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Economic growth and transitions between renewable and nonrenewable energy resources

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Abstract

We study transitions between nonrenewable and renewable energy forms at different development stages of an economy. It is shown that in the historical context the emphasis on energy production may evolve from renewables to nonrenewables and back to renewables. Typically both energy forms are used simultaneously. Along the equilibrium path, nonrenewable resource consumption may increase and their price decrease. An inverted-U relation between carbon emissions and income level may follow even without environmental policy.

JEL classification: Q30; Q40

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1. Introduction

At the end of 1997, 160 nations reached an agreement in Kyoto, Japan to limit their production of carbon dioxide and other greenhouse gases. As a consequence, various industrialized countries now face the problem of determining

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how these emission reductions can be carried out and at what cost. The Kyoto agreement was strongly influenced by the scientific work coordinated by the International Panel of Climate Change (IPCC, 1995). Their predictions for future climate change rest on certain scenarios for emissions up till the year 2100. Recently, these predictions have been questioned in two economic studies. Schmalensee et al. (1998) use an econometric model to construct predictions of fossil fuel consumption through 2050. Although they use the same scenarios for population and GDP growth as the IPCC, their model predicts appreciably higher emissions. In another study, Chakravorty et al. (1997) construct a Hotelling (1931) type model with various fossil fuels and a noncarbon backstop like solar energy. The model is simulated using demand and supply estimates, including predictions of the costs of solar energy. According to this study the IPCC emission scenarios, by neglecting backstop technology, seriously overestimate the future development of carbon emissions after the year 2050. The authors compare the IPCC failure to the Club of Rome predictions of the 1970s that many of the earth's minerals would be depleted before the next century.

Since predicting the future fossil fuels consumption has a clear economic dimension, there is no doubt that economists should continue this debate. However, it is worth keeping in mind that after Hotelling (1931) the main emphasis in the economics of nonrenewable resources has perhaps been put on physical resource depletion and on sustainability models that 'should not be taken as literal descriptions of the economy' (Krautkraemer, 1999).[1] This is in contrast to the present need to understand the history and future development of fossil fuels consumption. It is in contrast also to the present growth theory where models are evaluated against their empirical implications (Temple, 1999).

Backstop (or renewable, expendable) energy technology, which plays an important role in the study by Chakravorty et al. (1997), has been introduced into economic models by Nordhaus (1973). In Heal (1976) backstop technology refers to some future form of solar energy that is assumed to be available without limits but at high costs, which prevents its large scale commercial use. In typical models, the future switch to the backstop occurs when fossil fuels are physically depleted. In some models it is possible to speed up the introduction of a new energy technology (i.e. a discrete technological breakthrough) by investing in research and development (Dasgupta and Heal, 1974). More recently, a costly carbon-free future energy plays a vital role in a CGE model by Manne and Richels (1992). They predict that a switch to this technology may occur around the middle of the next century. A noncarbon backstop is included in a climate change differential game in Tahvonen (1994). In the Hotelling model that

[1] The Hotelling model was recently criticized by Adelman (1993), Toman and Walls (1995), and Watkins (1992). They note that resource economic models usually show increasing resource prices and declining resource consumption while the empirical development has rather been the reverse (see e.g. Barnett and Morse, 1963; Berk, 1995; Berk and Roberts, 1996).