Chapter 4 Part 2 : Endogenous Growth Model

EE312

Macroeconomics, Stephen Wiliamson, Chapter 7,8

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Outline

- Chapter 4: Growth Model
  4.1 Solow Growth Model
  4.2 Endogenous Growth Model

Outline (this part)

- Introduction :
  - Solow growth predictions
  - Growth facts
  - Growth in Solow model
- Endogenous growth

Endogenous Growth

1. Definition : human capital accumulation
2. Representative consumer : accumulation of human capital
3. The representative firm
    1. The firm's profit function
    2. Demand for efficiency units of labor
    3. Determination of the real wage
4. Competitive equilibrium
5. Growth of human capital
6. Factors in human capital growth
7. Consumption and output growth
8. Source of growth
9. Government policy on growth
10. No convergence
11. Human capital externality

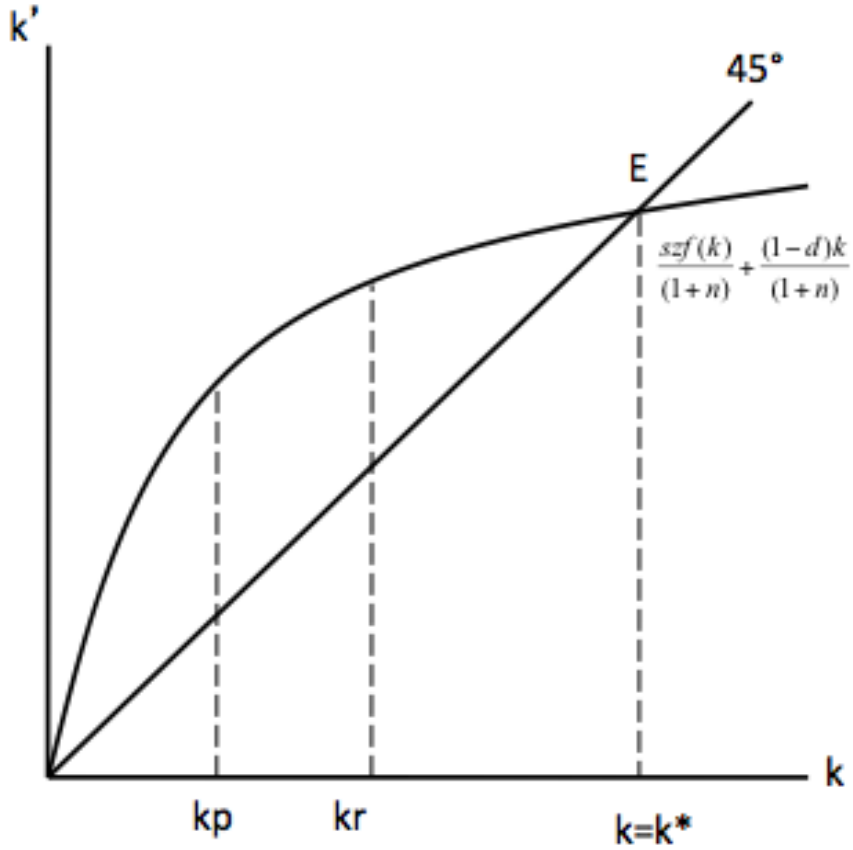
Solow growth predictions ((1) Absolute convergence, (2) Conditional Convergence)

(1) Absolute convergence

- If two countries start with:
  - the same population growth rate (n), saving rate (s) and total factor productivity (z),
  - but different per capita incomes (y), e.g., rich versus poor countries;
  - they will converge to the same steady-state k*, y* and c* — **Absolute convergence.**
- The poor country will have temporary higher growth and catch up with the rich.
- Absolute convergence (converence in k*, y* and c*),
  - Convergence in y*, Convergence in output growth path

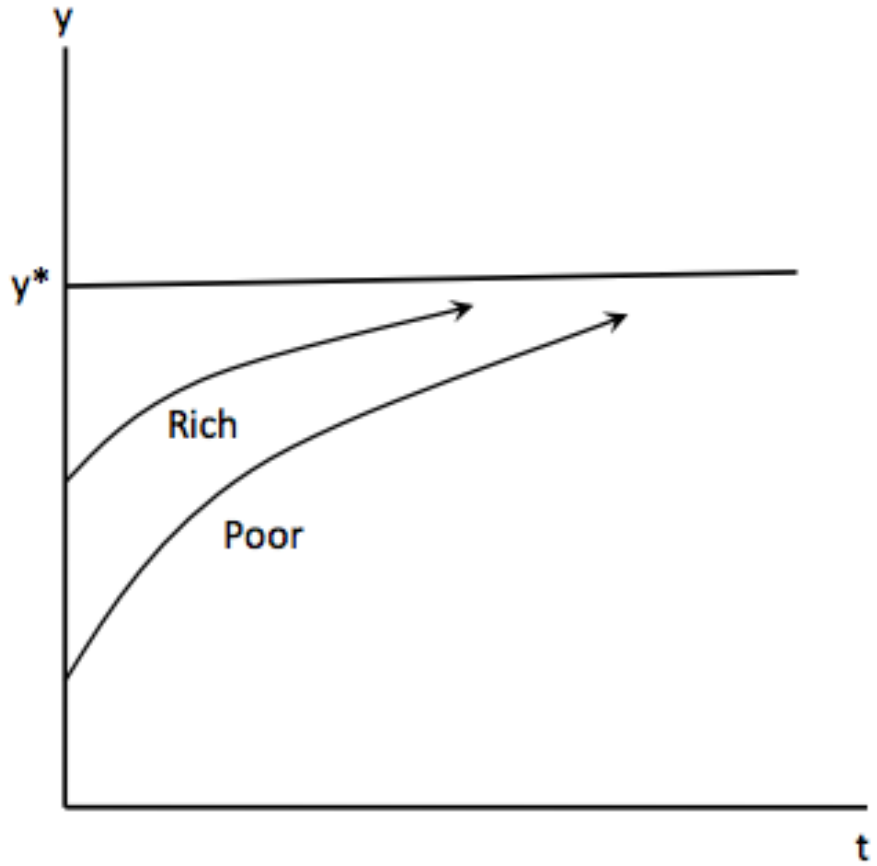
Absolute convergence

- The rich starts at k_r while the poor starts at k_p (with the same s, n and z).
- They converge to k* and y* in the long run.



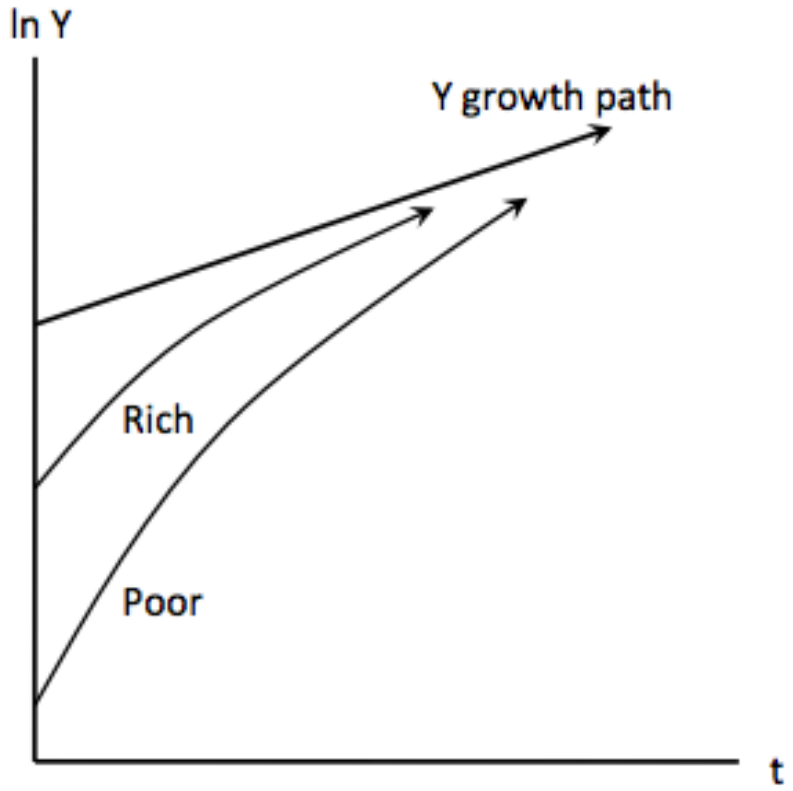
Convergence in per capita income

- The rich and the poor converge to the same level of y*.



Convergence in output growth path

- The rich and the poor converge to the long-run growth rate (n) of aggregate output (Y).



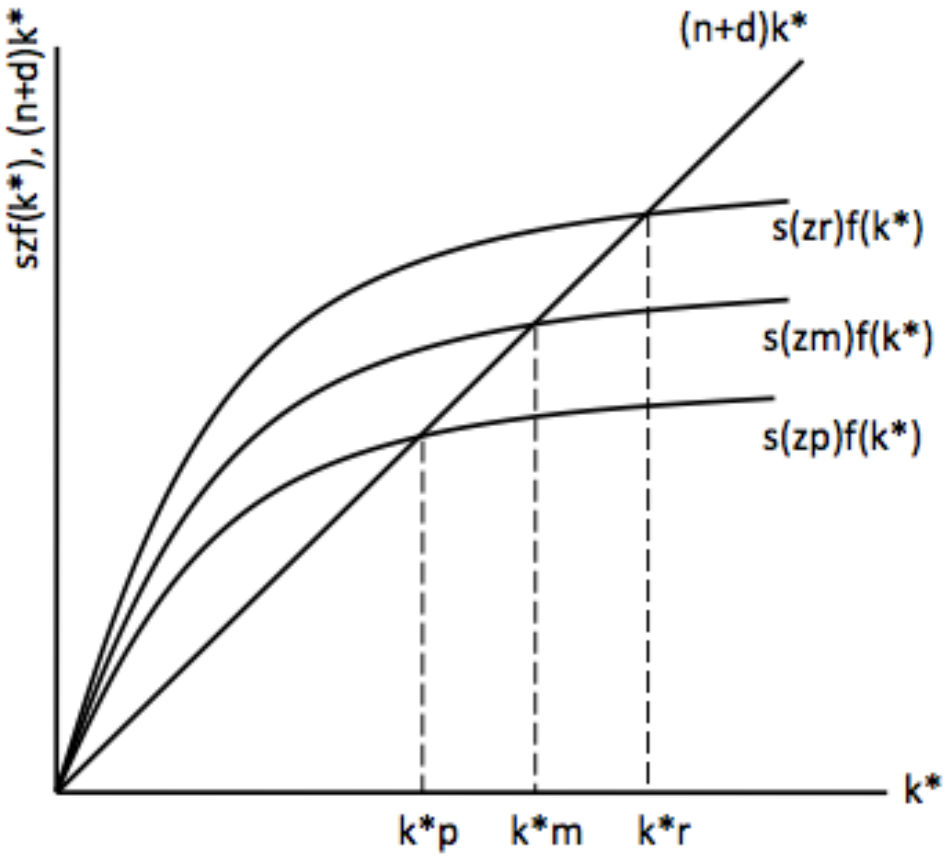
Solow growth predictions: (2) Conditional convergence

- With differences in n, z and s, the steady-state k*, y*, c* are different.
  - Each country has its own steady state.
  - The steady-state growth rate of aggregates (K, Y) is still n for each country.
- Countries are predicted to converge to their own steady state.
- Disparity among countries due to different values of n, z and s.

Solow growth predictions Vs. Growth Facts

- Absolute convergence has occurred among rich countries.
- No absolute convergence between rich and poor countries. Exception is East Asia.
- No absolute convergence among poor countries.
- Great diversity among poor countries.
- Why no absolute convergence?
  - Countries have different s, n and z.
  - Each country has different steady-state k*, y*, c*.
  - Each country is moving towards its own steady-state — **Conditional convergence**.
  - But differences in s and n are not large enough to explain all international disparity.
  - **Difference in access to technology (z)?**

- Countries with different z's will not converge to the same k* and y*.
- p = poor
- m = medium
- r = rich



Disparity due to different z's

- Different levels of total factor productivity (z) will perpetuate differences in capital per worker (k*), per capita income (y*) ...
- despite the same saving rate (s) and population growth (n).

Barriers to technology adoption

- **Labor legislation**: strong labor unions obstruct adoption of new technology.
- **Trade protectionism**: domestic firms with market power lack incentives to innovation.
- **Political corruption**: government's protection of inefficient firms.
- **Undeveloped financial system:** poor resource allocation mechanism.

How to catch up?

- Promotion of more competition among firms.
  - Liberalization and competition policy.
  - More pressure and incentive for firms to innovation.
- Free trade for greater international competition.
- Privatization of state enterprises.
  - State enterprises guarantee employment at the expense of efficiency.

Introduction : Growth in Solow model

- The Solow model does not explain the mechanism of growth itself.
  - Growth depends on exogenous factors.
  - Total factor productivity (z) is exogenously determined.
  - z depends on R&D by firms, education, training.
  - These are partly affected by government policy.
  - Government policy to raise z and long-term growth?

Endogenous growth model

- Explanation of growth within the model.
- Total factor productivity (z) depends on ‘human capital accumulation’.
- **Human capital**: the accumulated stock of skills and education workers have at a point in time.
  - Higher human capital; more production; more production of new human capital — faster growth over time.

- The higher human capital, the more efficiency the production of human capital has.
  - Better schooling, more future production, better passing on skills and knowledge.
- **Human capital is an investment**.
  - Opportunity cost of education and training — sacrifice of current consumption.
  - Benefits: more future production and consumption.

- Knowledge is '**non-rivalry**': one's acquisition of knowledge does not reduce others' ability to acquire the same knowledge.
- Human capital accumulation is **NOT subject to diminishing marginal returns**.
- No limit on how productive a person can become, given increasing knowledge and skills.
- **Unbounded growth** in endogenous models.
- Growth in Solow model is limited:
  - **Diminishing returns** on physical capital accumulation — rivalry in resource uses.

- The consumer allocates time between work and accumulating human capital.
- H^S = efficiency units of current human capital;
- u = time allocated to work;
- w = the real wage;
- C = current consumption;
- The **budget constraint** is total labor earnings:

$$C = uwH^S \tag{1}$$

Accumulation of human capital

- The consumer trades off current consumption for future consumption by accumulating human capital:
- $H^{s'}$ = future human capital;
- (1 - u) = time allocated to human capital accumulation;
- b = efficiency of human capital accumulation technology; b > 0.

$$H^{s/} = (1-u)bH^{s} \tag{2}$$

3. The representative firm

- The firm's production function using efficiency units of labor:
- Y = current output;
- z = marginal product of efficiency units of labor, where z > 0;
- uH^d = current input of efficiency units of labor:

$$Y = zuH^d \tag{3}$$

The firm's profit function

- uH^d is also the firm's demand for the efficiency units of labor.
- The function is characterized by **constant returns to scale** (CRS) — only one input.

$$\begin{aligned} \pi &= Y - wuH^d \\ \pi &= zuH^d - wuH^d \\ \pi &= (z-w)uH^d \end{aligned}$$

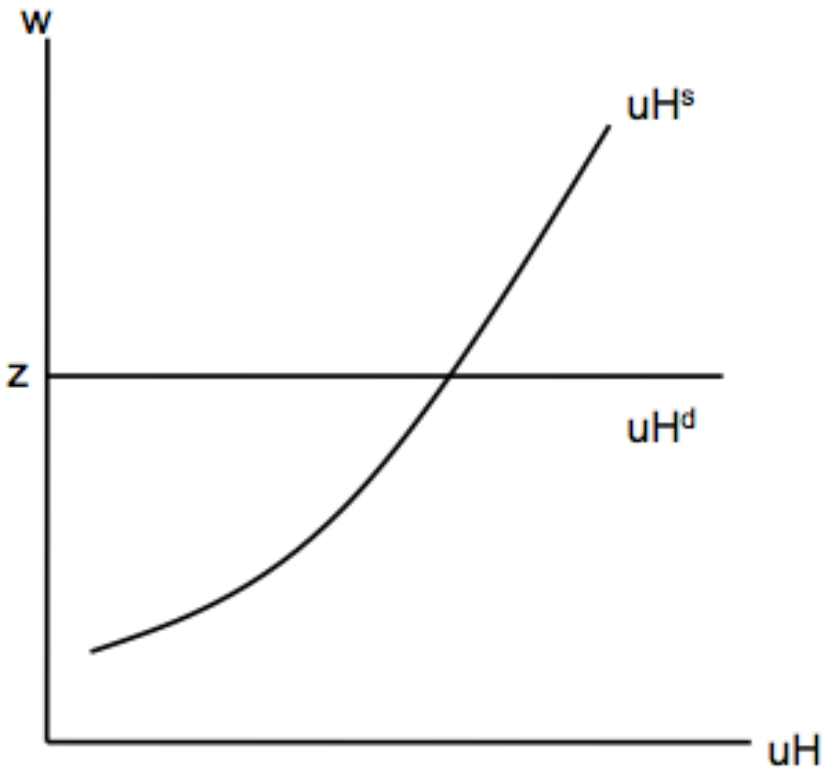
Demand for efficiency units of labor

$$\pi = (z - w)uH^d \tag{4}$$

- (z-w) < 0, π < 0; the firm hires no units of labor; or uHd = 0.
- (z-w) > 0, π > 0; the firm hires infinite units.
- z = w, π = 0; the firm is indifferent.
- The demand curve is infinitely elastic at w = z.

Determination of the real wage

- uH^d is horizontal at w = z.
- The real wage equals z, the marginal product of uH^s. Assume uH^s with slope > 0.



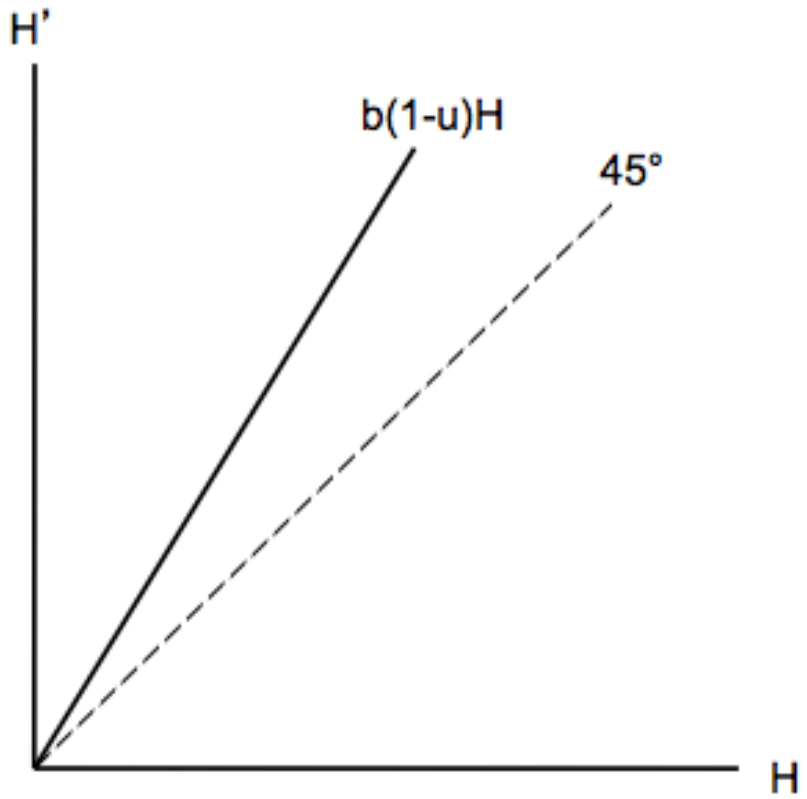
- The market clears at w = z where uH^d = uH^s.
- Equilibrium consumption and growth of human capital accumulation:

$$\begin{aligned} C &= zuH. \\ H' &= b(1-u)H. \\ \frac{H'}{H} - 1 &= b(1-u) - 1, \end{aligned}$$

where $b(1-u)-1$ is constant.

5. Growth of human capital

- H' is a function of H where $H' >$ H.
- Slope = b(1-u) = 1+ rate of growth of human capital.



6. Factors in human capital growth

$$\frac{H'}{H} - 1 = b(1-u) - 1, \tag{5}$$

- $\frac{H'}{H}$ is higher if b increases or u decreases.
  - b = efficiency of human capital accumulation technology (or efficiency of the education sector).
  - u = time spent on current output production.
  - Falling u (or rising 1-u) = more time spent on human capital accumulation.

7. Consumption and output growth

- Current consumption C = zuH also holds for future consumption C' = zuH'.
  - So consumption grows at the same rate of b(1-u) as human capital.
- Output also grows at the same rate as Y = C in every period.

$$\frac{C'}{C} - 1 = \frac{zuH'}{zuH} - 1 = \frac{H'}{H} - 1 = b(1-u) - 1 \tag{6}$$

8. Source of growth

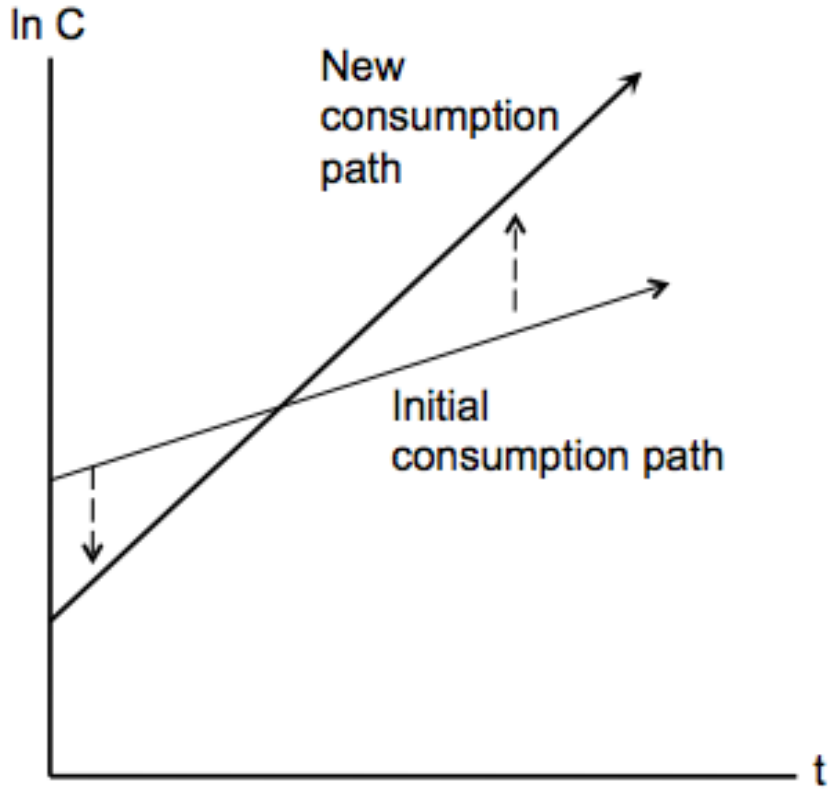
- **b and z are fixed:** constant technology.
- No population growth.
- Growth is determined inside the model, by the value of b and u.
- **Growth is unbounded** because human capital accumulation is not subject to diminishing returns to scale.
  - Output grows in proportion to human capital, given u.

9. Government policy on growth

- Government can increase growth:
  - Increases in b, the efficiency of human capital accumulation technology (education policy).
  - Reduction in u, taxes or subsidies to education.
  - Higher b(1-u), higher growth of human capital, consumption and output.
- But current consumption must be sacrificed as u is lower, given initial human capital (H).

Lower u and consumption

- a lower u results in lower current consumption but higher consumption in the long run.



Consumer preference

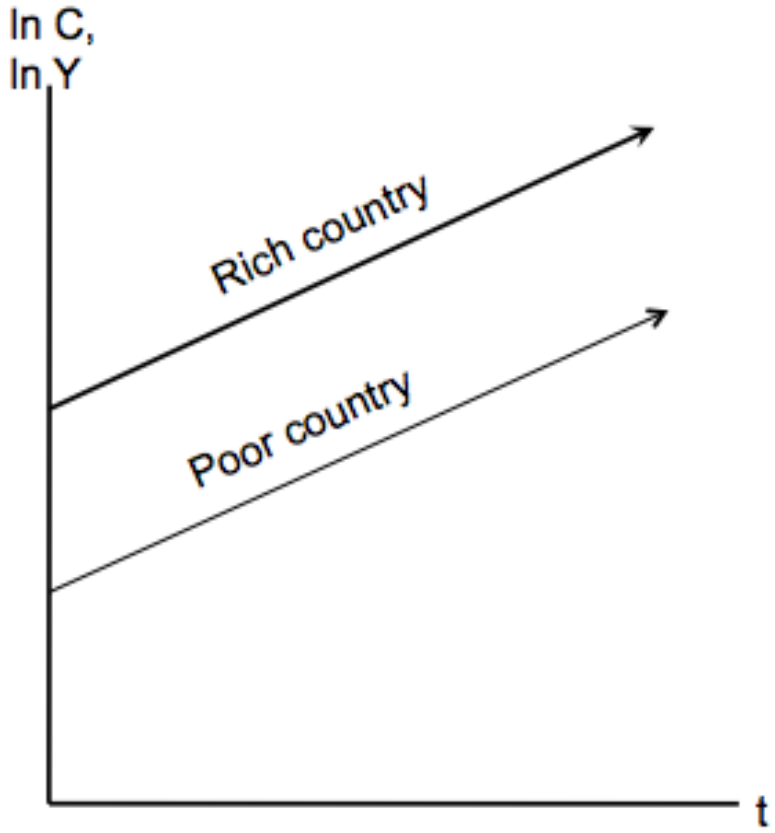
- Government's education policy (raising b) involves expenses of current resources and lower current consumption.
- Higher long-run growth is desirable?
  - This depends on the consumer's preference on current and future consumption.
  - The consumer may be worse off if current consumption is actually preferred.

9. No convergence

- Countries with all identical characteristics except differences in initial human capital will not converge on the levels of consumption and income.
  - **Poor countries**: low Y = C = zuH;
  - **Rich countries**: high Y = C = zuH.
  - But their C and Y grow at the same rate of b(1-u).

Rich and poor do not converge.

- The Y and Y time paths do not converge despite the same growth rate of b(1-u).



10. Human capital externalities

- The endogenous model explains the lack of convergence among poor countries and between rich and poor countries.
- But convergence occurs among rich countries, why? — Human capital externalities.
  - Contact with others with higher human capital increases our own human capital.
  - Capital and labor are highly mobile; skills are more easily transferred in rich countries.

- More opportunities and contact make levels of human capital in rich countries converge.
  - Convergence of income per worker.
- Lack of human capital externalities in poor countries.
  - Less contact with developed countries.
  - People with high human capital move to developed countries (i.e., brain drains).
  - Differences in human capital persist.