

7 Economic Growth I - Motivation

7.1 Introduction

Importance of sustained economic growth: Great **absolute differences** in the standards of living measured by GDP per capita: ¹

- GDP p.c. of USA in 2000 (in 1995 prices) was \$32,500 (2nd highest in the world)
- Russia - \$8,012, South Africa - \$7,540, China - \$3,750, India - \$2,480, Nigeria - \$712, Tanzania - \$482 (i.e. \$1.3 a day)
- corresponding differences in nutrition, literacy, infant mortality, life expectancy and other measures of well-being
- Czech Republic - \$13,673, Slovak Republic - \$11,417

Small **differential in growth rates** implies huge differences in final outcomes when compounded over long periods of time (centuries):

- With GDP p.c. \$3,300 in 1870, US was growing at average rate 1.785% per year in period 1870 - 2000²
- Though experiment 1: If the growth rate would be 0.785%, then GDP p.c. would be \$9,230 (i.e. 28% of the actual value)
 - similar GDP p.c. level to Estonia, Malaysia, Mexico, Poland
- Though experiment 2: If the growth rate would be 2.785%, then GDP p.c. would be \$118,744 (i.e. 3.6 times the actual value)

¹Data are from version 6.1 of Penn World Tables, <http://pwt.econ.upenn.edu>.

²Let y_0 be the GDP p.c. at year 0, y_T the GDP p.c. at year T , and x the average annual growth rate over that period. Then, $y_T = (1 + x)^T y_0$. We can compute x by taking logarithms, getting $\ln y_T - \ln y_0 = T \ln(1 + x) \approx Tx$, or $x \approx (\ln y_T - \ln y_0)/T$.

Even in the horizon of **one generation**, growth rates matter:

- If the Czech Republic would grow at the same average rate as throughout the period 2000-2004 (i.e. 2.6%), in 25 years it would almost double its real GDP p.c.
- However, if the Slovak Republic would grow at the same average rate as throughout the period 2000-2004 (i.e. 3.9%), in 25 years it would attain 2.6 times its real GDP p.c. and it would "outgrow" the Czech Republic.

7.2 World Distribution of Income and Growth Rates

High **cross-country dispersion** in the level of income - GDP p.c., persistent with time

- **Figure 1** distribution of GDP p.c. in 1960 across 113 countries from the Penn World Tables 6.1.
 - richest country - Switzerland (\$15,000), poorest - Tanzania (\$381)
 - wealthiest countries: OECD + Latin America (Venezuela, Argentina); poorest countries: Africa (Tanzania, Uganda) and Asia (China, India, Indonesia)
- **Figure 2** - distribution of GDP p.c. in 2000 across 150 countries from the Penn World Tables 6.1.
 - richest country - Luxembourg (\$44,000), poorest - Tanzania (\$482)
 - wealthiest countries: OECD + East Asia (Taiwan, Japan, Singapore); poorest countries: sub-Saharan Africa (Tanzania, Uganda); Latin America + Asia: mid-range
- **Comparison:**
 - similar cross-country dispersion of income over this period
 - mean of GDP p.c. in 2000 was 2.5 higher than in 1960 (compare \$8,490 and \$3,390)
 - change of relative position of countries (drop of Argentina, Venezuela, Israel or RSA; rise of China, India, Singapore) due to **differences in the rate of economic growth**
- **Figure 3** - distribution of growth rate of GDP p.c. from 1960 - 2000.
 - range from -3.2% for the Democratic Republic of Kongo to 6.4% for Taiwan
 - growth miracles: Singapore (6.2%), South Korea (5.9%), Hong Kong (5.4%), Thailand, Japan (after WWII), China, Ireland
 - growth disasters: sub-Saharan Africa (Niger, Angola, Madagascar, Nigeria, Rwanda) + Latin America (Venezuela, Bolivia, Peru, Argentina)

7.2.1 Convergence: Do the poor countries catch up rich countries, i.e. do they tend to grow faster?

(+ rationale)

- **Unconditional convergence:** $\Delta \ln y_{2000-1960} = \alpha + \beta \ln y_{1960}$
 - Figure 4, based on Penn World Tables data, shows that average growth rate over the period 1960-2000 has little (and slightly positive) correlation with initial level of GDP p.c.
- **Conditional convergence:** $\Delta \ln y_{2000-1960} = \alpha + \beta \ln y_{1960} + \gamma \mathbb{X}_{1960}$, where \mathbb{X}_{1960} is a set of country-specific controls (education, fiscal and monetary policy, competition level, etc.) - we compare countries with similar starting characteristics
 - After conditioning on the underlying characteristics, the countries with lower initial income tend to grow faster than their rich counterparts. For illustration, see Figure 5 for evidence of convergence within OECD countries and Figure 6 for the convergence among US states (both with apparent negative correlation).

What are the factors behind the differences in economic growth, and how can we control them?

- government policies with effects on long-term growth
- evaluation framework = models

7.3 Stylized Facts - Building Blocks of Models

Kaldor (1963) - balanced growth in the long run

1. Output per worker Y/L (GDP p.c.) grows over time and the growth rate does not tend to diminish
2. Physical capital per worker K/L grows over time
3. The capital to output ratio K/Y is nearly constant \Rightarrow capital and output grow at the same rate
4. The return to capital (r) is roughly constant
5. The income shares of labor and capital (wL/Y and rK/Y) stay roughly constant
6. The level as well as the growth rate of output per worker differs substantially across countries.

\Rightarrow applies to **developed countries**
 \Rightarrow explained by Solow model

7.4 Figures

Figure 1: Histogram for GDP p.c. in 1960 (reproduced from Barro, 2003). The data for 113 countries are taken from Penn World Tables 6.1. Representative countries within each group are labeled.

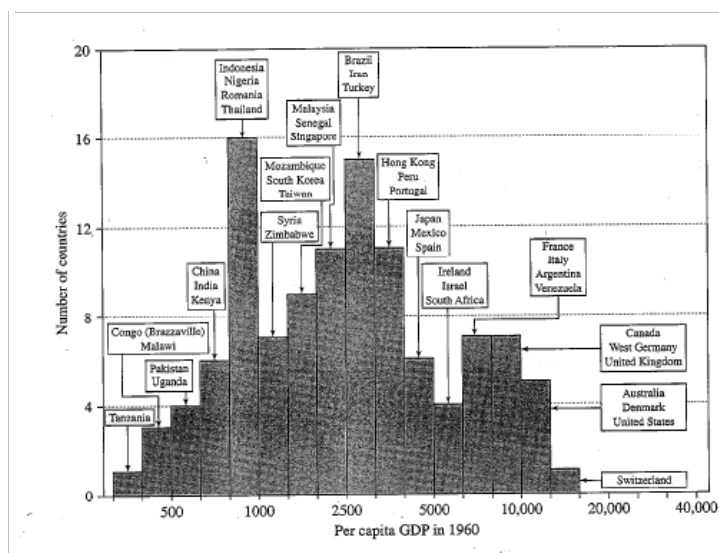


Figure 2: Histogram for GDP p.c. in 2000 (reproduced from Barro, 2003). The data for 150 countries are taken from Penn World Tables 6.1. Representative countries within each group are labeled.

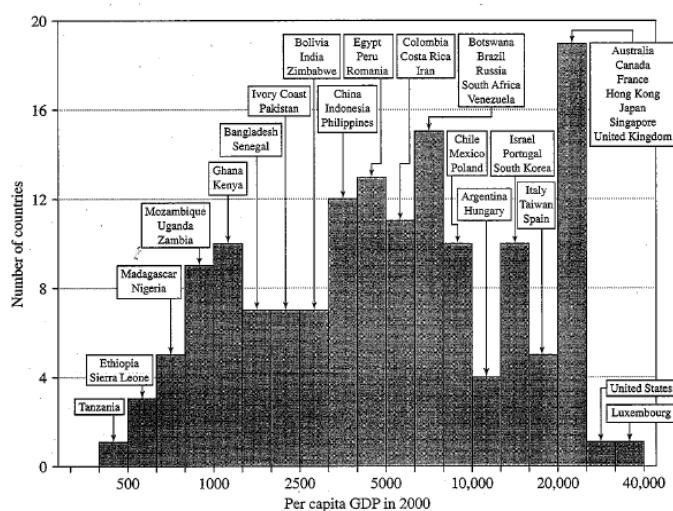


Figure 3: Histogram for growth rates of GDP p.c. from 1960-2000 (reproduced from Barro, 2003). The data for 150 countries are computed from the values of GDP p.c. shown in Figures 1 and 2. Representative countries within each group are labeled.

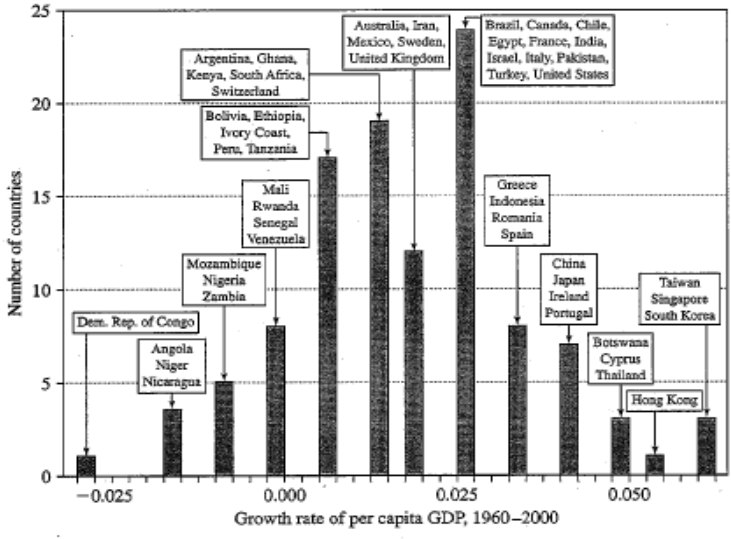


Figure 4: Convergence of GDP across countries: Growth rate from 1960 to 2000 over the initial level of real GDP p.c. for 114 countries (reproduced from Barro, 2003).

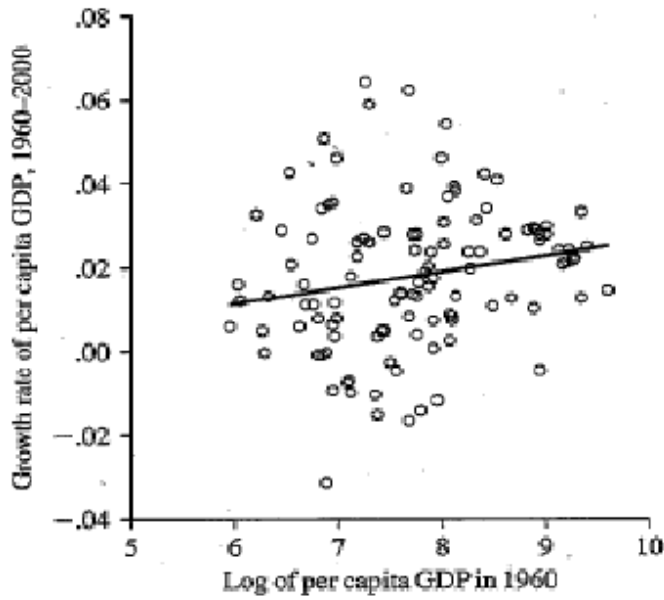


Figure 5: Convergence of GDP across OECD countries: Growth rate from 1960 to 2000 over the initial level of real GDP p.c. for 18 countries (reproduced from Barro, 2003).

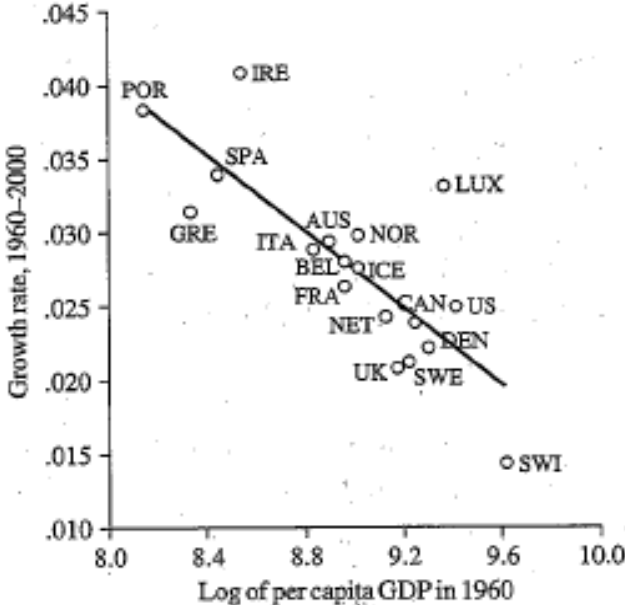
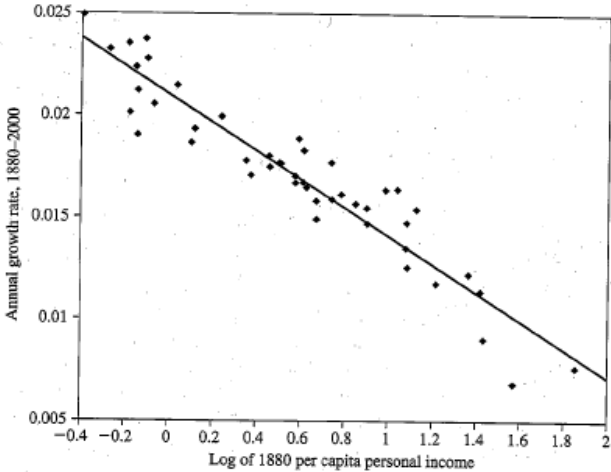


Figure 6: Convergence of personal income across US states: Growth rate of personal income from 1880 to 2000 over the initial level of personal income for 47 states (reproduced from Barro, 2003).



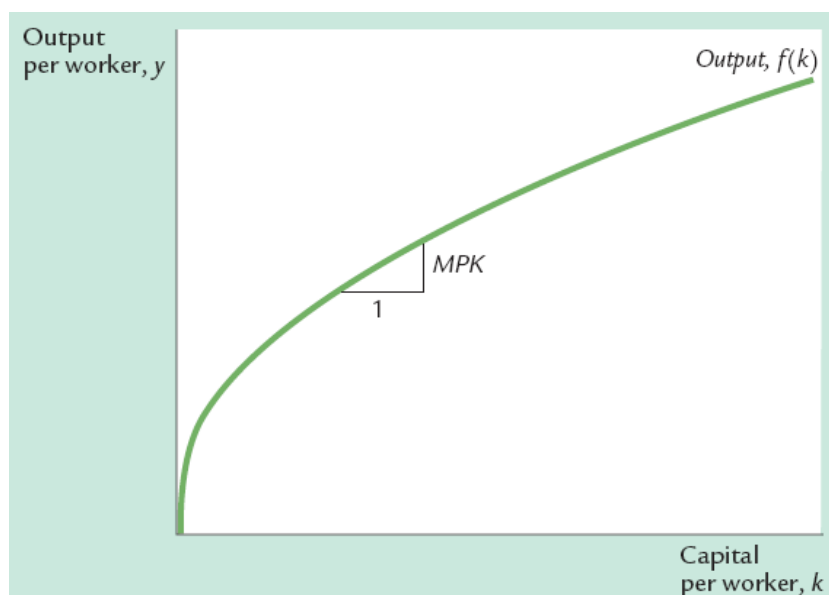
8 Economic Growth II - Solow model

- 3 main sources of growth - capital, people, technolog. progress
- SOLOW: how these three interact and affect national output; build up in steps

8.1 STEP 1: Accumulation of capital

8.1.1 Assumptions of the model:

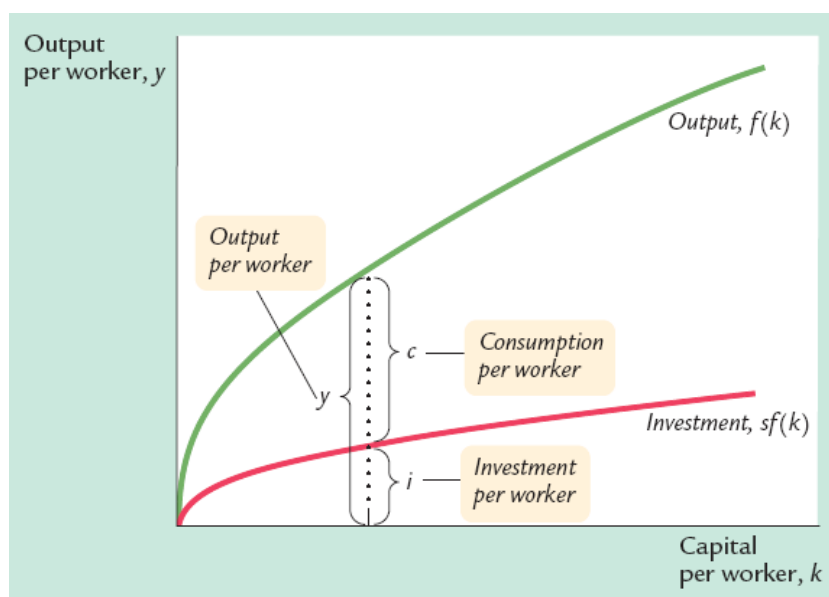
- **Neoclassical production function:** $Y = F(K, L)$
 - Ass.1: Constant returns to scale - i.e. $zY = F(zK, zL)$
 - allows us to analyze the per capita quantities: output per worker $y = Y/L$ and capital per worker $k = K/L$
 - take $z = 1/L \Rightarrow Y/L (= y) = F(K/L, 1) (= f(k))$
 - Ass.2: Marginal product is positive and diminishing
 - applies also for transformed function - $f'(k) > 0, f''(k) < 0$
 - Ass.3: Inada conditions + essentiality



- output is divided between consumption and investment: $y = c + i$
- HHs save a constant fraction of their income $s \in (0, 1)$: $i = sy, c = (1 - s)y$

8.1.2 Basic analysis:

- capital stock of economy changes over time
 - increases due to investment - new plants and equipment
 - decreased due to depreciation - wearing out of capital
- Investment: $i = sf(k)$
- Depreciation: fraction δ of capital stock "disappears" δk



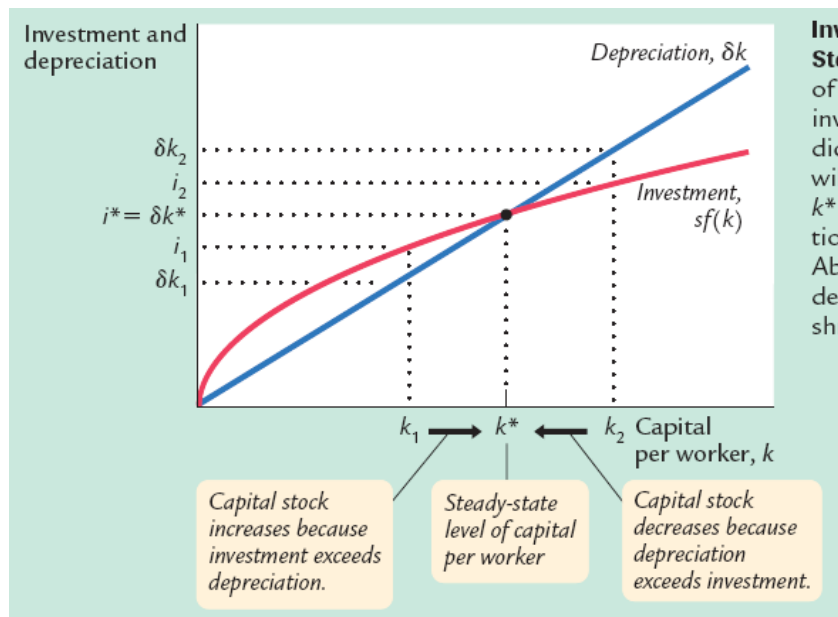
- **change of capital stock** = investment - depreciation

$$\Delta k = sf(k) - \delta k$$

- **STEADY STATE:** there exist single capital stock k^* for which amount of depreciation equals the invested amount

$$\exists! k^* : \Delta k = 0 \text{ or } sf(k) = \delta k$$

- if economy is in steady-state, it will stay there
 - if economy starts with any other level of capital, it will converge to steady state (stable equilibrium)
- **Prediction of model:**
 - in the long run, all economies will converge to their respective steady state
 - if country starts from relatively lower level of capita per person, it will grow faster (Japan, Germany after WWII)



• **Effect of savings:** as key determinant of capital stock

- higher saving rate \Rightarrow higher steady state level of capital and output per capita
- increase in saving rate \Rightarrow temporary increase in growth rate of economy

