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Non-renewable resources and growth with vertical innovations: optimum, equilibrium and economic policies ☆

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Abstract

We consider a Schumpeterian model of endogenous growth with creative destruction in which we introduce a non-renewable natural resource. We characterize the optimum and the equilibrium paths, and we derive the precise levels of economic policy instruments that allow the implementation of the optimum. Moreover, we study the effects of these policies on the relevant steady-state variables, in particular the rate of extraction of the resource.

Keywords: Non-renewable resources; Endogenous growth; Vertical innovations; Optimum; Equilibrium; Economics policies; R&D; Knowledge

1. Introduction

It may seem paradoxical to ask whether positive infinite growth is possible despite the fact that the production process uses non-renewable natural resources. For several decades, this question has given birth to an important economic literature, most notably in growth theory. This literature has established that under some properties of the resource and some technological characteristics, positive long-run growth is possible even if the stock of the natural resource is finite.

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In fact, many questions can be addressed and the following ones seem especially relevant to us:

- Is continuous growth compatible with a finite stock of natural resources?
- What is the optimal path, and what are its properties? In particular, even if positive growth is possible, is it optimal?
- What are the properties of the equilibrium path? Is it optimal? If not, are there economic policies that allow the implementation of the optimum? More generally, what are the effects of these policies?

In the 1970s, Dasgupta and Heal [6], Solow [14], Stiglitz [15], and Garg and Sweeney [8], among others, analyzed the problem in "standard" growth models ("à la Ramsey"). They showed that under certain technological conditions, positive long-run growth is possible in the presence of non-renewable natural resources. Moreover, they studied the optimal and the equilibrium paths. More recently, this analysis was relaunched within the context of endogenous growth models. In this new framework, the first-order conditions that characterize the optimum are, in some cases, not fulfilled at equilibrium, essentially because of the intertemporal externalities arising from the fact that knowledge is a public good. Indeed, if Barbier [3] and Aghion and Howitt [2] focus mainly on optimality aspects, and Scholz and Ziemes [11] on equilibrium, Schou [12] and Grimaud [9] make use of a model of horizontal innovations to show that while positive optimal long-run growth is possible, the equilibrium path is not optimal.

In this paper, we use a Schumpeterian model of endogenous growth (i.e., with vertical innovations) "à la Aghion–Howitt" [1] to tackle this problem which has generally been done with "à la Romer" [10] models and raise the same questions as above. In fact, our results partly resemble those obtained by authors working with "standard" growth models (e.g. [8,15]), but we also find noticeable differences that raise new questions that we investigate. Moreover, we employ a very simple framework (in particular, we assume that there is a single intermediate good) so as to avoid computational complexity and to highlight the relevant phenomena.

In our model, the natural resource is necessary but non-essential (as defined by Dasgupta and Heal [7]), and a positive long-run growth is always possible if the R&D sector is productive enough. However, we find that this positive long-run growth may be non-optimal, because the optimum could also be characterized by a negative growth of output. As in Schou's [12] paper, we show that, at equilibrium, growth (which can be positive or negative) is not optimal. However, contrary to Schou who finds that growth is under-optimal, we show that it may be either under or over-optimal. We then demonstrate that there exist economic policy tools that allow the implementation of the optimum and we compute the precise levels of these tools that equate both paths. We also perform some comparative statics exercises to analyze how the relevant variables of the model, in particular, the rate of extraction of the resource, are affected by these policy tools. Throughout the paper, we focus on optimum and equilibrium along the balanced growth paths only, i.e., on paths along which the growth rate of any variable is constant.

The remainder of the paper is organized in five sections. In Section 2, we present the model. We characterize the optimum in Section 3, and the equilibrium in Section 4. In the latter section, we also compare the optimum and the equilibrium and we analyze the impact of the economic policy tools on the relevant variables. Section 5 is devoted to the implementation of the optimum by means of these tools. A summary and some concluding remarks are given in Section 6.