Chapter 7

# MEASURING PRODUCTIVITY

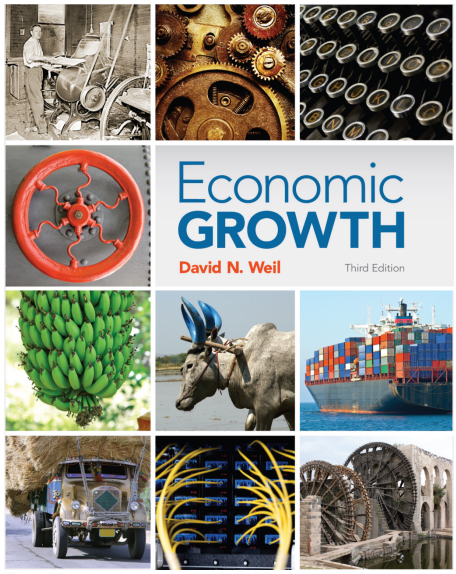
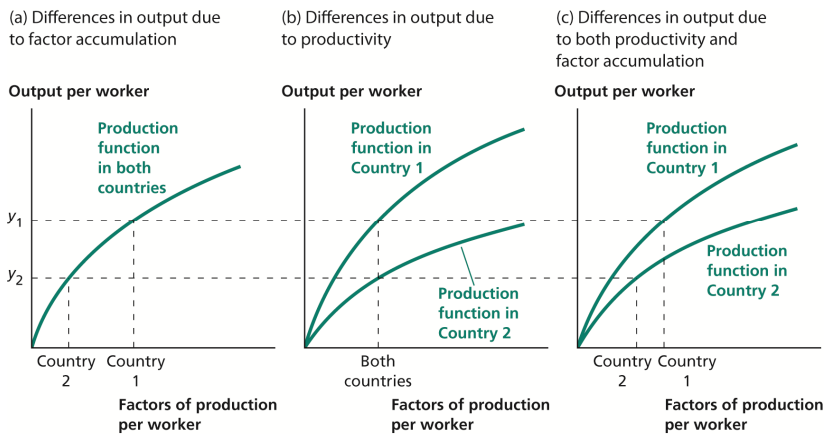


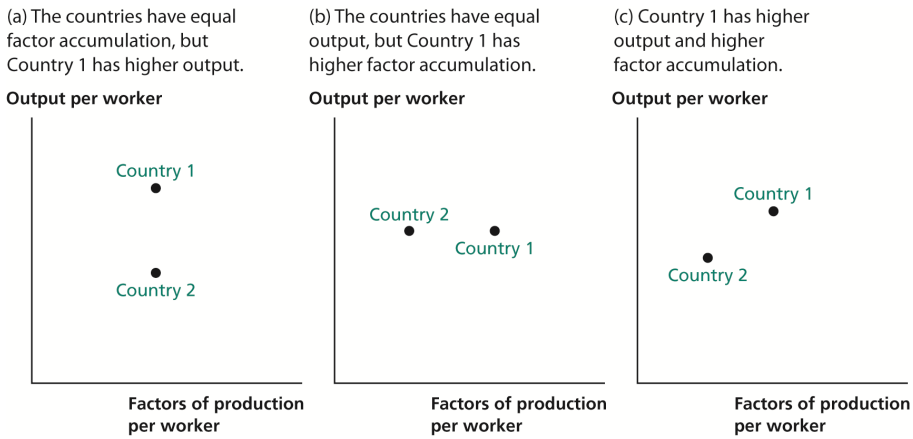





**Figure 7.1** Possible Sources of Differences in Output per Worker



## **Figure 7.2** Inferring Productivity from Data on Output and Factor Accumulation








## productivity accounting

Ratio of output=

Ratio of productivity * Ratio of factors of production

Ratio of productivity=

Ratio of income/Ratio of factors of production

## **Table 7.1** Data Used to Analyze Productivity in Country 1 and Country 2

| | Output per Worker, $y$ | Physical Capital per Worker, $k$ | Human Capital per Worker, $h$ |
|---|---|---|---|
| **Country 1** | 24 | 27 | 8 |
| **Country 2** | 1 | 1 | 1 |



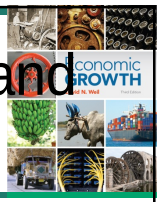


## **Table 7.2** Development Accounting

| Country | Output per Worker, $y$ | Physical Capital per Worker, $k$ | Human Capital per Worker, $h$ | Factors of Production, $k^{1/3}h^{2/3}$ | Productivity, A |
|---|---|---|---|---|---|
| United States | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Norway | 1.12 | 1.32 | 0.98 | 1.08 | 1.04 |
| United Kingdom | 0.82 | 0.68 | 0.87 | 0.80 | 1.03 |
| Canada | 0.80 | 0.81 | 0.96 | 0.91 | 0.88 |
| Japan | 0.73 | 1.16 | 0.98 | 1.04 | 0.70 |
| South Korea | 0.62 | 0.92 | 0.98 | 0.96 | 0.64 |
| Turkey | 0.37 | 0.28 | 0.78 | 0.55 | 0.68 |
| Mexico | 0.35 | 0.33 | 0.84 | 0.61 | 0.56 |
| Brazil | 0.20 | 0.19 | 0.78 | 0.48 | 0.42 |
| India | 0.10 | 0.089 | 0.66 | 0.34 | 0.31 |
| Kenya | 0.032 | 0.022 | 0.73 | 0.23 | 0.14 |
| Malawi | 0.018 | 0.029 | 0.57 | 0.21 | 0.087 |

*Sources*: Output per worker: Heston, Summers, and Aten (2011); physical capital: author's calculations; human capital: Barro and Lee (2010). The data set used here and in Section 7.3 is composed of data for 90 countries for which consistent data are available for 1975 and 2009.

# Problems with measuring capital and implications



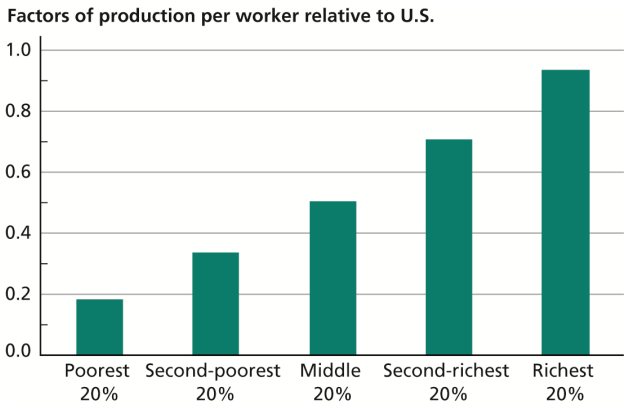

- Waste of investment
- Quality of investment

- There are estimate according to which the actual level of the capital stock is in between 60% to 75% of the official statistics...



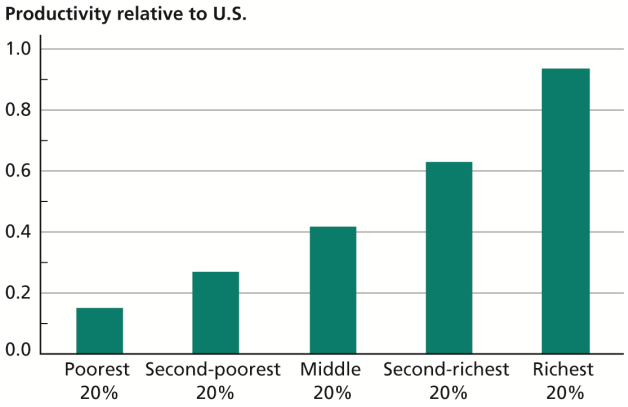


**Figure 7.3** Role of Factors of Production in Determining Output per Worker, 2009




For sources, see Table 7.2.

## **Figure 7.4** Role of Productivity in Determining Output per Worker, 2009




For sources, see Table 7.2.





## Growth accounting

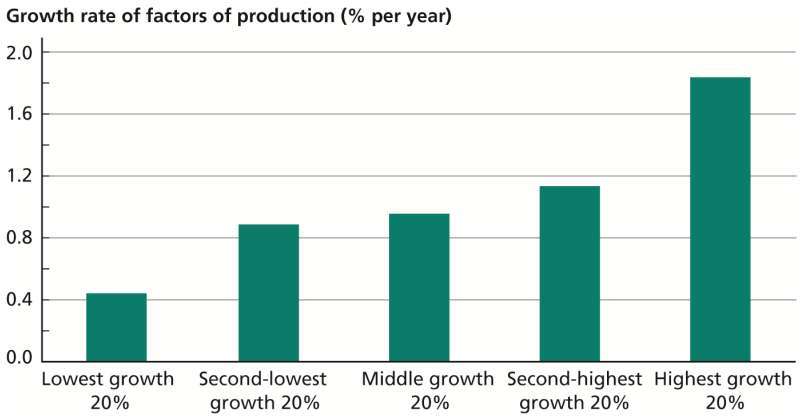
Output =productivity*factors of production

Output growth rate =
Productivity growth rate + growth rate of factors of production

The growth rate of factors of productions has to be weighted with respect to their share on output

Productivity growth rate=
Output growth rate – growth rate of factors of production

## **Figure 7.5** Role of Factors of Production in Determining Growth, 1975–2009

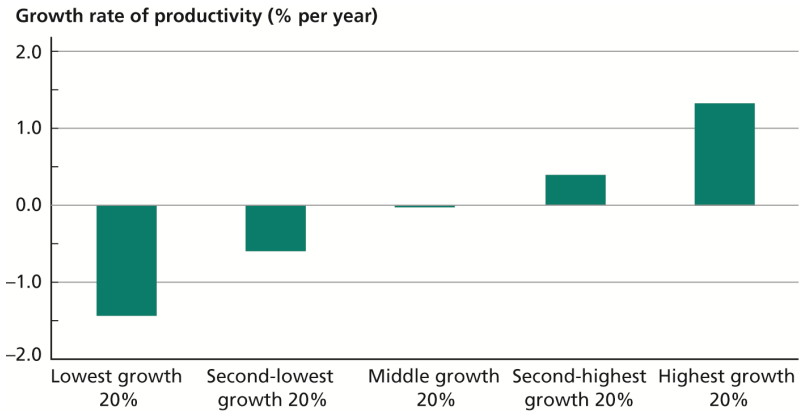



For sources, see Table 7.2.





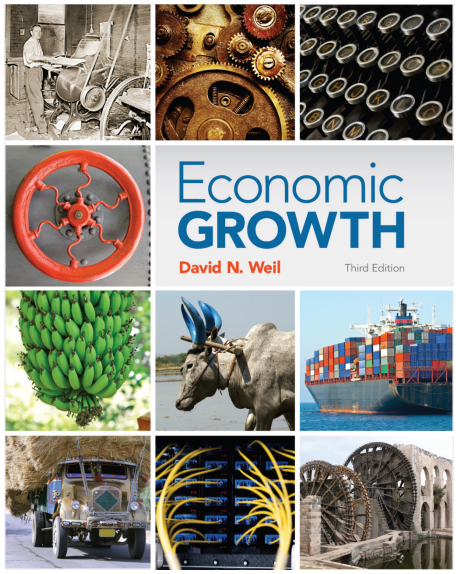
## **Figure 7.6** Role of Productivity in Determining Growth, 1975–2009




For sources, see Table 7.2.

Chapter 8

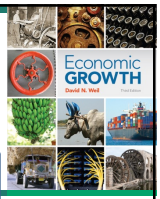
# THE ROLE OF TECHNOLOGY IN GROWTH








## **Table 8.1** Researchers and Research Spending, 2009

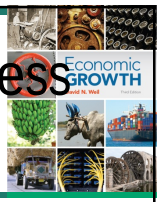


And Italy?

| Country | Number of Researchers | Researchers as a Percentage of the Labor Force | Research Spending ($ billions) | Research Spending as a Percentage of GDP |
|---|---|---|---|---|
| United States | 1,412,639 | 0.89% | 398.2 | 2.8% |
| Japan | 655,530 | 1.00% | 137.9 | 3.4% |
| Germany | 311,519 | 0.74% | 82.7 | 2.8% |
| France | 229,130 | 0.80% | 48 | 2.2% |
| Korea | 236,137 | 0.96% | 43.9 | 3.3% |
| OECD Total | 4,199,512 | 0.70% | 965.6 | 2.4% |

*Source:* OECD Main Science and Technology Indicators database.

# The nature of technological progress

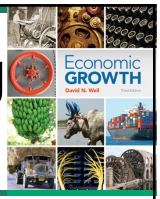



- Technology creation
- Technology transfer or diffusion
  - Non rivarly
  - Non excludability





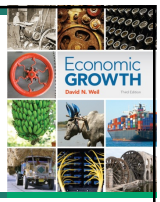
# Determinants of R&D spending




- Profit considerations
  - How much advantage with respect to followers
  - Size of the market
  - How long does the advantage last
  - Uncertainty

Concept of creative distruction

# One country model

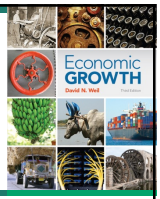



- Labour is the only factor
- Which can be used either in production or in the R&D
- $L = (L_Y + L_A)$
- $\gamma_A$ is the quota of labour used in R&D…
- Its function is similar to the saving rate in the Solow model





# Production function

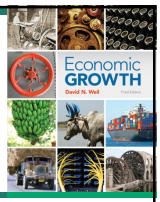



- Production function
- $Y=A(1-\gamma_A)L$

or in per worker terms

- $y=A(1-\gamma_A)$

# Process of productivity growth

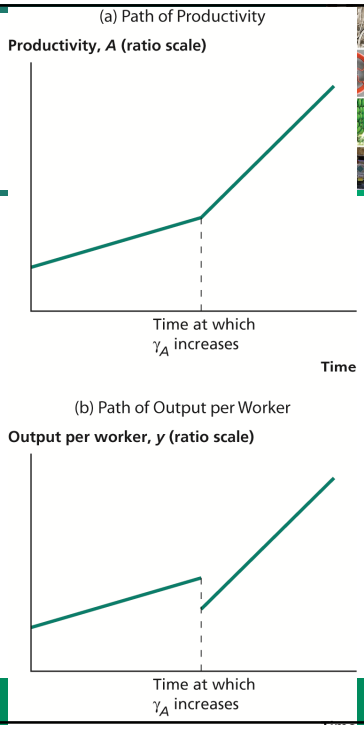



- Growth of A = $L_A/\mu$
- where $\mu$ represents the price/cost of the new invention
- The growth rate of A represents the growth rate of y

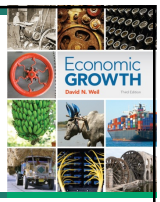




**Figure 8.1** Effect of Shifting Labor into R&D




# Two country model/1

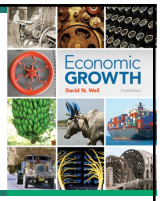



- $\gamma$ and $\mu$ are now different among countries
- One country invests more in R&D and it is the leader (country 1) the other one is the follower (country 2)
- $Y_1=A_1(1-\gamma_{A1})L_1$ .... $y_1=A_1(1-\gamma_{A1})$
- $Y_2=A_2(1-\gamma_{A2})L_2$ .... $y_2=A_2(1-\gamma_{A2})$
- where $\gamma_{A1} > \gamma_{A2}$



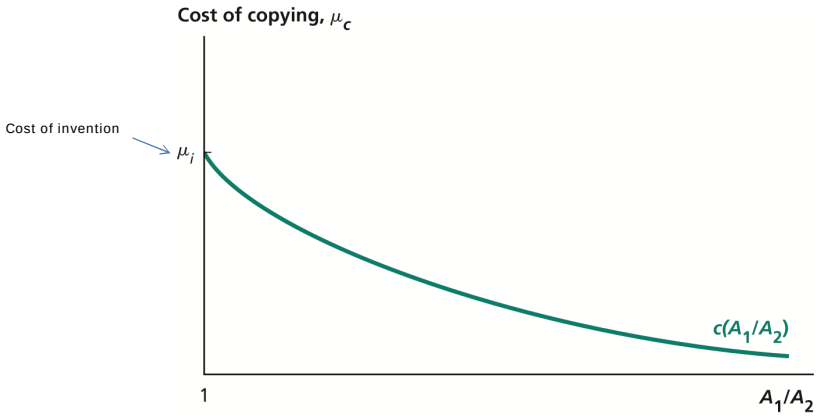


# Two country model/2




- Country 1 invents and innovates
- Country 2 imitates and/or does incremental innovation
- $\hat{A}_1 = (\gamma_{A1}/\mu_i)L$ where $\mu_i$ is the cost of invention
- $\mu_c$ is the cost of copying for country 2 and it is given by a function of $A_1/A_2$
- $\mu_c = c(A_1/A_2)$ and $A_2 = (\gamma_{A2}/\mu_c)L_2$

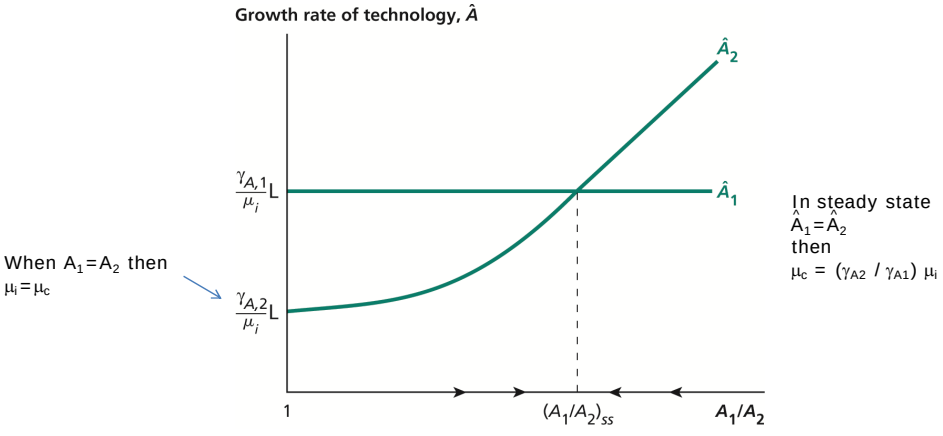
# **Figure 8.2** Cost of Copying for the Follower Country



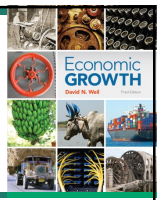


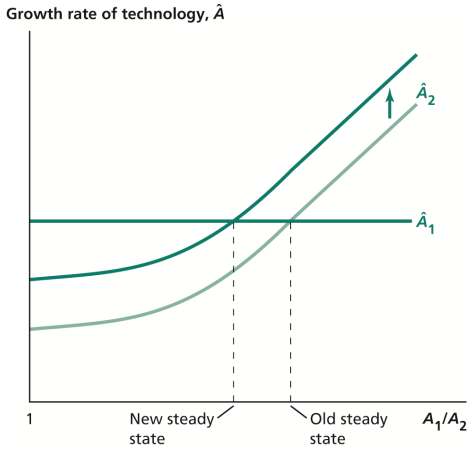



# **Figure 8.3** Steady State in the Two-Country Model



## **Figure 8.4** Effect of an Increase in R&D in the Follower Country on the Steady State

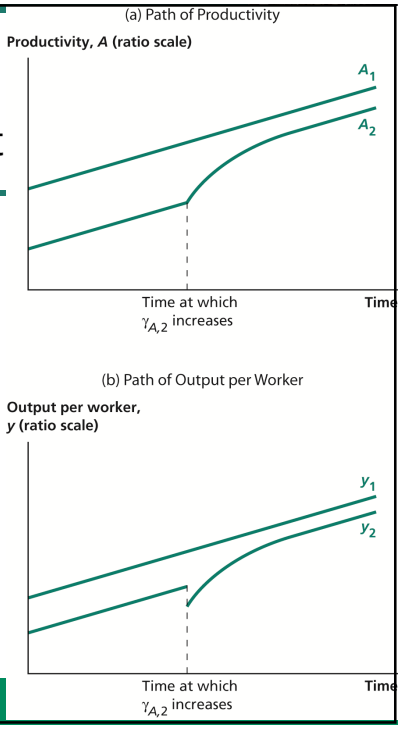


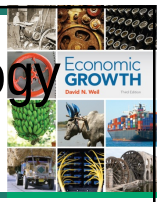





## **Figure 8.5** Effect of an Increase in $\gamma_{A,2}$ on Productivity and Output



# Barriers to international technology transfer

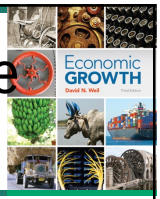



- Appropriate technology
- Tacit knowledge
- Patents and other tools to appropriate R&D returns



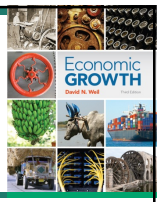


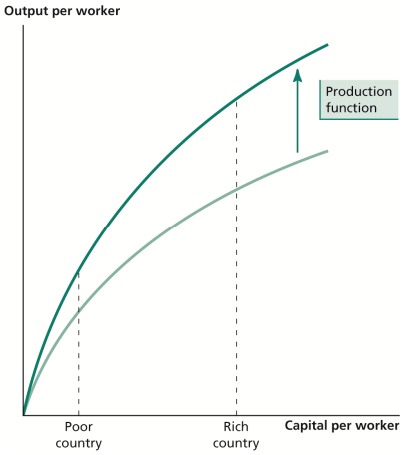
# Increasing returns to knowledge accumulation




- Let us take the example of tacit knowledge and of local public good
- ...then there might be increasing returns at the local level
- ..and the world (made of rich and poor countries) would be diverging rather than moving at the same speed

# **Figure 8.6** Neutral Technological Change

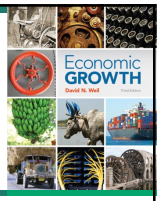


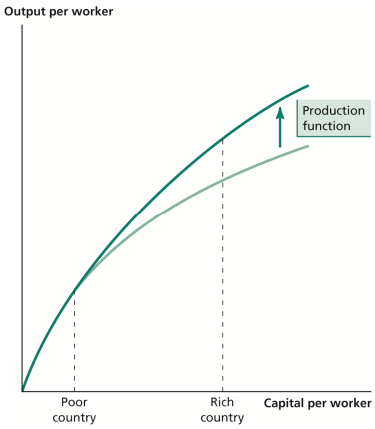







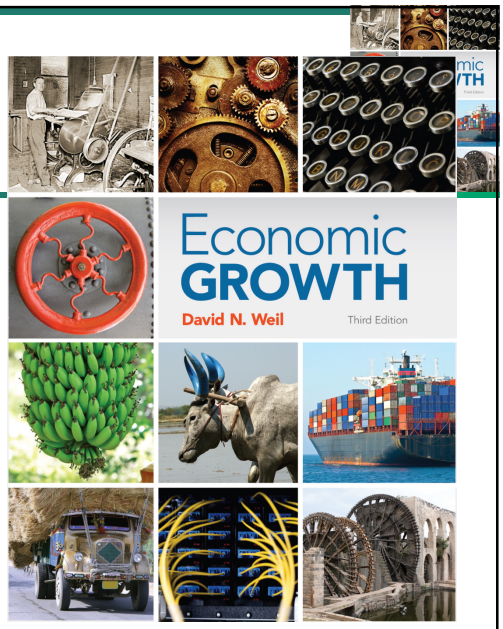

# **Figure 8.7** Capital-Biased Technological Change



Chapter 9

# THE CUTTING EDGE OF TECHNOLOGY

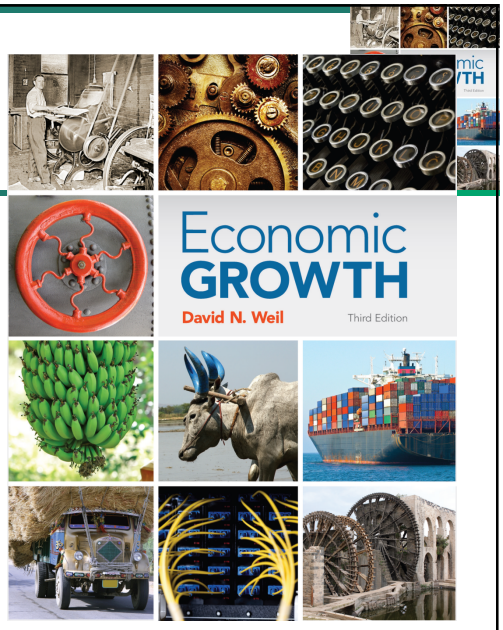


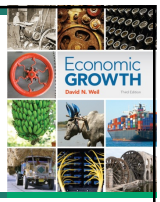





Chapter 10

# EFFICIENCY





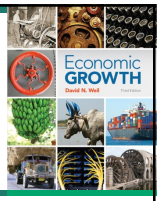

## **Table 10.1** Decomposition of Productivity Gap Between India and the United States

$A = T * E, \qquad A_{india}/A_{usa} = 0.35$

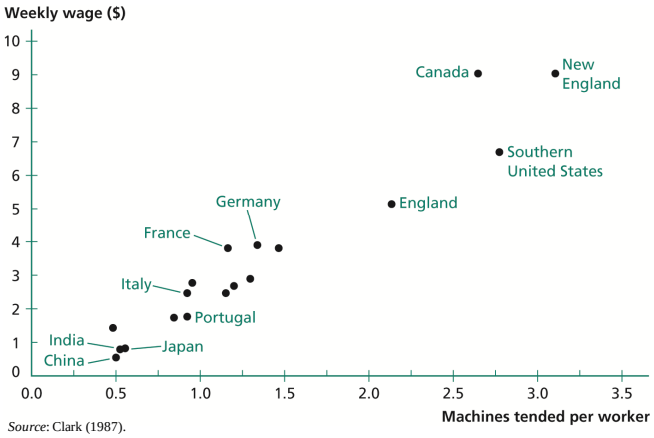
| Years India Lags United States in Technology (*G*) | Level of Technology in India Relative to United States (*T*) | Level of Efficiency in India Relative to United States (*E*) |
|---|---|---|
| 10 | 0.95 | 0.33 |
| 20 | 0.90 | 0.35 |
| 30 | 0.85 | 0.36 |
| 40 | 0.81 | 0.38 |
| 50 | 0.76 | 0.41 |
| 75 | 0.67 | 0.46 |
| 100 | 0.58 | 0.53 |
| 125 | 0.51 | 0.61 |





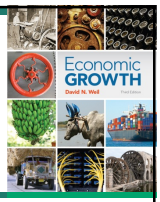



## **Figure 10.1** Wages and Machines in the Textile Industry, 1910




*Source*: Clark (1987).

## **Table 10.2** Productivity in Selected Industries in the Early 1990s

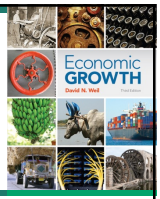



| | United States | Japan | Germany |
|---|---|---|---|
| **Automobiles** | 100 | 127 | 84 |
| **Steel** | 100 | 110 | 100 |
| **Food Processing** | 100 | 42 | 84 |
| **Telecommunications** | 100 | 51 | 42 |
| **Aggregate Productivity** | 100 | 67 | 89 |



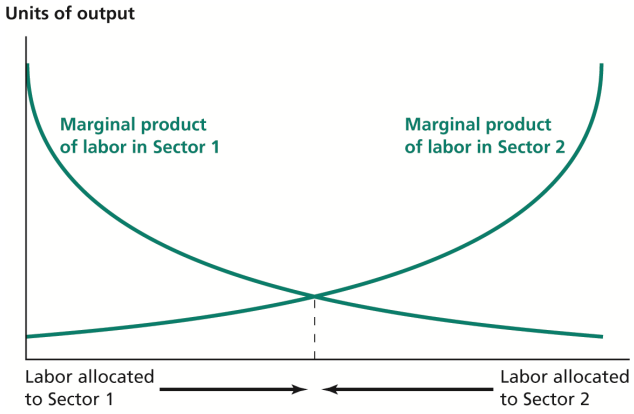


## Types of inefficiencies




- Unproductive activities
  - Rent seeking phenomena (licences)
- Idle resources
  - Unemployment
  - Under participation to labour force
- Misallocation of factors among sectors and firms
  - Barriers to mobility
  - Wages not equal to marginal product

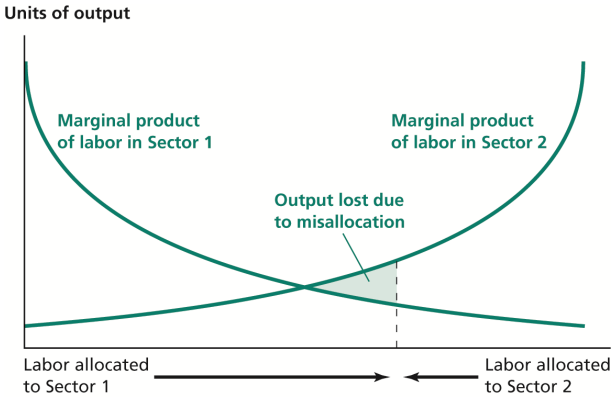
## **Figure 10.3** Efficient Allocation of Labor between Sectors



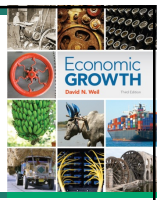


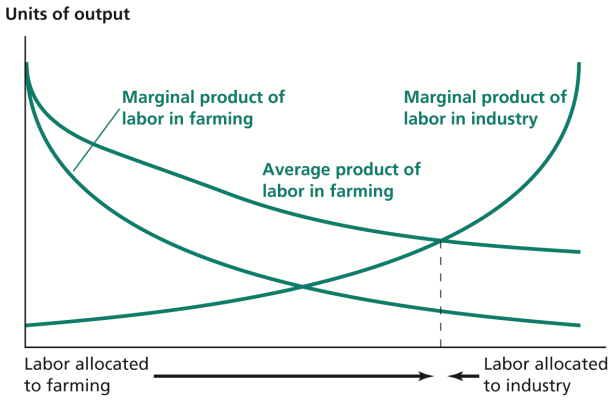



## **Figure 10.4** Overallocation of Labor to Sector 1



## **Figure 10.5** Overallocation of Labor to Farming When Farmworkers Are Paid Their Average Product



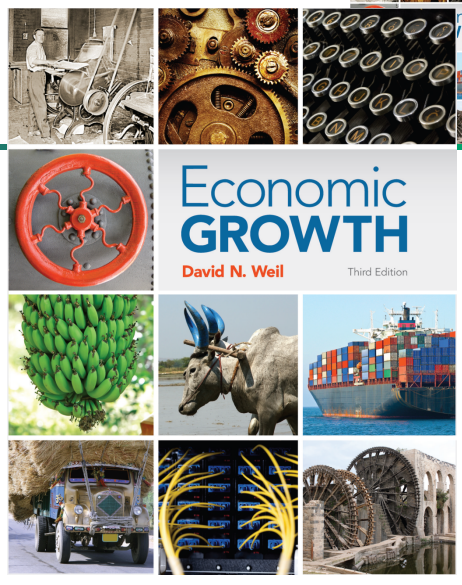





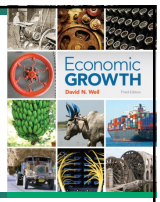



Chapter 11

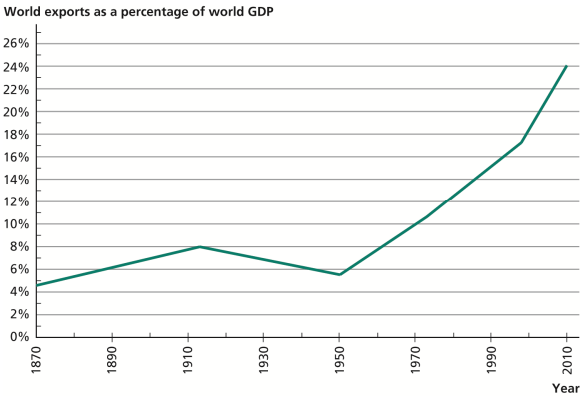
# GROWTH IN THE OPEN ECONOMY



# **Figure 11.1** Growth of World Trade, 1870–2010




Thanks to:
•Decreasing transport costs
•Easier diffusion of information
•Trade policy

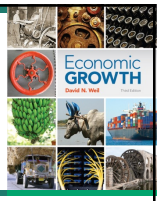


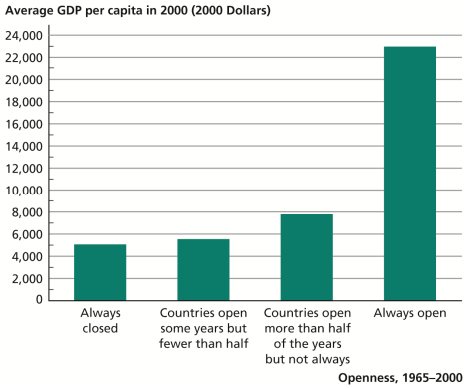

*Sources*: Maddison (2001), World Bank (2007a).





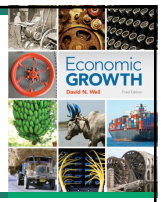
# **Figure 11.2** Relationship between Economic Openness and GDP per Capita

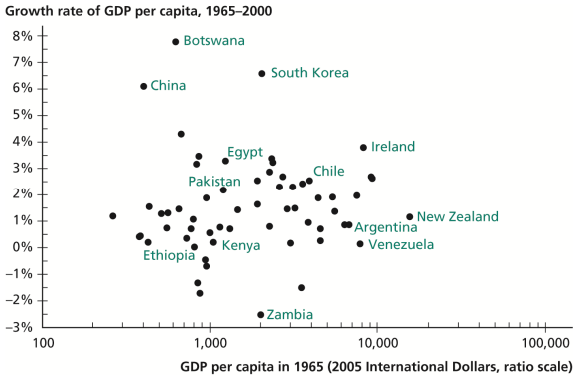



*Sources*: Sachs and Warner (1995), Wacziarg and Welch (2008).

# **Figure 11.3** Growth in Closed Economies



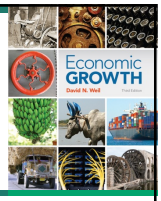



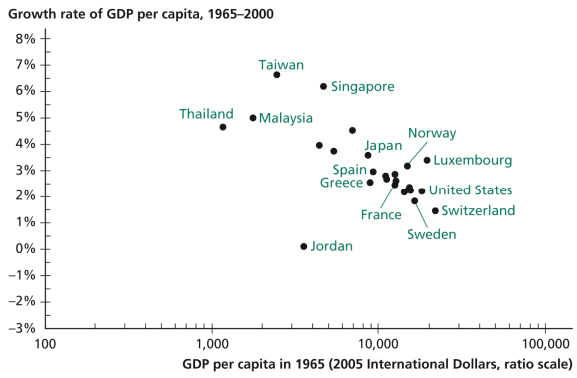

*Sources*: Sachs and Warner (1995), Wacziarg and Welch (2008), Heston et al. (2011).





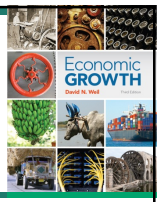
# **Figure 11.4** Growth in Open Economies




*Sources*: Sachs and Warner (1995), Wacziarg and Welch (2008), Heston et al. (2011).

# **Table 11.1** Prices in Japan before and after Opening to Trade



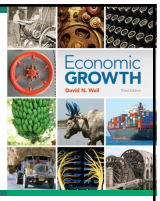

| | Price Before Opening (U.S. cents per pound) | Price After Opening (U.S. cents per pound) |
|---|---|---|
| **Tea** | 19.7 | 28.2 |
| **Sugar** | 22.7 | 11.2 |

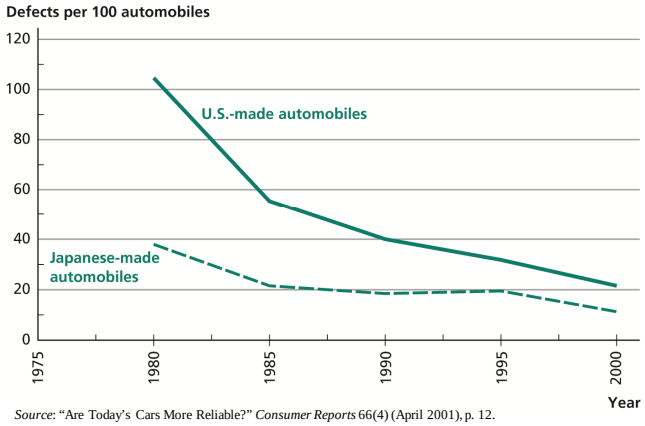
*Source*: Huber (1971).





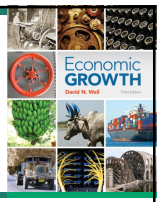
# **Figure 11.6** Quality of U.S.- and Japanese-made Automobiles




*Source*: "Are Today's Cars More Reliable?" *Consumer Reports* 66(4) (April 2001), p. 12.

# Effects of openess




- Specialisation
- More competition
- Better allocation of factors across countries
- ...