Macroeconomics Lecture 5

SGPE Summer School

Mengdi Song

August 10, 2017

Table of contents

Recap

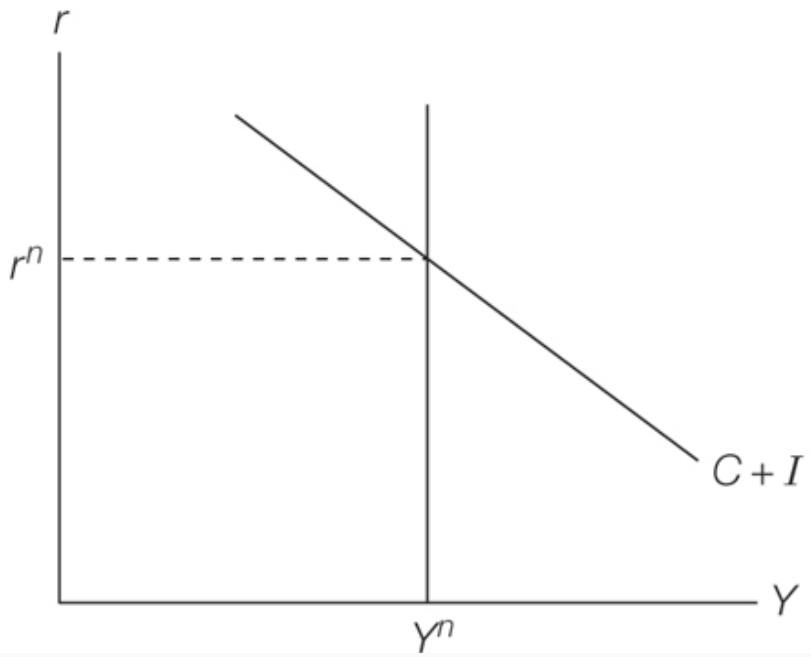
Recap

The natural levels of production and interest rate.

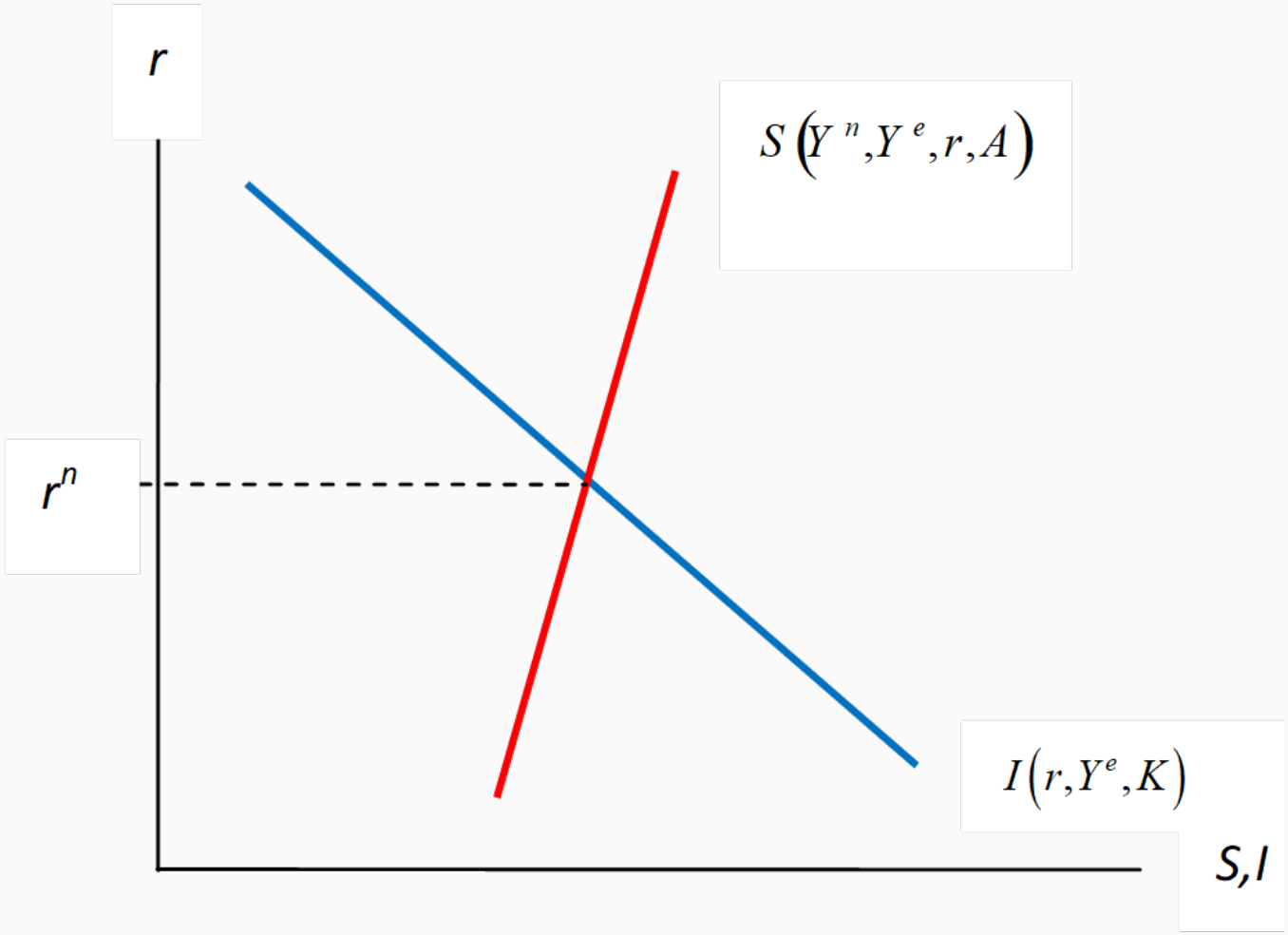
Supply $=$ Demand

The natural rate of interest for given K

Fig. 4.7 *Aggregate demand, long-run aggregate supply, and the natural rate of interest*



The natural rate of interest for given K



Growth

Question:

- What factors determine the capital stock, production and the real interest rate in the very long run?

Two cases:

- Constant population and technology
- Constant population growth and technical development

Constant population and technology

- Optimal capital stock $\frac{MPK}{1+\mu} - \delta = r$
- Euler Equation $\frac{u'(c_t)}{u'(c_{t+1})} = \frac{1+r}{1+\rho}$
- In a closed economy, long-run equilibrium, without growth in population or technology, consumption must be constant, so we must have $r = \rho$

Constant population and technology

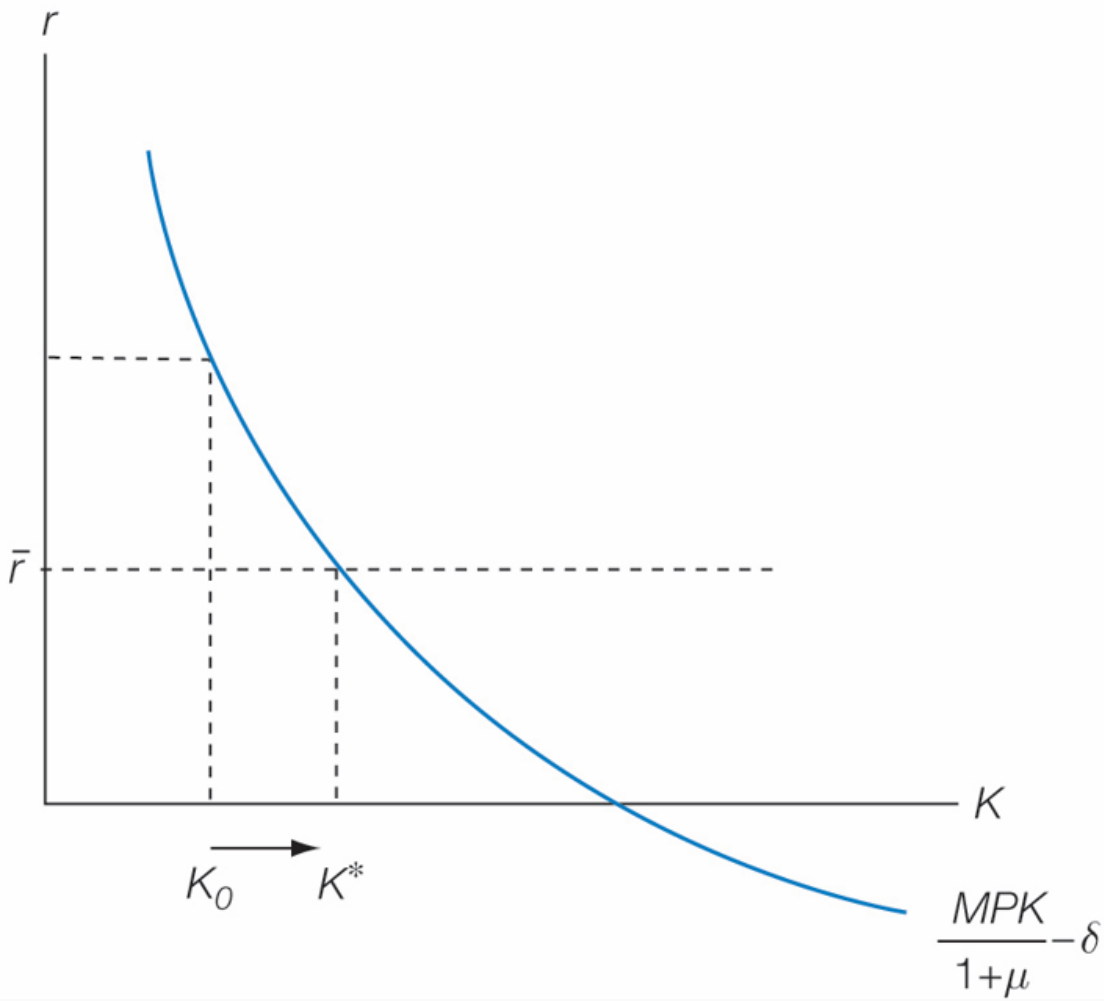
- Thus we have, in long-run equilibrium without growth in population or technology:

$$\frac{MPK}{1+\mu} - \delta = \rho \tag{1}$$

- We call K* that meets this criteria long-run equilibrium (steady state) level capital stock

Constant population and technology

Fig. 5.1 *The long-run adjustment of capital for constant population and technology*



Constant population and technology

What happens if we start with $K < K*$?

- MPK is high so companies want to invest and the real interest is high:
- With high real interest, consumers want to consume less today than in the future; they save and accumulate assets (= capital in a closed economy)
- The capital stock grows until it reaches equilibrium
- As the equilibrium level is reached, MPK falls and growth returns to zero

Constant population and technology

We can also illustrate the adjustment in the diagram with savings and investment.

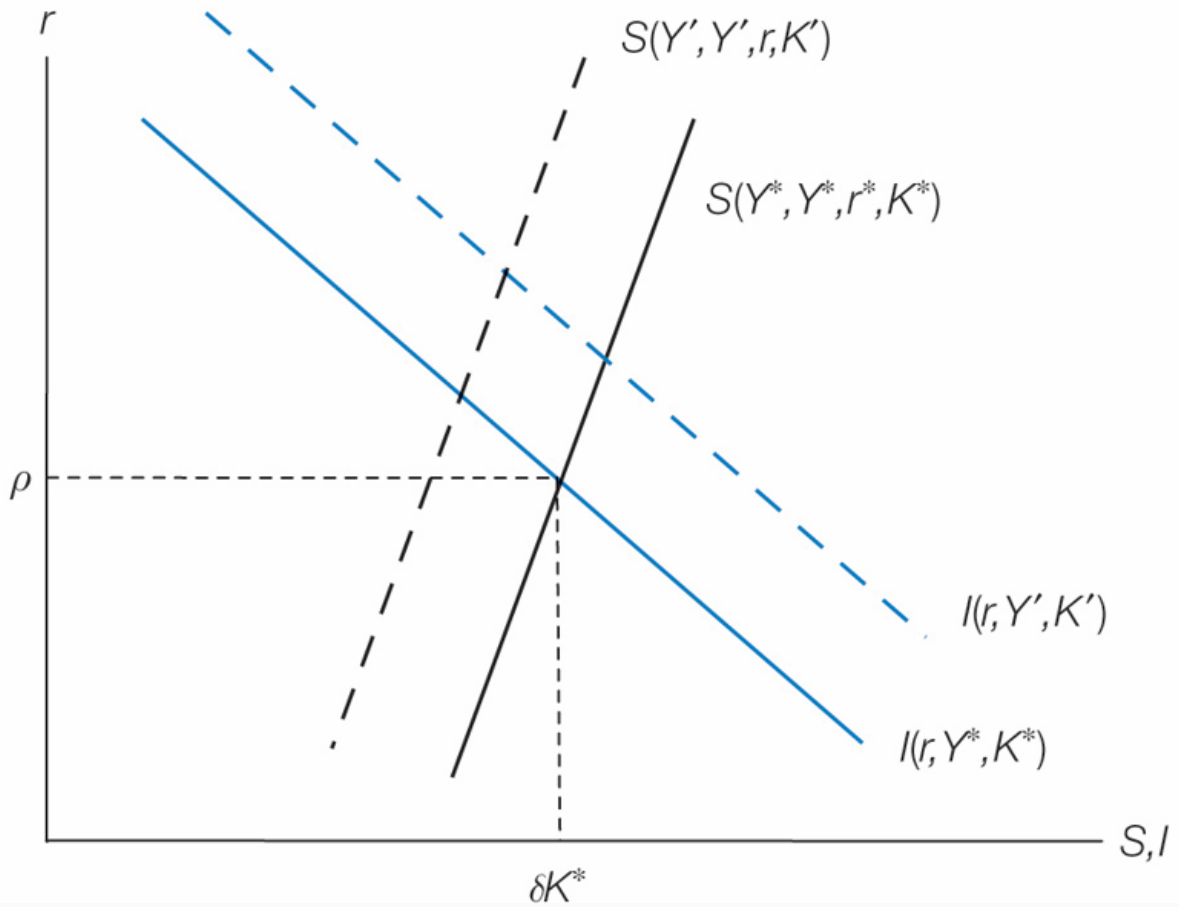
- In the long-run equilibrium (steady state):

$$S(Y*, Y, r, A) = I(r, Y*, K) \tag{2}$$

- If we start out with a lower capital K then investments are higher and income and savings are lower for a given real interest rate, so the real interest has to be higher

Constant population and technology

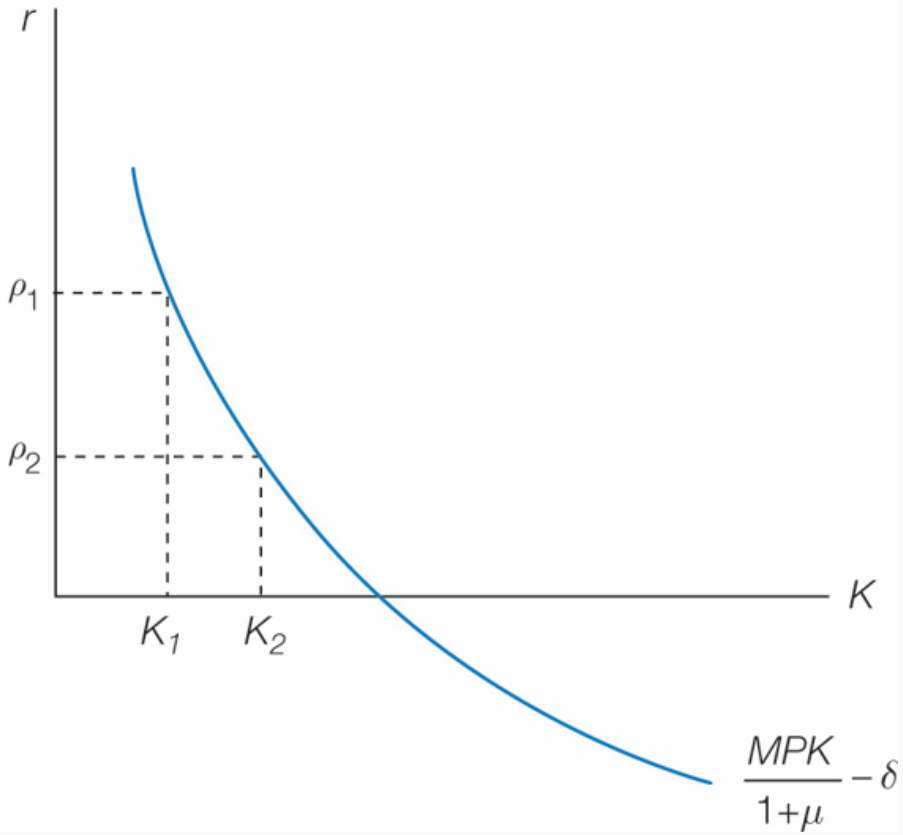
Fig. 5.2 *The effect of capital accumulation on investment, saving, and the real rate of interest*



Constant population and technology

What happens if the consumer starts to care more about the future (lower ρ)?

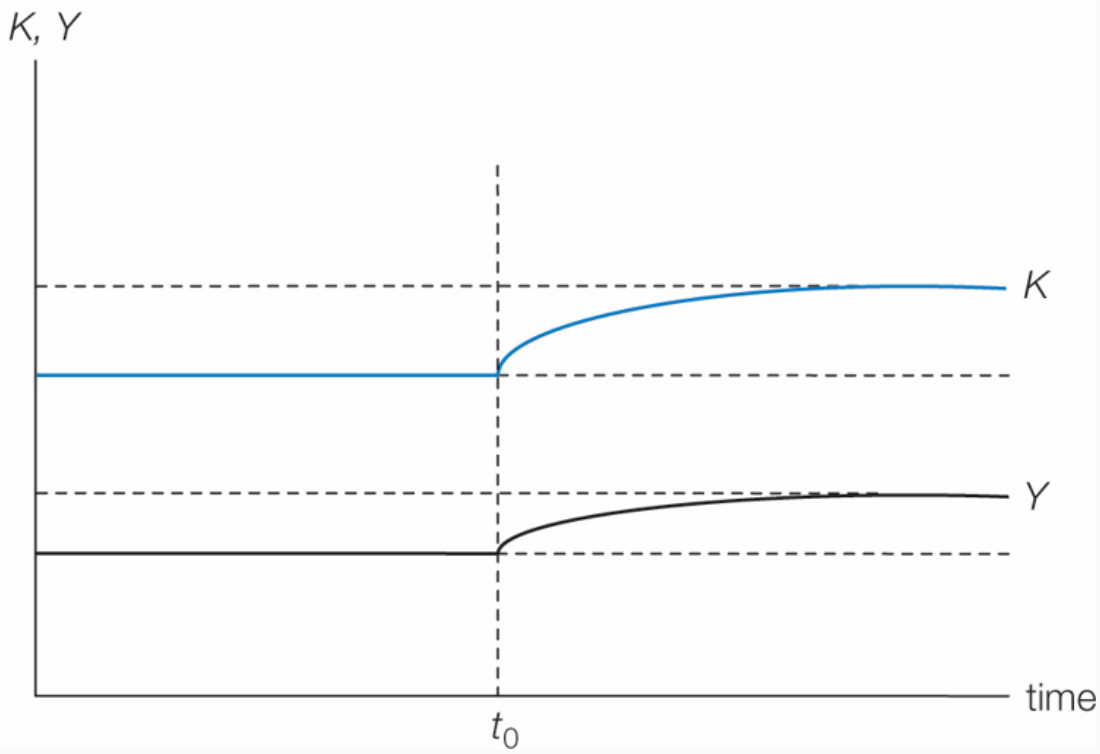
Fig. 5.3 *The long-run effect of a lower subjective discount rate*



Constant population and technology

What happens if the consumer starts to care more about the future (lower ρ)?

Fig. 5.4 *The effect of a decrease in the subjective discount rate at time* t_0



Constant population and technology

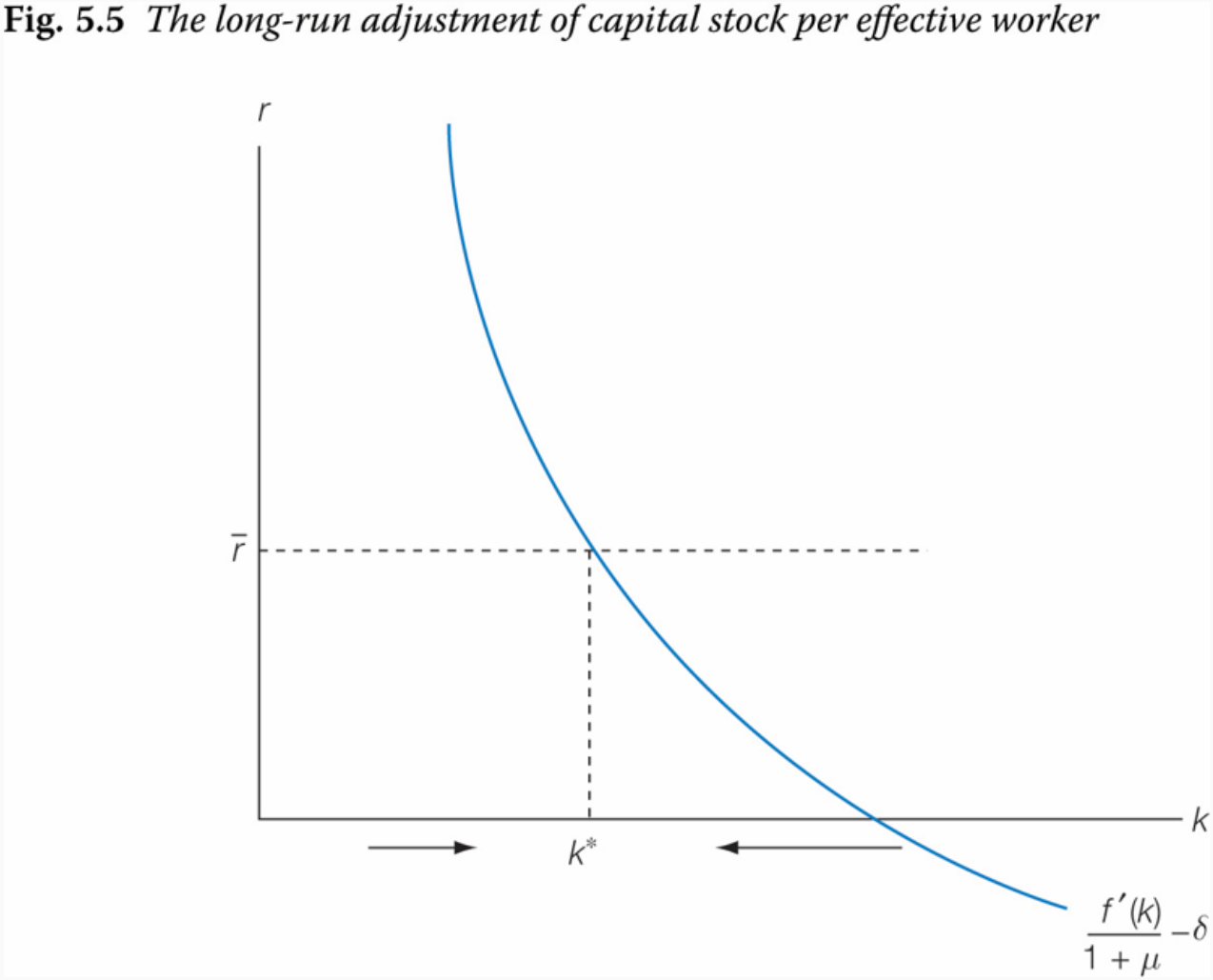
Convergence

- Under CRS, we can express the model in terms of capital and income per effective worker
- $K = k * EN$ and $Y = f(k) * EN$
- Condition for long run equilibrium $\frac{f'(k)}{1+\mu} - \delta = \rho$

Constant population and technology

Convergence

Fig. 5.5 *The long-run adjustment of capital stock per effective worker*



Constant population and technology

For given population and technology:

- The capital stock and production reach their long-run equilibrium levels over time
- In long-run equilibrium we have no growth
- If different countries have the same technology and same subjective discount rate, they will in the long run have the same real GDP per capita
- Convergence!

Population growth and technical development

- To explain growth in the very long run we have to have population growth and technical development.
- Assume that the population is growing and technology is improving at constant rates n and g

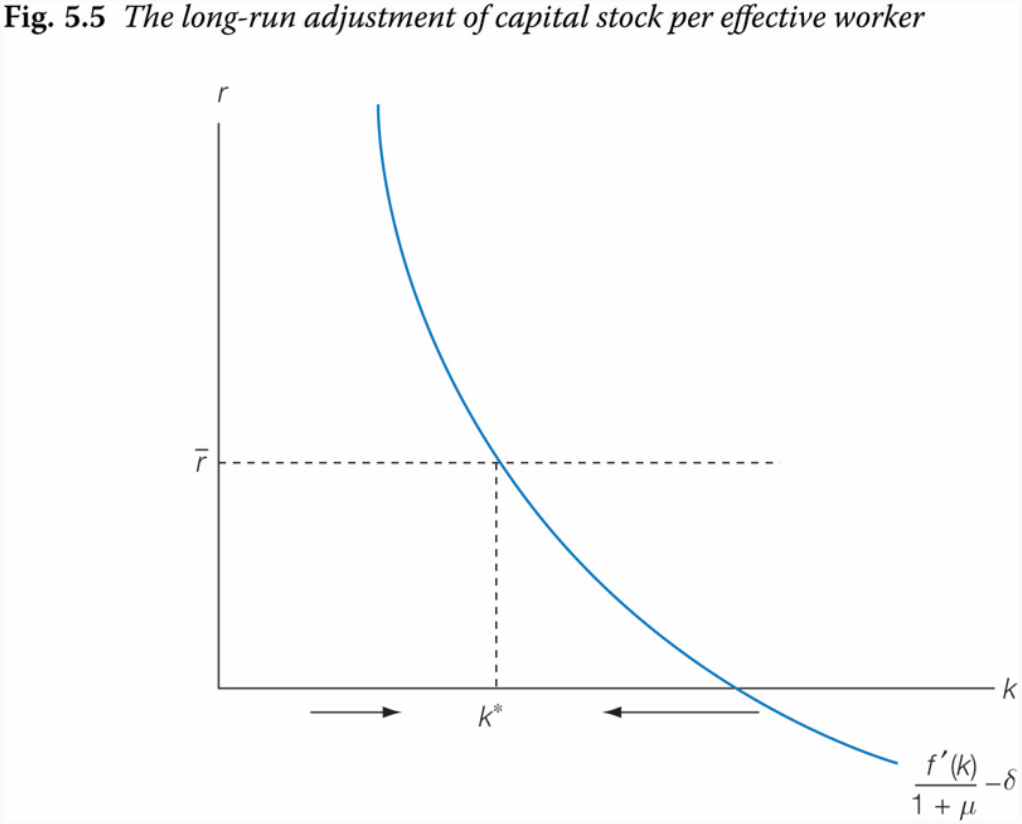
$$\frac{\Delta N}{N} = n \ , \ \frac{\Delta E}{E} = g$$

Population growth and technical development

Let us guess that real interest is constant on the long-term growth path:

The optimal capital stock per effective worker is determined by the same condition as before:

Fig. 5.5 *The long-run adjustment of capital stock per effective worker*



Population growth and technical development

What factors determine the real interest rate? To see this we assume a logarithmic utility function:

- $u(c_t) = ln(c_t)$
- By Euler equation $\frac{u'(c_t)}{u'(c_{t+1})} = \frac{c_{t+1}}{c_t} = \frac{1+r}{1+\rho}$
- Consumption grows at the same rate as output per labour
- $1 + g = \frac{1+r}{1+\rho}$
- $r = g + \rho$
- Real interest is determined by the subjective discount rate and the pace of technological development.

Population growth and technical development

In steady state:

$$\frac{K}{EN} = k^* \quad \Rightarrow \quad K = k^* EN \quad \Rightarrow \quad \frac{\Delta K}{K} = \frac{\Delta E}{E} + \frac{\Delta N}{N} = g + n$$

$$\frac{Y}{EN} = f\left(k^*\right) \quad \Rightarrow \quad Y = f\left(k^*\right) EN \quad \Rightarrow \quad \frac{\Delta Y}{Y} = \frac{\Delta E}{E} + \frac{\Delta N}{N} = g + n$$

- K/EN and Y/EN are constant
- K and Y grow at the rate g+n
- K/N and Y/N grow at the rate g

Population growth and technical development

Golden rule level of capital stocks

- Does a larger capital stock always mean more consumption?
- Which capital stock maximises consumption?
- $I = \Delta K + \delta K = (n + g)K + \delta K$
- $c = \frac{Y}{EN} - \frac{I}{EN} = f(k) - (n + g + \delta)k$
- $f'(k^{GR}) = n + g + \delta$

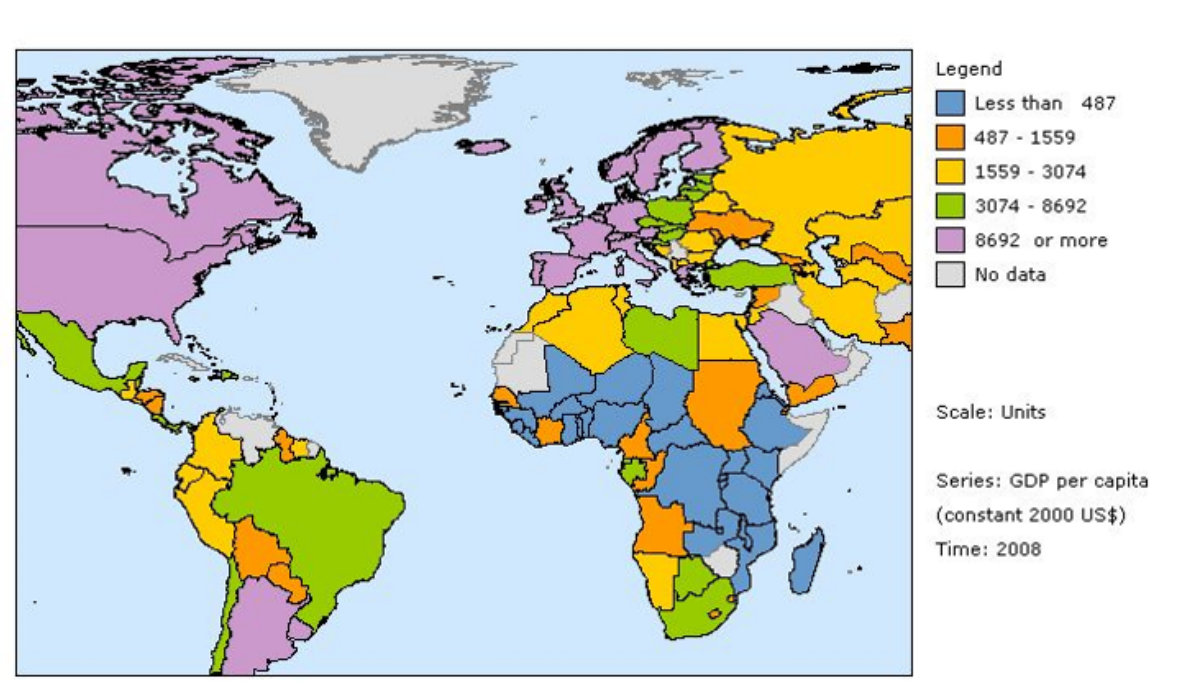
Population growth and technical development

Golden rule level of capital stocks

- $k^{GR} > k*$
- Consumption is not maximised in steady state.
- Why?
- Impatience!
- Higher savings would increase steady state consumption but consumers are not patient enough to do it

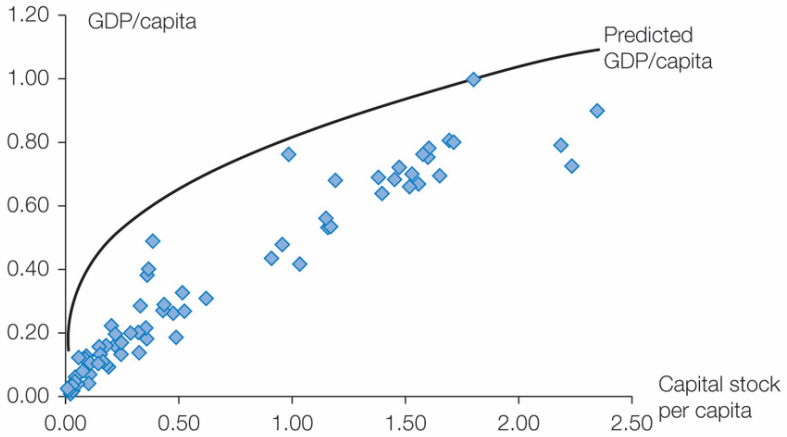
Income differences between countries

Why are some countries richer than others?



Why are some countries richer than others?

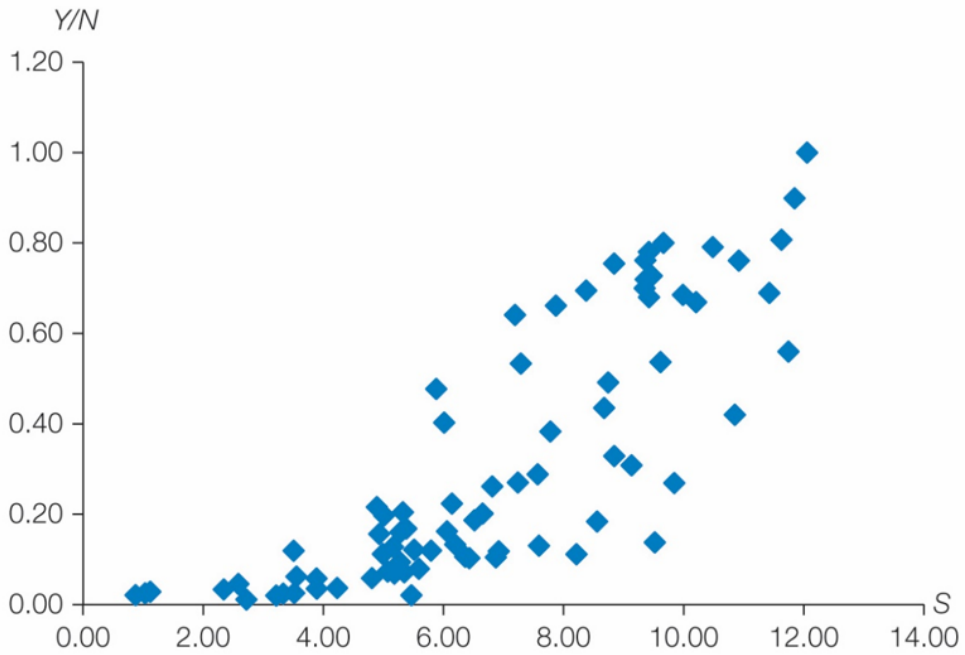
Fig. 5.7 *Capital stock and GDP per capita*



Note: GDP per capita in the US is set to 1.00. The curve shows predicted GDP per capita as a function of capital per capita with the technology factor set to match data for the US. The dots show actual data for different countries.
Sources: PWT 6.1, Alan Heston, Robert Summers, and Bettina Aten, Penn World Table Version 6.1, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, October 2002, and Chang.-Tai Hsieh and Peter J. Klenow, 'Development accounting', *American Economic Journal: Macroeconomics*, 2 (2010), 207–223; and R. Barro and J-W. Lee, 2001, 'International data on educational attainment: updates and implications', *Oxford Economic Papers*, 53 (2001), 541–563.

Why are some countries richer than others?

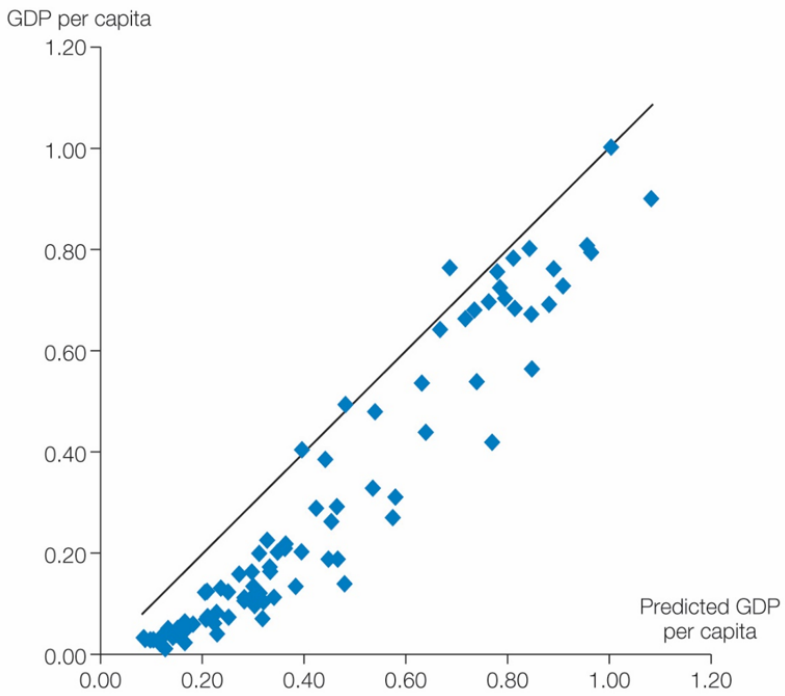
Fig. 5.8 *Schooling attainment and GDP per capita*



Sources: PWT 6.1, Alan Heston, Robert Summers, and Bettina Aten, Penn World Table Version 6.1, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, October 2002, and Chang.-Tai Hsieh and Peter J. Klenow, 'Development accounting', *American Economic Journal: Macroeconomics*, 2 (2010), 207–223; and R. Barro and J-W. Lee, 2001, 'International data on educational attainment: updates and implications', *Oxford Economic Papers*, 53 (2001), 541–563.

Why are some countries richer than others?

Fig. 5.9 *Predicted and actual GDP per capita based on capital and schooling*



Sources: PWT 6.1, Alan Heston, Robert Summers, and Bettina Aten, Penn World Table Version 6.1, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, October 2002, and Chang.-Tai Hsieh and Peter J. Klenow, 'Development accounting', *American Economic Journal: Macroeconomics*, 2 (2010), 207–223; and R. Barro and J-W. Lee, 2001, 'International data on educational attainment: updates and implications', *Oxford Economic Papers*, 53 (2001), 541–563.

Why are some countries richer than others?

- At most 50% of the income differences can be explained by differences in physical capital and schooling
- At least 50% of the differences in income must be explained by other factors than the differences in physical capital and schooling

Why are some countries richer than others?

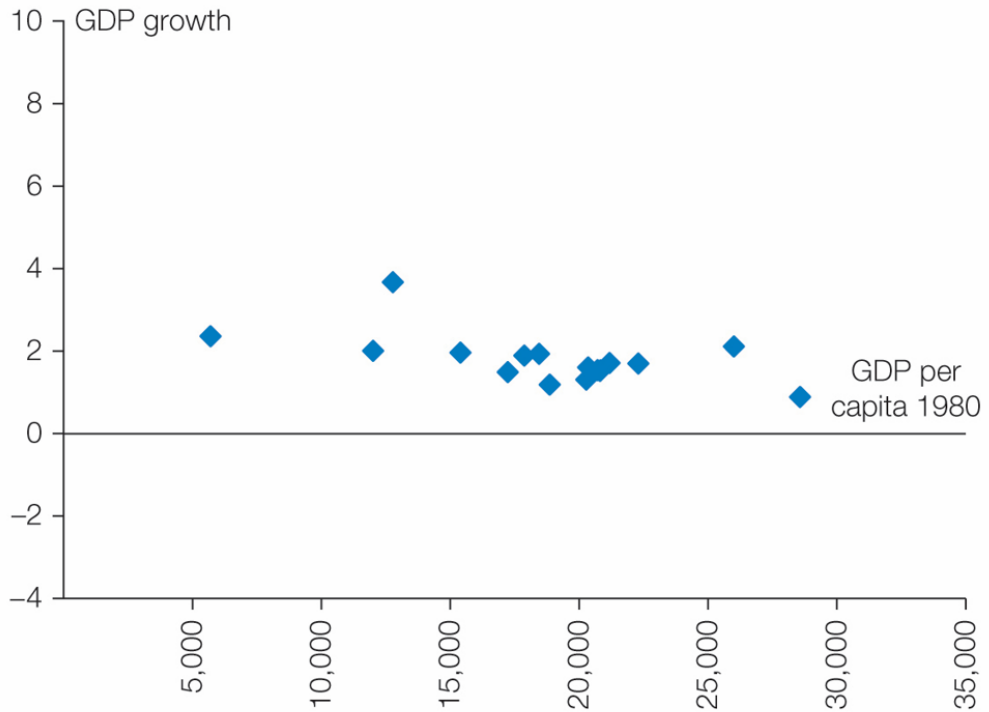
What other factors can explain differences in income?

- Technology
- Inadequate institutions
  - Corruption and lawlessness
  - Lack of competition
  - Poor public infrastructure
  - Taxes and regulations
  - Poorly functioning labour markets

Why are some countries richer than others?

Convergence?

Fig. 5.11 *GDP per capita in 1980 and growth 1980–2009, European market economies*

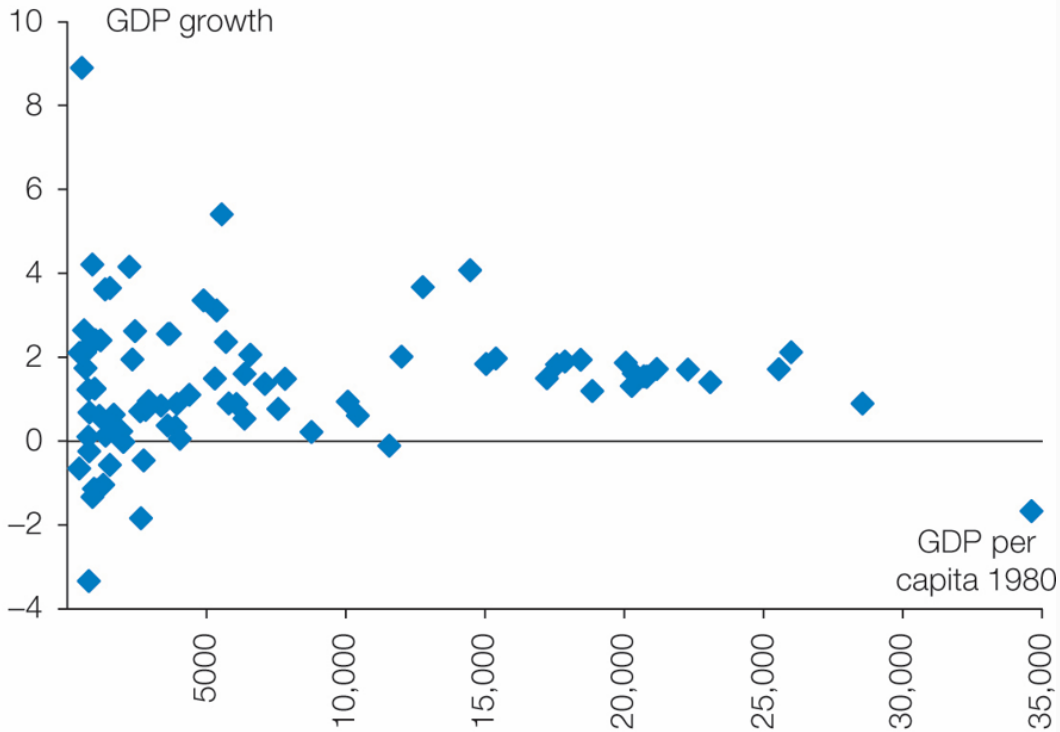


Note: GDP per capita, PPP (constant 2005 international $).
Source: World Bank, International Comparison Program database.

Why are some countries richer than others?

Convergence?

Fig. 5.15 *GDP per capita in 1980 and growth 1980–2009, all countries*



Note: GDP per capita, PPP (constant 2005 international $).
Source: World Bank, International Comparison Program database.

Why are some countries richer than others?

Does income per capita converge?

- Some convergence in Europe but no general convergence between rich and poor countries
- in rich countries, GDP per capita grows by about 2 per cent per year
- some poorer countries catch up, others fall behind