Growth and Policy

Chapter #4

Introduction

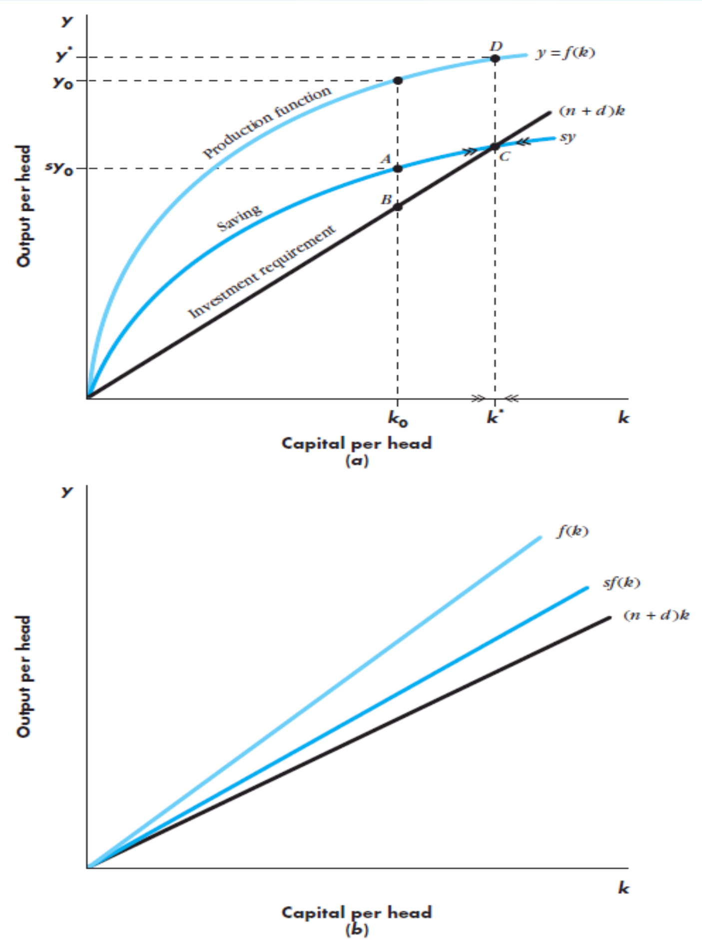
- Chapter 3 explained how GDP and GDP growth are determined by the savings rate, rate of population growth, and the rate of technological progress
- The question analyzed in this chapter is "How do society's choices affect these parameters?"
  - In many developed countries, invention and advances in technology are the key determinants of growth
  - Technological advances are much less important for poor countries → more important to invest in human and physical capital and borrow technological advances from others
- Endogenous growth theory (Romer, Lucas) explains how society's choices lead to technological progress and growth

Trouble With Neoclassical Growth Theory

- By the late 1980's there was great dissatisfaction with neoclassical growth theory since:
  1. It does not explain the economic determinants of technological progress
  2. It predicts that economic growth and savings rates are uncorrelated in the steady state
- Endogenous growth theory emphasizes different growth opportunities in physical and knowledge capital
  - Diminishing marginal returns to physical capital, but perhaps not knowledge capital
  - The idea that increased investment in human capital increases growth is key to linking higher savings rates to higher equilibrium growth rates

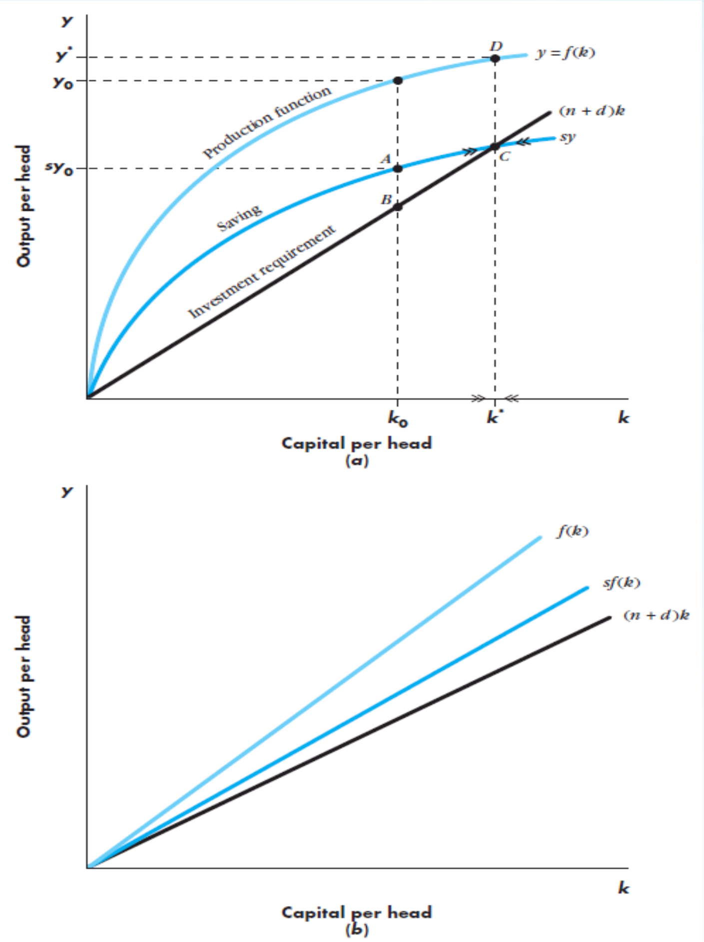
Mechanics of Endogenous Growth

- Need to modify the production function to allow for self-sustaining, endogenous growth
- Figure 4-1 (a) shows the Solow growth diagram, with the steady state at point C where savings equals required investment
  - If savings above required investment, economy is growing as more capital is added → process continues until savings equals required investment (reach the steady state)



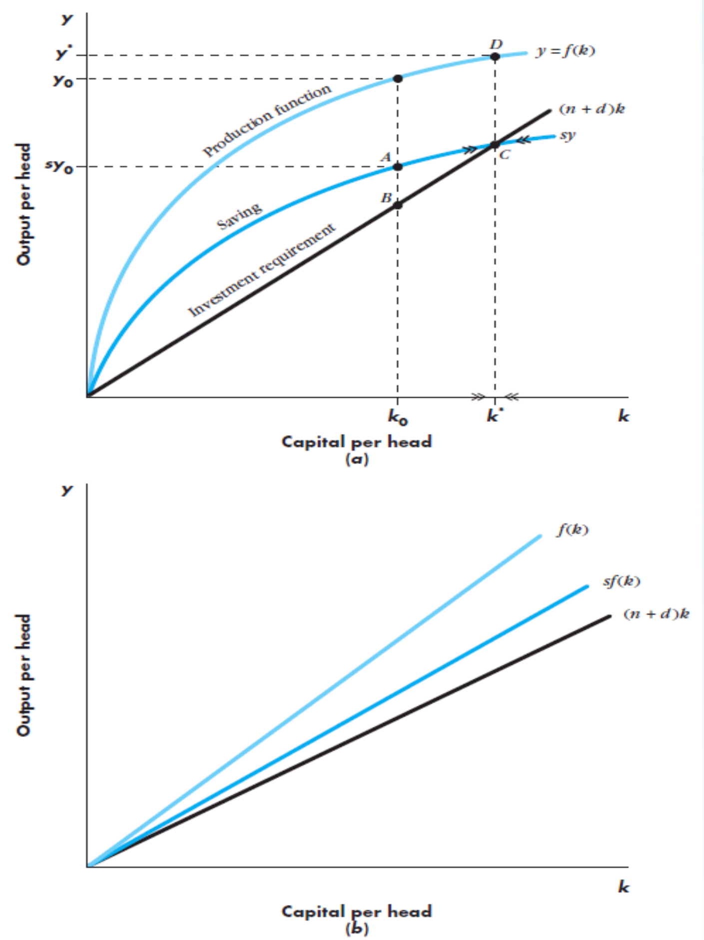
Mechanics of Endogenous Growth

- Need to modify the production function to allow for self-sustaining, endogenous growth
- Figure 4-1 (a) shows the Solow growth diagram, with the steady state at point C where savings equals required investment
  - Due to the diminishing MPK, the production function and savings function flatten out and cross the upward sloping required investment line once



Mechanics of Endogenous Growth

- Need to modify the production function to allow for self-sustaining, endogenous growth
- Economy illustrated in Figure 4-1 (b) is described by a production function with a constant MPK: Y = aK (1)
  - K is the only factor, a is the MPK
  - Production function and savings curve become straight lines, and are always greater than required investment → the higher the savings rate, the bigger the gap between savings and required investment = faster the growth



Mechanics of Endogenous Growth

- If the savings rate, s, is constant and there is neither population growth nor depreciation of capital, then the change in the capital stock is defined as:

$$\Delta K = sY = saK$$

$$OR \qquad (2)$$

$$\frac{\Delta K}{K} = sa$$

$\rightarrow$ *Growth rate of capital is proportional to the savings rate*

- Output is proportional to capital, thus the growth rate of output is

$$\frac{\Delta Y}{Y} = sa \qquad (3)$$

$\rightarrow$ *The higher s, the higher the growth rate of output*

Deeper Economics of Endogenous Growth

- Eliminating diminishing marginal returns to capital runs against prevailing microeconomic principles
  - If there are constant returns to capital alone, there will be increasing returns to scale to all factors taken together → larger and larger firms become increasingly efficient, and should see a single firm dominate the entire economy
    - Not realistic, so need to eliminate the possibility of increasing returns to scale to all factors, and constant returns to a single factor

Deeper Economics of Endogenous Growth

- Alternatively, a single firm may not capture all benefits of capital → some <u>external</u> to the firm (Romer)
  - When a firm increases K, firm's production increases, but so does the productivity of other firms
  - As long as <u>private</u> return has constant returns to all factors, there will be no tendency towards monopolization

Private vs. Social Returns to Capital

- Investment produces not only new machines, but also new ways of doing things
  - Firms DO capture the production benefits of a new machine (PRIVATE RETURNS)
  - Firms may NOT capture the benefits of new technologies and ideas, since they are easy to copy (SOCIAL RETURNS)
- Endogenous growth theory hinges on the notion that there are substantial external returns to capital
  - Not realistic for physical capital, but quite for human capital:
    1. Contribution of new knowledge only partially captured by creator
    2. From one new idea springs another $\rightarrow$ knowledge can grow indefinitely

N and the Endogenous Growth Model

Assume:

1. Technology is proportional to the level of capital per worker, or

$$A = \alpha \frac{K}{N} = \alpha\, k$$

2. Technology is labor augmenting, $Y = F(K, AN)$
3. Technology growth depends on capital growth, or

$$\frac{\Delta A}{A} = \frac{\Delta K}{K} - \frac{\Delta N}{N}$$

- The GDP growth equation from Chapter 3 was $\frac{\Delta y}{y} = \Theta \frac{\Delta k}{k} + (1-\Theta)\frac{\Delta A}{A}$
- If $\frac{\Delta A}{A} = \frac{\Delta K}{K} - \frac{\Delta N}{N} = \frac{\Delta k}{k}$, then

$$\begin{aligned}\frac{\Delta y}{y} &= \Theta \frac{\Delta k}{k} + (1-\Theta)\frac{\Delta A}{A} \\ &= \Theta \frac{\Delta k}{k} + (1-\Theta)\frac{\Delta k}{k} \\ &= \frac{\Delta k}{k}\end{aligned}$$

N and the Endogenous Growth Model

- Since the numerator and denominator of y/k grow at equal rates, y/k is constant
  - What is that constant? Find by dividing the production function by K and simplifying:

$$\frac{y}{k}=\frac{F(K,AN)}{K}$$
$$=F\left(\frac{K}{K},A\frac{N}{K}\right)$$
$$=F\left(\frac{K}{K},\alpha\frac{K}{N}\times\frac{N}{K}\right)$$
$$=F(1,\alpha)\equiv a$$

- The equation for capital accumulation can be written as:

$$\frac{\Delta k}{k}=s\frac{y}{k}-(n+d)$$

- Making the substitution for y/k, the growth rate of y and k becomes:

$$\frac{\Delta y}{y}=\frac{\Delta k}{k}=g=s\frac{y}{k}-(n+d)$$
$$=sa-(n+d)$$

Convergence

- Do economies with different initial levels of output eventually grow to equal standards of living or *converge*?
  - Neoclassical growth theory predicts *absolute convergence* for economies with equal rates of saving and population growth and with access to the same technology → should all reach the same steady state level of income
  - *Conditional convergence* is predicted for economies with different rates of savings and/or population growth → steady state level of income will differ, but the growth rates will eventually converge
- Endogenous growth theory predicts that a high savings rate leads to a high growth rate

Convergence

- Do economies with different initial levels of output eventually grow to equal standards of living or *converge*?
  - Robert Barro tested these competing theories, and found that:
    1. Countries with higher levels of investment tend to grow faster
    2. The impact of higher investment on growth is however transitory

    → Countries with higher investment will end in a steady state with higher per capita income, but not with a higher growth rate

    → Countries do appear to converge conditionally, and thus endogenous growth theory is not very useful for explaining international differences in growth rates

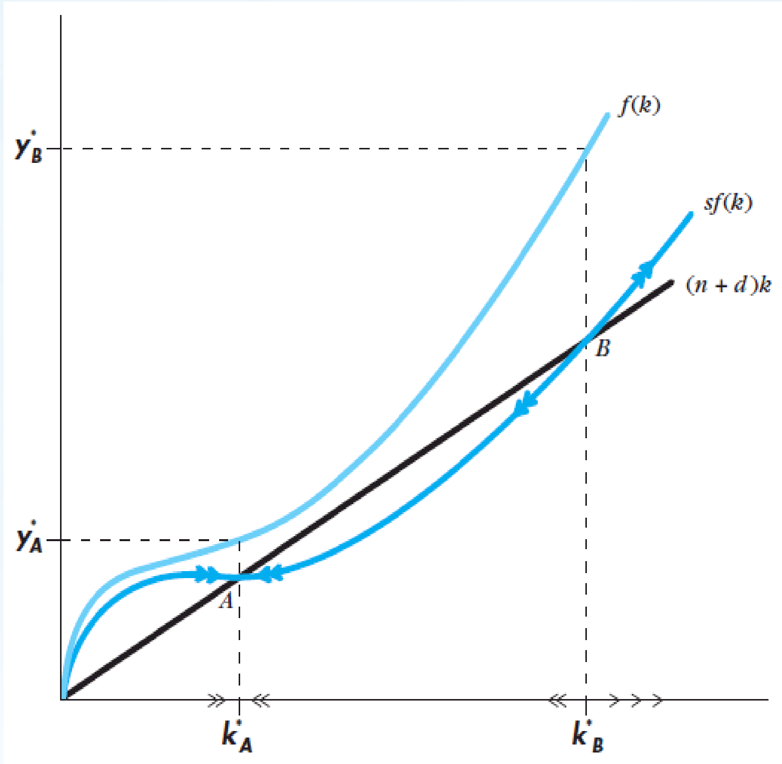
Growth Traps and Two Sector Models

- How do we explain a world with BOTH no growth AND high growth countries?
  - Ghana is an example of an economy that has experienced no growth since 1900
  - China is an example of an economy that has experienced rapid growth in recent years
- Need a model in which there is a possibility of both a no growth, low income equilibrium AND a high growth, high income equilibrium

→ Elements of both neoclassical and endogenous growth theories

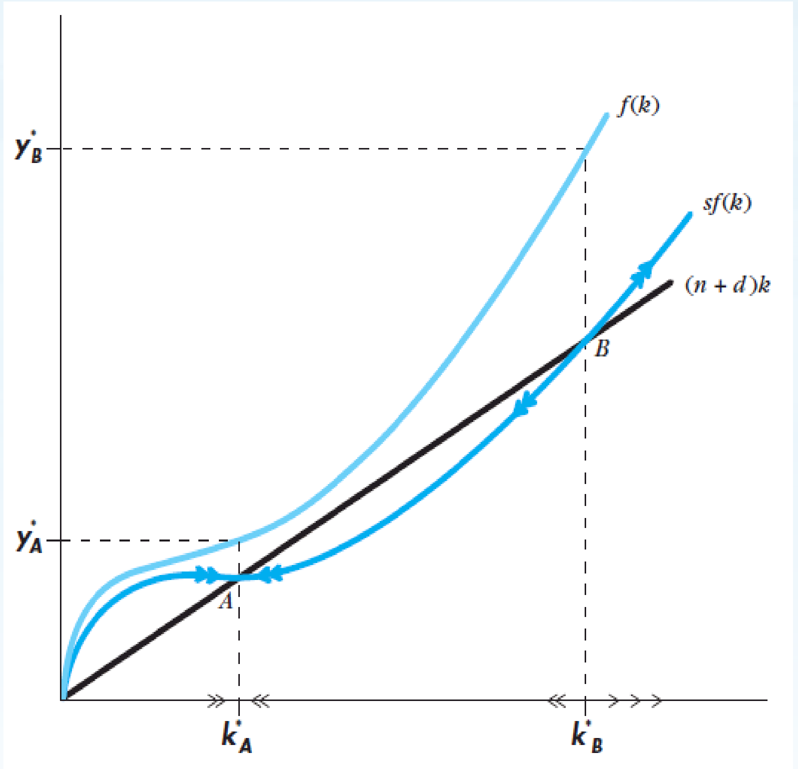
Growth Traps and Two-Sector Models

- Suppose there are two types of investment opportunities:
  1. Those with diminishing MPK at low income levels
  2. Those with constant MPK at high income levels
- Figure 4-2 illustrates such a situation
  - The production function has a curved segment at low levels of income and an upward sloping line at high levels
  - Point A is a neoclassical steady state equilibrium, while past point B there is ongoing growth (endogenous growth theory)



Growth Traps and Two-Sector Models

- Suppose there are two types of investment opportunities:
  1. Those with diminishing MPK at low income levels
  2. Those with constant MPK at high income levels
- With two outlets for investment, society must choose not only total investment, but also the division between the two
  – Societies that direct I towards research and development will have ongoing growth
  – Societies that direct I toward physical capital may have higher output in the short run at the expense of lower long run growth

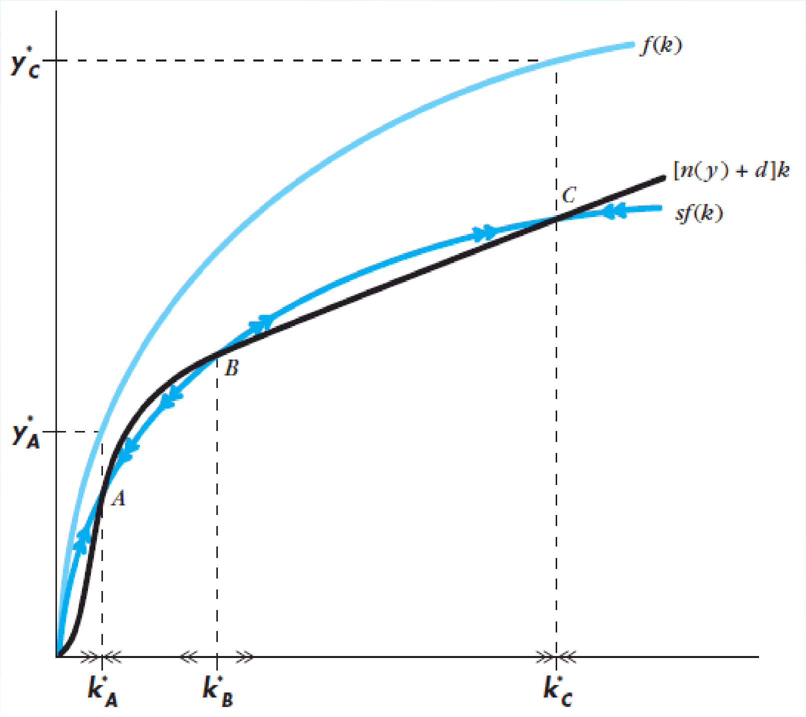


Solow Model with Endogenous Population Growth

- One of the oldest ideas in economics is that population growth works against the achievement of high income
  - The Solow growth model predicts that high population growth, n, means lower steady state income as each worker will have less capital to work with
- Over a wide range of incomes, population growth itself depends on income, n(y)
  - Very poor countries have high birth rates and high death rates, resulting in moderately high population growth
  - As income rises, death rates fall and population growth increases
  - At very high incomes, birth rates fall, some even approaching zero population growth (ZPG)

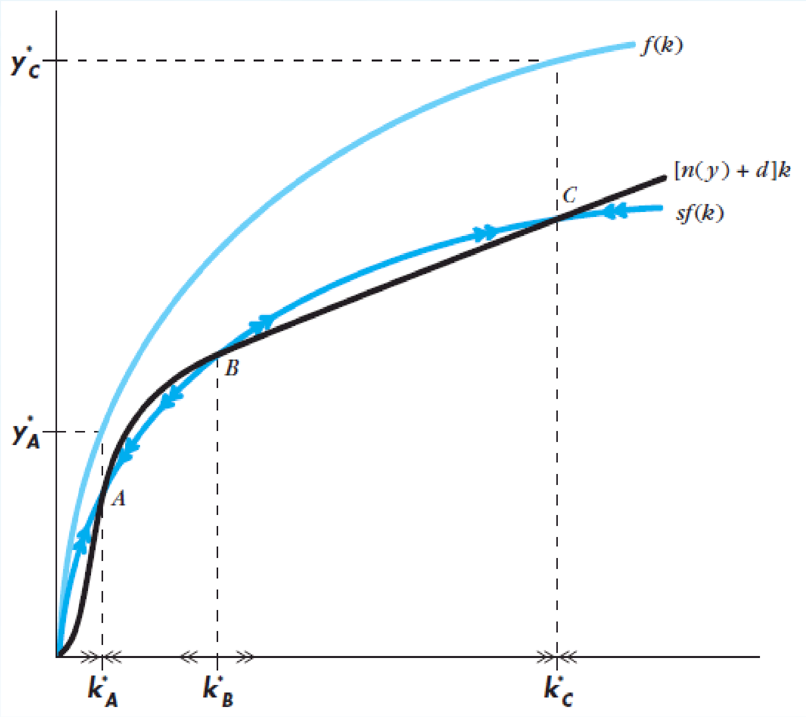
Solow Model with Endogenous Population Growth

- Figure 4-3 illustrates the modified investment requirement line on the Solow diagram to account for n as a function of y
- The investment requirement line, [n(y) + d]k, rises slowly at low levels of income, then sharply at higher levels, and finally levels off at high levels of income



Solow Model with Endogenous Population Growth

- The investment requirement line crosses the savings curve at points A, B, and C
  - Point A is a poverty trap with high population growth and low incomes
  - Point C has low population growth at high incomes
  - Points A and C are stable equilibriums because the economy moves towards these points
  - Point B is an unstable equilibrium since the economy moves away from it

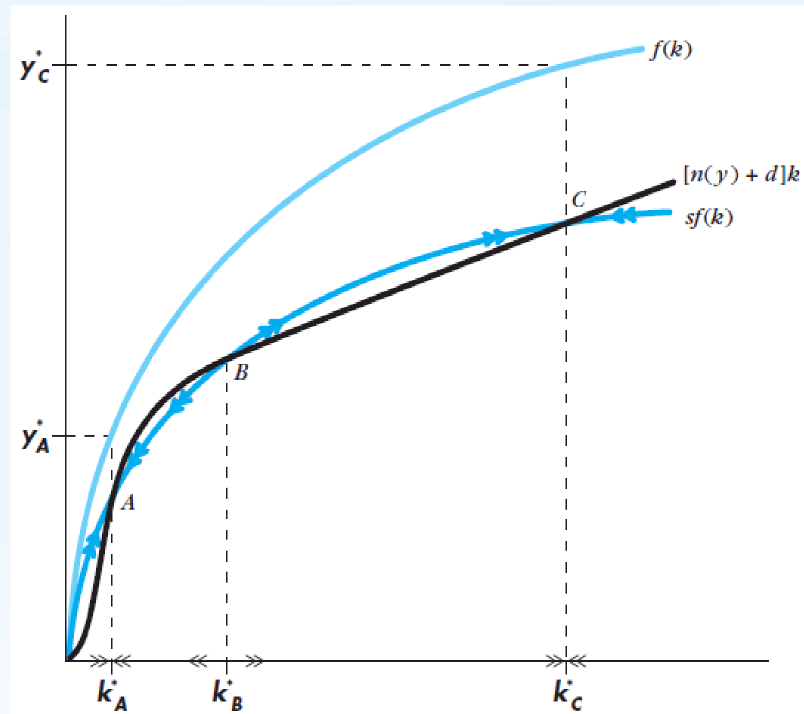


Solow Model with Endogenous Population Growth

- How can an economy escape from the low-level equilibrium? There are two possibilities.
  1. If a country can put on a “big push” that increases income past point B, the economy will continue unaided to the high-level at point C
  2. A nation can effectively eliminate the low-level trap by moving the savings curve up or the investment requirement line down so that they no longer touch at points A or B

     → raising productivity or increasing the savings rate raises the savings line

     → population control policies lower the investment requirement line



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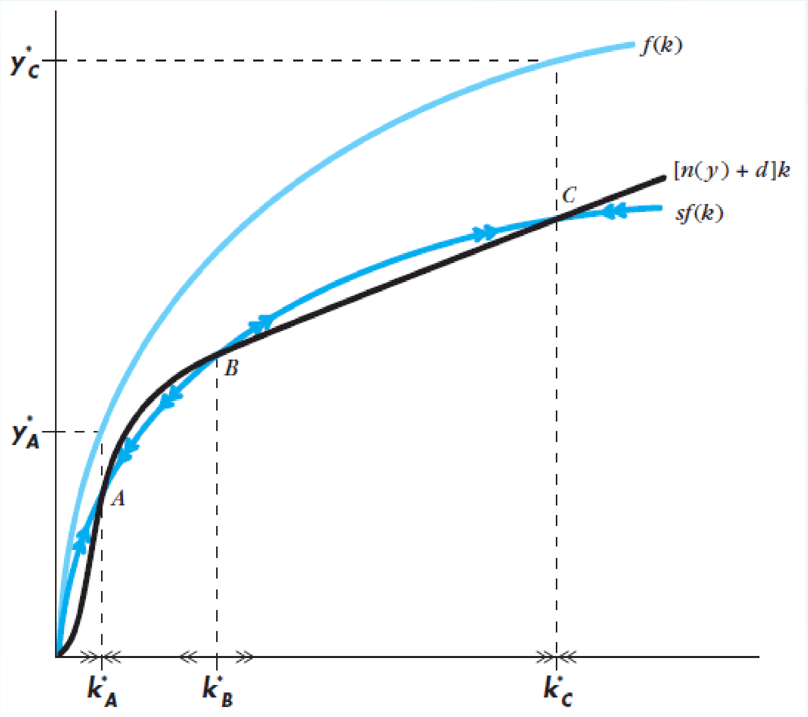

Truly Poor Countries

- Ghana, and many other countries, experienced very little growth in recent years
  - Income is so low that most of the population lives on the border of subsistence
- Can the Solow growth model explain these countries' experiences? <u>YES</u>
  - Savings in Ghana is quite low (9.3% of GDP vs. 34.3% and 19.4% of GDP in Japan and the US respectively)
  - Population growth is very high in Ghana and other poor countries relative to the US and Japan

→ *The effect of low savings rates and high population growth rates are as predicted by the Solow growth model: low levels of income and capital per capita*