


The theory of economic growth

The economy in the long run


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The long run

- In the long run what dominates is not fluctuations but growth in output per capita.
- Most countries exhibit an upward trend in output per capita. The growth rate of output per capita is almost always positive.
- What is the role of capital accumulation and technological progress in explaining long-run growth?

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The dynamic interaction between output and capital

- Output per worker in the long run depends on two relationships that determine the evolution of output and capital over time.
- Production function: from capital to output.
- Capital accumulation equation: from output to capital.

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The production function

- Output per worker depends on capital per worker. Assuming constancy of employed labour the production function is written as

$$\frac{Y_t}{N} = f\left(\frac{K_t}{N}\right)$$

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The production function

- Starting with the standard production and assuming constant returns to scale we get

$$\frac{Y}{N} = F\left(\frac{K}{N}, \frac{N}{N}\right) = F\left(\frac{K}{N}, 1\right) = f\left(\frac{K}{N}\right)$$

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Capital accumulation

- The effect of output on capital is captured through investment. In a closed economy investment must be equal to saving.
- Suppose that private saving is a constant proportion of output. Investment is given by

$$I_t = sY_t$$

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Capital accumulation

- Investment contributes to increasing the stock of capital of the economy. At the same time, the existing stock of capital depreciates over time. Hence,

$$K_{t+1} - K_t = I_t - \delta K_t$$

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Capital accumulation

- Dividing by employed labour and substituting for investment, the capital accumulation equation is given by

$$\frac{K_{t+1}}{N} - \frac{K_t}{N} = s \frac{Y_t}{N} - \delta \frac{K_t}{N}$$

- The capital accumulation equation relates output to capital.

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Capital and output per worker

- Combining both the production function and the capital accumulation equation leads to

$$\frac{K_{t+1}}{N} - \frac{K_t}{N} = sf\left(\frac{K_t}{N}\right) - \delta \frac{K_t}{N}$$

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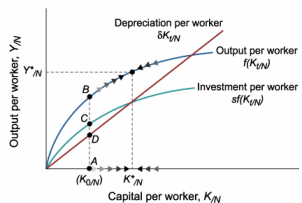
Capital and output per worker

- Capital per worker increases when investment per worker exceeds depreciation per worker. Output per worker increases accordingly.
- Capital per worker decreases when investment per worker is lower than depreciation per worker. Output per worker decreases accordingly.
- Capital per worker is constant when investment per worker is equal to depreciation per worker. Output per worker is constant.

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Capital and output per worker



$$\frac{K_{t+1}}{N} - \frac{K_t}{N} = s f\left(\frac{K_t}{N}\right) - \delta \frac{K_t}{N}$$

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Convergence?

- Suppose that a group of countries have the same long-run level of output per worker. Is there convergence? Yes!
- The countries that start with low levels of capital per worker must grow faster than countries with high levels of capital per worker for them to reach the same long-run level of output per worker.
- If countries are very different they will have different long-run levels of output per worker and convergence does not obtain!

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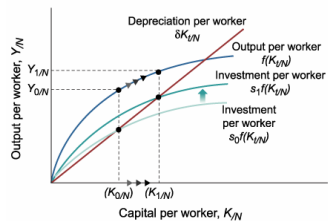
A higher saving rate

- Suppose that the saving rate increases. The investment schedule shifts upwards. This will lead to a higher capital stock per worker and thus, to higher output per worker.
- Output per worker grows during the process of adjustment. However (!), a higher saving rate has no effect on the long-run growth rate of output per worker, which is equal to zero.

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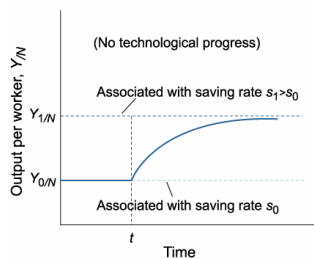
A higher saving rate



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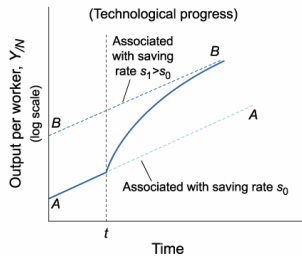


Without technological progress



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With technological progress



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Consumption per worker

- What is the saving rate that will bring the maximum level of consumption per worker in the economy?
- For a given level of output an increase in saving means lower consumption in the short run.
- What about the long run?

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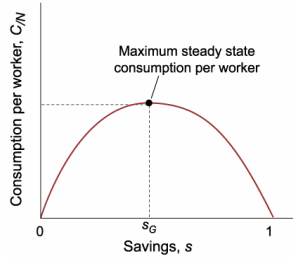
Consumption per worker

- Two extremes!
- A zero saving rate? Capital per worker and output per worker are both zero. So consumption per worker is zero!
- A unit saving rate? Capital per worker and output per worker are both large. But all output per worker is saved, so consumption per worker is zero.
- An intermediate saving rate is likely to maximise consumption per worker in the long run!

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Consumption per worker



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Consumption per worker

- For saving rates below s_G an increase in the saving rate will increase consumption in the long run.
- For saving rates above s_G an increase in the saving rate will reduce consumption in the long run.
- Empirical evidence suggests that most OECD countries could achieve higher consumption in the long run by saving more...

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Physical and human capital

- The set of skills of workers in the economy is called human capital.
- An economy with many skilled workers is likely to be much more productive than an economy in which most workers cannot read or write.
- The conclusions drawn about physical capital accumulation remain valid after the introduction of human capital in the analysis.

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The production function

- Extending the production function to allow for human capital:

$$\frac{Y}{N} = f\left(\frac{K}{N}, \frac{H}{N}\right)$$

- Higher capital per worker and higher skills per worker lead to higher output per worker.

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Measuring skills per worker

- Suppose an economy with 100 workers, half of them skilled and half of them unskilled. Suppose also that the wage of skilled workers is twice the wage of unskilled workers. Then,

$$H = (50 \times 1) + (50 \times 2) = 150 \Rightarrow \frac{H}{N} = \frac{150}{100} = 1.5$$

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Human capital and output

- An increase in how much society "saves" in the form of human capital – through education and on-the-job training – increases the long-run level of human capital per worker, leading to higher output per worker.
- In the long run, output per worker depends not only on the saving rate and but also on how much society spends on education.

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Technological progress

- Technological progress in modern economies is the result of firms' research and development (R&D) activities. The outcome of R&D is ideas.
- Spending on R&D depends on 1) the **fertility** of the research process, or how spending on R&D translates into new ideas and new products, and 2) the **appropriability** of research results, or the extent to which firms benefit from the results of their R&D.

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Fertility of research

The determinants of fertility include:

- the interaction between basic research (the search for general principles and results) and applied research (the application of results to specific uses),
- the country; some countries are more successful at basic research, other are more successful at applied research and development,
- time; it takes many years (decades) for the full potential of major discoveries to realize.

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Appropriability of research

- If firms cannot appropriate the profits from the development of new products, they will not engage into R&D.
- Nature of the research process? Is there a payoff in being first to develop a new product?
- Legal protection? Patents give firms that have discovered a new product the right to exclude anyone else from the production or use of the new product for a given period of time.

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Revisiting the facts of growth

- There are three main stylized facts.
- Sustained economic growth.
- A slowdown in growth starting in the mid-1970s.
- Convergence among specific countries.

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Sources of growth

Fast growth may come from two sources:

- A higher rate of technological progress allows for better use of existing resources.
- Capital accumulation means more resources per worker.

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Sources of growth

Table 12-2 Average Annual Rates of Growth of Output per Capita and of Technological Progress in Five Rich Countries, 1950-2000

	Rate of Growth of Output per Worker (%)			Rate of Technological Progress (%)		
	1950-1973 (1)	1973-2000 (2)	Change (3)	1950-1973 (4)	1973-2000 (5)	Change (6)
France	4.8	2.1	-2.7	5.3	1.6	-3.7
Japan	7.1	2.1	-5.0	7.0	1.4	-5.6
United Kingdom	3.4	1.7	-1.7	3.7	1.9	-1.8
United States	2.7	1.2	-1.5	2.9	1.4	-1.5
Average	4.5	1.8	-2.7	4.7	1.6	-3.1

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Facts of growth again...

- The period of high growth of output per capita from 1950 to 1973 was due to technological progress, not to unusually high capital accumulation.
- The slowdown in the growth of output per capita since 1973 has come from lower technological progress.
- Convergence of output per capita across countries arises from higher technological progress also, rather than from faster capital accumulation.

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Technological progress

- Why did technological progress slow down in the mid-1970s? The truth is that despite a large amount of research, this slowdown remain largely unexplained.
- One hypothesis is that there was a general decline in R&D... Another hypothesis is that the decline was not in the amount but rather in the fertility of R&D!

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Growth and institutions

- There seems to be a strong relationship between the degree of protection from expropriation and the level of output per capita.

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