Environment and Development Economics 2 (1997): 357–367
Copyright © 1997 Cambridge University Press

Summaries

Introduction to the environmental Kuznets curve special issue

EDWARD B. BARBIER

This special issue is concerned with environmental Kuznets curves (EKC)—the hypothesis that there is an 'inverted-U' relationship between various indicators of environmental degradation and levels of per capita income. 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.

Finally, the recent EKC literature has revived interest in the long-standing 'growth versus environment' policy debate.

Some recent estimates of EKC relationships for a variety of environmental indicators are depicted in Table 1, with the contributions of this Special Issue indicated in bold. These results confirm that EKC relationships hold for some, but not all, environmental indicators—fitting best for air pollution and a few water pollution indicators. Table 2 shows the income levels associated with the turning point, or 'peaks' of estimated EKCs. The fact that the turning points 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. In addition, some of the turning points appear to be unstable, suggesting that the EKCs may not be accurate representations of environment–income relationships.

The studies of this special issue point to several key factors underlying the observed EKC relationships. Structural economic change and transition, technological improvements and increased public spending on environmental R&D as incomes rise may play an important role. However, it is difficult to substantiate the view that the demand for environmental

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

quality rises with per capita income, which is often invoked as the explanation for EKC relationships. In addition, such relationships are more likely to hold for certain types of environmental damage, e.g., pollutants with more short-term and local impacts, than those with more global, indirect and long-term impacts. Environment–income relationships also vary considerably across countries; for example, air pollutants decrease with per capita income across US states, but in Malaysia, indicators of environmental degradation are still increasing with income. Nevertheless, there appears to be significant scope to change environment–income relationships through local, national and multilateral policy, and there is some evidence that the propensity to improve environmental policy and regulations will increase with rising incomes.

Overall, both existing EKC studies and the papers of this issue offer little support for the conclusion that economic growth alone can 'solve' environmental problems. There is wide scope for active policy intervention to reduce environmental degradation, particularly in rapidly industrializing and developing countries.

Income and the demand for environmental quality

KENNETH E. McCONNELL

Empirical research has shown that, as countries have grown over the last three decades, certain pollutants such as sulphur dioxide and nitrous oxides have tended to increase and then decrease with growing per capita income. This empirical relationship has come to be known as the environmental Kuznets curve (EKC). The EKC has strong implications for future pollution in local and global settings. A large part of the globe now experiences per capita incomes below the level at which, from the empirical evidence, they might be expected to suffer greater pollution with growing incomes. Yet the EKC predicts that poorer countries can anticipate eventually declining levels of pollutants.

Much of the discussion surrounding the EKC relates to household preferences for environmental quality. If these preferences are such that the damage from extra pollution grows as income grows, then we can say that preferences are consistent with a high income elasticity of demand for environmental quality. This paper looks at the combined effect of preferences, increasing costs of pollution control and the declining value of extra consumption as per capita incomes grow in an attempt to understand the

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

relationship between pollution and per capita income. Because preferences are only one of several influences on the relationship between pollutants and per capita income, the paper is able to show that a high income elasticity of demand for environmental quality is neither necessary nor sufficient for the EKC. The relationship between pollution and per capita income is governed not only by preferences but by the assimilative capacity of the environment and the cost of abating pollution as incomes grow.

There is a large body of research on the demand for environmental quality in the non-market valuation literature. This body of literature was surveyed to determine the congruence with the EKC results in general, and to find support for income effects in the demand for environmental quality in particular. For several reasons, including the difficulty in measuring income and isolating its effect on the demand for environmental quality and the fact that households are able to reduce the influence of environmental quality by making defensive expenditures, this body of literature does not provide strong support for the EKC.

The environmental Kuznets curve: an empirical analysis

M.A. COLE, A.J. RAYNER and J.M. BATES

This paper examines a wide range of environmental indicators using cross-country panel data sets and assesses whether environmental Kuznets curves (EKCs) exist for all such indicators—an issue raised by Arrow *et al.* The manner in which this has been done improves on many existing studies by using a larger number of environmental indicators and more recent data; by correcting for autocorrelation and heteroscedasticity in the estimation procedure; by calculating standard errors at the turning-point level of income to indicate the reliability of estimates; and by testing for simultaneity to ensure that no such bias was present in the estimates. These refinements overcome at least some of the weaknesses associated with the estimation of EKCs outlined by Stern *et al.*

In assessing whether EKCs exist for all environmental indicators, the paper also tests a subsidiary hypothesis that global pollutants will only peak within the observed income range if they have been subjected to a multilateral policy initiative. Three other hypotheses are also tested: first, that concentrations of local pollutants in urban areas peak at a lower per capita income level than total emissions per capita; second, that emissions

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

per capita of transport generated local air pollutants will peak at a higher per capita income level than total emissions per capita of the same local air pollutants; finally, that indirect environmental indicators, such as energy use or traffic volumes, will have a similar relationship with per capita income as global air pollutants, even though these indicators may be responsible for serious environmental problems.

Results suggest that meaningful EKCs only exist for local air pollutants, whilst indicators with a more global, or indirect, environmental impact either increase monotonically with income or else have turning points at high per capita income levels with large standard errors—unless they have been subjected to a multilateral policy initiative. All other hypotheses are also supported, and suggestions regarding the necessary future direction of environmental policy are made.

Testing for environmental Kuznets curves within a developing country

JEFFREY R. VINCENT

Studies of the association between pollution and income have tended to analyse cross-country data for a sample of developing and developed countries. The studies have found evidence of the existence of 'environmental Kuznets curves' (inverted U-shaped relationships; EKCs) for several pollutants. An alternative empirical approach is to analyse the relationship between pollution and income over time in an individual country. This paper presents such an analysis for Malaysia, which has more data on environmental quality than perhaps any other developing country. Moreover, Malaysia's economy has been one of the fastest growing in the world since the 1970s.

The analysis in the paper proceeds along two lines. First, for both air and water pollution, aggregate data on Malaysian pollution trends is compared with corresponding predictions from the cross-country studies. Then, with a panel data set containing observations across states from the late 1970s into the early 1990s, pollution–income relationships specific to Malaysia are estimated for one air pollutant, total suspended particulates (TSP), and five water-quality parameters: biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen, pH, and suspended solids.

Cross-country results imply that per capita emissions of four air pollutants, particulates, sulphur oxides, nitrogen oxides and carbon

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

monoxide, should have been rising in Malaysia during 1987–91. Actual per capita emissions did indeed rise between 1987 and 1991 for three out of the four pollutants, but the increases were much smaller than those predicted. Emissions of SO_x actually declined. This contrary result is a direct reflection of a non-environmental policy decision: having discovered substantial reserves of natural gas in the 1970s and 1980s, in the mid-1980s Malaysia decided to reduce dependence on imported fuel oil by converting power plants to natural gas.

Cross-country results also imply that ambient TSP concentrations should have been falling by the late 1980s. Contrary to this prediction, annual mean readings were substantially higher during 1985–91 than 1977–84. Econometric analysis of Malaysian monitoring data found that the relationship between TSP concentration and per capita GDP had neither the continually declining form reported by one cross-country study nor the inverted-U shape estimated by another. Instead, TSP concentration rose continually with income. This result is plausible in the Malaysian context, where rising emissions from manufacturing and waste disposal as industrialization proceeded more than offset declining emissions from agricultural land clearing.

Turning to water-quality parameters, trends in BOD, COD and ammoniacal nitrogen were not consistent with predictions of cross-country studies for a country at Malaysia's income level. Econometric analysis of Malaysian monitoring data found no evidence of an EKC for any of the parameters. In fact, per capita GDP was a significant explanatory variable for only two, ammoniacal nitrogen and pH, and in both cases higher income was associated with higher pollution levels.

The lack of evidence of EKCs in Malaysia does not prove that EKCs do not exist in any country. It does indicate, however, that policymakers in developing countries should not assume that economic growth will automatically solve air and water pollution problems. Addressing these problems requires effective environmental policy responses. The Malaysian analysis offers evidence of significant policy impacts for several pollutants, in particular BOD.

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

The relationship between air pollution emissions and income: US data

RICHARD T. CARSON, YONGIL JEON and DONALD R. McCUBBIN

The relationship between per capita income and per capita emissions is examined for seven major classes of air pollutants in the 50 US states. Greenhouse gases, air toxics, carbon monoxide, nitrogen oxides, particulates, sulphur dioxide and volatile organic carbons are examined in a cross-sectional analysis, and air toxics are also considered in a time-series analysis. A negative relationship between income and each class of air pollutant is found, providing some evidence for the environmental Kuznets curve, but the results suggest that changes in income take a while to affect pollution levels. It is also found that lower-income states display much greater variability in per capita emissions than higher-income states, suggesting that states (and countries) have widely divergent development paths.

Previous empirical work has looked across different countries and has generally supported the notion of an environmental Kuznets curve for some pollutants. The difficulty, of course, with looking at environmental quality data across countries, particularly for any long time span, is that of data quality and comparability. One possible approach is to use data from the US states.

In the cross-sectional analysis, the basic modelling approach adopted is simply to regress the per capita emissions for each emission class on per capita income. When heteroskedasticity was controlled for, it was found that the coefficients on GNP per capita are all negative, suggesting that air emissions per capita in the USA decrease as GNP per capita increases. The results are the same when robust regression is used and other (possibly confounding) predictors of per capita, such as industry composition and population density, are used.

If air toxics are looked at over a seven-year period, 1988–94, a non-parametric sign test rejects the null hypothesis that emissions are positively correlated (or uncorrelated) with income. Regression results show that no relationship between the change in state income and the change in the level of air toxics emitted per capita, although the initial income and emissions levels are important predictors. A fixed-effects panel data model of air toxics emissions at the level of the two-digit SIC code supports the interpretation of the data found in the simpler time-difference model.

The results suggest that, with respect to air toxic emissions, the relationship between changes in income and changes in toxic emissions is a very slow one. A uniformly improving technology story is capable of

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

explaining the general reduction in per capita emissions. The finding in this study, that the initial level of air toxic emissions matters, enriches the technology story in a way that accords with economic intuition: it is less expensive on a per-capita unit-of-pollution basis to clean up dirty plants than clean ones. The finding that a state's initial level of income matters provides some support for the possibility of a slow dynamic process and suggests that state income affects the zeal and effectiveness of its regulatory structure. In part, this is probably related to resources available to regulatory agencies, slowly changing public preferences and the perceived danger of emissions.

Are environmental Kuznets curves misleading us? The case of CO_2 emissions

WILLIAM R. MOOMAW and GREGORY C. UNRUH

Previous Kuznets-type analysis of national per capita carbon dioxide data has concluded that, unlike other pollutants, CO_2 either increases inexorably with growing per capita GDP, or else it only begins to decline at very high income levels. From an examination of 108 countries for which comparable national time series of per capita CO_2 emissions and GDP exist, we have identified 16 countries that have actually undergone a transition in which income continues to grow while per capita CO_2 emissions remain constant or decline. The actual per capita GDP in the peak year of emissions ranged from $8,800 for Austria to $15,400 for the United States, all well below the value of $35,000 projected by some authors. Suggestions of an 'N' rather than an inverted 'U-shaped' dependence is shown from this data set to be an artifact of fitting a third-order polynomial rather than reflecting some underlying structure. As an alternative, we propose a transitional model that appears to correlate with the historical oil price shock in 1973. Fitting the data with a simple linear fit from 1950 to 1972 showed a high correlation between CO_2 and per capita GDP. After 1973, the variance increased sharply, with France and Sweden showing a strong decrease in CO_2 with rising income. These findings suggest that assumptions that per capita CO_2 emissions depend in an autonomous fashion on per capita GDP are misleading, and that the particular policy and economic history of countries may dominate CO_2/GDP correlations.

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

Demystifying the environmental Kuznets curve: turning a black box into a policy tool

THEODORE PANAYOTOU

Earlier studies have found that for several pollutants there is an inverted U-shaped relationship between environmental degradation and levels of per capita income, which has come to be known as the environmental Kuznets curve (EKC). This finding, while providing some insights, has led to the unintended and misleading interpretation by some that countries can grow out of their environmental problems without establishing conscious environmental policies.

This paper makes a modest attempt to incorporate explicit policy considerations into the EKC and to explore its determinants both as a step towards better understanding of the income–environment relationship and as a basis for conscious policy intervention. It also explores whether the rate of economic growth, that is the speed with which higher levels of income are attained, makes a difference to the income–environment relationship. The main finding is that the quality of policies and institutions can significantly reduce environmental degradation at low income levels and speed up improvements at higher income levels. In other words, better policies, such as more secure property rights and better enforcement of contracts and effective environmental regulations, can help flatten the EKC and reduce the environmental price of economic growth. Faster economic growth and higher population density (beyond a certain point) do increase moderately the environmental price of economic growth, but better policies can easily offset these effects and make economic growth more environmentally friendly and sustainable.

The decomposition of the EKC into its determinants has revealed that those who argue that economic growth increases pollution levels are only partially right, because they focus only on the scale and industrialization effects and ignore the abatement effect of higher incomes. The reverse is true of those who see economic growth as an adequate way out of environmental problems. When all effects are considered, the relationship between growth and the environment turns out to be much more complex with a wide scope for active policy intervention to bring about more desirable and, in the presence of market and policy failures, more efficient economic and environmental outcomes.

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

Explaining the environmental Kuznets curve: structural change and international agreements in reducing sulphur emissions

SANDER M. de BRUYN

The relationship between economic growth and environmental degradation has been assumed to take on an inverted-U shape, implying that after certain income levels, rising incomes may be associated with improvements in environmental quality. This has been called the environmental Kuznets curve (EKC). The reasons why this may occur are however not entirely clear and have not yet been effectively investigated in empirical research.

Decomposition analysis is an attractive approach for finding the underlying reasons for the decline in emissions where the change in emissions is assigned to scale, technological and structural effects. Emissions may decline despite the growth in output if technological and structural improvements outweigh the detrimental scale effect. A decomposition of sulphur dioxide emissions in the Netherlands and Western Germany during the 1980s fails to find evidence for structural change as an important determinant of the distinct reduction in emissions. It appears that the combination of scale and technological effects explains the patterns of emissions satisfactorily where the potential increases due to the scale effect have been more than compensated by technological improvements in production. This is in line with other studies that found little evidence of structural change in energy consumption or some pollutants.

Technological change, and especially the instalment of sulphur-abating end-of-pipe technology, may have been enforced by environmental policy. An impetus to structure and tighten national environmental policy in Europe has been the negotiations on transboundary air pollutants through the First and Second Sulphur Protocols. The non-uniform reductions that have been agreed upon in the Second Sulphur Protocol have been tested for their relation to income. This provides the insight that countries with higher incomes have agreed upon more ambitious targets, although other factors are also important. In particular, a poor state of the environment seems an important driving force to implement environmental policy. The results of this study also imply that international cooperation may form an encouragement for environmental policy in those countries that have not yet reached their turning points on the hypothesized EKC and that would otherwise experience increasing emissions.

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

Income and environmental R&D: empirical evidence from OECD countries

MARINUS H.C. KOMEN, SHELBY GERKING and HENK FOLMER

Whether economic growth and environmental protection are compatible policy goals has become one of the most hotly debated topics among social and natural scientists interested in resource and environmental management. Alternative views on this matter have been expressed in the recent literature on the environmental Kuznets curve (EKC). The EKC suggests that in industrializing nations with low levels of per capita income, increased emissions of certain pollutants may result when the scale of economic activity expands. However, after per capita income reaches a threshold level, further economic growth may bring about environmental improvements through, for example:

- declining population growth rates;
- shifts in the composition of output favouring production and consumption of less pollution-intensive goods;
- increased imports of pollution-intensive goods;
- environmental policy as a consequence of, *inter alia*, better education, the establishment of government agencies aimed at pollution control, and development of technologies aimed at reducing emissions.

Numerous authors have presented empirical evidence suggesting that this inverted-U relationship holds between per capita income and environmental degradation, at least for some pollutants.

The main result of this paper, which analyses data from 19 OECD countries for the period 1980–94, is that the income elasticity of public research and development funding for environmental protection is positive and may be approximately equal to unity. This finding is of interest primarily because:

- Previous empirical studies of the EKC focus on the overall linkage between per capita income and environmental degradation, rather than on the role of individual underlying components such as research and technology development.
- It may help explain why the EKC appears to be negatively sloped for some pollutants among countries that are relatively industrialized.

In particular, if demand for environmental quality is income elastic, then environmental research and development may be expected to increase with income as well. Moreover, research is frequently an important first step in identifying causes and remedies of environmental problems and in many situations is a prerequisite for the introduction of environmental policy. In this regard, public research and development expenditures are

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press

crucial because the approaches to environmental problems at this level are mainly of a basic scientific nature and this type of research is primarily financed through government sources. Furthermore, public spending on environmental research and development can be a catalyst for private spending on development of cleaner technologies.

Additionally, empirical results presented concerning the income elasticity of public research and development funding are of interest in at least two interrelated contexts outside the immediate scope of the EKC literature. First, public and private research and development conducted in OECD countries may, in the long run, have a positive impact on the environmental problems faced by industrializing nations, because knowledge generated may be transferable internationally through publications, exchanges of personnel or international sales of abatement equipment. Second, income elasticities reported in this paper may be larger than expected, based on examining income elasticities for specific environmental goods considered in contingent valuation studies.

https://doi.org/10.1017/S1355770X97000181 Published online by Cambridge University Press