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On the effects of human capital and R&D policies in an endogenous growth model ☆

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Abstract

We introduce an external effect of existing technologies in human capital accumulation in an endogenous growth model and describe its steady-state and transition. We numerically solve the model to compare the quantitative effects of R&D policy with the quantitative effects of human capital policy in wealth and welfare. Although R&D subsidies have now an overall positive effect on growth, wealth and welfare, the calibration exercise shows that for plausible values for the parameters, human capital policy is simultaneously the most income and welfare-improving and the less expensive to the government.

JEL classification: O15; O30; O41

Keywords: Human capital; R&D; Endogenous growth; Welfare

1. Introduction

This paper considers an effect of existing technologies in new human capital production in a model with physical capital, human capital and R&D. The underlying model follows Arnold (1998, 2000) and Funke and Strulik (2000). In this literature, steady-state growth is not affected by innovative activities in the economy; but solely by human capital and preferences parameters. We show that the consideration of this novel effect also implies an effect of R&D productivity and subsidies in economic growth, consumption and income. According to Funke and Strulik (2000), a refinement of the human capital accumulation process might be a fruitful path of research. This contribution relies on one possible refinement of that process.

The idea of an effect of the stock of technological knowledge in human capital production builds on the complementarity between technology and human capital, already present in several contributions (e.g. Keller, 1996;

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Galor, 2005 and references therein). Some other references argue that in the final goods sector, technologies are absorpted by the production process (e.g. Eicher, 1996).

Zeng (2003) studied the impact of policies in the long-run growth in a model with R&D and human capital in which R&D policies also influence economic growth. He had considered that human capital accumulation depended on both human and physical capital, a different human capital function than that used in this article. As a matter of fact, Arnold (1998: footnote 11) already mentioned that his "invariance results would no longer hold, however, if we include knowledge, A, or physical capital as an argument in the education technology". While Zeng (2003) pursued the second approach, we pursue the first, proposing an intuitive function for human capital accumulation. Furthermore, as Zeng (2003) did not solve the model for the transition path, he did not provide a quantitative analysis of R&D and human capital policies. We intend to fill this gap. We do this calculating the whole transition path of a theoretical economy. In this sense, this article also provides an example of welfare analysis in the market equilibrium, which has not been done yet in this literature.[1]

In Section 2, we present the model and describe its transition dynamics and the steady-state. In Section 3, we describe the model quantitative properties and we quantitatively compare the effects of improving in education and R&D. Finally, we conclude in Section 4.

2. The model

The model builds on Arnold (1998, 2000), Funke and Strulik (2000) and Gómez (2005), who integrated human capital accumulation and R&D in the same model and studied its convergence. We add the consideration of an effect of the stock of knowledge in human capital production. This effect appears as a form of complementarity between technological knowledge and human capital. We assume that government subsidizes education expenditures of families, paying a proportion (s^H) of total expenses and also subsidizes R&D, paying a proportion (s^R) of R&D private costs. We assume, as Büttner (2006), that these subsidies are financed by lump-sum taxes.

2.1. Engines of growth

2.1.1. The human capital accumulation

Individuals may spend part of their human capital, H_H, on education. This non-market activity is described by a production function of the Uzawa (1965)–Lucas (1988) type. However, skills may also be accumulated through the contact to aggregated technological knowledge of the economy. This contact with technologies is made using the stock of individual human capital.

The following expression expresses these ideas

$$\dot{H} = \xi H_H + \gamma H^{\sigma} n^{1-\sigma}, \quad \xi, \gamma > 0; 0 < \sigma < 1. \tag{1}$$

where ξ is the productivity of schooling and it measures the incentive to spend time in education. This function interprets human capital accumulation as being dependent on schooling (ξH_H) and the new effect ($\gamma H^{\sigma} n^{1-\sigma}$), which we call "learning with varieties". The first process is only dependent on time dedicated to schooling (H_H) and the second is dependent on the stocks of individual human capital (H) and existing varieties on the economy (n); γ measures the relative importance of "learning with varieties" in the human capital function and σ measures the intensity of human capital needed to "learn" the existing technological knowledge.[2] The second parcel in (1) can be seen here as a process of learning the existing technologies, which efficiency depends on the already accumulated human capital. This learning process contributes to accumulate human capital in the economy.[3] As a referee pointed out, this constitutes an externality from R&D to human capital.

[1] We focus this article on the market equilibrium. Thus, when we refer to welfare analysis we mean the analysis of the utility level in the decentralized equilibrium solution and not to any comparison between this and the social planner solution.

[2] Making $\gamma=0$ transform this function into the Uzawa (1965)–Lucas (1988) framework and the model would transform into that studied in Gomez (2005), among others.

[3] This effect can be interpreted as an activity done in entrepreneurial activities. Iyigun and Owen (1999) considered the existence of separate production functions for professional and entrepreneurial human capital. Moreover, both human capital types contribute to the R&D process, which is also what happens here. We exclude the existence of human capital depreciation, as previous contributions also did, as this does not influence our results. We suggest that this process can be called a type of absorption of existing technologies by human capital.