Answers to Text Questions and Problems in Chapter 14

Answers to Review Questions

1. Since 1870, real GDP per person has grown almost tenfold in Canada and many other industrial countries; and by twenty-five-fold in Japan. These large increases in output per person have led to substantial increases in the material standard of living of the average person.

2. Real GDP per person (a basic determinant of living standards) equals average labour productivity times the share of the population that is employed. The share of the population that is employed can only rise so far; it can never exceed 100%. Thus, large long-term gains in output per person (and hence living standards) generally must come from increases in average labour productivity.

3. Human capital is the talents, education, training, and skills of workers. Human capital is important because workers with more human capital are more productive, implying higher levels of output per worker and higher living standards. New human capital is created through “investment in people,” as when individuals spend time and money acquiring an education, or an employer devotes resources to training workers.

4. To get the most output (in terms of ditches dug), you should give the first shovel to the strongest worker, the next shovel to the second strongest worker, and so on until you run out of shovels. Because a stronger worker can make better use of a shovel than a worker who is less muscular, this strategy is consistent with the principle that limited resources should be devoted first to their most productive uses. Since workers without shovels produce nothing, the more shovels you have, the more total output and output per worker will be produced; thus extra capital (shovels) enhances average labour productivity. However, because an extra shovel will be used by a worker who is weaker than those who already have shovels, the extra output made possible by each additional shovel is declining (diminishing returns to capital).

5. Entrepreneurs are people who create new business enterprises. By combining workers with new and more productive technologies, or by having them produce more highly valued products and services, entrepreneurs increase the productivity of any given set of workers.

6. Among the policies that governments can use to promote growth are encouraging the development of human capital (for example, by support of education); encouraging high rates of saving and investment (for example, through tax breaks); public investment in infrastructure (such as highways, bridges, and communications networks); and support of basic research. A particularly important function of government is to provide a political and legal environment conducive to growth, including a stable political system, well-defined property rights, free and open exchange of ideas, and a tax and regulatory system favourable to entrepreneurship and other economically productive activities.

7. An explanation that was popular in the 1970s, the fourfold increase in oil prices, fell out of favour when declines in oil prices did not restart productivity growth. Some economists believe that at least part of the slowdown is a figment of measurement procedures, which may understate improvements in quality and hence productivity. Another idea is the technological depletion hypothesis. According to this view, the 1950s and 1960s experienced rapid productivity growth because of the availability of a backlog of technological opportunities that were not commercially applied during the Depression and the Second World War. As these opportunities were used up, productivity began to slow. Consistent with this view is a recent pickup in productivity growth, which seems to be associated with a new wave of technological change in computing, communications, and genetics.
8. The environment may pose limits on the expansion of current types of economic activities (more and more cars and factories). Global environmental problems, which generally are not handled very well by the market or by individual national governments, also pose a concern. However, reasons that the “limits to growth” thesis may be overstated include: 1) economic growth includes the development of better and more efficient products and services, which may be less taxing on the environment than current products; 2) economic growth provides additional resources that can be used to help protect the environment; and 3) market mechanisms will tend to alleviate shortages of resources by dampening demand and encouraging supply, as happened in the 1970s energy crisis.

Answers to Problems

1. After one year, Richland’s real GDP per person equal 10,000 \times 1.01, after two years it equals 10,000 \times 1.01 \times 1.01 = 10,000 \times (1.01)^2, and so on. After ten years, Richland’s GDP per person equal 10,000 \times (1.01)^{10} = 11,046, and after twenty years it equals 10,000 \times (1.01)^{20} = 12,202. Poorland’s GDP per person after ten years is 5000 \times (1.03)^{10} = 6720, and after twenty years it equals 5000 \times (1.03)^{20} = 9031. So after twenty years Poorland has gone from half the level of income of Richland to about three-quarters the level.

Suppose that GDP per person in Richland and Poorland are equal after \( t \) years; our objective is to find \( t \). After \( t \) years Poorland’s GDP per person is 5000 \times (1.03)^t, and Richland’s GDP per person is 10,000 \times (1.01)^t. Setting these two expressions equal, and dividing both sides by 5000, we get (1.03)^t = 2 \times (1.01)^t. By solving the above equation for \( t \) (algebraically, graphically, or by trial and error), we find that Poorland catches up in between 35 and 36 years. Using the rule of 72, it will take 72 years for GDP per person to double in Richland (72/1), but only 24 years for GDP per person to double in Poorland (72/3).

2. From Table 14.3, Canadian average labour productivity grew by 2.1% per year over the period 1960-73, 0.8% per year during 1973-79, 0.7% per year in 1979-1992, and 1.4% per year in the period 1992-2006.

Let \( x \) be Canadian average labour productivity in 1973. If average labour productivity had grown at 2.1% per year over the 33-year period from 1973 to 2006, in 2006 it would have equaled \( x \times (1.021)^{33} \), or 1.985 \times x. We would like to compare that with actual Canadian productivity in 2006.

To determine actual Canadian labour productivity using only the information in Table 14.3, recall first that productivity grew by 0.8% per year during 1973-79. So if productivity in 1973 equaled \( x \), in 1979 productivity equaled \( x \times (1.008)^6 \). Over the next 13 years productivity grew at 0.7%, so productivity in 1992 equaled \( [x \times (1.008)^6] \times (1.007)^{13} \times x \). Then, over the next 14 years, productivity grew at 1.4%, so in 2006, productivity equaled \( [x \times (1.008)^6] \times (1.007)^{13} \times (1.014)^{14} \times x \).

Dividing 1.985 \times x by 1.395 \times x (and noting that the initial level of productivity, \( x \), cancels out), we get the answer 1.423. In short, if average labour productivity had continued to grow at its 1960-73 rate
until 2006, in the latter year, output per worker in the Canadian economy would have been 42.3% higher than was actually the case, quite a significant difference.

3. GDP per capita is average labour productivity times the share of the population that is employed. Hence, in 2007, GDP per capita was $77,688 \times 0.511$, or $39,736$ (with rounding). If average labour productivity had risen but the share of the population employed had stayed the same, then 2007 GDP per capita would have been $77,688 \times 0.332$, or $25,792$.

4. Since output per person equals average labour productivity times the share of the population employed, we know that average labour productivity equals output per person divided by the share of the population employed. Calculating average labour productivity for the two countries, we get

<table>
<thead>
<tr>
<th></th>
<th>1979</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>$44,182</td>
<td>$60,596</td>
</tr>
<tr>
<td>Japan</td>
<td>$34,743</td>
<td>$50,300</td>
</tr>
</tbody>
</table>

In Canada, average labour productivity increased by 37% over the period, while the employment-population ratio increased by 20%, so most of the increase in output per person in Canada was the result of increased labour productivity. In Japan, average labour productivity increased by 45%, while the employment-population ratio increased by 23%. For both countries, then, the bulk of the gains were from productivity increases.

5a. If Joanne goes to work, she will earn $20,000 per year for the next five years. After living expenses she will save $5000 per year, so at the end of the five years she will have savings of $25,000 (assuming zero interest earnings). If she goes to college, she will earn $38,000 per year in years 3-5, for a total of $114,000. Subtracting five years’ living expenses ($75,000) and student loan repayments ($12,000), she will be left with $27,000 in savings at the end of the five years. So she should go to college. Note that Joanne’s objective of maximizing her savings after five years takes no account of what is perhaps an even stronger economic incentive for further education, which is that after five years she will have a $38,000 per-year job rather than a $20,000 per-year job.

b. If Joanne can earn $23,000 per year with a high school degree, she will be able to save $8000 per year, leaving her $40,000 at the end of five years. Her savings after five years if she goes to college are $27,000, as we found in part a. So in this case she should not make the investment of furthering her education. Economically speaking, her opportunity cost of two years in college is higher when she can earn $23,000 rather than $20,000 by going directly to work.

c. If tuition and books cost $8000 per year, Joanne will have to repay $16,000 in student loans rather than $12,000, and her savings at the end of five years will be ($114,000 – $75,000 – $16,000) = $23,000, less than the $25,000 in savings she will have if she goes directly to work. A higher cost of obtaining an education makes doing so less economically attractive.

d. If she goes directly to work, Joanne will add $5000 to her savings at the end of each year, years 1 to 5. Let’s find her total savings, including interest, at the end of year 5. At the end of year 5, the $5000 Joanne deposits at the end of year 1 will be worth $5000 \times (1.10) \times (1.10) \times (1.10) \times (1.10) = $5000 \times (1.10)^4 = $7321$.

Similarly, at the end of year 5 the $5000 she deposits at the end of year 2 will be worth $5000 \times (1.10)^3 = $6655; her deposit at the end of year 3 will be worth $5000 \times (1.10)^2 = $6050; her deposit at the end of year 4 will be worth $5000 \times (1.10) = $5500; and her last deposit will be worth $5000. Adding these five amounts yields total saving at the end of year 5 of $30,526.

If Joanne goes to college, at the end of year 1 she will have a debt of $21,000 (living expenses plus tuition and books). At 10% interest, at the end of year 5 this debt will have grown to $21,000 \times (1.10)^4 = $30,746. Another debt of $21,000 at the end of year 2 will have grown to $21,000 \times (1.10)^3 = $27,951 by
the end of year 5. In years 3 to 5, Joanne will earn $38,000 and spend $15,000 on living expenses, saving $23,000 each year. At the end of 5 years the value of these savings will be $(23,000) \times (1.10)^2 + (23,000) \times (1.10) + 23,000 = 27,830 + 25,300 + 23,000 = 76,130.

Subtracting Joanne’s debts of $30,746 and $27,951 from her saving yields $17,433 in assets at the end of five years, less than if she skips college. So, on purely economic grounds, Joanne should go directly to work. This example illustrates that a higher interest rate reduces the value of activities that involve incurring costs now in exchange for higher benefits later.

6a. With four employees and two lanes, both lanes have a checker and a bagger. Total output is 80 customers per hour. Average labour productivity is $80/4 = 20$ customers per hour per worker.

b. A bagger increases output by 15 customers per hour (the difference between the 40 customers serviced by a checker and a bagger and the 25 customers served by a checker only). If there is an empty lane available, a checker increases output by 25 customers. So the best strategy is to take one of the baggers and make him or her a checker in the new lane. Total output is $40 + 25 + 25 = 90$ customers per hour, and average labour productivity is 22.5 customers per hour. Note that adding capital (the extra lane) increases both total output and average labour productivity.

c. With four lanes, all four employees become checkers. Total output is 100 customers and average labour productivity is 25 customers per hour. Because there are only four employees, a fifth lane adds no output (average labour productivity remains 25 customers per hour). We do observe diminishing returns to capital, at least for the fifth lane. Adding a third lane increases output by 10 customers per hour, as does adding a fourth lane. However, adding a fifth lane does not increase output further.

7a. As a team, the three painters can paint 84 square metres in 3 painter-hours. So productivity is $84/3 = 28$ square metres per painter hour.

b. The first roller should be given to Fred, as it increases his production by the largest amount. The second and third rollers should be given to Harrison and Carla (in either order). There is no one to use the fourth roller. With this information we can calculate total output for the team per hour and total output per painter-hour as follows:

<table>
<thead>
<tr>
<th>Number of rollers</th>
<th>Output by team</th>
<th>Output per painter-hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>84</td>
<td>84/3 = 28</td>
</tr>
<tr>
<td>1</td>
<td>120</td>
<td>120/3 = 40</td>
</tr>
<tr>
<td>2</td>
<td>150</td>
<td>150/3 = 50</td>
</tr>
<tr>
<td>3</td>
<td>180</td>
<td>180/3 = 60</td>
</tr>
<tr>
<td>4</td>
<td>180</td>
<td>180/3 = 60</td>
</tr>
</tbody>
</table>

The first roller increases the team’s output by 36, the second increases it by 30, the third by 30, and the fourth by zero. Since the extra output produced by an extra roller declines with more rollers (except for the third roller, which has the same addition to output as the second), we observe diminishing returns to capital.

c. With the technological improvement, the table in part b becomes:

<table>
<thead>
<tr>
<th>Number of rollers</th>
<th>Output by team</th>
<th>Output per painter-hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100.8</td>
<td>100.8/3 = 33.6</td>
</tr>
<tr>
<td>1</td>
<td>144</td>
<td>144/3 = 48</td>
</tr>
<tr>
<td>2</td>
<td>180</td>
<td>180/3 = 60</td>
</tr>
<tr>
<td>3</td>
<td>216</td>
<td>216/3 = 72</td>
</tr>
<tr>
<td>4</td>
<td>216</td>
<td>216/3 = 72</td>
</tr>
</tbody>
</table>
After the technological improvement, the first roller increases the team’s output by 43.2, the second by 36, the third by 36, and the fourth by zero. So we still observe diminishing returns to capital. However, the economic value of additional rollers has increased, since each roller adds more output than before.

8a. Zero, as that will allow her stock of fish to double by next year.
8b. Maximizing the growth of her stock of fish has the disadvantage that it allows Hester no current income to spend. In other words, Hester can have the benefit of a very high income and consumption next year only at the cost of starving herself this year. Analogously, the more a country is willing to “starve itself” this year, by saving and investing its resources in new capital goods rather than consuming, the faster it will grow.
8c. To maximize her current income Hester should sell all her fish this year, realizing $5000. The problem with this strategy is that it leaves no source of income for the future.
8d. If Hester harvests none of her fish this year, she has no income this year; and if she harvests all of her fish this year, she has no income next year. Having very low or zero income in either year is very unpleasant for Hester. A better choice is to sell some fish this year, allowing for a reasonable level of current income and consumption, while leaving enough fish in the hatchery to provide for reasonable income in the future as well. In the same way, a country should choose a rate of economic growth that balances the cost of sacrificing consumption today against the benefits of higher income and consumption in the future.

9. The chapter argues that this statement is true. One way to see this point is to compare rich and poor countries in the world today. In principle, at a given time all countries have access to the same basic scientific information. But poor countries do not benefit from existing scientific knowledge to the same degree rich countries do, because they lack the resources to apply the knowledge widely. Thus, medical knowledge is of limited help without hospitals, medicines, and trained personnel (not to mention adequate nutrition and sanitation). Similarly, new developments in communications and computing can be utilized only when there are sufficient resources to support an infrastructure of communications equipment, computers, and the like.

Sample Homework Assignment

1. You have a choice between depositing your $100 into an account that earns 5% simple interest for 10 years or one that earns 4% compound interest for 10 years. Which would you choose? What if you were depositing your $100 for 25 years?

2. The country Delta has a real GDP per person of $1000. What is the difference in Delta’s real GDP per person after 10 years if it has a 1% growth rate in real GDP per person versus 2%?

3. The country Delta has a population of 30, 20 employed workers, and a real GDP of $18,600. Find:
   a. average labour productivity.
   b. the share of the population that is employed.

Multiple Choice Quiz

1. Economists focus on which of the following measures as an indication of a country’s standard of living?
   a. The unemployment rate.
   b. Inflation.
   c. GDP.
d. GDP per person.
e. Interest rates.

2. The payment of interest not only on the original deposit but on all previously accumulated interest is known as
a. compound interest.
b. real interest.
c. nominal interest.
d. prime interest.
e. natural interest.

3. Which of the following has not contributed to the increase in real GDP in Canada over the past four decades?
a. Increasing female labour force participation.
b. The baby boom.
c. Increasing average labour productivity.
d. The rising share of Canadians with jobs.
e. Decreasing male labour force participation.

4. The talents, education, training, and skills of workers are known as
a. physical capital.
b. personal capital.
c. human capital.
d. labour capital.
e. worker capital.

5. A good that is long-lasting and is used to produce other goods is called
a. physical capital.
b. personal capital.
c. human capital.
d. labour capital.
e. worker capital.

6. Diminishing returns to capital imply that, holding labour and other inputs constant, as more capital is added, each additional unit of capital adds
a. more to production.
b. less to production.
c. more to costs.
d. less to costs.
e. more to labour productivity.

7. People who create new economic enterprises are known as
a. managers.
b. founders.
c. entrepreneurs.
d. labour.
e. CEOs.
8. Which of the following is not a measure that policymakers might take to raise a country’s rate of economic growth?
   a. Increase human capital.
   b. Promote saving and investment.
   c. Support research and development.
   d. Provide an appropriate political and legal framework.
   e. Restrict international trade.

9. To promote economic growth, most poor countries especially need to improve which of the following?
   a. Human capital.
   b. Saving and investment.
   c. Research and development.
   d. An appropriate legal and political framework.
   e. Physical capital.

10. The influential 1972 book that reported the results of computer simulations suggesting that, unless population growth and economic expansion were halted, the world would run out of natural resources was titled
    a. *Collapse of the World Economy*.
    c. *Preserving Natural Resources*.
    d. *Silent Spring*.
    e. *The Limits to Growth*.

### Problems/Short Answer

1. How much would $500 deposited in an account be worth after two years with
   a. 5% simple interest?
   b. 5% compound interest?

2. The country Delta has a real GDP of $18,600, a population of 30, and 20 employed workers. If a new technology is introduced that increases real GDP to $25,000, what is the increase in average labour productivity in Delta as a result of the technological change?

### Answer Key to Extra Questions in Instructor’s Manual

#### Sample Homework Assignment

1. $100 deposited for 10 years at 5% simple interest would be worth $100 + 10 ($5) = $150. $100 deposited for 10 years at 4% compound interest would be worth $100 (1.04)^{10} = $148.02. So you would choose 5% simple interest.

   $100 for 25 years at 5% simple interest would be worth $100 + 25 ($5) = $225. $100 deposited for 25 years at 4% compound interest would be worth $100 (1.04)^{25} = $266.58. So you would choose 4% compound interest.
2. A 1% growth rate will raise real GDP per person to \(1000 \times (1.01)^{10} = 1104.62\), while a 2% growth rate will raise real GDP per person to \(1000 \times (1.02)^{10} = 1218.99\).

3a. \(\frac{18,600}{20} = 930\).
   b. \(\frac{20}{30} = 0.67\) or 67%.

**Multiple Choice**

1. d  
2. a  
3. e  
4. c  
5. a  
6. b  
7. c  
8. e  
9. d  
10. e

**Problems/Short Answer**

1a. \(500 + (2 \times 25) = 550\).
   b. \(500 \times (1.05)^2 = 551.25\).

2. Average labour productivity goes from \(18,600/20 = 930\) to \(25,000/20 = 1250\). This is an increase of \$320, which is a 34% increase (320/930).