

Recent Research in Endogenous Growth: A Review of Aghion and Howitt's Textbook

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1. Introduction

At the end of the 1980s, two influential papers by Romer (1986) and Lucas (1988) have led to a re-awakening of interest in determinants of economic growth. The breakthrough to studying technological change and growth was achieved by Romer (1990), building on Grossman and Helpman (1989) from modelling point of view¹. Important early contributions were also made by Rebelo (1991), Grossman and Helpman (1991a, b, c) and Aghion and Howitt (1992)². The scale-effect critique was made most forcefully by Jones (1995) which was incorporated into a growth model that met this objection by Young (1998). One or the other of the early models³ was used to analyse a broad range of issues, covering almost all aspects of economics.

Both the huge success of this research program and its maturing led some economists to write textbooks. The earliest was by Barro and Sala-i-Martin (1995), followed by Jones (1998) and now Aghion and Howitt (1998). Even earlier, Grossman and Helpman's book appeared in 1991. Other textbooks include Arnold (1997) and Maußner and Klump (1996).

The publication of Aghion and Howitt's book is taken as a welcome occasion to take stock of what is known about economic growth. The next section proposes what one ideally would like to know about economic growth. In the subsequent section, Aghion and Howitt's book is read with these questions in mind. A final section briefly discusses where research on economic growth could go to.

2. What research about economic growth should tell us

Any normative statement is to some extent arbitrary. No attempt is therefore made here to defend that underdevelopment, unemployment and wage inequality, and environmental issues are the most pressing problems of our time, apart from mentioning

¹ Grossman and Helpman study how the number of firms in a dynamic monopolistically competitive environment is determined. To this end, they introduced an intertemporal zero profit condition that underlies Romer's growth model.

² This chronology is by date of publication which does not necessarily reflect date of first versions of papers. See Grossman and Helpman (1994, fn 8) for some more chronology.

³ The AK-type models were not introduced by the endogenous growth literature but predate it, as stressed e.g. by Bardhan (1995).

that this view might result from a purely distributional perspective. Underdevelopment is a question of distribution between rich and poor countries, unemployment and wage inequality is a question of distribution between high and low labour income, and environmental issues are a question of distribution between present and future generations. Economic growth is related to all three of those questions: in a least controversial way to underdevelopment, in at least some way to unemployment and wage inequality and maybe in the most ambiguous way to environmental questions.

Given this point of view, theoretical and empirical advances in economics of growth should lead to policy recommendations that allow - in an ideal case - to make unambiguous predictions about determinants of growth rates. One should then be able to understand why some developing countries grow, why some other developing countries do not, why there has been a productivity slowdown in industrialized countries and why industrialized countries became industrialized; put short, why there is *underdevelopment*.

A recurrent theme in public discussions about growth and *unemployment* is the job destroying effect of new technologies. New technologies have always been the object of criticism and origin of social unrest, think e.g. of the Luddite revolt in 19th century England (Thomis, 1970). Does this criticism stand up to scrutiny? Are these arguments internally consistent? This is one (of many other) questions, economic growth theory should try to answer.

Finally, what is the effect of growth on the *environment*? Does growth lead to more pollution? Do new technologies help to reduce pollution in absolute or at least in relative terms? Is this technological gain sufficient to overcompensate more pollution from growth? A popular argument cast in economic terms states that individuals that both neglect current externalities and have a finite planning horizon bequeath capital and environmental quality that leads to lower welfare for future generations. Again, is this argument internally consistent? Is there some empirical relevance to it?

3. What Aghion and Howitt's book teaches us

According to the authors, the book's objective is to provide a comprehensive account of both economic growth theory itself and of its applications. This is what they indeed achieve. In the first chapter, they present the Solow-Swan model without and with optimal saving, mention in passing the Harrod-Domar model, discuss the, what they call, Frankel-Romer model (Frankel, 1962 and Romer, 1986) and conclude with an overview of the empirical evidence, based mainly on Barro and Sala-i-Martin (1995). Aghion and Howitt's (1992) main contribution to the literature is then presented in chapter 2 with an extension to include capital accumulation in chapter 3. The effects of learning by doing (possibly lower growth), market structure, education (the Lucas, 1988, model) and international trade are studied in chapters 6, 7, 10 and 11. Applications to unemployment, environmental issues, business cycles and distributional and political economy questions are studied in chapters 4, 5, 8 and 9. Finally, chapter 12 presents tests of the endogenous growth theory and the last two chapters 13 and 14 study organizational questions of R&D, i.e. private management (as in Aghion and Tirole, 1994) and public aid to innovation, respectively.

If a reader's primary interest in economic growth consists in understanding why some countries do *not* grow, the book (and the endogenous growth literature) offers two answers. The simple one is the "parameter answer": Either because total factor productivity (in the AK model), productivity in the education sector (in the Lucas model) or the human capital level or labour endowment (in the Aghion-Howitt, Romer or Grossman-Helpman model) are not sufficiently high (or impatience not sufficiently low).

A more sophisticated answer results from multiple equilibria models: Aghion and Howitt present both the Azariadis and Drazen (1990) and the Redding (1996) model. Azariadis and Drazen assume an intergenerational education externality which implies that the amount of human capital that can be accumulated by the current generation, more precisely the productivity of the human capital accumulation technology, depends positively on the amount of human capital accumulated by the last generation. As a consequence, a country may find itself in a low-development trap if human capital investment of the last generation was too low. If it was sufficiently high, individuals invest more in human capital and the economy grows faster. Multiple equilibria, selected by *history*, exist.

Redding analyses an economy where households decide upon their investment in human capital taking total factor productivity as given while firms invest in total factor productivity growth taking the human capital stock as given. As this gives rise to a strategic complementarity, multiple *expectational* equilibria exist and scope for coordination arises. If households believe that firms will invest in R&D and firms believe that households will invest in human capital accumulation, the economy finds itself in a high-growth equilibrium. If both agents have negative expectations, the economy's growth rate is low, possibly zero.

A reader interested in (frictional) unemployment finds in chapter 4 "Unemployment and Growth" an extended version of Aghion and Howitt (1994). The Diamond-Mortenson-Pissarides matching model is extended to allow for an endogenous separation rate. This is achieved by assuming "overhead costs" a , decreasing returns to scale ($\beta < 1$) and a fixed total factor productivity A_t in perfectly competitive firms that employ one worker and human capital x to produce y , $y = A_t[x - a]^\beta$, together with an exogenously growing total factor productivity in the economy. When total factor productivity in the economy has sufficiently grown, a firm has to shut down, the worker is dismissed and has to search for a new job (human capital is always fully employed). In this setup, faster growth has two effects. First, the capitalisation effect known from Pissarides (1990) increases the equilibrium level of vacancies and therefore decreases unemployment. Second, the length workers are employed in a firm falls (direct creative destruction effect) and the value of a new technology falls faster, as profits fall faster during its lifetime (indirect creative destruction effect). Overall, unemployment first rises as the growth rate rises but after some threshold level (depending on parameter values) it falls. Interestingly, when growth is endogenous, the unemployment rate does not change as the growth rate increases when higher growth is caused by a higher frequency of innovations but rises in the growth rate if a change of the latter is caused by a change in the size of innovations.

Chapter 5 "Endogenous Growth and Sustainable Development" contains a focused discussion on the notion of sustainable development leading to the definition that constant positive growth rates of output (development) are sustainable if the quality of the

environment does not fall below a critical ecological threshold. Both AK type and Schumpeterian models are used to work out conditions under which economic growth is sustainable. Aghion and Howitt show that in a world where the pollution to output ratio is invariable (the AK model version), long-run positive growth can not be reconciled with a non-decreasing quality of the environment. In a (Schumpeterian) world where technological progress allows the pollution to output ratio to sufficiently fall, however, long-run positive growth can be achieved. Hence, output growth is sustainable only if new technologies improve, i.e. decrease, the pollution-output ratio. Unfortunately, these results are found for somewhat restrictive parameter assumptions (e.g. that the elasticity of marginal utility of consumption exceeds unity), as the authors note themselves.

4. Where one could go

Aghion and Howitt assume risk-neutral households in their main 1992 contribution, presented in chapter 2. When their basic model is extended to allow for capital accumulation (chapter 3), they continue for most of their discussion to assume risk-neutral households. When risk-averse households are explicitly introduced (chapter 5), their consumption growth rates indicate that they implicitly assume that technological progress is risky on the micro-level but deterministic in the aggregate, as e.g. in quality ladder model of Grossman and Helpman (1991c). A natural next step would therefore be to study optimal consumption and investment behaviour of risk-averse households that face non-diversifiable aggregate risk that stems from R&D⁴. Apart from being a methodological contribution, new economic insights can be obtained as has been shown in Wälde (1999), who introduces risk-averse households in the Aghion and Howitt (1992) model.

Clearly more could be said about growth and development. Yet, endogenous growth theory, especially when based on technological change and R&D, primarily aims at understanding growth in developed economies (despite North-South models and regressions run on cross-country data where the majority of countries is not industrialized). One might therefore conclude, as e.g. Bardhan (1995) did, that the contribution of endogenous growth theory to understanding development issues is limited. Obviously, one can not find (or should even look for) *one* policy recommendation for around 90 low- and lower-middle-income countries. Still, the problem of underdevelopment seems much more related to non-existent or non-functioning institutions rather than to mechanisms stressed by endogenous growth models, even when taking multiple equilibria models into account. The applicability of these models is sometimes hard to be seen in the field.

It would be unfair to argue that countries with high unemployment are not countries with high growth rates, as one would expect from Aghion and Howitt's analysis. It was not their objective to explain high unemployment but to clarify the link between new technologies and unemployment. The endogeneity of the separation rate is clearly a major contribution (though estimates generally indicate that firms operate under mildly

⁴ For first steps in this direction, cf. Wälde (1998).

increasing returns to scale; cf. Basu, 1996, for references and a critical discussion). Yet, unemployment in most industrialized countries is, in the first place, probably not a frictional but a structural problem. In the case of Germany, it is often argued that a tax reform that reduces tax-evasion, broadens the tax base and reduces total labour costs (but not *net* wage income) could be an important step forward.

The analysis of growth and the environment is performed in a centrally planned economy with an infinite horizon planner. Coming back to the questions posed at the beginning, what happens in a decentralized economy where households neglect current and intertemporal spillovers? The literature has provided partial answers to this question (John and Pecchenino, 1994, 1997) but more remains to be understood (Smulders, 1995, provides an introduction to the literature). It appears possible that the current externality is internalized by a voting mechanism but is this enough to prevent major ecological disruptions given the intertemporal externality?

Overall, Aghion and Howitt's textbook provides a broad overview and introduction to the literature on endogenous growth. As their approach has a slight bias towards their own contributions to the literature, this book nicely complements other textbooks mentioned above. For a reader not familiar with the literature, it provides an in-depth introduction that can be highly recommended. Needless to say, this almost 700 pages book offers many more models and original research than what was presented here. In addition, it contains problem sections at the end of each sector *and* solutions to these problems at the end of the book.

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