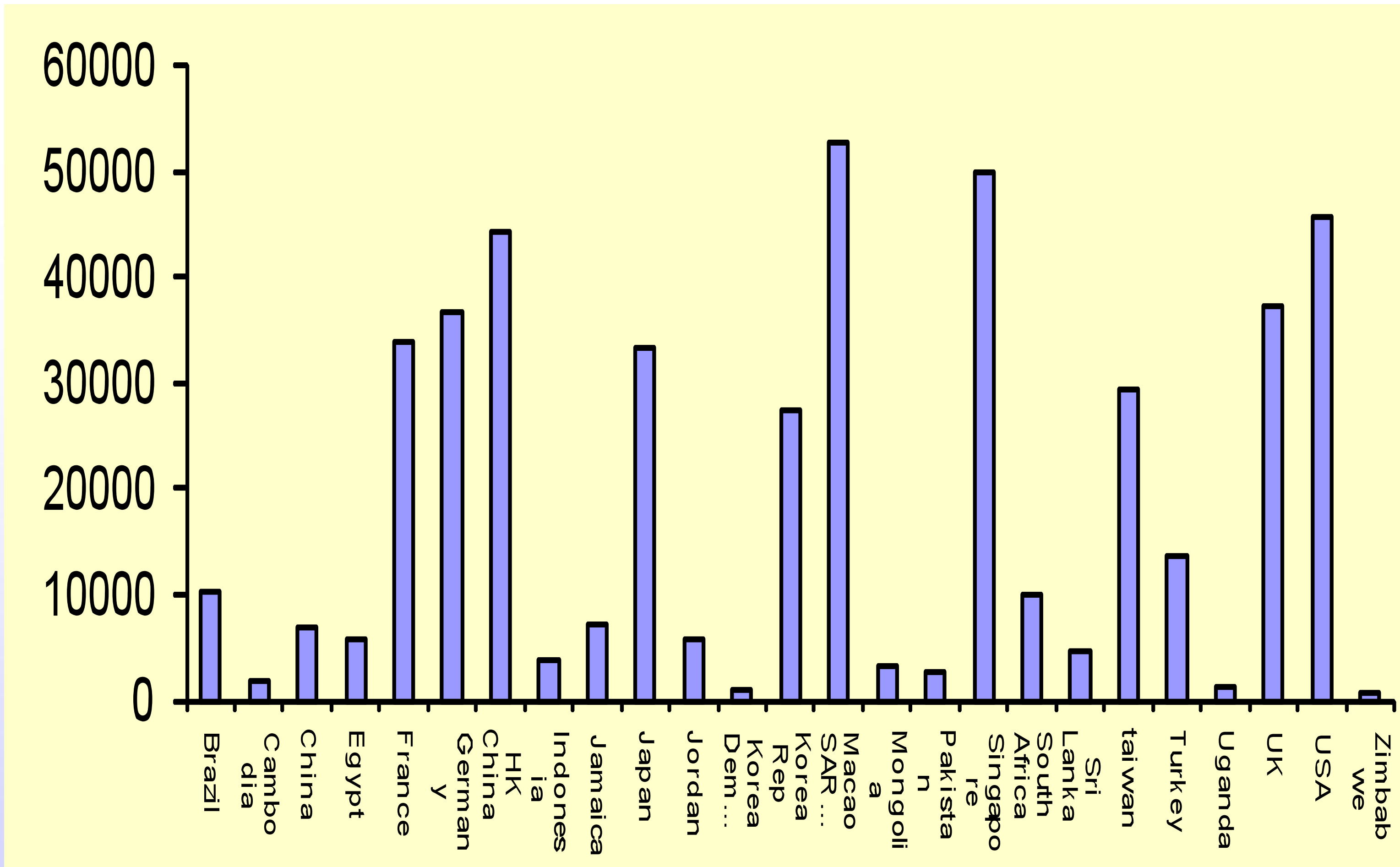
Some Stylised Facts Concerning Economic Growth and Development

- “ In 1996, 4.5 billion of the world’s 5.6 billion people lived in developing countries ”
- “ Mean US per capita income in 1995 was $18,500 compared to $200 in Tanzania, a country that has experienced sustained political and social stability ”
- “ If Ethiopia were to grow at the average rate of growth of the United States in the nineteenth century (1.75%), it would take 239 years for it to obtain current US living standards ”
- “ Between 1960 and 1990 17 countries experienced negative growth and declining standards of living ”

Gross National Income per capita(PPP Intl $), 2009



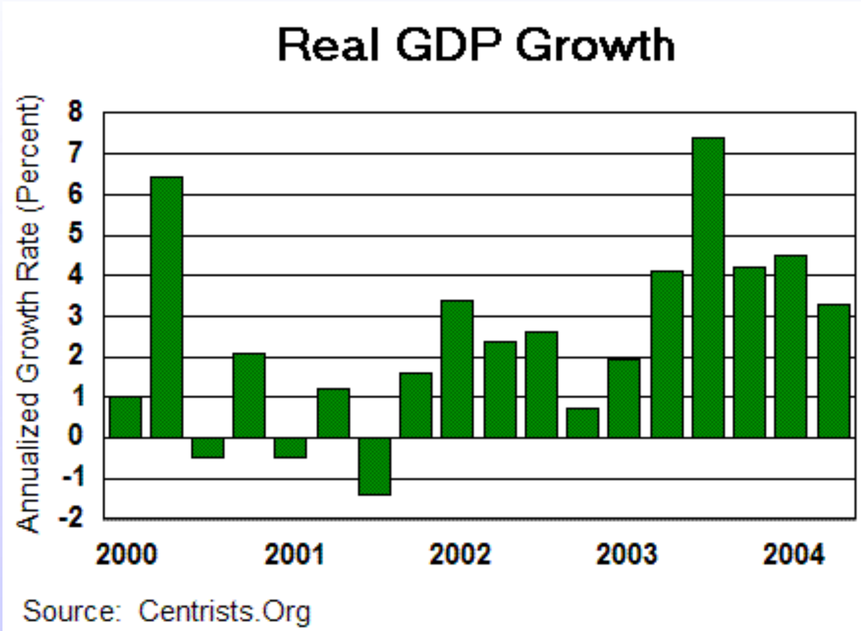
World Development Indicators database, World Bank, 15 December 2010

10-3

Thinking About Growth: A Primer

- To think about the facts presented in the previous sections, we use the framework of analysis developed by Trevor Swan, from the Australian National University, and Robert Solow, from MIT, in the late 1950s. Particularly:
  - What determines growth?
  - What is the role of capital accumulation?
  - What is the role of technological progress?

Topic 16 Economic Growth



The Data

The Theory

• <u>Exogenous Growth Theory</u>

– The Solow Growth Model (1956)

– The Augmented Solow Model (Mankiw, Romer and Weil, 1992)

<u>• Endogenous Growth Theory</u>

– The AK Model

» The ‘Basic’ AK Model

» An AK Model of Learning-by-Doing (Arrow 1962; Romer 1986)

» An AK Model with Human Capital (Lucas 1988)

– R&D Models (Romer 1990)

Government Policy and Growth

The Solow Growth Model

1. The Accumulation of Capital

- The supply and Demand for Goods

Assume production function： $Y = F(K, L)$

and has constant return to scale, $\lambda Y = F(\lambda K, \lambda L)$

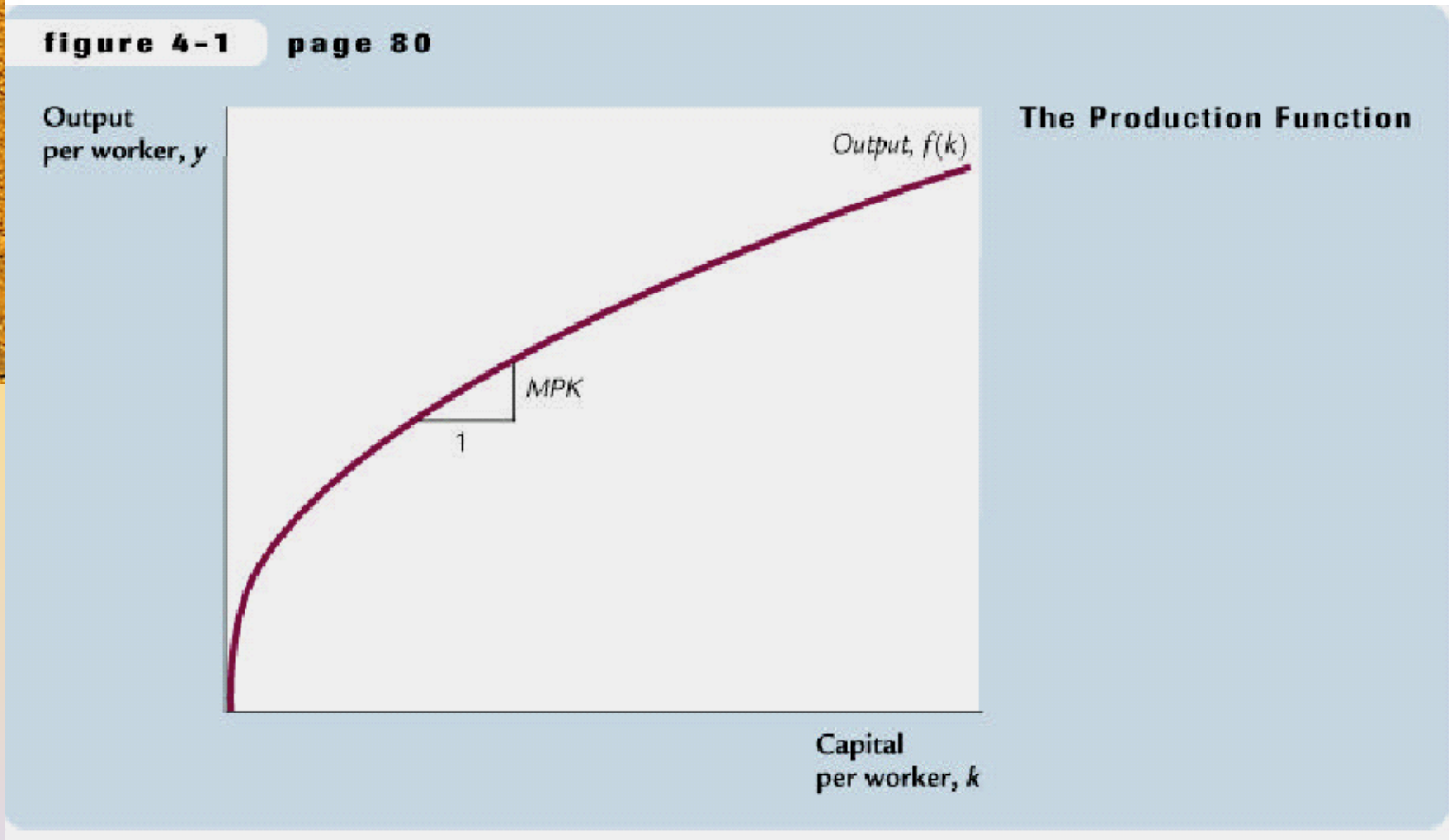
set $\lambda = 1/L$ so $Y/L = F(K/L, 1)$

$y = Y/L,$ is output per worker $k = K/L,$ is capital per worker.

we can then write the production function as：

$$y = f(k)$$

Diminishing Returns to Capital



- The demand for Goods and the consumption Function

$$y = c + i$$

we use s denote saving rate, so $c = (1-s)y$

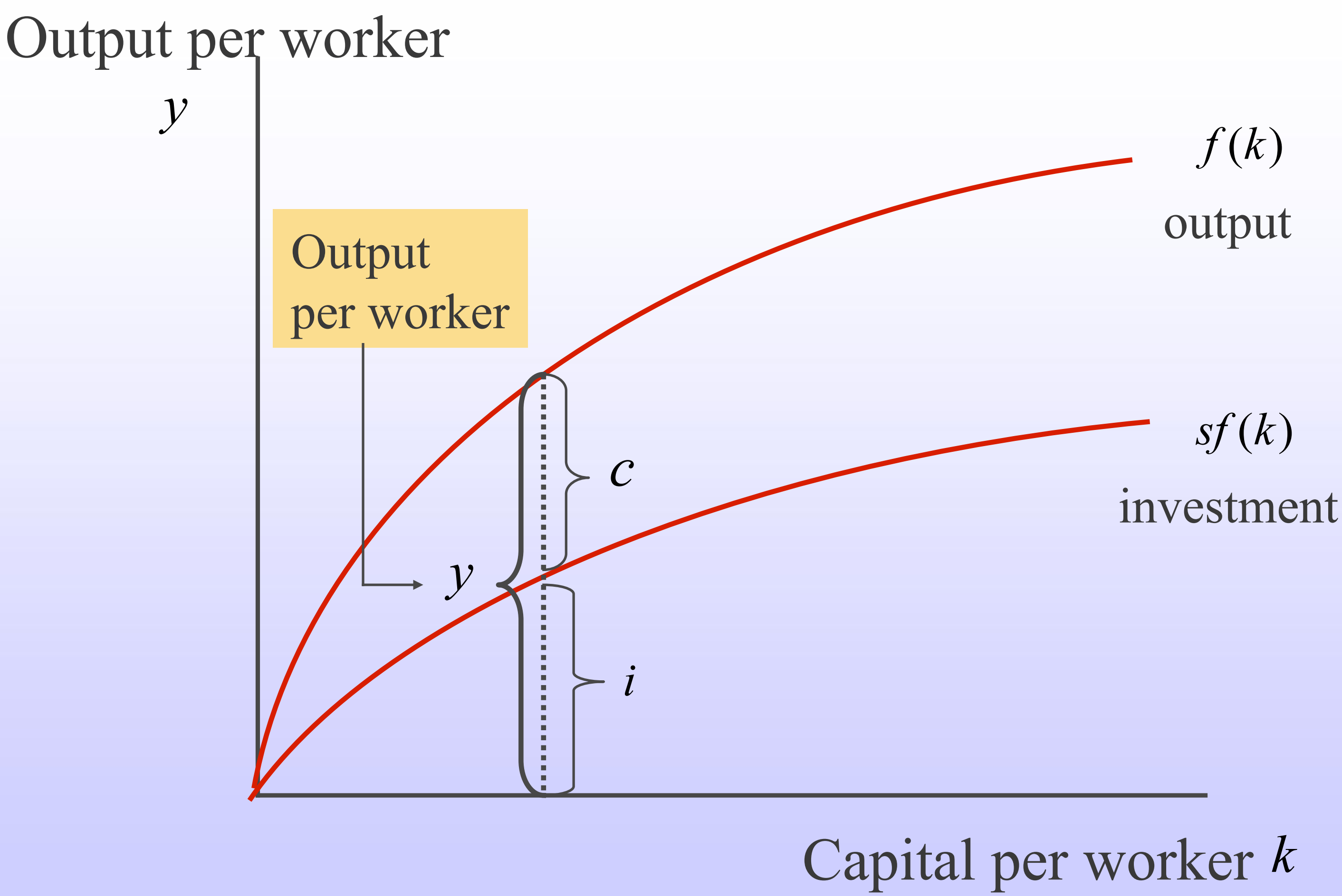
➡ *<u>Keep in mind that various government policies can potentially influence a nation's saving rate, so one of our goal is to find what saving rate is desirable. For now, however, we just take the saving rate as given.</u>*

$$y = (1-s)y + i$$

$$i = sy$$

➢ Growth in the Capital stock and the Steady State

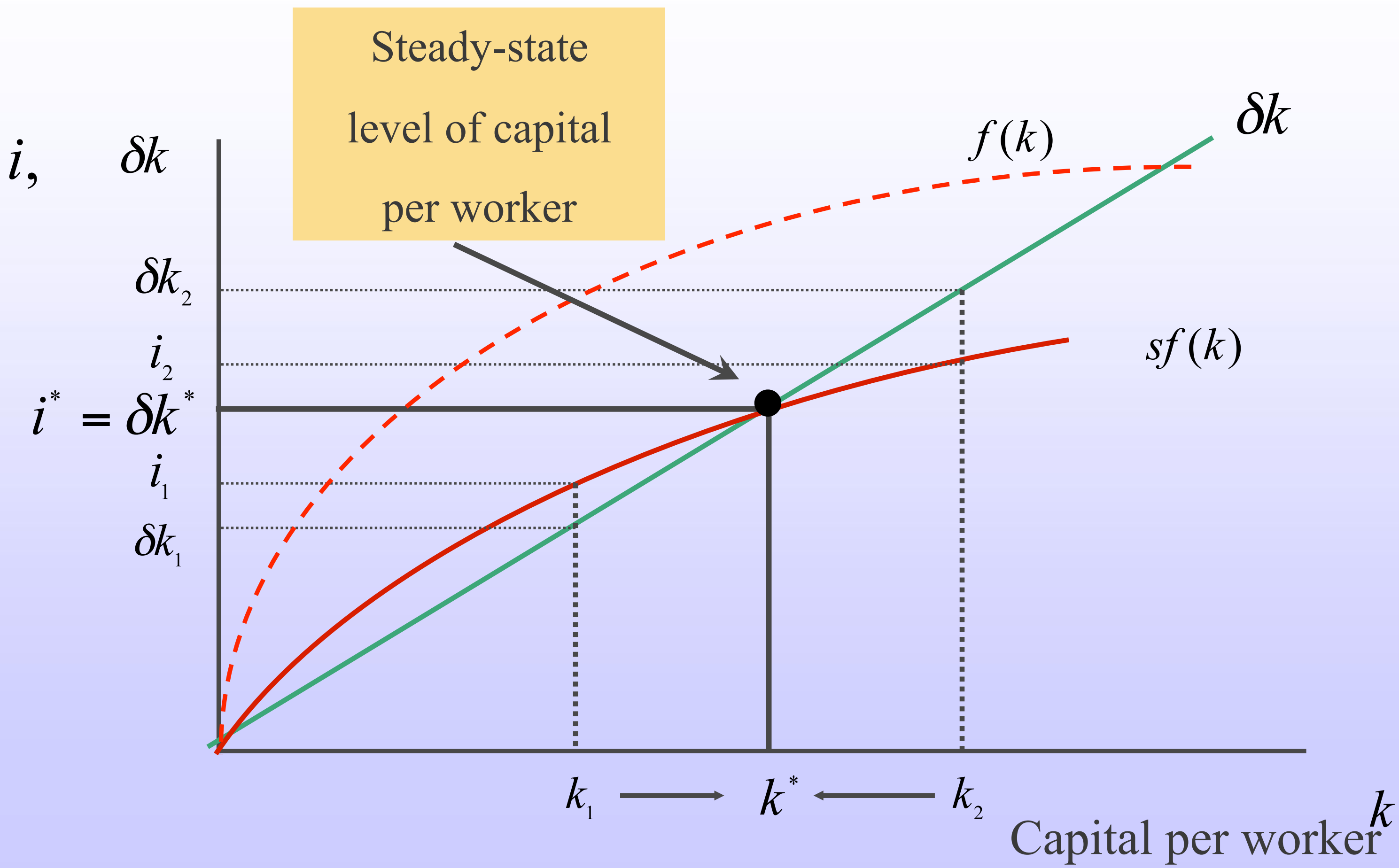
$$i = sf(k)$$



Assume *depreciation rate* is δ

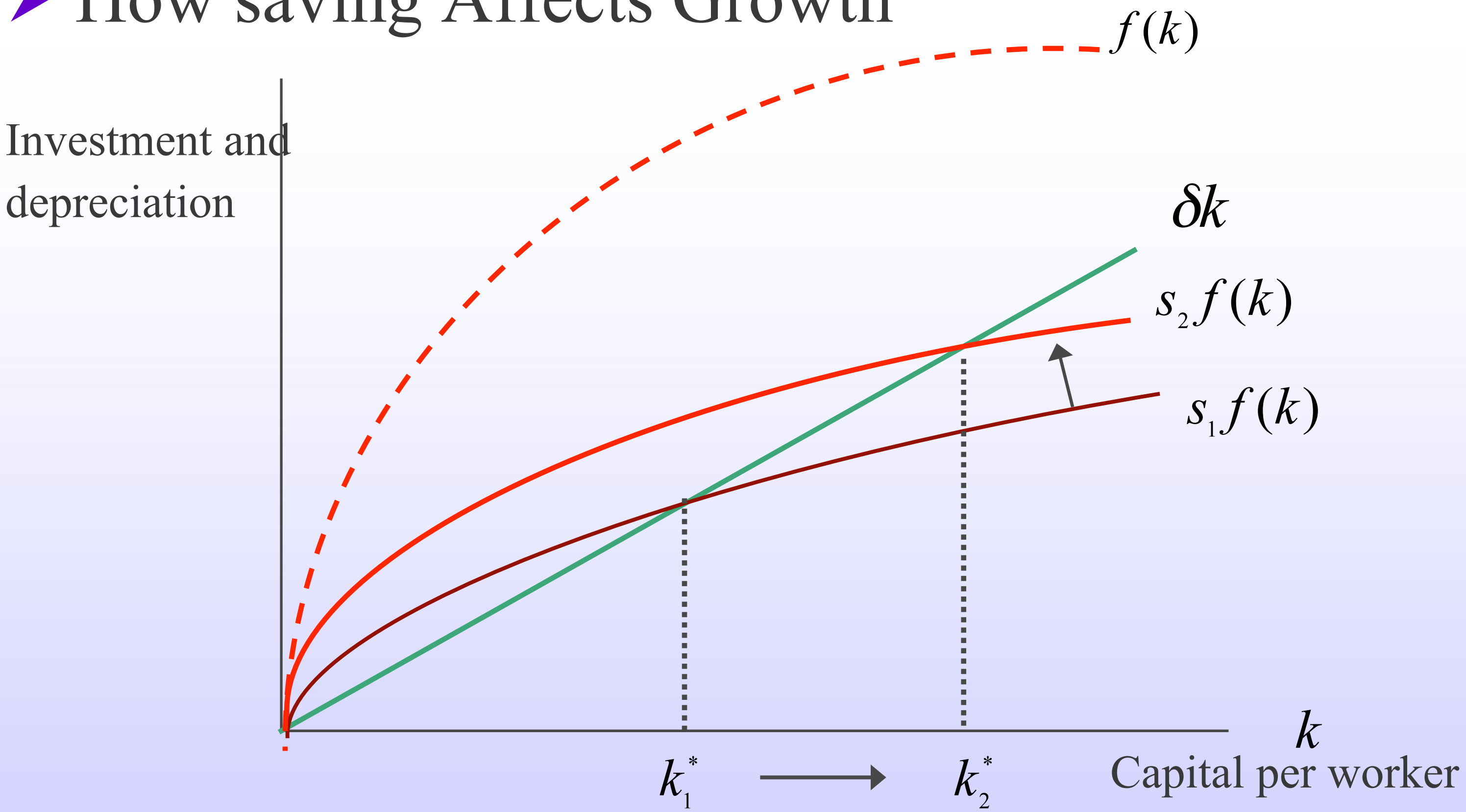
So the change in capital stock is equal to investment minus depreciation

$$\Delta k = i - \delta k \qquad \Delta k = sf(k) - \delta k$$



📖Case study： The Miracle of Japanese and German Growth

➢ How saving Affects Growth



The Solow model shows that:

If the saving rate is low, the economy will have a small capital stock and a low level of output. If the saving rate is high, the economy will have a large capital stock and a high level of output, but it will NOT maintain a high rate of growth forever.

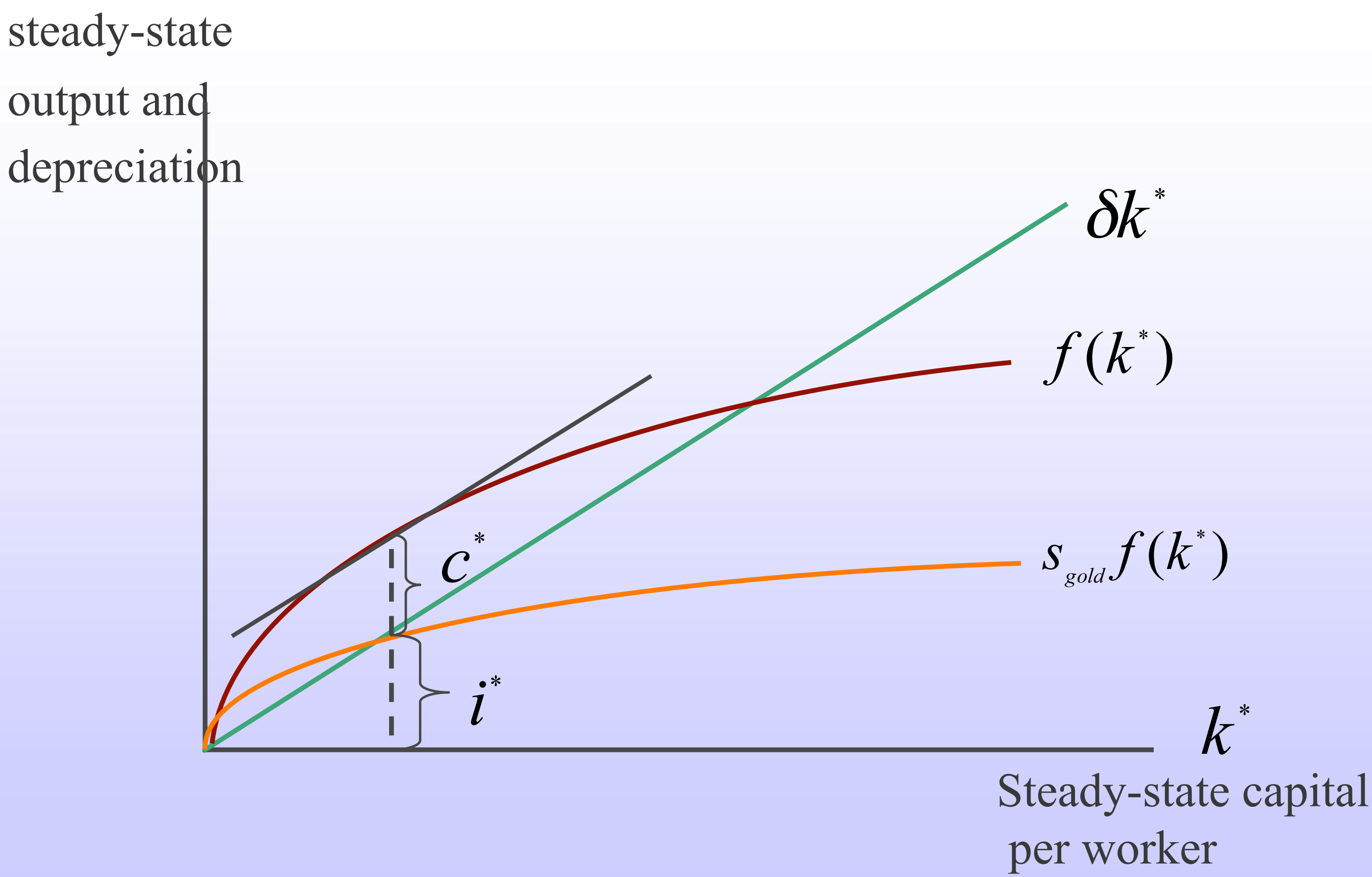
Case study: Saving and Investment Around the World

2. The Golden Rule Level of Capital

Comparing Steady States

$$y = c + i \qquad c = y - i$$

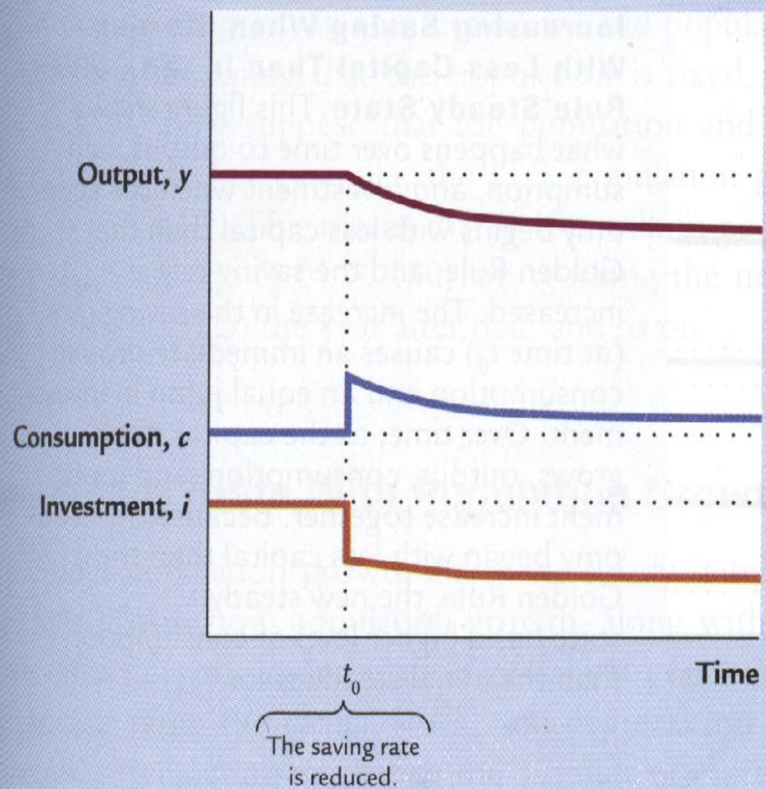
$$c^* = f(k^*) - \delta k^* \qquad MPK = \delta \Rightarrow S_{gold}$$



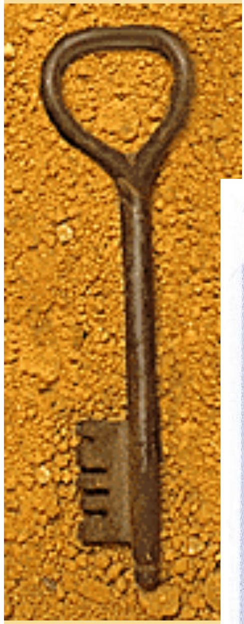
♦ The transition to the Golden rule steady state

Starting with too much capital

figure 4-9

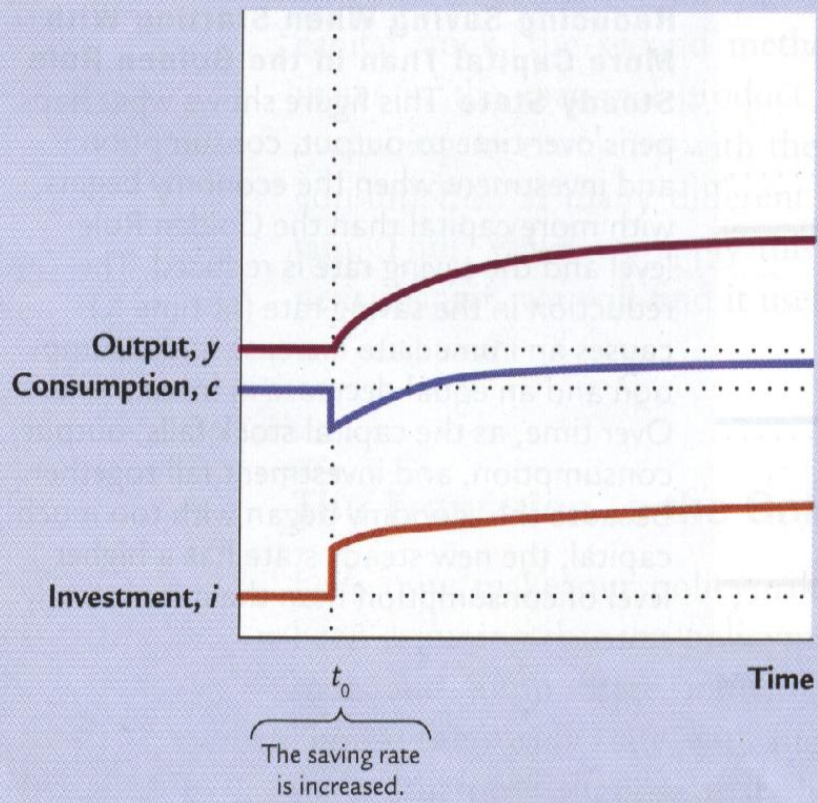


Reducing Saving When Starting With More Capital Than in the Golden Rule Steady State This figure shows what happens over time to output, consumption, and investment when the economy begins with more capital than the Golden Rule level and the saving rate is reduced. The reduction in the saving rate (at time t_0) causes an immediate increase in consumption and an equal decrease in investment. Over time, as the capital stock falls, output, consumption, and investment fall together. Because the economy began with too much capital, the new steady state has a higher level of consumption than the initial steady state.



Starting with too little capital

figure 4-10



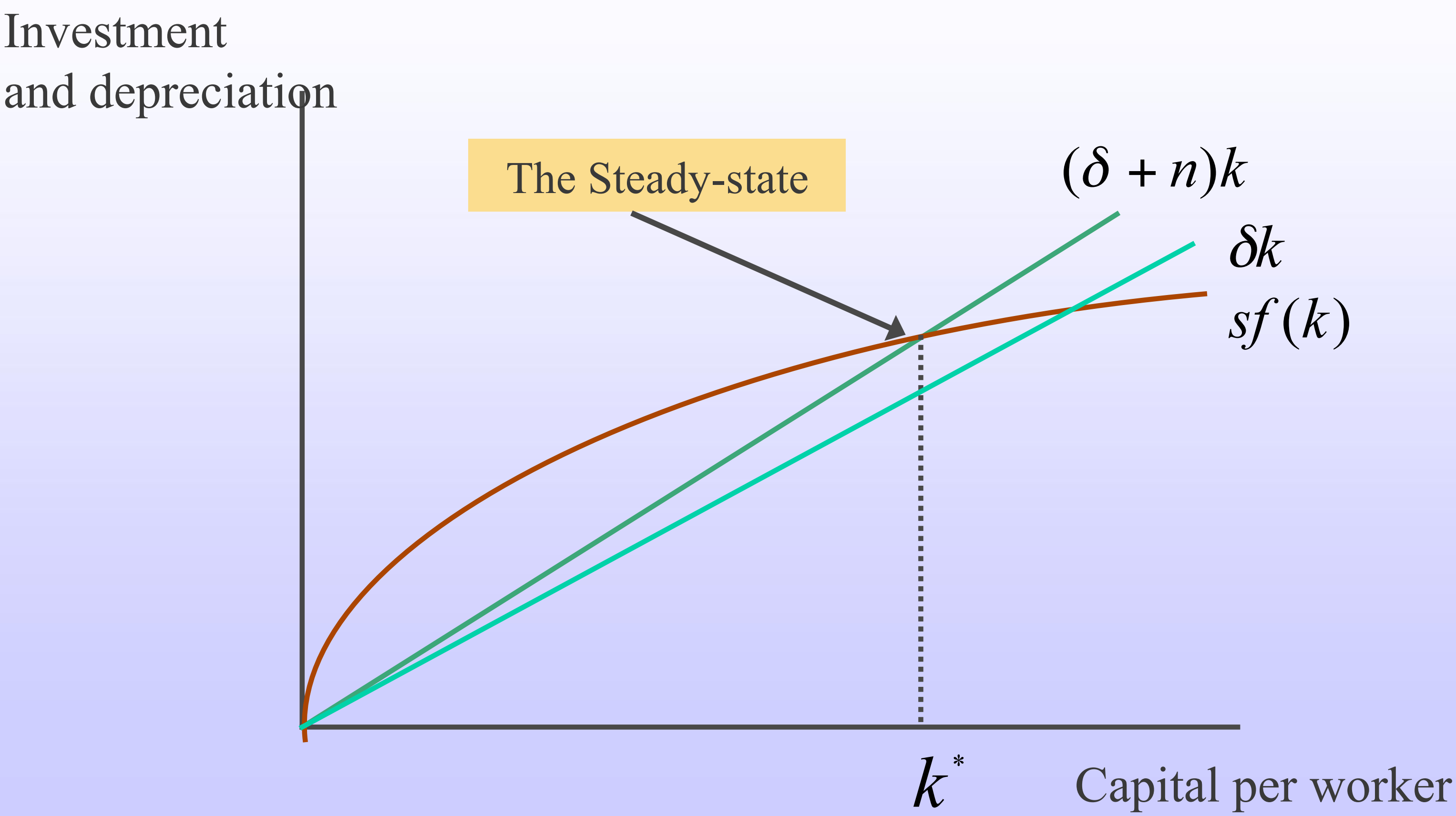
Increasing Saving When Starting With Less Capital Than in the Golden Rule Steady State This figure shows what happens over time to output, consumption, and investment when the economy begins with less capital than the Golden Rule, and the saving rate is increased. The increase in the saving rate (at time t_0) causes an immediate drop in consumption and an equal jump in investment. Over time, as the capital stock grows, output, consumption, and investment increase together. Because the economy began with less capital than the Golden Rule, the new steady state has a higher level of consumption than the initial steady state.

3. Population Growth

- **The Steady State with Population Growth**

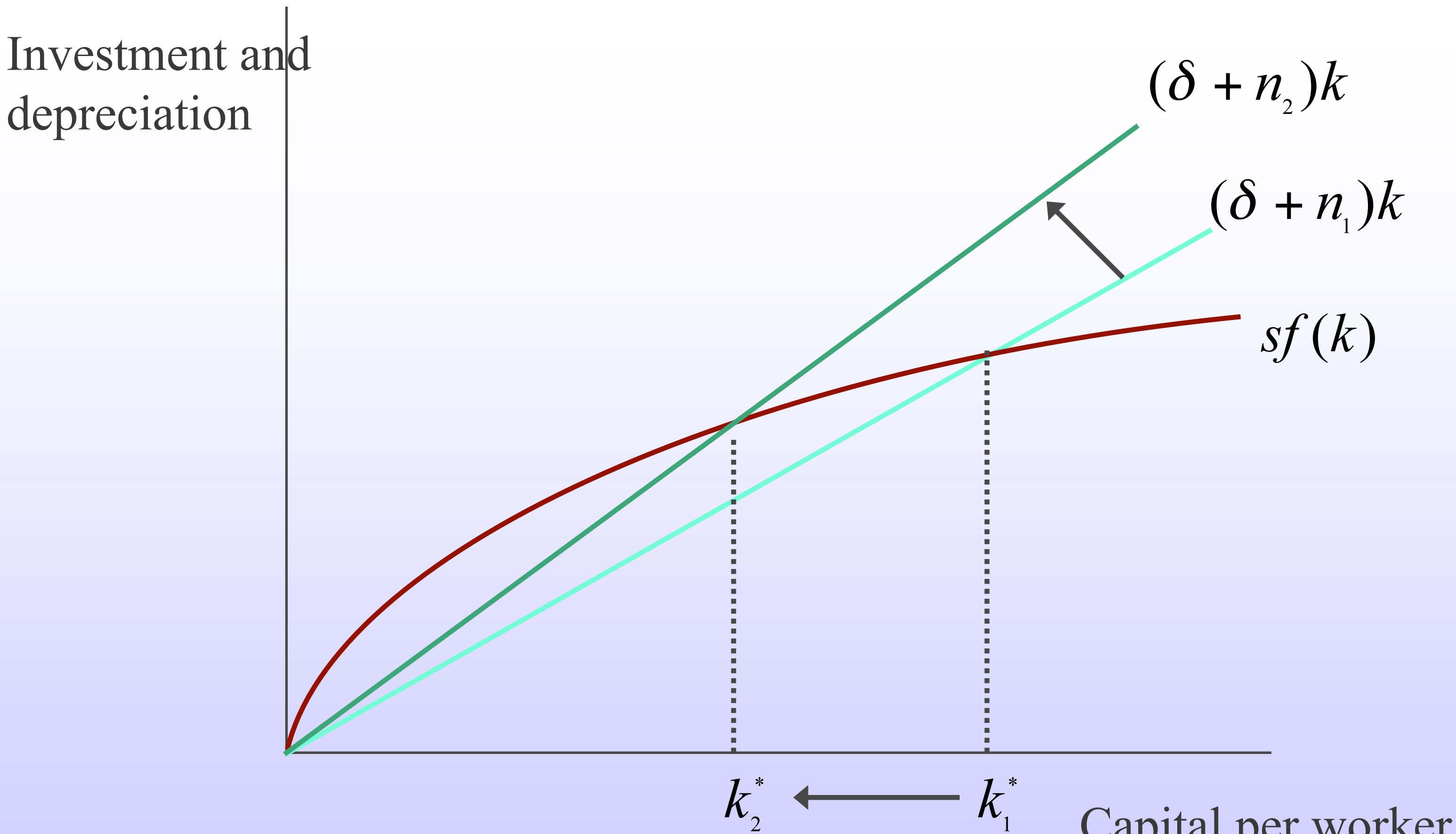
$$\Delta k = i - (\delta + n)k$$

n is population growth rate。 $\Delta k = sf(k) - (\delta + n)k$



➢The Effects of Population Growth

$$y^* = f(k^*) \qquad MPK = \delta + n \Rightarrow S_{gold}$$



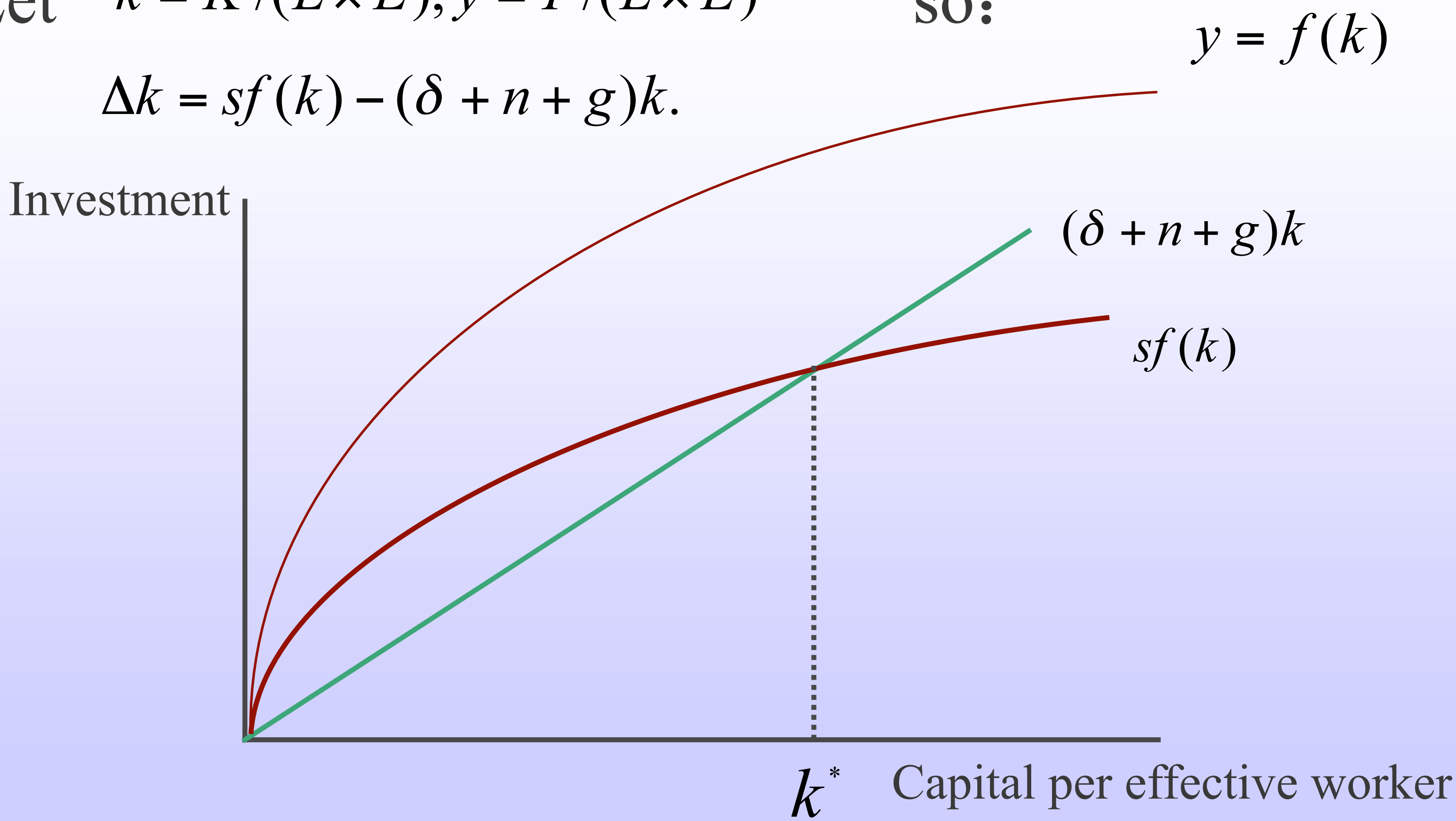
4. Technological Progress

- **The efficiency of labour and the S-S with Technological Progress**

$$Y = F(K, L \times E)$$

Let $k = K/(L \times E), y = Y/(L \times E)$ so:

$$\Delta k = sf(k) - (\delta + n + g)k.$$



➢The Effects of Technological Progress

$$c^* = f(k^*) - (\delta + n + g)k^* \qquad MPK - \delta = n + g$$

Steady-state Growth Rates in the Solow Model with Technological Progress

Variable	Symbol	S-S Growth Rate
Capital per effective worker	$k = K/(E \times L)$	0
Output per effective worker	$y = Y/(E \times L) = f(k)$	0
Output per worker	$Y/L = y \times E$	g
Total Output	$Y = y \times (E \times L)$	$n + g$

Policies and Growth

What's the Optimal Rate of Saving?

Changing the Saving-Rate

Allocating the Economy's Investment

Fertility Programmes

Encouraging Technological Progress

Cross-Country Implications of the Solow Model

Conditional Convergence

- assume all countries have access to the global stock of technology

Long-run,

- all will grow at *g*.

Short-run

- growth-rates will depend inversely on the distance between
  – the capital stock and steady-state level, which is determined by the savings-rate, depreciation-rate, and so on.

- In terms of cross-country comparisons, there is no tendency to convergence. Countries which save more are predicted to have permanently faster growth, and income levels will therefore diverge over time!

Implications of the Solow Model

Long-run

- The model predicts that long-run growth in standards of living (y) is equal to the rate of technological progress, which is exogenously given.
- It follows that government is unable to influence growth permanently!

Short-Run

In the short-run, however, (where effective capital per head, *k* is not in its steady-state), growth is affected by a number of variables. Transitional growth (and the steady-state level of output per head) is

- increasing in the rate of saving,
- decreasing in the rate of population growth and rate of depreciation.

Government has greater scope to affect growth in the short-run, by, for example, influencing fertility-rates and encouraging more household saving

Endogenous Growth

- Explaining long-run growth from within
  – what drives technological progress?
  – how government may influence long-run growth.

Broadly, there are *two* class of endogenous growth model.

- The AK model
  – emphasizes the role of capital in long-run growth.
- The R&D-type models
  – focus on the determinants of technological progress.

1. The AK Model

- **The Basic AK Model**
- An AK Model with Learning-by-Doing
- An AK Model with Public Services
- An AK Model with Human Capital

These models generate long-run growth by assuming ‘constant returns to capital’

The Basic AK Model

Production function

$$Y = \bar{A}K$$

Expressing this in terms of per capita output, and substituting into the equation of motion,

$$\partial k = s\bar{A}k - (\delta + n)k$$

Dividing through by k, the growth-rate of capital per head

$$\partial k / k = s\bar{A} - (\delta + n)$$

Growth

$$\partial k \big/ k = \partial y \big/ y$$

so growth-rate is constant (I.,e, sustained) and non-zero when

$$s\overline{A} > (\delta + n)$$

Implications

- In contrast to the Solow model, long-run growth does not depend on technology
  – capital accumulation is sufficient to cause perpetual increase in standards of living.
- Variables that only affect S-run growth in Solow impact on L-run growth, i.e., s, n and d.

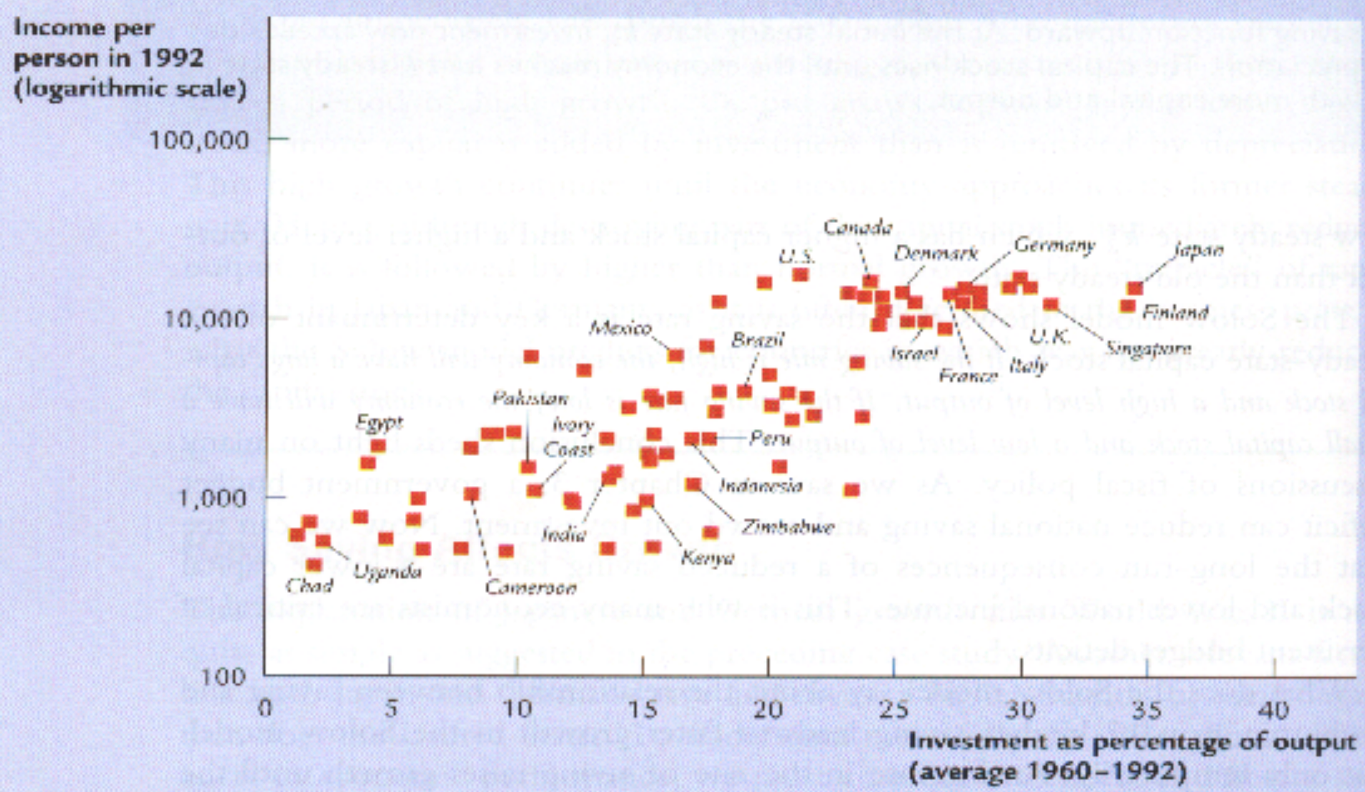
A Synthesis

It is widely believed that;

- endogenous growth by R&D may explain growth of the world's leading economy

- exogenous growth emphasising capital best explains catch-up of developing countries

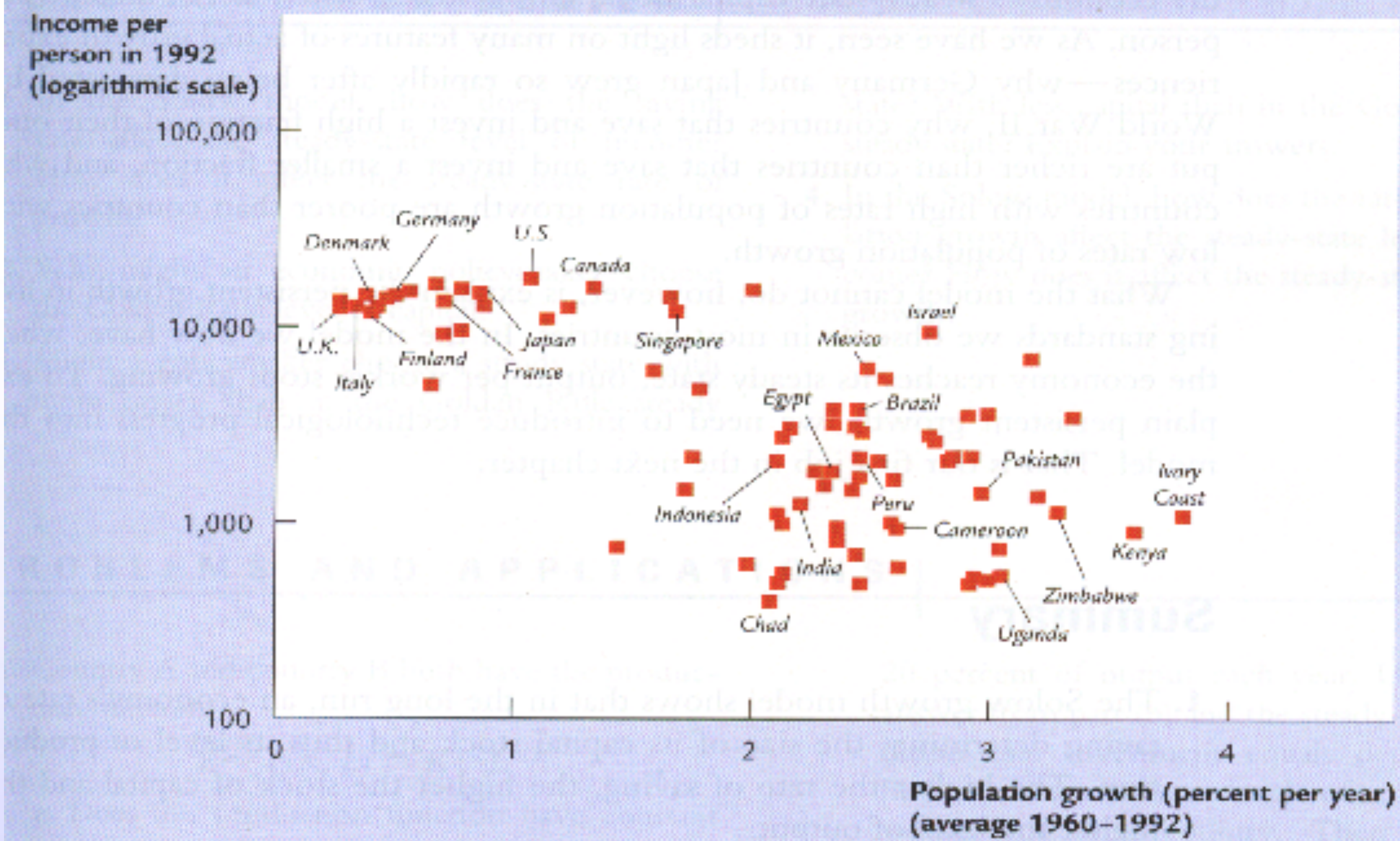
figure 4-6



International Evidence on Investment Rates and Income per Person This scatterplot shows the experience of 84 countries, each represented by a single point. The horizontal axis shows the country's rate of investment, and the vertical axis shows the country's income per person. High investment is associated with high income per person, as the Solow model predicts.

Source: Robert Summers and Alan Heston, Supplement (Mark 5.6) to "The Penn World Table (Mark 5): An Expanded Set of International Comparisons 1950–1988," *Quarterly Journal of Economics* (May 1991): 327–368.

figure 4-13



International Evidence on Population Growth and Income per Person This figure is a scatterplot of data from 84 countries. It shows that countries with high rates of population growth tend to have low levels of income per person, as the Solow model predicts.

Source: Robert Summers and Alan Heston, Supplement (Mark 5.6) to "The Penn World Table (Mark 5): An Expanded Set of International Comparisons 1950–1988," *Quarterly Journal of Economics* (May 1991): 327–368.