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On endogenous growth with physical capital, human capital and product variety

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Abstract

We set up an endogenous growth model with physical capital, human capital and blueprints for intermediate goods. The model can generate steady-state growth or stagnation. Along the adjustment path for a developing economy we can distinguish different stages of development. The first stage is characterized by physical factor accumulation. At the second stage the economy follows a growth path which is mainly characterized by the accumulation of skills. Growth of the fully developed economy is identified by an increasing variety of goods originating from costly R&D efforts. Transition to a higher stage of development is explained endogenously. Thus, the model provides a high degree of generality by encompassing the standard neoclassical growth model and modern endogenous growth theory.

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1. Introduction

Modern textbooks on economic growth usually contain three main theoretical parts, each devoted to a 'different' approach in growth theory. The first part

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usually begins with a discussion of Solow's (1956) neoclassical growth model together with the endogenous savings extention of Cass (1965) and Koopmans (1965). The second part introduces endogenous growth through physical capital and human capital accumulation following Uzawa (1965) and the modern formulation of Lucas (1988), Rebelo (1991), or Caballé and Santos (1993). The third part explains the mechanics of R&D-based growth models, where main contributions were developed by Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992). Asked by the layman to identify the 'right' model out of this three-part – set the professionals' most heard answers are: (a) it depends, (b) each model has its own merits. One purpose of the paper is to show that these answers are sound and theoretically well founded.

The paper presents a model where growth is driven by physical capital accumulation, knowledge accumulation and R&D-based technological progress. It combines the Uzawa–Lucas setting with the basic model of Grossman and Helpman (1991, Chapter 3) which introduces endogenous technological change through increasing variety of inputs. The main difference to existing contributions in the literature is that we do not focus solely on the case were individuals invest in human capital and R&D but also consider cases were they do not invest due to 'too small' incentives. It will be shown that the neoclassical growth model as well as the Uzawa–Lucas economy are not only included in the augmented Grossman–Helpman model as special cases, but that each of these models may serve as the best approximation out of this three-type set for a transitional period during the development process. However, a sufficiently high productivity of the educational system together with the permission to invent new products ensures that the economy ends up as an innovative one. For reasonable parameterizations physical capital contributes approximately 50% to steady state growth. The other half are contributions from the 'growth engines' increasing labour quality and technological progress with approximately equal shares. Whereas innovations (or technological progress) are an engine for growth, knowledge formation is the engine for innovations.

Long-run growth is independent of scale effects. It is semi-endogenous in the terminology of Jones (1995), i.e. steady-state growth of the fully developed economy is determined by parameters of preference and technology that are often regarded to be exogenous. Besides the original Jones (1995) contribution these characteristics are also displayed in models developed by Keller (1996) and Arnold (1998). Whereas in Jones (1995) the rate of innovations is driven by population growth (born researchers), in Arnold's, Keller's and our setting innovations are driven by human capital accumulation (skills of researchers). Both Jones (1995) and Arnold (1998) allow a more general production function for new blueprints that includes not only knowledge spillovers but also duplication externalities. All three authors concentrate their analysis on the advanced innovative economy. Our model emphasizes the role of physical capital which allows an analysis that encompasses the development process towards an