Economic Growth and Sustainable Development

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Chapter 1

1) Does negative economic growth necessarily mean real national output has declined?

Explain. For example, in Venezuela, the growth rates in real gross domestic product for 2009 and 2010 were -3.3 percent -2.3 percent, respectively. Specifically, what factors could account for Venezuela’s decreases in real national output?

A: Negative economic growth (dy/y < 0) occurs when the growth rate of population, dP/P, exceeds the growth rate of real national output (real national income), dY/Y. That is:

\[ dy/y = dY/Y - dP/P, \]

and if \( dP/P > dY/Y, \) then \( dy/y < 0 \) and real per capita output (\( y \)) declines.

With declines in real GDP in 2009 and 2010, Venezuela could have experienced declines in aggregate demand (for example, with declines in exports or gross private domestic investment) and/or declines in aggregate supply (for example, with an increase in inflationary expectations, sharp depreciation in the domestic currency which raised the cost of necessary imported inputs, or disruption in the domestic economy with civil strife, crime, or corruption which reduced domestic production). In both 2009 and 2010 Venezuela’s exports of goods and services fell by 12.9 percent. Imports of goods and services declined by 19.6 percent and by 2.9 percent, respectively, in 2009 and 2010. The inflation rates (measured by the percentage change in the implicit price deflators for GDP) were 8.4 percent in 2009 and 46.7 percent in 2010. The combination of high inflation and falling real national output suggests that declines in aggregate supply dominated. (Statistics are from the World Bank, World Development Indicators 2011 and 2012, Table 4.a) In Chapter 6 an aggregate demand-aggregate supply model will be developed to explain macroeconomic fluctuations.
2) Suppose for a country, Atlantica, Gross National Income (GNI) equals $100 million; labor income earned by residents of Atlantica working abroad equals $1.5 million; labor income earned by foreigners (nonresidents) working in Atlantica equals $.6 million; interest and dividends paid by Atlantica to foreign investors equals $.8 million; and interest and dividends received by residents of Atlantica from foreign investments equal $.1 million. Calculate Atlantica’s Gross Domestic Product (GDP). Show your work.

A: Atlantica’s GDP = GNI + F, where F = net factor income payments to rest of the world.

\[ F = \text{labor income earned by foreigners (nonresidents) working in Atlantica ($.6) - labor income earned by residents of Atlantica working abroad ($1.5)} + \text{interest and dividends paid by Atlantica to foreign investors ($.8 million) - interest and dividends received by residents of Atlantica from foreign investments ($.1)} = -.2 \]

Therefore, Atlantica’s GDP = GNI + F = $100 + (-.2) = 99.8 million

3) Suppose for a country, Pacifica, GNI per capita is 8,000 pesos and that the foreign exchange rate between the peso and the U.S. dollar is 10 pesos to $1.00. What would be the per capita GNI for Pacifica expressed in U.S. dollars?

If prices in Pacifica for goods and services not entering into international trade are exactly 40 percent of the prices for similar commodities in the United States, i.e., any item costing $1 in the U.S. costs 4 pesos in Pacifica, estimate the per capita GNI for Pacifica in international or purchasing power parity-adjusted dollars. Assume that 60 percent of Pacifica’s national output is not internationally traded.

A: The PPP-adjusted exchange rate for Pacifica is:
er* = .6 (4p/$1) + .4(10p/$) = 2.4p/$1 + 4p/$1 = 6.4p/$1 or 6.4 pesos = $1.00

Pacifica’s GNI per capita in PPP$ is: 8000p/(6.4p/$1) = $1,250.

4) Given the per capita incomes for 2010 for Bangladesh and Belgium of $700 and $45,840, and assuming the average growth rates in real national outputs and population for 2000-2010 are maintained into the future:

Average growth rate (2000-2010)

<table>
<thead>
<tr>
<th>Real GDP</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>5.9%</td>
</tr>
<tr>
<td>Belgium</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

In what year would the per capita income in Bangladesh equal the per capita income in Belgium?

What would be the level of the per capita incomes at that point?

A: Per capita incomes for Belgium and Bangladesh, $y_{\text{Bel}}$ and $y_{\text{Ban}}$, projected in year $T$ are respectively: $y_{\text{Bel}} = 45840e^{0.10T}$ and $y_{\text{Ban}} = 700e^{0.05T}$. Setting $y_{\text{Bel}} = y_{\text{Ban}}$ and solving for $T$, we find: $T = 119.5$ (in the year 2130) where the per capita incomes of the two countries would be approximately $151,400.

5) Given two nations, A and B, each with five thousand in population, with the following distributions of income (in PPP dollars per capita per day):

<table>
<thead>
<tr>
<th></th>
<th>Population A</th>
<th>Population B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poorest thousand</td>
<td>$ .50</td>
<td>$ .60</td>
</tr>
<tr>
<td>Second thousand</td>
<td>$1.30</td>
<td>$ .80</td>
</tr>
<tr>
<td>Middle thousand</td>
<td>$2.00</td>
<td>$1.50</td>
</tr>
<tr>
<td>Fourth thousand</td>
<td>$4.00</td>
<td>$2.50</td>
</tr>
<tr>
<td>Richest thousand</td>
<td>$8.00</td>
<td>$6.00</td>
</tr>
</tbody>
</table>

Assuming an international poverty line of $1.00 a day:
a) Determine the average daily per capita incomes in each nation.

b) Determine the poverty headcount and incidence of poverty in each nation.

c) Determine the poverty gaps in each nation.

A:  
a) Average daily per capita incomes, \( y_A = $3.16 \) and \( y_B = $2.28 \).

b) The poverty headcounts (incidences) are:

Population A: one thousand (20 percent) and Population B: two thousand (40 percent)

c) The poverty gaps are:

Population A = \( [.50 + 0 + 0 + 0 + 0]/5 = .10 \) (10 percent)

Population B = \( [.40 + .20 + 0 + 0 + 0]/5 = .12 \) (12 percent)

For example, in Population B it would take \( ($ .12)(5,000) = $600 \) per day to lift the 2,000 extremely poor up to the poverty line or \( ($ .30 \) per poor person).
Chapter 2

1) In mid-2010 the world population was estimated to be 6.89 billion, with the population of sub-Saharan Africa estimated to be .85 billion. Assuming that the world population grows at the annual rate of 12 per thousand, while the population of sub-Saharan Africa grows at an annual rate of 25 per thousand (the annual average population growth rates for the 2000-2010 period), when would the population of Sub-Saharan Africa constitute 50 percent of the world total? At that time (the nearest year), what would be the size of the world population? Discuss whether you think this is likely to happen.

A: The populations of sub-Saharan Africa (P_{SSA}) and the world (P_W) projected for year T are respectively: \( P_{SSA} = .85e^{.025T} \) and \( P_W = 6.89e^{.012T} \). Setting \( P_{SSA} = .5P_W \) and solving for T gives T = 107.7 or approximately 108 years. In the year 2118 the projected populations of sub-Saharan Africa and the world would be respectively 12.6 billion and 25.2 billion.

This is unlikely to happen due to sub-Saharan African countries, like other regions of the world, completing their demographic transitions and reducing fertility rates to replacement level or even below. Moreover, the carrying capacity of the world is likely to be well below 25.2 billion. The world population is expected to stabilize at below 10 billion by the end of the twenty-first century.

2) Discuss why in the demographic transition model it is intuitive that mortality rates would decline before fertility rates. Even so, in France during the early nineteenth century, it appears that mortality and fertility rates declined concurrently. Discuss possible explanations.

A: Given that in the traditional stage of the demographic transition high and volatile crude death rates are offset, on average, by high and somewhat less variable crude birth rates,
yielding minimal population growth, if the crude birth rate significantly declined before the crude death rate, then the population would diminish in size. Such depopulation wouldn’t last for very long. There would be little motivation for reducing fertility when mortality rates were equally high. Moreover, in traditional societies, improved mortality would likely precede lower fertility, if parents were seeking a desired number of surviving sons. If birth rates do fall and birth intervals increase, however, infant mortality rates would likely decline with improved health and care for those children born. Maternal mortality rates would likely also decline with fewer pregnancies and child births.

3) If the logistic curve mirrors the historical trend in population growth, what would happen if there were a fourth stage to the demographic transition, where crude birth rates fell below crude death rates? Do you think this is likely? Discuss.

If there were a fourth stage in the demographic transition with negative crude rates of natural increase, would there then have to be a fifth stage? Discuss.

A: If below level fertility rates were maintained for some time, there would be natural depopulation, and unless offset by net in-migration, populations would decline. Some European nations, particularly the former transition economies of Eastern Europe and the Soviet Republics, already are experiencing negative crude rates of natural increase. All the developed nations and an increasing number of developing nations are below replacement level fertility. If enough countries fall below replacement level fertility for long enough, then the population growth through positive population momentum in the rest of the developing nations could be offset and the world population would decline in size. The logistic curve would bend downwards, reflecting a fourth stage of the demographic transition. This may well happen in
the latter part of the twenty-first century, but then it is likely that the world population would return to replacement level fertility, the long run equilibrium of zero population growth in a final fifth stage of the demographic transition, where the logistic curve of the world population would level off again.

4) If the contemporary developing nations had not experienced the significant declines in mortality largely due to imported medical technologies and disease control in the middle of the twentieth century, what might have been the consequences for the world population at the beginning of the twenty-first century?

A: The demographic transitions of the developing nations would have been delayed and the world population would be significantly smaller at the beginning of the twenty-first century. Moreover, with the advances in contraception and family planning programs that have occurred over the last half century, it is likely that the fertility transitions the developing nations then experienced might have been accelerated and sharper, so that the rapid population growth set off by the declines in mortality during the transition stage would have been less.

5) Do you think in the long run a zero rate of population growth for the world is inevitable? Explain why or why not. If so, would or should all the nations of the world have a zero crude rate of natural increase?

A: If there is a carrying capacity for the earth, then in the long run a zero rate of population growth for the world seems inevitable. Nevertheless, this need not imply that all nations have replacement level fertility. Allowing for international migration could offset any national crude rates of natural increase that were not zero. The world’s population is not, and need not be, evenly distributed across the nations of the world.
Chapter 3

1) Given two countries, France and Italy, and two goods, cheese and wool, with the following unit labor costs:

<table>
<thead>
<tr>
<th></th>
<th>Labor hours per unit of output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>cheese (C)</td>
</tr>
<tr>
<td>France</td>
<td>4 hours</td>
</tr>
<tr>
<td>Italy</td>
<td>3 hours</td>
</tr>
</tbody>
</table>

Assume constant costs of production.

a) Determine the absolute and comparative advantages in the production of cheese and cloth.

b) If the international terms of trade were 1C = .4W (or 1W = 2.5C), determine the gains from trade (per unit of the export good traded) for France and Italy.

c) If France has 900 hours of labor and Italy has 600 hours of labor available each day, sketch the production possibilities boundaries for the two countries. What are the slopes of the production possibilities boundaries? Given the international terms of trade of 1C = .4W, sketch the consumption possibilities boundaries of the two countries. What are the slopes of the consumption possibilities boundaries?

d) If in autarky, France were producing (and consuming) 100 units of cheese, how much wool could it produce? If in autarky, Italy were producing (and consuming) 96 units of cheese, how much wool could it produce?

e) Given the autarkic or pre-trade productions and consumptions, and assuming complete specialization in production with trade, suppose France exports half of its comparative advantage good. Find the gains from trade for France and Italy.

f) How would the above analysis change if the international terms of trade were instead: 1W = 2.4C?

g) When would trade not take place between the two countries? Why not?
A:  
a) Italy has the absolute advantage (lower resource cost) in both cheese (C) and wool (W). Italy has the comparative advantage (lower opportunity cost) in wool; while France has the comparative advantage in cheese.

b) With 12 hours of labor, France could produce 1W or 3C. If France traded the 3C for 1.2W, at the international terms of trade of 1C = .4W, it would gain .2W per 3C traded, or (1/15)W per 1C traded.

With 3 hours of labor, Italy could produce 1C or .5W. If Italy traded the .5W for 1.25C, at the international terms of trade of 1W = 2.5C, it would gain .25C per .5W traded, or .5C per 1W traded.

c) With 900 hours of labor, France could produce either 225C or 75W. The slope of France’s production possibilities boundary is ΔC/ΔW = -3.

With 600 hours of labor, Italy could produce either 200C or 100W. The slope of Italy’s production possibilities boundary is ΔC/ΔW = -2. The slope of the consumption possibilities boundaries for both is ΔC/ΔW = -2.5, reflecting the international terms of trade.

d) In autarky, if France were producing (and consuming) 100C, it could produce 41.67W. In autarky, if Italy were producing (and consuming) 96C, it could produce 52W.

e) With complete specialization in trade, France produces 225C and exports 112.5C for 45W. Therefore, France consumes 112.5C and 45W, with gains from trade of 12.5C and 3.33W.

With complete specialization in trade, Italy produces 100W and exports 45W for 112.5C. Therefore, Italy consumes 55W and 112.5C, with gains from trade of 16.5C and 3W.
f) If the international terms of trade were 1W = 2.4C, closer to Italy’s opportunity costs, the gains from trade for Italy would be less than before (16.5C and 1.125W) and the gains from trade for France would be greater than before (12.5C and 5.205W).

g) Trade would not take place if the opportunity costs were the same in Italy and France.

2) If France experienced advances in technology which halved its unit labor costs of the two goods to 2 hours (from 4 hours) in cheese production and to 6 hours (from 12 hours) in wool production, repeat problema 1) parts a) through e). What do you conclude about technological progress, the gains from trade, and the standard of living, as measured by final consumption per hour of labor?

A:

a) France has the absolute advantage (lower resource cost) in cheese (C). There is no absolute advantage in wool (W).

Italy has the comparative advantage (lower opportunity cost) in wool; while France has the comparative advantage in cheese.

b) With 6 hours of labor, France could produce 1W or 3C. If France traded the 3C for 1.2W, at the international terms of trade of 1C = .4W, it would gain .2W per 3C traded, or (1/15)W per 1C traded.

With 6 hours of labor, Italy could produce 2C or 1W. If Italy traded the 1W for 2.5C, at the international terms of trade of 1W = 2.5C, it would gain .5C per 1W traded.

c) With 900 hours of labor, France could produce either 450C or 150W. The slope of France’s production possibilities boundary is ΔC/ΔW = -3.

With 600 hours of labor, Italy could produce either 200C or 100W. The slope of Italy’s
production possibilities boundary is $\Delta C/\Delta W = -2$. The slope of the consumption possibilities boundaries for both is $\Delta C/\Delta W = -2.5$.

d) In autarky, if France were producing (and consuming) 100C, it could produce 116.67W. In autarky, if Italy were producing (and consuming) 96C, it could produce 52W.

e) With complete specialization in trade, France produces 450C and exports 225C for 90W. Therefore, France consumes 225C and 90W, with gains from trade of 125C and -26.67W.

With complete specialization in trade, Italy produces 100W and exports 90W for 225C. Therefore, Italy consumes 10W and 225C, with gains from trade of 129C and -42W.

Here France is the bigger country (with more labor) and with the advances in technology, its production possibilities boundary is much greater than Italy’s. So, with trade and complete specialization, assuming France exports half of its cheese, the world production of wool decreases by 68.67, while the world production of cheese increases by 254. Still, before trade and specialization, the world was operating within its production possibilities boundary.

Now, with trade and complete specialization, the world is operating on its production possibilities boundary.

Note: A better example would have been for Italy to have experienced the gains from technology. Then pretrade Italy would have been producing and consuming 96C and 152W.

With trade and complete specialization, France would produce 225C and exports 112.5C for 45W, consuming 112.5C and 3.3W, as before. Italy would produce 200W, exporting 45W for 112.5C, ending with consumption of 112.5C and 155W. Italy’s gains from trade would be 16.5C and 3W, as before. So, with the neutral gains in technology in Italy (that didn’t affect the opportunity costs, but reduced the labor costs), while the gains from trade are the same, given
the cheese exports of France, Italy's overall levels of production and consumption are greater, here by 100W.

3) Discuss what you think is the weakest link in Malthus’ theory of population. Can his theory of population be disproved? Discuss why or why not.

A: The assumption that increases in income lead to increases in fertility with earlier marriage and larger families affordable, might be the weakest link. As the demographic transition illustrated, with economic growth and development, fertility declines, although usually with a significant delay after the declines in mortality. Accompanying the rise in income are increased education and socioeconomic mobility of females, urbanization and higher consumer aspirations, all of which contribute to reduced fertility. Parents have fewer children, but invest more in each child. Decreases in the cost of effective contraception also promotes greater fertility control. In Chapter 10 a model of fertility behavior will be developed.

For Malthus checks to population growth through reduced birth rates were either vice (birth control) or moral restraint. The former were largely responsible for the fertility transitions, once the demand for children decreased.

Malthus’ assumption that food production (means of subsistence) could only increase arithmetically (linearly) might also be a flaw in his theory, since this understated the later technological advances in agriculture.

Malthus’ theory can’t really be disproved unless there is evidence that food production can continue to increase exponentially. In the aggregate the global food supply has grown faster than population, which reflects not only advances in agricultural productivity, but checked population growth, primarily through the reduced birth rates with economic
development. Whether unchecked population growth would have outpaced the food supply, resulting in misery through the ultimate check of famine, is a counterfactual.

4) According to Malthus and Ricardo, could population growth and labor force growth continue in the long run? Discuss why or why not.

A: According to Malthus and Ricardo, population growth could not continue in the long run due to diminishing returns to labor with the fixed supply of cultivatable land. Although technological progress in agriculture could offset diminishing returns to labor for some time, eventually given the finite supply of cultivatable land, the cost of producing food would increase as the land was used more intensively and extensively. Rents on the land would rise, squeezing economic profits down to zero, net capital formation would cease, and real wages would fall to subsistence, i.e., an average real income where the crude rate of natural increase was zero.

5) Discuss whether Mill’s optimistic view of the stationary state has appeal or is even realistic.

A: Mill’s conception of the stationary state as an opportunity for enlightenment with development but not economic growth may seem a bit utopian and contrary to the acquisitive drive of humans, always seeking to consume more. Nevertheless, as discussed in Chapter 5, some argue that a stationary state of zero economic growth and zero population growth may not only be inevitable, but desirable, with human development still possible.
Chapter 4

1. Given a firm with a production function, \( Q = A \cdot K^\alpha L^\beta \) \( (0 < \alpha, \beta < 1) \), let \( A = 1.0 \) (index of technology) and \( \alpha = .5 \) and \( \beta = .7 \) (i.e., the production function has increasing returns to scale).

Exogenous to the firm are the market user costs of labor and capital:

\[
\begin{align*}
    w_0 & = \text{user cost of labor} = 10 \\
    r_0 & = \text{user cost of capital} = 2
\end{align*}
\]

a) Find the cost-minimizing combination of \( K \) and \( L \) for producing the output \( Q_0 = 100 \).

b) Determine the optimal capital-labor ratio, \( (K/L)_0 \), and associated capital-output ratio, \( (K/Q)_0 \), and output per unit of labor, \( (Q/L)_0 \).

c) Determine the effects of the following independent changes, \textit{ceteris paribus}, on the firm’s cost-minimizing combinations of \( K \) and \( L \) and on the firm’s optimal capital-labor and associated capital-output ratio and output per unit of labor.

i) an increase in the selected level of output to \( Q_1 = 120 \).

ii) a decrease in the user cost of capital to \( r' = 1.5 \)

iii) a change in technology to a more capital-intensive production process with an increase in \( \alpha \) to \( \alpha' = .6 \) and a decrease in \( \beta \) to \( \beta' = .6 \).

iv) an increase in the index of technology to \( A' = 1.2 \) (neutral technical change)

\[ A: \]

a) The cost-minimizing combination of \( K \) and \( L \) for producing the output \( Q_0 = 100 \) is \( K_0 = 97.4 \) and \( L_0 = 27.3 \).

b) The optimal capital-labor ratio \( (K/L)_0 = 97.4/27.3 = 3.57 \); capital-output ratio \( (K/Q)_0 = 97.4/100 = .97 \); and output per unit of labor, \( (Q/L)_0 = 100/27.3 = 3.66 \).

c) i) After an increase in the selected level of output to \( Q_1 = 120 \), the cost-minimizing combination of \( K \) and \( L \) is \( K_1 = 113.4 \) and \( L_1 = 31.8 \). The optimal capital-labor ratio \( (K/L)_1 = 3.57 \);
capital-output ratio \(K/Q_1 = .95; \) and output per unit of labor, \((Q/L)_1 = 3.77. \textit{Ceteris paribus},\) with increasing returns to scale, an increase in output leaves the \(K/L\) ratio constant, decreases the \(K/Q\) ratio, and increases the \(Q/L\) ratio.

c) ii) After a decrease in the user cost of capital to \(r' = 1.5\), the cost-minimizing combination of \(K\) and \(L\) is \(K_2 = 115.3\) and \(L_2 = 24.2\). The optimal capital-labor ratio \((K/L)_2 = 4.76;\) capital-output ratio \((K/Q)_2 = 1.15;\) and output per unit of labor, \((Q/L)_2 = 4.13. \textit{Ceteris paribus},\) a decrease in the user cost of capital increases the \(K/L, K/Q,\) and \(Q/L\) ratios.

c) iii) After a change in technology to a more capital-intensive production process with an increase in \(\alpha\) to \(\alpha' = .6\) and a decrease in \(\beta\) to \(\beta' = .6\), the cost-minimizing combination of \(K\) and \(L\) is \(K_3 = 103.7\) and \(L_3 = 20.7\). The optimal capital-labor ratio \((K/L)_3 = 5.0;\) capital-output ratio \((K/Q)_3 = 1.04;\) and output per unit of labor, \((Q/L)_3 = 4.83. \textit{Ceteris paribus},\) with increasing returns to scale, a more capital-intensive production process increases the \(K/L, K/Q,\) and \(Q/L\) ratios.

c) iv) After an increase in the index of technology to \(A' = 1.2\) (neutral technical change) the cost-minimizing combination of \(K\) and \(L\) is \(K_4 = 83.7\) and \(L_4 = 23.4\). The optimal capital-labor ratio \((K/L)_4 = 3.57;\) capital-output ratio \((K/Q)_4 = .84;\) and output per unit of labor, \((Q/L)_4 = 4.27. \textit{Ceteris paribus},\) with increasing returns to scale, an in the index of technology leaves the \(K/L\) ratio constant, decreases the \(K/Q\) ratio, and increases the \(Q/L\) ratio.

2. Repeat problem 1) assuming the production function is now characterized by decreasing returns to scale: \(Q = A \cdot K^\alpha L^\beta \) \((0 < \alpha, \beta < 1)\) where \(A = 1.0\) (index of technology) and \(\alpha = .3\) and \(\beta = .5.\) Exogenous to the firm are the market user costs of labor and capital:

\[ w_0 = \text{user cost of labor} = 10 \]
$r_0 = \text{user cost of capital} = 2$

a) Find the cost-minimizing combination of $K$ and $L$ for producing the output $Q_0 = 100$.

b) Determine the optimal capital-labor ratio, $(K/L)_0$, and associated capital-output ratio, $(K/Q)_0$, and output per unit of labor, $(Q/L)_0$.

c) Determine the effects of the following independent changes, ceteris paribus, on the firm’s cost-minimizing combinations of $K$ and $L$ and on the firm’s optimal capital-labor and associated capital-output ratio and output per unit of labor.

i) an increase in the selected level of output to $Q_1 = 120$.

ii) a decrease in the user cost of capital to $r' = 1.5$

iii) a change in technology to a more capital-intensive production process with an increase in $\alpha$ to $\alpha' = .6$ and a decrease in $\beta$ to $\beta' = .2$ (Note: error in the text had $\beta' = .6$)

iv) an increase in the index of technology to $A' = 1.2$ (neutral technical change)

A:  

a) The cost-minimizing combination of $K$ and $L$ for producing the output $Q_0 = 100$ is $K_0 = 628.5$ and $L_0 = 209.5$.

b) The optimal capital-labor ratio $(K/L)_0 = 628.5/209.5 = 3.0$; capital-output ratio $(K/Q)_0 = 628.5/100 = 6.29$; and output per unit of labor, $(Q/L)_0 = 100/209.5 = .48$.

c) i) After an increase in the selected level of output to $Q_1 = 120$, the cost-minimizing combination of $K$ and $L$ is $K_1 = 789.3$ and $L_1 = 263.1$. The optimal capital-labor ratio $(K/L)_1 = 3.0$; capital-output ratio $(K/Q)_1 = 6.58$; and output per unit of labor, $(Q/L)_1 = .46$. Ceteris paribus, with decreasing returns to scale, an increase in output leaves the $K/L$ ratio constant, increases the $K/Q$ ratio, and decreases the $Q/L$ ratio.

c) ii) After a decrease in the user cost of capital to $r' = 1.5$, the cost-minimizing combination of $K$ and $L$ is $K_2 = 752.1$ and $L_2 = 188.0$. The optimal capital-labor ratio $(K/L)_2 = 4.0$;
capital-output ratio \((K/Q)_{2} = 7.52\); and output per unit of labor, \((Q/L)_{2} = .53\). *Ceteris paribus,* a decrease in the user cost of capital increases the \(K/L\), \(K/Q\), and \(Q/L\) ratios.

c) iii) After a change in technology to a more capital-intensive production process with an increase in \(\alpha\) to \(\alpha' = .6\) and a decrease in \(\beta\) to \(\beta' = .2\), the cost-minimizing combination of \(K\) and \(L\) is \(K_3 = 622.5\) and \(L_3 = 41.5\). The optimal capital-labor ratio \((K/L)_3 = 15.0\); capital-output ratio \((K/Q)_3 = 6.23\); and output per unit of labor, \((Q/L)_3 = 2.41\). *Ceteris paribus,* with decreasing returns to scale, a more capital-intensive production process increases the \(K/L\) ratio, decreases \(K/Q\) ratio, and increases the \(Q/L\) ratio.

c) iv) After an increase in the index of technology to \(A' = 1.2\) (neutral technical change) the cost-minimizing combination of \(K\) and \(L\) is \(K_4 = 500.4\) and \(L_4 = 166.8\). The optimal capital-labor ratio \((K/L)_4 = 3.0\); capital-output ratio \((K/Q)_4 = 5.00\); and output per unit of labor, \((Q/L)_4 = .60\). *Ceteris paribus,* with decreasing returns to scale, an increase in the index of technology leaves the \(K/L\) ratio constant, decreases the \(K/Q\) ratio, and increases the \(Q/L\) ratio.

3. Discuss the implications for labor (employment and real wages) if firms shift to more capital-intensive methods of production.

A: If either the ratio of the user cost of labor to the user cost of capital (\(w/r\)) increases or the partial output of capital (\(\alpha\)) increases or the partial output elasticity of labor (\(\beta\)) decreases, *ceteris paribus,* the level of employment would fall. With a decline in the demand for labor, real wages would also likely fall.
4. Do you think the U.S. would have returned to healthy economic growth in the 1940s if not for the increased defense spending required by World War II? Discuss.

A: After the Great Depression ended in 1933, the U.S. economy grew rapidly until 1938. Real GDP increased at annual rates of 10.8, 8.9, and 12.9 percent from 1934 through 1936. Then in 1937 tighter fiscal and monetary policies led to a recession, beginning in May and lasting until June of 1938. While U.S. real GDP still increased by 5.1 percent in 1937, it fell by 3.3 percent in 1938. Rapid growth in real GDP resumed in 1939 (8.0 percent) and 1940 (8.8 percent), then accelerated to 17.7 percent in 1941, when, at the end of the year, the United States formally entered World War II. It is unlikely that the growth of the U.S. economy would have been as strong if not for the defense spending during the war years.

5. Have we learned any economic lessons from the Great Depression? Discuss.

A: Keynesian economics, with the recommendation of countercyclical demand management fiscal and monetary policy, while not embraced by many economists, (for example, monetarists, supply-siders, and new classicals), nevertheless was employed during the Great Recession of 2008-09. Large fiscal stimulus of increased spending and tax cuts and a massive monetary injection by the Federal reserve likely prevented the Great Recession, set off by a financial crisis in the U.S., from becoming another depression. Recall that during the Great Depression tighter fiscal policies were adopted in an ill-conceived effort to balance the federal budget and adherence to the gold standard required tighter monetary policies.

The chronic large federal budget deficits, however, since the 1980s, except for the four year period 1998-2001, suggest, that fiscal policy in the U.S. has generally erred on the expansionary side and has not been stabilizing over the business cycle. Ironically, the surge in
deficits occurred under Republican administrations (Reagan, G. H. W. Bush, and G.W.Bush) with increased defense spending and their supply-side inspired tax cuts. Moreover, the housing boom and then bust, was, in part, due to overly expansionary monetary policy in the early 2000s. The federal budget deficits exploded during the Great Recession to reach 10 percent of GDP, and, while receding since then, remain large. Entitlement spending (especially Medicare and Social Security) are increasingly the main drivers of federal expenditures.
Chapter 5

1. In the Limits to Growth World3 simulation model, discuss which of the four scenarios illustrated in Figure 5.2 you think is the most likely in the future. Explain why.

A: The authors of the World3 simulation model maintain the world’s ecological footprint has exceeded its carrying capacity and thus the options are ‘overshoot and oscillate’ (if there has been no irreversible damage to the environment and if mitigating actions are taken) or ‘overshoot and collapse’ with a significant decline in the world population and human condition. While signs of climate change and environmental stress are increasingly evident, it is important to note, however, that the earth’s carrying capacity is not fixed and may well increase in the future with technological progress. Nevertheless, continual growth in population and incomes, as if there were no constraints, is unlikely (scenario 1). Therefore, asymptotic growth (as the logistic curve in scenario 2 illustrates) may be the most hopeful. While it is unclear where the world currently is on that curve (i.e., how close to the carrying capacity), it is probable that the world’s population will begin to stabilize within the next half century. There is no sign, however, that growth in incomes and consumption are tapering.

2. Daly argues that a steady state economy is a “necessary and desirable state of affairs.” Do you agree? Discuss.

A: If you accept Daly’s argument that the supply of low entropy matter and energy is the ultimate limit to growth on a finite planet, and are concerned with the viability of future generations, then a version of Daly’s steady state economy (SSE) may well be necessary. Clearly, most people would find continued economic growth to be more desirable, but increasing signs of environmental stress suggest for the world this may not be possible for
much longer. Daly would argue that the unbridled pursuit of economic growth or ‘growthmania’ is neither healthy nor ultimately satisfying. In any case, Daly’s proposed institutions for a SSE are highly controversial, implying a large sacrifice of human freedom with an increased role for governments. Whether there are better ways (more efficient or fairer) to ensure a SSE is open to debate. Moreover, generating acceptance and implementation of a SSE across nations at various levels of development would be difficult.

3. Daly outlines three institutions for a steady state economy. Would all three be necessary? That is, could a steady-state economy be attained otherwise or with only one or two of these institutions? Discuss.

A: In theory, it would seem that a SSE would need these or similar institutions to ensure the zero population growth and zero economic growth. With respect to population growth, however, if, as according to demographic transition theory, a modern equilibrium is characterized by low and offsetting crude birth and death rates, and moreover, given that all the developed nations and many developing nations are currently below replacement level fertility, then Daly’s marketable birth licenses may not be needed. With respect to output growth then, depletion quotas set by the government for nonrenewable resources could restrain the production of goods and private property rights should restrict the use of renewables to below their regeneration capacities. Carbon taxes or marketable pollution permits might be used to also deal with negative externalities. The distibutist institution of limits on income and wealth would be necessary to address poverty and inequality in a SSE where average per capita income is constant. Theoretically through taxes and transfers the government could implement this income system, but questions of incentive, evasion, and
dependency abound. Barring widespread and fundamental changes in attitudes, the heavy role played by government in a SSE would be strongly resisted.

4. Discuss why the concern with limits to growth keeps reoccurring through history, i.e., from the classical economists, to the macroeconomists in the 1930s, to the limits to growth World3 simulation model and Daly’s steady state economics.

A: Arguments that there are limits to growth have reoccurred over the past two centuries, although the emphases have somewhat differed. The classical economists saw a long run stationary state with subsistence incomes as inevitable due to finite supplies of cultivatable land and unchecked population growth. In contrast, the macroeconomists of the 1930s saw insufficient population growth as a primary cause of economic stagnation. The World3 simulation model added to the finite supplies of nonrenewable resources the capacity of the environment to absorb the wastes generated by humans as a constraint on economic and population growth. Nevertheless, population growth (although slowing since the 1960s) and economic growth (in contrast, quickening in much of the developing world over the past three decades), have continued with technological progress. Limits to growth now center on climate change and global warming, consequences of the unprecedented population and economic growth over the past two centuries that will make future growth less likely.

5. Is the IMF medicine necessary for developing nations with balance of payments crises?
Discuss.

A: Nations with balance of payments deficits and currencies under pressure are forced to turn to the IMF for help. Usually these developing economies are overextended with high inflation,
large government budget deficits and accumulated foreign debts, so the orthodox prescription, as embodied in the IMF medicine is fiscal discipline (meaning reduced government spending and higher taxes) and tighter monetary policy (meaning higher interest rates). In addition, the IMF often recommends devaluation if the national currencies are overvalued, privatization of state-owned enterprises, reduced government regulation of markets (e.g., interest rate ceilings), and liberalization of trade barriers. Initially the net consequences are usually further economic distress. Often the cuts in government spending are on social programs that helped the poor or human capital formation as in public education and health care. The higher interest rates will reduce private investment and the capital formation important for economic growth. Domestic industries may not yet be internationally competitive and so will be hurt by trade liberalization.

Critics argue that the IMF has been insensitive to poverty and to the vulnerability of developing nations to the policies and practices of the developed economies. For example, the nation with the largest external debt in the world is the United States, and yet, the IMF medicine has not been administered, in part, because the U.S. dollar is a key currency. The East Asian currency crisis in the late 1990s was set off by the flight of international capital, which had earlier poured into these rapidly growing economies. Whether there are better policies, whether more efficient, equitable, or effective, for the IMF to implement is open to question. What is clearer is that the IMF might do a better job in monitoring nations to identify and mitigate incipient balance of payments problems.
Chapter 6

1) Given the following linear Aggregate Demand-Aggregate Supply Model:

\[ P^D = D_0 \cdot (1 + d) - fY \]  
Aggregate Demand Schedule

\[ P^S = S_0 \cdot (1 - s) + \beta(P_{-1} - P_{e-1}) + hY \]  
Short Run Aggregate Supply Schedule

\[ P^D(Y) = P^S(Y) \]  
Equilibrium Condition

where:

\( P^D \) = aggregate demand price, i.e., the aggregate price level associated with a given quantity of real national output demanded

\( P^S \) = aggregate supply price, i.e., the aggregate price level associated with a given quantity of real national output produced and supplied

\( Y \) = real national output and real national income

and

\( P_{-1} \) = actual price level from the previous year

\( P^e_{-1} \) = expected price level from the previous year.

Assume initially: \( D_0 = 5, d = 0, f = .004, S_0 = .8, s = 0, h = .002, \) and \( P_{-1} = P^e_{-1} \).

a) Plot the aggregate demand and aggregate supply curves on a large graph, using scales for the axes of \( 1.9 < P < 2.6 \) and \( 650 < Y < 750 \).

b) Find the initial equilibrium real national output \( (Y_0) \) and aggregate price level \( (P_0) \) algebraically and graphically.

A: The initial aggregate demand and aggregate supply schedules are respectively:

\[ P^D = 5 - .004Y \] and \( P^S = .8 + .002Y \). The initial equilibrium is: \( Y_0 = 700 \) and \( P_0 = 2.2 \).
2) Find the new equilibrium real national output \((Y_1)\) and aggregate price level \((P_1)\) when
\[
d = .03, \ s = .02, \text{ and } \beta = 1, \text{ with } P^e_{-1} = 2.15 < 2.20 = P_{-1}.
\]
[Round off the answers to the nearest hundredth place.]

a) Plot the new aggregate demand and aggregate supply curves on the same graph as the initial curves.

b) Determine whether there has been demand-pull or cost-push inflation in period 1. Explain.

c) Determine the growth rate in real national output and inflation rate in period 1.

**A:** The new aggregate demand and aggregate supply schedules are respectively:
\[
P^D = 5.15 - .004Y \text{ and } P^S = .834 + .002Y.
\]
The new equilibrium is: \(Y_1 = 719.33\) and \(P_1 = 2.27\).

With the increase in aggregate demand there is demand-pull inflation. The decrease in aggregate supply has added some cost-push inflation. The growth rate in real national output is 2.76% and the inflation rate is 3.18%.

3) Return to the initial equilibrium and find the new equilibrium real national output \((Y_1)\) and aggregate price level \((P_1)\) when \(d = -.015, \ s = -.01, \beta = 1, \text{ and } P^e_{-1} = 2.15 < 2.20 = P_{-1}.
\]
[Round off the answers to the nearest hundredth place.]

a) Plot the new aggregate demand and aggregate supply curves on a new large graph together with the initial curves.

b) Determine whether there has been demand-pull or cost-push inflation in period 1. Explain.

c) Determine the growth rate in real national output and inflation rate in period 1.

**A:** The new aggregate demand and aggregate supply schedules are respectively:
\[
P^D = 4.925 - .004Y \text{ and } P^S = .858 + .002Y.
\]
The new equilibrium is: \(Y_1 = 677.83\) and \(P_1 = 2.21\).

With the decrease in aggregate supply there is cost-push inflation. The growth rate in real
national output is -3.17% and the inflation rate is 0.45%.

4) Do you think lessons really have been learned from the Great Recession? Discuss, noting the implications for economic growth in the future.

A: As a result of the financial crisis there is increased regulation of banks and financial institutions by the Federal Reserve. In addition, the Consumer Financial Protection Bureau was instituted to help and protect individuals in financial matters. Households may have learned to be more conservative and have increased their saving rates to rebuild wealth lost during the Great Recession. Higher personal saving rates are welcome, in part to provide for retirement, after the declines over the past three decades. Banks are more careful in their lending, especially for home purchases. Banks still, however, hold many excess reserves, and while interest rates have been historically low over the past few years, bank credit for private investment has been limited.

The effectiveness of demand-management fiscal and monetary policy was confirmed and will likely be used again in the future, especially during sharp downturns in the economy. Inflation has been moderate, but unemployment remains stubbornly high. The political gridlock, if not animosity, that has characterized Washington since 2008 has hampered effective long run economic policy, including entitlement reform, investment in the nation’s infrastructure and renewable energy, and climate change mitigation.

5) Will the euro zone prevail? Discuss.

Likely the euro zone will prevail, although there may be some nations exiting, for example Greece, and fewer new members at least in the next few years. Generally, the economic
advantages of the euro zone, including promotion of foreign trade and investment within the union with the common currency and generally more disciplined monetary policy, have outweighed the disadvantages, including the sacrifice in member nation economic autonomies. There does need to be greater fiscal policy coordination, however, to prevent large government budget imbalances. Hopefully lessons can be learned from the financial crises experienced by the nations in the euro zone. The alternative of disbanding and returning to national currencies doesn’t seem likely, if only for the logistics of changing back, although an adjustable exchange rate system with national currencies tied to the euro might be a possibility.
Chapter 7

1) Given the following basic Solow growth model:

S1) \(Y(t) = [K(t)]^{0.4} [L(t)]^{0.6}\)

S2) \(I(t) = S(t)\)

S3) \(S(t) = .10Y(t)\)

S4) \(L(t) = 30e^{0.02t}\)

a) Derive the fundamental equation of this growth model.

b) Plot the net saving and required net investment per unit of labor curves for the following values of the capital-labor ratio: \(k = 0, 5, 10, 15, 20, \text{ and } 25\).

Solve graphically for the steady-state equilibrium capital-labor ratio, \(k_0^*\).

c) Solve mathematically for the steady-state equilibrium capital-labor ratio, \(k_0^*\), output per unit of labor, \(y_0^*\), and capital-output ratio, \(v_0^*\). [Round off your answers to two decimal places.]

d) Determine the levels of real national output, physical capital, and labor at time \(t = 3\), i.e., \(Y(3), K(3), \text{ and } L(3)\).

e) Suppose that after \(t = 3\), the natural growth rate of the labor force decreases to \(n = .015\). Find the new steady-state equilibrium capital-labor ratio, \(k_1^*\), output per unit of labor, \(y_1^*\), and capital-output ratio, \(v_1^*\). Discuss the transition to the new steady-state equilibrium.

f) Suppose instead that after \(t = 3\) the saving rate decreases to \(s = .08\). Find the new steady-state equilibrium capital-labor ratio, \(k_2^*\), output per unit of labor, \(y_2^*\), and capital-output ratio, \(v_2^*\). Discuss the transition to the new steady-state equilibrium.
A:  
a) The fundamental equation, obtained by differentiating the capital-labor ratio, k, and the incorporating the conditions of the model is: \[ \frac{dk}{dt} = sy - nk = .10k^4 - .02k. \]

b) The graphical solution is approximately \( k_0^* \approx 15 \).

c) The equilibrium values are: \( k_0^* = 14.62 \), \( y_0^* = 2.92 \), and \( v_0^* = 5.0 \).

d) \( Y(3) = 87.6e^{0.02(3)} = 93.02 \); \( K(3) = 438.6e^{0.02(3)} = 465.72 \); and \( L(3) = 30e^{0.02(3)} = 31.86 \)

e) If after \( t = 3 \), the natural growth rate drops from \( n = .02 \) to \( n' = .015 \), the new steady-state equilibrium values are: \( k_1^* = 23.63 \), \( y_1^* = 3.54 \), and \( v_1^* = 6.68 \). A decrease in the natural growth rate of labor results in an excess of net saving over the required net investment at the initial equilibrium capital-labor ratio, \( k_0^* \). This reduces the interest rate or the user cost of capital, which stimulates investment and induces firms to shift to a more capital-intensive method of production. The capital-labor ratio rises, \( k \uparrow \), which increases output per unit of labor, \( y \uparrow \) (at a diminishing rate) until the new steady-state equilibrium in reached where \( sy_1^* = n'k_1^* \).

f) If after \( t = 3 \), the saving rate decreases from \( s = .10 \) to \( s' = .08 \), the new steady-state equilibrium values are: \( k_2^* = 10.08 \), \( y_2^* = 2.52 \), and \( v_2^* = 4.0 \). A decrease in the saving rate results in a shortage of net saving in terms of the required net investment at the initial equilibrium capital-labor ratio, \( k_0^* \). This increases the interest rate or the user cost of capital, which reduces investment and leads firms to shift to a less capital-intensive method of production. The capital-labor ratio falls, \( k \downarrow \), which decreases output per unit of labor, \( y \downarrow \), until the new steady-state equilibrium in reached where \( s'y_2^* = nk_2^* \).
2) Given the following Solow growth model with neutral technological progress and effective capital and effective labor:

\[ \text{S1)} \quad Y(t) = 2e^{0.015t} [K(t)]^{0.4} [L(t)]^{0.6} \quad \text{where} \quad K(t) = e^{0.01t} K(t) \quad \text{and} \quad L(t) = e^{0.012t} L(t) \]

\[ \text{S2)} \quad I(t) = S(t) \]

\[ \text{S3)} \quad S(t) = .10Y(t) \]

\[ \text{S4)} \quad L(t) = 30e^{0.02t} \]

a) Derive the equation for the growth rate for real national output per unit of labor, \( \frac{dy}{y} \).

b) Given an initial value of the capital-labor of \( k(0) = 46.4515 \), find the equilibrium values for output per unit of labor at \( t = 0, 1, \) and \( 2 \), i.e., find \( y(0), y(1), \) and \( y(2) \).

What is happening to the growth rate in output per unit of labor over time? Explain why.

[Round off your calculations to four decimal places.]

A:  

a) The growth rate in real national output per unit of labor is:

\[ \frac{dy}{y} = .0262 + .4(\frac{dk}{k}) = .0262 + .4([.1y - .02k]/k), \text{ where } y = 2e^{0.0262t} k^{0.4}. \]

b) If \( k(0) = 46.4515 \) then \( y(0) = 2e^{0.0262t}(46.4515)^{0.4} = 9.2860. \)

In period 0, \( dk = .1(9.2860) - .02(46.4511) = .0004 \), so \( k(1) = 46.4515 - .0004 = 46.4511 \) and 
\( y(1) = 2e^{0.0262(1)}(46.4511)^{0.4} = 9.5325. \)

In period 1, \( dk = .1(9.5325) - .02(46.4511) = .0242 \), so \( k(2) = 46.4511 + .0242 = 46.4753 \) and 
\( y(2) = 2e^{0.0262(2)}(46.4753)^{0.4} = 9.7876. \)

The approximate growth rates in output per unit of labor are:

\[ (\frac{dy}{y})_1 = (9.5325 - 9.2860)/9.2860 = .0265 \quad \text{and} \quad (\frac{dy}{y})_2 = (9.7876 - 9.5325)/9.5325 = .0268. \]

The growth rate in output per unit of labor is increasing over time due to capital deepening. In addition to the growth rate in total factor productivity, here .0262, the rising per capita income increases net saving per unit of labor beyond the required net investment, which increases the
capital-labor ratio and adds to the growth rate in output per unit of labor.

3) If the natural growth rate in the basic Solow model were negative, i.e., \( n < 0 \), could there be a steady-state equilibrium? Discuss, and illustrate, if possible. How would your answer change if neutral technical change at an annual rate of \( g \) percent were allowed?

A: If the natural growth rate of labor became negative after a certain capital-labor ratio, i.e., after a certain level of development was reached, then the required net investment (nk) ray from the origin would bend downwards, becoming curvilinear and intersecting the net saving per unit of labor (sy) curve now in two places. The lower steady-state equilibrium capital labor ratio, \( k_0^* \), would be stable, while the higher steady-state equilibrium capital-labor ratio, \( k_1^* \), would be unstable. Any increase in the capital-labor ratio beyond \( k_1^* \), would result in further increases and continued economic growth.

If neutral technical change were added, then the sy curve would be rotating counterclockwise over time, resulting in a moving steady-state equilibrium with increasing economic growth. The sy curve could eventually rotate entirely above the new nk curve.

4) Given the following Solow model that includes effective natural resources, \( R(t) \):

S1) \[ Y(t) = 2e^{0.015t} [K(t)]^3 [L(t)]^{0.6} [R(t)]^{0.1} \]

where \( K(t) = e^{0.01t} K(t) \), \( L(t) = e^{0.012t} L(t) \), and \( R(t) = e^{0.002t} R(t) \)

S2) \( I(t) = S(t) \)

S3) \( S(t) = 0.10Y(t) \)

S4) \( L(t) = 30e^{0.02t} \)

S5) \( R(t) = 100e^{-0.005t} \)

a) Derive the equation for the growth rate for real national output per unit of labor, \( dy/y \),
where $y = Y/L$.

b) Contrast this with the equation for the growth rate in labor productivity from the Solow model in question 2). Discuss the insights from incorporating effective natural resources in the growth model.

A: 

a) The growth rate of output per unit of labor, $dy/y$, is equal to:

$$dy/y = .0254 + .3\frac{dk}{k} + .1\frac{dr}{r} = .0254 + .3\frac{dk}{k} + .1[-.005 -.02] = .0229 + .3\frac{dk}{k}$$

b) The growth rate of output per unit of labor in the Solow model in question 2) is:

$$dy/y = .0262 + .4\frac{dk}{k},$$

where the partial output of elasticity is equal to .4. Incorporating effective natural resources in the growth model where physical natural resources are being depleted at an annual rate of 0.5 percent, while the quality of the natural resources is increasing at an annual rate of 0.2 percent, reduces the growth rate of output per unit of labor, $dy/y$. Here the growth rate in total factor productivity is now .0254 (or 2.54 percent), equal to the sum of the neutral technical change (1.5 percent) and the products of the partial output elasticities of capital, labor, and natural resources with the respective growth rates in their qualities $$[(.3)(.01) + (.6)(.012) + (.1)(.002)] = .0104 or 1.04 percent. [Note, the partial output elasticity of capital is now .3, with the partial output elasticity of natural resources of .1.]$$ The growth rate in total factor productivity (.0254) exceeds the product of the partial output elasticity of natural resources and the depletion rate in natural resources per unit of labor (.0025), so the growth rate in output per unit of labor is positive and increasing overtime, albeit at a slower rate with the natural resource constraint.
Chapter 8

1) Given observations on the average annual growth rates for real GDP (GY) and population (GP) for the period 2000-2010 for the following six developing countries:

<table>
<thead>
<tr>
<th>Country</th>
<th>GY</th>
<th>GP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>5.4%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Bolivia</td>
<td>4.1%</td>
<td>1.8%</td>
</tr>
<tr>
<td>Chad</td>
<td>9.0%</td>
<td>3.1%</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>8.3%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Nepal</td>
<td>3.8%</td>
<td>2.1%</td>
</tr>
<tr>
<td>Vietnam</td>
<td>7.5%</td>
<td>1.1%</td>
</tr>
</tbody>
</table>

a) Find the means, standard deviations, and variances for GY and GP.

b) Find the covariance and simple correlation coefficient for GY and GP.

c) Plot these six ordered pairs on a scatter diagram with GY on the vertical axis and GP on the horizontal axis. With a ruler, sketch as best you can a ‘line of best fit’ for these observations and estimate its slope and vertical intercept. Discuss whether correlation implies causation here.

A: 

a) The means ($\bar{GY}$ and $\bar{GP}$), standard deviations ($S_{GY}$ and $S_{GP}$), and variances ($S_{GY}^2$ and $S_{GP}^2$) for GY and GP are: $GY = 6.35 \text{ and } GP = 1.75$; $S_{GY} = 2.219 \text{ and } S_{GP} = 0.794$;

$b) S_{GY}^2 = 4.923 \text{ and } S_{GP}^2 = .631$

and $r_{GY,GP} = .046$.

c) Plotting the six ordered pairs shows the observation for Chad to be an extreme outlier. The actual estimated line of best fit is: $\hat{GY} = 6.125 + .128GP$ (with $R^2 = .002$). If Chad were omitted from the sample, the actual estimated line of best fit is $\hat{GY} = 15.62 - 4.02GP$ (with
$R^2 = .96)$. This illustrates the potential for distortion with an extremely influential observation. Correlation does not imply causation. As discussed in Chapter 1, the growth rate in national output reflects technical change and growth rates in the effective factors of production. As discussed in Chapter 2, the growth rate in population reflects the crude birth rate, crude death rate, and net migration rate. The growth rates in output and population, however, may be related. For example, growth in population increases aggregate demand for national output. Increases in real national output and income may be associated with reductions in the crude death rate and increases in the population growth rate.

2) Given the multiple regression results for determinants of the economic growth rate for the sample of 64 low- and middle income economies for the 2000-2008 period below:

$$
\begin{align*}
\hat{GYP} & = -13.05 + .086 \text{SY} - .047 \text{NY} - .067 \text{YP0} + .204 \text{LFP} + .030 \text{FYL} \\
& \quad + .173 \text{GI} + .109 \text{GX} + 1.45 \text{DL} \\
\end{align*}
$$

\[ \begin{array}{cccc}
(2.00) & (0.21) & (0.18) & (0.27) \\
(0.02) & (0.018) & (0.043) & (0.013) \\
\end{array} \]

$R^2 = .729$ \hspace{1cm} $F = 23.58$

where:

GYP = average annual growth rate in real gross domestic product per capita for 2000-08


YP0 = real gross national income per capita in PPP-adjusted dollars in 2000 (U.S. = 100).

LFP = ratio of the population aged 15-64 to the total population in 2000.

FYL = female youth literacy rate for 2000

GI = average annual growth rate in gross domestic investment for 2000-08.

GX = average annual growth rate in real exports of goods and services for 2000-08
DL = dummy variable for a landlocked country.

a) Discuss why each of the explanatory variables (SY, NY, YP0, LFP, FYL, GI, and GX) is included as a theoretical influence in this regression for the growth rate in real gross domestic product per capita.

b) Discuss what additional theoretical influences should be included in a regression for the growth rate of real gross domestic product per capita. How might you measure or quantify these influences?

c) Interpret the coefficients of all the significant explanatory variables, i.e., the marginal effect of each explanatory variable on the dependent variable.

d) Compare these estimation results for the 2000-2008 period with the results in the chapter for the 2000-2009 period for the same 64 low- and middle-income economies.

A: a) The net saving rate (SY) reflects the potential for investment and physical capital formation which increases labor productivity.

   The natural resource depletion rate (NY) reduces natural capital and labor productivity.

   The initial per capita real income (YP0) is included to test for convergence theory, i.e., lower income nations would tend to grow faster with diminishing returns to capital intensity.

   The share of the population in the prime labor force years of 15 to 64 (LFP) captures the demographic dividend, with a higher share of the population of labor force age increasing economic growth for a given labor productivity.

   The female youth literacy rate (FYL) is a proxy for human capital or the quality of labor.

   The growth rate in gross domestic investment (GI) is a demand-side influence on economic growth reflecting the extent to which savings are invested.

   The growth rate in exports of goods and services (GX) is another demand-side influence.
on economic growth reflecting foreign demand for the nation’s output. Also, GX may capture the efficiency of the economy and access to foreign technology through imports.

The dummy variable for a landlocked nation (DL) captures the hypothesized disadvantages in international trade with increased transportation costs and lack of direct access to the resources in the ocean of a landlocked nation.

b) Additional theoretical influences that should be in a regression for the growth rate of real gross domestic product per capita include technological progress, both neutral technical change and embodied in physical capital and intermediate goods. Indirectly growth in exports may capture efficiency in production and access to foreign technology. Also measures for the change in the quality of natural resources, which may decline as these resources are used, and the quality of governance and political-economic institutions and the constraint of government regulations, would have been good to include as explanatory variables. Moreover, much of the economic activity in developing economies is not measured, confined to the informal sectors. These theoretical influences, while difficult to quantify, would have been included if adequate data had been available.

c) *Ceteris paribus*, the impact on the predicted value of $\hat{GYP}$, the average annual growth rate in real GDP per capita for 2000-08 for this sample of 64 low- and middle-income economies, of an increase of:

one percentage point in SY is an $0.086$ percentage point increase in $\hat{GYP}$.

one percentage point in NY is an $0.047$ percentage point decrease in $\hat{GYP}$.

one percentage point in YP0 is an $0.067$ percentage point decrease in $\hat{GYP}$.

one percentage point in LFP is an $0.204$ percentage point increase in $\hat{GYP}$. 
one percentage point in FYL is an \(^\hat{}\) .030 percentage point increase in GYP.

one percentage point in GI is an \(^\hat{}\) .173 percentage point increase in GYP.

one percentage point in GX is an \(^\hat{}\) .109 percentage point increase in GYP.

being a landlocked country is a \(^\hat{}\) 1.45 percentage point increase in GYP.

All of these predicted effects of the explanatory variables are statistically significant at the one percent level, except for NY, YP0, and FYL, which are statistically significant at the five percent level.

d) Compared to the estimation results for the 2000-2009 period, the results for the 2000-2008 period show greater marginal impacts for the SY, NY, LFP, FYL, GX explanatory variables and for the landlocked dummy, but smaller marginal impacts for the GI variable. The overall explanatory power (an adjusted coefficient of determination of \(^\hat{}\) .729) is lower for the 2000-2008 sample than for the 2000-2009 sample \(^\hat{}\) .807.
Chapter 9

1) Calculate the crude death rate (CDR) for the following population given its age structure and the age-specific death rates (ASDRs).

<table>
<thead>
<tr>
<th>Age Interval (years)</th>
<th>% of Population</th>
<th>ASDR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under age 1</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>1-14</td>
<td>35</td>
<td>4</td>
</tr>
<tr>
<td>15-44</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>45-64</td>
<td>26</td>
<td>40</td>
</tr>
<tr>
<td>65 and over</td>
<td>5</td>
<td>120</td>
</tr>
</tbody>
</table>

If the crude birth rate (CBR) were 50 (births per thousand mid-year population) and the net in-migration rate (NMR) were -2 (net in-migrants per thousand mid-year population), find the annual population growth rate and estimate the population doubling time.

A: The crude death rate (CDR) is 22 (per thousand).

\[
CDR = (0.04)30 + .35(4) + .30(10) + .26(40) + .05(120) = 22.
\]

The annual population growth rate, \(r\), is 2.6 percent.

\[
r = CBR - CDR + NMR = 50 - 22 + (-2) = 26\text{ (per thousand)}.
\]

The population doubling time is approximately 27 years. \(T = \frac{0.693}{0.026} = 26.7\).

2) Given the following age-specific births rates (ASBRs), calculate the total fertility rate (TFR) of the population.

<table>
<thead>
<tr>
<th>Age Interval of Mother (years)</th>
<th>ASBR</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-14</td>
<td>2</td>
</tr>
<tr>
<td>15-19</td>
<td>120</td>
</tr>
<tr>
<td>20-24</td>
<td>230</td>
</tr>
<tr>
<td>25-29</td>
<td>200</td>
</tr>
<tr>
<td>30-34</td>
<td>150</td>
</tr>
<tr>
<td>35-39</td>
<td>80</td>
</tr>
<tr>
<td>40-44</td>
<td>10</td>
</tr>
<tr>
<td>45-49</td>
<td>1</td>
</tr>
</tbody>
</table>
A: The total fertility rate (TFR) is 3.97.

\[ \text{TFR} = 5(2 + 120 + 230 + 200 + 150 + 80 + 10 + 1) = 5(793) = 3965 \text{ births per thousand women or} \]
\[ 3.97 \text{ births per woman.} \]

3) Construct a life table for a hypothetical cohort of armadillos under the following assumptions:
The life span of armadillos is five years, i.e., no armadillo lives beyond its fifth birthday. For each year, including the first year of life, armadillo deaths are evenly distributed over the age interval. There is no migration, i.e., this is a closed population. The radix equals 1000.

The age-specific death rates for armadillos, \( _1^M_x \) are:

\[
_1^M_0 = .20 \quad _1^M_1 = .10 \quad _1^M_2 = .40 \quad _1^M_3 = .60
\]
e.g., \( _1^M_2 = \) age-specific death rate for armadillos of ages 2-3 = 400 per thousand.

Fill in the life table below. (Round off decimals to three places and show your calculations.

Please though, no fractional armadillos in the \( l_x \) and \( L_x \) columns.)

<table>
<thead>
<tr>
<th>age x</th>
<th>( _1^q_x )</th>
<th>( l_x )</th>
<th>( _1^d_x )</th>
<th>( _1^L_x )</th>
<th>( T_x )</th>
<th>( e_x )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>.182</td>
<td>1,000</td>
<td>182</td>
<td>909</td>
<td>2,818</td>
<td>2.818</td>
</tr>
<tr>
<td>1-2</td>
<td>.095</td>
<td>818</td>
<td>78</td>
<td>779</td>
<td>1,909</td>
<td>2.334</td>
</tr>
<tr>
<td>2-3</td>
<td>.333</td>
<td>740</td>
<td>246</td>
<td>617</td>
<td>1,130</td>
<td>1.527</td>
</tr>
<tr>
<td>3-4</td>
<td>.462</td>
<td>494</td>
<td>228</td>
<td>380</td>
<td>513</td>
<td>1.038</td>
</tr>
<tr>
<td>4-5</td>
<td>1.000</td>
<td>266</td>
<td>266</td>
<td>133</td>
<td>133</td>
<td>.500</td>
</tr>
</tbody>
</table>

a) What is the proportion of armadillos ages 2-3 that will survive another two years?

b) What is the chance that an armadillo will survive from birth to the age interval 3 to 4?

A: See the table above.
a) \( S_2^2 = \frac{1L_4}{1L_2} = \frac{133}{617} = .216 \) or 21.6\% of armadillos ages 2-3 will survive another two years.

b) \( S_0^{3 to 4} = \frac{1L_3}{1L_0} = \frac{380}{1000} = .38 \) or 38\% chance that an armadillo will survive from birth to the age interval 3 to 4.

4) Using the information below for the U.S. population in 1970, calculate the following statistics:

a) crude birth rate (CBR)

b) schedule of age-specific fertility rates (ASBR\(_x\))

c) total fertility rate (TFR)

d) gross reproduction rate (GRR)

e) net reproduction rate (NRR)

Note: Round off decimals to four places and show your calculations.

Assume the population numbers refer to the midpoint populations.

<table>
<thead>
<tr>
<th>Age x</th>
<th>Females to Females</th>
<th>Births to Females of Age x</th>
<th>from Life Table (females)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>8391</td>
<td></td>
<td>490,648</td>
</tr>
<tr>
<td>5-9</td>
<td>9848</td>
<td></td>
<td>489,242</td>
</tr>
<tr>
<td>10-14</td>
<td>10232</td>
<td>10,468</td>
<td>488,524</td>
</tr>
<tr>
<td>15-19</td>
<td>9477</td>
<td>604,654</td>
<td>487,440</td>
</tr>
<tr>
<td>20-24</td>
<td>8351</td>
<td>1,356,448</td>
<td>485,756</td>
</tr>
<tr>
<td>25-29</td>
<td>6824</td>
<td>957,314</td>
<td>483,797</td>
</tr>
<tr>
<td>30-34</td>
<td>5852</td>
<td>423,672</td>
<td>481,349</td>
</tr>
<tr>
<td>35-39</td>
<td>5711</td>
<td>189,750</td>
<td>477,800</td>
</tr>
<tr>
<td>40-44</td>
<td>6154</td>
<td>54,502</td>
<td>472,430</td>
</tr>
<tr>
<td>45-49</td>
<td>6250</td>
<td>3,398</td>
<td>464,375</td>
</tr>
<tr>
<td>50-54</td>
<td>5735</td>
<td></td>
<td>452,518</td>
</tr>
<tr>
<td>55-59</td>
<td>5229</td>
<td></td>
<td>435,829</td>
</tr>
<tr>
<td>60-64</td>
<td>4610</td>
<td></td>
<td>412,546</td>
</tr>
<tr>
<td>65-69</td>
<td>3873</td>
<td></td>
<td>379,846</td>
</tr>
<tr>
<td>70-74</td>
<td>3132</td>
<td></td>
<td>333,666</td>
</tr>
<tr>
<td>75-79</td>
<td>2282</td>
<td></td>
<td>270,248</td>
</tr>
<tr>
<td>80-84</td>
<td>1406</td>
<td></td>
<td>190,550</td>
</tr>
<tr>
<td>85+</td>
<td>970</td>
<td></td>
<td>181,176</td>
</tr>
</tbody>
</table>
Sex ratio of U.S. population (1970) = 94.78

Sex ratio of births in U.S. (1970) = 105.30

A: a) crude birth rate: CBR = 3,600,206 / 203,208,000 = .0177 or 17.7 births per thousand mid-year population.

b) schedule of age-specific fertility rates (ASBRₙ)

<table>
<thead>
<tr>
<th>Age interval</th>
<th>Females</th>
<th>Births</th>
<th>ASBRₙ</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-14</td>
<td>10232</td>
<td>10,468</td>
<td>.0010</td>
</tr>
<tr>
<td>15-19</td>
<td>9477</td>
<td>604,654</td>
<td>.0638</td>
</tr>
<tr>
<td>20-24</td>
<td>8351</td>
<td>1,356,448</td>
<td>.1624</td>
</tr>
<tr>
<td>25-29</td>
<td>6824</td>
<td>957,314</td>
<td>.1403</td>
</tr>
<tr>
<td>30-34</td>
<td>5852</td>
<td>423,672</td>
<td>.0724</td>
</tr>
<tr>
<td>35-39</td>
<td>5711</td>
<td>189,750</td>
<td>.0332</td>
</tr>
<tr>
<td>40-44</td>
<td>6154</td>
<td>54,502</td>
<td>.0089</td>
</tr>
<tr>
<td>45-49</td>
<td>6250</td>
<td>3,398</td>
<td>.0005</td>
</tr>
</tbody>
</table>

c) total fertility rate: TFR = 2.41

TFR = 5(.0010 + .0638 + .1624 + .1403 + .0724 + .0332 + .0089 + .0005) = 2.41

d) gross reproduction rate: GRR = 1.17

GRR = (female births/total births) · TFR = .4871 (2.41) = 1.17

e) net reproduction rate: NRR = 1.14

NRR = 5[.0005 (.9770) + .0311(.9749) + .0791(.9715) + .0683(.9676) + .0353(.9627) + .0162(.9556) + .0043(.9449) + .0003(.9288)] = 1.14

5) Given the following two populations, both closed to migration and each consisting of females only, draw the initial population pyramids (here just the right sides). Which of the two populations has the greater potential for further growth? Why?
Using the vital rate information given below, project the two populations forward at ten-year intervals for a total of 60 years. This means six projections for each population. In your calculations for the population projection matrix, round off the fertility factors to the nearest thousandths. Round off the populations in each age group to the nearest integer (whole person).

Fill in the table:

<table>
<thead>
<tr>
<th>Age Interval</th>
<th>Population A</th>
<th>Population B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>3500</td>
<td>1500</td>
</tr>
<tr>
<td>10-20</td>
<td>2500</td>
<td>1700</td>
</tr>
<tr>
<td>20-30</td>
<td>2000</td>
<td>2000</td>
</tr>
<tr>
<td>30-40</td>
<td>1000</td>
<td>1600</td>
</tr>
<tr>
<td>40-50</td>
<td>500</td>
<td>1400</td>
</tr>
<tr>
<td>50-60</td>
<td>400</td>
<td>1000</td>
</tr>
<tr>
<td>60+</td>
<td>100</td>
<td>800</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10000</strong></td>
<td><strong>10000</strong></td>
</tr>
</tbody>
</table>

Population size at time T

<table>
<thead>
<tr>
<th></th>
<th>T 0</th>
<th>T 10</th>
<th>T 20</th>
<th>T 30</th>
<th>T 40</th>
<th>T 50</th>
<th>T 60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population A</td>
<td>10,000</td>
<td>11,352</td>
<td>12,833</td>
<td>13,951</td>
<td>14,430</td>
<td>14,631</td>
<td>14,605</td>
</tr>
<tr>
<td>Population B</td>
<td>10,000</td>
<td>9,637</td>
<td>9,333</td>
<td>9,118</td>
<td>9,026</td>
<td>8,939</td>
<td>8,982</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age Interval</th>
<th>ASBR_x^f</th>
<th>_nL_x</th>
<th>l_0 = 100000</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>0</td>
<td>900,000</td>
<td></td>
</tr>
<tr>
<td>10-20</td>
<td>.025</td>
<td>882,000</td>
<td></td>
</tr>
<tr>
<td>20-30</td>
<td>.070</td>
<td>837,900</td>
<td></td>
</tr>
<tr>
<td>30-40</td>
<td>.026</td>
<td>754,110</td>
<td></td>
</tr>
<tr>
<td>40-50</td>
<td>0</td>
<td>603,288</td>
<td></td>
</tr>
<tr>
<td>50-60</td>
<td>0</td>
<td>452,466</td>
<td></td>
</tr>
<tr>
<td>60+</td>
<td>0</td>
<td>226,233</td>
<td></td>
</tr>
</tbody>
</table>

ASBR_x^f = female birth rate for women of age x to x+10
a) Draw the population pyramids for Populations A and B at times T = 30 and T = 60.

What do you notice about the age distributions of the two populations over time?

b) Calculate the net reproduction rate. What do you conclude with respect to the immediate imposition of replacement level fertility and population growth?

A: See the table above. (There may be some rounding error.) Population A has an expansive population pyramid, with significant positive population momentum, reflecting fertility rates above replacement level (NRR > 1). Population B has a constrictive population pyramid, with negative population momentum, reflecting fertility rates below replacement level (NRR < 1).

a) Overtime the population pyramids of the two populations, projected using the same set of age-specific birth rates and death rates, will increasingly assume the same shape, here that of a stationary population.

b) The NRR is equal to one.

\[
\text{NRR} = 10 \cdot [.025(882,000/1,000,000) + .070 (837,900/1,000,000) + .026(754,110/1,000,000)] \\
= 10 \cdot [.0221 + .0587 + .0196] = 1.004 \approx 1.00
\]

Imposing replacement level fertility will increase the size of Population A for some time before stabilizing (with a stationary population size that is 46 percent greater), but will decrease the size of Population B before stabilizing (with a stationary population that is 10 percent smaller. This illustrates positive and negative population momentum, respectively.
Chapter 10

1) Given the following utility-maximizing model for a representative couple in a developing economy:

Maximize \( U = U(C, X) \)  subject to  \( QC + PX = I \)

where  \( U = \) lifetime total utility of the couple

\( C = \) number of children

\( X = \) quantities of other goods and services unrelated to childrearing

\( Q = \) expenditures per child (desired quality of children)

\( P = \) price index of goods and services unrelated to childrearing

\( I = \) permanent income

a) Assume initially:  \( I_0 = 100, P_0 = 1 \) and \( Q_0 = 10 \). Assume also that the couple is indifferent among the following ten combinations of \( C \) and \( X \) on one of its indifference curves, \( U_0 \):

\[
\begin{array}{cccccccccccc}
C & 10 & 9 & 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1 \\
X & 20 & 22 & 26 & 32 & 40 & 52 & 68 & 90 & 115 & 150 \\
\end{array}
\]

Using a large graph and graph paper, carefully sketch the couple's indifference curve, \( U_0 \), placing \( C \) on the vertical axis. Graphically determine the utility maximizing combination of children and other goods and services.

b) Discuss whether the demand for children found in part a. will necessarily equal the actual fertility of the representative couple.

c) Suppose that with economic development, permanent income rises to \( I_1 = 330 \), the price index for other goods and services doubles, \( P_1 = 2 \), and a representative couple triples their desired quality of children to \( Q_1 = 30 \).

Assume also that the tastes and preferences of a representative couple change. Different mapping
is relevant, and that the following combinations of C and X on a new indifference curve $U_1^\prime$ are given below.

<table>
<thead>
<tr>
<th>C</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>77</td>
<td>78</td>
<td>80</td>
<td>84</td>
<td>90</td>
<td>98</td>
<td>108</td>
<td>120</td>
<td>138</td>
<td>160</td>
</tr>
</tbody>
</table>

On the same graph, sketch the new indifference curve, $U_1^\prime$, and determine the new utility-maximizing combination of children and other goods and services. With economic development and the rise in income, what has happened to the relative preference for children? Specifically, how can you tell?

A:

a) The point of tangency of the plotted indifference curve and income constraint is $C_0 = 6$ and $X_0 = 40$.

b) The demand for children, by itself, need not determine the actual fertility of the representative couple. There are the supply-side factors of fecundity and exposure to the risk of conception to consider, as well as the costs of birth control. Supply-side constraints could reduce actual fertility to below the couple’s demand for children. High costs of birth control, on the other hand, could result in excess fertility, or more births than the couple desires.

c) With economic development and the rise in income, the new utility-maximizing combination of children and other goods is $C_1 = 3$ and $X_1 = 120$. The relative preference of the couple for children has declined, indicated by the steeper indifference mapping and the greater willingness of the couple to trade-off children for other goods.

2) The per capita GNPs (in international dollars) and total fertility rates in 1993 are listed below for four countries.
<table>
<thead>
<tr>
<th>Country</th>
<th>2010 per capita GNI</th>
<th>2010 total fertility rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bangladesh</td>
<td>$1,810</td>
<td>2.2</td>
</tr>
<tr>
<td>Morocco</td>
<td>$4,600</td>
<td>2.3</td>
</tr>
<tr>
<td>Mozambique</td>
<td>$930</td>
<td>4.9</td>
</tr>
<tr>
<td>Yemen</td>
<td>$2,500</td>
<td>5.2</td>
</tr>
</tbody>
</table>

a) Discuss the factors that might explain the why Bangladesh and Morocco had identical the total fertility rates, but significantly different incomes. Check the World Bank's *World Development Indicators* for evidence supporting your hypotheses.

b) Repeat part a. for Mozambique and Yemen.

c) Based on these two pairs of countries, can you draw any conclusions about the determinants of fertility in developing countries? Discuss.

A: a) Despite a much higher per capita income, Morocco had a slightly higher total fertility rate than Bangladesh. Reasons for Bangladesh’s success in lowering its total fertility rate might include lower infant mortality, higher female education and labor force participation, more urbanization, and more effective family planning programs. Checking the *World Development Indicators 2013*, shows:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Bangladesh</th>
<th>Morocco</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant mortality rate (2011)</td>
<td>37</td>
<td>28</td>
</tr>
<tr>
<td>Female youth literacy rate (2005-11)</td>
<td>78%</td>
<td>72%</td>
</tr>
<tr>
<td>Female adult literacy rate (2005-11)</td>
<td>52%</td>
<td>44%</td>
</tr>
<tr>
<td>Female labor force participation rate (2011)</td>
<td>57%</td>
<td>26%</td>
</tr>
<tr>
<td>Percent of population urban (2012)</td>
<td>29%</td>
<td>57%</td>
</tr>
<tr>
<td>Contraceptive prevalence rate (2006-11) (% married women ages 15-49: any method)</td>
<td>61%</td>
<td>67%</td>
</tr>
<tr>
<td>Adolescent fertility rate (2011) (births per 1000 women ages 15-19)</td>
<td>70</td>
<td>12</td>
</tr>
</tbody>
</table>
Of these possible reasons, Bangladesh’s higher female literacy rates and labor force participation rates seem to account for its lower fertility compared to Morocco, which is more urbanized, has lower infant mortality, greater social sanctions on teenage fertility, and somewhat higher contraceptive prevalence.

b) Despite a much higher per capita income, Yemen had a higher total fertility rate than Mozambique. Reasons for Yemen’s higher fertility rate might include higher infant mortality, lower female education and labor force participation, less urbanization, and less effective family planning programs. Checking the World Development Indicators 2013, shows:

<table>
<thead>
<tr>
<th></th>
<th>Mozambique</th>
<th>Yemen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant mortality rate (2011)</td>
<td>72</td>
<td>57</td>
</tr>
<tr>
<td>Female youth literacy rate (2005-11)</td>
<td>65%</td>
<td>74%</td>
</tr>
<tr>
<td>Female adult literacy rate (2005-11)</td>
<td>43%</td>
<td>47%</td>
</tr>
<tr>
<td>Female labor force participation rate (2011)</td>
<td>86%</td>
<td>25%</td>
</tr>
<tr>
<td>Percent of population urban (2012)</td>
<td>31%</td>
<td>33%</td>
</tr>
<tr>
<td>Contraceptive prevalence rate (2006-11)</td>
<td>12% (married women ages 15-49: any method)</td>
<td>28%</td>
</tr>
<tr>
<td>Adolescent fertility rate (2011)</td>
<td>129 (births per 1000 women ages 15-19)</td>
<td>69</td>
</tr>
<tr>
<td>Percent of population with HIV (2011)</td>
<td>11.3% (% population ages 15-49 with HIV)</td>
<td>0.2%</td>
</tr>
<tr>
<td>Women’s share of population with HIV (2011)</td>
<td>63% (% of population ages 15 and over living with HIV)</td>
<td>45%</td>
</tr>
</tbody>
</table>

Of the primary determinants of fertility, the only factor consistent with Yemen’s higher fertility rate is its much lower female labor force participation rate. Exploring a bit further, Mozambique’s high incidence of HIV, especially for females, may have reduced the total fertility rate, in part by reducing exposure to the risk of conception. Greater use of condoms to prevent
the transmission of HIV/AIDS, however, should be reflected in a higher contraceptive prevalence rate, which is not evident here.

c) The primary determinants of fertility, drawn from the theoretical model in the chapter, are female education and labor force participation, infant mortality, and the costs of birth control. Income may indirectly affect fertility with higher incomes stimulating consumer aspirations and reducing the desired number of children. Also, with economic development and lower child mortality and increased educational opportunities, parents opt for smaller families but invest more in each child. Empirical support for these factors with these two pairs of countries, however, is mixed, illustrating that fertility is also culturally determined.

3) In Iran the median age of the population is projected to increase from 27.1 years in 2010 to 44.6 years in 2040. In Japan the median age of the population is projected to increase from 44.7 years on 2010 to 52.6 years in 2040. [These median ages reflect the medium variant population projections from the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2010 Revision, (http://esa.un.org/wpp/unpp/panel_indicators.htm).

a) Discuss the underlying cause and likely consequences of the aging of the Iranian population.

b) In 2040, the percentages of the populations under age fifteen are projected to be 13.6 percent in Iran and 12.8 percent in Japan. Which nation in 2040 do you think will be better able to provide for their elderly? Discuss why.

A: a) The aging of the Iranian population largely reflects the sharp declines in fertility experienced over the past two decades. The total fertility rate in Iran fell from 4.8 in 1990 to 1.6 by 2011. As a result Iran will be able to reap a demographic dividend for economic growth, with
a falling youth burden of dependency and increased share of the population in the labor force years for the next few decades. The former will allow for greater savings and investment in human and physical capital, increasing labor productivity.

In 2011, Iran’s youth and elderly burdens of dependency were: 32 and 7 (per hundred population ages 15-64). In comparison, Japan’s youth and elderly burdens of dependency were 21 and 37. From 2000-11 Iran had a much higher average annual economic growth rate than Japan: 4.3 percent versus 0.6 percent, mainly reflecting Iran’s higher growth rate in real national output (5.4 percent versus 0.7 percent for Japan) which more than offset Iran’s higher population growth rate (1.2 percent versus 0.1 percent for Japan).

b) In 2040, Iran will have a much lower elderly burden of dependency than Japan. Moreover, Japan’s economy has stagnated for the last two decades and whether significant growth will be restored with its aging population and declining labor force is unclear. Japan’s total fertility rate has been well below replacement level for some time: 1.5 in 1990 and 1.4 in 2011 and there are no signs of a rebound. In contrast, Iran’s economy will likely continue to grow, although its population will be aging and it will eventually experience natural depopulation if its fertility rates remain below replacement level. Whether either nation will increase immigration to offset the low fertility is also unclear. Therefore, even if Japan still has a higher per capita income than Iran in 2040, Iran may be in a better position to provide for its relatively fewer elderly.

4) Given the following average annual growth rates for population and net migration for 2005-2010 for the Philippines, an East Asian-Pacific nation of 93 million with a 2010 per capita gross national in 2010 in PPP$ of $3,980, and the United Arab Emirates, a Middle Eastern nation of 8
million with per capita gross national income in 2010 in PPP$ of $50,580:

Average Annual Growth Rates (2005-2010)

<table>
<thead>
<tr>
<th></th>
<th>Population</th>
<th>Net Migration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Philippines</td>
<td>1.73%</td>
<td>-.28%</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>12.3%</td>
<td>10.63%</td>
</tr>
</tbody>
</table>

a) Determine the average crude rates of natural increase in the two countries for 2005-10.
b) What might account for the Philippines having net out-migration over this period?
c) What might account for the United Arab Emirates having net in-migration over this period?

A:  
a) The average crude rates of natural increase (CRNI) are derived from the difference between the population growth rates and net migration rates. For Philippines and United Arab Emirates the CRNIs were 2.01 percent and 1.67 percent, respectively.
b) Philippines net outmigration largely reflects the emigration of young workers for better employment opportunities.
c) The United Arab Emirates received much labor migration. The average annual growth rate in the population fifteen and older in the United Arab Emirates from 2000-2010 was 10.5 percent. In 2010, 83 percent of the UAE population was between the ages of fifteen and sixty-four.

5) The World Health Organization in *World Health Statistics 2008* predicted the following changes in the leading causes of mortality in the world from 2004 to 2030:

- Diarrheal diseases would decline from the 5th leading cause (3.6 percent of all deaths in 2004) to the 23rd leading cause (0.9 percent of all deaths in 2030).
- HIV/AIDS would decline from the 6th leading cause (3.5 percent of all deaths in 2004) to the
10th leading cause (1.8 percent of all deaths in 2030).

- Road traffic accidents would rise from the 9th leading cause (2.2 percent of all deaths in 2004) to the 5th leading cause (3.6 percent of all deaths in 2030).
- Diabetes would rise from the 12th leading cause (1.9 percent of all deaths in 2004) to the 7th leading cause (3.3 percent of all deaths in 2030).
- Malaria would decline from the 13th leading cause (1.7 percent of all deaths in 2004) to the 41st leading cause (0.4 percent of all deaths in 2030).
- Alzheimer and other dementias would rise from the 25th leading cause (0.8 percent of all deaths in 2004) to the 17th leading cause (1.2 percent of all deaths in 2030).

Note that the top four causes of deaths projected for 2030 are the same as actually prevailing in 2004: ischemic heart disease, stroke and other cerebrovascular diseases, chronic obstructive pulmonary disease, and lower respiratory infections (projected collectively to account for 38.7 percent of all deaths worldwide in 2030 versus a collective 34.0 percent in 2004).

a) In each case, try to explain the reason for the change in mortality rank and incidence.

b) Discuss whether these projections are consistent with the epidemiological transition.

A: a) The decline in diarrheal diseases will largely reflect improvements in access to safe water and adequate sanitation that accompany economic development. Increases in income and public investment in this essential infrastructure will reduce the incidence of this disease which primarily reflects unsanitary conditions.

The decline in HIV/AIDS will be due to greater awareness of the transmission of this disease and consequent prevention (e.g., increased use of condoms) as well as the greater access of individuals with HIV/AIDS to the improved antiretroviral treatment. There may
eventually be a vaccine against HIV.

With the rise in incomes in the developing world, especially in China and India, more individuals will own automobiles and be driving on the roads. The transportation infrastructure and road traffic laws will be under significant stress.

Poor diets, as more individuals can afford meat and processed foods heavy in calories, salt and sugar, and the rise in obesity will account for the increased incidence of diabetes.

Malaria should decline with greater control over the mosquitos that transmit the disease, whether increased spraying and use of insecticide-treated bed nets or just more secure housing with higher incomes. Generally healthier populations and more effective medicines to treat malaria will also reduce the mortality from this disease. Nevertheless, global warming could actually increase the potential incidence of malaria in the developing economies in the southern hemisphere.

As life expectancies increase and people live longer, the incidence chronic diseases associated with aging will increase, especially Alzheimer and other dementias. While medical advances will continue, identifying those susceptible to dementias and preventing, treating, or even curing these with these cognitive diseases remains a challenge.

b) These projections are consistent with the epidemiological transition, and the changing pattern of mortality with economic development from infectious and parasitic diseases (e.g., diarrhea, tuberculosis, and malaria) to degenerative and man-made afflictions (e.g., cardiovascular diseases and cancers) to delayed degenerative diseases (e.g., dementias and old age).
Chapter 11

1) Given the statistics for the following three island nations for 2011:

<table>
<thead>
<tr>
<th>Nation</th>
<th>Madagascar</th>
<th>Sri Lanka</th>
<th>Cuba</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life expectancy at birth (years)</td>
<td>66.7</td>
<td>74.9</td>
<td>79.1</td>
</tr>
<tr>
<td>Mean years of schooling</td>
<td>5.2</td>
<td>8.2</td>
<td>9.9</td>
</tr>
<tr>
<td>Expected Years of schooling</td>
<td>10.7</td>
<td>11.9</td>
<td>17.5</td>
</tr>
<tr>
<td>Gross national income per capita (PPP$)</td>
<td>824</td>
<td>4,943</td>
<td>5,416</td>
</tr>
</tbody>
</table>

a) Calculate the Human Development Index values for the nations.

b) Calculate Sri Lanka’s Human Development Index not discounting the contribution of income to human development, i.e., use gross national income per capita instead of the natural logarithm of gross national income per capita.

c) Cuba’s HDI rank is 51st among the 187 nations listed by the United Nations Development Program in its *Human Development Report 2011*. Cuba’s gross national income per capita rank, however, is 103rd. What insight does this give you about Cuba’s economic growth?

A:  

a) Madagascar: Human Development Index $[(0.737)(0.497)(0.302)]^{1/3} = 0.480$

where Life Expectancy Index = 0.737; Education Index = 0.486; Income Index = 0.302

Sri Lanka: Human Development Index $[(0.866)(0.657)(0.559)]^{1/3} = 0.683$

where Life Expectancy Index = 0.866; Education Index = 0.657; Income Index = 0.559

Cuba: Human Development Index $[(0.932)(0.877)(0.572)]^{1/3} = 0.776$

where Life Expectancy Index = 0.932; Education Index = 0.877; Income Index = 0.572

b) Sri Lanka’s Human Development Index not discounting the contribution of income to human development, i.e., use gross national income per capita instead of the natural logarithm
of gross national income per capita is equal to .295, since the Income Index undiscounted is .045.

c) Cuba has had modest economic growth, due in large part to its inefficient socialist economic system. Nevertheless, Cuba has invested in the education and health of its population, reflected in its high life expectancy at birth and average years of education. The difference between Cuba’s Gross National Income per capita and HDI rankings in 2011 of +52 is the greatest of the 187 countries listed in the Human Development Report 2011. At the other extreme, the nation with the largest negative difference between the income and HDI rankings (-91) in 2011 is Equatorial Guinea, a small sub-Saharan African country ruled by a dictator since 1979. Exploiting its large offshore oil and gas deposits, Equatorial Guinea has generated considerable economic growth, a per capita GNI in 2011 of over $17,600, but with little investment in its population, with an average life expectancy at birth of just over 51 years and a mean of only 5.4 years of education for its adult population ages 25 and older.

2) Using the Ehrlich identity, \( I = P \cdot A \cdot T \), where we measure \( I \) as total primary energy produced in the world (million tons of oil equivalent), \( P \) is the world population, \( A \) is per capita output, and \( T \) is the energy intensity of output (measured as primary energy per unit of output).

Suppose that the world’s primary energy production in 2008 were 12.4 billion metric tons of oil equivalent; the world population was 6.7 billion, and per capita world GDP was $10,000 (PPPS), and world output per kilogram of oil equivalent was $5.4. (Note: one metric ton is equivalent to 1000 kilograms). Thus, in 2008: \( I = 12.4 \text{ billion tons of energy production}; \ P = 6.7 \text{ billion people}; \ A = $10,000; \) and \( T = 1/5,400 \). Further, suppose the carrying capacity of the world is 16 billion tons of energy production (\( I' = 16.0 \)), the world population will eventually stabilize
at 9 billion \( (P' = 9) \), and per capita world GDP will increase to $15,000 \( (A' = 15,000) \). What will be the implied level of technology \( (T') \) needed to keep the world below the carrying capacity?

A: From \( I = P' \cdot A' \cdot T' \), for the carrying capacity \( (I') \) of 16 billion tons of energy production, a world population \( (P') \) of 9 billion, and a per capita world GDP \( (A') \) of $15,000, the implied level of technology is \( T' = \frac{1}{8437.5} = .0001185 \), a decrease in the energy intensity of output from \( \frac{1}{5400} \) or \(.0001851 \) in 2008. That is, output per kilogram of oil equivalent would have to increase from $5.4 to $8.4375.

3) The statistics in Table 11.5 suggest that South Korea is currently more successful in sustainable development than the United States. Discuss. What are the policy implications for the United States?

A: South Korea’s Index of Youth Investment in 2009 of .678 exceeded that of the United States (.624), despite a per capita Gross National Income of $27,240 that was only sixty percent of the United States ($45,640). From the beginning of its independence from Japan following World War II, South Korea has invested heavily in its education. As noted in the text, South Korea ranked second of the 38 nations in Table 11.5 in the index of school quality (measured by average scores on the 2009 Program for International Student Assessment tests). Its economic growth has been unusually equitable, based on the expansion of its labor-intensive manufactures. South Korea also had the highest adjusted net saving rate in 2009 of the 38 countries listed in Table 11.5. In contrast, the United States income distribution has grown increasingly unequal over the past three decades. Real wages for production workers have been flat. The U.S. has ranked fairly low among industrial nations on international student test scores. Access to health care also has been unequal in the United States. So, despite having
arguably the best universities and hospitals in the world, the United States has not effectively provided widespread quality public education and health care. Moreover, reflected in its almost unbroken string of current account deficits over the past three decades, the United States has consumed beyond its means. The lessons for the United States seem to be greater investment in human capital from the outset, beginning with pre-kindergarten education, early nutrition and health care, better primary and secondary schools, and more equitable economic growth. At the same time, greater fiscal discipline is called for to address the government deficits and higher personal saving rates to address the accumulation of private debt.

4) Given the production function: \( Y = A \cdot H^\alpha R^\beta \), \((0 < \alpha, \beta < 1)\), where the growth of H (human resources) and R (natural resources) are given by the equations: \( H(t) = H(0)e^{jt} \) and \( R(t) = R(0)e^{ut} \). The growth in neutral technological change is given by; \( A(t) = A(0)e^{gt} \).

a) Determine the growth rate in output, \( \frac{dY}{Y} \).

b) Find the equation for the expansion path given the ratio of user costs, \( P_H/P_R = 2 \).

A: 
\[ a) \quad \frac{dY}{Y} = \frac{dA}{A} + \alpha \cdot \frac{dH}{H} + \beta \cdot \frac{dR}{R} = g + \alpha \cdot j + \beta \cdot u \]

b) Setting the MRFS = \(- MPH/MPR\) = \(- (\alpha/ \beta)(R/H)\) = - 2 = - \( P_H/P_R \) and solving for R, the equation for the expansion path is: \( R = 2(\beta/\alpha)H \)

5) Given the fixed coefficients production function: \( Y = A \cdot \min[H/h, R/r] \), where the growth of H (human resources) and R (natural resources) are given by the equations:

\( H(t) = H(0)e^{jt} \) and \( R(t) = R(0)e^{ut} \). The growth in neutral technological change is given by; \( A(t) = A(0)e^{gt} \). Determine the growth rate in output, \( dY/Y \).

A: 
\[ dY/Y = \frac{dA}{A} + \min[\frac{dH}{H}, \frac{dR}{R}] = g + \min[j, u] \]
Chapter 12

1) Has there been any movement in the Doomsday Clock since January 2012? To check, access the website of the Bulletin of the Atomic Scientists (http://www.thebulletin.org).


2) Compare the compositions of sources of electricity (coal, natural gas, oil, hydropower, and nuclear power) for the following countries: Brazil, China, Russia, France, and the United States. What might account for the differences? [See the table on sources of electricity in World Bank’s World Development Indicators.]


<table>
<thead>
<tr>
<th>Sources of Electricity Production (2011)</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coal</td>
</tr>
<tr>
<td>Brazil</td>
<td>2.3%</td>
</tr>
<tr>
<td>China</td>
<td>79.0%</td>
</tr>
<tr>
<td>Russia</td>
<td>15.5%</td>
</tr>
<tr>
<td>France</td>
<td>3.1%</td>
</tr>
<tr>
<td>U.S.</td>
<td>43.3%</td>
</tr>
</tbody>
</table>

The differences in the sources of electricity reflect the natural resource endowments. Brazil is richly endowed with large rivers, China and the U.S. have large coal deposits, and Russia has abundant natural gas. France has heavily invested in nuclear power.
3) The reserves to production ratios (R/P), presented for oil, natural gas, and coal for the world in Table 12.2, indicate the length of time the proved reserves remaining at the end of any year would last if the rate of production prevailing in that year were to continue.

a) What can be concluded if the R/P ratio for a fossil fuel increases over time?

b) In 2009 the R/P ratios for oil, natural gas, and coal were 45.7, 62.8, and 119 years, respectively. In 2010, the R/P ratios were 46.2, 58.6, and 118 years respectively. [Statistics are from the BP Statistical Review of World Energy (June 2010 and June 2011.)] What does this suggest about fossil fuel supplies?

A: a) An increase in the R/P ratio for a fossil fuel can reflect either the discovery of new proven reserves or a decrease in the rate of production of the fossil fuel.

b) These statistics likely indicate the discovery of new deposits for oil, increased production of natural gas, and the depletion of coal deposits. The supplies of these fossil fuels are finite, although exploration and advances in technology may lead to the discovery and recovery of additional deposits, previously unknown or uneconomical. Moreover, advances in technology may allow for more efficient recovery and utilization of these reserves, in effect extending the R/P ratios.

4) If the carbon dioxide emissions per capita of India in 2008 (1.4 metric tons) were to increase to the level of the United States in 2008 (19.3 metric tons of carbon dioxide emissions per capita), what would be the percentage increase in world carbon emissions (approximately 31 billion metric tons) in 2008. Assume India’s population is 1.2 billion and the U.S. population is 315 million.

A: The increase in per capita metric tons for India would be 17.9. With a population of 1.2
billion, India’s total increase would be 21.48 billion metric tons or an increase of 69.3 percent for the world in carbon dioxide emissions.
Chapter 13

1) In the low-income nation of Guinea-Bissau, data indicate 17 percent of children under five are overweight and 17 percent are underweight, discuss why child malnutrition is a concern. What policies should be implemented in Guinea-Bissau to improve child nutrition?

A: Malnutrition, especially undernourishment, impairs the physical and cognitive development of children. Their vulnerability to disease and illness is greater and their ability to learn in school is undermined. For the first six months, at least, infants should be breastfed, if possible.

Breastfeeding has numerous benefits, for both the infants and mothers. Breastfeeding provides all the essential nutrients to infants and strengthens their immune systems, serves as a natural contraceptive that increases birth intervals, and even reduces the risks to mothers of ovarian, uterine, and breast cancers. Moreover, breastfeeding is economical, saving families on the expense of infant formula.

While being overweight is unhealthy and needs to be addressed, especially for children, with nutrition education for parents, including labelling of processed food products, the greater concern might be with children who are stunted (low height for age), which indicates chronic malnutrition, usually due to poverty. Food stamps and conditional cash transfers might be used to help parents provide a nutritious diet for their children. School breakfast and lunch programs. Adequate nutrition for children is a good investment in human capital.

2) Do you think there is a relationship between the high income, time constraints, fast food, and obesity in the United States? As with cigarettes, should there be an additional excise tax on fast food and soft drinks? Discuss.

A: Participation in the modern labor force can be stressful, not just the commuting to the work
place, but in eating healthy. With the time constraints, especially for families with children, often the convenience of fast food, whether from restaurants or quick-to-prepare processed foodstuffs, is appealing. Often relatively inexpensive (especially considering the time cost of preparation) and usually tasty (heavy in salts, sugars, and fats) fast food is not very healthy and has contributed to obesity, diabetes, and cardiovascular disease. Since the medical costs of poor diets, as well as the loss in productivity, are not borne entirely by the unhealthy individuals, the social costs are negative externalities that warrant government intervention, like excise taxes on fast food and soft drinks. The taxes would decrease the quantities consumed of these unhealthy foods and the tax revenues could be used for the health costs as well as public information campaigns.

3) The World Bank (2007) in the World Development Report 2008: Agriculture for Development classified Ghana, as an agriculture-based country, Thailand as a transforming country, and Mexico as an urbanized country. Using the latest World Development Indicators, collect data on the three economies for the share of GDP from agriculture (including forestry and fishing), the share of the population that is rural, the cereal yield (kilograms per hectare), and agricultural value added per worker.

<table>
<thead>
<tr>
<th>A:</th>
<th>Ghana</th>
<th>Thailand</th>
<th>Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of Agriculture in GDP (2012)</td>
<td>23%</td>
<td>12%</td>
<td>4%</td>
</tr>
<tr>
<td>Share of Population Rural (2012)</td>
<td>47%</td>
<td>66%</td>
<td>22%</td>
</tr>
<tr>
<td>Cereal Yield: kilograms per hectare (2012)</td>
<td>1,768</td>
<td>3,092</td>
<td>3,392</td>
</tr>
<tr>
<td>Agricultural Value Added per Worker in 2005$ (2012)</td>
<td>. . .</td>
<td>$1,136</td>
<td>$4,103</td>
</tr>
</tbody>
</table>

4) What can the developed economies, in particular, the United States and the high-income nations in Europe do to improve the global food supply?

A: The developed countries could reduce their trade barriers in agriculture, whether import tariffs and quotas on agricultural produce or subsidies to domestic farmers. This would lead to a more efficient allocation of resources in agriculture and increase agricultural production in the developing countries. The United States and other developed countries could cease subsidizing the production of ethanol from corn, reducing the diversion of corn from the food supply. The developed countries could increase the research and development of genetically engineered crops and agricultural inputs and could provide agricultural extension services to transfer technologies to farmers in developing countries.

5) Will the Gene Revolution ensure that the global food supply will keep pace with population? Discuss.

A: The Gene Revolution will clearly help the global food supply keep pace with population growth, especially given the expected climate change that could reduce agricultural production with the increased weather volatility and diminished water supplies. Concerns about the genetically-modified crops, from environmental threats with their transmission to traditional crops, the evolution of pests and new crop diseases, and food safety, however, have limited the adoption of the Gene Revolution technology, especially in Europe. Also important for the adequacy of the food supply is reducing the wastes in the food that is produced but not eaten, whether due to spoilage or simply discarded. The widespread adoption of the less efficient American diet (heavier in meat, especially beef) will be a concern, not only in terms of health, but for the adequacy of the global food supply.
6) Is the Blue Revolution the answer to the depletion of the oceans fish stocks? Discuss.

A: The Blue Revolution with the growth and development of aquaculture will help reduce the depletion of the oceans’ fishing stocks. Open access to the oceans, at least beyond the exclusive economic zones of nations (which are not always enforced by the coastal developing nations), and the subsidization of large fishing vessels have depleted much of the global fishing stocks. With more secure property rights, aquaculture should lead to better conservation. Nevertheless, there are signs of environmental degradation from intensive aquaculture production, so like any natural resource, sustainable management is important. International agreements on ocean fishing, for example, marketable production quotas, would also be helpful for restoring the fish stocks. Greater compliance with the Marine Stewardship Council standards for sustainable fishing would also help.
Chapter 14

1) Compare the insights from Adam Smith (the invisible hand) and Garrett Hardin (tragedy of the commons) for achieving sustainable development. Which perspective do you think is the more relevant? Why?

A: Adam Smith’s invisible hand referred to the natural order in a market economy with perfect competition, whereby individuals and firms pursuing their self-interests would promote the public welfare. That is, households seeking to maximize their utilities from expenditures on goods and services and firms seeking to maximize their profits in providing those goods and services as efficiently as possible would benefit the nation. Government should not attempt to regulate markets. There are, however, market failures, such as public goods (e.g., national defense and highways), merit goods (e.g., public education and health care), imperfect competition (e.g., natural monopolies, where economies of scale make competition infeasible, and oligopolies seeking to restrain trade), and externalities (where markets don’t incorporate social costs and social benefits), that call for government intervention. Others would argue that governments need to regulate firms in the interests of product and workplace safety, address poverty where market incomes are inadequate, and stabilize the macroeconomy to promote full employment and price stability.

Garrett Hardin pointed out that in the case of the commons, where there is open access to a common resource, e.g., pastureland or the oceans, individuals pursuing their self-interest may undermine the common good, resulting in unsustainable depletion of the natural resource or environmental deterioration. In particular, Hardin addressed the freedom to procreate which could easily lead to overpopulation when individuals do not bear the full cost of their
childbearing. In such cases, Hardin argued for ‘mutual coercion, mutually agreed upon’, or social regulation of private behavior for the common good.

2) Given the market demand and supply curves in a competitive market:

\[ Q^d = 60 - 5P \quad \text{and} \quad Q^s = -10 + 2P \]

a) Find the market equilibrium price and quantity transacted. Calculate the consumer surplus and producer surplus.

b) Suppose that the production of this good generated negative externalities, so that the comprehensive supply curve, including social costs, is given by \( Q^{s'} = -13.5 + 2P \). Find the socially optimal quantity produced and price.

c) Determine the excise tax on suppliers required to yield the socially optimal output. Calculate the tax revenues.

d) Suppose the market demand increases to \( Q^{d''} = 63.5 - 5P \), find the new market equilibrium price and quantity transacted. Determine the new socially optimal quantity transacted.

A:  

a) The market equilibrium price and quantity transacted are: \( P_0 = $10 \) and \( Q_0 = 10 \).

Consumer surplus (CS) and producer surplus (PS) are: \( CS = (.5)(12-10)(10) = $10 \) and \( PS = (.5)(10-5)(10) = $25 \).

b) The socially optimal quantity produced and price are: \( Q_1 = 7.5 \) and \( P_1 = $10.5 \).

c) The required excise tax on suppliers is \( t = $1.75 \). The tax revenues are \( $13.125 \).

Note: The initial supply schedule can be written as \( P = 5 + .5Q \). The supply schedule incorporating the negative externality (social costs) is \( P' = 6.75 + .5Q \).

\[ d) \text{ The new market equilibrium price and quantity transacted are: } P_2 = $10.5 \text{ and } Q_2 = 11. \text{ The new socially optimal quantity transacted is: } Q_3 = 8.5 \text{ (with } P_3 = $11). \]
3) Given the market demand and supply curves in a competitive market:

\[ Q^d = 40 - 4P \quad \text{and} \quad Q^s = -5 + 5P \]

a) Find the market equilibrium price and quantity transacted. Calculate the consumer surplus and producer surplus.

b) Suppose that the consumption of this good generated positive externalities, so that the comprehensive demand curve, including social benefits, is given by \( Q^{d*} = 49 - 4P \). Find the socially optimal quantity produced.

c) Determine the subsidy to suppliers required to yield the socially optimal output.

A:

a) The market equilibrium price and quantity transacted are: \( P_0 = 5 \) and \( Q_0 = 20 \).

Consumer surplus (CS) and producer surplus (PS) are: \( CS = (0.5)(10 - 5)(20) = 50 \) and \( PS = (0.5)(5 - 1)(20) = 40 \).

b) The socially optimal quantity produced is: \( Q_1 = 25 \).

c) The subsidy to suppliers required to yield the socially optimal output is: \( s = 2.25 \).

Note: With the market supply curve of \( P = 1 + .2Q \), the supply price for a quantity transacted of \( Q_1 = 25 \) is \$6. To increase the quantity demanded to \( Q_1 = 25 \), however, would require a demand price of \$3.75. \( Q^d = 40 - 4P' = 25 \), so \( P' = 3.75 \). The per unit subsidy to suppliers would have to be \$2.25 (or \$6 - 3.75). To increase the quantity supplied to 25 where the unit price is \$3.75 would require an increase in supply from: \( P = 1 + .2Q \) to \( P'' = 1 + .2Q - 2.25 \) (or a supply schedule of \( Q'' = 6.25 + 5P \)).

4) What is the appropriate role for the government in an economy? That is which of the market failures warrant government involvement? Who should determine this? Discuss.

A: The appropriate role for the government in an economy is normative and controversial.
There is a consensus among economists that public goods (e.g., national defense and the judicial system) with nonrival and nonexcludable consumption, as well as merit goods (e.g., public education), should be provided by the government. Moreover, with natural monopolies (e.g., public utilities) where competition is not practical or efficient, regulatory commissions are used to set prices. Antitrust legislation to promote competition is advocated when a few large firms dominate a market. In the United States regulation of the goods and services produced to protect consumer health and safety (e.g., the Food and Drug Administration) and worker safety (e.g., Occupational Health and Safety Administration) is generally accepted, but other government oversight, e.g., banking services and financial products (Consumer Financial Protection Bureau) is more controversial. Negative externalities like pollution are regulated by the Environmental Protection Agency, although the degree and most appropriate type of regulation are subject to debate. Positive externalities, for example, basic scientific research, may justify government subsidies. Poverty and socially divisive inequalities in income can be addressed through government transfers and taxes, although here too there is considerable controversy. Demand-management fiscal and monetary policies are favored by some economists, e.g., Keynesians, to reduce macroeconomic instability, especially high unemployment during recessions. Other macroeconomists believe the government does more harm than good in trying to manage the economy. Finally, government investment in important industries, or potentially leading sectors of the economy, such as space exploration and renewable energy, is advocated by some, but not all.

5) With respect to global warming, do you think Hardin’s mutual coercion or Ostrom’s mutual trust will most likely address the problem? Discuss.
A: Ostrom’s conditions for effective cooperation to self-regulate common resources include feasible communication among and known reputations of all the participants, high marginal benefits for cooperation, with flexibility in entering and exiting agreements, a shared longer run perspective, and agreed upon sanctions, seem not to apply to global warming. First, the atmosphere is shared by all nations and peoples. Historically the majority of the greenhouse gas accumulations has been due to economic growth of the developed nations, although increasingly the emerging economies like China and India are contributing a large share of the GHG emissions. Moreover, the consequences of global warming are not uniformly spread across the nations. Developing nations in the southern hemisphere will bear the brunt of the costs. Political leaders in all countries, especially elected officials in democracies, have short run horizons. Costs of addressing climate change up front are required to reduce the adverse long run consequences of even greater global warming. With the exception of the 1987 Montreal Protocol to protect the earth’s ozone layer by reducing the production of chlorofluorocarbons, international agreements to address climate change have not been very effective. For example, the Kyoto Protocol was never agreed to by the United States or China, the two major polluting nations of the world, and only marginally implemented by those nations that did adopt the treaty. There were no international penalties for not abiding.

Without a supranational authority that can enforce international agreements and impose sanctions on offending nations, mutual coercion will be absent. It remains to be seen whether the nations of the world will rise to the occasion and adopt an effective agreement to mitigate climate change, e.g., a universal carbon tax.
Chapter 15

1) The noted philosopher and inventor, Buckminster Fuller, was quoted in 1967 saying:

“Humanity’s mastery of vast, inanimate, inexhaustible energy resources and the accumulated doing more with less of sea, air and space technology have proven Malthus wrong. Comprehensive physical and economic success for humanity may now be accomplished in one-fourth of a century.”

Compare Fuller’s optimism with Herman Daly’s (1977) call for a steady state economy as discussed in Chapter 5. Which view do you think is more likely to hold in the future? Why?

A: Fuller believed economic growth could continue without limits. While he was aware of nonrenewable natural resources, advances in technology and substitution of renewable natural resources (e.g., solar energy for fossil fuels) might actually increase the effective supply of natural resources, removing this as a possible constraint to growth. Moreover, with no limits to human creativity and ingenuity, technological progress could indeed allow for doing more with less. At the time Fuller was writing, however, there was little attention given to environmental deterioration, and much less to climate change and global warming. The incidence of poverty in the world was high, however, and even by the end of the twentieth century, nearly a third of the six billion world population lived in extreme poverty.

Daly, writing a decade later, argued that a steady-state economy with “constant stocks of people and artifacts, maintained at some desired, sufficient levels by low rates of maintenance throughput” was a necessary and desirable future. For Daly, the limits to growth, both population and economic, were the finite supply of low entropy, or the available matter and energy in the world. Daly proposed three institutions to achieve and maintain a steady state economy: marketable birth licenses to maintain zero population growth; resource depletion quotas auctioned off by the government to limit output growth; and limits on income
Evidence of environmental stress and climate change (air and water pollution, declining aquifers, deforestation, soil erosion, deterioration of coral reefs, depletion of fishing stocks, greenhouse gas accumulations, rising temperatures and melting of polar ice) is clear and ominous. While advances in technology and increased exploration have led to recovery of additional fossil fuels and minerals, the ultimate supplies are still finite and the costs of extracting and using these resources, usually of lower quality, are rising. Moreover, some of the essential life support services rendered by the environment, in particular, clean air to breath, have no substitutes.

So, while the optimism of Fuller might be hoped for, the realism of Daly who recognizes a carrying capacity of a finite earth and argues there are limits to growth seems more likely. Nevertheless, how to achieve sustainable development remains a challenge.

2) Discuss whether there is a conflict between economic growth and sustainable development. How would you define sustainable development for the world? Is sustainable development possible with extreme poverty afflicting many throughout the world?

A: Economic growth is defined as the percentage change in output per capita. Sustainable development, in contrast, has no clear or concise definition, several dimensions and multiple indicators. The most famous definition was given by the World Commission on Environment and Development (1987) as "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: the concept of ‘needs,’ in particular the essential needs of the world’s poor, to which overriding priority should be given; and the idea of limitations
imposed by the state of technology and social organization on the environment’s ability to meet present and future needs.” While technology, preservation of the natural environment, and poverty, are noted, there is no explicit mention of economic growth. And, given the finite stocks of nonrenewable resources, and even the finite flows of renewable resources available for production in any period, along with limits on the ability of the environment to absorb the wastes generated by human economic activity without significant deterioration, it is arguable that economic growth or population growth can be sustained into the future.

The carrying capacity of the planet, however, depends on the available natural resources, technology, population, and the rate of resource consumption. For given technology and natural resources, for any carrying capacity there is a trade-off then between population size and the average per capita consumption of resources. If the world population eventually stabilizes and then begins to decline, then sustainable development may well occur with economic growth, at least for the time that population is declining. So too, if the world economy is well below the carrying capacity of the planet, then economic growth may well continue with technological progress for some time. Eventually, or in the very long run, however, it is likely that there will be zero economic growth and zero population growth. As John Stuart Mill argued, zero economic growth need not mean a stagnant quality of life or that human development can’t continue.

Essential parameters for sustainable development would seem to include constant supplies of effective renewable natural resources, stabilization of greenhouse gas accumulations in the atmosphere and global average temperatures, the preservation of the natural environment and biodiversity, and the reduction, if not elimination, of absolute
poverty. The stocks of knowledge, human capital, and social capital could and should increase, even if the population size and stocks of physical capital do not.

3) Are Rawls’ veil of ignorance and the precautionary principles useful guides for achieving sustainable development? Discuss.

A: Yes, the precautionary principle seems prudent, if we are concerned about the welfare of our children, grandchildren, and future generations. The evidence of climate change and global warming due to human behavior, mainly the fossil-fuel driven economic growth over the past two centuries, is overwhelming, but not proven. Nevertheless, the consequences of the expected increases in global temperatures and volatility in weather are severe enough that effective actions should be taken now, if not yesterday. Weak and delayed mitigating actions will only increase the costs and impair more severely livelihoods in the future.

All nations and populations will be affected, although not uniformly, so some nations have less incentive to incur the costs of mitigation. Developing nations argue that the developed economies are mostly responsible for the greenhouse gas accumulations and are the best equipped with the technology and resources to take the lead. Developed nations argue that increasingly the rapid growth in the developing nations is adding to greenhouse gas accumulation and so these nations, despite their much lower incomes, need also to take appropriate steps. What is fair and appropriate clearly is influenced by one’s point of view, which depends on their circumstances...their age, ability, income, and where they live, i.e., their perceived self-interest. So, if it were possible, adopting Rawls’ veil of ignorance would lead to more just and effective policies to mitigate and then adapt to climate change.

Nevertheless, widespread adoption of the precautionary principle and veil of ignorance...
faces strong headwinds under the prevailing political-economic conditions, and may even be contrary to prevailing consumerism and relativism that drives much of human behavior.

4) What is your assessment of the next half-century for the world population, average standard of living, and the condition of planet earth? Discuss.

A: The United Nations projects the world population will exceed 9.5 billion by 2050 and will still be growing, reaching 10.8 billion by 2100 (See Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, *World Population Prospects: The 2012 Revision* at http://esa.un.org/wpp/unpp/p2k0data.asp). While necessarily speculative, a case can be made for the world population stabilizing in the next fifty years, perhaps in the neighborhood of nine billion, as developing nations complete their demographic transitions. Whether the developed nations and the many other developing nations with total fertility rates currently below two children raise their rates back to replacement level is unclear. Moreover, whether the developing nations, after completing their transitions, will reduce their fertility rates to below replacement level, will also affect the world population size. The world population will be older, with a reduced youth burden of dependency, but a higher elderly burden.

The average standard of living will be higher. The high-income developed economies will likely experience some economic growth, although much slower than the developing economies, especially Asia. Consequently, while large gaps in per capita income will remain between the developed and developing nations, there will be some convergence. The incidence of extreme poverty should be reduced further, from approximately one-sixth of the world population in 2010 to well below one-tenth of the world population in 2050. If so the extreme
poverty headcount would fall from 1.2 billion to under 1 billion. Whether income inequalities in nations will be even greater will depend on the type of economic growth pursued as well as the social policies adopted.

Economic growth and the average standard of living, however, will be lower with the predicted climate change and deterioration in the environment. It is likely that the average world temperature will have increased by at least 2°C. As the World Bank (2010: 70, 10) in the 2010 World Development Report cautioned:

*If the world is able to limit the human-caused temperature increase to about 2°C above the preindustrial level, it might be possible to limit significant loss from the Greenland and West Antarctic ice shelves and subsequent sea level rise; to limit the increase in floods, droughts, and forest fires in many regions; to limit the increase of death and illness from the spread of infections and diarrheal diseases and from extreme heat; to avoid extinction of more than a quarter of all known species; and to prevent significant declines in global food production.*

...stabilizing global warming around 2°C above preindustrial temperatures [would necessitate] by 2050 that emissions be 50 percent below 1990 levels and be zero or negative by 2100...[This would] require global emissions to begin declining by about 1.5 percent a year....a ten year delay in mitigation would most likely make it impossible to keep warming from exceeding 2°C.

Little progress in implementing effective mitigation to reduce greenhouse gas emissions has been made so far. Along with the loss in biodiversity, other environmental tipping points might well be breached, resulting in even greater deterioration in the natural environment.

5) Why should we be concerned with the welfare of future generations?

A: Altruistically, we should care. Like current generations, future generations of our children and grandchildren deserve the opportunities for sustainable development. It seems to be a
moral obligation of current generations to preserve these opportunities. Extending Rawls’ veil of ignorance, if you didn’t know in which generation you would be born, what kind of world would you want?

6) Write down three things, conditions, or experiences that presently give you the most happiness or satisfaction. Which of these are dependent on income?
   A: This is highly personal and will depend on one’s priorities and motivations. Likely included in this list would be the enjoyment of family and friends, the pleasure and feeling of accomplishment from work, and the sense that you are contributing to a better world, whether in the lives of your family members and friends, or in the wider society. While related to income (reflecting in part your career success) and the ability to afford a comfortable life style and perhaps support the work of charities, much happiness seems independent of income, depending on attitude and good fortune.

7) As you evaluate your life, say at age eighty, what three things, conditions, or experiences do you think will have defined a ‘good life’?
   A: Likely reflecting the answer to the previous question, loving family, good friends, and good health will be near the top of most lists. As a parent, one wishes for the happiness of their children. After spending much of your adult life working, you hope that your work was meaningful and enriching. And, you hope made a positive difference...as a spouse, parent, friend, worker, community member, and citizen. There will likely be many memories of experiences associated with each, and while you’ll have undoubtedly made mistakes along the way and suffered some misfortunes, you’ll hope that you always tried to do your best.