

Capital accumulation, interest rate, and the income–pollution pattern. A simple model

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Abstract

In this paper we use a modified Ramsey–Cass–Koopmans model to show that the inverse U-shaped income–pollution relationship may be explained through the decreasing of the interest rate over time and with a growth in income. If the problem of the benevolent planner is (whether and how) to implement a policy for environmental pollution abatement to maximize social welfare, the rate of interest plays a fundamental role in determining the moment at which such a policy should be adopted. In particular, growth and capital accumulation together reduce the marginal rate of return of savings (and capital), making it possible to implement environmentally friendly devices at the moment when the country grows richer and its rate of interest becomes lower than the social discount rate.

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1. Introduction

The income–pollution relationship is currently one of the most important topics of research in economic literature. The so-called Environmental Kuznets Curve (hereafter EKC) is an issue in both theoretical and empirical studies because of its immediate relevance for the policy-maker, who uses it to define the most appropriate measures to adopt for environmental protection.

Since the pioneering article of Grossman and Krueger (1991), which established an inverse U-shaped income–pollution pattern, many other researchers have attempted to support this relationship with possible theoretical arguments. Without meaning to be exhaustive, we can refer to the transit from an agricultural economy to an industrialized one and later to the implementation of cleaner production processes; to government corruption, backstop technologies, institution failures, satiation of consumers, increasing returns to scale in pollution abatement processes, negative externalities on production or consumption, and so on (John and Pecchenino, 1994; Arrow et al., 1995; Selden

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and Song, 1995; Jaeger, 1998; Stokey, 1998; Suri and Chapman, 1998; Rothman, 1998; Jones and Manuelli, 2000; López and Mitra, 2000; Magnani, 2000; Panayotou, 2000; Andreoni and Levinson, 2001; Tahvonen and Salo, 2001; Di Vita, 2004).¹

In this paper we attempt to supply a new explanation for the inverse U-shaped pattern followed by some pollutants in relation to a growth in income (Harbaugh et al., 2002), by means of capital accumulation and the dynamics of the interest rate, which in the steady state should be equal to the marginal rate of return of capital.

We assume the marginal rate of return of capital to be high at a lower level of income, such that individuals want to invest in capital accumulation and to satisfy their present needs, without considering the negative externality represented by pollution in their utility function. It is not until the country becomes wealthier and the marginal return of capital decreases that agents will prove more willing to invest their savings in pollution abatement devices. This is also because ‘impatience’ decreases as people grow richer (Chavas, 2004).

The theoretical justification for choosing to delay adoption of more environmentally friendly measures until the interest rate drops may alone explain why pollution initially increases together with income and later falls as production grows. By means of the simple mechanism of a decrease in the interest rate as the economy develops, well-known since the paper of Ramsey (1928) and the theoretical framework elaborated by Cass (1965) and Koopmans (1965) (for the sake of simplicity called the RCK model) we are able to explain the inverse U-shaped behavior of some pollutants as income rises. The question that we bear in mind in writing this paper is: can the decrease in the interest rate as income grows explain the inverse U-shaped income–pollution pattern? We will show that pollution emissions first increase and later decrease as income grows, depending on whether the interest rate is greater or lower than the discount rate.

We are thus able to derive an inverse U-shaped EKC. Moreover, emissions increase in the rate of interest and decrease in the pure time preference parameter index. Using the simple theoretical framework outlined above, we demonstrate that even if some human resources are allotted to the pollution abatement sector and with increasing returns to scale in the green sector, pollution emissions will not necessarily fall. It is only at some levels of income, and for a lower marginal rate of return on capital (saving), that pollution emissions and income move in opposite directions. This may also explain why pollution abatement policies cannot be adopted during the early stages of economic development of a country.

The relevance of the interest rate in explaining the relationship between income and pollution is a recent topic and has not been discussed in economic literature before now. The only paper concerning this question, by Gruver (1976), was written before the EKC was discovered: in it the author introduces the portfolio choice between investments in productive capital and pollution control capital and underlines the fact that, at some optimal level of capital accumulation, savings are allotted to the green industry to reduce emissions. The results of this paper are not general but based on some configuration of parameters of capital and do not explicitly deal with the EKC (Pfaff et al., 2004). The added value of the present paper is that here the interest rate is held to be endogenous, while in previous analyses it was considered exogenous (see for example Di Vita, *in press*). This has allowed us to obtain more interesting results from the analysis, because it is well-known that in real economy the interest rate declines with a growth in income. The next step is to render the discount rate endogenous also. Other researchers have tackled the question using a very different theoretical framework, less general than the model we have employed here.

The novelty of this simple but original explanation of the up-and-down behavior of some pollutants explains why there are no econometric analyses considering the interest rate as an explanatory variable of pollution dynamics.

In the paper we use a very simple RCK growth model of a closed economy with an infinite temporal horizon, slightly modified in order to consider two sectors: the primary good is produced in the first; the second is the green sector dealing with the pollution abatement policy. In the economy we have depicted in our model, if no labor time is allotted to the emissions abatement sector only the industry in which inputs are transformed into a final output will be considered. A very simple production function is used, exhibiting constant returns to scale in inputs, capital and labor. The population is assumed to be constant, and normalized to one, for the sake of simplicity. In the hypothesis where pollution reduction does take place, the labor will be divided between the two sectors. The emissions abatement technology is described by a simple production function that exhibits increasing returns to scale (Andreoni and Levinson, 2001). The utility function is additively separable into two areas: per-capita consumption and stock of pollution (Hoel, 1978; Huhtala, 1999; Lusky, 1976; Plourde, 1972; Smith, 1972). We assume a functional form of the utility function that satisfies the constant intertemporal elasticity of substitution (CIES) in both.

¹ For a more detailed survey of the theoretical explanations of the EKC see Borghesi, 1999 and the introduction of Di Vita, *in press*.

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