Environment and Development Economics 2 (1997): 369–381

Environmental Kuznets Curve Special Issue

Introduction to the environmental Kuznets curve special issue

EDWARD B. BARBIER
Environment Department, University of York, Heslington, York YO1 5DD, UK

ABSTRACT. This short piece introduces the special issue on environmental Kuznets curves (EKC)—the hypothesized 'inverted-U' relationship between levels of environmental degradation and per capita income. Although the analysis of EKC relationships has been a relatively recent phenomenon, there is widespread interest on the part of academics in this analysis, and on the part of policymakers in the resulting implications for environment and development. The following introduction outlines the contributions to EKC analysis of the papers comprising the special issue. This is done in two ways: first, the empirical results of the special issue papers are compared with previous analyses of the EKC relationships; and second, the additional insights offered by the special issue papers on EKCs are discussed.

Introduction: Why the interest in environmental Kuznets curves?[1]

The environmental Kuznets curve (EKC) hypothesis maintains that there exists an 'inverted-U' shaped relationship between a variety of indicators of environmental pollution or resource depletion and the level of per capita income.[2] That is, environmental degradation will initially increase,

[1] I am grateful for comments provided by Charles Perrings on the following introductory paper and his support throughout for this Special Issue on environmental Kuznets curves in *Environment and Development Economics*. I also thank Lynne Fiddy and Susan Davis for their editorial assistance and, of course, all the authors for their excellent contributions to this special issue.

[2] The origins of the environmental Kuznets curve hypothesis are somewhat ambiguous, and appear to be the product of numerous studies conducted simultaneously in the early 1990s. Most sources point to the analysis by Grossman and Kreuger (1993) of air quality measures in a cross-section of countries for different years, which was part of a wider investigation into whether the claims that the economic growth accompanying the North American Free Trade Agreement might foster greater environmental degradation. Similarly, the study by Shafik (1994) was originally a background paper for the World Bank's enquiry into growth and environment relationships for *World Development 1992* (World Bank, 1992). Finally, Panayotou (1995) offers 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' in analysis conducted for the World Employment Programme of the International Labour Office in 1992.

but eventually declines, as per capita income increases. This EKC relationship draws its inspiration from the income distribution theory developed by Kuznets (1955), who found an 'inverted-U' relationship between an indicator of income inequality and the level of income.

Although interest in the possibility of EKC relationships for a variety of environmental indicators has really emerged only in the 1990s, the debate over EKCs is likely to continue for some time. There are several reasons for this.

First, the EKC relationship is a falsifiable hypothesis that can and will continue to be tested by a variety of empirical investigations. Thus, an increasing number of studies are attempting to examine through different analytical methodologies whether the EKC hypothesis holds for a variety of indicators of environmental damage or resource depletion, both over time and across countries, regions, states, districts and even cities.

Second, the EKC hypothesis poses an important intellectual challenge. Explanations as to why environmental degradation should first increase then decline with income have focused on a number of underlying relationships, including:

- the effects of structural economic change on the use of the environment for resource inputs and to assimilate waste;
- the link between the demand for environmental quality and income;
- types of environmental degradation and ecological processes.

It is not clear that we understand fully these critical relationships, nor is it clear which ones—if any—explain why we might observe an EKC relationship. For example, many of the original explanations of the EKC hypothesis focused on changes in the composition of goods and services due to structural shifts in the economy, the efficiency of resource use, the composition of inputs and technological innovation. However, increasingly it has been recognized that the effect of such changes on environment–income links are not exogenous processes but influenced by policy choices (Panayotou, 1995; Stern *et al.*, 1996; World Bank, 1992). Similarly, previous conjecture that the environmental quality is simply a 'luxury good', i.e., the demand for improved environmental quality increases more than proportionately with income, is proving difficult to substantiate (McConnell, 1997). In addition, it has been suggested that EKC relationships may hold only for certain types of environmental damage, e.g., pollutants with more short-term and local impacts rather than those with more global and long-term impacts (Arrow *et al.*, 1995; Cole *et al.*, 1997; Selden and Song, 1994).

Finally, and perhaps most importantly, the EKC hypothesis has revived interest in the long standing debate over the environmental implications of economic growth (Ansuategi *et al.*, 1997). Some commentators have argued that the empirical evidence on EKC relationships supports the general proposition that the solution to combating environmental damage is economic growth itself (Beckerman, 1992). Others have been more cautious, noting that conclusive evidence of an EKC relationship applies only to a few pollutants, thus making it difficult to use this evidence to speculate more generally about growth–environment linkages (Arrow *et al.*, 1995).

Still others have pointed out that, even for those pollutants displaying EKC characteristics, aggregate global emissions are projected to rise over time, demonstrating that the existence of an EKC relationship for such pollutants does not necessarily imply that, at the global level, any associated environmental damage is likely to disappear with economic growth (Selden and Song, 1994; Stern *et al*., 1996). Policymakers are following this renewed debate with interest: for them, the critical policy issue is whether economic growth should continue to be the main priority, with protection of the environment a secondary consideration to be addressed mainly in the future, or whether explicit policies to control environmental degradation at the local, national and global level are urgently required today.

The contribution of this special issue

The selection of papers comprising this special issue touches on all three aspects of the EKC debate indicated above.

Several of the papers provide new empirical estimations of the EKC relationship, for different countries and indicators. For example, Cole *et al*. (1997) employ broad cross-country panel data to examine whether the EKC hypothesis is empirically valid for a wide range of environmental indicators, attempting in the process to correct a number of econometric weaknesses identified in previous EKC analyses (Grossman and Kreuger, 1995; Stern *et al*., 1996). Cole *et al*. also test the subsidiary hypothesis that pollutants with a local short-term impact (e.g., suspended particulate matter) will have estimated turning points at lower per capita income than those environmental indicators whose impact is more global in nature (e.g., carbon dioxide).

However, EKC relationships that are estimated across countries may not necessarily be valid for individual countries. Thus also included in this special issue are new analyses for a developed country (United States) by Carson *et al.* (1997) and for a rapidly industrializing developing country (Malaysia) by Vincent (1997). Equally, not all indicators of environmental degradation fit the EKC hypothesis. One of the most notorious for conflicting results has been carbon dioxide (CO_2) emissions. Thus Moomaw and Unruh (1997) use both structural transition models and more conventional EKC models to investigate the relationship between CO_2 emissions and income levels across countries and time.

Some of the papers in this special issue attempt to explore critical relationships thought to underlie the EKC hypothesis. For example, McConnell (1997) addresses the relationship between the demand for environmental quality and income by looking at the combined effect of preferences, increasing costs of pollution control and the marginal utility of consumption in a growing economy in order to decompose the reduced form effect of income on pollution. He also assesses the microeconomic literature on the demand for environmental quality for evidence of support for the EKC hypothesis. Komen *et al*. (1997) examine another important relationship believed to underlie the EKC relationship—the role of rising incomes in promoting development of new technologies directed toward environmental improvements. This effect is analysed through empirical estimation of the income elasticity of public research and development funding for environmental protection across 19 OECD countries over 1980–94.

Finally, Panayotou (1997) and de Bruyn (1997) attempt to 'decompose' the structural economic factors influencing emissions of an important pollutant that does appear to exhibit an EKC relationship—sulphur dioxide (SO_2). Panayotou separates the cross-country EKC relationship for SO_2 into its pure income, scale and sectoral composition effects, as well as testing independently for the impacts of the rate of growth and a policy variable (enforcement of contracts). Decomposition analysis is used by de Bruyn to determine whether structural change or technological innovation has been the main influence behind declining SO_2 emissions in the Netherlands and West Germany. He also analyses whether multilaterally negotiated emission targets for SO_2 reduction are related to per capita income.

The environmental Kuznets curve: recent evidence

Empirical analyses of the EKC have focused on two key pieces of evidence:

- whether a given indicator of environmental degradation displays an 'inverted-U' relationship with levels of per capita income;
- the calculation of the 'turning point', the level of per capita income at which the EKC 'peaks'—i.e. where a marginal change in the indicator of environmental degradation is zero.

Table 1 summarizes recent findings of empirical analyses of the EKC relationship across a variety of environmental degradation indicators. The contributions of the papers in this special issue are indicated in bold in the table. The results depicted in Table 1 confirm that the EKC hypothesis appears to hold for some, but not all, environmental indicators. The analyses conducted in this special issue also support this general conclusion.

The EKC hypothesis seems mainly to be valid for air pollution indicators, with perhaps the exception of CO_2 emissions. The evidence for SO_2 in particular, and to a lesser extent solid particulate matter (SPM), supports the existence of an EKC for these pollutants. However, the results across all countries may not necessarily be valid for individual countries. For example, Vincent (1997) found SPM to be increasing with income in Malaysia, whereas Carson *et al.* (1997) find that all major air pollutants decline with increasing levels of income across the 50 US states. Several studies have found that CO_2 emissions are less likely to conform to the EKC hypothesis. The analysis by Moomaw and Unruh (1997) shows that the correlation between CO_2 emissions and per capita GDP is affected by structural economic conditions across countries, and in particular three countries—Canada, Luxembourg and the United States—may explain the resulting 'N-shaped', or cubic, relationship between CO_2 and income for a subset of 16 OECD countries.[3]

[3] However, as indicated in Table 1, Carson *et al.* (1997) found that in their cross-sectional analysis of the United States, greenhouse gases generally decline with state-level per capita income. They obtained very similar results when only CO_2 was analysed. This result may confirm rather than refute the analysis of Moomaw and Unruh (1997) that suggests that the income–CO_2 relationship in the United States may be due to that economy's unique structural transition.

Table 1. *Summary of recent estimates of environmental Kuznets curve relationships*

Environmental indicator	*EKC (inverted U shape)*	*Increasing*	*Decreasing*	*Constant*	*Cubic (N Shape)*
1. Air pollution					
Sulphur dioxide (SO_2)	S, GK1, GK2, SS[1], P1[1], **CRB**[1], **P2**		**CJM**[1,7]		
SPM	S, SS[1], P1[1], **CRB**[1]	**V**[6]	GK1, **CJM**[1,7]		
Heavy particles			GK2		
Smoke	GK2				
Dark matter	GK1				
Nitrogen oxides (NO_x)	SS[1], P1[1], **CRB**[1]		**CJM**[1,7]		
Carbon monoxide (CO)	SS[1], **CRB**[1]		**CJM**[1,7]		
Carbon dioxide (CO_2)	HS, **CRB**[1,5]	S[1]			**MU**[1,4]
CFCs	**CRB**[1,8]		**CRB**[1,9]		
GHGs			**CJM**[1,7]		
Air toxics			**CJM**[1,7]		
VOC			**CJM**[1,7]		
2. Water pollution					
Faecal coliform	GK2				S
BOD	GK2				
COD	GK2				
Total coliforms					GK2
Lead			GK2		
Cadmium				GK2	
Arsenic	GK2				
Nitrates	**CRB**[5]				
Ammoniacal nitrogen		**V**[6]			
pH		**V**[6]			
3. Deforestation					
Global	P1, AH				
Regional	CG[2]				
4. Others					
Lack of clean water			S		
Lack of urban sanitation			S		
Municipal waste		S[1], **CRB**[1]			
Heavy metals	R[3]				
Toxic intensity	HLW[3]				
Energy	**CRB**[1,5]				
Traffic volumes	**CRB**[1,5]				

Empirical results from this special issue are indicated in bold. Although some of the studies have analysed other environmental indicators, only those indicators displaying statistically significant relationships with income per capita are included in the table.
Notes: [1] Per capita indicator. [2] Significant for African and Latin American tropical countries but not for tropical Asia. [3] Per GDP indicator. [4] Based on 16 OECD countries, including Canada, Luxembourg and the United States. [5] High turning point with large standard error in the quadratic log form. Nitrate indicator is in mg N/litre. [6] Analysis of a single developing country, Malaysia. [7] Analysis of a single developed country, United States. [8] Includes halons. Log quadratic function, for 1990 only. [9] Includes halons. Log linear function, for 1986 only.
Key to indicators: BOD = biological oxygen demand, CFCs = chlorofluorocarbons, COD = chemical oxygen demand, GHGs = greenhouse gases, SPM = suspended particulate matter, VOC = volatile organic carbon.
Key to studies: AH = Antle and Heidebrink (1995), CJM = Carson *et al.* (1997), CRB = Cole *et al.* (1997), CG = Cropper and Griffiths (1994), GK1 = Grossman and Kreuger (1993), GK2 = Grossman and Kreuger (1995), HLW = Hettige *et al.* (1992), HS = Holtz-Eakin and Selden (1995), MU = Moomaw and Unruh (1997), P1 = Panayotou (1995), P2 = Panayotou (1997), R = Rock (1996), SS = Selden and Song (1994), S = Shafik (1994), V = Vincent (1997).
Source: Based on Ansuategi *et al.* (1997), McConnell (1997) and cited studies.

The evidence for water pollution is more mixed. Many studies appear to have difficulty in finding any significant relationship between water pollution indicators and income, although there is evidence of an EKC-type relationship for biological oxygen demand (BOD), chemical oxygen demand (COD), arsenic and nitrates (see Table 1). Dissolved oxygen and lead may actually decline with income levels. However, for rapidly industrializing Malaysia, Vincent (1997) has found that two water pollution indicators, ammoniacal nitrogen and pH, are actually increasing with income.

Perhaps the most significant resource depletion indicator that has been examined for evidence of an EKC relationship has been deforestation. As indicated in Table 1, some studies provide evidence that deforestation conforms to the EKC hypothesis; however, others have found it difficult to establish a relationship between indicators of deforestation and income (Shafik, 1994). A major difficulty in conducting an EKC analysis for deforestation is the poor time and cross-sectional data on the two main indicators, changes in forest area and annual deforestation rates, particularly for tropical developing countries (Ansuategi *et al.*, 1997; Barbier and Burgess, 1997; Cropper and Griffiths, 1994).

A myriad of other environmental indicators have also been examined for evidence of an EKC-type relationship. With the exception of heavy metals and a measure of toxic intensity, these indicators generally do not appear to support the EKC hypothesis (see Table 1).

Table 2 displays various turning point levels of income calculated for those environmental indicators for which an EKC has been estimated. Analysis of EKC turning points can provide two important pieces of information:

- The estimated level of per capita income associated with the turning point can be compared with the actual income levels of the observed data set, thus indicating whether the turning point income falls within or outside the observed income range.
- Analysis of the stability of the turning point can also shed light on the reliability of the EKC estimates.

To place the turning point estimates of Table 2 in perspective, the 1992 per capita income in constant 1985 US dollars was $408 in Chad, $1,282 in India, $12,724 in the United Kingdom and $17,945 in the United States (Cole *et al.*, 1997; Summers and Heston, 1991). It therefore follows that the majority of countries in the world—and certainly virtually all developing countries—are clearly at per capita income levels to the left of the peak turning points reported in Table 2. For example, in the recent analysis by Cole *et al.*, (1997), none of the estimated EKC turning points for environmental indicators are below the minimum income level of the sample of countries analysed and the turning points for nitrates, carbon dioxide, energy consumption and traffic volumes are well outside the income range of the countries analysed.[4] In the case of deforestation rates for tropical

[4] With the exception of carbon dioxide, methane and CFCs and halons, the analysis of Cole *et al.* (1997) is applied to advanced economy members of the Organization of Economic Cooperation and Development (OECD). As the authors note, for their OECD data sets, the minimum and maximum 1992 levels of per capita income in constant 1985 US dollars are $2,202 and $18,095 respectively.

Table 2. *Estimated turning points for selected environmental Kuznets curves studies (US$)*

1. Air pollution

	SO_2	*SPM*	NO_x	*CO*	CO_2	*CFCs*
Studies						
CRB[1]	**6,900**	**7,300**	**14,700**	**9,900**		**12,600**
GK1	4,107					
GK2	4,053					
HS					35,428	
MU[1,2]					**12,800**	
P1[1]	3,000	4,500	5,500			
P2	**5,000**					
SS[1]	10,700	9,600	21,800	19,100		
S	3,670	3,280				

2. Water pollution

	Faecal coliform	*BOD*	*COD*	*Arsenic*	*Nitrates*
Studies					
CRB[1,3]					**15,600**
GK2	7,955	7,623	7,853	4,900	

3. Deforestation

	Global	*Latin America*	*Africa*
Studies			
AH	2,049		
CG		5,420	4,760
P1	823		

4. Others

	Heavy metals	*Toxic intensity*
Studies		
HLW[4]		12,790
R[4]	10,800	

Empirical results from this special issue are indicated in bold. All estimates in US$ 1985 except for AH, HLW and P1.
Notes: [1] Per capita indicator. [2] 16 OECD countries, including Canada, Luxembourg and the United States; first turning point in the N-shaped curve. [3] Quadratic estimation. For quadratic log estimation the turning point is US$25,000. [4] Per GDP indicator.
Key to indicators: See Table 1.
Key to studies: AH = Antle and Heidebrink (1995), CRB = Cole *et al*. (1997), CG = Cropper and Griffiths (1994), GK1 = Grossman and Kreuger (1993), GK2 = Grossman and Kreuger (1995), HLW = Hettige *et al*. (1992), MU = Moomaw and Unruh (1997), P1 = Panayotou (1995), P2 = Panayotou (1997), R = Rock (1996), SS = Selden and Song (1994), S = Shafik (1994).

countries, Cropper and Griffiths (1994) found that per capita income levels of most countries in Latin America and Africa were to the left of the respective peaks reported in Table 2.

The fact that turning point levels of income estimated for most EKC curves are generally high, and that the current global distribution of income is far from normal, suggests that most countries have not yet reached levels of per capita income for which environmental improvement is likely to occur. The implications are a worsening global problem of environmental degradation, even for those environmental indicators that display EKC relationships.

To illustrate this, Stern *et al.* (1996) project EKC estimates for sulphur dioxide and deforestation based on aggregation of individual country projections. The resulting medium-term projections show a rise in both indicators through the medium term. For example, total global emissions of SO_2 rise from 383 million tonnes in 1990 to 1,181 million tonnes in 2025, or from 73 to 142 kg per capita. Global forest cover declines from 40.4 million km^2 in 1990 to a minimum of 37.2 million km^2 in 2016, and then increases slightly to 37.6 million km^2 in 2025; however, tropical forests decline from 18.4 to 9.7 million km^2 over this period. Selden and Song (1994) conduct similar projections for the four air pollutants for which they estimate an EKC relationship, SO_2, SPM, nitrogen dioxides (NO_x) and carbon monoxide (CO). Their results show world emissions increasing for all four pollutants through 2025, and for SPM and NO_x, emissions rise through 2050.

Finally, confidence in many estimated EKC relationships is weakened if the turning points prove to be very unstable. Cole *et al.* (1997) analyse the turning points for their estimated EKC indicators and find that the standard errors are extremely large for carbon dioxide, nitrates, energy and traffic volumes. Thus it is possible that these indicators do not necessarily follow an EKC relationship.

The environmental Kuznets curve: explaining the results

A number of important lessons for the EKC debate are already emerging from the literature. In this regard, the papers from this special issue have clearly made an important contribution.

The role of structural economic change

Several papers in this issue have sought to explore explicitly structural economic factors that might underlie EKC relationships. For example, Komen *et al.* (1997) find that the income elasticity of public research and development funding for environmental protection is positive and may be approximately equal to unity for 19 OECD countries over the 1980–94 period. This result indicates the key role of such public investments for environmental improvements in reducing environmental degradation as income levels rise and could explain the strong EKC and even decreasing relationships found for some pollution indicators in OECD countries. In his decomposition of the EKC for sulphur dioxide emissions across countries, Panayotou (1997) examines explicitly the effect of shifts in the sectoral structure of the economy, as represented by industry's share of GDP. The income-induced SO_2 abatement effect appears to be greater as the industrial share of GDP rises; however, with industry shares of around 20–30 per cent, SO_2 emissions appear to rise to their highest levels. In comparison, de Bruyn (1997) finds that structural change is less important than technological innovation, represented by the change in the emission intensity across sectors, in explaining declining SO_2 emissions in the Netherlands and West Germany. In interpreting these results, de Bruyn acknowledges that these two developed countries have fairly stable production structures, whereas in rapidly industrializing and developing countries the effects of structural change on emissions may be less obvious. Finally, Moomaw and Unruh (1997) demonstrate that the high correlation between CO_2 and income in most EKC analyses is largely attributable to structural economic transition, and only 16 countries—a subset of OECD member states—show a significant 'break' in this positive CO_2/GDP correlation. Moreover, the N-shaped or cubic relationship between CO_2 and income for these countries is largely attributable to Canada, Luxembourg and the United States, which appear to have undergone similar economic transitions.

Income and the demand for environmental quality

The paper by McConnell (1997) casts doubt on whether the assumption that environmental quality is a 'luxury good' is an adequate explanation of observed EKC relationships for some pollutants. First, through the construction of a simple model, he shows that preferences that are consistent with high income elasticity of demand for environmental quality are neither necessary nor sufficient for yielding an EKC-type income–pollution relationship. Other factors, such as abatement costs or the impact of pollution on production may over-ride income elasticity effects on the demand for environmental quality. For example, it is feasible for pollution to decline with a zero income elasticity of demand for environmental quality, or to increase with a high income elasticity of demand for environmental quality. Moreover, microeconomic environmental valuation studies do not offer conclusive evidence in support of a high income elasticity of demand for environmental quality. Environmental quality is not a homogenous commodity; for some environmental 'goods' the income effect is difficult to detect, for others (e.g., water quality) there is some evidence of zero or even negative effects, and, finally, for some pollutants, higher-income households may be more willing to protect themselves through averting or defensive expenditures rather than be willing to pay for greater public intervention.

Local versus global pollution

The results summarized in Tables 1 and 2 appear to confirm the view that EKC relationships are more likely to hold for certain types of environmental damage, e.g., pollutants with more short-term and local impacts, rather than those with more global, indirect and long-term impacts (Arrow *et al*., 1995; Cole *et al*., 1997; Selden and Song, 1994). For example, the paper by Cole *et al*. (1997) sets out explicitly to test this proposition. The results suggest that significant EKCs exist only for local air pollution, e.g., sulphur dioxide, suspended particulate matter, nitrogen oxides and carbon monoxide, and also support the hypothesis of Selden and Song (1994) that urban air concentrations will peak at lower income levels than total per capita emissions. In contrast, environmental indicators with a more global or indirect impact, e.g., carbon dioxide, municipal waste, energy consumption and traffic volumes, either increase monotonically with income or else have high turning points with large standard errors. However, even for local air pollutants, estimated turning points for transport sources of emissions are generally higher than for total emissions, indicating in particular the need to tackle emissions generated by the transport sector.

Country specific effects

Stern *et al.* (1996) concluded that ‘a more fruitful approach to the analysis of the relationship between economic growth and environmental impact would be the examination of the historical experience of individual countries, using econometric and also qualitative historical analysis.’ The diametrically opposite results for Malaysia and the United States reported in Table 1 would support this view. For example, reviewing their cross-sectional analysis of the United States in light of recent developments, Carson *et al.* (1997) suggest that the large differences in state-level per capita emissions could be attributable to marked differences across states in allowing particular types of point sources to be built up in the first place, in enforcing federal pollution laws and, possibly most importantly, in employing outdated industrial technology. Vincent (1997) indicates that the increasing relationship between SPM and income in Malaysia may be due to the fact that low-income states are still sources of emissions because of land conversion through burning and replanting of tree crops, while at the same time high-income states are emitting increasing emissions because of industrial processing and the burning of industrial and municipal wastes. Rapid urbanization and industrialization, which are correlated with rising income in Malaysia, are responsible for the increasing concentrations of ammoniacal nitrogen and pH in water, as the expansion of municipal and industrial sewage treatment has lagged behind.

The role of national and local policy

Virtually all EKC studies have concluded with the observation that any income–environmental degradation relationship is likely to be affected significantly by national and local polices. Several studies in this issue have attempted to estimate the influence of policy explicitly. Panayotou (1997) has found that improved policies and institutions in the form of more secure property rights, better enforcement of contracts and effective environmental regulations can help to ‘flatten’ the EKC for sulphur dioxide across countries. In the case of the Netherlands and West Germany, the impact of technological change in reducing SO_2 emissions is largely attributable to the instalment of better end-of-pipe abatement technology, which is in turn related to tougher environmental policy and regulation (de Bruyn, 1997). The implications of the findings by Komen *et al.* (1997) are that increased public spending on environmental research and development as income levels rise may not only directly account for greater environmental improvement but also act as a catalyst for private spending on development of cleaner technologies. Carson *et al.* (1997) have concluded that the absolute level of income of a US state appears significant in determining the ‘zeal and effectiveness’ of its air pollution regulatory structure, mainly because a richer state is likely to have more resources available to regulatory agencies, higher public preferences for improved air quality and a greater perceived danger from emissions.

The role of multilateral policy

Cole *et al.* (1997) provide evidence that a multilateral policy initiative may prove highly significant in influencing the relationship between per capita income and an environmental problem with global effects, in this case emissions of CFCs and halons. The authors find that a log-linear function for emissions in 1986 is increasing across countries, reflecting the fact that in 1986 countries may have been reluctant to reduce unilaterally their emissions of CFCs and halons. However, the 1987 Montreal Protocol committed signatories to reduce the use of CFCs and halons substantially, and as a result, the authors' estimate for emissions in 1990 shows an EKC-type relationship, with a turning point of US$12,600. However, the willingness of countries to agree stricter environmental targets through multilateral agreements may also be influenced, at least partly, by their levels of per capita income. For example, de Bruyn (1997) shows that countries with higher per capita income have agreed stricter environmental targets, although a 'dirtier' environment (in terms of higher emissions/km^2) is a more important factor.[5]

Conclusion: implications for the EKC debate

As the studies of this special issue demonstrate, EKC analysis has developed rapidly from simply estimating EKC relationships to attempting to analyse some of the underlying factors behind such relationships. In the process, these studies and other recent analyses have shed more light on the wider 'growth versus the environment' debate that has been revived by EKC analysis.

However, the first lesson to be learned from these studies is that they offer very little support for the strong policy conclusion that economic growth alone is the solution to all environmental problems; rather, it is clear from the EKC literature that specific policies to protect the environment are necessary to reduce environmental degradation problems that are imposing real welfare losses. Or, as Arrow *et al.* (1995) have succinctly put it: 'Economic growth is not a panacea for environmental quality; indeed it is not even the main issue.'

On the other hand, the EKC literature does offer some evidence that for certain environmental problems, particularly air pollutants with localized or short-term effects, there is an eventual reduction in emissions associated with higher per capita income levels, which may be attributable to the 'abatement effect' that arises as countries become richer (Panayotou, 1997). Also, both the willingness and the ability of political jurisdictions to engage in and enforce improved environmental regulations, to increase public

[5] With the exception of the United States, the 27 countries analysed by de Bruyn (1997) are signatories of the Second Sulphur Protocol, which agreed national targets for emissions reductions by 2000. The national target for the United States was estimated from the agreement on reductions in emissions from power plant sources.

spending on environmental research and development or even to engage in multilateral agreements to reduce emissions may also increase with per capita income levels (Carson *et al*., 1997; de Bruyn, 1997; Komen *et al*., 1997). However, it requires a great leap of faith to jump from these results to the conclusion that economic growth on its own will foster environmental improvement automatically. As Panayotou (1997) has concluded, 'when all effects are considered, the relationship between growth and the environment turns out to be much more complex with wide scope for active policy intervention to bring about more desirable (and in the presence of market failures) more efficient economic and environmental outcomes.'

This conclusion holds even more true for low-income and rapidly industrializing developing countries, the current per capita income levels of which are usually well below the levels associated with the turning points of most estimated EKCs. The implication is that, in the absence of national and multilateral policy interventions, environmental degradation will continue to decline in these countries as per capita income increases, at least over the medium term. In this regard, the final observation of Vincent (1997) holds generally: 'The lack of evidence of EKCs in Malaysia does not prove that EKCs do not exist anywhere. It does indicate, however, that policy makers in developing countries should not assume that economic growth will automatically solve air and water pollution problems.'

References

Ansuategi, A., E.B. Barbier and C.A. Perrings, (1997) 'The environmental Kuznets curve'. Paper presented at the USF Workshop 'Economic Modelling of Sustainable Development: Between Theory and Practice', Free University, Amsterdam, 20 December 1996.

Antle, J.M. and G. Heidebrink (1995), 'Environment and development: theory and international evidence', *Economic Development and Cultural Change* **43**(3): 603–625.

Arrow, K., B. Bolin, R. Costanza, P. Dasgupta, C. Folke, C.S. Holling, B-O. Jansson, S. Levin, K-G. Mäler, C.A. Perrings and D. Pimentel (1995), 'Economic growth, carrying capacity, and the environment', *Science* **268**: 520–521.

Barbier, E.B. and J.C. Burgess (1997), 'The economics of tropical forest land use options', *Land Economics* **73**(2): 174–195.

Beckerman, W. (1992), 'Economic growth and the environment: whose growth? whose environment?', *World Development* **20**: 481–496.

Carson, R.T., Y. Jeon and D.R. McCubbin (1997), 'The relationship between air pollution emissions and income: US data', Special Issue on Environmental Kuznets Curves, *Environment and Development Economics* **2**(4): 433–450.

Cole, M.A., A.J. Rayner and J.M. Bates (1997), 'The environmental Kuznets curve: an empirical analysis', Special Issue on Environmental Kuznets Curves, *Environment and Development Economics* **2**(4): 401–416.

Cropper, M. and C. Griffiths (1994), 'The interaction of population growth and environmental quality', *American Economic Review* **84**(2): 250–254.

De Bruyn, S.M. (1997), 'Explaining the environmental Kuznets curve: structural change and international agreements in reducing sulphur emissions', Special Issue on Environmental Kuznets Curves, *Environment and Development Economics* **2**(4): 485–503.

Grossman, G.M. and A.B. Kreuger (1993), 'Environmental impacts of a North

American Free Trade Agreement', in P. Garber, ed., *The US–Mexico Free Trade Agreement*, Cambridge, MA: MIT Press.

Grossman, G.M. and A.B. Kreuger (1995), 'Economic growth and the environment', *Quarterly Journal of Economics* **110**(2): 353–377.

Hettige, H., R.E.B. Lucas and D. Wheeler (1992), 'The toxic intensity of industrial production: global patterns, trends and trade policy', *American Economic Review* **82**(2): 478–481.

Holtz-Eakin, D. and T.M. Selden (1995), 'Stoking the fires? CO_2 emissions and economic growth'. *Journal of Public Economics* **57**: 85–101.

Komen, M.H.C., S. Gerking and H. Folmer (1997), 'Income and environmental R&D: empirical evidence from OECD countries', Special Issue on Environmental Kuznets Curves, *Environment and Development Economics* **2**(4): 505–515.

Kuznets, S. (1955), 'Economic growth and income inequality', *American Economic Review* **49**: 1–28.

McConnell, K.E. (1997), 'Income and the demand for environmental quality', Special Issue on Environmental Kuznets Curves, *Environment and Development Economics* **2**(4): 383–399.

Moomaw, W.R. and G.C. Unruh (1997), 'Are environmental Kuznets curves misleading us? The case of CO_2 emissions', Special Issue on Environmental Kuznets Curves, *Environment and Development Economics* **2**(4): 451–463.

Panayotou, T. (1995), 'Environmental degradation at different stages of economic development', in I. Ahmed and J.A. Doeleman, eds., *Beyond Rio: The Environmental Crisis and Sustainable Livelihoods in the Third World*, London: Macmillan Press.

Panayotou, T. (1997), 'Demystifying the environmental Kuznets curve: turning a black box into a policy tool', Special Issue on Environmental Kuznets Curves, *Environment and Development Economics* **2**(4): 465–484.

Rock, M. (1996), 'Pollution intensity of GDP and trade policy: can the World Bank be wrong?', *World Development*. **24**: 471–479.

Selden, T.M. and D. Song (1994), 'Environmental quality and development: is there a Kuznets curve for air pollution emissions?', *Journal of Environmental Economics and Management* **27**: 147–162.

Shafik, N. (1994), 'Economic development and environmental quality: an econometric analysis', *Oxford Economic Papers* **46**: 757–773.

Stern, D., M.S. Common and E.B. Barbier (1996), 'Economic growth and environmental degradation: the environmental Kuznets curve and sustainable development', *World Development* **24**(7): 1151–1160.

Summers, R. and A. Heston (1991), 'The Penn world table (mark 5): an expanded set of international comparisons, 1950–1988', *Quarterly Journal of Economics* **106**(2): 327–368.

Vincent, J.R. 'Testing for environmental Kuznets curves within a developing country', Special Issue on Environmental Kuznets Curves, *Environment and Development Economics* **2**(4): 417–431.

World Bank (1992), *World Development Report 1992*, New York: Oxford University Press.