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A comparative study of energy saving technical progress in a vintage capital model

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Abstract

We analyze the hypothesis about the effectiveness of energy saving technologies to reduce the trade-off between economic growth and energy preservation. In a general equilibrium vintage capital model with embodied energy saving technical progress, we show that positive growth is only possible if the growth rate of the energy saving technical progress exceeds the decreasing rate of the energy supply.

JEL Classification: C68; O31; O41; Q32; Q43

Keywords: Non-renewable resources; Energy saving technical progress; Vintage capital

1. Introduction

Fossil fuel – more precisely petroleum and its refinery products – is an essential input in all modern economies. It has been argued that the limited availability of this basic input and the stabilization of greenhouse gases concentration call for a reduction of fossil fuel consumption. However, the reduction in petroleum consumption could have a negative impact on economic growth and development through cutbacks in energy use (Smulders and de Nooij, 2003). Therefore, there is a clear trade-off between energy reduction and growth.

Some authors (see, for instance, Carraro et al. (2003)) suggest that this trade-off could be less severe if energy conservation is raised by energy saving technologies. In this paper, we re-examine the exhaustion problem of fossil fuel. In particular, we study the previous trade-off in a

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general equilibrium framework with energy saving technical progress. This model based on Boucekkine et al. (1997), considers an economy with exogenous energy saving technical progress embodied in the new equipment. As Baily (1981) observes, technical advances are typically incorporated to the economy through investment. Therefore, the old capital goods get less and less efficient over time, which might well induce the firms to scrap them (obsolescence). In our economy, we assume that different vintages of capital coexist in each period. Since new vintages are less energy consuming, firms may decide to replace the oldest and less efficient vintage. Indeed, if we model the idea of minimum energy requirement to use a machine by assuming complementarity between capital and energy inputs, finite scrapping time is optimal (Boucekkine and Pommeret (2004)). This idea is implemented in our paper, and it is consisted with the empirical evidence put forward by Hudson and Jorgenson (1974), or Berndt and Wood (1975).

Our model incorporates two new elements with respect to the standard framework. First, we assume embodied technical progress in contrast to the typical neoclassical specification of neutral and disembodied technical progress. Second, we consider a vintage capital model, with endogenous scrapping decision. The standard models consider homogenous and infinitely lived capital stock.

We perform a comparative study to contrast constant and decreasing returns to scale, for two possible scenarios: constant (optimistic) and decreasing (pessimistic) exogenous energy supply. We find that, under the assumption of existence of a balance growth path defined by constant growth rate of all the endogenous variables and constant scrapping age, constant returns to scale[1] achieves positive long run growth if the growth rate of the energy saving technical progress exceeds the decreasing rate of the energy supply.

The paper is organized as follows. In Section 2, we describe the general case model, with the representative consumer's problem and the rules that depicts both the optimal investment and the scrapping behavior of firms. The balanced growth path is presented in Section 3, where we show the necessary conditions for its existence in both constant and decreasing returns to scale. Finally, some concluding remarks are considered in Section 4.

2. The Model

Following Boucekkine et al. (1997), we consider an economy where the population is constant and there is only one good (the numeraire good), which can be assigned to consumption or investment. The good is produced in a competitive market by mean of a technology defined over vintage capital. Both constant and decreasing returns to scale are considered here. Also, we assume a competitive labor market and exogenously available energy supply.

2.1. Household

Let us assume that the representative household considers the following standard inter-temporal maximization problem with a constant relative risk aversion (CRRA) instantaneous utility function

$$\max_{c(t)} \int_0^\infty \frac{c(t)^{1-\theta}}{1-\theta} \mathrm{e}^{-\rho t}\, \mathrm{d}t, \tag{1}$$

[1] Constant return to scale cannot ensure long run growth in our model because of the endogenous scrapping decision and the minimum energy requirement to use a machine.