

Economic Growth Nonlinearities

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Abstract

Nonlinearities in growth have important implications for cross-country income inequality. In particular, they imply that countries may spend long periods of time in a low-growth poverty trap. However, finding evidence of such nonlinearities in the data and accounting for their emergence pose unique challenges to researchers.

1. Nonlinear growth models

Nonlinear growth models are characterized by a country's subsequent performance being critically dependent upon its initial conditions. In particular, these models tend to imply that countries which have unfavourable initial conditions may either experience substantial periods of time in low-growth/low-income poverty traps or be altogether caught in one. In some cases, it has been explicitly suggested that active (exogenous) policy interventions may be necessary in order to kick-start a country into a more favourable equilibrium. Nonlinear growth models can be broadly classified into two classes: structural change (or 'stages of development') models, and models that emphasize endogenous technological development and cross-country interactions in terms of technological diffusion.

Structural change models focus on the (internal) transformations of an economy as it transits through critical phases or 'stages' (see Lewis, 1956; Rostow, 1960) leading to industrialization. The aim of this work is to clarify the conditions for such transitions to occur. Early work in the economic development literature (see Rosenstein-Rodan, 1943; Nurkse, 1953; Scitovsky, 1954; Fleming, 1955; formalized by Murphy, Shleifer, and Vishy, 1989) emphasized the importance of increasing returns and the size of the

market in industrialization. The key idea behind this view is that countries could be locked in a no-industrialization trap because of the small size of the market for each sector of the economy. No single sector can achieve growth on its own. However, the growth of one sector results in the enlargement of markets for other sectors. The enlargement of markets then encourages investment and growth in the corresponding sectors. These spillover effects and strategic complementarities imply that a ‘big push’ – that is, coordinated investments (or ‘balanced growth’) across sectors – may be sufficient to push the economy out of the trap and into a ‘take-off’ towards industrialization. Other models are explicitly informed by the analysis of historical data (see Maddison, 2004), and emphasize the importance of explaining simultaneously both historical patterns of other state variables associated with growth and growth itself. An important recent work that models the demographic transition in growth take-offs is Galor and Weil (2000). Because these models require that certain conditions be met before countries are able to achieve take-off, those who do not meet these requirements could find themselves trapped in a phase of economic stagnation for extended periods of time.

The second class of models focuses on the role of technological progress in growth. In particular, the emphasis of these models is on the diffusion of technology from countries which are technological leaders to less developed countries. Lucas (2000) is a seminal work in this area (see also Basu and Weil, 1998; Parente and Prescott, 1994; Howitt and Mayer-Foulkes, 2005). Particular attention has been paid to exploring the channels through which less advanced countries imitate or adopt technologies in leader countries. If there are no barriers to technological diffusion across countries, then these models typically predict that rich and poor countries would gradually converge in per capita income. However, if such barriers exist, then countries may differ in their ability to adopt technologies leading to the creation of ‘clusters’ of countries defined by a set of common barriers to technological adoption. Countries within each of these clusters or ‘convergence clubs’ converge to common levels of mean per capita income. Nevertheless, the per capita incomes across convergence clubs need never converge and the polarization of per capita incomes across countries may be permanent.

2. Growth empirics

In both classes of models, therefore, the primary concern is that countries may become separated – perhaps permanently – into multiple growth regimes corresponding to different levels of long-run per capita income. The fact that nonlinear growth models imply that global inequality may be persistent has sparked major advances in the area of cross-country growth empirics. Driven by such concerns, the central preoccupation of growth empirics has been to evaluate the conditions under which poor countries catch up with rich ones or fail to do so. Initial work along these lines focused on the concept of ‘conditional convergence’. Conditional convergence is said to occur if permanent per capita income differences between countries can be accounted for solely by structural differences (and not initial conditions). Researchers initially argued that because conditional convergence was predicted by the canonical neoclassical growth model (see Ramsey, 1928; Solow, 1956; Swan, 1956; Cass, 1965; Koopmans, 1965) whereas nonlinear growth models potentially predict dependence on initial conditions, tests for conditional convergence could be used to discriminate between these classes of theories.

Following Mankiw, Romer and Weil (1992) and Barro and Sala-i-Martin (1992), the canonical way such tests were conducted was to first construct a linearized version of the neoclassical growth model about the (unique) steady state with average growth rates across a time period as the dependent variable, and measures of physical and human capital, population growth rates, and initial per capita income as covariates. Researchers then applied the linearized neoclassical model to cross-country data with the aim of testing to see whether the data supported a negative coefficient on initial per capita income. A finding of a negative coefficient on initial per capita income was taken to imply that, conditional on countries having similar structural characteristics (as defined by the set of covariates), poorer countries would close the income gap with the rich – that is, conditional convergence.

An important outcome of the, oftentimes heated (see Sala-i-Martin, 1996), convergence debates of the 1990s was precisely to weaken the idea that such tests of convergence could be interpreted as model selection tests. In a highly influential work, Bernard and Durlauf (1996) strongly disputed the interpretation of such ‘conditional convergence’ tests by pointing out that these tests were not able to discriminate against a

class of nonlinear growth theories that have dramatically different ergodic implications from the neoclassical model. The class of models they were referring to was developed by Azariadis and Drazen (1990). Azariadis and Drazen extended the spillover models of Lucas (1988) and Romer (1986) and showed that, if (local) nonconvexities in the production function were sufficiently strong, then countries that are similar in all aspects except for initial conditions may nevertheless be organized into multiple growth regimes, each of which corresponds to a different steady state for long-run per capita income.

Bernard and Durlauf showed that the multiple-regimes Azariadis–Drazen model was theoretically consistent with a finding of conditional convergence in the data. Therefore, even in the narrowly restricted sense of countries being structurally similar, the finding of a negative coefficient to initial income in the data was no guarantee that countries would converge to a common steady state. Galor (1997) lent further support to the relevance of the Azariadis–Drazen model by arguing that standard ways of augmenting the traditional Solow model increased the likelihood that the true data-generating process followed a multiple-regimes rather than a single steady-state model. Clearly, evidence of multiple regimes and nonlinearities in growth raises questions about misspecification in empirical studies that assume that all countries follow the same growth process, and casts doubt on inferences and policy recommendations that are drawn from these studies.

The work by Bernard and Durlauf has spurred a large quantity of research searching for the existence of multiple-growth regimes. One direction of this new research has been to argue that the finding of parameter heterogeneity in the neoclassical model may be suggestive of the existence of multiple growth regimes. In a seminal work, Durlauf and Johnson (1995), employing a classification and regression tree methodology, implemented a version of Azariadis and Drazen’s model and showed that there was evidence in the data to suggest that countries grouped according to initial per capita income and literacy rates correspond to four different growth regimes. Their work has inspired a long list of confirmatory works using a wide variety of econometric approaches (for example, Bloom, Canning and Sevilla, 2003; Canova, 2004; Durlauf, Kourtellos and Minkin, 2001; Kourtellos, 2005; Liu and Stengos, 1999; and Tan, 2005).

While there now is a strong consensus in the literature that there exists substantial

heterogeneity across countries, it should be emphasized that this finding is only suggestive of multiple-growth regimes and is not conclusive evidence of it. These heterogeneities could arise because of small deviations in the specification of the production function (see Masanjala and Papageorgiou, 2004) which need not correspond to multiple-growth regimes. Further, even within the context of Azariadis–Drazen model, if non-convexities in the production function are not strong enough, the finding of parameter heterogeneity would not imply the existence of multiple regimes (see Durlauf and Johnson, 1995, Figure 2).

An alternative approach to investigating the existence of multiple regimes or convergence clubs has focused on the evolution of the world distribution of per capita income. The aim of this research has been to look for evidence of emerging multimodality (typically, bimodality) in the world income distribution. A secondary aim has been to evaluate the degree of churning within the multimodal distribution. If the world income distribution is characterized by emerging multimodality with little evidence of countries moving freely within the distribution (that is, churning), then this finding would suggest, in a manner analogous with the finding of multiple-growth regimes, that global income inequality is real, intensifying, and persistent in nature. In fact, these are the precise findings by Quah (1993). By estimating transition probabilities for the cross-country per capita income distribution, Quah finds emerging ‘twin peaks’ in the world income distribution as well as substantial persistence within the distribution. Quah’s seminal work has been confirmed by subsequent work (for example, Bianchi, 1997; Fiaschi and Lavezzi, 2003; and Paap and van Dijk, 1998) even though there had been questions about the robustness of his initial methodology (see Kremer, Onatski and Stock, 2001).

While the findings of the ‘twin peaks’ literature have been suggestive of growth nonlinearities and multiple equilibria, it is not definitive. It is quite possible, for instance, that the aggregate production functions across countries actually exhibit decreasing marginal productivity of capital, so that there is only one steady state. However, other growth factors are sufficiently strong to overcome the convergence effect of diminishing marginal returns to produce divergence and bimodality in cross-country incomes nevertheless. Without an explicit theory to explain the observed income divergence, there

is also the question of whether the bimodality in the cross-country income distribution is a transitional or permanent feature of growth (see Galor, 1997; Lucas, 2000).

3. Conclusion

Nonlinearities in growth have been highly influential in shaping the thinking of both growth theorists and empiricists in recent years. The work on multiple-growth regimes and the world income distribution suggests that there may exist growth factors strong enough to overcome the decreasing marginal productivity of the neoclassical production function, thereby producing increasing inequality across countries. Nevertheless, while an increasingly large body of work finds evidence that is suggestive of growth nonlinearities, many questions remain open and are the subject of current research. What are the factors that are responsible for generating multiple growth regimes or convergence clubs? Are the effects of these factors transient or permanent? If the former, what are the applicable timescales? This area of research continues to be promising and fruitful.

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