Chapter 3: Productivity, Output, and Employment

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The Production Function
The Demand for Labor
The Supply of Labor
Labor Market Equilibrium
Unemployment
Relating Output and Unemployment: Okun’s Law
The most fundamental determinant of economic well-being in a society: The economy’s productive capacity.

The amount of output an economy produces depends on two factors:

- The quantities of inputs (such as labor, capital, and raw materials) utilized in the production process;
- The productivity of the inputs, i.e., the effectiveness with which they are used.

The most important input to production is labor. We focus on the labor market in this chapter. We first assume that the quantities of labor supplied and demanded are equal so that all labor resources are fully utilized, and later we introduce unemployment.
The Production Function

- Factors of production:
  - Capital \((K)\)
  - Labor \((N)\)
  - Others (raw materials, land, energy)
  - Productivity of factors depends on technology and management

- The production function (the effectiveness with which capital and labor are used):

\[ Y = AF(K, N), \quad (1) \]

\(Y\) is real output produced in a given period of time. \(A\) is a number measuring overall productivity or “total factor productivity”.

- Increases in \(A\) correspond to improvements in production technology or to any other change in the economy that allows capital and labor to be utilized more effectively.
The production function of the U.S. economy and U.S. productivity growth. Cobb-Douglas production function works well for U.S. economy:

\[ Y = AK^{0.3}N^{0.7} \]  

Data for U.S. economy — Table 3.1.

Output, capital, and labor in Table 3.1 are measured directly, but there is no way to measure productivity directly.

Productivity growth calculated using production function:

- Productivity moves sharply from year to year.
- Productivity grew rapidly in the second half of the 1990s, but grew more slowly in the 2000s.
### Table 3.1 The Production Function of the United States, 1991-2010

<table>
<thead>
<tr>
<th>Year</th>
<th>(1) Real GDP, $Y$ (billions of 2005 dollars)</th>
<th>(2) Capital stock, $K$ (billions of 2005 dollars)</th>
<th>(3) Labor, $N$ (millions of workers)</th>
<th>(4) $A^a$</th>
<th>(5) Growth in $A$ (% change in $A$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>8008</td>
<td>9388</td>
<td>117.7</td>
<td>18.29</td>
<td></td>
</tr>
<tr>
<td>1992</td>
<td>8260</td>
<td>9521</td>
<td>118.5</td>
<td>18.74</td>
<td>2.5</td>
</tr>
<tr>
<td>1993</td>
<td>8516</td>
<td>9710</td>
<td>120.3</td>
<td>18.96</td>
<td>1.2</td>
</tr>
<tr>
<td>1994</td>
<td>8863</td>
<td>9932</td>
<td>123.1</td>
<td>19.29</td>
<td>1.7</td>
</tr>
<tr>
<td>1995</td>
<td>9086</td>
<td>10,216</td>
<td>124.9</td>
<td>19.41</td>
<td>0.6</td>
</tr>
<tr>
<td>1996</td>
<td>9426</td>
<td>10,544</td>
<td>126.7</td>
<td>19.75</td>
<td>1.8</td>
</tr>
<tr>
<td>1997</td>
<td>9846</td>
<td>10,924</td>
<td>129.6</td>
<td>20.09</td>
<td>1.7</td>
</tr>
<tr>
<td>1998</td>
<td>10,275</td>
<td>11,357</td>
<td>131.5</td>
<td>20.51</td>
<td>2.1</td>
</tr>
<tr>
<td>1999</td>
<td>10,771</td>
<td>11,821</td>
<td>133.5</td>
<td>21.02</td>
<td>2.5</td>
</tr>
<tr>
<td>2000</td>
<td>11,216</td>
<td>12,327</td>
<td>136.9</td>
<td>21.24</td>
<td>1.0</td>
</tr>
<tr>
<td>2001</td>
<td>11,338</td>
<td>12,691</td>
<td>136.9</td>
<td>21.28</td>
<td>0.2</td>
</tr>
<tr>
<td>2002</td>
<td>11,543</td>
<td>12,912</td>
<td>136.5</td>
<td>21.60</td>
<td>1.5</td>
</tr>
<tr>
<td>2003</td>
<td>11,836</td>
<td>13,108</td>
<td>137.7</td>
<td>21.91</td>
<td>1.4</td>
</tr>
<tr>
<td>2004</td>
<td>12,247</td>
<td>13,332</td>
<td>139.3</td>
<td>22.38</td>
<td>2.1</td>
</tr>
<tr>
<td>2005</td>
<td>12,623</td>
<td>13,584</td>
<td>141.7</td>
<td>22.66</td>
<td>1.3</td>
</tr>
<tr>
<td>2006</td>
<td>12,959</td>
<td>13,920</td>
<td>144.4</td>
<td>22.79</td>
<td>0.6</td>
</tr>
<tr>
<td>2007</td>
<td>13,206</td>
<td>14,297</td>
<td>146.0</td>
<td>22.86</td>
<td>0.3</td>
</tr>
<tr>
<td>2008</td>
<td>13,162</td>
<td>14,615</td>
<td>145.4</td>
<td>22.70</td>
<td>-0.7</td>
</tr>
<tr>
<td>2009</td>
<td>12,758</td>
<td>14,673</td>
<td>139.9</td>
<td>22.58</td>
<td>-0.5</td>
</tr>
<tr>
<td>2010</td>
<td>13,063</td>
<td>14,769</td>
<td>139.1</td>
<td>23.17</td>
<td>2.6</td>
</tr>
</tbody>
</table>

*Note:* Total factor productivity is calculated by the formula $A = Y/(K^{0.3}N^{0.7})$. The calculation of $A$ in this table is based on more precise values for $Y$, $N$, and $K$, so the reported numbers for $A$ here may differ very slightly from what you would calculate by using the numbers in this table for $Y$, $N$, and $K$.

*Sources:* $Y$ is real GDP in billions of 2005 chained dollars from the St. Louis FRED database, research.stlouisfed.org/fred2/series/GDPCA; $K$ is real net stock of fixed private nonresidential capital in billions of 2005 dollars from Bureau of Economic Analysis, Fixed Asset Table 1.2, www.bea.gov/bea/dn/faweb/AllFATables.asp; $N$ is civilian employment in millions of workers from Bureau of Labor Statistics, Current Population Survey, bls.gov/cps/cpsaat01.htm
The shape of the production function

- Two main properties of production functions:
  - Slopes upward: more of any input produces more output.
  - Slope becomes flatter as input rises: diminishing marginal product as input increases.

- The shape of the production function ($Y$ vs. one input; hold other input and $A$ fixed).
  - Marginal product of capital,
    \[ MPK = \frac{\Delta Y}{\Delta K}, \]  
    is the slope of production function graph ($Y$ vs. $K$). $MPK$ always positive. Diminishing marginal productivity of capital: $MPK$ declines as $K$ rises. When $K$ is low, there are many workers for each machine, and the benefits of increasing capital further are great.
  
- Marginal product of labor,
    \[ MPN = \frac{\Delta Y}{\Delta N}, \]  
    is the slope of production function graph ($Y$ vs. $N$). $MPN$ always positive. Diminishing marginal productivity of labor.
Figure 3.1 The Production Function Relating Output and Capital
Figure 3.2 The marginal product of capital
**Figure 3.3** The production function relating output and labor
Supply shocks

- The production function of an economy does not usually remain fixed over time. Supply shock = productivity shock = a change in an economy’s production function.
- Supply shocks affect the amount of output that can be produced for a given amount of inputs.
- Shocks may be positive (increasing output) or negative (decreasing output).
  - Examples: weather, inventions and innovations, govt. regulations, oil prices.
- Supply shocks shift graph of production function (Fig. 3.4):
  - Negative (adverse) shock: Usually slope of production function decreases at each level of input (for example, if shock causes parameter $A$ to decline).
  - Positive shock: Usually slope of production function increases at each level of output (for example, if $A$ increases).
Figure 3.4  An adverse supply shock that lowers the MPN
How much labor do firms want to use?

- **Assumptions:**
  - Hold capital stock fixed—short-run analysis. The capital stock is long-lived and has been built up over many years: New investment only slowly has a significant impact on the aggregate capital stock. When we examine long-term economic growth, we will drop this assumption and examine how the capital stock evolves over time.
  - Workers are all alike. Ignore heterogeneity in workers’ abilities, ambitions, and so on.
  - Labor market is competitive. Firms and worker take the wage rate determined in the competitive labor market as given.
  - Firms maximize profits. The firm will demand the amount of labor that maximizes its profit. Firms must compare the costs and benefits of hiring each additional worker.

- **MPN:** the benefit of employing an additional worker in terms of the extra output produced.
(Conti.) $\text{MRPN}$: the benefit of employing an additional worker in terms of the extra revenue produced. To calculate $\text{MRPN}$, we need to know the price of the firm’s output ($P$).

Example (Table 3.2): The Clip Joint—setting the nominal wage equal to the marginal revenue product of labor (MRPN):

$$\text{MRPN} = P \times \text{MPN}$$

(5)

where $W = \text{MRPN}$ is the nominal wage, i.e., the wage measured in today’s dollars.

$w$ denotes the real wage measured in terms of units of output. Note that the real wage is also the real cost of adding another worker. The above equation is just the same condition as $w = \text{MPN}$, since $W = P \times w$ and $\text{MRPN} = P \times \text{MPN}$.
Table 3.2  The Clip Joint’s Production Function

<table>
<thead>
<tr>
<th>Number of workers, $N$</th>
<th>Number of dogs groomed, $Y$</th>
<th>Marginal product of labor, $MPN$</th>
<th>Marginal revenue product of labor, $MRPN = MPN \times P$ (when $P = $30 per grooming)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>11</td>
<td>$330</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>9</td>
<td>$270</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>7</td>
<td>$210</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
<td>5</td>
<td>$150</td>
</tr>
<tr>
<td>4</td>
<td>32</td>
<td>3</td>
<td>$90</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
<td>1</td>
<td>$30</td>
</tr>
<tr>
<td>6</td>
<td>36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A change in the wage

- Begin at equilibrium where \( W = MRPN \).
  - A rise in the wage rate means \( W > MRPN \), unless \( N \) is reduced so the \( MRPN \) rises.
  - A decline in the wage rate means \( W < MRPN \), unless \( N \) rises so the \( MRPN \) falls.

- Analysis at the margin: costs and benefits of hiring one extra worker (Fig. 3.5)
  - If real wage (\( w \)) > marginal product of labor (\( MPN \)), profit rises if number of workers declines.
  - If \( w < MPN \), profit rises if number of workers increases.
  - Firms’ profits are highest when \( w = MPN \).
**Figure 3.5** The determination of labor demand
### Comparing the Benefits and Costs of Changing the Amount of Labor

<table>
<thead>
<tr>
<th>To maximize profits, the firm should:</th>
<th>Increase employment if, for an additional worker</th>
<th>Decrease employment if, for the last worker employed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real terms</strong></td>
<td>$MPN &gt; w$</td>
<td>$MPN &lt; w$</td>
</tr>
<tr>
<td></td>
<td>$(MPN &gt; W/P)$</td>
<td>$(MPN &lt; W/P)$</td>
</tr>
<tr>
<td><strong>Nominal terms</strong></td>
<td>$P \times MPN &gt; W$</td>
<td>$P \times MPN &lt; W$</td>
</tr>
<tr>
<td></td>
<td>$(MRPN &gt; W)$</td>
<td>$(MRPN &lt; W)$</td>
</tr>
</tbody>
</table>

$MPN = \text{marginal product of labor}$  
$P = \text{price of output}$  
$MRPN = \text{marginal revenue product of labor} = P \times MPN$  
$W = \text{nominal wage}$  
$w = \text{real wage} = W/P$
Labor demand curve shows relationship between the real wage rate and the quantity of labor demanded.

It is the same as the MPN curve except that the vertical axis measures the real wage for the labor demand curve and measures the marginal product of labor for the MPN curve. Note that \( w = MPN \) at equilibrium.

So the labor demand curve is downward sloping; firms want to hire less labor as the real wage rises.
Factors that shift the labor demand curve

- Note: A change in the wage causes a movement along the labor demand curve, not a shift of the curve.
- Supply shocks: Beneficial supply shock raises $MPN$ at all levels of labor input, so shifts labor demand curve to the right; opposite for adverse supply shock. Think about some improvement in technology.
- Size of capital stock: Higher capital stock (e.g., giving each worker more machines or equipment to work with) raises $MPN$, so shifts labor demand curve to the right; opposite for lower capital stock.
Table 3.3  The Clip Joint’s Production Function After a Beneficial Productivity Shock

<table>
<thead>
<tr>
<th>Number of workers, $N$</th>
<th>Number of dogs groomed, $Y$</th>
<th>Marginal product of labor, $MPN$</th>
<th>Marginal revenue product of labor, $MRPN = MPN \times P$ (when $P = $30 per grooming)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>22</td>
<td>$660</td>
</tr>
<tr>
<td>1</td>
<td>22</td>
<td>18</td>
<td>$540</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>14</td>
<td>$420</td>
</tr>
<tr>
<td>3</td>
<td>54</td>
<td>10</td>
<td>$300</td>
</tr>
<tr>
<td>4</td>
<td>64</td>
<td>6</td>
<td>$180</td>
</tr>
<tr>
<td>5</td>
<td>70</td>
<td>2</td>
<td>$60</td>
</tr>
<tr>
<td>6</td>
<td>72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Aggregate labor demand

- Aggregate labor demand is the sum of all firms’ labor demand. The aggregate labor demand curve looks the same as the labor demand curve for an individual firm.

- Same factors (supply shocks, size of capital stock) that shift firms’ labor demand cause shifts in aggregate labor demand.
Figure 3.6  The effect of a beneficial supply shock on labor demand

A beneficial supply shock raises the MPN at all levels of labor input.
### Summary 3

**Factors That Shift the Aggregate Labor Demand Curve**

<table>
<thead>
<tr>
<th>An increase in</th>
<th>Causes the labor demand curve to shift</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Productivity</strong></td>
<td>Right</td>
<td>Beneficial supply shock increases MPN and shifts MPN curve up and to the right.</td>
</tr>
<tr>
<td><strong>Capital stock</strong></td>
<td>Right</td>
<td>Higher capital stock increases MPN and shifts MPN curve up and to the right.</td>
</tr>
</tbody>
</table>
The supply of labor

- Supply of labor is determined by individuals or members of a family making a joint decision.
- Each person of working-age must decide how much (if at all) to work in a wage-paying sector vs. non-wage-paying alternatives: going to school, home production, or being retired.
- Aggregate supply of labor is the sum of individuals’ labor supply.
- Labor supply of individuals depends on labor-leisure choice. In deciding how much to work, an individual should weigh the benefits against the costs of working.
The income-leisure trade-off

- Utility depends on consumption and leisure.
- Need to compare costs and benefits of working another day:
  - Costs: Loss of leisure time.
  - Benefits: More consumption, since income is higher.
- If benefits of working another day exceed costs, work another day.
- Keep working additional days until benefits equal costs.
Real wages and labor supply

- The real wage is the amount of real income that a worker receives in exchange for giving up a unit of leisure (an hour, a day, or a week).
- An increase in the real wage has offsetting income and substitution effects:
  - Substitution effect: Higher real wage encourages work, since reward for working is higher.
  - Income effect: Higher real wage increases income for same amount of work time, so person can afford more leisure, so will supply less labor.
- A pure substitution effect: a one-day rise in the real wage. A temporary real wage increase has just a pure substitution effect, since the effect on wealth is negligible.
- A pure income effect. Winning the lottery:
  - Winning the lottery doesn’t have a substitution effect, because it doesn’t affect the reward for working.
  - But winning the lottery makes a person wealthier, so a person will both consume more goods and take more leisure; this is a pure income effect.
The substitution and income effects together: a long-term increase in the real wage.

- The reward to working is greater: a substitution effect toward more work.
- But with higher wage, a person doesn’t need to work as much: an income effect toward less work.
- The longer the high wage is expected to last, the stronger the income effect; thus labor supply will increase by less or decrease by more than for a temporary reduction in the real wage.

Empirical evidence on real wages and labor supply:

- Overall result: Labor supply increases with a temporary rise in the real wage.
- Labor supply falls with a permanent increase in the real wage.
The labor supply curve

- Increase in the current real wage should raise quantity of labor supplied.

- *Labor supply curve* relates quantity of labor supplied to real wage, holding constant all other factors (including the expected future real wage rate) that affect the amount of labor supply.

- Labor supply curve slopes upward because higher wage encourages people to work more.

- Factors that shift the labor supply curve:
  - Wealth: Higher wealth reduces labor supply at *any real wage* (shifts labor supply curve to the left, as in Fig. 3.8).
  - Expected future real wage: Higher expected future real wage is like an increase in wealth, so reduces labor supply (shifts labor supply curve to the left).
Figure 3.7  The labor supply curve of an individual worker
Aggregate labor supply

- Aggregate supply of labor is the total amount of labor supplied by everyone in the economy.

- Aggregate labor supply rises when current economywide real wage rises because:
  - Some people work more hours.
  - Other people enter labor force.
  - Result: Aggregate labor supply curve slopes upward.

- Factors increasing labor supply:
  - Decrease in wealth.
  - Decrease in expected future real wage.
  - Increase in working-age population (higher birth rate, immigration): increased number of potential workers.
  - Increase in labor force participation (increased female labor participation, elimination of mandatory retirement): increased number of people wanting to work.
Figure 3.8  The effect on labor supply of an increase in wealth
# Summary 4

## Factors That Shift the Aggregate Labor Supply Curve

<table>
<thead>
<tr>
<th>An increase in</th>
<th>Causes the labor supply curve to shift</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wealth</td>
<td>Left</td>
<td>Increase in wealth increases amount of leisure workers can afford.</td>
</tr>
<tr>
<td>Expected future real wage</td>
<td>Left</td>
<td>Increase in expected future real wage increases amount of leisure workers can afford.</td>
</tr>
<tr>
<td>Working-age population Participation rate</td>
<td>Right</td>
<td>Increased number of potential workers increases amount of labor supplied.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased number of people wanting to work increases amount of labor supplied.</td>
</tr>
</tbody>
</table>
Equilibrium: aggregate labor supply equals aggregate labor demand. (Called “the classical model of the labor market”.) Fig. 3.9.

Classical model of the labor market — real wage adjusts quickly to equate labor supply and labor demand. If labor supply is less than labor demand, firms competing for scarce workers bid up the real wage, whereas if many workers are competing for less jobs, the real wage will tend to fall.

Determines full-employment level of employment $\overline{N}$ and market-clearing real wage $\overline{w}$.

Problem with classical model: can’t study unemployment.
Figure 3.9 Labor market equilibrium
(Conti.) Full-employment output = potential output = level of output when labor market is in equilibrium:

\[ \bar{Y} = AF(K, \bar{N}) \]  \hspace{1cm} (6)

- It is affected by changes in full employment level or production function (example: supply shock, Fig. 3.10).
- Application: output, employment, and the real wage during oil price shocks:
  - Sharp oil price increases in 1973 – 1974, 1979 – 1980, 2003 – 2008 (Fig. 3.11).
  - Adverse supply shock—lowers labor demand, employment, the real wage, and the full-employment level of output.
  - First two cases: U.S. economy entered recessions.
  - Research result: 10% increase in price of oil reduces GDP by 0.4%.
Figure 3.10  Effects of a temporary adverse supply shock on the labor market

1. A temporary adverse supply shock

2. Real wage falls

2. Employment falls
Measuring unemployment

- BLS Survey Categories: employed (if the person worked full-time or part-time during the past week), unemployed (if the person did not work during the past week but look for work during the past four weeks), not in the labor force (if the person did not work during the past week and didn’t look for work during the past four weeks, e.g., full-time students, homemakers, retirees).
- Labor Force = Employed + Unemployed.
- Unemployment Rate = Unemployed/Labor Force.
- Participation Rate = Labor Force/Adult Population.
- Employment Ratio = Employed/Adult Population.
- Table 3.4 shows current data.
Table 3.4  Employment Status of the U.S. Adult Population, July 2012

<table>
<thead>
<tr>
<th>Category</th>
<th>Number (millions)</th>
<th>Share of labor force (percent)</th>
<th>Share of adult population (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employed workers</td>
<td>142.2</td>
<td>91.7</td>
<td>58.4 (employment ratio)</td>
</tr>
<tr>
<td>Unemployed workers</td>
<td>12.8</td>
<td>8.3 (unemployment rate)</td>
<td>5.3</td>
</tr>
<tr>
<td>Labor force (employed + unemployed workers)</td>
<td>155.0</td>
<td>100.0</td>
<td>63.7 (participation rate)</td>
</tr>
<tr>
<td>Not in labor force</td>
<td>88.3</td>
<td></td>
<td>36.3</td>
</tr>
<tr>
<td>Adult population (labor force + not in labor force)</td>
<td>243.4</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Figures may not add up because of rounding.*

*Sources: The Employment Situation, July 2012, Table A-1.*
Figure 3.11 Relative price of energy, 1960-2011

Sources: Producer price index for fuels and related products and power from research.stlouisfed.org/fred2/series/PPIENG; GDP deflator from research.stlouisfed.org/fred2/GDPDEF. Data were scaled so that the relative price of energy equals 100 in year 2000.
Changes in employment status

- Flows between categories (Fig. 3.12).
- Discouraged workers (among the 21% of the unemployed people who leave the labor force each month): people who have become so discouraged by lack of success at finding a job that they stop searching.
- Other unemployed workers leave the labor force to engage in some activity such as homemaking or going to school.
Figure 3.12 Changes in employment status in a typical month (July 2012)
Table 3.4  Employment Status of the U.S. Adult Population, July 2012

<table>
<thead>
<tr>
<th>Category</th>
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<td></td>
</tr>
</tbody>
</table>

*Note: Figures may not add up because of rounding.*

*Sources: The Employment Situation, July 2012, Table A-1.*
How long are people unemployed? Two seemingly contradictory statements

- Most unemployment spells are of short duration, about two months or less:
  - Unemployment spell = period of time an individual is continuously unemployed.
  - Duration = length of unemployment spell.

- Most unemployed people on a given date are experiencing unemployment spells of long duration.
Numerical Example

- Labor force = 100; on the first day of every month, two workers become unemployed for one month each; on the first day of every year, four workers become unemployed for one year each.
- Result: 28 spells of unemployment during a year; 24 short (one month), four long (one year); so most spells are short.
- At any date, unemployment = six; four have long spells (one year), two have short spells (one month); so most unemployed people on a given date have long spells.
Mean duration of unemployment rises in recessions.

In 2007 – 2009 recession, the rise in duration was larger than ever before (Fig. 3.13).

Four possible explanations for the increase in duration:

- measurement issues. In 2011, the survey allows respondents to indicate that they have been unemployed for up to 5 years; before then it was 117 weeks.
- the extension of unemployment benefits.
- very large job losses.
- weak economic recovery.
Figure 3.13  Mean duration of unemployment, 1960-2012
Why there are always unemployed people

- **Frictional unemployment**
  - Search activity of firms and workers due to heterogeneity. In reality, neither jobs nor workers are identical.
  - Matching process takes time.
  - As the economy is dynamic, with jobs continually being created and destroyed and workers continually entering and exiting the labor force, there is always some frictional unemployment.

- **Structural unemployment**
  - Chronically unemployed: workers who are unemployed a large part of the time.
  - Structural unemployment: the long-term and chronic unemployment that exists even when the economy is not in a recession.
  - One cause: Lack of skills prevents some workers from finding long-term employment.
  - Another cause: Reallocation of workers out of shrinking industries or depressed regions; matching takes a long time.
The natural rate of unemployment

- Natural rate of unemployment ($\bar{u}$): when output and employment are at full-employment levels = frictional + structural unemployment
- Cyclical unemployment: difference between actual unemployment rate and natural rate of unemployment

$$u - \bar{u}.$$ (7)

- In touch with data and research: labor market data
  - Establishment survey: jobs.
Relationship between output (relative to full-employment output) and cyclical unemployment

\[
\frac{\bar{Y} - Y}{\bar{Y}} = 2 (u - \bar{u}), \tag{8}
\]

where \( Y \) is actual output and \( u \) is actual unemployment rate.

Why is the Okun’s Law coefficient 2, and not 1?

- Other things happen when cyclical unemployment rises: Labor force falls, hours of work per worker decline, average productivity of labor declines. All these factors magnify the effect of the increase in unemployment.
- Result is 2% reduction in output associated with 1% increase in unemployment rate.

Alternative formulation if average growth rate of full-employment output is 3%:

\[
\frac{\Delta Y}{Y} = 3 - 2\Delta u. \tag{9}
\]
Figure 3.14  Okun’s Law in the United States: 1951-2011