EE312 Macroeconomic Theory

Chapter 6

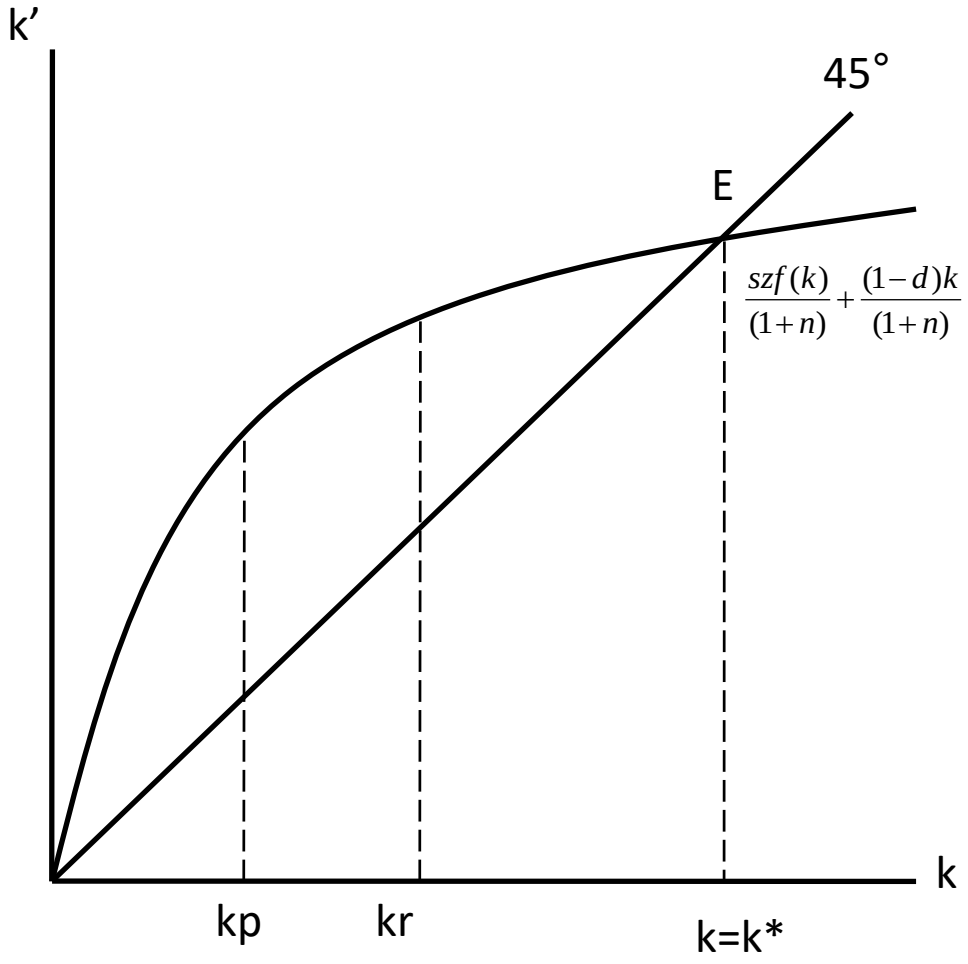
Endogenous Growth Model

Solow growth predictions

- If two countries start with:
  - the same population growth rate (n), savings 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.

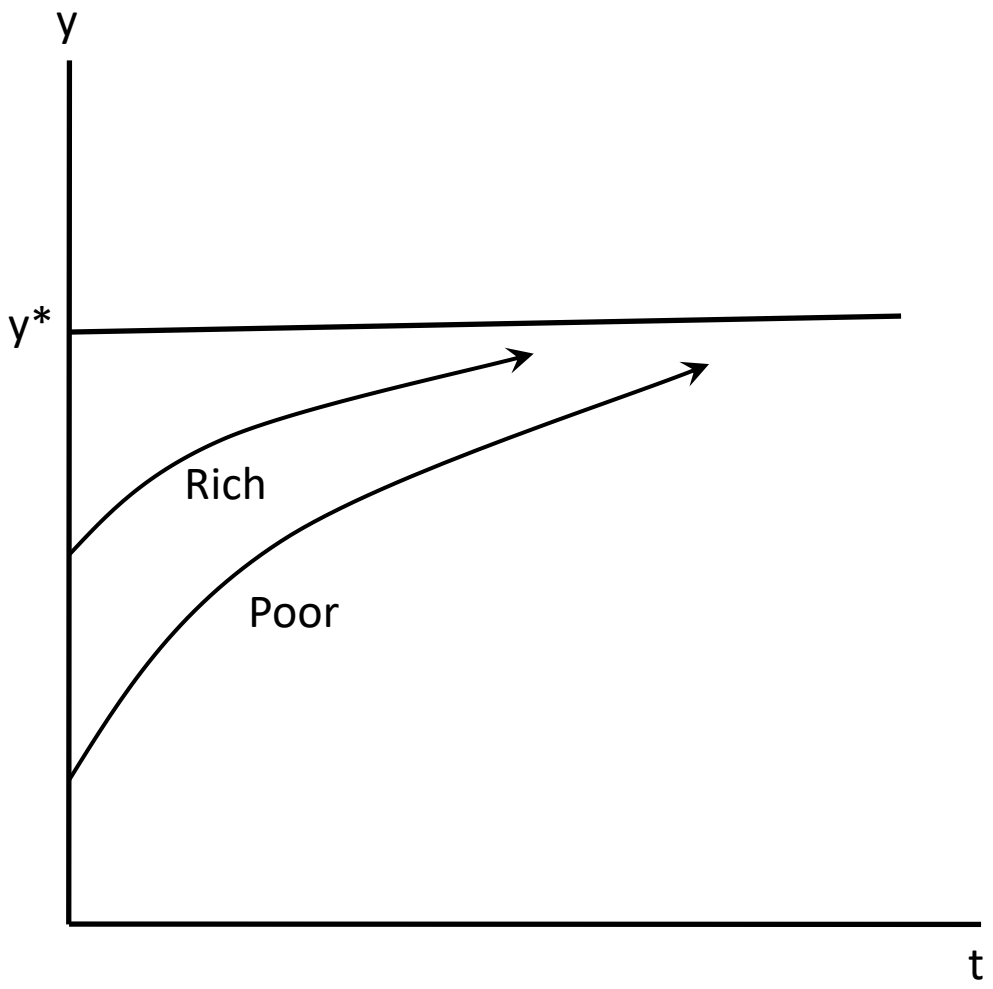
Absolute convergence

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



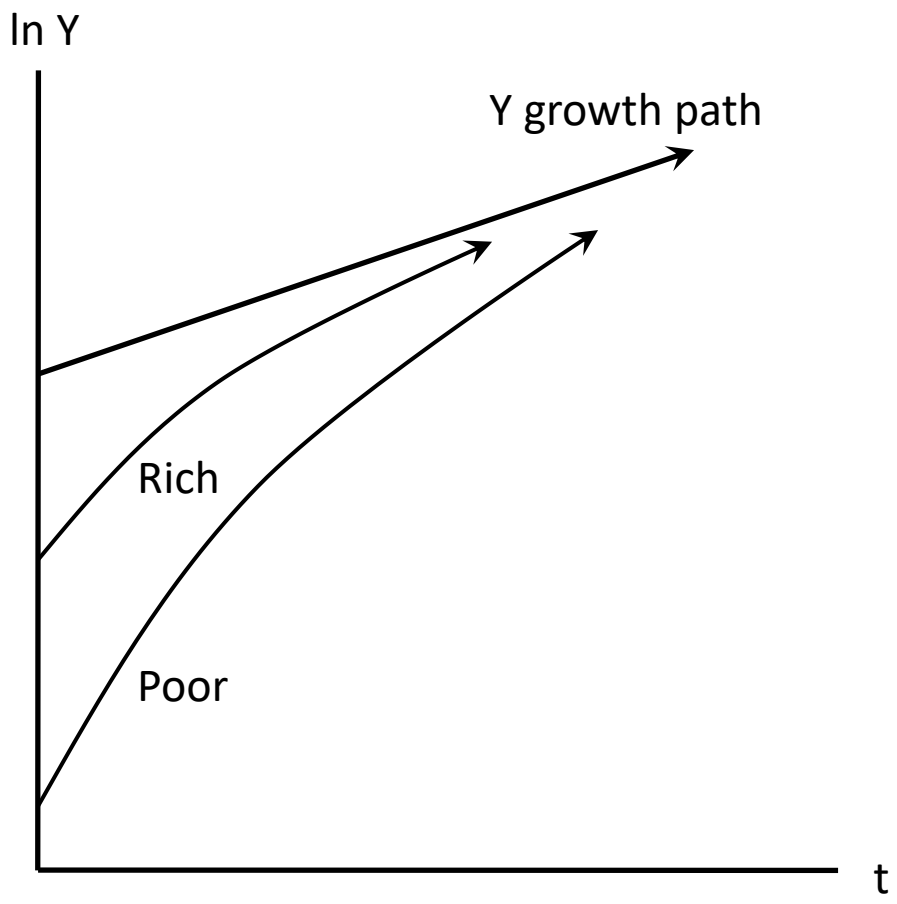
Convergence in per capita income

- 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).



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.

- **Disparity among countries due to different values of n, z and s.**

Growth facts

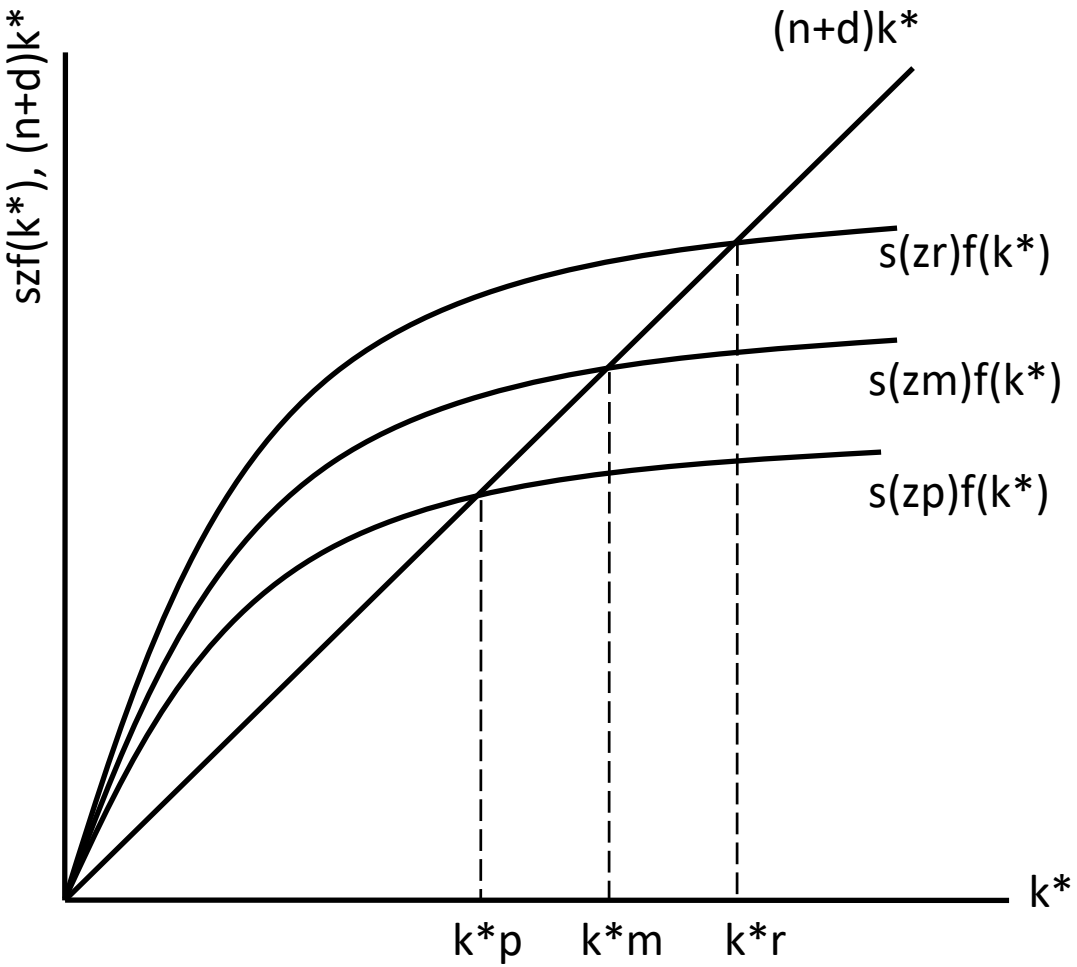
- Absolute convergence has occurred among rich countries.
- No absolute convergence between rich and poor countries.
  - Exception is East Asia.
- No absolute convergence among poor countries.
  - Great diversity among poor countries.

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**.
- However, empirically, differences in s and n are not large enough to explain all international disparity.
- **Difference in access to technology (z)?**

No convergence with different z's

- Countries with different z's will not converge to the same k* and y*.
  - zp = poor
  - zm = medium
  - zr = rich



Disparity due to different z's

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

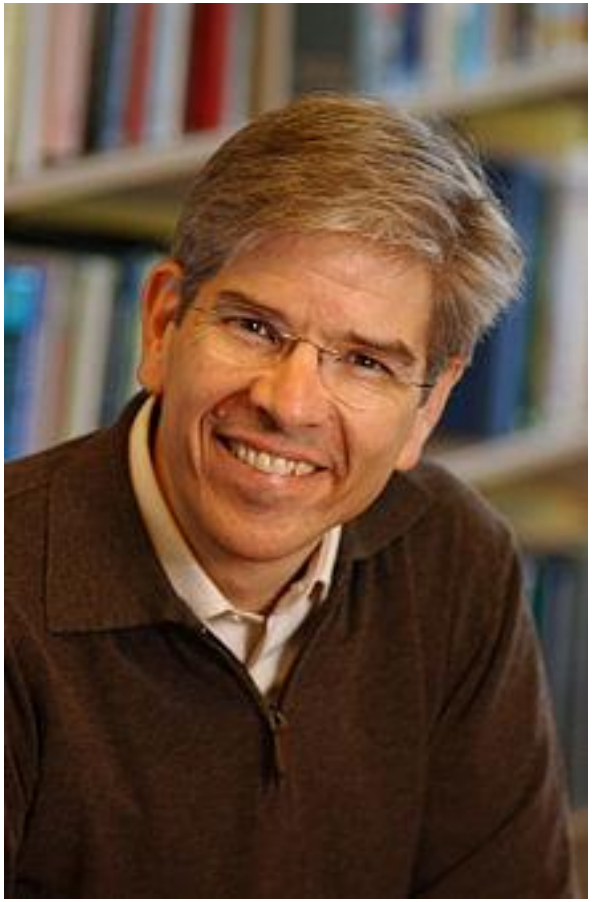
- Promotion of more competition among firms.
  - **Liberalization and competition policy**.
  - More pressure and incentive for firms to innovation.
- **Free trade** for greater international competition.
- **Privatization** of state enterprises.
  - State enterprises guarantee employment at the expense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

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.
- Economic growth 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.



Paul M. Romer (b.1955),
the Stern School of Business, New York University.

Human capital accumulation

- 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 representative consumer

- 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:

$$C = wuH^s$$

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.

$$H^{s'} = b(1-u)H^{s}$$

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:

$$Y = zuH^d$$

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.

$$\pi = Y - wuH^d$$

$$\pi = zuH^d - wuH^d$$

$$\pi = (z - w)uH^d$$

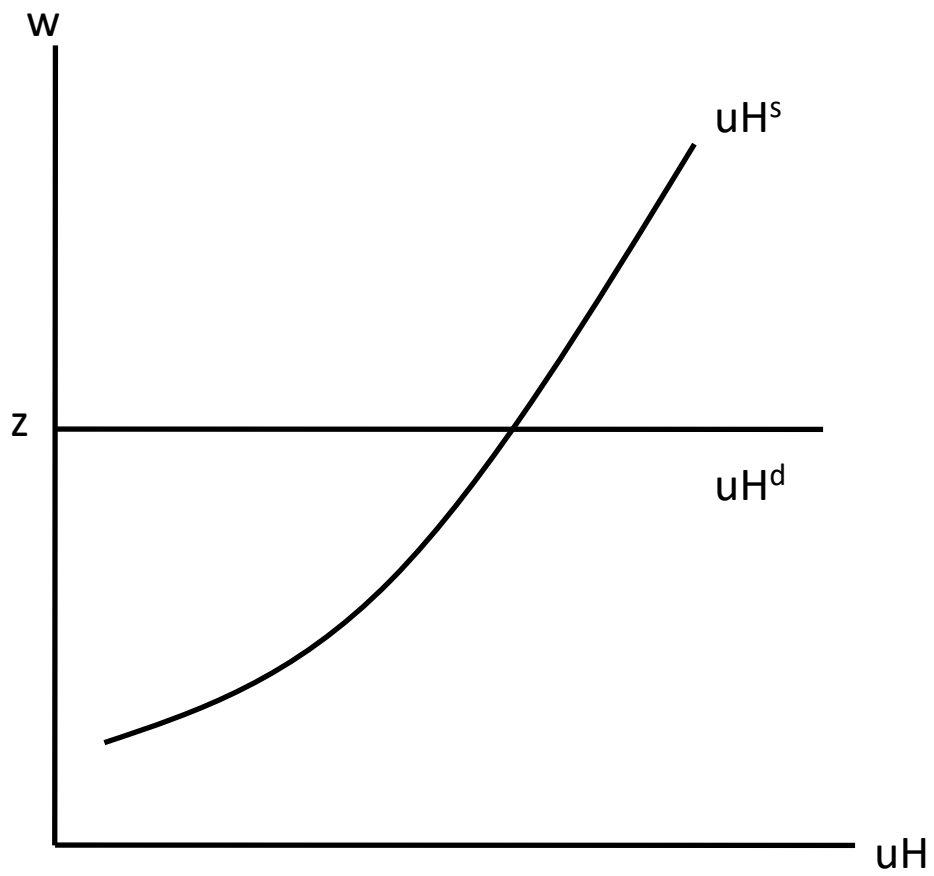
Demand for efficiency units of labor

$$\pi = (z - w)uH^d$$

- (z-w) < 0, π < 0; the firm hires no units of labor; or $uH^d = 0$.
- (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.



Competitive equilibrium

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

$$C = zuH$$

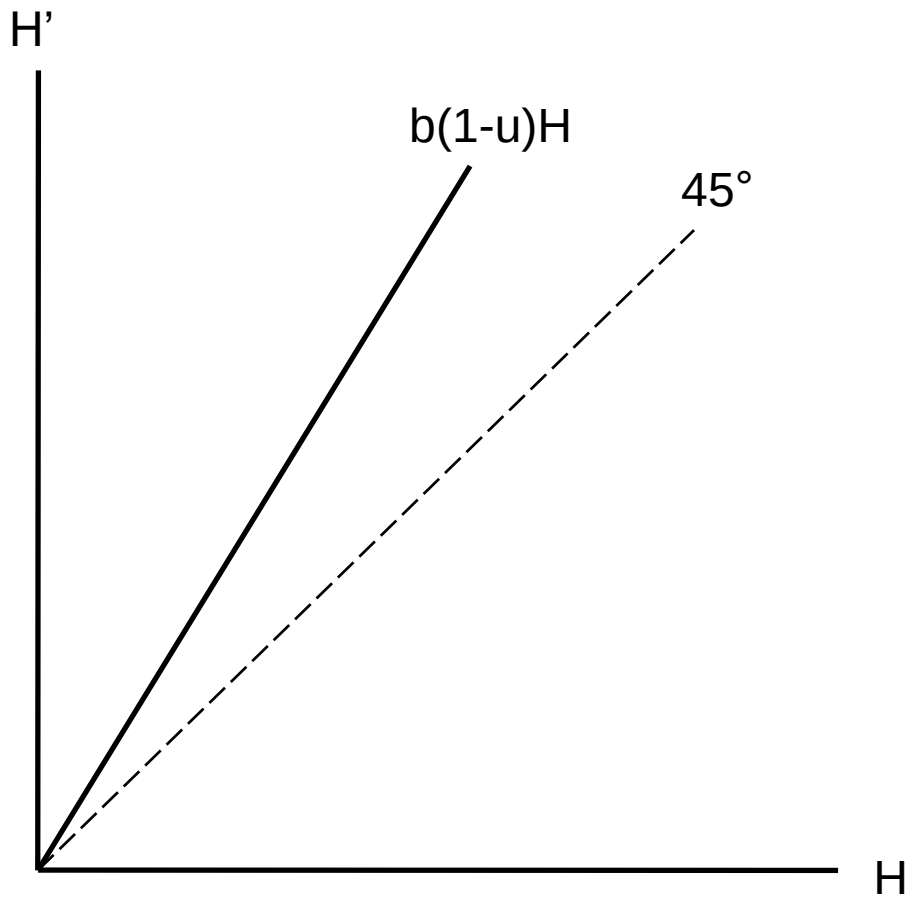
$$H' = b(1-u)H$$

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

where b(1 – u) -1 is a constant.

Growth of human capital

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



Factors in human capital growth

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

- 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.

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.

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

Endogenous growth

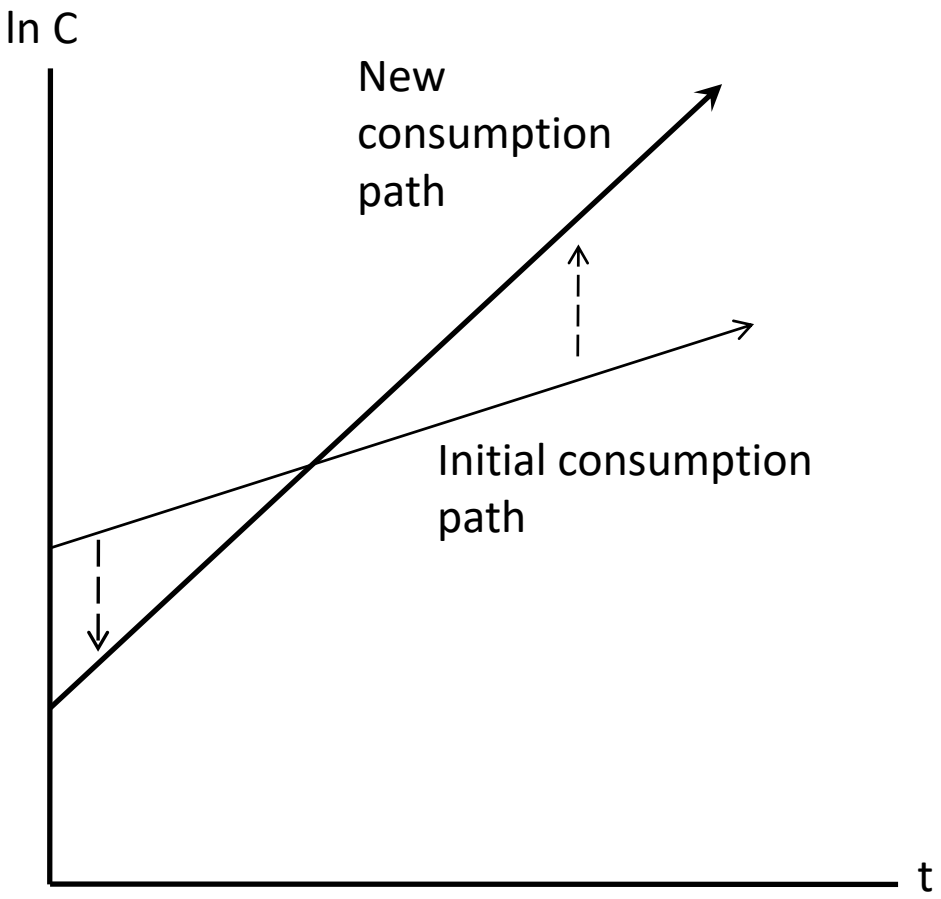
- **b and z are fixed**: constant technology.
- No population growth.
- Growth is determined inside the model, by the value of b and u.
- **Growth is unbounded** because human capital accumulation is not subject to diminishing returns.
  - Output grows in proportion to human capital, given u.

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

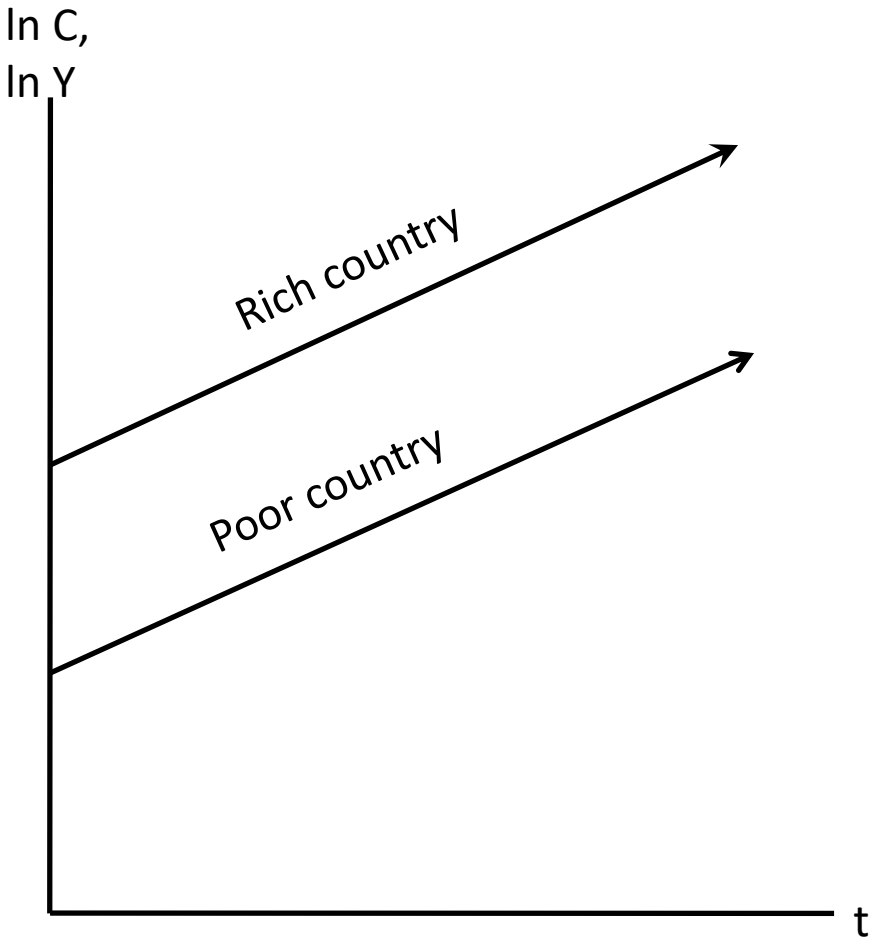
- Government's education policy (raising b) involves expenses of current resources and lower current consumption.
- Higher long-run growth is desirable?
  - This depends on the consumer's preference on current and future consumption.
  - The consumer may be worse off if current consumption is actually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

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).



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.