2. The convergence debate – Intermezzo (April 22, 2015)

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Introduction

- **Important policy question**
  - Will poor countries catch up with rich countries? In other words: Can we expect international convergence of per capita income (PCI) in the long run?
  - There are indeed important theories that provide an affirmative answer.

- Neoclassical growth model indicates that poor countries should grow faster than rich countries. **Neoclassical convergence mechanism** provides the theoretical foundation:
  - Poor countries should exhibit a higher marginal product of capital, implying comparatively **strong incentives to invest**.
  - High marginal product of capital furthermore signifies a comparatively **strong growth impulse** of a given increase in capital.

- Provided that rich countries feature a higher PCI because they employ technologically superior methods of production, there should be ‘**advantages of backwardness**’ (Abramovitz, 1986).
  - Poor countries have the possibility to **adopt superior foreign technologies**.
  - One should expect that poor countries are catching up with rich countries. This describes the **technological catching-up-mechanism**.
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Unconditional β-convergence: reminder on theory (1)

- **Solow model**
  \[ \dot{k}(t) = sA k(t)^\alpha - (\delta + n)k(t) \]
  \[ k(0) = \text{given} \]

- **Growth rate of } k\]
  \[ \dot{k}(t) = sA k(t)^{\alpha-1} - (\delta + n) \]

- **Notice**
  \[ y(t) = Ak(t)^{\alpha} \]
  \[ \Rightarrow \hat{y}(t) = \alpha \hat{k}(t) \]
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Unconditional β-convergence: reminder on theory (2)

- **Rate of convergence**
  - We now turn to the speed at which the economy converges to its steady state.
  - Measured by the **rate of convergence** (ROC). The ROC of any variable $x(t)$ is defined by
    \[
    \psi_x(t) := - \frac{\dot{x}(t)}{x(t) - x^*}
    \]
    \(\psi_x > 0\) : convergence
    \(\psi_x < 0\) : divergence

- **Important tool: linearization**
  - Consider following general, possibly non-linear, differential equation (DE)
    \[
    \dot{x}(t) = F[x(t)]
    \]
  - DE is assumed to posses a stationary equilibrium defined by \(F(x^*)=0\).
  - Linearization of \(F(x)\) around \(x^*\) by means of a first-order Taylor approximation
    \[
    \dot{x}(t) \approx F\left(x^*\right) + F'\left(x^*\right)\left[x(t) - x^*\right]
    \]
  - Hence, noting that \(F(x^*)=0\), \(x(t)\) converges at the following rate against \(x^*\)
    \[
    \psi_x(t) := - \frac{\dot{x}}{x - x^*} = -F'(x^*)
    \]
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Unconditional β-convergence: reminder on theory (3)

- To determine **ROC for the Solow model** recall (k:=K/AL)

\[
\dot{k} = s\, \tilde{k}^\alpha - (\delta + n + g)\tilde{k} \quad \text{and} \quad \tilde{k}^* = \left(\frac{s}{n + \delta + g}\right)^{\frac{1}{1-\alpha}}
\]

- **Linearizing above DE around** \(k^*\)

\[
\dot{k} = \left[ \alpha s\, \tilde{k}^{*\alpha-1} - (\delta + n + g) \right] (\tilde{k} - \tilde{k}^*)
\]

\[
\dot{k} = \left[ \alpha s \left(\frac{s}{n + \delta + g}\right)^{\alpha-1} - (\delta + n + g) \right] (\tilde{k} - \tilde{k}^*)
\]

\[
\dot{k} = \frac{1}{\psi_k} (\alpha - 1)(\delta + n + g)(\tilde{k} - \tilde{k}^*)
\]

\[
\dot{k} = \frac{1}{\psi_k} (\alpha - 1)(\delta + n + g)(\tilde{k} - \tilde{k}^*)
\]

- The (local) **rate of convergence** reads \(\psi_k = (1-\alpha)(\delta+n+g) > 0\).
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Unconditional β-convergence: empirics

- **Unconditional β-convergence**: Poor economies grow faster than rich countries.

  - Prediction of neoclassical model, assuming that all countries exhibit *same fundamentals* \((A, s, n, \delta\text{ etc.)} and differ only in their initial stock of capital.\)

  - Empirical test for unconditional β-convergence is based on the following *bivariate cross-sectional regression*

\[
\hat{y}_i = \alpha + \beta y_{i,0} + u_i, \quad i \in \{1, \ldots, n\}
\]

- Unconditional β-convergence requires that \(\beta < 0\) (statistically significant).

- Finding of \(\beta < 0\) means that poor countries grew, on average, faster than rich countries.
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Unconditional $\beta$-convergence: evidence (1)

$\Rightarrow$ Convergence of PCI in structural similar economies!

Source: Jones (2002)
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Unconditional β-convergence: evidence (2)

⇒ Structural similar economies ("bivariate correlations")!
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Unconditional β-convergence: evidence (3)

⇒ Global sample of countries: no evidence in favor of unconditional β-convergence!

Source: Jones (2002)
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Conditional β-convergence: theory

\[
\begin{align*}
\hat{k}_P & < \hat{k}_R \\
\hat{k}_P(0) & < \hat{k}_P < k_R(0) < \hat{k}_R \\
\delta + n & > s_R > s_P \\
0.04 & < 0.06 < 0.08 < 0.10 < 0.12 < 0.14
\end{align*}
\]
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Conditional β-convergence: empirics

- **Conditional β-convergence**: Growth rate of PCI is higher, the farer the economy under consideration is away from its (individual) steady-state.

  - Attenuated convergence implication of neoclassical model is suitable for sample of countries that differ not only with regard to initial capital endowments but also with regard to other fundamentals.

  - Empirical test for conditional β-convergence is based on following **multivariate cross-sectional regression**:

    \[ \hat{y}_i = \alpha_0 + \beta y_{i,0} + \alpha_1 x_{1,i} + \ldots + \alpha_m x_{m,i} + u_i, \quad i \in \{1, \ldots, n\} \]

  - Variables \( x_{1,i}, \ldots, x_{n,i} \) are control variables, which capture the **long-run growth rate**.
  - Conditional β-convergence requires \( \beta < 0 \) (statistically significant).
  - Interpretation of \( \beta < 0 \) reads that economies with a low PCI level, ceteris paribus, grow faster than economies with a comparatively high PCI. The ceteris-paribus condition guarantees that other factors are held constant.
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Conditional β-convergence: evidence

⇒ ‘Deviation from steady state’ points to conditional β-convergence. Note: 1/4 means that the respective economy has realized a PCI (in 1960) that amounts to 25% of its steady-state PCI; the smaller the value on the horizontal axis, the farer the economy is away from its steady state.

Source: Jones (2002)
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**σ-convergence**

- **σ-convergence**: Dispersion of international income distribution decreases over time.
- Dispersion in a sample of \( n \) countries is typically measured by standard deviation

\[
\sigma_y(t) := \sqrt{\frac{1}{n-1} \left[ y_i(t) - \bar{y}(t) \right]^2}
\]

where \( \bar{y}(t) := \frac{\sum_{i=1}^{n} y_i}{n} \)

- Empirical evidence shows standard deviation of **global PCI distribution** (‘World’) has increased after WWII.
- Evidence for **σ-divergence**.
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Twin peaks and club convergence

- Quah (1996) argues that global income distribution has increasingly polarized over time. A pattern of ‘twin peaks’ appears to emerge.

- This is compatible with club convergence identified by Baumol (1986). International convergence observable in small (homogeneous) subgroups of economies, which share similar fundamentals.

- Empirical findings are compatible with growth models that imply multiple equilibria and macroeconomic poverty traps.
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The German case

- Factor movements in opposite directions
  - Between 1991 and 2009 about 60,000 people (0.4 percent of the population) emigrated from East Germany per year
  - Capital inflows from 1991 to 2004 amounted to 80 to 90 billion EUR, about 20 percent of GDP, each year (Burda, 2006, p. 368)

- Limited East-West convergence (Uhlig, 2006)

- Regional divergence

There are two distinct convergence clubs for GDP per employee in East Germany (Vollmer et al., 2010, p. 10)
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Summary

- In global samples **unconditional convergence** (β-convergence) is typically rejected.

- **Conditional convergence** (β-convergence) usually meets strong empirical support.

- Estimated **rate of convergence** (ROC) is surprisingly stable in the range of 2% to 4% (Barro, 1991; Mankiw et al., 1992; Bond et al., 2001).

- ROC can be translated into more informative **half life** \( (t_{0.5}) \)

\[
(t_{0.5} = \frac{\ln(0.5)}{\text{ROC}})
\]

\[
(y - y^*) e^{-\text{ROC} t_{0.5}} = 0.5 (y - y^*) \quad \Rightarrow \quad \text{ROC} = -\frac{\ln(0.5)}{t_{0.5}}
\]