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INCOME AND THE POLLUTION PATH: UPDATE AND EXTENSIONS

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Income and the pollution path: Update and extensions

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Abstract: Searching for a behavioural explanation of the empirical occurrence of Environmental Kuznets Curve (EKC) the literature has usually assumed additive preferences, i.e. that the marginal utility of consumption does not depend on pollution levels. We update and extend previous literature on the EKC and show that the signing of the slope of the elasticity of substitution between consumption and environmental quality determines the occurrence of the EKC. This novel result does not require imposing restrictions on the sign of the cross-partial derivative of utility with respect to consumption and environmental quality. Under the assumption of a decreasing elasticity of substitution we derive a closed form of the EKC and show that this more general model encompasses as special cases most of the relevant EKC-generating models described in earlier literature.

Keywords: Environmental Kuznets curve, elasticity of substitution, non-homothetic preferences

JEL Classification: C23, Q53**,** Q58

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1. Introduction

Since the early 1990s, the so-called environmental Kuznets curve (EKC), an empirical inverted U curve which illustrates the relationship between pollution and income per capita, has been studied in different contexts due to its potentially promising implications for planning sustainable economic growth in the future. According to this relationship, the emission levels of a given pollutant in the environment, or its concentration levels in the environment, initially rise as the income per capita of a country or city increases over time and then, after reaching a maximum (a 'turning point'), the emissions or concentration levels decline although income per capita continues to grow (see Barbier, 1997; Dinda, 2004 and Yandle et al. 2004 for empirical illustrations). Based on this, some authors expected economic growth to contain the mechanisms for reversing the initial upward trend in pollution emissions or concentrations observed in several countries and for several pollutants (Beckerman, 1992; Selden and Song, 1994; Grossman and Krueger, 1995). However, this initial optimism about the implications of the EKC was soon challenged by other authors who were skeptical of the existence of an automatism built into the EKC relationship (Panayotou, 1997; Stern, 2004).

In more recent literature there have been several attempts to understand the underlying behavioral mechanisms on the part of consumers and/or producers which could explain the empirical occurrence of an EKC. Untangling these mechanisms is relevant because it would allow assessing the extent to which an EKC is automatic and/or inducted by policy. Also, it would reveal which regulatory or other public policy measures, if any, can speed up development or bring down the costs of achieving it. The aim of this paper is to contribute to these efforts, finding restrictions on people's preferences which are consistent with the EKC hypothesis and can shed light on the conditions under which it can be expected to occur in the real world.

Theoretical explanations for the EKC hypothesis rely either in changes in technology or changes in preferences as income grows. Examples of models with technological change are Arrow et al (1995), Suri and Chapman (1998), Jones and Manuelli (1995) John and Pechenino (1994), Andreoni and Levinson (2001) and Stokey (1998).

Lopez (1994), Lieb (2002), McConnell (1997) and Copeland and Taylor (2003) focus on preferences rather than technology. Lopez presents a model of a small, open economy in which if preferences are homothetic, pollution growths monotonically with income; however, if preferences are non-homothetic, then a non-monotonic relationship between pollution and income (i.e., the EKC) can be found, depending on the interaction between, on the one hand, the elasticity of substitution between pollution and other conventional factors of production and, on the other hand, the relative degree of curvature of utility in income. Copeland and Taylor (2003) present a closed reduced form of the EKC, relying on the assumption of an increasing elasticity of marginal damage. Because in their model preferences are separable their assumption of an increasing elasticity of marginal damage is equivalent to Lopez´s assumption of an increasing relative degree of curvature of the utility function. Lieb (2002) presents a representative consumer model in which pollution is generated by consumption and is abated as long as more resources are devoted to abatement. In his model, "an upper bound in utility" is a necessary condition (along with some restrictions on the technological side of the model) for an EKC to arise. McConnell (1997) focuses on the role of the income elasticity of demand for environmental quality in a model where pollution is generated by consumption and is reduced by abatement. He finds no special role for income elasticity equal to or greater than one.

All of the above models assume separable preferences i.e. the cross-partial derivative of utility with respect to consumption and environmental quality is equal to zero. Thus the utility associated to a marginal unit of consumption is the same if individuals live in a pristine environment or if they live in a highly polluted environment. This assumption has helped to derive simple conditions on the slope of income-elasticity of marginal utility to explaining the EKC while avoiding additional complexities associated to the sign of partial derivatives; however, it seems to be at odds with factual observation. Fortunately, as we show in this paper, no assumption about the cross-partial derivative of preferences with respect to consumption and environmental quality is necessary to derive a simple condition on the signing of the slope of the elasticity of substitution between consumption and environmental quality that guarantees the empirical occurrence of the EKC.

We propose a theoretical model in which individuals at early stages of development and low levels of income, when they have available a large endowment of environmental quality (hence low levels of pollution), they are willing to trade some environmental quality in order to increase consumption; while at later stages of development, when they have attained acceptable levels of income, they regard both goods, consumption and environmental quality, as complements to each other. In our model, rather than attempting to maximize welfare through consumption alone — as it is the case in the typical one-good model — people have more balanced aspirations or objectives as early proposed by theorists analyzing human economic behavior (Davis, 1945) and more recently by researchers in behavioral and experimental economics (Kahneman et al 1999) . People seek to increase their consumption but, at the same time, they want to enjoy other non-market, valued goods such as a clean environment, a safety city, the ability to raise healthy children, recognition from their peers, and so on.

This desired "high complementarity" between market and non-market valued goods can only be achieved by wealthy individuals; low-income individuals with abundant clean environment and low levels of consumption can only regard both goods — environment and consumption-, as substitutes. If this is the case, then the elasticity of substitution between consumption and environmental quality – a key parameter neglected in the current literature- must be a decreasing function of income.

Certainly at early stages of development, low-income individuals are endowed with a sufficiently large amount of clean environment while at the same time they are likely to have level of consumption that does not fulfill minimum required standard. Therefore, in such circumstances, they would be willing to trade some environment in exchange for consumption which enables them filling the gap between current consumption and minimum required standards of consumption. In this context, pollution is viewed as the "good smell of money", as people in the city of Iquique, Chile, used to describe the unpleasant odor from new fishmeal mills that pervaded the city in the early stages of the fish meal industry's growth in the 1960s. However, at more advanced stages of development, the situation reverses because people is getting closer to a better and an acceptable standard of consumption, and environmental quality and other non-market valued goods have deteriorated as a result of the expansion of economic activity. At this point, people are willing to sacrifice some consumption growth in exchange for higher levels of environmental quality and other non-market valued goods. This explains why in the 1980s, when the residents of Iquique enjoyed a much higher level of income and lower environmental quality than they had in the 1960s, they began to demand regulations to reduce the unpleasant effects of the fishmeal industry.

This paper is organized as follows: in Section 2 we set up the model. In Section 3 we derive a closed form for the environmental Kuznets curve and, in Section 4, we compare our model to other relevant models in the literature and we discuss in further detail the intuition upon which the model is based as well as the contribution of this paper to the existing literature. Finally, in Section 5 we present our conclusions.

2. Set-up of the model

We develop a static general equilibrium model with a representative agent who maximizes a utility function increasing in consumption C and decreasing in pollution P Because the absence of dynamics in this model, consumption C is assumed to be equal to income f, and hence both variables are used indistinctly throughout the paper. Intra and inter-generational aspects are not addressed here. Technological progress is assumed to be exogenous, as in Lopez (1994) and Stokey (1998).

Another assumption, usual in this kind of models, is that pollution levels are optimal and determined by an efficient price system, i.e. there is always a price that equals pollution demand with pollution supply. There is no doubt that this assumption can be quite extreme, in particular in environmental analysis where, in most of the cases, there exist no prices. Nevertheless it is worth to point out that very often other institutional arrangements resemble the functioning of a price system such as a transparent political process that follows the changes in people's preferences and translates them into environmental regulation which economic agents (consumers and firms) must comply. The increasing stringency acts very often as an implicit (virtual) price that induces economic agents to invest in better environmental practices. On the other hand, models which assume that competitive prices do exist are used in the literature as a benchmark against which more realistic policies are contrasted. For example, Lopez and Mitra

(2000) assume as a benchmark a model of optimal levels of pollution to show that corruption distorts prices and increases pollution.

At the setup of our model utility function is given by:

$$U = U(C, P) \quad (1)$$

$U(\cdot)$ is assumed to be strictly concave in C and P. Therefore we assume $U_C > 0$, $U_P < 0$, $U_{CC} < 0$, $U_{PP} > 0$, where subscript denote differentiation.

The production function $f(\cdot)$ is kept deliberately simple in order to isolate preferences from technology; we only impose constant returns to scale in production factors. Production function is given by:

$$C = f(K, P) \quad (2)$$

where aggregate consumption (C) is identical to aggregate income f, K is a broad definition of capital that includes both physical and human capital and grows over time (neutral growth); and P is the flow of pollution generated and used in the productive process. This production function complies with the usual assumptions (increasing and concave in factors, Inada conditions, etc). In this model, following Tahvonen and Kuuluvainen (1993) and Lopez (1994), pollution plays a role as a factor of production. We assume that P is a flow of pollution rather than a stock. In a static model such as the model we present here the difference between pollution flow and stock is not relevant, but it becomes relevant in the case of contaminants that accumulate in the atmosphere and have climate impact such as CO2. We do not further address this issue.

When the representative agent optimally chooses P we obtain:

$$h(C, P) \equiv -\frac{U_P(C,P)}{U_C(C,P)} = f_P(K, P) \quad (3)$$

where $f_P = \partial f / \partial P$ corresponds to the marginal product of pollution and $h(C, P)$ is the marginal rate of substitution between pollution P and consumption C.

If $h(\cdot)$ in equation (3) is positive and differentiable, indifferences curves between consumption and pollution are convex and thus the following expression holds:

$$\frac{d^2C}{dP^2}_{U=\bar{U}} = h(C,P)h_C(C,P) + h_P(C,P) > 0 \qquad (4)$$

In equation (4) h_C and h_P are the partial derivatives of h with respect to C and P respectively.

The slope for the consumption path and for the pollution path can be found by differentiating (2) and (3) with respect to K,

$$\frac{dC}{dK} = \frac{f_{PK}f_P + f_K(h_P - f_{PP})}{\Delta}, \qquad \text{where } \Delta = hh_C + h_P - f_{PP} > 0$$

Condition $f_{PK} > 0$ (i.e., both production factors are complements) is sufficient for dC/dK >0. However the sign of,

$$\frac{dP}{dK} = -\frac{h_c f_k - f_{PK}}{\Delta}$$

is ambiguous and depends on $f_K h_C$ being greater, equal or lower than f_{PK}; in particular,

$\frac{dP}{dK} \gtreqless 0$ if and only if $H \lesseqgtr 0$

where $H = h_C f_K - f_{PK}$ (5)

It is possible to rewrite H in (5) as:

$$H = \frac{f_K f_P}{C}\left(\frac{ch_c}{h} - \frac{1}{\rho}\right) \qquad (6)$$

To obtain equation (6), equations (5) was used in addition to the condition $c = f$ (equation 2) and $h = f_P$ (equation 3) where $\rho = \frac{f_K f_P}{f_{PK} f}$ corresponds to the elasticity of substitution between pollution and capital in the production function (see Lopez, 1994). If it is assumed that environmental quality R is a linear function of pollution P such that $R = D - P$, where D is the best environmental quality attainable, then $-U_P = U_R$ and the first term inside the brackets in (6) $\frac{ch_c}{h}$ is equivalent to the inverse of the elasticity of substitution between consumption and environmental quality in preferences defined as $\epsilon = (h/x)\,\partial x/\partial h$, where $x = C/R$ corresponds to the ratio of consumption to environmental quality. Then it is possible to rewrite the slope of the pollution path as:

$$\frac{dP}{dK} = -\frac{H}{\Delta} = \frac{1}{\Delta}\frac{1}{\epsilon\rho}\frac{f_K f_P}{C}(\epsilon - \rho) \qquad (7)$$

And this slope depends on which elasticity is higher, the preference-elasticity of substitution between income and environmental quality – ϵ – or the technology-elasticity of substitution between pollution and conventional factors of production ρ. Note that in the case of Cobb-Douglas or linear production functions, $\rho = 1$ and thus dP/dK is greater, equal or less than zero depending on whether the preference-elasticity of substitution ϵ is greater, equal or less than one, respectively. In the particular case of a constant ρ and a decreasing with income (or consumption) preference-elasticity of substitution (such that $\partial\epsilon/\partial C < 0$) , H goes from negative to positive and the slope of the pollution path dP/dK goes from positive to negative describing the shape of the EKC. It is important to note that in signing (7) no assumption has been made about the partial cross derivative of utility with respect to consumption and environmental quality U_{CR}.

The reason for a decreasing in income preference-elasticity of substitution (the key element explaining the presence of an EKC) was already explained above: a growth path that balances consumption and environment is preferred by high-income people (i.e. ϵ is low or possibly zero); however, when people are poor, with a large amount of clean environment available and a low level of consumption they have no other option but to regard both goods as highly substitutes (i.e. ϵ is high); as a consequence, the preference-elasticity of substitution between consumption and environmental quality is a decreasing function of income.

3. Deriving the environmental Kuznets curve

To gain more insights from equation (7), we assume for the implicit welfare function in (1) the following explicit form:

$$U(C,P) = -\frac{\mu}{1+\mu}\left(m - \frac{C}{\mu}\right)^{1+\mu} - \frac{P^{1+\mu}}{1+\mu} \qquad m \geq 0 \qquad (8)$$

Note that no restrictions are imposed on the signs of the parameters in (8) other than m being non-negative. The first term on the right-hand side of (8) is social utility in income, with a form similar to an hyperbolic absolute risk aversion (HARA) class of preferences broadly used in the economics of risk and uncertainty (see, for example, Eeckhoudt, Gollier and Schlesinger, 2005). The HARA system of preferences encompasses the most commonly used forms of utility functions depending on the values assigned to the underlying parameters μ and m (see Feigenbaulm 2003 for a comprehensive description of this class of utility functions). To have a well-behaved utility function, if $\mu \geq 0$ (8) is defined for $c \leq \mu m$ such that μm is an upper bound on consumption. On the contrary, if $\mu \leq 0$ the welfare function is defined in the domain $c \geq \mu m$, such that μm is a lower bound in consumption. If $m = 0$ and $\mu < 0$, (8) collapses to the constant elasticity of substitution (CES) utility function with elasticity of substitution $-1/\mu$. Furthermore, the parameter μ reflects the weight given to pollution in the welfare function, and thus it is possible to associate the parameter μ with the level of perceived harmfulness of the contaminant, with a higher value implying a less harmful pollutant.

According to (8) the marginal rate of substitution between consumption and pollution is given by:

$$h(C,P) = \left(\frac{\mu P}{\mu m - C}\right)^{\mu} \qquad (9)$$

Equation (9) allows to express the first term inside the brackets on the right-hand side of equation (6) as:

$$\frac{C h_C}{h} = \frac{\mu C}{\mu m - C} \qquad (10)$$

The expression in (10) is the inverse of the preference-elasticity of substitution between consumption and environmental quality ϵ, which can be expressed as:

$$\epsilon(c) = \frac{\mu m - c}{\mu c} \qquad (11)$$

Note that for $m > 0$ this elasticity is a decreasing function of income:

$$\frac{\partial \epsilon}{\partial C} = -\frac{\mu^2 m}{(\mu C)^2} < 0 \qquad (12)$$

From Equation (7) and equation (11) it is possible to derive the corresponding turning point of the EKC, c^T, as given by:

$$c^T(\mu, m, \rho) = \frac{\mu m}{1 + \mu\rho} \geq 0. \qquad (13)$$

If $\mu > 0$, C^T is positive and finite for any $m > 0$. On the contrary, if $\mu < 0$ a necessary condition for C^T being positive and finite for any $m > 0$ is $1 + \mu\rho < 0$. Both cases correspond to utility functions bounded from above as required by Lieb (2002). However, regardless of any of these two cases, the elasticity of substitution ϵ is a decreasing function of income (see equation (12))

Differentiating (13), we have

$$c_\mu^T(\mu, m, \rho) = \frac{m}{(1 + \mu\rho)^2} \geq 0$$

$$c_m^T(\mu, m, \rho) = \frac{\mu}{1 + \mu\rho} \geq 0$$

$$c_\rho^T(\mu, m, \rho) = -\frac{\mu^2 m}{(1 + \mu\rho)^2} \leq 0 \qquad (14)$$

From (14) we realize that an increase in either μ or m, or a decrease in ρ, would increase the income level at which the turning point c^T occurs. An increase in μ – associated to a less harmful pollutant – increases the preference elasticity of substitution ϵ for each level of income, allowing a preference for higher levels of consumption for each unit of pollution and, consequently, a higher turning point. An increase in m increases the consumption bound μm for a given level of harmfulness of the pollutant μ, leading to a higher turning point and therefore implying that societies become "greener" at higher levels of income in comparison to societies with lower values of m. This is consistent with recent empirical studies showing different turning points for different countries (Koop and Tole, 1999; List and Gallet, 1999; Markandya et al, 2006) and particularly with Figueroa and Pasten (2009) which found that for a given pollutant, Canada and the United States have higher turning points than European countries. Finally, a decrease in ρ implies that for firms it is more difficult to substitute polluting factors with non-polluting factors and therefore a turning point would be reached at higher levels of income (i.e., ϵ will equal ρ at a higher level of income).

If we assume $\mu > 0$ (i.e. an upper bound in consumption) and a CES production function of the following form:

$$C = f(K,P) = \left[K^{\frac{\rho-1}{\rho}} + P^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \quad (15)$$

Maximizing (8) subject to (15) yields the following first-order condition:

$$\left(\frac{\mu P}{\mu m - c}\right)^{\mu} = q = \left(\frac{C}{P}\right)^{\frac{1}{\rho}} \quad (16)$$

where q corresponds to the equilibrium relative price of pollution in terms of consumption. The left-hand side of (16) is the marginal damage caused by pollution while the right-hand side is its marginal benefit. If the marginal damage is fully internalized by society, the EKC income-pollution relationship can be derived in a straightforward fashion from (16):

$$P = \mu^{-\mu} C^{\frac{1}{1+\mu\rho}} (\mu m - C)^{\frac{\mu\rho}{1+\mu\rho}} \qquad (17)$$

Assuming a linear production function (i.e., $\rho = 1$), taking logs and totally differentiating (16) and making use of the definition of environmental demand as $R = D - P$, it is possible to find the equilibrium income elasticity for environmental quality, i.e., the income elasticity when all prices adjust to their equilibrium values.

$$\eta = \frac{1}{1+\mu}\left(\frac{\mu c}{\mu m - c} - 1\right)\left(\frac{D-R}{R}\right) \qquad (18)$$

Where η represents the equilibrium income elasticity of environmental quality and the first term inside the first brackets represents the structural income elasticity. [1]

4. Two relevant issues related to the literature

4.1. On the EKC characterization

To highlight the contribution of our model to determining behavioral mechanisms which can explain the occurrence of the EKC, we now analyze the connections of the model with four important previous works on the topic: Lopez (1994), McConnell (1997), Lieb (2002) and Copeland and Taylor (2003)

In the first of these papers (Lopez, 1994), the existence of an EKC arises when the following condition holds:

$$\frac{dP}{dC} \gtreqless 0 \text{ if and only if } \frac{1}{\rho} \gtreqless a(C) \qquad (19)$$

Where $a(C) = -CU_{CC}/U_C$ is the degree of curvature of the utility function in income. With separable preferences, $a(C) = \frac{1}{\epsilon}$, and the condition becomes

$$\frac{dP}{dC} \gtreqless 0 \text{ if and only if } \epsilon \gtreqless \rho$$

[1] There is a difference between the "structural income elasticity of pollution" $\mu c/(\mu m - c)$ and the "equilibrium elasticity of pollution" η. The former corresponds to the income elasticity of environmental demand assuming that prices are fixed while the latter corresponds to the elasticity of environmental demand when all prices adjust to equilibrium prices.

which after some rearrangements is the same condition highlighted in equation (7). However, condition $a(C) = \frac{1}{\epsilon}$ only holds with separable preferences. In the more general case of non-additive preferences the preference-elasticity of substitution ϵ is what determines the presence of an EKC. A second contribution of this paper to Lopez's work and current EKC literature overall is that we have found a closed form for the EKC which makes it empirically testable as a behavioral hypothesis with well-defined theoretical and empirical interpretations.

McConnell (1997) focuses on the role of the income elasticity of demand for environmental quality and finds no special role for an income elasticity equal to or greater than one. Equation (18) helps to clarify this point. In equation (18), the equilibrium elasticity is negative below the turning point and positive above it, and indeed this elasticity plays no role being equal or greater than one. However, the structural income elasticity does have a relevant role. In fact, having an structural income elasticity greater than one is the necessary condition for the downward-sloping portion of the EKC to occur.

Lieb (2002) uses graphic explanations to show that an EKC arises when there is an upper bound in the utility function. In our model if $\mu > 0$ utility is bounded from above because consumption is bounded from above. In the case of $\mu < 0$, a necessary condition for the presence of an EKC is $1 + \mu\rho < 0$. It is easy to see than in the case of a linear or Cobb-Douglas production function (i.e. $\rho = 1$), this necessary condition becomes $-\mu > 1$ which also implies that utility function in consumption (in equation 7) is bounded from above.

Finally, Copeland and Taylor (2003, page 84) present a closed structural form for the EKC where the main driver of the EKC is an increasing in income elasticity of marginal damage. It is possible to show that the elasticity of marginal damage derived from the left-hand side in equation (16) is given by:

$$\epsilon_{MD,C} = \frac{\mu c}{\mu m - c} \qquad (20)$$

and becomes the particular form on page 85 of Copeland and Taylor (2003) when $\mu \to \infty$.

$$\epsilon_{MD,C} = \frac{c}{m} \qquad (27)$$

Therefore, Copeland and Taylor's model is also embedded within our more general model.

4.2. On the paradigm(s) of (balanced) aspiration consumption and environment levels

In our model, high-income individuals would like to have a balance between consumption of material goods and environmental quality. However, at low levels of income, individuals are endowed by nature with a positive amount of clean environment, while in terms of consumption they are below minimum required standards. This initial imbalance determines an initial high elasticity of substitution between consumption and environmental quality while they are poor, and therefore it is rational that at the initial low levels of income they trade some relatively abundant environment in exchange for additional amounts of relatively scarce consumption

The preference-elasticity of substitution between consumption and environmental quality interplays with the technology-elasticity of substitution between pollution and conventional production factors, which for simplicity is assumed constant, and they jointly reflect into the price system the changes in the willingness to pay for environmental quality resulting from the changes in the relative income-environmental quality scarcity provoked by economic growth. What is crucial in our model for this behavioral-adaptive mechanism to operate is the ability of the allocation system (such as the market or a social planner) to adjust the relative price of environmental quality relative to consumption to reflect the increasing willingness to pay for better environmental quality.[2]

Balancing material and non-material goods is a long standing idea in economics. As Davis (1945) explains it: "The plane or content of life is a reality experienced by an individual or group. It is made up of a complex combination of consumption, working conditions, possessions, freedoms and "atmosphere' and the balance or harmony among them, in relation to needs and felt wants."[3]

In our closed form of the EKC, as long as consumption (or income) increases, the utility function of the representative agent tends to an upper bound, a point made earlier by Lieb (2002). This idea is embodied also in Easterlin (2001), who states that at any given point in time, happiness (an indicator of individual well-being) is positively associated with income but tends to be stationary during the lifecycle of an individual; and in Frank (1997), who provides empirical evidence suggesting that beyond a certain consumption level consuming more goods does not make people happier.. For more empirical evidence on the topic see Ahuvia (2008).

5. Conclusions

The contribution of this paper is to determine what kind of social preferences can explain that a society attempting to maximize its welfare and behaving according to the usual rationality assumptions of economic theory will exhibit a development path with the shape of an environmental Kuznets curve (EKC). The paper presents a model with a

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[2] In the real world, this implies that there are enough and efficient market and regulatory mechanisms which translate social preferences, appropriately and adequately, into the relevant explicit and shadow prices.

[3] Davis (1945), page 7.

more general form of preferences which not only include as special cases those types of preferences generally employed in the EKC literature, but also are not separable as most of the others are. We show that a decreasing in income elasticity of substitution between consumption and environmental quality is the key element determining the occurrence of the EKC.

In our model, at early stages of development, individuals are relatively well endowed with environment but fall short of minimum required standards of consumption. If they have “balanced aspirations” of market (consumption) and non-market (environmental) goods, it makes sense for them to trade some environment in exchange for additional consumption when income is low to put them on a track toward higher levels of consumption (and wellbeing). If the preference-elasticity of substitution between consumption and environmental quality is a decreasing function of income, individuals will reach, in the long run, a balanced consumption of both, material consumption and environmental quality.

Necessary and sufficient conditions for the occurrence of the virtuous path described above are a positive degree of substitution between capital and pollution in production and a social decision-making processes that accurately reflect the changes in preferences as income changes.

The closed form of social welfare function we present is similar in structure to the well-known hyperbolic absolute risk aversion (HARA) preferences. It requires no ad hoc, additional restrictions on the demand or supply side of individuals’ behavior for society to follow a development path which exhibits the shape of the environmental Kuznets curve as income increases.

Moreover, the social preference-driven explanation of the EKC we propose is aligned not only with basic intuition and broadly accepted ideas in the literature, but also with economic theory and recent experimental evidence from behavioral sciences. Thus, it opens new and interesting areas for study, employing more dynamic analytical frameworks than the static one used here. For example, on the supply side, the induced technical change hypothesis would make the occurrence of the EKC both more plausible and rapid.

Finally, regarding the debate about the eventual "automatism" of the EKC, it is worth reiterating that in our model the social development path will have an EKC shape only if market and implicit prices adequately reflect changes in preferences provoked by economic growth. This implies that, in the real world, the occurrence of the EKC it is very much conditioned not only by the efficient operation of markets, but also by the adequate design and implementation of environmental regulations.

References

Ahuvia A. (2008) ´If money doesn´t make us happy, why do we act as if it does?´ *Journal of Economic Psychology* doi: 10.1016/j.joep.2007.11.005

Andreoni, J. and A. Levinson (2001), `The simple analytics of the environmental Kuznets curve´, *Journal of Public Economics* **80**: 269-286.

Arrow, K., B. Bolin, R. Constanza, P. Dasgupta,C. Folke, C. Holling, B.O. Jansson, S. Levin, K.G. Maler, C. Perring, and D. Pimentel (1995), `Economic growth, carrying capacity and the environment´, *Science* **268**: 520-521.

Beckerman, W. (1992), ´Economic growth and the environment. Whose growth? Whose environment? *World Development* **20**: 481-496.

Barbier, E. B. (ed) (1997), Special issue: `The environmental Kuznets curve´, *Environment and Development Economics* **2**. Part 4.

Brock, W.A. and Taylor, M.S. (2010), `The Green Solow model´, *Journal of Economic Growth* **15**; 127-153

Copeland, B.R., Taylor, M.S. (2003), Trade and the Environment: Theory and Evidence. Princeton, New Jersey: Princeton University Press.

Davis, J.S. (1945), ´Standards and content of living´ *American Economic Review*, **35**: 1-15

Dinda, S. (2004), ´Environmental Kuznets Curve Hypothesis: A Survey´, *Ecological Economics* **49**: 431-455.

Easterlin, R.A. (2001), ´Income and happiness: Toward a unified theory´, *The Economic Journal* **111**: 465-484.

Eeckhoudt, L., C. Gollier, and H. Schlesinger (2005), Economic and Financial Decisions Under Risk. Princeton, New Jersey: Princeton University Press.

Feigenbaum, J., (2003), ´Symmetries of the HARA class´ Department of Economics, University of Pittsburgh .

Figueroa, E. and R. Pasten. (2009) ´Country-specific environmental Kuznets curves: a random coefficient approach applied to high-income countries´ *Estudios de Economia* ***36**: 5-32* .

Frank, R.H. (1997), ´The frame of reference as a public good´, *The Economic Journal* 107: 1832-1847.

Grossman, G. and A. Krueger (1995), ` Economic growth and the environment´, *Quarterly Journal of Economics* **110**: 2, 352-377.

John A, and R. Pechenino (1994), `An overlapping generations model of growth and the environment´, *The Economic Journal* **104**: 1393-1410.

Jones L. E. and R.E. Manuelli (1995), `A positive model of growth and pollutions controls´, Working Paper No. 5205, NBER.

Kahneman, D., Diener, E., & Schwarz, N. (Eds.). (1999). *Well-being: The foundations of hedonic psychology*. New York: Russell Sage Foundation.

Kahneman, D.; Krueger, A.; Schkade, D.; Schwarz, N.; Stone, A. (2006). "Would you be happier if you were richer? A focusing illusion". *Science* **312**: 5782.

Konow, J., and Earley, J. (2007), ´The hedonistic paradox: is homo economicus happier?´ Journal of Public Economics, doi 10.1016/j.jpubeco 2007.04.006

Koop, G. and L. Tole (1999), `Is there an environmental Kuznets curve for deforestation? ´, *Journal of Development Economics* **58**: 231-244.

Lieb, C.M. (2002), ´The environmental Kuznets curve and satiation: a simple static model´, *Environment and Development Economics* **7**: 429-448.

List, J. A and C.A. Gallet (1999), ` The environmental Kuznets curve: does one size fit all? ´, *Ecological Economics*. **31:** 409-423.

Lopez, R. (1994), ´The environment as a factor of production: the effects of economic growth and trade liberalization´, *J. Environ. Econ. Manage*. **27**: 163-184.

Lopez, R. and S. Mitra (2000), ´Corruption, pollution and the Kuznets environment curve´, *Journal of Environmental Economics and Management´* **40**: 137-150.

Markandya, A., A. Golub and S. Pedroso-Galinato (2006), ` Empirical analysis of national income and SO2 emissions in selected European countries´, *Environmental & Resources Economics* **35**: 221-257.

McConnell, K., E. (1997), ´Income and the demand for environmental quality´ *Environment and Development Economics* **2**: 383-399.

Panayotou, T. (1997), `demystifying the environmental Kuznets curve: turning a black box into a policy tool´, *Environment and Development Economics* **2**: 465-484.

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.

Stern, D. I. (2004), `The rise and fall of the Environmental Kuznets Curve´, *World Development* Vol 32, No 8 1419-1439.

Stokey, N.L. (1998), `Are there limits to growth?´, *International Economic Review* Vol. 39, No 1 1-31.

Stutzer, A. (2004), `The role of income aspiration in individual happiness´, Journal of Economic Behavior & Organization Vol 54, 89-109

Suri, V. and D. Chapman D (1998), `Economic growth, trade and energy: implications for the environmental Kuznets curve´, *Ecological Economics* **25**(2): 195-208.

Tahvonen, O., and Kuuluvainen, J., (1993), ´Economic growth, pollution and renewable resources´ *J. Environ. Econom. and Manage*. 24, 101-118.

Yandle, B., M. Bhattarai and M. Vijayaraghavan M (2004), `Environmental Kuznets curves: A review of findings, methods, and policy implications´, PERC. Research Study 02-1.