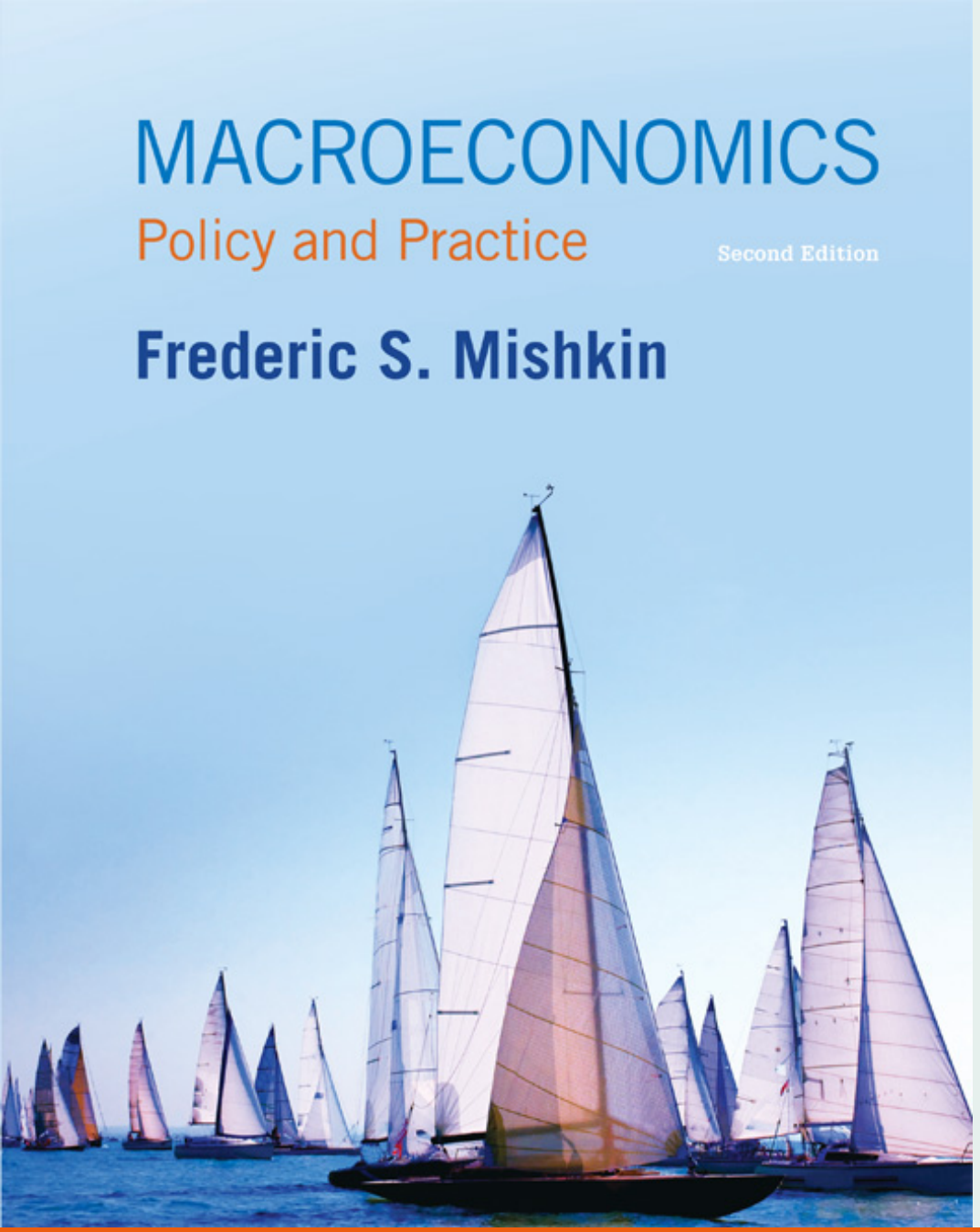


Chapter 7

Drivers of Growth: Technology, Policy, and Institutions

Preview

- To understand how technology differs from the conventional production inputs of capital and labor
- To examine policies to promote productivity growth
- To examine how basic institutions drive economic growth
- To develop a theory of economic growth that analyzes productivity changes endogenously

Endogenous Growth Theory

- **Endogenous growth theory** explains why advances in technology *endogenously* fuel sustained economic growth
- The models are often referred to as **Romer models** after Paul Romer

Allocation of Labor

- The Romer model differs from the Solow model in its assumption about labor, which is the same as the population $\bar{N}$:

$$\bar{N} = L_p + L_A$$

where

L_p = Labor that produces goods/services

L_A = Labor that produces R&D

Allocation of Labor (cont'd)

- Assume that the fraction of the population devoted to R&D is α, the amounts of labor devoted to producing R&D and goods and services are, respectively:

$$L_A = \alpha \bar{N}$$

$$L_P = (1 - \alpha)\bar{N}$$

Production Function

- The production function is the largely the same as that of the Solow model, except that *A* now can change over time:

$$Y_t = A_t K_t^{0.3} L_t^{0.7}$$

- Because labor in the above equation is only the subset of labor devoted to producing goods and services:

$$Y_t = A_t K_t^{0.3} L_{Pt}^{0.7}$$

Production Function (cont'd)

- Similarly, output per worker is expressed in terms of only workers devoted to producing goods and services:

$$y_{Pt} = A_t k_{Pt}^{0.3}$$

where

$$y_{Pt} = \frac{Y_t}{L_p}$$

$$k_{Pt} = \frac{K_t}{L_p}$$

Production of Technology

- Assume the increase in technology is proportional L_A, so that the production function for technology is:

$$A_{t+1} - A_t = \Delta A_t = \chi A_t L_A$$

where χ indicates how productive labor is in producing ideas.

- Because technology is nonrivalrous, A_t is used in producing more technology ΔA_t

Production of Technology (cont'd)

- *Incorporating nonrivalry into our economic model allows us to explain sustained growth in per-capita income. Without it, as in the Solow model, diminishing returns to capital eventually lead output per capita to rest at a steady state without growth.*
- The production function in terms of the growth rate of technology g_A:

$$\frac{\Delta A_t}{A_t} = g_A = \chi \alpha \bar{N}$$

Sustained Growth in the Romer Model

- From the Solow model, the production function (with a time subscript) with a steady state k_P^* is:

$$y_{Pt}^* = A_t k_P^{*0.3}$$

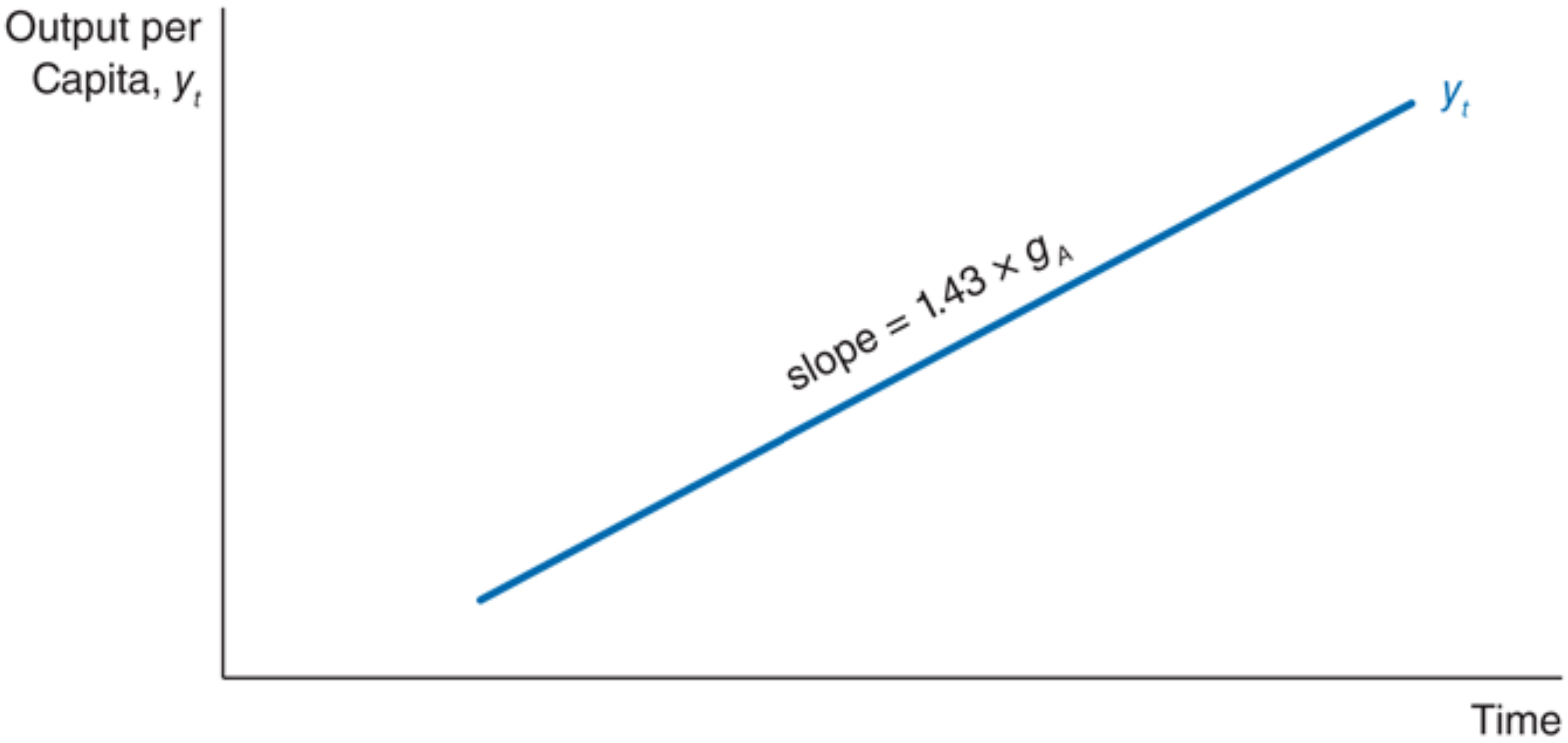
- Because $y_t = Y_t / \bar{N} = y_{Pt} \times (L_P / \bar{N})$ and $L_P / \bar{N} = (1 - \alpha)$,

$$y_t^* = (1 - \alpha) A_t k_P^{*0.3}$$

Sustained Growth in the Romer Model (cont'd)

- In this Romer model, output per person grows at a *constant rate*, which is called a balanced growth path
- This steady rate of growth contrasts with the Solow model, where output per person reaches a *steady state*
- In Figure 7.1, the vertical axis is a **ratio scale** (or **logarithmic scale**), in which equal distances reflect the same percentage change: The balanced growth path in the Romer model is a straight line so that its slope represents the rate of growth at 1.43 over time

FIGURE 7.1 Balanced Growth Path in the Romer Model



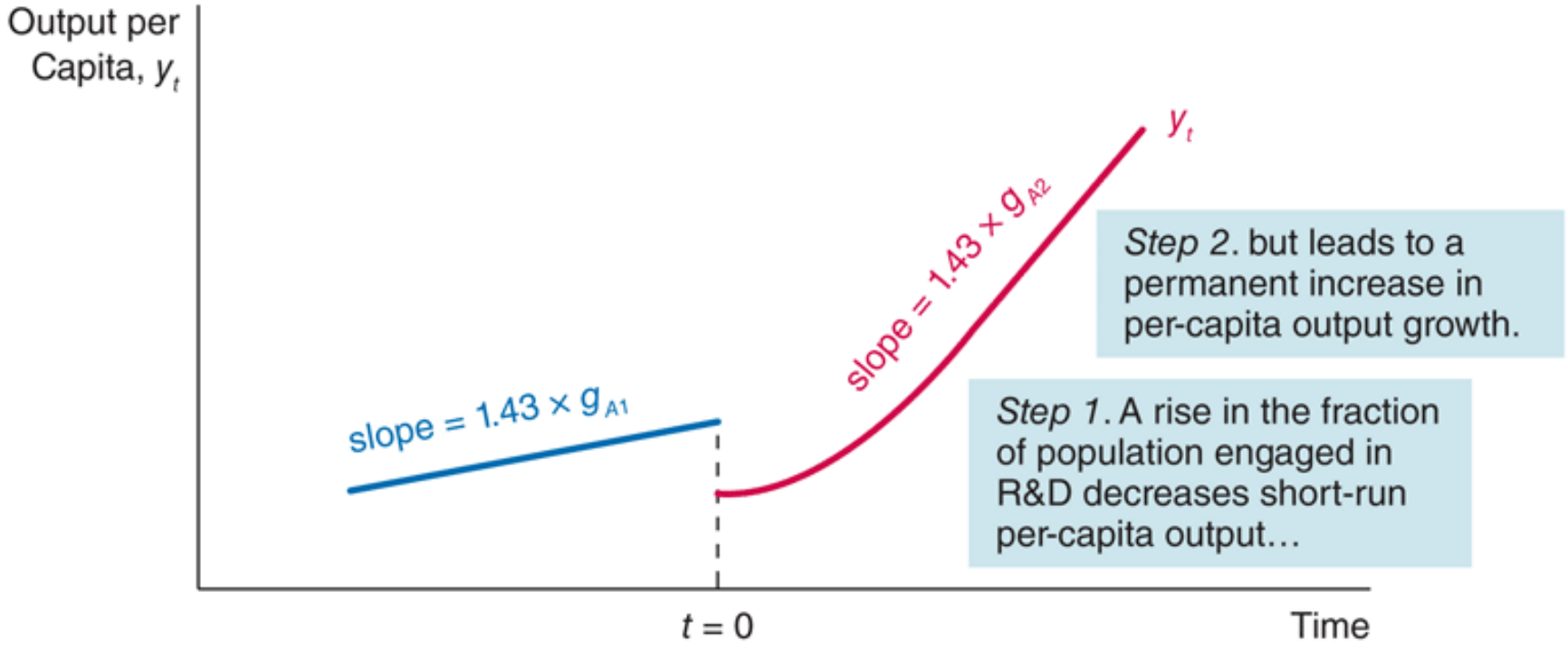
Factors That Affect Endogenous Growth

- Three factors in the Romer model can change the economy's growth rate:
  1. The fraction of the population that is engaged in R&D
  2. The productiveness of R&D
  3. The total population in the economy

Effects of an Increase in the Fraction of the Population Engaged in R&D

- *When more resources are devoted to research and development, the level of per capita output at first falls, but the growth rate of per capita output will rise permanently*:
  - As more labor is devoted to R&D production, less labor goes to producing goods and services, thus L_P drops immediately
  - The decline in L_P pushes up the capital-labor ratio k_{Pt}, which in turn will approach the steady state over time, so that the economy will be on a new, higher balance growth path

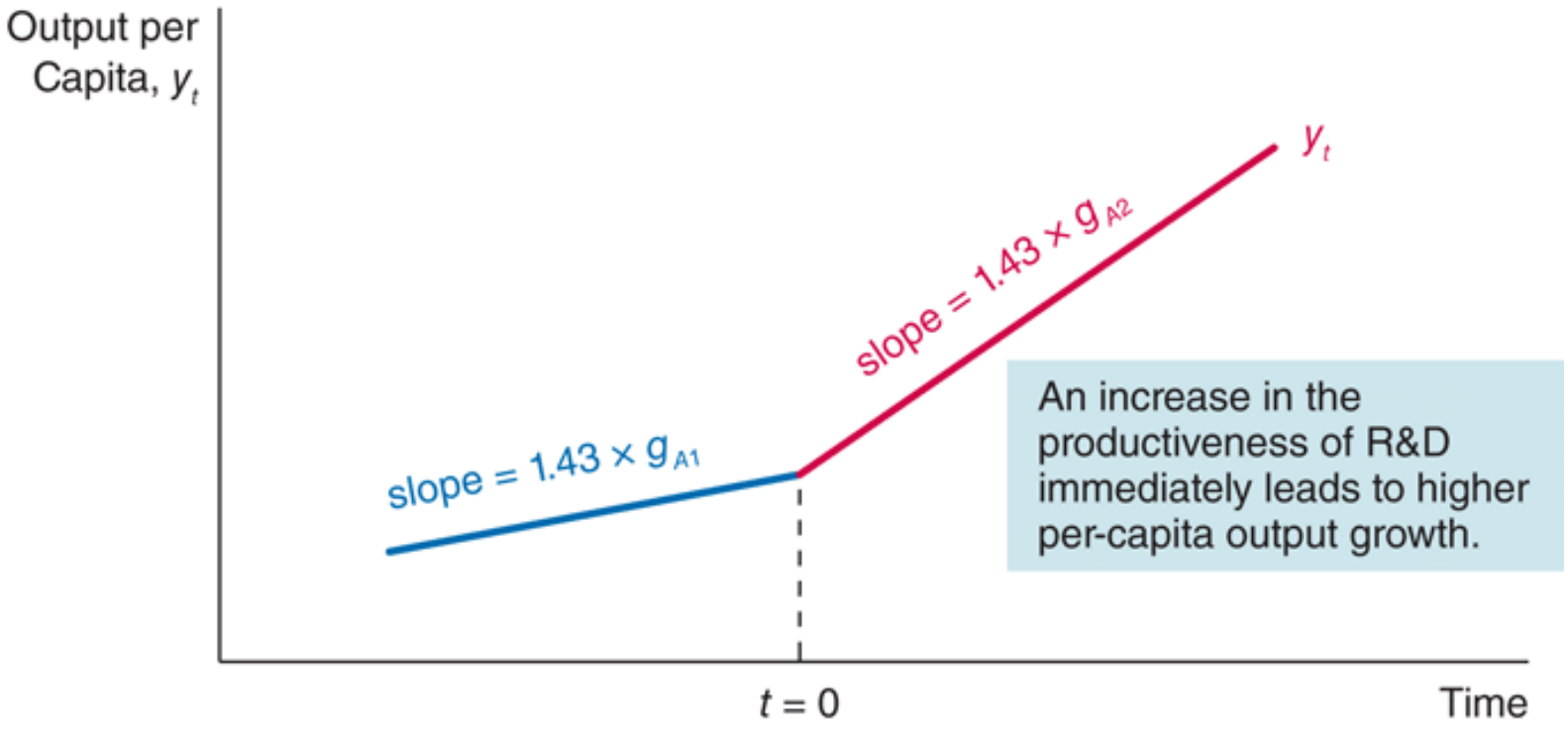
FIGURE 7.2 Response to an Increase in the Fraction of the Population Engaged in R&D



Effects of Changes in the Productiveness of R&D

- *When R&D becomes more productive, output per capita grows at a more rapid rate*:
  - An increase in the productivity of R&D, x, rises the growth rate of A, g_A
  - The slope of y_t is higher (steeper)

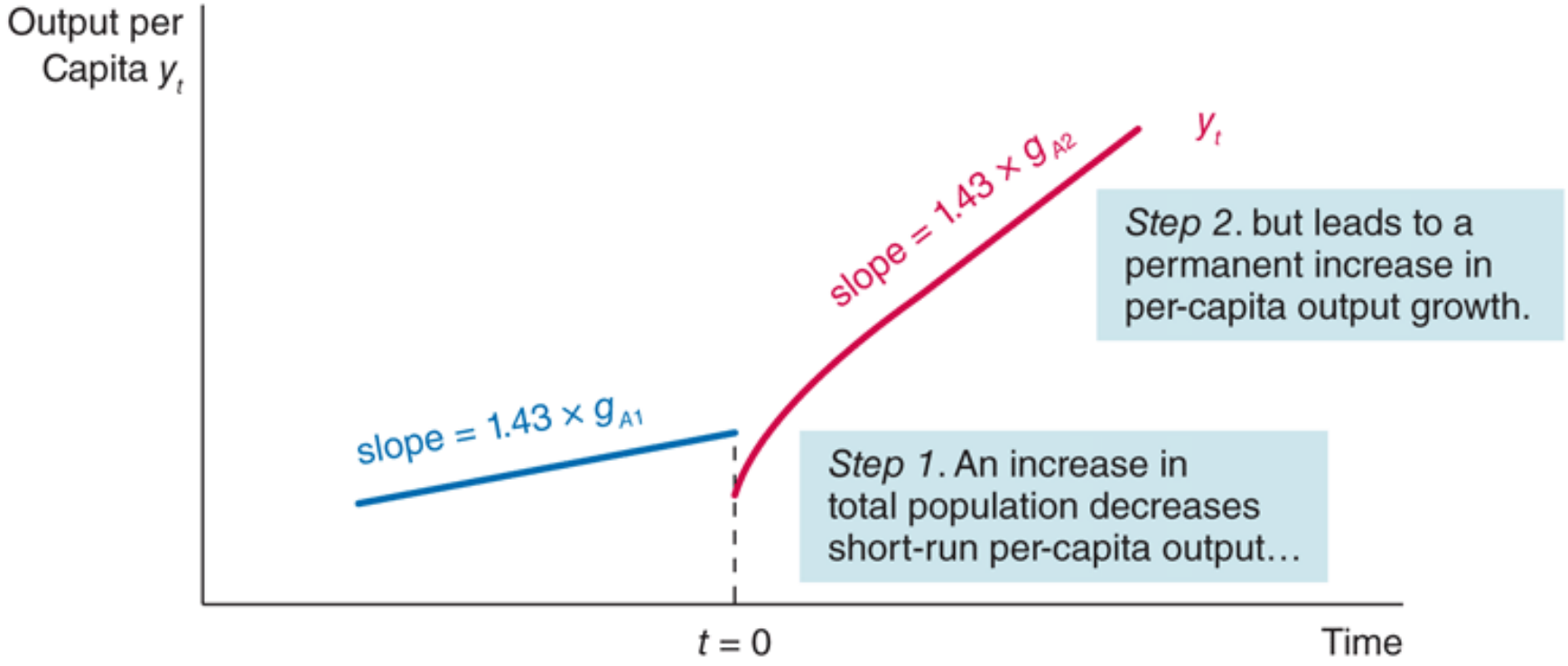
FIGURE 7.3 Response to a Rise in the Productiveness of R&D



Response to an Increase in the Total Population, $\bar{N}$

- *A rise in population at first leads to a decline in per-capita output, but the growth rate of per-capita output will rise permanently:*
  - The capital-labor ratio k_{Pt} falls immediately, so that y_t falls at first
  - As $k_{Pt} < k_P^*$, it will grow for a time above the long-run growth rate
  - An increase in population leads to a decline in living standards in the short run, but it improves living standards in the long run

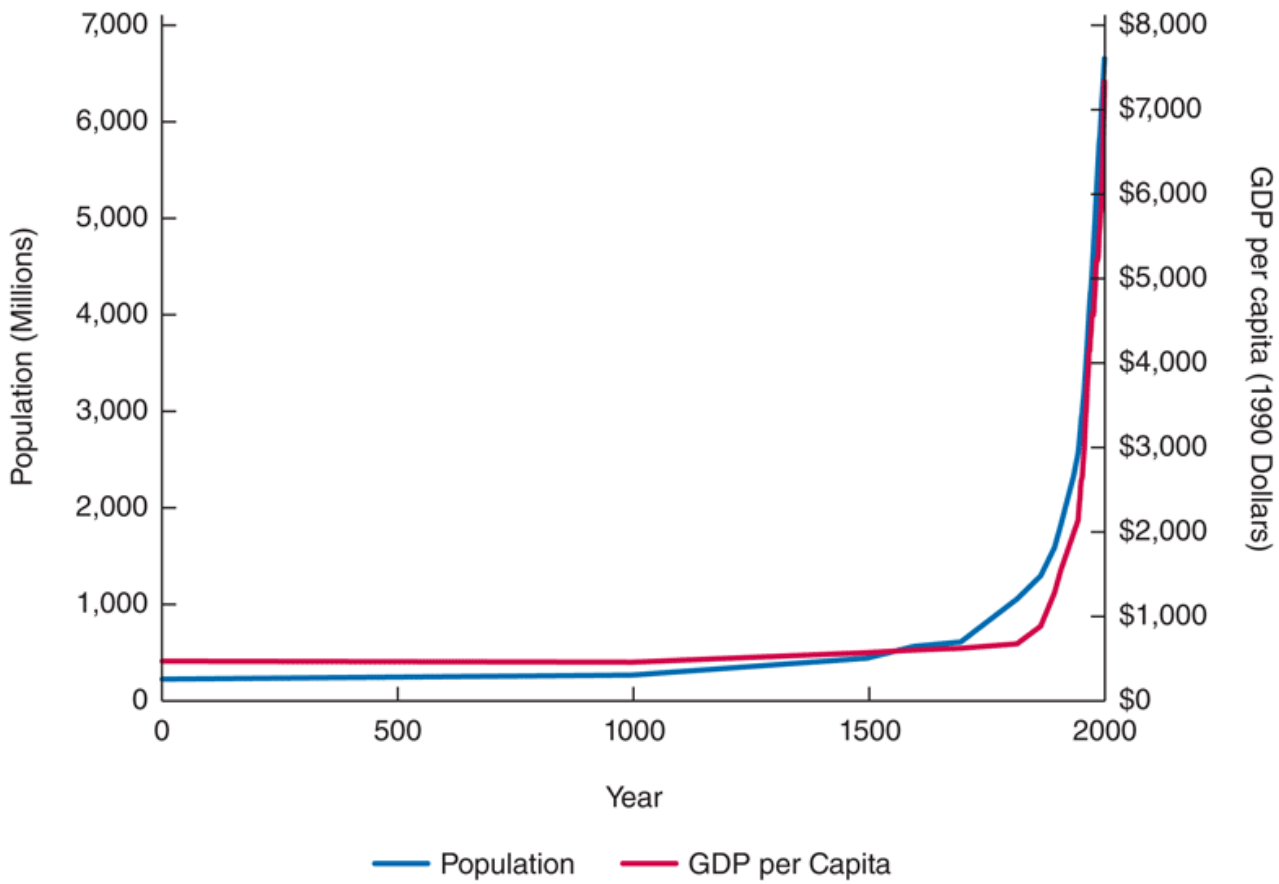
FIGURE 7.4 Response to an Increase in the Total Population



Application: Does Population Growth Improve Living Standards?

- Does population growth leads to lower living standards (the Solow model prediction) or higher living standards (the Romer model prediction)?
- The nonrivalry of ideas leads to **technological spillover**, which might explain why countries with high population growth don't have high per-capita income
- But for the world as a whole, historical evidence suggests that higher populations are positively associated with higher living standards

FIGURE 7.5 World Population and Per-Capita GDP over the Very Long Run



Source: Maddison, Angus. *Historical statistics,* population and per capita GDP levels, 1-2006. www.ggdc.net/maddison/

The Romer Model and Saving

- *A higher saving rate results in a higher level of output per capita, but not a higher sustained growth rate:*
  - Greater saving raises investment in capital, and so k_{Pt}
  - As k_{Pt} reaches a higher steady-state value, the economy returns to a balanced growth path where Y_t is growing at the same rate as before

FIGURE 7.6 Response to a Rise in the Saving Rate