Does S. Kuznets' Belief Question the Environmental Kuznets Curves?

Alain BOUSQUET* and Pascal FAVARD†

November 6, 2000

Abstract

This paper examines the link between pollution and income. It shows how income inequality affects environmental policies and therefore pollution. The Environmental Kuznets Curve (EKC) hypothesis proposes that there is an inverted U-shape relation between environmental degradation and income per capita. This paper invalidates this common result. Indeed we find for a set of parameters a two-hump curve. (JEL: D3, H4, Q2)

*Commissariat à l'Energie Atomique, Université des Sciences Sociales Toulouse. Email : bousquet@cict.fr.

†Université de la Rochelle, Email: pfavard@cict.fr.

We would like to thank Philippe Bontems and Larry Karp for their helpful comments.

1 Introduction

In the 1970's the limits to growth argument was that pollution is an inexorable by-product of industrialization and that increasing material affluence will entail a decreasingly attractive world. Since the early nineties some economists argue that this view could be excessively pessimist since it neglects the possibility of changes in technology, education, economic and political structure which might mitigate the environmental problems. Taking into account the fact that with economic growth, society could react and possibly resorb environmental difficulties leads to position like Beckerman (1992) who says that everything will work out fine in the end "There is clear evidence that although economic growth leads to environmentall degradation in the early stages of the process, in the end the best -and probably only- way to attain a decent environment in most countries is to become rich".

Recent studies give empirical support to this view. The World Development Report (1992) was one of the first studies to show some indicators of environmental degradation increase with income. Later, several empirical studies focused on the phenomenon of increasing and then decreasing levels of pollutant with respect to GDP. Often cited papers on the relationship between pollution and economic growth find that many forms of air and water pollution follow an inverted-U relationship with respect to GDP per capita. Among them, Grossman and Krueger (1994), Shafik and Bandyopadahyay (1992), Panayotou (1993) and Selden and Song (1994), found that pollution levels increase as a country develops, but begin to decrease as rising income pass beyond a turning point.

This inverted-U relationship has been defined as the Environmental Kuznets Curve (henceforth EKC) after Simon Kuznets, as it resembles the shape of the relationship that the Nobel Prize economist first observed between income inequality and economic growth. Panayotou (1993) noted the similarity between the two patterns and then applied the name of Kuznets to environmental studies.

A tremendous body of literature examine the link between pollution and growth (see for example the recent survey of Borghesi (1999)).

In the same time theoretical explanations for the relationship between pollution and economic growth has been proposed (Selden and Song (1995), Stokey (1998) and Andreoni and Levinson (1998)).

The main theoretical underpinnings behind the EKC put forward arguments relative to either technological choices or preferences concerning environmental quality. The inverted-U relationship reflects the changing strength of three influences on the environment, the scale, composition and technique effect. In the first place, growth exhibits a **scale effect** on the environment because increases in economic activity generate more pollution. In the second place, growth induces structural changes of the economy and a **composition effect**, for example the large share of services in GDP in the post industrial phase of development, could have a positive impact on the environment. Moreover with economic growth technical progress could enhance cleaner technologies, this is known as the **technique effect**.

Recent theoretical literature (see Vogel 1999) recognizes the importance of the distribution of income through efficiency and equity in the provision of environmental quality but little attention has been paid to the link between Environmental Kuznets Curve and the original Kuznets curve. In this Review (1955), Simon Kuznets postulates that income inequality increases and then decreases during the process development. This is precisely the starting point of our study. Suppose that conditions are met to provide an EKC, i.e. that when income exceeds a threshold, pollution starts to decrease. What is the new pattern for pollution, if we consider not only changes in average income but also changes in income inequality according to the Kuznet's inverted U-shaped hypothesis?

Research into the causal effects of income inequality on environmental policy is scarce and limited to empirical studies. Torras and Boyce (1998) provide a reduced form specification of the EKC in which income inequality is included as a regressor, and find ambiguous support for their hypothesis that income inequality reduces environmental quality.

In order to highlight this possible ambiguous effect of income inequality, we consider a simple environmental model where the income inequalities follow a bell curve. In this case we show that EKC is not necessarily a bell curve. It could be an "environmental camel curve" i.e. a curve with two humps. Our result is based on a public good model of the provision of environmental quality. In this type of model, environmental policies are a way to diminish inequality. Improving environmental quality is in fact an in-kind transfer, in terms of welfare. Such a policy, obviously, is more appropriate for a high income country. We have this case in mind, and our result is consistent with the estimations of Taskin and Zaim (2000) for a sample of rich countries (OECD).

2 A public good model of the provision of environmental quality

2.1 The representative consumer economy

Consider a consumer's utility function $U(C,P) = C^{\alpha} - P$ where C is the consumption level and P represents aggregate emissions. This utility function is increasing in C and decreasing in P. The consumer is endowed with exogenous income M. Pollution P is assumed to be proportional to consumption and we note by a the emission coefficient by unit of consumption. Moreover the consumer could decide not to devote the entire endowment to consumption and in this case she (he) will make a strictly positive effort, $M - C$, to finance pollution abatement costs.

We use specific functional forms from the start because few analytical results are available in a general framework[1],

$$\begin{aligned} U(C,P) &= C^{\alpha} - P \\ P &= aC - b(M-C)^{\beta} \end{aligned}$$

The consumer's problem takes the form

$$\max_{C} C^{\alpha} - aC + b(M-C)^{\beta}$$

subject to

$$0 \leq C \leq M$$

$$P \geq 0.$$

We assume that α and β belong to $[0,1]$ so that the above program is convex, and $a > 0$, $b > 0$. Assuming an interior solution, the consumer's optimum consumption satisfies the first order condition:

[1] More general models, like McConnell (1997), give us poor results about the restriction on either the utility function or the abatement technology that are necessary to generate an EKC.

$$\alpha C^{\alpha-1} - a - b\beta(M-C)^{\beta-1} = 0.$$

Even if with our previous assumptions, this equation does not lead to explicit solutions. We first solve the problem with $\beta = 1$ and then use numerical simulations to derive optimal solutions in the more general case.

Straightforward computation give us the optimal level of consumption and pollution for $\beta = 1$:

$$(C,P) = \begin{cases} (M, aM) & \text{if } 0 \leq M < \underline{M} \\ ((\frac{a+b}{\alpha})^{\frac{1}{\alpha-1}}, ((a+b)(\frac{a+b}{\alpha})^{\frac{1}{\alpha-1}} - bM) & \text{else if } \underline{M} \leq M < \overline{M} \\ (\frac{b}{a+b}M, 0) & \text{otherwise} \end{cases}$$

where $\underline{M} = (\frac{a+b}{\alpha})^{\frac{1}{\alpha-1}}$ and $\overline{M} = \frac{a+b}{b}\underline{M}$. We note that optimal solutions, for consumption and pollution, may belong to three different regimes depending on the income level. In the first regime C is equal to M because gross marginal utility of consumption is greater than $a+b$ the net marginal disutility of pollution. Because consumption and pollution are increasing in income, following Vogel (1999) we call that the “development phase”. In a second regime (interior solution), the consumer’s optimum consumption satisfies the first order condition $\alpha C^{\alpha-1} - a - b = 0$. There consumption is constant[2] and pollution is decreasing. This regime is an “environment phase”, using Vogel’s terminology. The last regime is due to the non negativity constraint on pollution. Our purpose in this section was just to find a model as simple as possible that provides an EKC in order to be able to tract this model with income inequalities.

2.2 Heterogeneous households

With the simple model solved above we got an EKC, i.e. that when income exceeds a threshold, pollution starts to decrease. Now we introduce income inequalities in this economy. According to Kuznets (1955) these inequalities follow a bell curve when average income increases. Doing that we want to show what is the new pattern for pollution.

[2]For the general model ($\beta < 1$) consumption is increasing over each phase.

We take environmental quality to be a pure, Samuelsonian public good; this is a world in which all individuals in society consume exactly the same quality of air, water and other environmental goods, or suffer of the same quantity of pollution.

The economy is populated by a large number of individuals. Population size is normalized to one. All individuals have identical preferences over a consumption good c, and aggregate pollution P. The consumption good is always provided privately, while pollution is a public good. Individuals do not earn the same income; let note m the individual income. The cumulative density function of individuals income is denoted by F. The support of income distribution is the non-negative real line and $I_\alpha(m)$, represents the Atkinson Kolm and Sen (AKS) inequality index[3].

In order to finance abatement costs, we assume that government collects a consumption tax[4] at the uniform rate t.

Since utility is increasing in consumption and the consumer does not contribute voluntarily to the reduction of pollution, c is equal to $\frac{m}{1+t}$.

Welfare is maximized by the social planner with respect to t

$$\max_t \int_0^{+\infty} \left[\left(\frac{m}{1+t} \right)^\alpha - a \left(\frac{m}{1+t} \right) + b \left(\frac{t}{1+t} \int_0^{+\infty} m dF(m) \right)^\beta \right] dF(m)$$

with obvious notation we can write

$$\max_t \frac{\mathsf{E}(m^\alpha)}{(1+t)^\alpha} - a \frac{\mathsf{E}(m)}{1+t} + b \mathsf{E}(m)^\beta \left(\frac{t}{1+t} \right)^\beta$$

and so the optimal rate of tax is the solution of the following first order condition:

$$-\frac{\alpha}{(1+t)^{\alpha+1}} \mathsf{E}(m^\alpha) + \frac{a}{(1+t)^2} \mathsf{E}(m) + b\beta \mathsf{E}(m)^\beta \frac{t^{\beta-1}}{(1+t)^{\beta+1}} = 0. \qquad (1)$$

---

[3] In our case the AKS index of inequality $I_\alpha(m)$ is equal to $1 - \frac{(\mathsf{E}(m^\alpha))^{\frac{1}{\alpha}}}{\mathsf{E}(m)}$ (see Blackorby, Bossert and Donaldson 1999).

[4] We consider the case in which the government uses the whole tax revenues in order to reduce pollution. Introducing, for example, lump sum transfers is one way to generalize our model.

For the same reason as in the previous section, we now study the case $\beta = 1$. The optimal triplet tax pollution consumption is then:

$$(t, P, C) = \begin{cases} (0, a\mathsf{E}(m), \mathsf{E}(m)) & \text{if } \mathsf{E}(m) \in]0, \underline{M(I_\alpha)}] \\ \Bigg(\left(\frac{\alpha(1-I_\alpha(m))^\alpha}{a+b} \right)^{\frac{1}{\alpha-1}} \mathsf{E}(m) - 1, & \\ \left(\alpha(\frac{1-I_\alpha(m)}{a+b})^\alpha \right)^{\frac{1}{1-\alpha}} - b\mathsf{E}(m), & \text{if } \mathsf{E}(m) \in]\underline{M(I_\alpha)}, \overline{M(I_\alpha)}] \\ (\frac{a+b}{\alpha})^{\frac{1}{\alpha-1}} (1 - I_\alpha(m))^{\frac{\alpha}{1-\alpha}} \Bigg) & \\ (\frac{a}{b}, 0, \frac{b}{a+b}\mathsf{E}(m)) & \text{otherwise} \end{cases}$$

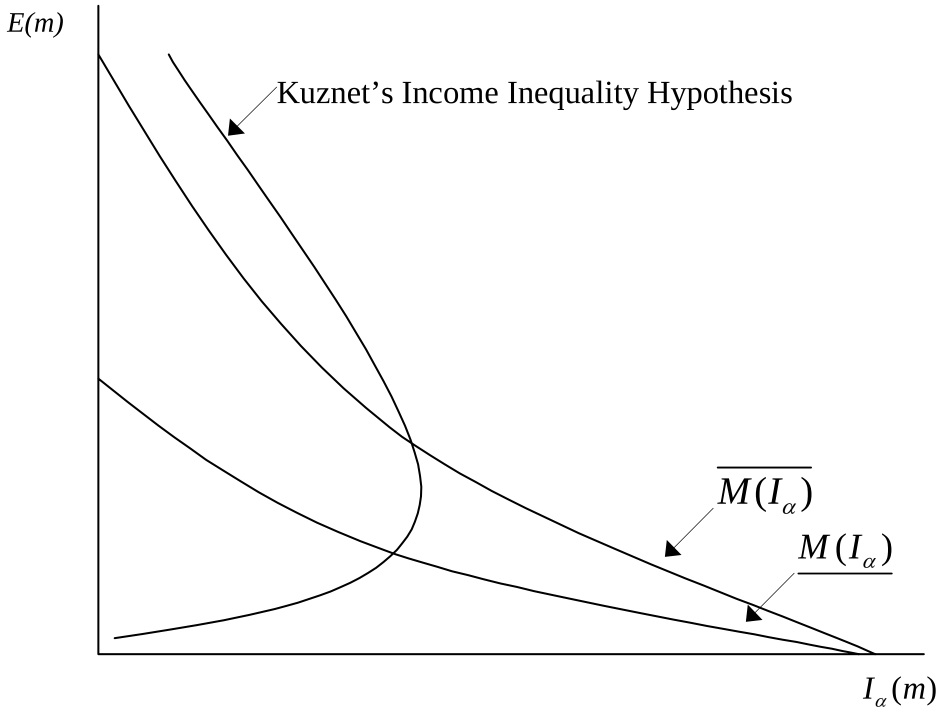
where $\underline{M(I_\alpha)} = \left(\frac{\alpha(1-I_\alpha(m))^\alpha}{a+b} \right)^{\frac{1}{1-\alpha}}$ and $\overline{M(I_\alpha)} = \frac{a+b}{b}\underline{M(I_\alpha)}$.

The figure below illustrates our results. For a given inequality index I_α, $\underline{M(I_\alpha)}$ and $\overline{M(I_\alpha)}$ are the lower respectively the upper bound for average income delimiting the environment phase.

First note that both income thresholds are decreasing functions of the inequality index. This means that a society crosses the line between the development phase and the environment phase for a lower average income when inequality is large. This is due to the redistribution impact of environmental policies which are more stringent in highly unequal societies.

Second, we draw on the same figure the income inequality relationship according to the Kuznet's hypothesis. Straightforward computation shows that in the environment phase $\frac{\partial P}{\partial I_\alpha} < 0$ with fixed $\mathsf{E}(m)$. This implies that it is not possible to determine the sign of the variation for pollution, when average income increases and income inequality decreases. For particular values of the parameters it is then possible to have an increasing part for the pollution curve in this phase. In order to obtain a two hump curve for pollution it is necessary (not sufficient) that the maximum inequality occurs in this phase.

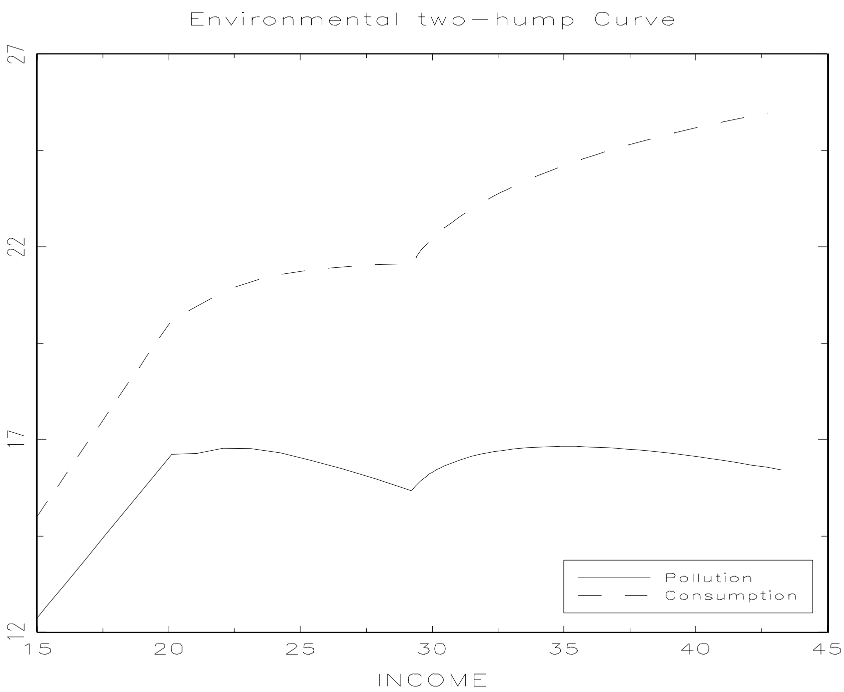
Remark finally that in the two others phases pollution is always independent of income inequality. If income inequality is maximum in one of these two regions then pollution follows a simple inverted U curve.



2.3 Simulations and Conclusion

To illustrate these results consider the following example: $\alpha = 0.2$, $\beta = 0.9$, $a = 0.01$ and $b = 0.005$. The optimal value of t is obtained by solving[5] numerically equation (1). Income follows a Lognormal distribution namely $\Lambda(\mu, \sigma^2)$. We pick a grid of 100 pairs (μ, σ), where μ increases over $[1, 3.5]$ and σ increases $[0.7, 1.6]$ and after decreases to go back 0.7. The optimal values of consumption and pollution are represented below as function of average income $\mathsf{E}(m)$. Consumption is always increasing in this case. The next figure representing both pollution and consumption as a function of average income, shows an unusual EKC, with two modes.

[5] We use the library NLSYS in a GAUSS program which is available upon request.



When the inequality index in a society follows a Kuznets curve as in our case, there is for one average income a maximal inequality. Increasing level of environmental quality reduces the impact of inequality. For a given average income, a higher inequality index leads to a higher tax and environmental quality. As a result it is then possible to have a local minimum of pollution at the index inequality maximum. It is interesting to note that original Kuznets income inequality may invalidate the environmental income relationship in the recent theoretical models on EKC. In addition, our result is consistent with the curve estimated by Taskin and Zaim (2000). These authors use nonparametric methods in order to get more general estimations than the quadratic and the cubic ones, used in most applied studies.

To conclude our article we want to stress again two points. One of them is that EKC could be non consistent with Kuznets' works. Therefore the label EKC does not make sense. At first glance, this point seems irrelevant and just an anecdote. But let's think about the tremendous body of applied literature which has took as given this "Kuznets shape" for the income-pollution relationship. These works have been interpreted by decision makers, at least one of them, as a justification of *laissez faire*: "growth will do the job".

The other point is, even if our model is simple it gives an explanation for environmental evolution in the richest countries over the last twenty years. During this period in these countries investment on pollution abatement technologies have increased as the inequalities (i.e. there is a negative impact of inequality on pollution). There are few theoretical works Magnani (2000), Marsiliani and Renström (2000) taking into account the evolution of the inequalities and when it is the case these papers show a positive impact of inequality on pollution. Our aim is not to say they are wrong but to find the relation between inequality and pollution when the need of redistribution is the most important. One way, for a planner, in an unequal society (but a developed one) to make redistribution is to reduce pollution in order to increase welfare. Our theoretical result is reinforced by the empirical paper of Torras and Boyce (1998). They found, for the case of sulfur dioxide and smoke, that greater income inequality is associated with less pollution in high-income countries.

References

[1] Andreoni, J. and Levinson. A., 1998, "The simple analytics of the Environmental Kuznets Curve", Working Paper University of Wisconsin.

[2] Beckerman, W., 1992,"Economic growth and the environment: whose growth? whose environment?", World Development, Vol. 20, n. 4, pp 481-496.

[3] Blackorby, C., Bossert, W. and Donaldson, D., 1999, Income Inequality Measurement: The Normative Approach, in *Handbook on Income Inequality Measurement*, J. Silber ed, Kluwer Academic Publishers, Boston.

[4] Borghesi, S., 1999, "The Environmental Kusnets Curve: a Survey of the literature" Economics Energy Environment Working Paper 85.99.

[5] Grossman, G.M., and Krueger, A.B., 1995, "Economic growth and the environment", Quaterly Journal of Economics, Vol. 110, pp. 353-377.

[6] Kuznets, S., 1955, "Economic Growth and Income Inequality", American Economic Review 445, pp. 1-28.

[7] Magnani, E., 2000, "The Environmental Kuznets Curve, Environmental Protection Policy and Income Distribution", Ecological Economics, vol. 32, n. 3, pp.431-443.

[8] Marsiliani, L. and Renström, T. I., 2000, "Inequality, Environmental Protection and Growth", CentER working papers n°2000-34.

[9] McConnell, K.E., 1997, "Income and the demand for environmental quality", Environment and Development Economics, Vol. 2, Part 4, pp. 383-400.

[10] Panayotou, T., 1993, "Empirical tests and policy analysis of environmental degradation at different stages of economic development", World Employment Programme Research, Working Paper 238, International Labour Office, Geneva.

[11] Selden, T.M., and Song, D., 1994 "Environmental Quality and Development: is there a Kuznets curve for air pollution emissions?" Journal of Environmental Economics and Management, n. 27, pp. 147-162.

[12] Selden, T.M., and Song D., 1995, "Neoclassical Growth, the J Curve for Abatment and the Inverted U Curve for Pollution", Journal of Environmental Econmics and Management, n. 29, pp. 162-168.

[13] Shafik, N., and Bandyopadayay, S., 1992, "Economic growth and the Environmental Quality", Background Paper for the 1992 World Development Report, The World Bank, Washington D.C.

[14] Stokey, N., 1998, "Are there limits to growth", International Economic Review, Vol. 39, n. 1, pp. 1-31.

[15] Taskin, F. and Zaim, O., 2000, "Searching for a Kuznets curve in environmental efficiency using kernel estimation", Economics Letters, n.68, pp. 217-223.

[16] Torras, M. and Boyce, J.K., 1998, "Income Inequality and pollution: a reassessment of the Environmental Kuznets Curve", Ecological Economics, vol. 25, n. 2, pp.147-160.

[17] Vogel, M.P., 1999, Environmental Kuznets Curve. In Lecture Notes in Economics and mathematical Systems, n.469, eds. Springer.