GRP	%GLB	CH_4	%GRP	%GLB	Other	%GRP	%GLB
Burkina Faso	0.8	4.54	0.00									
Ethiopia	5.2	31.16	0.02	57.5	76.24	0.23	43.3	63.2	0.18	0.0	0.00	0.00
Ghana	7.4	43.89	0.03	8.7	11.47	0.04	8.5	12.4	0.03	0.2	100.00	0.00
Mali	0.6	3.30	0.00									
Rwanda	0.7	4.40	0.00									
Zambia	2.1	12.70	0.01	9.3	12.29	0.04	16.8	24.5	0.07	0.0	0.00	0.00

Source of raw data: World Development Indicators online

Definitions:

1. CO_2 = million tons of carbon dioxide emissions; N_2O = nitrous oxide million tons of CO_2 equivalent emissions; CH_4 = methane million tons of CO_2 equivalent emissions; and Other = sulfur hexafluoride (SF_6), hydroflourocarbons (HFC), and perflourocarbons (PFC) million tons of CO_2 equivalent emissions.
2. %GRP is percentage share to group total, and %GLB is percentage share to 31 countries total

Table 2: *Emissions, Population, and Income, including shares to group total and G-31 total*

Europe and U.S.	TGHG	%GRP	%GLB	TPOP	%GRP	%GLB	GDPPC	%GRP	%GLB
Finland	73.7	0.74	0.30	5.2	0.92	0.13	38,242.8	12.06	8.50
Germany	1,001.7	10.10	4.09	82.4	14.46	2.02	34,469.4	10.87	7.66
Italy	561.7	5.66	2.29	58.5	10.27	1.44	30,684.8	9.68	6.82
Norway	63.7	0.64	0.26	4.6	0.81	0.11	65,138.4	20.54	14.47
Poland	400.8	4.04	1.64	38.2	6.69	0.94	8,074.6	2.55	1.79
Romania	132.4	1.34	0.54	21.6	3.80	0.53	4,865.4	1.53	1.08
Sweden	67.4	0.68	0.28	9.0	1.59	0.22	41,572.4	13.11	9.24
Switzerland	50.4	0.51	0.21	7.4	1.30	0.18	50,365.8	15.88	11.19
Ukraine	431.6	4.35	1.76	47.1	8.27	1.16	1,923.4	0.61	0.43
United States	7,132.8	71.93	29.10	295.9	51.89	7.26	41,733.2	13.16	9.27
Latin America	**TGHG**	**%GRP**	**%GLB**	**TPOP**	**%GRP**	**%GLB**	**GDPPC**	**%GRP**	**%GLB**
Argentina	316.4	14.98	1.29	38.7	10.32	0.95	4,849.6	14.47	1.08
Brazil	1,009.9	47.82	4.12	186.0	49.55	4.56	4,839.0	14.44	1.08
Chile	85.5	4.05	0.35	16.3	4.34	0.40	7,317.6	21.84	1.63
Mexico	594.9	28.17	2.43	103.1	27.48	2.53	8,281.8	24.72	1.84
Peru	68.2	3.23	0.28	27.8	7.42	0.68	2,939.6	8.77	0.65
Uruguay	37.1	1.76	0.15	3.3	0.88	0.08	5,276.2	15.75	1.17
Asia and Pacific	**TGHG**	**%GRP**	**%GLB**	**TPOP**	**%GRP**	**%GLB**	**GDPPC**	**%GRP**	**%GLB**
Australia	568.4	4.61	2.32	20.4	0.68	0.50	31,932.2	32.89	7.09
China	6,149.3	49.92	25.09	1,303.4	43.62	31.97	1,814.4	1.87	0.40
India	2,328.6	18.90	9.50	1,094.7	36.63	26.85	764.4	0.79	0.17
Indonesia	588.4	4.78	2.40	219.2	7.34	5.38	1,431.2	1.47	0.32
Japan	1,435.7	11.66	5.86	127.8	4.28	3.13	34,644.6	35.68	7.70
Malaysia	194.7	1.58	0.79	25.6	0.86	0.63	5,564.4	5.73	1.24
South Korea	525.9	4.27	2.15	48.2	1.61	1.18	17,478.2	18.00	3.88
Thailand	347.7	2.82	1.42	65.8	2.20	1.62	2,832.4	2.92	0.63
Vietnam	179.6	1.46	0.73	83.1	2.78	2.04	637.0	0.66	0.14
Sub-Sahara Africa	**TGHG**	**%GRP**	**%GLB**	**TPOP**	**%GRP**	**%GLB**	**GDPPC**	**%GRP**	**%GLB**
Burkina Faso	0.8	0.47	0.00	13.8	9.63	0.34	395.4	16.10	0.09
Ethiopia	106.0	65.88	0.43	74.7	52.24	1.83	173.2	7.05	0.04
Ghana	24.7	15.32	0.10	21.9	15.32	0.54	497.6	20.27	0.11
Mali	0.6	0.34	0.00	11.8	8.28	0.29	458.6	18.68	0.10
Rwanda	0.7	0.46	0.00	9.0	6.32	0.22	272.8	11.11	0.06
Zambia	28.2	17.51	0.11	11.8	8.22	0.29	657.6	26.78	0.15

Source of raw data: World Development Indicators online

Definitions:
1. TGHG = total greenhouse gas (in millions CO_2 equivalent emissions); TPOP = total population (in millions); and GDPPC = gross domestic product per capita (in US$)

2. %GRP is percentage share to group total, and %GLB is percentage share to 31 countries total.

Table 3: *Fair marginal value of greenhouse gas emission per ton, (in US$)*

Europe and U.S.	**CO_2**	**N_2O**	**CH_4**	**Other**	**Average**
Finland	-18.75	-23.47	-19.47	-35.47	-19.32
Germany	-239.19	-299.47	-248.39	-452.65	-251.83
Italy	-134.61	-168.53	-139.79	-254.74	-142.01
Norway	-47.98	-60.07	-49.82	-90.79	-50.52
Poland	-6.08	-7.61	-6.31	-11.50	-6.23
Romania	-1.25	-1.57	-1.30	-2.37	-1.31
Sweden	-38.16	-47.77	-39.62	-72.21	-39.95
Switzerland	-46.09	-57.71	-47.86	-87.22	-48.67
Ukraine	-0.43	-0.53	-0.44	-0.81	-0.44
United States	-1,258.41	-1,575.55	-1,306.81	-2,381.42	-1,301.18
Latin America	**CO_2**	**N_2O**	**CH_4**	**Other**	**Average**
Argentina	3.54	5.11	4.62	2.62	4.22
Brazil	16.90	24.42	22.07	12.54	20.94
Chile	3.39	4.89	4.42	2.51	3.81
Mexico	27.46	39.67	35.85	20.37	30.51
Peru	0.93	1.35	1.22	0.69	1.12
Uruguay	0.36	0.52	0.47	0.27	0.47
Asia and Pacific	**CO_2**	**N_2O**	**CH_4**	**Other**	**Average**
Australia	-123.53	71.67	37.26	-101.70	-54.47
China	-25.44	14.76	7.67	-20.94	-16.49
India	-3.79	2.20	1.14	-3.12	-1.54
Indonesia	-2.66	1.54	0.80	-2.19	-0.85
Japan	-908.97	527.36	274.19	-748.28	-825.89
Malaysia	-4.70	2.73	1.42	-3.87	-3.55
South Korea	-87.21	50.60	26.31	-71.79	-76.28
Thailand	-3.13	1.82	0.94	-2.58	-1.86
Vietnam	-0.20	0.12	0.06	-0.16	-0.05
Sub-Sahara Africa	**CO_2**	**N_2O**	**CH_4**	**Other**	**Average**
Burkina Faso	1.35				1.35
Ethiopia	0.05	-0.05	-0.03		-0.04
Ghana	0.25	-0.13	-0.07		0.14
Mali	0.04				0.04
Rwanda	0.03				0.03
Zambia	0.22	-0.12	-0.06		-0.09

Source of raw data: World Development Indicators and calculations of the author.

Notes:
1. Negative notation means greenhouse gas emission is environmental bad; positive notation means greenhouse gas emission is environmental good.
2. Burkina Faso, Mali, and Rwanda do not have data for N_2O, CH_4 and other greenhouse gases. Not enough information to generate "other" for Sub-Sahara Africa.

APPENDIX

Table A: *Europe and United States*

	Baseline	CO_2	CH_4	N_2O	Other
Log Z		-0.0501	-0.0520	-0.0627	-0.0948
		-7.5882	-7.9151	-9.1391	-14.697
log income		0.4566	0.4710	0.4475	0.4319
		15.147	16.060	14.951	14.746
Air quality – local		0.0029	0.0034	0.0043	0.0106
		0.1490	0.1757	0.2185	0.5388
Air quality – global		0.1049	0.1023	0.1005	0.0852
		3.5835	3.4887	3.4321	2.9031
Age	-0.0392	-0.0419	-0.0420	-0.0419	-0.0406
	-11.112	-11.827	-11.865	-11.828	-11.463
Age-square	0.0003	0.0003	0.0003	0.0003	0.0003
	10.327	10.870	10.894	10.859	10.538
Gender	-0.0289	-0.0439	-0.0440	-0.0431	-0.0427
	-1.5315	-2.3150	-2.3233	-2.2770	-2.2511
Ex-married	-0.2357	-0.2423	-0.2418	-0.2434	-0.2556
	-7.0342	-7.1628	-7.1433	-7.1941	-7.5572
Widowhood	-0.2542	-0.2375	-0.2379	-0.2386	-0.2390
	-5.9673	-5.5919	-5.6014	-5.6175	-5.6349
Single	-0.2145	-0.2407	-0.2414	-0.2412	-0.2379
	-7.6526	-8.5353	-8.5597	-8.5516	-8.4240
Tertiary education	0.3782	0.3666	0.3712	0.3523	0.2882
	8.2048	7.7239	7.8353	7.4167	6.0489
Secondary education	0.3096	0.3115	0.3169	0.3049	0.2617
	7.1317	6.9983	7.1206	6.8516	5.8783
Elementary education	0.2899	0.2553	0.2574	0.2516	0.2058
	6.6006	5.7017	5.7471	5.6234	4.6071
Unemployed	-0.4484	-0.4309	-0.4363	-0.4302	-0.4247
	-9.8579	-9.4462	-9.5652	-9.4369	-9.3714
Top income (decile 10-8)	0.3287	0.2594	0.2645	0.2642	0.2534
	8.2307	6.4159	6.5516	6.5383	6.2502
Mid income (decile 7-4)	0.0916	0.1032	0.1059	0.1049	0.0979
	2.6916	3.0150	3.0912	3.0636	2.8526
Low income (decile 3-1)	-0.2275	-0.2291	-0.2256	-0.2298	-0.2561
	-6.1114	-6.1432	-6.0540	-6.1611	-6.8386
Dummies	Yes	Yes	Yes	Yes	Yes
Pseudo-R^2	0.0389	0.0479	0.0480	0.0484	0.0509

Notes:
1. N= 12,211; numbers below the coefficients are z-statistics
2. Ordered probit results with QML (Huber/White) standard errors and covariance

Table B: *Latin America*

	Baseline	CO_2	CH_4	N_2O	Other
Log Z		0.0714	0.0932	0.1031	0.0529
		9.0508	9.0981	9.3706	10.807
log income		0.4092	0.2460	0.1970	0.2792
		6.1839	3.5927	2.8227	4.1564
Air quality – local		-0.0734	-0.0684	-0.0684	-0.0717
		-2.9015	-2.7103	-2.7127	-2.8414
Air quality – global		0.0612	0.0607	0.0617	0.0688
		1.5654	1.5530	1.5774	1.7569
Age	-0.0191	-0.0200	-0.0200	-0.0199	-0.0198
	-4.5574	-4.7788	-4.7695	-4.7660	-4.7326
Age-square	0.0001	0.0002	0.0002	0.0002	0.0002
	4.2839	4.6632	4.6723	4.6824	4.7082
Gender	0.0392	0.0435	0.0444	0.0441	0.0416
	1.7250	1.9086	1.9486	1.9383	1.8273
Ex-married	-0.2217	-0.2429	-0.2415	-0.2409	-0.2381
	-4.9927	-5.4458	-5.4184	-5.4048	-5.3361
Widowhood	-0.1354	-0.1479	-0.1470	-0.1472	-0.1494
	-2.3496	-2.5662	-2.5518	-2.5559	-2.5944
Single	-0.1518	-0.1390	-0.1384	-0.1375	-0.1325
	-4.8168	-4.4096	-4.3889	-4.3614	-4.2075
Tertiary education	-0.0230	0.0483	0.0548	0.0557	0.0528
	-0.5027	1.0395	1.1805	1.1990	1.1391
Secondary education	-0.0618	0.0016	0.0093	0.0107	0.0101
	-1.5949	0.0408	0.2393	0.2728	0.2586
Elementary education	-0.0497	0.0074	0.0151	0.0170	0.0182
	-1.3126	0.1948	0.3952	0.4440	0.4778
Unemployed	-0.1608	-0.2138	-0.2182	-0.2185	-0.2146
	-3.7284	-4.8950	-4.9920	-4.9972	-4.9075
Top income (decile 10-8)	0.2063	0.1877	0.1505	0.1452	0.1433
	3.7500	3.3944	2.7254	2.6277	2.5847
Mid income (decile 7-4)	-0.0882	-0.0529	-0.0843	-0.0854	-0.0658
	-2.3066	-1.3483	-2.1816	-2.2097	-1.6989
Low income (decile 3-1)	-0.2623	-0.1598	-0.1933	-0.1954	-0.1809
	-6.3353	-3.7218	-4.5497	-4.6015	-4.2540
Dummies	Yes	Yes	Yes	Yes	Yes
Pseudo-R^2	0.0087	0.0131	0.0132	0.0133	0.0142

Notes:
1. N= 8,469; numbers below the coefficients are z-statistics
2. Ordered probit results with QML (Huber/White) standard errors and covariance

Table C: *Asia and Pacific*

	Baseline	CO_2	CH_4	N_2O	Other
Log Z		-0.0265	0.0080	0.0154	-0.0218
		-3.1459	0.8476	1.8774	-5.2200
log income		0.0995	0.1035	0.1077	0.1205
		6.8393	6.6836	7.0576	7.8321
Air quality – local		0.0032	0.0090	0.0102	0.0028
		0.1800	0.5072	0.5732	0.1589
Air quality – global		0.1380	0.1509	0.1542	0.1305
		5.8160	6.3485	6.4942	5.4939
Age	-0.0236	-0.0224	-0.0237	-0.0239	-0.0217
	-6.3260	-6.0099	-6.3644	-6.4176	-5.8373
Age-square	0.0002	0.0002	0.0002	0.0002	0.0002
	7.5834	7.1360	7.4944	7.5381	6.9484
Gender	-0.0415	-0.0359	-0.0369	-0.0370	-0.0347
	-2.3358	-2.0240	-2.0796	-2.0862	-1.9557
Ex-married	-0.2743	-0.3009	-0.2921	-0.2939	-0.3092
	-4.9588	-5.4123	-5.2535	-5.2843	-5.5632
Widowhood	-0.0845	-0.0790	-0.0708	-0.0690	-0.0828
	-1.7375	-1.6271	-1.4580	-1.4218	-1.7033
Single	-0.1708	-0.2021	-0.1923	-0.1899	-0.2068
	-5.8687	-6.9376	-6.5902	-6.5033	-7.1014
Tertiary education	0.3986	0.3344	0.3381	0.3391	0.3347
	10.600	8.6937	8.7816	8.8050	8.7094
Secondary education	0.3540	0.2789	0.2882	0.2899	0.2729
	10.980	8.3863	8.6741	8.7217	8.2031
Elementary education	0.2991	0.2405	0.2594	0.2631	0.2294
	9.2314	7.2465	7.8407	7.9539	6.9036
Unemployed	-0.1434	-0.1532	-0.1494	-0.1481	-0.1524
	-3.2381	-3.4507	-3.3733	-3.3439	-3.4249
Top income (decile 10-8)	0.3397	0.2767	0.3155	0.3242	0.2614
	7.2086	5.7019	6.5592	6.7418	5.4123
Mid income (decile 7-4)	-0.0397	-0.0847	-0.0479	-0.0379	-0.0979
	-0.9507	-1.9610	-1.1044	-0.8747	-2.2798
Low income (decile 3-1)	-0.3681	-0.3751	-0.3609	-0.3563	-0.3768
	-8.1581	-8.2635	-7.9348	-7.8276	-8.3131
Dummies	Yes	Yes	Yes	Yes	Yes
Pseudo-R^2	0.0164	0.0182	0.0180	0.0181	0.0185

Notes:
1. N= 13,978; numbers below the coefficients are z-statistics
2. Ordered probit results with QML (Huber/White) standard errors and covariance

Table D: *Sub-Sahara Africa*

	Baseline	CO_2	CH_4	N_2O	Other
Log Z		0.1758	-0.2743	-0.5372	
		4.9930	-6.2652	-6.2652	
log income		0.4963	0.1769	-0.3631	
		16.710	3.3921	-2.7324	
Air quality – local		-0.0018	-0.0316	-0.0316	
		-0.0674	-0.8671	-0.8671	
Air quality – global		0.1123	0.1314	0.1314	
		4.0201	3.4383	3.4383	
Age	-0.0171	-0.0148	-0.0128	-0.0128	
	-3.8620	-3.2573	-1.7342	-1.7342	
Age-square	0.0001	0.0001	0.0001	0.0001	
	3.7289	2.9550	1.6937	1.6937	
Gender	-0.0138	-0.0165	-0.0559	-0.0559	
	-0.6189	-0.7375	-1.7883	-1.7883	
Ex-married	0.0095	-0.0075	-0.0094	-0.0094	
	0.1749	-0.1258	-0.1286	-0.1286	
Widowhood	-0.1629	-0.1769	-0.1881	-0.1881	
	-3.0542	-2.9954	-2.0011	-2.0011	
Single	-0.0536	-0.0435	0.0144	0.0144	
	-1.7678	-1.4538	0.3640	0.3640	
Tertiary education	0.2367	0.2555	0.3464	0.3464	
	3.8238	4.4435	4.3414	4.3414	
Secondary education	0.1522	0.1332	0.1498	0.1498	
	4.7835	4.1787	3.2879	3.2879	
Elementary education	0.0970	0.0894	0.1338	0.1338	
	3.4990	3.1914	3.0372	3.0372	
Unemployed	0.0120	0.0012	-0.0705	-0.0705	
	0.4301	0.0424	-1.9056	-1.9056	
Top income (decile 10-8)	0.5191	0.5355	0.3351	0.3351	
	9.2016	8.6207	3.9229	3.9229	
Mid income (decile 7-4)	0.0827	0.1160	0.0372	0.0372	
	1.8127	2.3376	0.5051	0.5051	
Low income (decile 3-1)	-0.4079	-0.4177	-0.4623	-0.4623	
	-8.7589	-8.0192	-5.8496	-5.8496	
Dummies	Yes	Yes	Yes	Yes	NA
Pseudo-R^2	0.0207	0.0277	0.0302	0.0302	NA

Notes:
1. N= 8,750. Numbers below the coefficients are z-statistics. Not enough information to generate “other”.
2. Ordered probit results with QML (Huber/White) standard errors and covariance