Available online at www.sciencedirect.com

SCIENCE DIRECT®

Ecological Economics 53 (2005) 403–413

ECOLOGICAL ECONOMICS

www.elsevier.com/locate/ecolecon

ANALYSIS

A theoretical basis for the environmental Kuznets curve

Soumyananda Dinda*

Economic Research Unit, Indian Statistical Institute, 203, B.T. Road, Kolkata-108, India
S.R. Fatepuria College, Beldanga, Murshidabad, West Bengal, India

Received 14 June 2003; received in revised form 4 August 2004; accepted 25 October 2004
Available online 3 February 2005

Abstract

This paper attempts to explain the Environmental Kuznets Curve (*EKC*) or inverted U-shaped relationship between income and environmental degradation in the framework of endogenous growth model. Considering a closed economy, one part of capital is used for commodity production, which generates pollution that degrades existing environment, and the remaining part is used for abating pollution (i.e., upgrading environment). Sufficient abatement activity improves/restores environmental quality. A sufficient abatement activity (associated with commodity production) could only lead optimally towards steady state. The ratio of allocation of capital between two sectors (production and abatement) is fixed along the optimal path, but it varies along the non-optimal path that exists in the off-steady state. In the economy, allocation of capital for abatement activity varies over time. Thus, a change from insufficient to sufficient allocation of capital (i.e., investment) for abatement activity is the basis for an inverted U-shaped relationship between environmental quality and economic growth.

Keywords: EKC; Abatement activity; Environmental quality; Two-sector model; Endogenous growth model

JEL classification: H41; O40; Q20

1. Introduction

Worldwide environmental degradation makes people worried about the issue of the link between economic growth and environmental degradation. A sizeable literature[1] on that subject, both theoretical as well as empirical, has grown in recent period. Among the vast empirical studies an important finding is the Environmental Kuznets Curve (*EKC*), viz., the inverted U-shaped relationship between pollution and

* c/o Dipankor Coondoo, Economic, Research Unit, Indian Statistical Institute, 203 B.T. Road, Kolkata-108, India. Tel.: +91 33 2544 1269; fax: +91 33 2577 8893.
E-mail addresses: sdinda2000@yahoo.co.in, s_dinda@hotmail.com, s.dinda@rediffmail.com.

[1] See, for example, Agras and Chapman (1999), Bimonte (2002), Cole et al. (1997), Dinda et al. (2000), Dinda (2004), Gawande et al. (2000), Grossman and Krueger (1995), Munasinghe (1999), Pasche (2002), Rothman (1998), Selden and Song (1994), Shafik (1994), Suri and Chapman (1998), Tisdell (2001), World Bank (1992).

0921-8009/$ - see front matter
doi:10.1016/j.ecolecon.2004.10.007

economic growth. Environmental quality deteriorates initially and improves with economic development in later stage. The literature has mostly considered *EKC* as an empirical phenomenon. In order to strengthen connection between theoretical and empirical analyses, one needs models and stylized facts. One should analyze theoretical model(s) and observe under what conditions *EKC* is generated. An empirical regularity provides a relevant dimension for calibration of environmental aspects of growth model. This is useful to evaluate models on the basis of their analytical tractability and that of their compatibility with facts. The empirical evidence depends only on the reduced-form rather than the structural-forms. So, the question, why pollution-income follows this inverted U-shaped curve is not yet resolved fully.

Lopez (1994) and Seldon and Song (1995) consider exogenous technological change and pollution is generated by production. The relationship between pollution and income level depends on the elasticities of substitution of goods and the risk preference of household (Lopez, 1994). John and Pecchenino (1994) develop model based on overlapping generations where pollution is generated by consumption rather than production. Stokey (1998) allows endogenous technological change and Lieb (2002) generalizes Stokey's model and argues that satiation in consumption is needed to generate *EKC*. Andreoni and Levinson (2001) show that economies of scale in abatement are sufficient to generate *EKC*. They derive it directly from technological link between consumption of a desired good and abatement of its undesirable byproduct. The role of abatement expenditure is crucial to reduce the pollution in production side (Selden and Song, 1994), however, the abatement activity starts when a considerable capital stock is achieved (Seldon and Song, 1995). In addition, Lopez (1994) and Bulte and van Soest (2001) develop models for the depletion of natural resources[2] such as forest or fertility of land. Thus, these models generate *EKC*s under appropriate assumptions. Recently, Stern (2004) reviews the latest theories and Brock and Taylor (2004) discuss that pollution declines in high-income countries due to technological change.

This paper lays out an explanation for the *EKC*, not only that it also discusses the dynamics of the *EKC* in the framework of endogenous growth model.[3] A distinctive feature of the model is that the environmental capital enters into the utility function as well as the production function. Thus, this paper is slightly different from the existing literature.[4] Most of the existing papers have focused on the amenity value of environment without considering the environment as a productive asset. One important and unique feature of the production function is the substitutability of man-made capital (physical and human capital) and natural capital (i.e., environmental assets) that ensures long run growth. It is closely connected to the view of Tahvonen and Kuuluvainen (1993)—'a model of economic growth with stock pollution allows smooth substitution between emissions and capital'. Pollution is endogenous in our model and abatement activity plays a crucial role to check the environmental degradation. However, our model actually combines stock of capital, pollution, stock of environment (natural capital) in an endogenous growth model. In addition, it discusses the transitional dynamics rather than just steady state.

The rest of the paper is organized as follows: an endogenous growth model is built up on the basis of capital and environmental stock in Section 2, for analytic tractability specific models are used in Section 3, the steady state condition is discussed in Section 4, the existence of *EKC* is examined in Section 5 and finally, the conclusion is drawn.

2. Model setup

Consider a one-good (closed) economy for which environment, E, understood as a stock variable, affects production level and utility of the representative agent. For simplicity, we consider this economy

[2] See Krautkraemer (1985), Tahvonen and Kuuluvainen (1993).

[3] See Aghion and Howitt (1998), Mulligan and Sala-I-Martin (1993), Barro and Sala-I-Martin (1995), Bovenberg and Smulders (1995), Elbasha and Roe (1996), Michel and Rotillon (1995), Beltratti (1996), etc.

[4] There is an extensive literature on pollution and growth, including early papers by Keeler et al. (1972), D'Arge and Kogiku (1973) Forster (1973), Gruver (1976) and more recent work by Tahvonen and Kuuluvainen (1993), Gradus and Smulders (1993), John and Pecchenino (1994), etc.