Technological Progress and Growth
Intermediate Macroeconomics

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Outline

- Technological Progress and the Balanced Growth
- The Determinants of Technological Progress

Technological Progress and the Production Function

Capital accumulation cannot by itself sustain growth: sustained growth requires technological progress.

- ▶ Technological progress can lead to:
  - ▶ larger quantities of output for given quantities of capital and labor
  - ▶ better products
  - ▶ new products
  - ▶ a larger variety of products
- ▶ The state of technology (A) is a variable that tells us how much output can be produced from given amounts of capital and labor at any time:

$$Y = F(K, AN)$$

so AN is the amount of effective labor.

Investment and Required Investment

- With constant returns to scale and a given state of technology (A), if the amounts of capital and labor changes by x times, output changes by x times: $xY = F(xK, xAN)$

- If $x = 1/(AN)$, output per effective worker is a function of capital per effective worker: $\frac{Y}{AN} = F(\frac{K}{AN}, 1) \equiv f(\frac{K}{AN})$.
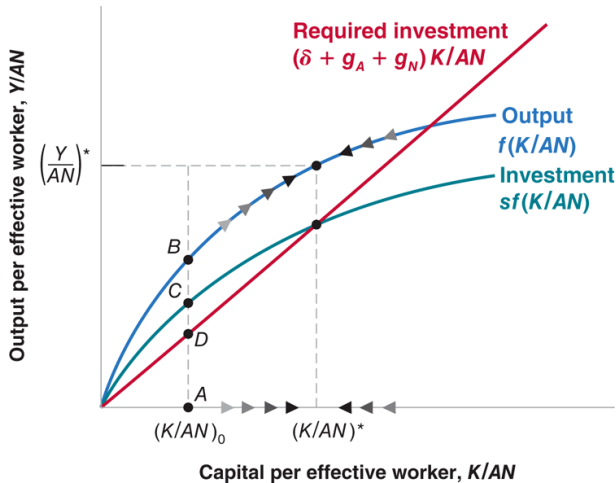
- Recall that $I_t = S_t = sY_t$, so

$$\frac{I_t}{A_t N_t} = sf(\frac{K_t}{A_t N_t})$$

- The level of investment needed to maintain a given(constant) level of capital per effective worker over time(required investment) is:

$$I_t = (\delta + g_A + g_N)K_t,$$

where δ is the capital depreciation rate, g_A is the rate of technological progress, and g_N is the rate of population growth.

Output v.s. Capital per Effective Worker

Steady-state and Balanced Growth

- The steady state of the economy is such that capital per effective worker and output per worker are constant, and equal to $(K/AN)^*$ and $(Y/AN)^*$, respectively.

- Because output, capital, and effective labor all grow at the same rate $(g_A + g_N)$ in steady state, the steady state of this economy is also called a state of **balanced growth**.

- In steady state, output and the two inputs, capital and effective labor, grow "in balance" at the same rate.

The Characteristics of Balanced Growth

		Growth Rate
1	Capital per effective worker	0
2	Ouput per effective worker	0
3	Capital per worker	g_A
4	Ouput per worker	g_A
5	Labor	g_N
6	Capital	$g_A + g_N$
7	Output	$g_A + g_N$

Table: The Characteristics of Balanced Growth

Back to The Effects of the Saving Rate

- saving rate does not affect the growth rate of output.
- saving rate affects the level of output per effective worker.
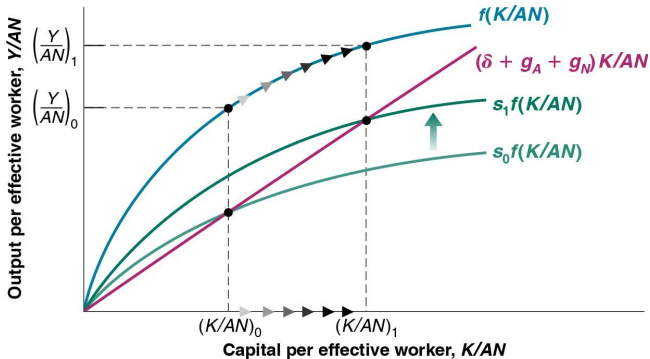
The Determinants of Technological Progress

- Most technological progress is the outcome of firms research and development ($R\&D$) activities.

- The level of $R\&D$ spending depends not only on the fertility of research (how spending on $R\&D$ translates into new ideas and new products) but also on the appropriability of research results (the extent to which firms can benefit from the results of their own $R\&D$).

- Patents give a firm that has discovered a new product the right to exclude anyone else from the production or use of that new product for some time.

Growth through Innovation v.s. Imitation

- To sustain growth, advanced countries that are at the technology frontier must innovate.
- Innovation requires substantial spending on $R\&D$. Immitation is achieved by importing and adapting existing technologies.
- The difference between innovation and imitation explains why countries that are less technologically advanced often have poor patent protection.

Why not all Countries Immitate?

- Institution matters! Most importantly, the protention of property rights. There is a strong positive relation between the degree of protection from expropriation and the level of GDP per person. This highlights the importance of the protection of property rights.
- In practice, it means
  - good political system
  - good judical system