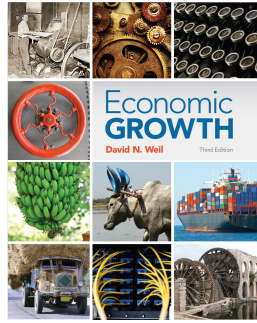


# Chapter 7

## MEASURING PRODUCTIVITY



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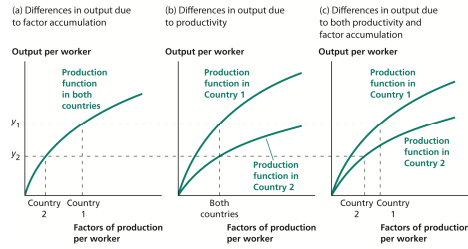
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**Figure 7.1** Possible Sources of Differences in Output per Worker



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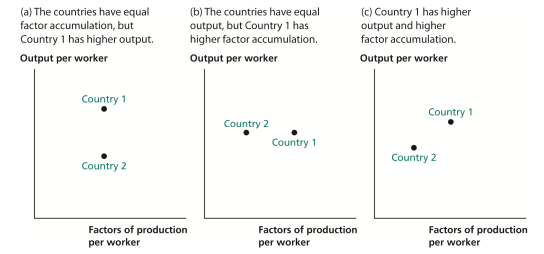
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**Figure 7.2** Inferring Productivity from Data on Output and Factor Accumulation



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## productivity accounting

Ratio of output =

Ratio of productivity \* Ratio of factors of production

Ratio of productivity =

Ratio of income / Ratio of factors of production

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**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

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**Table 7.2** Development Accounting

Country	Output per Worker, $y$	Physical Capital per Worker, $k$	Human Capital per Worker, $h$	Factors of Production, $A^{1/3}y^{2/3}$	Productivity, $A$
United States	1.00	1.00	1.00	1.00	1.00
Norway	1.12	1.22	0.96	1.08	1.04
United Kingdom	0.82	0.98	0.87	0.80	1.03
Canada	0.80	0.81	0.98	0.91	0.88
Japan	0.73	1.16	0.95	1.04	0.70
South Korea	0.62	0.92	0.98	0.90	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	0.75	0.48	0.42
India	0.10	0.069	0.66	0.34	0.21
Kenya	0.032	0.022	0.73	0.23	0.14
Maliawi	0.016	0.028	0.67	0.21	0.067

Source: Output per worker: Heston, Summers and Aten (2002); physical capital: author's calculations; human capital: Barro and Lee (2001). The data set used here is all in constant 1990 US dollars for physical capital and constant 2000 US dollars for output.

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## Problems with measuring capital and implications

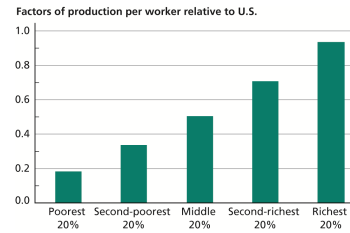


- Waste of investment
- Quality of investment
- There are estimate according to which the actual level of the capital stock is in between 60% to 75% of the official statistics...

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



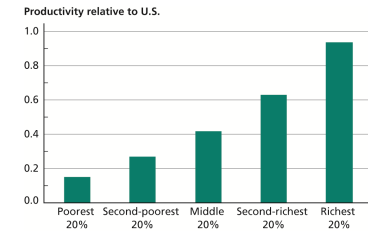
For sources, see Table 7.2.

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



For sources, see Table 7.2.

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### 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 production has to be weighted with respect to their share on output

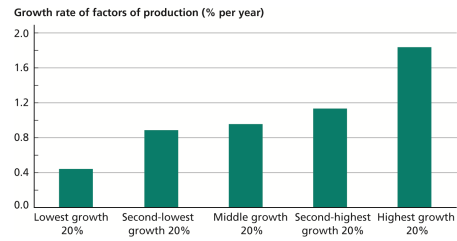
Productivity growth rate =  
Output growth rate - growth rate of factors of production

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



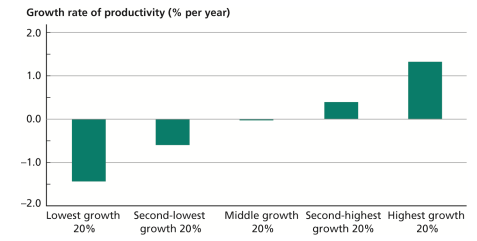
For sources, see Table 7.1.

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



For sources, see Table 7.1.

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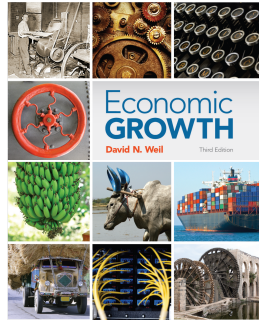
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Chapter 8

# THE ROLE OF TECHNOLOGY IN GROWTH



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**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.

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## The nature of technological progress

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

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## 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 destruction

## One country model



- Labour is the only factor
- Which can be used either in production or in the R&D
- $\gamma_A$  is the quota of labour used in R&D...
- Its function is similar to the saving rate in the Solow model

## 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  $y$

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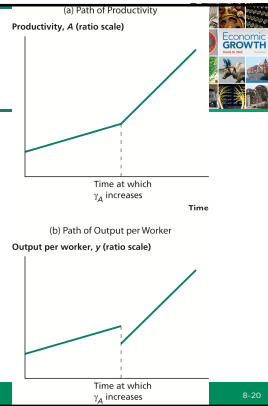
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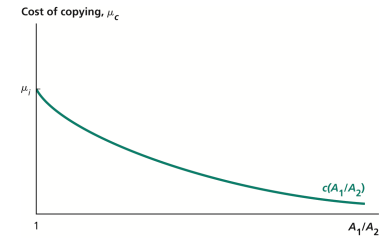
**Figure 8.1** Effect of Shifting Labor into R&D



## Two country model

- $\mu$  is now different among countries
  - One country invests more in R&D and it is the leader the other one is the follower
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**Figure 8.2** Cost of Copying for the Follower Country




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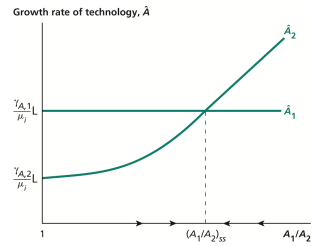
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**Figure 8.3** Steady State in the Two-Country Model



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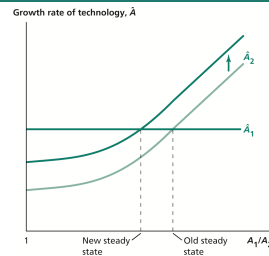
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**Figure 8.4** Effect of an Increase in R&D in the Follower Country on the Steady State



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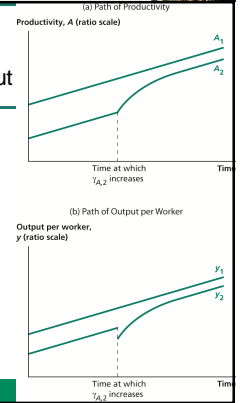
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**Figure 8.5** Effect of an Increase in  $\gamma_{A,2}$  on Productivity and Output



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## Barriers to international technology transfer



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

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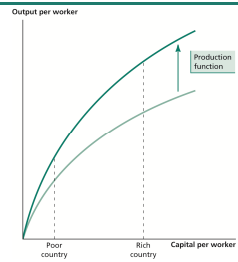
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### Figure 8.6 Neutral Technological Change



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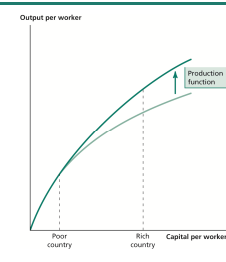
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### Figure 8.7 Capital-Biased Technological Change



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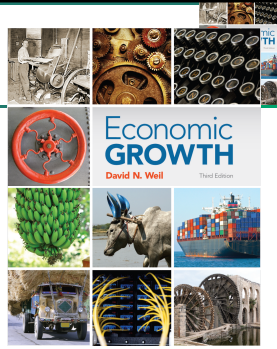
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## Chapter 9

# THE CUTTING EDGE OF TECHNOLOGY



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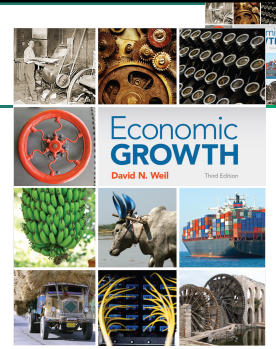
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## Chapter 10

# EFFICIENCY



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

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

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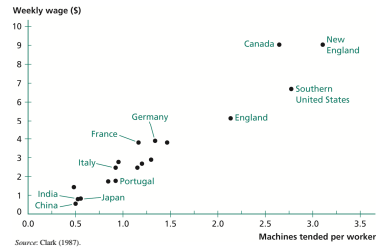
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**Figure 10.1** Wages and Machines in the Textile Industry, 1910



Source: Clark (1987).  
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**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

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## Types of inefficiencies

- Unproductive activities
  - Rent seeking phenomena
- Idle resources
- Misallocation of factors among sectors
  - Barriers to mobility
  - Wages not equal to marginal product

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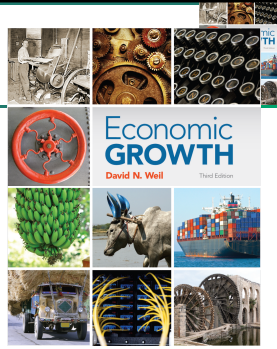
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# Chapter 11

## GROWTH IN THE OPEN ECONOMY



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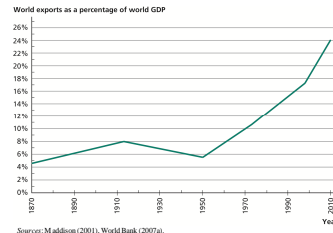
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### Figure 11.1 Growth of World Trade, 1870–2010



Source: M. Addison (2011), World Bank (2007a).

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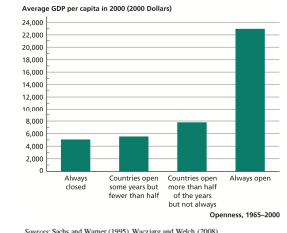
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### Figure 11.2 Relationship between Economic Openness and GDP per Capita



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

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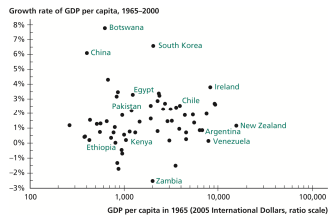
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**Figure 11.3 Growth in Closed Economies**



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

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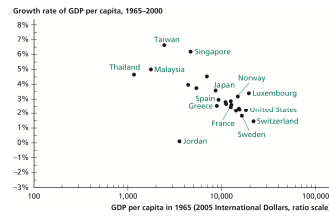
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**Figure 11.4 Growth in Open Economies**



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

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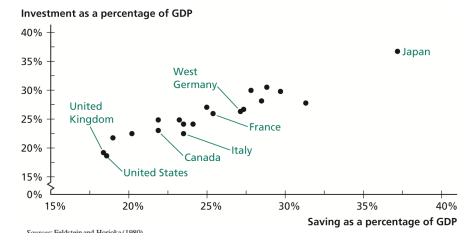
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**Figure 11.5 Saving and Investment Rates of Industrialized Countries, 1960–1974**



Source: Fildes and Horikawa (1980).

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**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)
<b>Tea</b>	19.7	28.2
<b>Sugar</b>	22.7	11.2

Source: Haber (1971).

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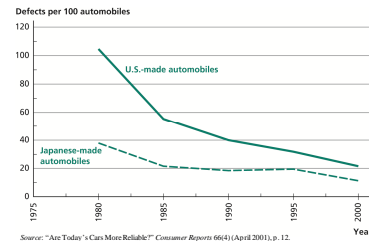
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**Figure 11.6** Quality of U.S.- and Japanese-made Automobiles



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

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