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Convergence?: Inferences from Theoretical Models

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Abstract

This essay suggests that the convergence controversy may reflect, in part, differences in perception regarding the viable set of competing testable hypotheses generated by existing growth theories. It argues that in contrast to the prevailing wisdom, the traditional neoclassical growth paradigm generates the club convergence hypothesis as well as the conditional convergence hypothesis. Furthermore, the inclusion of empirically significant variables such as human capital, income distribution, and fertility in conventional growth models, along with capital markets imperfections, externalities, and non-convexities, strengthens the viability of club convergence as a competing hypothesis with conditional convergence.

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1. Introduction

The convergence hypothesis has been the subject of intense controversy in the past few years. The controversy has been largely empirical, focusing primarily on the validity of three competing hypotheses:

- *The absolute convergence hypothesis* - countries converge to one another in the long-run independently of their initial conditions.[1]
- *The conditional convergence hypothesis* - countries that are similar in their structural characteristics (e.g., preferences, technologies, rates of population growth, government policy, etc.) converge to one another in the long-run independently of their initial conditions.[2]
- *The club convergence hypothesis* (polarization, persistent poverty, and clustering)[3] - countries that are similar in their structural characteristics converge to one another in the long-run if their initial conditions are similar as well.[4]

This essay contributes to the convergence debate from a theoretical viewpoint. It suggests that the prevailing controversy may reflect, in part, differences in perception regarding the viable set of testable hypotheses that existing theories of economic growth could generate. An empirical resolution of the convergence debate therefore necessitates a better understanding of the range of competing testable hypotheses generated by plausible growth models.

The essay analyzes a variety of theories that have lead to the existing controversy, examining their robustness and plausibility. In particular, in light of the existing range of inferences that growth theory offers, the essay attempts to assess the justification for the current hegemony of the conditional convergence hypothesis. It argues that the existing domination of the conditional convergence hypothesis may be attributed partly to insufficient familiarity

[1] See Romer (1986), Lucas (1988), and Barro (1991) for conclusive evidence against the hypothesis.

[2] See Barro (1991), Mankiw, Romer and Weil (1992), and Barro and Sala-i-Martin (1995) for supporting cross-country evidence for the conditional convergence hypothesis. Note, however, that this evidence is to a large extent consistent with the club convergence hypothesis as well.

[3] See Durlauf and Johnson (1995) and Quah (1996) for supporting evidence for the club convergence hypothesis.

[4] That is, countries converge to one another if their initial conditions are in the basin of attraction of the same steady-state equilibrium.

with its theoretical non-robustness. Contrary to prevailing wisdom, the traditional neoclassical growth paradigm generates both the conditional convergence hypothesis and the club convergence hypothesis. Furthermore, inclusion of empirically significant variables such as human capital, income distribution, and fertility, in conventional growth models, along with capital markets imperfections, externalities, and non-convexities, strengthens the viability of club convergence as a competing hypothesis with conditional convergence.

The origin of the current debate is in the *absolute convergence hypothesis*, which suggests that countries converge to one another in the long-run independently of initial conditions. Since an economy's long-run equilibrium depends on its structural characteristics (e.g., technology, preferences, population growth, government policy, factor market structure, etc.) absolute convergence requires convergence in structural characteristics across countries. Not surprisingly, therefore, the absolute convergence hypothesis has been refuted in recent empirical studies based on cross-country regressions (e.g., Barro (1991)) and the evolution of the distribution of income across nations (e.g., Quah (1996)).[5] Ironically, however, despite the fact the neoclassical growth model does not generate the absolute convergence hypothesis, the empirical rejection of this hypothesis was one of the prime factors that led some of the originators of the endogenous growth literature to reject the neoclassical growth model as a framework for the study of economic growth. As argued however by Barro (1991), Mankiw, Romer and Weil (1992), and Barro and Sala-i-Martin (1995), the neoclassical growth model leads to the conditional convergence hypothesis rather than to the absolute one, and thus rejection of the absolute convergence hypothesis naturally does not imply rejection of the neoclassical growth model.

The *conditional convergence hypothesis* suggests that among countries that are similar in preferences, technologies, rates of population growth, government policy, etc., the lower the levels of output per capita the higher the growth rates. Thus, countries that are similar in all respects except for their initial level of output per capita are expected to converge

[5]The presence of convergence in a sub-sample of countries selected according to their proximity in initial or terminal conditions (e.g., Baumol (1986)), does not provide empirical support for the absolute convergence hypothesis, but rather to the conditional convergence hypothesis (see De Long (1988)).

to the same steady-state equilibrium and hence to one another. Transitory shocks in this scenario affect the income ranking of an economy in the short-run, but do not have a lasting effect. The conditional convergence hypothesis is intimately related to the notion that each economy is characterized by a unique, globally stable, (non-trivial) steady-state equilibrium. Hence countries that are identical in their fundamentals (and therefore in their dynamical system) converge to one another regardless of their initial conditions (see Figure 1). Clearly, if the dynamical system were characterized by multiple locally stable steady-state equilibria, a *(conditional) club convergence hypothesis* rather than a conditional convergence hypothesis would emerge. That is, countries that are similar in their structural characteristics converge to the same steady-state equilibrium if their initial per capita output levels are similar as well (see Figure 2).[6] Transitory shocks in this scenario may affect the economic performance of a country permanently.

The assessment of the two competing hypotheses is therefore nearly isomorphic to the examination of the plausibility of scenarios in which an economic system is characterized by a unique and globally stable, steady-state equilibrium rather than by multiple, locally stable steady-state equilibria.

This essay traces the theoretical origin of the conditional convergence hypothesis within the prominent neoclassical growth frameworks of the one-sector growth model and the one-sector overlapping-generations model. It demonstrates that, indeed, given the neoclassical specifications, the conditional convergence hypothesis emerges as the sole hypothesis of the growth model (Solow (1956)) as well as the optimal growth model (Ramsey (1928)).[7] The economy is characterized by a unique (non-trivial) steady-state equilibrium and its growth rate declines as the economy evolves towards this stationary equilibrium. In the overlapping-

[6]Clearly, "similar initial per-capita output" is a rather arbitrary term. Countries that are close to one another and are on different sides of an unstable steady-state equilibrium will diverge from one another. A more precise, but somewhat less tangible terminology would be that countries with similar fundamentals that are in the same basin of attraction to a given steady-state equilibrium will converge in the long-run.

[7]Due to the deterministic nature of these models the income ranking of countries is unaffected in the convergence process. A stochastic version of the growth model will generate conditional convergence as well as ranking reversals.

generations model, in contrast, conditional convergence shares the stage with club convergence, unless additional restrictions beyond the neoclassical ones are imposed on preferences and technologies.

It is customarily argued that the source of conditional convergence is the assumption about diminishing marginal productivity of factors of production. That is, as the economy grows and the capital-labor ratio increases, the marginal productivity of capital declines and consequently saving and capital accumulation increase at decreasing rates. In the one-sector growth model, the neoclassical per capita production function is strictly concave in the capital-labor ratio. Saving, which is assumed to be a constant fraction of *aggregate* output (due to the implicit homogeneity of individuals), is therefore a strictly concave function of the capital-labor ratio as well. Hence, the evolution of the capital-labor ratio is characterized by a unique globally stable steady-state equilibrium, and conditional convergence emerges as the sole hypothesis generated by the model.

However, if heterogeneity is permitted across individuals, the dynamical system of the Solow growth model could be characterized by multiple steady-state equilibria and (conditional) club convergence would become a viable testable hypothesis despite diminishing marginal productivity of capital. Heterogeneity in factor endowments may cause saving rates out of interest income to differ from saving rates out of wage income. Specifically, if saving is a constant fraction of the wage share in output (rather than the entire income), since wages are not necessarily a concave function of the capital-labor ratio there may be a region over which saving is a convex function of the capital-labor ratio. The growth rate may not be monotonically decreasing in the capital-labor ratio despite the neoclassical production technology, the economic system may be characterized by multiple steady-state equilibria, and club convergence may become a viable hypothesis as well.

As to the conventional one-sector overlapping-generations model, since saving in this model is *inherently* a function of the wage share in total output, and since the wage share is not necessarily a concave function of the capital-labor ratio, the growth rate may not be a monotonically decreasing function of the capital-labor ratio. As established in Galor and

Ryder (1989) and Azariadis (1996), the economic system may be characterized by multiple steady-state equilibria and both club convergence and conditional convergence may emerge as viable hypotheses.[8]

In sharp contrast to the existing conventional wisdom, even in the austere neoclassical growth models, multiplicity of steady-state equilibria is consistent with the neoclassical paradigm. Club convergence is perfectly consistent with constant returns to scale and diminishing marginal productivity, and it cannot be excluded *a-priori* in a non-increasing returns to scale environment. Moreover, adding realism to the one-sector neoclassical growth models will result in an increase in the dimensionality of the economy's dynamical system. The range of parameters that lead to multiple steady-state equilibria would be augmented and the conditional club convergence hypothesis would rest on a more plausible set of assumptions.[9]

Once the neoclassical growth models are augmented so as to capture additional empirically significant elements such as human capital, income distribution, and fertility, along with capital market imperfections, externalities, non-convexities, and imperfectly competitive market structure, club convergence emerges under broader plausible configurations. The incorporation of *human capital* formation into basic growth models provides an environment in which club convergence is a viable theoretical hypothesis under plausible scenarios. Countries that are identical in their structural characteristics but differ in their initial level or distribution of human capital may cluster around different steady-state equilibria in the presence of social increasing returns to scale from human capital accumulation (e.g., Lucas (1988) and Azariadis and Drazen (1990)), capital market imperfections (e.g., Galor and Zeira (1993)), parental and local effects in human capital formation (e.g., Benabou (1996), Durlauf (1996), and Galor and Tsiddon (1994)), imperfect information (e.g., Tsiddon (1992))

[8] In contrast to prevailing wisdom, the one-sector growth model and the one-sector overlapping-generations model may share an identical dynamical system and thus the possibility for multiple steady-state equilibria and club convergence (see section 2).

[9] For instance, in a two-sector overlapping-generations model in which a distinction is made between consumption goods and investment goods (Galor (1992)), multiplicity of steady-state equilibria occurs in a neoclassical CRS framework under a less restrictive set of assumptions than those required in the one-sector model.

and non-convex production function of human capital (e.g., Becker, Murphy, and Tamura (1990)).

The introduction of heterogeneous agents into growth models provides a channel through which *income distribution* affects economic growth. A large number of theoretical studies have documented the importance of initial conditions with respect to the distribution of income for the evolution of economies and their steady-state behavior. Countries that are similar in their structural characteristics and in their initial level of output per capita, but differ in their initial distribution of income, may cluster around different steady-state equilibria (e.g., Galor and Zeira (1993), Aghion and Bolton (1996), Benabou (1996), Durlauf (1996), and Quah (1996)).

The endogenization of *fertility* decision provides an additional plausible framework that generates the club convergence hypothesis. Countries that are identical in their fundamentals and differ in their initial level of physical capital or human capital may cluster around different steady-state equilibria in terms of output per-capita and fertility rate (e.g., Barro and Becker (1989), Becker, Murphy, and Tamura (1990)'s non-convex model, and Galor and Weil (1996)'s convex economy).

Finally, sectoral and technological complementarities, along with a non-competitive market structure or non-convexities, may generate multiple steady-state equilibria due to aggregate demand spillovers (e.g., Murphy, Shleifer and Vishny (1989) and Durlauf (1993)). Thus, countries that are identical in their fundamentals and differ in their initial level of output per-capita may cluster around different steady-state equilibria.

2. The Robustness of Conditional Convergence in Neoclassical Growth Models

This section traces the theoretical origin of the conditional convergence hypothesis within the prominent neoclassical growth frameworks of the one-sector growth model and the one-sector overlapping-generations model. It analyzes the robustness of the hypothesis and examines critical assumptions for the emergence of this hypothesis within these frameworks of analysis. Contrary to conventional wisdom, it demonstrates that the presence of multiple steady-state equilibria and thus club convergence is consistent with the neoclassical paradigm

in general and with constant returns to scale and diminishing marginal productivity in particular.

2.1. The Neoclassical One-Sector Growth Model

Given the specifications of the neoclassical one-sector growth model the conditional convergence hypothesis emerges as the sole hypothesis. The economy is characterized by a unique, globally stable (non-trivial) steady-state equilibrium and its growth rate declines as the economy approaches this stationary equilibrium. However, the introduction of heterogeneous individuals may give rise to a non-monotonic evolution of the growth rate and multiplicity of steady-state equilibria.

2.1.1. Conditional Convergence

Consider a world in which economic activity is performed over infinite discrete time.[10] In each period a single good is produced, using two factors – capital and labor – in the production process. The good can be either consumed or saved for future consumption. The endowment of labor at time $t+1$, is $L_{t+1} = (1+n)L_t$, where $n \geq 0$ is the rate of population growth, and the endowment of capital at time $t+1$, is $K_{t+1} = (1-\delta)K_t + S_t$, where S_t is aggregate savings at time t, and $\delta \in (0,1]$ is the rate of capital depreciation. Production occurs within a period according to a constant return to scale neoclassical production technology, which is stationary across time. The output produced at time t, $Y_t = F(K_t, L_t) = L_t F(K_t/L_t, 1) \equiv L_t f(k_t)$, where $k_t \equiv K_t/L_t$ is the capital-labor ratio employed in production at time t.

The economy allocates a fraction $s \in (0,1)$ of aggregate output in every period to saving, and the remaining fraction is consumed. The aggregate saving at time t, S_t, is therefore $S_t = sY_t = sL_t f(k_t)$. The evolution of the capital-labor ratio from a given initial condition, k_0, is governed by the following non-linear dynamical system:

$$k_{t+1} = \frac{(1-\delta)k_t + sf(k_t)}{1+n} \equiv \phi(k_t). \tag{1}$$

[10]The dynamical system of the growth model is described in a discrete time framework to facilitate comparability with the inherently discrete dynamical system of the overlapping-generations model.

As depicted in Figure 1 (for positive initial conditions), the economy is characterized by a unique and globally stable nontrivial steady-state equilibrium, and its growth rate declines monotonically in the capital-labor ratio. Countries that are identical in their technology, population growth, depreciation rate, and saving rate, converge to the steady-state equilibrium $\overline{k}$ and hence to one another regardless of their initial level of output per capita. The evolution of the initial cross-country distribution of capital-labor ratio, $f_0(k_0)$, reflects conditional convergence.

2.1.2 Club Convergence

Suppose that output per capita in the one-sector growth model, $f(k_t)$, is divided into a labor share and a capital share according to the marginal productivity of labor and capital. That is $f(k_t) = w(k_t) + r(k_t)k_t$ where $w(k_t) \equiv f(k_t) - f'(k_t)k_t$ and $r(k_t) \equiv f'(k_t)$. Suppose further that the saving rates from wage income, $s^w \in [0,1]$, and interest income, $s^r \in [0,1]$, differ.[11] It follows that the evolution of the capital-labor ratio is governed by the non-linear dynamical system:

$$k_{t+1} = \frac{(1-\delta)k_t + s^w f(k_t) + (s^r - s^w)f'(k_t)k_t}{1+n} \equiv \psi(k_t), \tag{2}$$

and a positive, steady-state equilibrium is therefore given by $\overline{k}$ such that

$$s^w[f(\overline{k})/\overline{k}] + (s^r - s^w)f'(\overline{k}) = n + \delta. \tag{3}$$

As depicted in Figure 2, and demonstrated in Galor (1996), the dynamical system may be characterized by multiple locally stable steady-state equilibria, and club convergence is a viable hypothesis. Multiplicity of stationary equilibria occurs if saving out of labor income is larger than that out of capital income (not implausible in a life-cycle configuration) and if production technology is either CES with low elasticity of substitution or a member of a class of non-CES production functions.[12] Countries with an initial k_0 in the interval $[0, \overline{k}^b)$ converge to the low steady-state equilibrium $\overline{k}^a$, whereas those with initial k_0 in the

[11] Heterogeneity of factor endowments across individuals may lead to this outcome.
[12] Figure 2 is drawn for a non-CES production technology

interval $[\overline{k}^b, \infty)$ converge to the high steady-state equilibrium $\overline{k}^c$. Thus, the initial cross-country distribution of capital-labor ratio, $f_0(k_0)$, becomes gradually polarized. Despite the neoclassical features of the model (e.g., constant returns to scale and diminishing marginal productivity of factors of production), the growth rate of the capital labor-ratio may not be monotonically decreasing in the capital-labor ratio: the economic system may be characterized by multiple steady-state equilibria, and club convergence is a viable hypothesis. Conditional convergence would emerge in this model if saving is assumed to be a constant fraction of *total* output rather than a fraction of some non-linear function of output (e.g., the wage share and the capital share in total output). Since the per capita production function is strictly concave in the capital-labor ratio, saving would be a strictly concave function of the capital-labor ratio as well. The economy's dynamical system would be characterized by a unique, globally stable steady-state equilibrium and conditional convergence would emerge as the sole hypothesis of the model. But if, due to heterogeneity, individuals' saving were a constant fraction of the wage share in output, rather than of the entire output, since wages are not necessarily a concave function of the capital-labor ratio, there might be a region in which saving would be a convex function of the capital-labor ratio despite the neoclassical characteristics of the production technology. Thus, the club convergence hypothesis may emerge.

2.2. The One-Sector Overlapping-Generation Model

Consider a perfectly competitive world in which economic activity is performed over infinite discrete time. In each period a single homogeneous good is produced using two factors – capital and labor – in the production process. In accordance with the one-sector growth model the endowment of labor at $t+1$, is $L_{t+1} = (1+n)L_t$, where $n > -1$ is the rate of population growth, and the capital stock at time $t+1$ is $K_{t+1} = S_t + (1-\delta)K_t$, where $\delta \in [0,1]$. Production occurs within a period according to a neoclassical constant returns to scale production technology, which is stationary across time. Producers operate in a perfectly competitive environment. Given the wage rate w_t and the rate of return to capital r_t at time

t, producers' inverse demand for factors of production is $w_t = f(k_t) - f'(k_t)k_t \equiv w(k_t)$ and $r_t = f'(k_t) \equiv r(k_t)$.

In every period t, L_t individuals are born. Individuals are identical within as well as across time. Individuals live two periods. In the first period they work and in the second period they are retired. Individuals born at t are characterized by their intertemporal utility function $u(c_t^t, c_{t+1}^t)$ defined over consumption during the first and the second periods of their life. The utility function is monotonic increasing and strictly quasi-concave, and old-age consumption is a normal good. In the first period of their lifetime individuals born at time t supply their unit-endowment of labor inelastically and allocate the resulting wage income between first-period consumption, c_t^t, and saving, s_t. That is, $s_t = w_t - c_t^t$. Savings earn the rate of return r_{t+1} in period $t+1$ and enable individuals to consume during retirement. Second-period consumption of an individual of generation t, is therefore, $c_{t+1}^t = [1 + r_{t+1} - \delta]s_t$. The level of saving is chosen so as to maximize the intertemporal utility function: $s_t = s(w_t,\ r_{t+1}) = \text{argmax}\ u[w_t - s_t,\ (1 + r_{t+1} - \delta)s_t]$, subject to, $0 \leq s_t \leq w_t$, where r_{t+1} is the rationally anticipated return to capital in the next period. Given (w_t, r_{t+1}), the properties of the utility function imply that $s(w_t, r_{t+1})$ exists and is unique.

The evolution of the capital-labor ratio from an initial level k_0 is governed by the non-linear dynamical system

$$k_{t+1} = \frac{s[w(k_t), r(k_{t+1})]}{(1+n)}. \tag{4}$$

If saving is a non-decreasing function of the interest rate, there exists a monotonic increasing single-valued function $\phi(k_t)$ such that $k_{t+1} = \phi(k_t)$.

The neoclassical restrictions on preferences and technology do not preclude multiple steady-state equilibria as follows from the potential non-monotonicity of $\phi''(k_t)$. Specifically, if preferences are log-linear, saving is a fixed fraction of wages and is therefore not necessarily a concave function of the capital-labor ratio. The growth rate may not be a monotonic decreasing function of the capital-labor ratio, and multiple steady-state equilibria could emerge

(see Galor and Ryder (1989).[13] Note that in this case the overlapping-generations model is identical to the Solow growth model for the case in which saving out of interest income equals zero. Figure 1 depicts a dynamic system in which each economy is characterized by a unique, globally stable steady-state equilibrium and countries that are identical in their fundamentals would convergence to this steady state regardless of initial conditions (i.e., the initial cross-country distribution of the capital-labor ratio, $f_0(k_0)$, contracts over time). Figure 2 depicts a system in which each economy's dynamical system is characterized by two locally stable steady-state equilibria. Countries that are identical in their structural characteristics converge, provided that their initial conditions belong to the same basin of attraction. Thus, polarization takes place in the world economy.

3. Club Convergence in Augmented Growth Models

This section demonstrates that the incorporation of empirically significant elements such as human capital, income distribution, and fertility into the basic neoclassical growth model, along with capital market imperfections, externalities, non-convexities, and imperfectly competitive market structures, strengthens the viability of the club convergence hypothesis.

3.1 Human Capital

The incorporation of human capital formation into the basic models provides an environment in which club convergence is a viable hypothesis under a plausible set of assumptions. The introduction of social increasing returns to scale from human capital accumulation permits initial conditions with respect to human capital accumulation to dictate the ultimate fate of otherwise identical economies and to generate club convergence (e.g., Lucas (1988), and Azariadis and Drazen (1990)). In the presence of capital market imperfections along with some non-convexities in the production of human capital club convergence emerges. Countries that are similar in their structural characteristics and in their initial levels of output and human capital per capita, but differ in their initial distribution of human capital,

[13] Alternatively, multiplicity of steady-state equilibria may occur if saving is a non-homothetic function of the wage rate, or in the presence of subsistence level of consumption (see Azariadis (1996).

may cluster around different steady-state equilibria (e.g., Galor and Zeira (1993)). Parental and local effects in offspring's' human capital formation generate a role for the initial *distribution* of human capital in the determination of the steady-state equilibrium of otherwise identical economies (e.g., Benabou (1996), Durlauf (1996), and Galor and Tsiddon (1994)), and non-convexities in the production function of human capital generate club convergence based on the initial *average* level of human capital accumulation (e.g., Becker, Murphy, and Tamura (1990)).

3.2 Income Distribution

As documented in recent empirical studies (e.g., Alesina and Rodrik (1994), Persson and Tabellini (1994), and Perotti (1996)), income distribution is a significant explanatory variable of economic growth. A large number of theoretical studies have documented the importance of the distribution of income for the evolution of economies and their steady-state behavior. The presence of capital market imperfections, along with some fixed cost in the production of human capital or final goods, will generate the club convergence hypothesis according to which countries that are similar in their structural characteristics and in their initial levels of output per capita, but differ in their initial distribution of income, may cluster around different steady-state equilibria (e.g., Galor and Zeira (1993), Aghion and Bolton (1996), Benabou (1996), Durlauf (1996), and Quah (1996)). Income distribution may affect the long-run level of output even in the absence of capital market imperfections as long as the parental human capital is an input in the production of the offspring's' human capital (Galor and Tsiddon (1994)).[14]

3.3 Endogenous Fertility

The endogenization of fertility decisions provides an additional plausible avenue for generating club convergence. As argued by Barro and Becker (1989), multiplicity of steady-state equilibria is feasible in a growth model with endogenous fertility. Becker, Murphy, and

[14]In a related contribution, Benhabib and Rustichini (1996) demonstrates that in the presence social conflict over the distribution of income, low initial level of wealth may persist due to its effect on the incentives for accumulation.

Tamura (1990) demonstrate that if the production of human capital is non-convex, and if the discount rate of future dynastic utilities declines with the number of offspring, the economy may be characterized by multiple steady-state equilibria and initial conditions with respect to the number of children as well as the level of human capital may dictate the economy's steady-state equilibrium. In a convex economy, Galor and Weil (1996) demonstrate that differences in comparative advantage between male and female may be a viable source of multiple steady-state equilibria. If capital complements women's labor input more than men's labor input and if consistent with empirical evidence an increase in women's relative wages decreases fertility then, a low capital-labor ratio lead to low relative wages for women, high fertility rate, and thus the low capital-labor ratio may persist. A high capital labor-ratio, in turn, lead to high relative wages for women, low fertility rate, and the high capital-labor ratio may persist. Thus, countries that are identical in their fundamentals but differ in their initial level of physical capital may converge to different steady-state equilibria in terms of output per capita and fertility rates.

4. Robustness of Club Convergence

This section examines the robustness of the club convergence hypothesis in the presence of international capital movements and technological progress.

4.1 International Capital mobility

The existence of perfect international capital movements eliminates the importance of initial conditions in neoclassical growth models in which the evolution of the economy is dictated uniquely by the evolution of the capital-labor ratio.[15] Thus, in light of the presence of some movements of capital across countries, one may view this observation as an element that weakens the club convergence hypothesis.[16] However, in more realistic settings, where the evolution of the economy is based upon the evolution of human capital as well as

[15]However, if the production function exhibits locally increasing returns to scale, then a single interest rate may be associated with several wage rates and, despite perfect capital mobility, economies may experience persistent differences in output per capita.

[16]One may argue however that in light of the arguments raised by Lucas (1990) this effect is not very significant.

physical capital, international movements of capital will not resolve the dependency of an economy on initial conditions with respect to human capital. Hence, since human capital is not perfectly mobile across countries, and since the parental-environmental effects on human capital formation are immobile across families, club convergence remains a viable and plausible hypothesis. As documented in Galor and Zeira (1993), in the presence of capital market imperfections in the domestic economy, multiple steady-state equilibria will prevail despite perfect international capital movements; and as argued in Galor and Tsiddon (1994), perfect capital mobility does not preclude multiple steady-state equilibria in an environment where the parental effect is a factor in the offspring's' production of human capital.

4.2. Technological Progress and Technological Diffusion

Labor-augmenting technological progress does not affect the qualitative nature of dynamical systems in the neoclassical growth models, and the conditions that lead to a club convergence hypothesis remain intact. However, in some augmented growth models technological progress may turn a system, that under a given level of technology, is characterized by multiple locally stable steady-state equilibria, into one characterized by a unique globally stable steady-state equilibrium. Conditional convergence will be observed in these models in the long-run. Nevertheless, provided that for some technological level the system is characterized by multiple steady state equilibria, the transition to the long-run steady-state is associated with non-monotonic evolution of the distribution of income across countries (e.g., Galor and Tsiddon (1994)). Thus, convergence may be preceded by polarization and clustering, and club convergence will be generated by these models in the medium run. As depicted in Figure 3, given the technological parameter λ_1, the dynamical system is characterized by multiple steady-state equilibria. However, technological progress increases the technological parameter to λ_2 and shifts the dynamical system upward. The dynamical system changes qualitatively and the number of non-trivial steady-state equilibria is reduced to one. Consequently, the cross-country distribution of capital-labor ratios evolves non-monotonically and polarization in period t is followed by convergence as depicted for a later period, s.

5. Concluding Remarks

This essay suggests that the convergence controversy may reflect, in part, differences in perception regarding the viable set of testable hypotheses that existing theories of economic growth have generated. An empirical resolution of the debate therefore necessitates a better understanding of the range of competing testable hypothesis generated from plausible growth models. It is argued that the current hegemony of the conditional convergence hypothesis may be attributed in part to insufficient familiarity with its theoretical non-robustness. In contrast to conventional wisdom, the essay demonstrates that an economic system may be characterized by multiple steady-state equilibria and may thus lead to club convergence even in traditional neoclassical growth models that exhibit diminishing marginal productivity of capital and constant returns to scale. Furthermore, the inclusion of empirically significant variables such as human capital, income distribution, and fertility in conventional growth models, along with capital market imperfections, externalities and non-convexities, strengthens the viability of multiple steady-state equilibria and presents club convergence as a competing hypothesis with conditional convergence.

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