LSE EC1B5 Macroeconomics

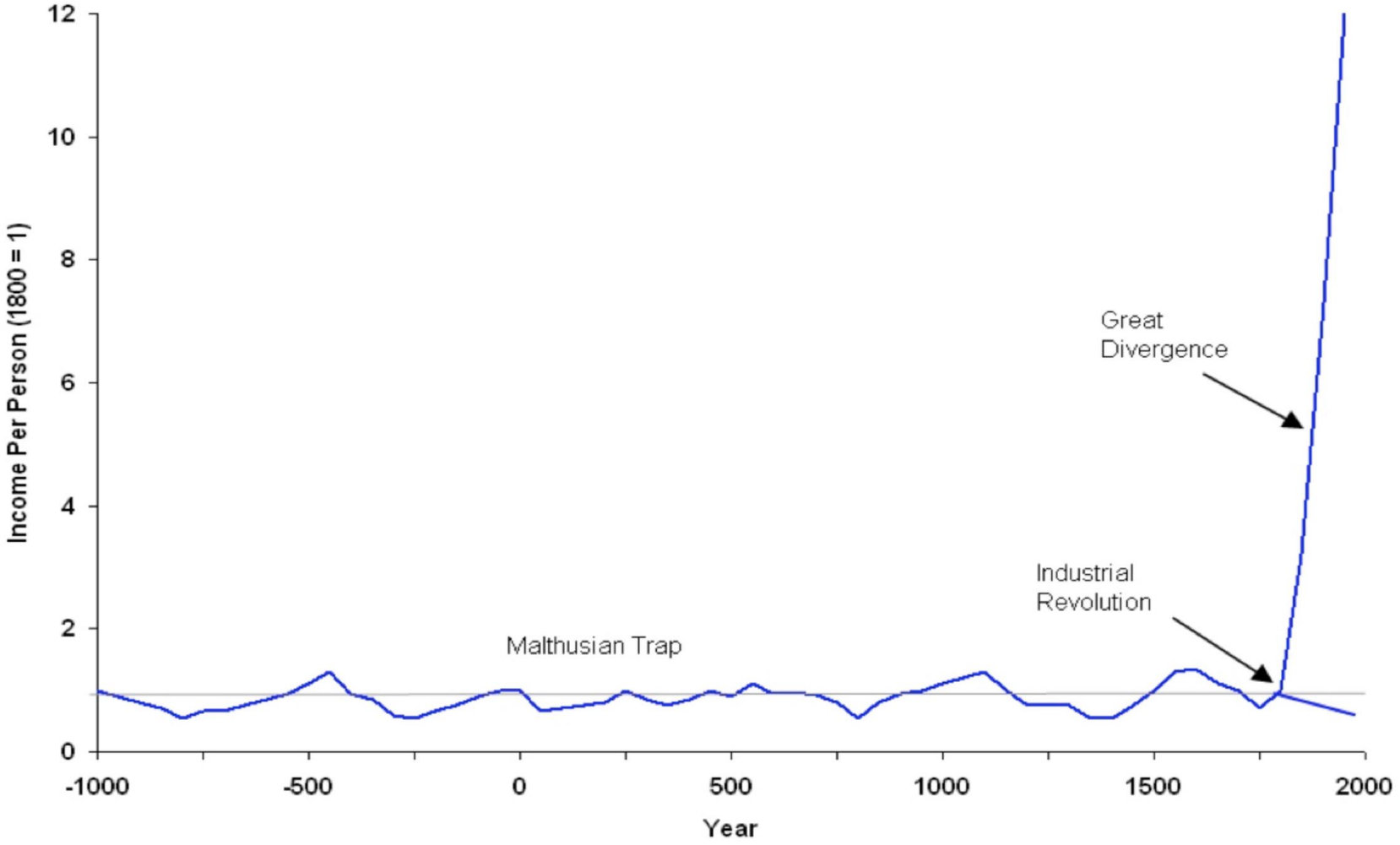
Handout 5

Malthus to Solow

Key Ideas

1. Malthusian Theory – population growth offsets growth in aggregate output, thus no sustained growth in output per capita
2. Solow Growth Model
   - capital accumulation as mechanism for growth in the short run.
   - Technological change as mechanism for growth in the long run.
3. Technological change leads to sustained growth in output per capita in the Solow model but not in the Malthusian Theory.

Growth over Millennia



Jeff Speakes, Economic History of the World

Malthusian Theory

- Thomas Malthus, writing in 1798, argued that humankind was destined to live at the subsistence level—the minimum level of income per person necessary to survive.
- According to the **Malthusian theory**, any increase in income per capita above the subsistence level would lead to higher fertility rates.

Malthusian Theory

- The higher fertility rates would fuel higher population growth, which in turn would drive income per capita back down to the subsistence level (because of limits of food supply)
- The Malthusian theory predicts that a technological advance will just increase population, with no long-run change in the standard of living, which is consistent with the data prior to the industrial revolution.

Pre-1800

- Malthus theory provides a good explanation for pre-1800 growth facts around the world. Before the industrial revolution,

➢ GDP per capita is roughly constant – stagnation

➢ population growth is increasing in living standards

➢ production was mainly agricultural where fixed factor such as land plays an important role

Modern Growth

- After the industrial revolution,
  - there is sustained growth in GDP per capita – modern economic growth
  - demographic transition (a decline in population growth rate)
  - structural transformation (from agricultural into industry and services) and urbanization (from rural to urban)

Malthus to Solow

What are missing in Malthusian Theory?

- Demographic Transition: The effects of technological advances on fertility – the opportunity cost of raising a large family and the role of human capital
- Industrial Revolution: Technological progress and the role of capital accumulation. In contrast to land, which is limited in supply, capital is reproducible.

The Solow Growth Model

The Solow Growth Model

- Robert Solow was awarded the Nobel Prize in 1987 mainly based on his paper on growth published in 1956 (>28,000 citations on Google Scholar)
- The Solow model allows for both capital accumulation and technological progress.
- For simplicity, we abstract from population or human capital growth so $H = L \times h = 1$.

The Three Building Blocks of the Solow Model

1. The aggregate production function—the first block of the Solow model—determines the level of real GDP:

$$Y = A \times F(K, H)$$

The Three Building Blocks of the Solow Model

2. An equation for physical capital accumulation:

$$K_{t+1} = (1 - d) \text{ x } K_t + I_t$$

where K is the stock of capital, d is the depreciation rate and I is the flow of new investment. The subscript t denotes the time.

The Three Building Blocks of the Solow Model

3. Saving by households:

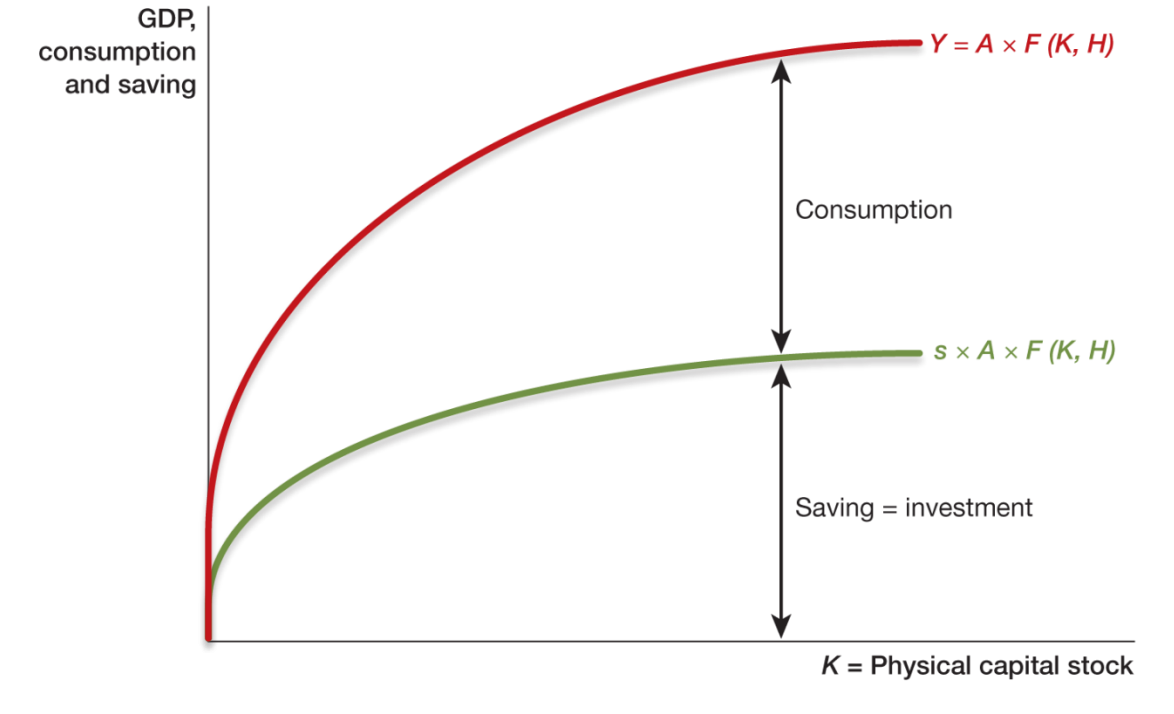
$$I = \text{saving} = s \times Y$$

$$I = s \times Y = s \times A \times F(K, H)$$

where s is the constant saving rate.

Aggregate Income and Aggregate Saving

Total output Y is divided between C and I:



Steady-State Equilibrium in the Solow Model

A steady-state equilibrium is when the physical capital stock remains constant over time:

$$K_{t+1} = K_t = K^*$$

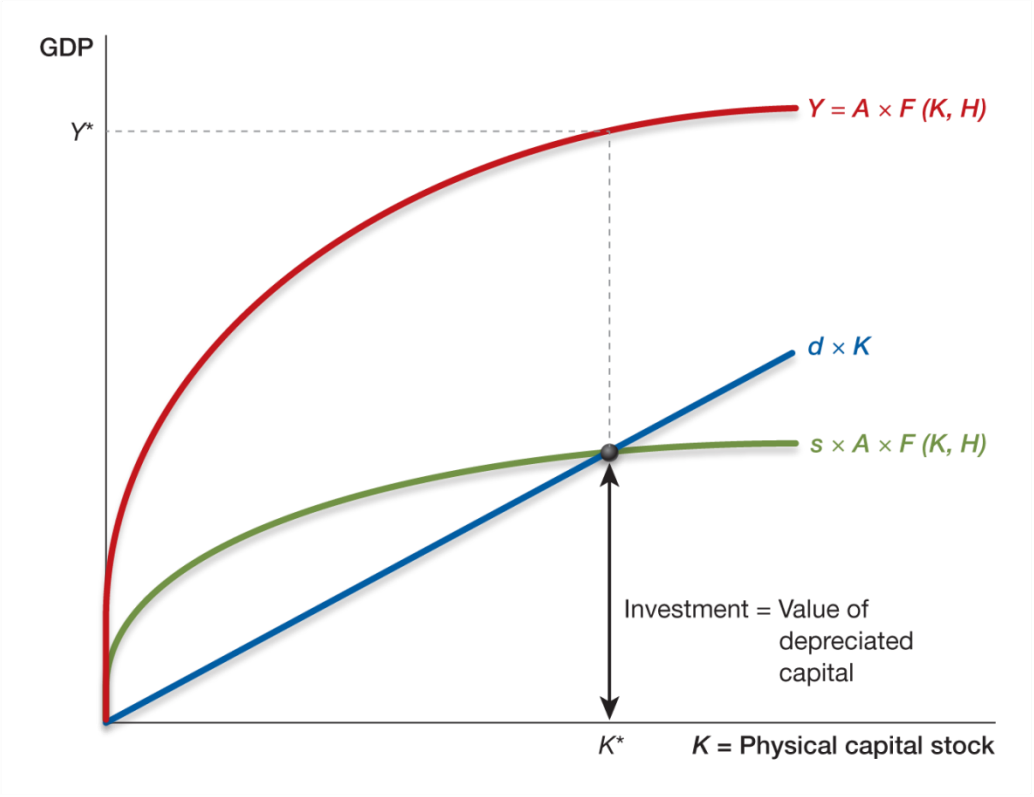
This occurs when

$$K^* = (1\text{-}d) \text{ x } K^* + I$$

which implies

$$d \text{ x } K^* = I = S = s \text{ x } A \text{ x } F(K^*,L)$$

Steady-State Equilibrium in the Solow Model



Steady-State Equilibrium in the Solow Model

- In the steady state with constant technology A, the capital stock K^* is constant so output Y is also constant.

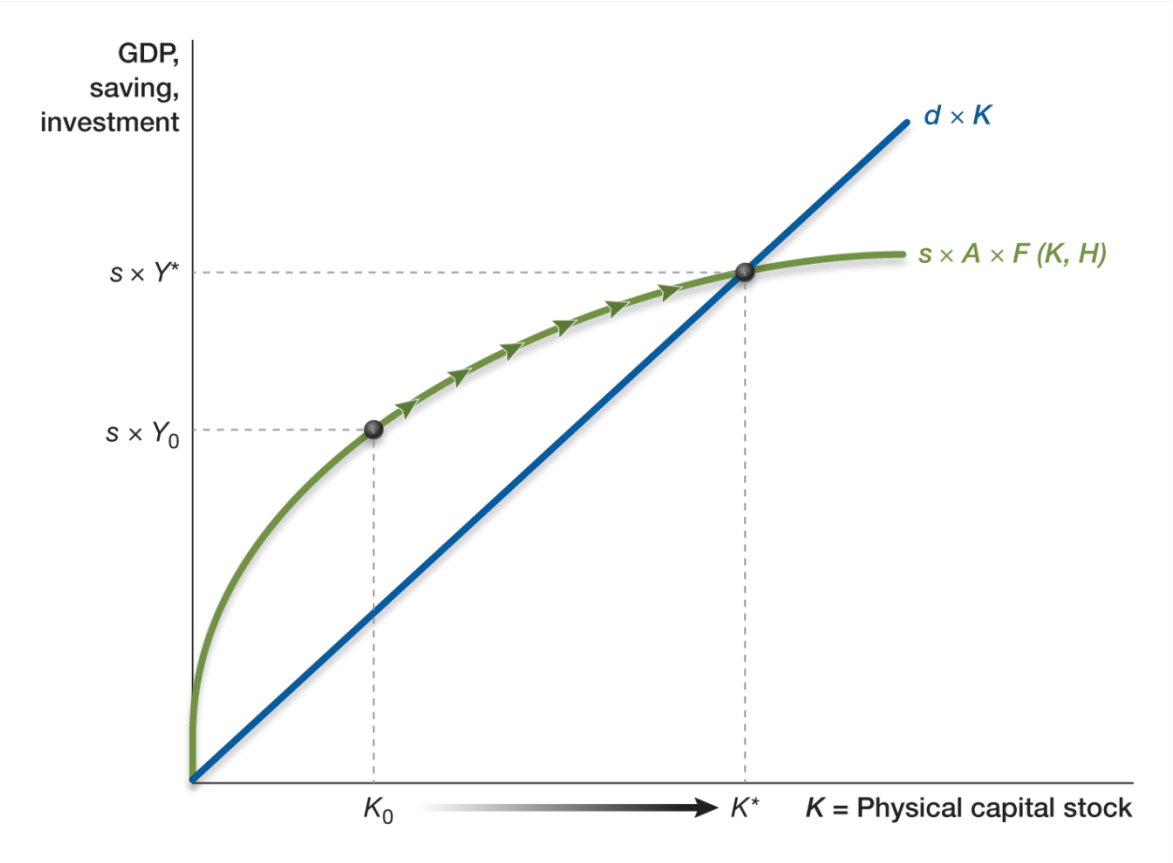
- Under the assumption of constant population,
  - Capital per capita is constant
  - Output per capita is constant

Dynamic Equilibrium in the Solow Model

A **dynamic equilibrium** traces the behavior of the economy over time.

Suppose the economy begins with a physical capital stock of $K_0 < K^*$.

Dynamic Equilibrium in the Solow Model

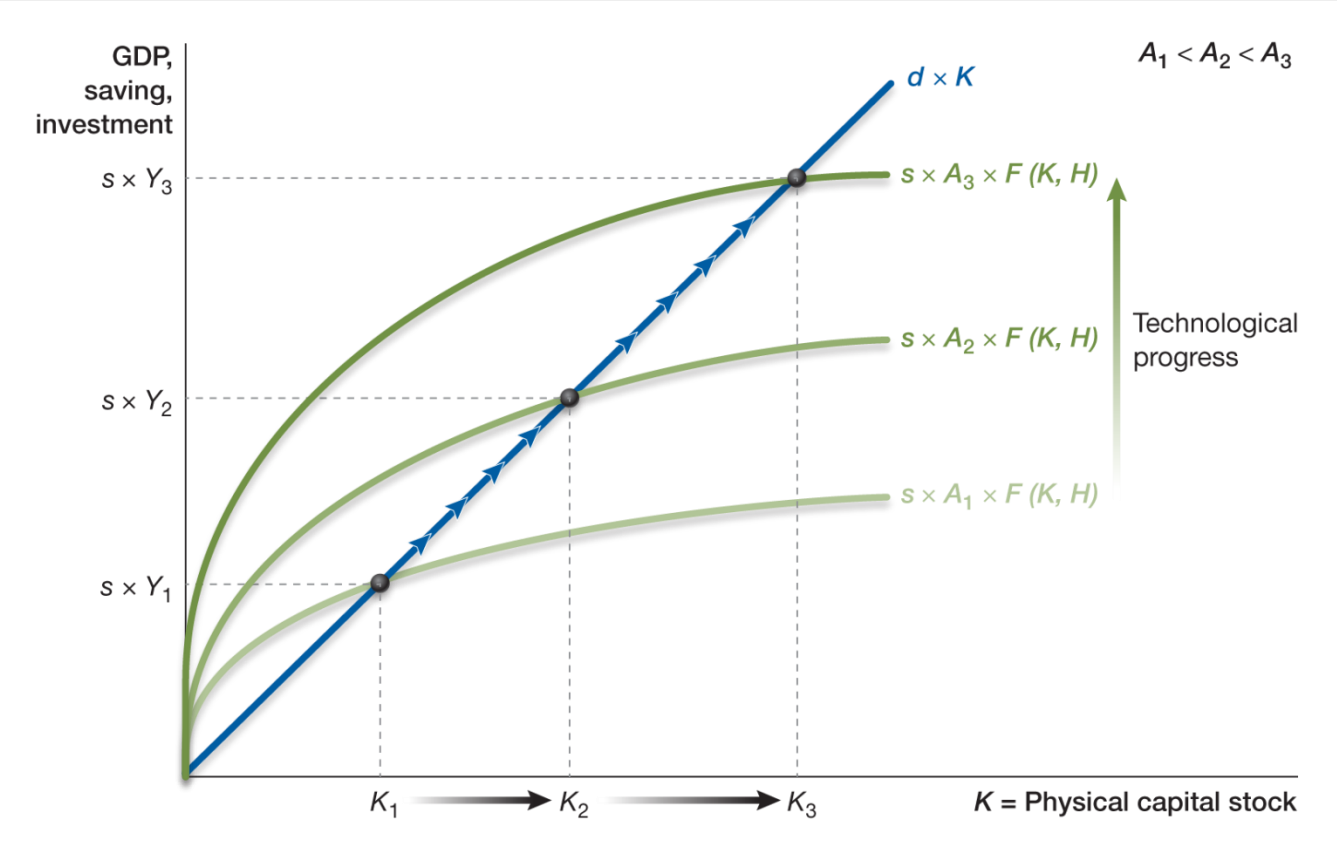


Economy grows from K_0 to reach the steady state K*

Convergence (Catch-up Growth)

- The Solow model predicts convergence (catch-up growth), i.e. countries that are further below the steady state grow faster than those that are closer to steady state.
- Convergence is driven by capital accumulation.
- Eventually, countries with the same saving rate and technology converge to the same steady state, i.e. catch-up growth is not a source of sustained growth in real GDP. (The growth miracle experienced by Asian Tigers during 1960-90)

Impact of Technological Change

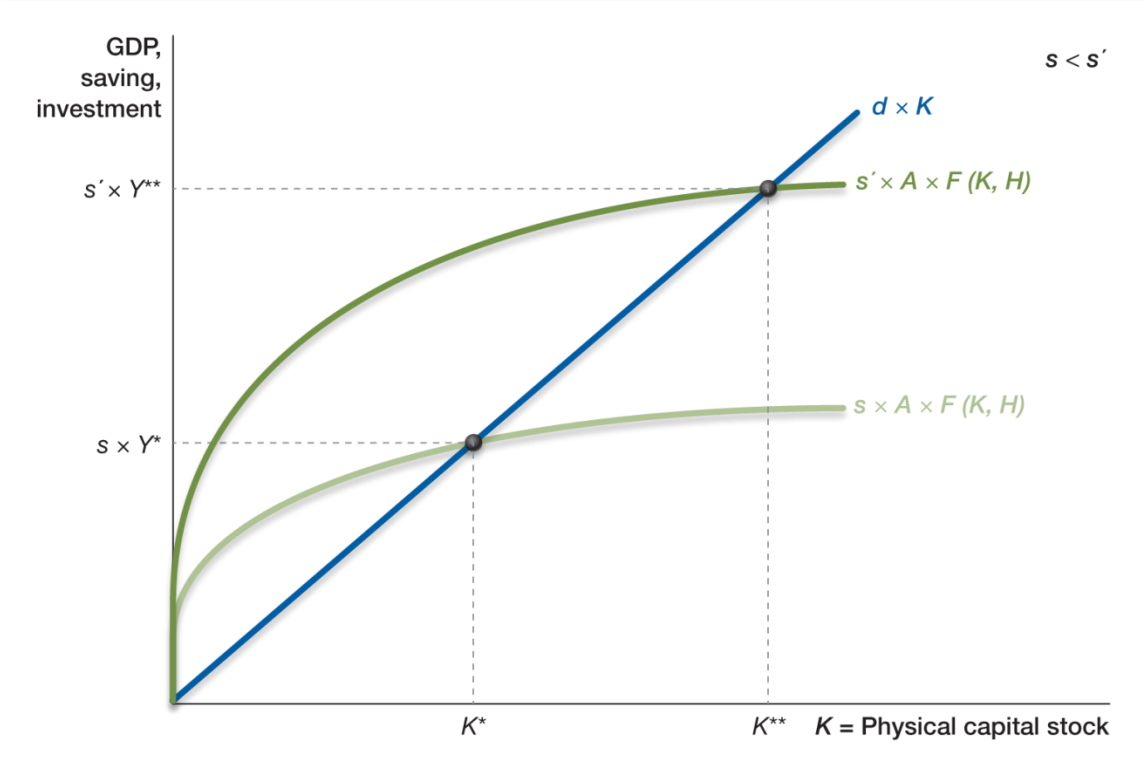


Growth in A drives growth in steady state K*

Sources of Growth in the Solow Model

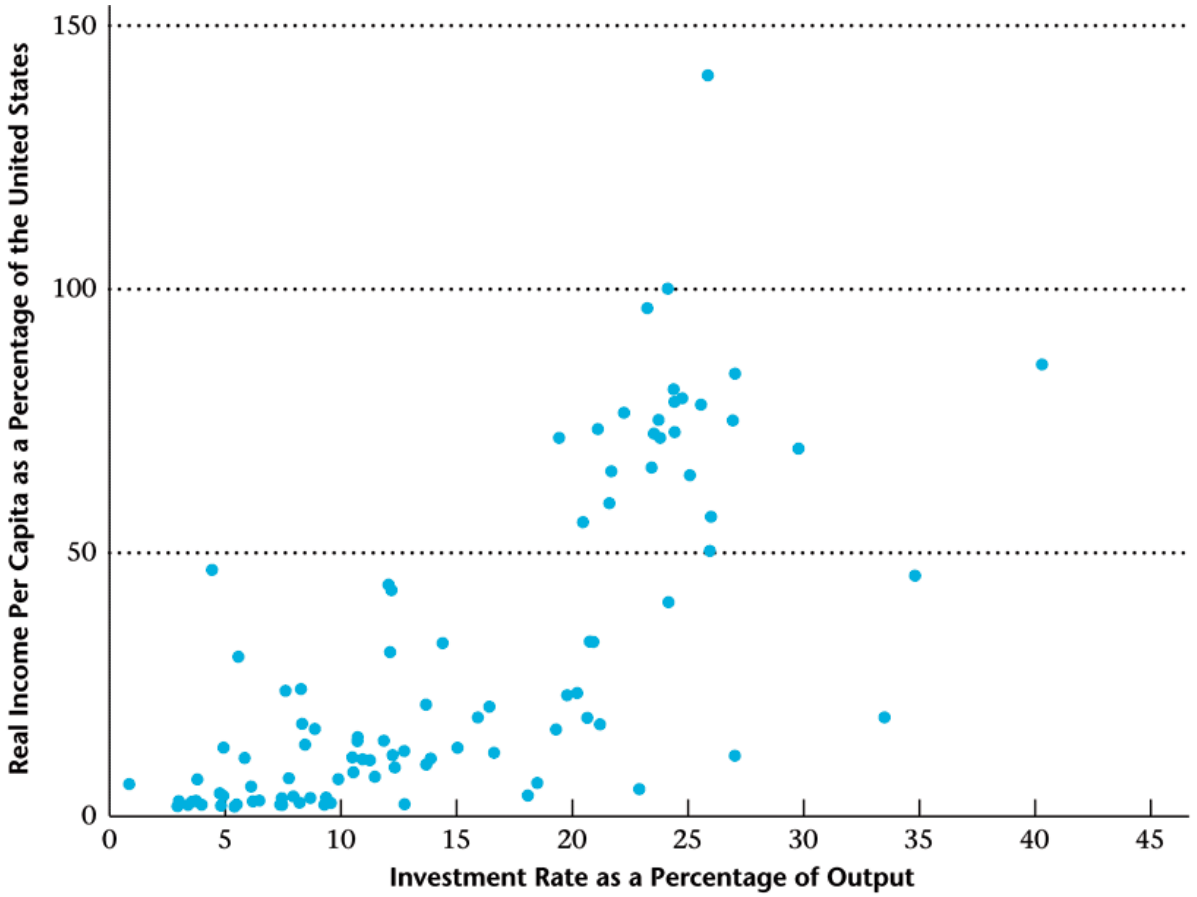
1. Capital accumulation – generates growth in the short run but not in the long run when the economy reach the steady state (due to diminishing marginal product of capital)
2. Technological progress – generates growth in the long run because it increase the steady state capital per capita. It is a source of sustained growth in real GDP.

The Impact of the Saving Rate



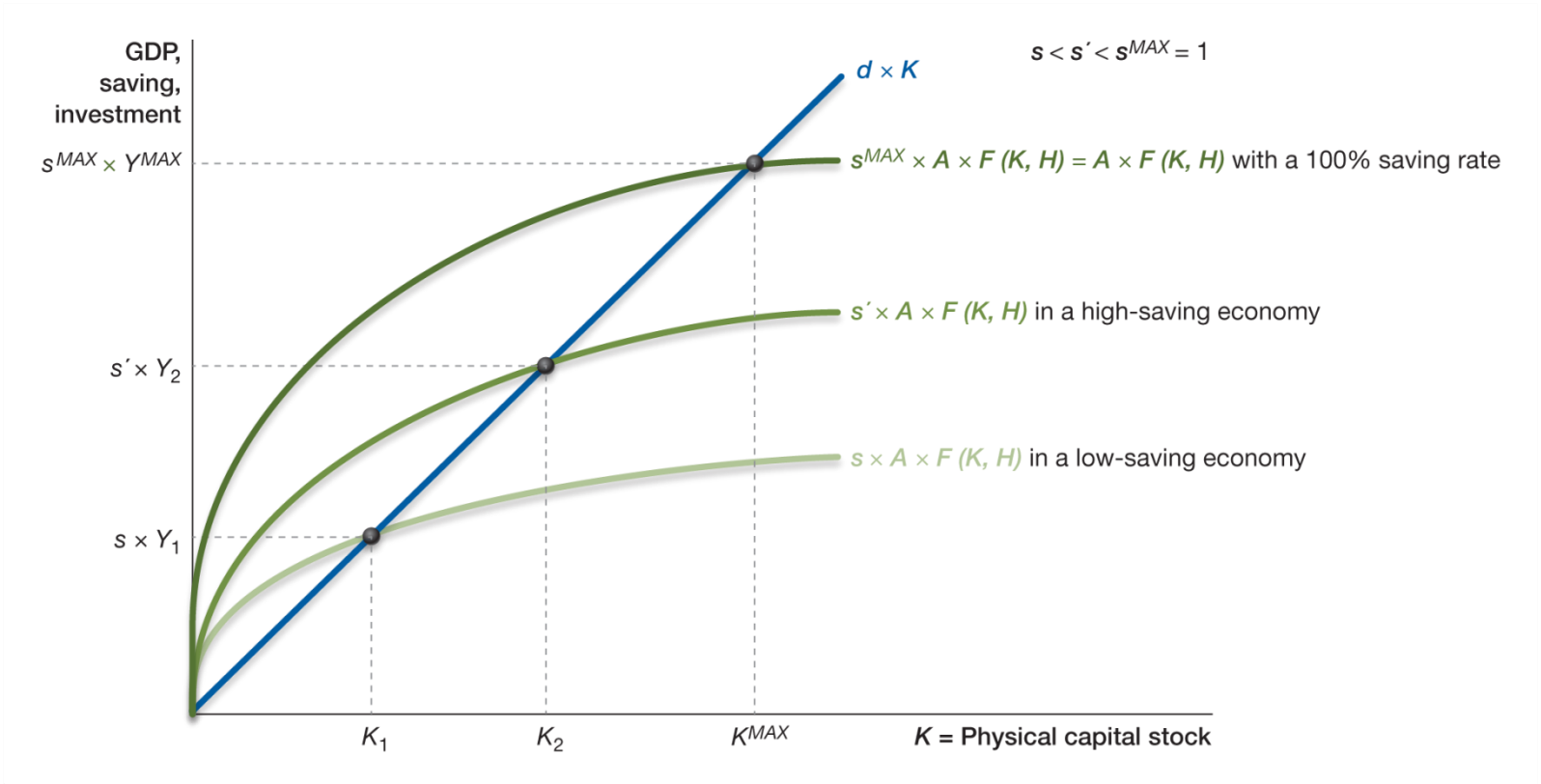
Increases in saving shift the investment curve up and leads to a higher steady state

Investment (Saving) Rate and GDP per capita



Source: A. Heston, R. Summers, and B. Aten, *Penn World Table Version 6.1*, Center for International Comparisons at the University of Pennsylvania (CICUP), October 18, 2002, available at pwt.econ.upenn.edu.

Increases in the Saving Rate is not a source of sustained growth!



Is Increasing the Saving Rate Always a Good Idea?

- Higher saving rate leads to higher steady state income, does it mean a higher saving rate is always better?
- Not necessary for the objective of improving living standard as there is a trade-off.
  - Higher saving rate increase total output but
  - It reduces the consumption share of output
- There is an optimal level of saving rate s*. Any s above s* implies a lower consumption, i.e. a lower living standard.

“Malthus to Solow” and “Stagnation to Modern Growth”

Different response to technological change:

- In the Malthusian theory, it increases output and consumption at first, but higher living standard quickly leads to a rise in population leaving output per capita constant – stagnation.
- In the Solow Model, it increases output, consumption and investment, which increases future capital stock, thus future output. The process continues and leads to a sustained growth in living standard – modern growth.