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ECONOMIC GROWTH AND THE ENVIRONMENT: SOME ISSUES REVISITED

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ABSTRACT

The most enduring explanation to the systematic relationship between economic growth and environmental quality has been the 'Environmental Kuznets' Curve (EKC). Since 1991, the EKC has become standard fare in technical conversations about environmental policy.

This paper seeks to revisit and test the EKC in a comprehensive 'world-view' perspective by tracking all countries of the world in a cross-section, classifying them on the basis of their income levels and estimating the EKC for each sub-group of countries. In the process, it also relates the issue of health expenditures with environmental deterioration. The link between energy use in terms of traditional fuel and electricity consumption and environmental pollution is also explored.

The principle measure of environmental quality used in the study is per capita CO2 emissions. The study makes use of secondary data on per capita CO2 emissions (metric tons in 2000), per capita GDP (in 2002 US$), per capita health expenditures, use of traditional fuel as % of total energy requirements, and electricity consumption per capita (in kilowatt hours). Data for subsequent analysis are drawn from UNDP's Human Development Report, 2004 which report data on all the above variables for the year 2000 and 2002. The complete list of countries selected on the basis of availability of data on all variables, is given in the Appendix.

The study reveals that while the EKC is indeed valid for the high-income countries, such relationship is not observed for the low-income and middle-income countries i.e. the latter have yet to reach the turning point, threshold level of income. Also, given the nature of relationship between growth and environment combined with the adverse health impacts of a deteriorating environment, it is not surprising to find a kuznets relationship of health expenditures with rising incomes for all income sub-group countries. The relationship between energy consumption and environment quality is stronger for low- and middle-income sub-group and weak for the high-

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income sub-group.

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Theme: Resource and Environmental Policy

JEL Classification: Q56

Since 1970s, concerns regarding adverse environmental implications of economic growth have been gaining center-stage in economic discussions and literature. Intermittent environmental movements across the world have sought to focus attention on the harm that is being done to the physical environment in the name of growth and development. Constant debates on these issues, in turn, have borne fruit to a parallel thinking on the benefits of economic growth in terms of the resources needed to protect the very environment that is being harmed. Thus, economists and ecologists, alike, have been confronted with a constant dialectic dilemma in trying to create a balance between economic growth and environmental protection. While material growth in the economic system necessarily increases both the extraction of environmental resources and the volume of waste deposited in the environment, the same material growth also generates resources that are such a prerequisite for environmental protection and for maintaining environmental quality.

So who does one turn to? Which side is one on? Does one strive to be an out-and-out environmentalist and castigate all development and cease all growth? Or does one simply be a pure economist and fight for the generation of material resources on the argument that *without resources, the environment is forever doomed*? Economic growth, at least provides an economy with the necessary equipments to deal with environmental degradation and mitigate any further deterioration in environmental quality. So far, both sides have been strong in their „weaponry". Rightly so, because the answers to these questions depend on which country one belongs to, quite literally. If you are a developing country, you strive towards furthering your material interests and enhance your standard of living. After all, what „they" can achieve, „we" can achieve better! If you are a developed country, you take to the streets against all intellectual discussions on economics, per se; you discard all meaningful economic solutions to environmental problems, your sole aim being to see that the forests are not cut down, the air is as clean as it can be, the water is as pure and clear as crystal, and so it goes on….. How does one overcome the dilemma that while some environmental problems are a result of economic growth (pollution), some are the precise result of *lack* of economic growth (degradation)?

This leads us to a somewhat more meaningful explanation to the dilemma. While environmental

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pollution caused by more cars, increased industrialization, greater energy use etc. can be tackled by devoting more resources (via economic growth) to mitigating these problems and technological upgradation of production processes, environmental degradation associated with lack of economic growth (poverty, to put it simply!) is a much more deep-rooted and serious problem to overcome. You can‟t possibly sermonize to a poor man on the dangers of cutting trees when all that he wants is his daily quota of firewood to cook his two square meals a day! What‟s environment to him, anyway; it‟s actually his very bread and butter!

The Scenario between Growth and Environment

The most enduring explanation to the systematic relationship between economic growth and environmental quality has been the „Environmental Kuznets‟ Curve (EKC) named after the Nobel Prize-winning work of Simon Kuznets (1954). Economists first reported a systematic relationship between income changes and environmental quality in 1991, (Grossman and Krueger 1991). Since then the EKC has become standard fare in technical conversations about environmental policy. The EKC represents a relationship between levels of income and certain measures of environmental quality and impact. More precisely, the EKC describes the relationship between some pollutants and income as an inverted-U. The early estimates showed that some important indicators of environmental quality such as the concentrations of sulfur dioxide and particulates in the air actually improved as incomes and levels of consumption went up. This happy outcome occurred when incomes were higher. Before that point, however, at lower income levels, environmental quality deteriorated as incomes began to rise. To put it succinctly, the EKC hypothesized that environmental pressure tends to rise faster than income growth in the early stages of economic growth, then slows down, reaches a turning point and declines with further income growth.

This paper seeks to revisit the above premise and test the EKC in a comprehensive „world-view‟ perspective by tracking all countries of the world in a cross-section, classifying them on the basis of their income levels and estimating the EKC for each sub-group of countries. In the process, it also relates the issue of health expenditures with environmental deterioration. The link between energy use in terms of traditional fuel and electricity consumption and environmental pollution is also explored. The principle measure of environmental quality used in the study is per capita CO_2 emissions for the simple reason of consistent data availability for all major countries of the world. The study makes use of secondary data on per capita CO_2 emissions (metric tons), per capita GDP (in 2002 US$), per capita health expenditures, use of traditional fuel as % of total energy requirements, and electricity consumption per capita (in kilowatt hours). Data for subsequent analysis are drawn from UNDP‟s Human Development Report, 2004 which report data on all the above variables for the year 2000 and 2002. The complete list of countries

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selected on the basis of availability of data on all variables, is given in the Appendix.

Theoretical Basis[1]

Initial studies point to the analysis by Grossman and Krueger (1991) of air quality measures in a cross-section of countries for different years. They identified the turning point where higher incomes yield improved air quality. An early EKC study by Shafik (1994) reported similar findings in their paper which was originally a background paper (Shafik and Bandyopadhyay, 1992) for the World Bank‟s inquiry into growth and environment relationships for the Bank‟s 1992 World Development Report. Panayotou (1995) offered perhaps the earliest and most detailed explanation of a possible Kuznets-type U-shape relationship between the rate of environmental degradation and the level of economic development.

The observed relationship between income levels and environmental quality focuses on the fact that when poverty vanishes, people (or society) will start to worry about quality of life and environmental amenities, eventually producing the EKC relationship. Similarly, the notion of "too poor to be green" suggests that the poor either lack awareness (no preference for environmental amenities), have other more immediate necessities, or do not have enough income to invest in environmental improvement. However, the transition to the environmental stage is much more complex than it sounds.

One theory to explain the EKC‟s U-shape is that environmental quality becomes a luxury good at higher levels of income. Stated more formally, this means that the income elasticity of demand for environmental resources varies with the level of income. At the threshold where further income increases yield environmental improvement, income elasticity of demand is greater than one; environmental quality is a luxury good. When attempting to explain EKC turning points, it is appealing to think that at some income level environmental quality becomes a normal good rather than a luxury good and that this leads to a reshuffling of consumer demand favoring environmental protection. However, like most economic models, this too assumes a world where other things are held constant. Since EKCs seem to be generated over rather long periods of time, holding other things constant becomes quite a challenge.

Thus, a cross-section analysis of a reasonably large sample of countries consisting of high-income, middle-income and low-income as done in the present paper seems justified. It must be understood that while time-series analysis does not reveal the level of disparity and „catching-up‟ of low-income, developing countries with the high-income, developed ones, a cross-section analysis precisely does that. Once the existing threshold level of income is identified for all the

[1] Parts of arguments and observations in this section draw from Yandle, Bhattarai, and Vijayaraghavan, 2004.

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countries of the world as a whole, it can be used to compare the development stage of the low-income countries and identify whether they are on the rising portion of the EKC or the falling portion. Logically, all countries whose income is below the threshold level would be expected to be on the rising portion of the EKC i.e. their environments will continue to deteriorate with rising incomes till their incomes reach the threshold. At the time, a time frame can be charted for the low-income countries to catch up and transition to the developed world.

Methodology

Basic empirical analyses of the EKC focuses on two critical areas: 1) whether a given indicator of environmental degradation displays an inverted-U relationship in association with rising levels of per capita income and 2) the calculation of the threshold where environmental quality improves with rising per capita income (Barbier 1997).

The present study follows the above proposition and applies them to a cross-section of the sub-group of countries based on their levels of economic growth as measured by per capita GDP in US$ for 2002. Given the nature and empirical evidence so far regarding the expected relationship between rising incomes and environmental quality, it is hypothesized that while high-income countries are likely to exhibit the inverted-U pattern since they would have probably crossed their threshold level of income, the same may not be observed for low-income countries who are still in their initial stages of growth. The same argument applies to middle-income countries.

The relation between income and environmental pressure can be sketched in a number of ways. On a basic level, one may distinguish between monotonic and non-monotonic curves representing the relationship. Monotonic curves may show either increasing pollution with rising incomes – a continuously upward rising curve or decreasing pollution with rising incomes – a continuously downward sloping curve. However, our interest is in the non-monotonic curve that will most ideally represent the inverted-U nature of relationship. A simple manner to establish such inverted-U pattern of relationship is to test the quadratic form of the regression equation –

$$CO_2 = b0 + b1y + b2y^2 + u \qquad \text{(model 1)}$$

where,

CO_2 = per capita metric tons of Carbon dioxide emissions in 2000[2].
y = per capita GDP in US$ in 2002

[2]anthropogenic (human-originated) CO2 emissions stemming from burning of fossil fuels, gas flaring and the production of cement.

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u = standard error term

For an inverted-U, it could be reasonably expected that b1 > 0 while b2 < 0.

Applying the above regression to all countries of the world reveals the scenario as observed in Exhibit 1.

Exhibit 1 very clearly brings out the inverted-U relationship between rising income levels and environmental quality as measured by per capita metric tons of CO_2 emissions. The world view suggests that generally as countries transition from low income to high income, initially there is deterioration in environmental quality with increasing carbon dioxide emissions. Rapid industrialization, greater reliance on natural resources combined with low levels of technology, increasing levels of material consumption, greater number of automobiles serve to exacerbate carbon emissions. At a later stage, with sufficiently high levels of income, there is a conscious demand for cleaner environment so that resources are increasingly diverted towards environmental management and improvement. Higher incomes enable technological upgradation and a reduced dependence on natural resources. As the curve is drawn, it is observed that the threshold level of income where the turnaround in environmental quality occurs is close to US$29000.

The coefficients of income, b1 and b2 show the hypothesized signs and the significance of the relationship is quite high at the 1% level as seen from the R-squared and F values.

While the world view gives a comprehensive perspective of the EKC and the expected threshold level of income, it becomes interesting to test the EKC hypothesis with respect to the income sub- groups.

The same model when applied to the high-income sub-group of countries reveals a rather disappointing result (Exhibit 2). Though the coefficients of income, b1 and b2 exhibit the correct signs pointing to the inverted-U relationship, the strength of the relationship is rather weak in terms of both the R-squared and F values. The „turnaround" level of income remains approx. US$29000. The inference is that the EKC doesn"t seem to be applicable to high-income countries that have already crossed the developing stage and the threshold level of income. Also, the comprehensive world-view EKC seems to be dominated by the high-income countries.

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Exhibit 1

Environmental Kuznets' Curve : All Countries - World View

Independent: Y

Dependent	Mth	Rsq	d.f.	F	Sigf.	b0	b1	b2
CO2	LIN	.350	171	92.06	.000	1.7362	.0004	
CO2	QUA	.388	170	53.88	.000	.8503	.0009	-1.E-08

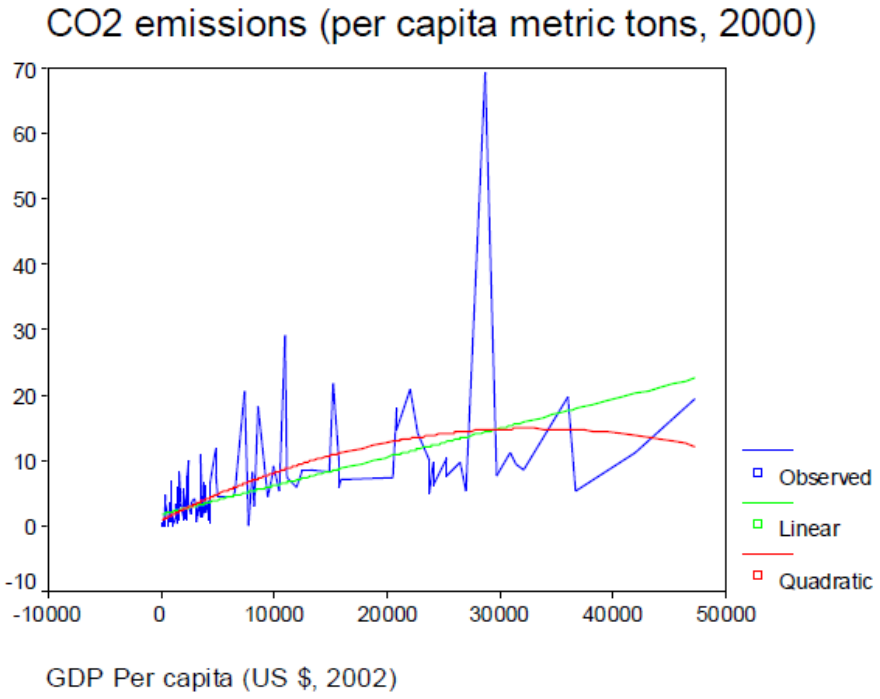

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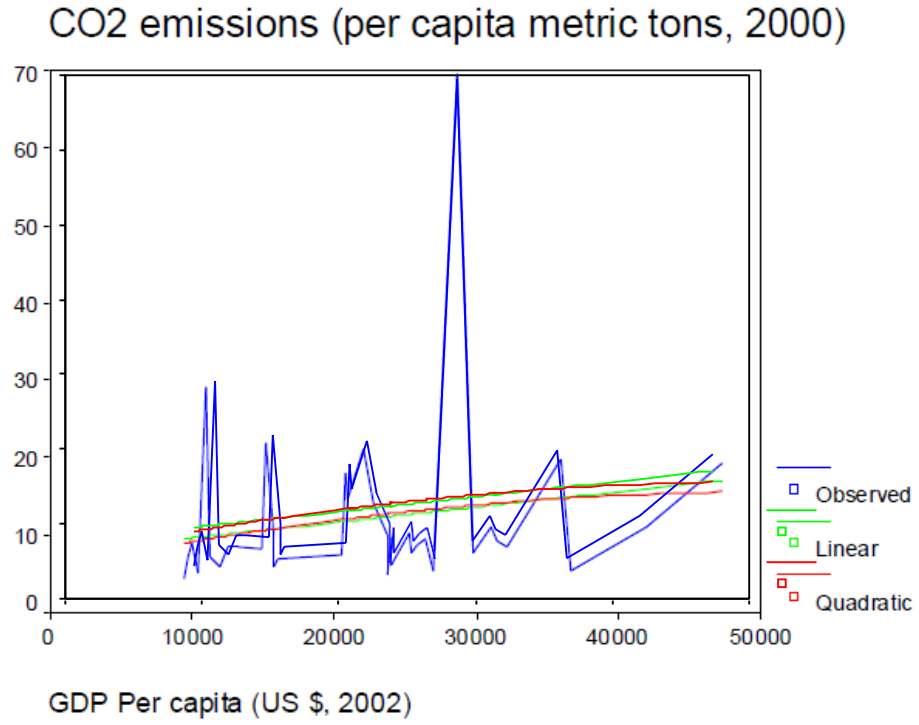
Exhibit 2

Environmental Kuznets' Curve : High-Income Countries [Y>US$9000]

Independent: Y

Dependent	Mth	Rsq	d.f.	F	Sigf	b0	b1	b2
CO2	LIN	.028	35	1.02	.319	7.6603	.0002	
CO2	QUA	.030	34	.52	.599	5.6988	.0004	-4.E-09



Exhibits 3 and 4 display the results for the middle-income and low-income sub-group of countries respectively. This is where the results become interesting and are a departure from previous studies which were based on time-series data.

As the exhibits reveal, the signs of both the income coefficients b1 and b2 are positive for both the income sub-group of countries. The implication is that these countries are still on the rising portion of the EKC – rising incomes leading to environmental deterioration. Thus, the EKC we get for the two sub-groups are monotonic in nature.

The growing body of EKC evidence that supports the notion of turning points has inspired

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researchers to probe deeper into the time path that may be followed by EKCs for a particular cross-section of countries. For example, if a turning point for sulfur dioxide emission concentrations is found for a sample of countries in 1990, is the income turning point about the same in 1980 and 1970? That is, is there evidence of technology change or other changes that might make the resulting EKCs more sensitive to income and therefore more likely to improve faster environmentally?[3]

[3] Yandle, Bhattarai, and Vijayaraghavan, April 2004

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Exhibit 3

Environmental Kuznets' Curve : Middle Income Countries [US$750 < Y < US$9000]

Independent: Y

Dependent	Mth	Rsq	d.f.	F	Sigf.	b0	b1	b2
CO2	LIN	.275	80	30.33	.000	.7457	.0010	
CO2	QUA	.284	79	15.65	.000	1.6234	.0004	7.7E-08

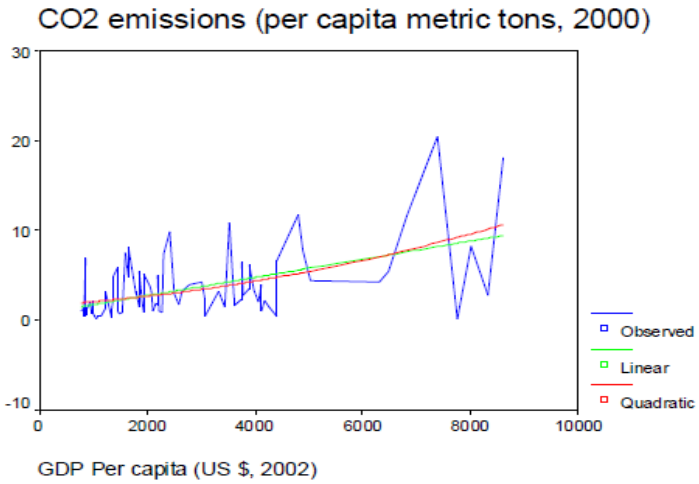
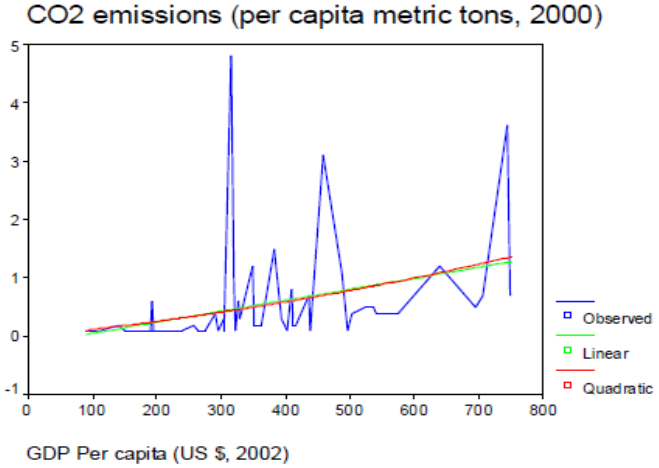


Exhibit 4

Environmental Kuznets' Curve : Low-Income Countries [Y<US$750]

Independent: Y

Dependent	Mth	Rsq	d.f.	F	Sigf.	b0	b1	b2
CO2	LIN	.120	52	7.11	.010	-.1284	.0019	
CO2	QUA	.122	51	3.53	.037	.0032	.0011	9.5E-07



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Hill and Magnani (2002) found the inverted-U EKC for carbon dioxide, which is consistent with the present study. Other researchers find a simple linear relationship between income and carbon dioxide emissions. Hill and Magnani divided their sample of countries into three income groups and made EKC estimates for each of the pollutants for each sub-sample. They found the inverted-U EKC for the higher income group for carbon dioxide and nitrogen oxide. However, unlike the present study, a turning point was found for sulfur dioxide for the middle-income group, but not for the low and high income groups. These and other statistical findings enabled the authors to infer that richer countries were reducing their levels of emissions when energy prices rose significantly, suggesting that energy price shocks also induced technology change. The same effect was not seen for the lower-income countries.

Environmental Quality, Health Expenditures and Income

Given the accumulated data on the income-environment linkage, it would be surprising to observe no statistical linkage between environment and health expenditures and incomes and health expenditures. If the EKC is indeed valid, it should follow that health expenditures must relate to rising incomes in much the same manner as environmental quality. For such a relationship, it must be first proved that health expenditures do relate positively to environmental quality. As environmental quality deteriorates with rising incomes, health expenditures must rise initially. Beyond the threshold turning point, as environmental quality improves, health expenditures must decline. To put in the EKC perspective, rising incomes must reflect rising health expenditures in the initial stages of development of a country when income levels are low and environmental quality is deteriorating. Thereafter, beyond the threshold income, health expenditures must decline as income levels rise and environmental quality improves.

A study by Gangadharan and Valenzuela (2001) examined 1996 data for 51 countries in an effort to isolate the two-stage effect between income, the environment, and human health. Their study examined conventional emissions – carbon dioxide, sulfur dioxide, nitrogen oxides, and total suspended particulates – in an effort to identify the linkages between income change, environmental change, and human health. They used measures of infant mortality, life expectancy, and other variables in their analysis of health effects.

The results of the Gangadharan-Valenzuela estimate are rather weak. Of the environmental variables considered, the carbon dioxide estimate was the only one that shows a statistically significant relationship with GNP. Graphically, the results of their estimate show an S-shaped, rather than an inverted-U shaped curve. The health effect estimates suggest that rising incomes do indeed lead to health improvements, but that the environmental effect associated with getting the higher income must be taken into account, especially in the early stages of income growth.

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Based on the observations of previous researchers, the analysis here uses health expenditures as a measure of health impacts of a deteriorating environment. A simple regression analysis is undertaken here to establish the link between environmental quality and health expenditures and thereafter an EKC application to rising incomes and health expenditures.

A linear regression equation is applied to establish the link between environmental quality and health expenditures. The sample remains the same as that for the earlier EKC analysis. Per capita health expenditures are regressed on per capita metric tons of CO_2 emissions. The equation takes the form –

$$hexpc = \alpha + \beta CO_2 + \mu \qquad \text{(Model 2)}$$

where,

hexpc = per capita health expenditures, PPP US$, 2001

CO_2 = per capita metric tons CO_2 emissions, 2002

The results of the regression analysis are presented in Table 1.

The regression estimates are meant to substantiate the environment-health relationship. Except for the high-income sub-group of countries, the results show that health expenditures do vary positively with environmental changes. The comprehensive world view suggests that overall, environmental deterioration does entail increased health expenditures per capita. This is seen to be particularly the case for middle- and low-income countries but not for high-income countries. This is to be expected since, given the EKC, high-income countries are already on the path of environmental improvement and their health expenditures necessary do not reflect any environmental concerns. Rather, such expenditure is determined, in most part, by factors other than the environment. The other two sub-groups with lower incomes are faced with a number of environmental problems that manifest themselves in the form of polluted/contaminated water sources, unclean air, lack of proper sanitation and sewage disposal, dirty surroundings etc. Hence, the likelihood of adverse health impact is much more in these countries and such expenditure on health becomes a curative measure rather than preventive.

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Table 1: Environmental quality and Health expenditures

Dependent Variable : per capita health expenditures, PPP US$, 2001						
Sp.no.	*Sample*	*Constant*	*CO_2*	*Adj. R^2*	*F*	*N*
1	All countries – world view	367.8 (5.33)	51.9 (6.44)** *	0.20	41.53** *	167
2	High-Income	2003.23 (8.42)	-11.6 (0.80)	0.01	0.64	37
3	Middle-Income	293.34 (8.22)	21.48 (3.19)*	0.11	10.19*	77
4	Low-Income	56.0 (8.44)	14.1 (2.24)*	0.07	5.00*	51

t-value in parentheses ; ** = significant at 1% ; * = significant at 5%

Source : Author‟s calculations

Now the question comes whether one can apply the EKC to the relationship between rising incomes and health expenditures. To reiterate, if the EKC is indeed valid, and given the positive relationship between environmental deterioration and health expenditures, rising incomes must reflect a kuznets curve for health. Thus, we would have

$$hexpc = b0 + b1y + b2y^2 + u \qquad \text{(model 3)}$$

where, *y* and *pchex* are as defined earlier in Models 1 and 2 respectively. Once again, for a kuznets curve one would expect b1 > 0 and b2 < 0.

The scenarios unfold in Exhibits 5 through 8 for all countries and the sub-groups.

The results and the graphical illustrations emphatically bring out the kuznets relationship between rising incomes and per capita health expenditures for all the sub-groups. b1 and b2 have the expected signs. The robustness of the results is glaring and is more pronounced for middle- and low-income sub-groups. In all the sub-groups, per capita health expenditures increase with rising incomes in the early stages as the surrounding physical environment deteriorates. It may be inferred that during this stage, health expenditures are more or less enforced by a dirty environment. A substantial part of income is spent on curative health. Beyond a threshold level of income, however, as the environment begins to improve, health expenditures reduce. A lesser proportion of income is spent on health.

A very interesting point to note is that the threshold incomes for environmental recuperation and

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health expenditure reversal *are not identical*. While the former occurs at around US$ 29000, the latter occurs around US$ 35000 (exhibits 1 & 5). This means that health expenditure reversal comes *after* environmental recuperation. This time lag between recuperation and reversal is logical since past environmental hazards leave an impact on health for a reasonably long time. The continued health expenditures beyond an improved environment are reversed only after past effects are completely cured.

Exhibit 5

Kuznets Curve for Health Expenditures and Income : All Countries - World View

Independent: Y

Dependent	Mth	Rsq	d.f.	F	Sigf.	b0	b1	b2
HEXPC	LIN	.811	165	709.37	.000	111.336	.0774	
HEXPC	QUA	.816	164	362.90	.000	75.7092	.0938	-5.E-07

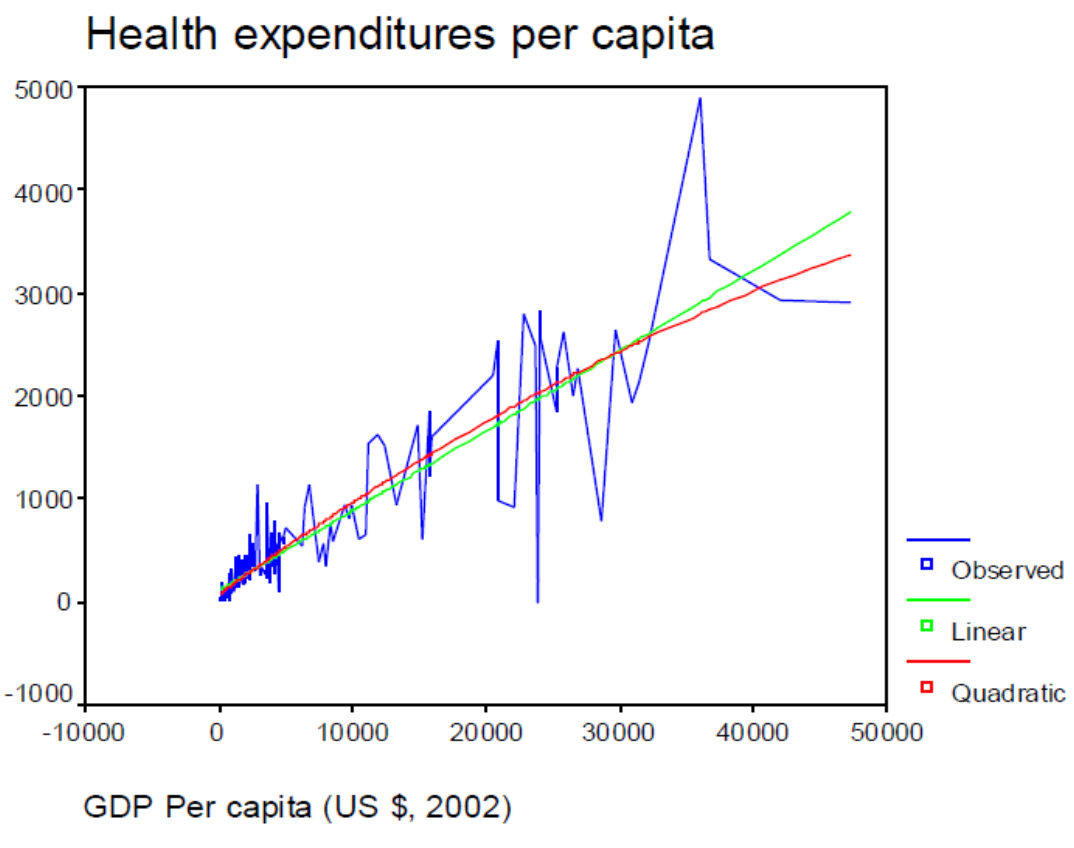

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Exhibit 6

Kuznets Curve for Health Expenditures and Income : High-Income Countries [Y>US$ 9000]

Independent: Y

Dependent	Mth	Rsq	d.f.	F	Sigf.	b0	b1	b2
HEXPC	LIN	.456	35	29.30	.000	320.449	.0692	
HEXPC	QUA	.459	34	14.42	.000	50.8840	.0946	-5.E-07

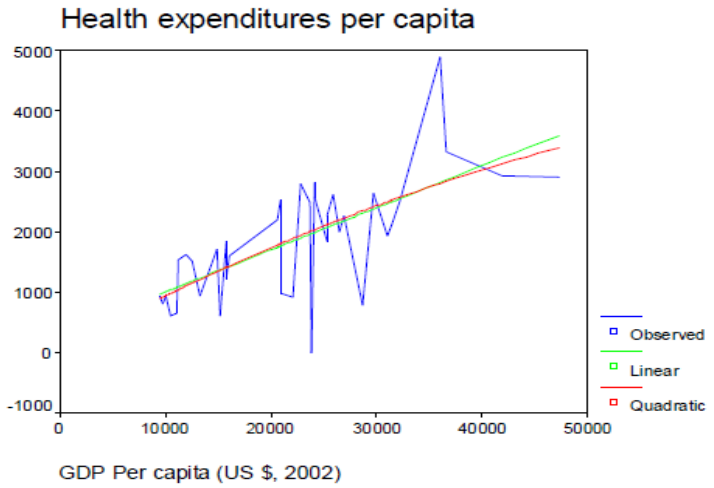

Exhibit 7

Kuznets Curve for Health Expenditures and Income : Middle-Income Countries [US$750<Y<US$9000]

Independent: Y

Dependent	Mth	Rsq	d.f.	F	Sigf.	b0	b1	b2
HEXPC	LIN	.363	76	43.36	.000	163.954	.0724	
HEXPC	QUA	.417	75	26.85	.000	25.5668	.1706	-1.E-05

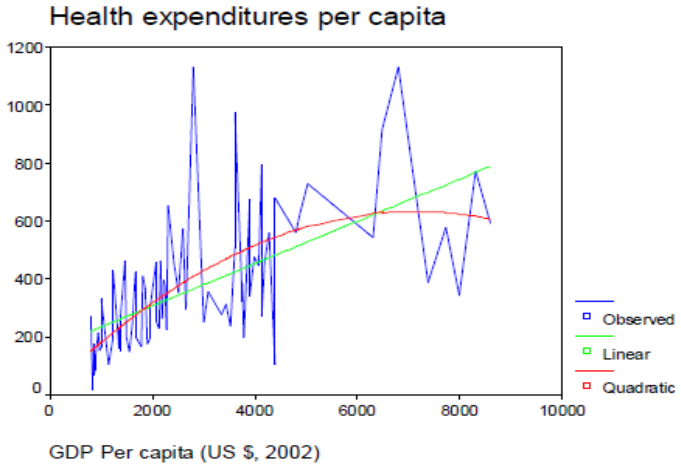

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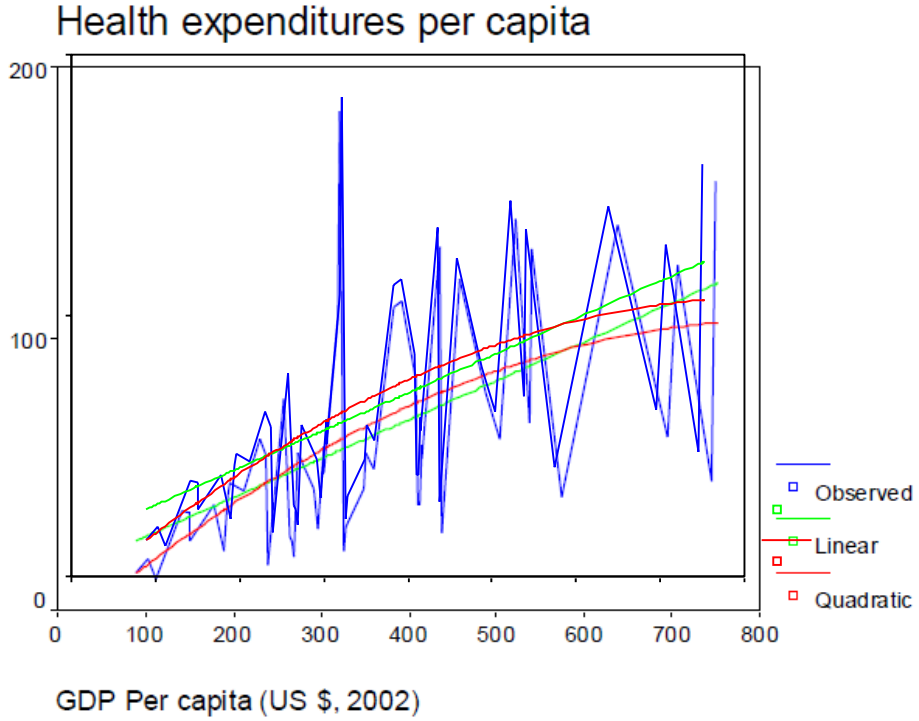
Exhibit 8

Kuznets Curve for Health Expenditures and Income : Low-Income Countries [Y<US$750]

Independent: Y

Dependent	Mth	Rsq	d.f.	F	Sigf.	b0	b1	b2
HEXPC	LIN	.319	50	23.46	.000	13.0950	.1430	
HEXPC	QUA	.337	49	12.44	.000	-9.9943	.2802	-.0002



Energy Consumption and Environmental Deterioration

This final section attempts to identify the main determinants of environmental deterioration in terms of its energy component. The study by Gangadharan and Valenzuela (2001) quoted earlier also estimated the link between GDP and energy consumption, assuming that, all else equal, increased energy consumption leads to environmental degradation. The present analysis is restricted to traditional fuel and electricity consumption as the two main determinants. Once again, a regression analysis is performed to establish the link between CO_2 emissions and energy consumption. The equation takes the following form –

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$CO_2 = \alpha + \beta fuel + \lambda elec + \mu$ (Model 4)

where,

fuel = traditional fuel consumption as % of total energy requirements, 2001[4]
elec = electricity consumption per capita, kilowatt-hours, 2001[5]

The hypothesis is that $\beta < 0$, $\lambda > 0$. Traditional fuel consumption reduces dependence on more environmentally harmful forms of fuel and thus mitigates environmental degradation while increased electricity consumption entails energy production at faster rates that create a pressure on the environment and thus leads to its deterioration. The results of the regression are presented in table 2.

Table 2: Energy determinants of Environmental deterioration

Dependent Variable : CO_2 emissions (per capita metric tons, 2000)							
Sp.no.	*Sample*	*Const.*	*fuel*	*elec*	*Adj. R^2*	*F*	*N*
1	All countries – world view	2.90 (3.92)	-0.004 (2.88)**	0.0001 (8.9)**	0.45	67.47**	166
2	High-Income	7.58 (2.28)	-0.48 (1.87)	0.0001 (2.40)*	0.14	3.92*	36
3	Middle-Income	0.72 (1.21)	-0.003 (2.18)*	0.0002 (9.36)**	0.62	62.63**	77
4	Low-Income	1.10 (3.84)	-0.001 (3.18)**	0.0001 (2.72)**	0.47	23.55	51

t-value in parentheses ; ** = significant at 1% ; * = significant at 5%
Source : Author"s calculations

Once again, the results in Table 2 underline the fact that greater use of traditional fuel eases the pressure on the environment whereas greater electricity consumption exacerbates environmental degradation. The relationship is stronger for low- and middle-income sub-group and weak for the high-income sub-group. Overall, the results do confirm the hypothesized relationship between

[4] include fuelwood, charcoal, bagasse (sugarcane waste), animal, vegetal and other wastes.
[5] Gross production per capita – includes consumption by station auxiliaries and any losses in the transformers considered integral parts of the station – also includes total electrical energy produced by pumping installations without deduction of electrical energy absorbed by pumping.

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energy consumption and environment. The argument for high-income countries continues to be valid. As observed for health-environment relationship, most cases where the environmental impact of energy consumption is pronounced, do not apply to high-income countries because of their already developed stage of growth.

Conclusions and Policy Implications

This paper has attempted to investigate certain issues in the growth-versus-environment debate in a different perspective. The cross-section analysis in the study reveals that low-income and middle-income countries do conform to the EKC, while the high-income countries do not. Since the latter are already on the path of environmental improvement given their higher income levels, the former sub-groups are yet to catch-up with the developed countries. The study further reveals that all countries also conform to the kuznets phenomenon with respect to incomes and health expenditures. This is based on the evidence that environmental deterioration and increased health expenditures show a positive relationship.

The growing body of EKC evidence that supports the notion of turning points has inspired researchers to probe deeper into the time path that may be followed by EKCs for a particular cross-section of countries. For example, as in the present study, if a turning point for carbon dioxide emission concentrations is found for a sample of countries in 2002 to be US$ 29000, is this income turning point the same in the previous years? That is, is there evidence of technology change or other changes that might make the resulting EKCs more sensitive to income and therefore more likely to improve faster environmentally? Similarly, why do health expenditures experience a turning point *later* than the EKC? Is this time lag the same for all income sub-groups? These are questions that are thrown up in the process of the present study.

The most important question is – can economic growth provide a solution rather than be a problem to the environment? If the EKC is to be generalized for all countries (which it should not), then low-income countries need not worry about environmental degradation with rising incomes because beyond a certain income level, the environment will improve as more and more resources are devoted towards environmental improvement.

But there is more to environmental improvement than simply rise in incomes. Rising incomes do not automatically improve the environment. Important role is played by *how* the rising incomes are utilized and the direction in which the income is diverted. Because of the externalities generated by environmental degradation and given the difficulty in internalizing these externalities, government intervention must be actually „ensured". Policies and institutions that support environmental improvement and make effective use of the market need to be established. Establishment of property rights will also go a long way. Finally, policies and measures that

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impose a price on environmental resources will develop effective markets for such resources.

Despite a trend towards urbanization, majority of population of developing, low-income countries still lives in rural areas. As these economies develop, one of the greatest challenges facing local and regional governments is providing people in rural areas with access to energy. Renewable energy projects - in the form of solar-, wind-, and hydropower-generated electricity - are the key to providing rural areas with energy where power is in short supply. In addition, replacing coal- and other fossil fuel-generated electricity supplied to cities with energy from renewable energy sources could aid in reducing air pollution and help to meet the growing energy needs of the countries‟ large metropolises as well.

If economic growth is good for the environment, policies that stimulate growth (trade liberalization, economic restructuring, energy substitution, and price reform) should be good for the environment. Hopefully, this study will encourage further research into the above issues that try to incorporate policy, institutions and markets into the analysis. The EKC may be further investigated with respect to a single country to chart a time path of its turning point and the time lag of its „catching-up‟ process. For this, a sectoral composition of GDP and nature of production technologies at the micro level would serve as good measures. Till then, we must take the accumulated evidence on EKC only at its face value without generalizing it to be either exhaustive or conclusive in any manner.

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Appendix

List of countries selected for analysis* *(the list may not match the number of observations in the regression because of unavailability of data for some countries, for some variables)*

High-Income countries [GDP per capita > US $ 9000]

1. Antigua & Barbuda	14. Greece	26. New Zealand
2. Australia	15. Hong Kong	27. Norway
3. Austria	16. Iceland	28. Portugal
4. Bahamas	17. Ireland	29. Qatar
5. Bahrain	18. Israel	30. Singapore
6. Barbados	19. Italy	31. Slovenia
7. Belgium	20. Japan	32. Spain
8. Canada	21. Korea, Rep. of	33. Sweden
9. Cyprus	22. Kuwait	34. Switzerland
10. Denmark	23. Luxembourg	35. UAE
11. Finland	24. Malta	36. UK
12. France	25. Netherlands	37. USA
13. Germany		

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Middle-Income countries [GDP per capita ranging from US $ 750 to US $ 9000]

1. Albania	26. Gabon	51. Poland
2. Algeria	27. Grenada	52. Romania
3. Argentina	28. Guatemala	53. Russian Federation
4. Armenia	29. Guyana	54. Saint Kitts & Nevis
5. Belarus	30. Honduras	55. Saint Lucia
6. Belize	31. Hungary	56. St. Vincent & Grenadines
7. Bolivia	32. Iran, Islamic Rep.	57. Western Samoa
8. Bosnia & Herzegovina	33. Jamaica	58. Saudi Arabia
9. Brazil	34. Jordan	59. Seychelles
10. Bulgaria	35. Kazakhstan	60. Slovakia
11. Cape Verde	36. Latvia	61. South Africa
12. Chile	37. Lebanon	62. Sri Lanka
13. China	38. Libyan Arab Jamahiriya	63. Suriname
14. Columbia	39. Lithuania	64. Syrian Arab Rep.
15. Costa Rica	40. Macedonia, TFYR	65. Thailand
16. Croatia	41. Malaysia	66. Tonga
17. Czech Rep.	42. Maldives	67. Trinidad & Tobago
18. Djibouti	43. Mauritius	68. Tunisia
19. Dominica	44. Mexico	69. Turkey
20. Dominican Rep.	45. Morocco	70. Turkmenistan
21. Ecuador	46. Oman	71. Ukraine
22. Egypt	47. Panama	72. Uruguay
23. El Salvador	48. Paraguay	73. Vanuatu
24. Estonia	49. Peru	74. Venezuela
25. Fiji	50. Philippines	

* the list is as reported in the Human Development Report, 2004 of the UNDP.

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Low-Income countries [GDP per capita < US $ 750]

1. Angola	20. Ghana	40. Pakistan
2. Azerbaijan	21. Guinea	41. Papua New Guinea
3. Bangladesh	22. Guinea-.Bissau	42. Rwanda
4. Benin	23. Haiti	43. Sao Tome & Principe
5. Bhutan	24. India	44. Senegal
6. Burkina	25. Indonesia	45. Sierra Leone
7. Burundi	26. Kenya	46. Solomon Island
8. Cambodia	27. Kyrgyzstan	47. Sudan
9. Cameroon	28. Lao PDR	48. Tajikistan
10. Central African Rep.	29. Madagascar	49. Tanzania
11. Chad	30. Malawi	50. Togo
12. Comoros	31. Mali	51. Uganda
13. Congo	32. Mauritania	52. Uzbekistan
14. Congo, Dem. Rep.	33. Moldova, Rep. of	53. Vietnam
15. Cote d'Ivoire	34. Mongolia	54. Yemen
16. Equatorial Guinea	35. Mozambique	55. Zambia
17. Eritrea	36. Nepal	56. Zimbabwe
18. Ethiopia	37. Nicaragua	
19. Gambia	38. Niger	
	39. Nigeria	

