Environmental Kuznets curve

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Abstract

Pollution often appears first to worsen and later to improve as countries' incomes grow. Because of its resemblance to the pattern of inequality and income described by Simon Kuznets, this pattern of pollution and income has been labelled an 'environmental Kuznets curve'. While many pollutants exhibit this pattern, peak pollution levels occur at different income levels for different pollutants, countries and time periods. This link between income and pollution cannot be interpreted causally, and is consistent with either efficient or inefficient growth paths. The evidence does, however, refute the claim that environmental degradation is an inevitable consequence of economic growth.

Environmental Kuznets curve

Some forms of pollution appear first to worsen and later to improve as countries' incomes grow. The world's poorest and richest countries have relatively clean environments, while middle-income countries are the most polluted. Because of its resemblance to the pattern of inequality and income described by Simon Kuznets (1955), this pattern of pollution and income has been labelled an 'environmental Kuznets curve' (EKC).

Grossman and Krueger (1995) and the World Bank (1992) first popularized this idea, using a simple empirical approach. They regress data on ambient air and water quality in cities worldwide on a polynomial in GDP per capita and other city and country characteristics. They then plot the fitted values of pollution levels as a function of GDP per capita, and demonstrate that many of the plots appear inverse-U-shaped, first rising and then falling. The peaks of these predicted pollution-income paths vary across pollutants, but 'in most cases they come before a country reaches a per capita income of $8000' in 1985 dollars (Grossman and Kruger, 1995, p. 353).

In the years since these original observations were made, researchers have examined a wide variety of pollutants for evidence of the EKC pattern, including automotive lead emissions, deforestation, greenhouse gas emissions, toxic waste, and indoor air pollution. Some investigators have experimented with different econometric approaches, including higher-order polynomials, fixed and random effects, splines, semi- and non-parametric techniques, and different patterns of interactions and exponents. Others have studied different groups of jurisdictions and different time periods, and have added control variables, including measures of corruption, democratic freedoms, international trade openness, and even income inequality (bringing the subject full circle back to Kuznets's original idea).

Some generalizations across these approaches emerge. Roughly speaking, pollution involving local externalities begins improving at the lowest income levels. Fecal coliform in water and indoor household air pollution are examples. For some of these local externalities, pollution appears to decrease steadily with economic growth, and we observe no turning point at all. This is not a rejection of the EKC; pollution must have increased at some point in order to decline with income eventually, and there simply are no data from the earlier period. By contrast, pollutants involving very dispersed externalities tend to have their turning points at the highest incomes, or even no turning

points at all, as pollution appears to increase steadily with income. Carbon emissions provide one such example. This, too, is not necessarily a rejection of the EKC; the turning points for these pollutants may come at levels of income per capita higher than in today's wealthiest economies.

Another general empirical result is that the turning points for individual pollutants differ across countries. This difference shows up as instability in empirical approaches that estimate one fixed turning point for any given pollutant. Countries that are the first to deal with a pollutant do so at higher income levels than following countries, perhaps because the following countries benefit from the science and engineering lessons of the early movers.

Most researchers have been careful to avoid interpreting these reduced-form empirical correlations structurally, and to recognize that economic growth does not automatically cause environmental improvements. All of the studies omit country characteristics correlated with both income and pollution levels, the most important being environmental regulatory stringency. The EKC pattern does not provide evidence of market failures or efficient policies in rich or poor countries. Rather, there are multiple underlying mechanisms, some of which have begun to be modelled theoretically.

In theory, the EKC relationship can be divided into three parts: scale, composition, and technique (see Brock and Taylor, 2005). If as an economy grows the *scale* of all activities increases proportionally, pollution will increase with economic growth. If growth is not proportional but is accompanied by a change in the *composition* of goods produced, then pollution may decline or increase with income. If richer economies produce proportionally fewer pollution-intensive products, because of changing tastes or patterns of trade, this composition effect can lead to a decline in pollution associated with economic growth. Finally, if richer countries use less pollution-intensive production *techniques*, perhaps because environmental quality is a normal good, growth can lead to falling pollution. The EKC summarizes the interaction of these three processes.

Beyond this aggregate decomposition of the EKC, some attempts have been made to formalize structural models that lead to inverse-U-shaped pollution-income patterns. Many describe economies at some type of corner solution initially, where residents of poor countries are willing to trade environmental quality for income at a faster rate than possible using available technologies or resources. As the model economies become wealthier and their environments dirtier, eventually the marginal utility of income falls and the marginal disutility from pollution rises, to the point where people choose costly abatement mechanisms. After that point, the economies are at interior solutions, marginal abatement costs equal marginal rates of substitution between environmental quality and income, and pollution declines with income (see Stokey, 1998). In frameworks of this type, there is typically zero pollution abatement until some threshold income level is crossed, after which abatement begins and pollution starts declining with income.

To date, the practical lessons from this theoretical literature are limited. Most of the models are designed to yield inverse-U-shaped pollution-income paths, and succeed using a variety of assumptions and mechanisms. Hence, any number of forces may be behind the empirical observation that pollution increases and then decreases with income. Moreover, that pattern cannot be interpreted causally, and is consistent with either efficient or inefficient growth paths. Perhaps the most important insight is in Grossman

and Krueger's original paper: 'We find no evidence that economic growth does unavoidable harm to the natural habitat' (1995, p. 370). Economists have long argued that environmental degradation is not an inevitable consequence of economic growth. The EKC literature provides empirical support for that claim.

Arik Levinson

See also environmental economics; growth and international trade; ideas, externalities and growth; inequality and growth; pollution havens

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Index terms

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