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

- Introduction
- Unconditional $\beta$-convergence
- Conditional $\beta$-convergence
- $\sigma$-convergence
- Twin peaks and club convergence
- The German case
- Summary
2. The convergence debate

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.
2. The convergence debate

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
  \[ y(t) = A k(t)^{\alpha} \]
  \[ \Rightarrow \quad \hat{y}(t) = \alpha \hat{k}(t) \]
2. The convergence debate

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
    \[
    \dot{x}(t) \cong F(x^*) + F'(x^*)[x(t) - x^*]
    \]
  - Hence, noting that \( F(x^*) = 0 \), \( x(t) \) converges at the following rate against \( x^* \)
    \[
    \psi_x(t) := - \frac{\dot{x}}{x - x^*} = -F'(x^*)
    \]
2. The convergence debate

Unconditional β-convergence: reminder on theory (3)

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

\[
\dot{k} = s \tilde{k}^\alpha - (\delta + n + g)\bar{k}
\]

and

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

**Linearizing above DE around** $k^*$

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

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

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

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

→ Recall

\[
\dot{x}(t) \equiv F'(x^*)[x(t)-x^*]
\]

→ Recall

\[
\psi_k := -\frac{\dot{k}}{\bar{k} - \tilde{k}^*}
\]
2. The convergence debate

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* \((A, s, n, \delta\) 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.
2. The convergence debate

Unconditional $\beta$-convergence: evidence (1)

$\Rightarrow$ Convergence of PCI in structural similar economies!
2. The convergence debate

Unconditional β-convergence: evidence (2)

⇒ Structural similar economies ("bivariate correlations")!
2. The convergence debate

Unconditional β-convergence: evidence (3)

⇒ Global sample of countries: no evidence in favor of unconditional β-convergence!
2. The convergence debate

Conditional β-convergence: theory

\begin{align*}
    s_R A k^{\alpha-1} \\
    s_R > s_P
\end{align*}
2. The convergence debate

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.
2. The convergence debate

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)
2. The convergence debate

**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**.

![Graph showing dispersion of GDP across 110 countries](image)
2. The convergence debate

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.
2. The convergence debate

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)
2. The convergence debate

- 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 ($t_{0.5}$)

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