Growth and non-renewable resource when R&D uses capital

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Abstract. This paper studies efficient and optimal growth paths in a two-sector R&D-based growth model with an essential non-renewable resource. A crucial feature of the model compared with standard two-sector models with non-renewable resources is that it takes into account that not only labour, but also capital, is an input in R&D. Thereby the non-renewable resource, which is a necessary input in the manufacturing sector, is indirectly a necessary input also for the R&D sector. This affects the conclusions in important ways: more narrow limits to growth arise; the scope for various policy tools changes; no knife-edge condition is any longer needed for fully endogenous growth; there is no scale effect on growth; and population growth can easily be integrated.

Keywords: R&D; endogenous growth; non-renewable resources; scale effects; limits to growth.

JEL Classification: O31, Q32.

Introduction. A series of papers has analysed the role of non-renewable natural resources for endogenous growth (Robson 1980, Takayama 1980, Jones and Manuelli 1997, Aghion and Howitt 1998, Chapter 5, Scholz and Ziemes 1999, Schou 2000, Schou 2002, Grimaud and Rougé 2003). This literature typically analyses an economy with two sectors, a manufacturing sector and a ”knowledge sector” where a fraction of the labour force is employed in R&D or education. The conclusions reached are pretty much in conformity with those of the conventional endogenous growth models without non-renewable resources. In particular, the cited papers associate sustained per capita growth with the usual (but problematic) knife-edge condition that the knowledge sector has exactly constant returns to scale with respect to the producible input(s) (at least asymptotically). And in the R&D-based models, the controversial scale effect on growth tends to pop up (although sometimes hidden by the labour force being normalized to one). The general impression is that limited non-renewable resources may be a drag on long-run growth, but never an impediment.
However, common to these papers is the assumption that labour is the only input in the growth-generating sector (the "growth engine"). Thus, natural resources do not appear in the growth-generating sector, not even indirectly in the sense of such resources being a necessary ingredient in the production of physical capital goods which are then used in the growth engine (e.g., a research sector). However, this is an unrealistic feature. It seems unlikely that the growth-generating sector should be completely independent of the non-renewable resource. Like other production sectors, research labs and educational institutions use not only skilled labour, but also physical capital in the form of instruments, computers, buildings etc. And one level back in the chain of production these inputs used minerals and oil products in their production.

The present paper shows that taking this fact into account changes the conclusions in several respects. More narrow limits to growth enter the picture. The unwelcome scale effect on growth disappears; hence, population growth is easily incorporated into the model. The parameter restriction required for "fully endogenous growth" no longer has the character of a "knife-edge condition". In contrast to the standard approach we also find that in general, for policy to enhance long-run growth, it has to slow down the speed of resource depletion. In this way, conservation and growth go hand in hand.