

Chapter Outline

- The Production Function
- The Demand for Labor
- The Supply of Labor
- Labor Market Equilibrium
- Unemployment
- Relating Output and Unemployment: Okun's Law

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The Production Function

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

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The Production Function

- The production function
$$Y = AF(K, N) \tag{3.1}$$
 - Parameter A is “total factor productivity” (the effectiveness with which capital and labor are used)

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The Production Function

- Application: The production function of the U.S. economy and U.S. productivity growth
 - Cobb-Douglas production function works well for U.S. economy:

$$Y = A K^{0.3} N^{0.7} \quad (3.2)$$

- Data for U.S. economy—Table 3.1

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Table 3.1 The Production Function of the United States, 1979-2004

Year	(1) Real GDP, Y (billions of 2000 dollars)	(2) Capital stock, K (billions of 2000 dollars)	(3) Labor, N (millions of workers)	(4) A ^a	(5) Growth in A (% change in A)
1979	5173	5615	98.8	15.58	
1980	5162	5831	99.3	15.32	-1.7
1981	5292	6090	100.4	15.40	0.6
1982	5189	6296	99.5	15.07	-2.2
1983	5424	6383	100.8	15.50	2.8
1984	5814	6814	105.0	15.98	3.1
1985	6054	6863	107.2	16.22	1.5
1986	6264	7050	109.6	16.38	1.0
1987	6475	7239	112.4	16.51	0.8
1988	6743	7429	115.0	16.79	1.7
1989	6981	7623	117.2	17.01	1.3
1990	7113	7809	118.8	17.06	0.3
1991	7101	7932	117.7	17.06	0.0
1992	7337	8045	118.5	17.47	2.4
1993	7533	8208	120.3	17.84	1.9
1994	7830	8396	123.1	17.94	1.2
1995	8032	8638	124.9	18.04	0.6
1996	8329	8917	126.7	18.35	1.7
1997	8704	9242	129.6	18.87	1.8
1998	9067	9605	131.5	19.03	1.9
1999	9470	9986	133.5	19.44	2.1
2000	9817	10392	136.9	19.57	0.6
2001	9881	10669	136.9	19.55	-0.1
2002	10049	10841	136.5	19.82	1.3
2003	10321	11010	137.7	20.13	1.6
2004	10786	11249	139.3	20.68	2.8

^aReal factor productivity is calculated by the formula $A = Y/K^{0.3}N^{0.7}$.
Sources: Y is real GDP in billions of 2000 (chain) dollars from the U.S. GNP Database, research.stlouisfed.org; RealGDP; K is real net stock of fixed private nonresidential capital in billions of 2000 dollars from Bureau of Economic Analysis, www.bea.gov/neer/tables/tables.asp; N is civilian employment in millions of workers from Bureau of Labor Statistics, ftp://ftp.bls.gov/pub/licenat/regsum1.txt.

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The Production Function

- Productivity growth calculated using production function
 - Productivity moves sharply from year to year
 - Productivity grew slowly in the 1980s and the first half of the 1990s, but increased in the second half of the 1990s

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The Production Function

- 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

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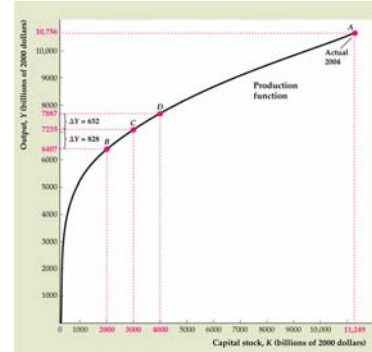
The Production Function

- The shape of the production function
 - Graph production function (Y vs. one input; hold other input and A fixed)
 - Figure 3.1

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Figure 3.1 The Production Function Relating Output and Capital



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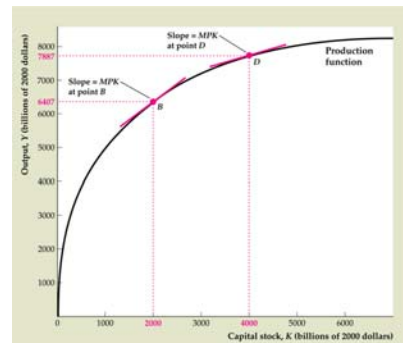
The Production Function

- The shape of the production function
 - Marginal product of capital, $MPK = \Delta Y / \Delta K$ Figure 3.2 = Key Diagram 1
 - Equal to slope of production function graph (Y vs. K)
 - MPK always positive
 - Diminishing marginal productivity of capital
 MPK declines as K rises

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Figure 3.2 The marginal product of capital



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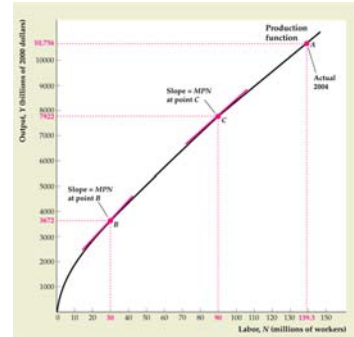
The Production Function

- The shape of the production function
 - Marginal product of labor, $MPN = \Delta Y/\Delta N$ Figure 3.3
 - Equal to slope of production function graph (Y vs. N)
 - MPN always positive
 - Diminishing marginal productivity of labor

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Figure 3.3 The production function relating output and labor



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The Production Function

- Supply shocks
 - 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, government regulations, oil prices

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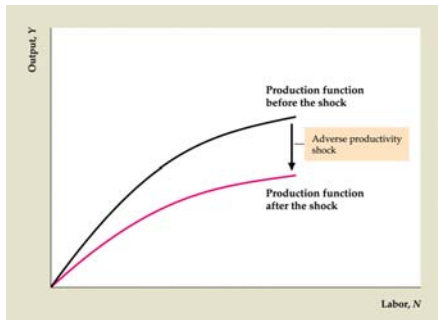
The Production Function

- Supply shocks
 - 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 parameter A increases)

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Figure 3.4 An adverse supply shock that lowers the *MPN*



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The Demand for Labor

- How much labor do firms want to use?
 - Assumptions
 - Hold capital stock fixed—short-run analysis
 - Workers are all alike
 - Labor market is competitive
 - Firms maximize profits

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The Demand for Labor

- The marginal product of labor and labor demand: an example
 - Example: The Clip Joint—setting the nominal wage equal to the marginal revenue product of labor

$$MRPN = P \times MPN \quad (3.3)$$
 - $W = MRPN$ is the same condition as $w = MPN$, since $W = P \times w$ and $MRPN = P \times MPN$

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Table 3.2 The Clip Joint's Production Function

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

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The Demand for Labor

- The marginal product of labor and labor demand: an example
 - 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

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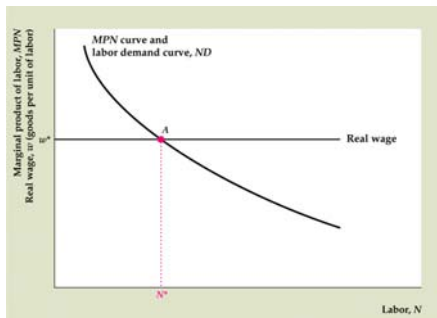
The Demand for Labor

- How much labor do firms want to use?
 - 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 $w = MPN$

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Figure 3.5 The determination of labor demand



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Summary 2

Comparing the Benefits and Costs of Changing the Amount of Labor		
To maximize profits, the firm should:	Increase employment if, for an additional worker	Decrease employment if, for the last worker employed
Real terms	$MPN > w$ ($MPN > W/P$)	$MPN < w$ ($MPN < W/P$)
Nominal terms	$P \times MPN > W$ ($MRPN > W$)	$P \times MPN < W$ ($MRPN < W$)

MPN = marginal product of labor
 P = price of output
 $MRPN$ = marginal revenue product of labor = $P \times MPN$
 W = nominal wage
 w = real wage = W/P

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The Demand for Labor

- The marginal product of labor and the labor demand curve
 - Labor demand curve shows relationship between the real wage rate and the quantity of labor demanded
 - It is the same as the MPN curve, since $w = MPN$ at equilibrium
 - So the labor demand curve is downward sloping; firms want to hire less labor, the higher the real wage

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The Demand for Labor

- 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 , so shifts labor demand curve to the right; opposite for adverse supply shock
 - Size of capital stock: Higher capital stock raises MPN , so shifts labor demand curve to the right; opposite for lower capital stock

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Table 3.3 The Clip Joint's Production Function After a Beneficial Productivity Shock

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

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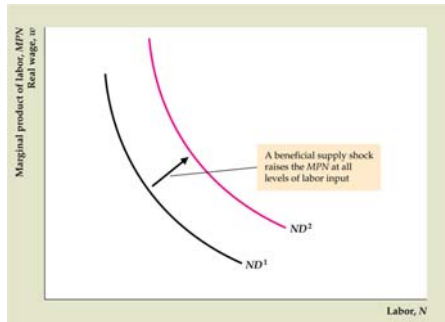
The Demand for Labor

- Aggregate labor demand
 - Aggregate labor demand is the sum of all firms' labor demand
 - Same factors (supply shocks, size of capital stock) that shift firms' labor demand cause shifts in aggregate labor demand

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Figure 3.6 The effect of a beneficial supply shock on labor demand



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Summary 3

Factors That Shift the Aggregate Labor Demand Curve		
An increase in	Causes the labor demand curve to shift	Reason
Productivity	Right	Beneficial supply shock increases <i>MPN</i> and shifts <i>MPN</i> curve up and to the right.
Capital stock	Right	Higher capital stock increases <i>MPN</i> and shifts <i>MPN</i> curve up and to the right.

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The Supply of Labor

- Supply of labor is determined by individuals
 - Aggregate supply of labor is the sum of individuals' labor supply
 - Labor supply of individuals depends on labor-leisure choice

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The Supply of Labor

- 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

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The Supply of Labor

- Real wages and labor supply
 - 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

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The Supply of Labor

- Real wages and labor supply
 - 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

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The Supply of Labor

- Real wages and labor supply
 - 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

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The Supply of Labor

- Real wages and labor supply
 - The substitution effect and the income effect 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

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The Supply of Labor

- Real wages and labor supply
 - 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

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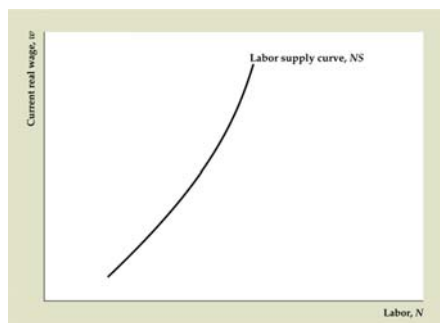
The Supply of Labor

- Real wages and labor supply
 - The labor supply curve (Fig. 3.7)
 - Increase in the current real wage should raise quantity of labor supplied
 - Labor supply curve relates quantity of labor supplied to real wage
 - Labor supply curve slopes upward because higher wage encourages people to work more

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Figure 3.7 The labor supply curve of an individual worker



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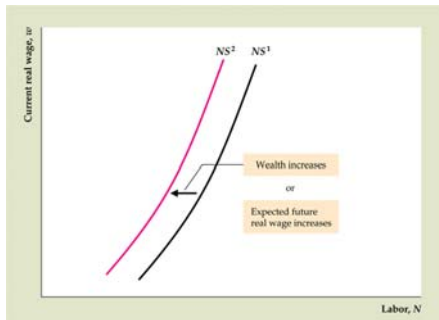
The Supply of Labor

- Factors that shift the labor supply curve
 - Wealth: Higher wealth reduces labor supply (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)

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Figure 3.8 The effect on labor supply of an increase in wealth



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The Supply of Labor

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

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The Supply of Labor

- Aggregate labor supply
 - Factors increasing labor supply
 - Decrease in wealth
 - Decrease in expected future real wage
 - Increase in working-age population (higher birth rate, immigration)
 - Increase in labor force participation (increased female labor participation, elimination of mandatory retirement)

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Summary 4

Factors That Shift the Aggregate Labor Supply Curve		
An increase in	Causes the labor supply curve to shift	Reason
Wealth	Left	Increase in wealth increases amount of leisure workers can afford.
Expected future real wage	Left	Increase in expected future real wage increases amount of leisure workers can afford.
Working-age population	Right	Increased number of potential workers increases amount of labor supplied.
Participation rate	Right	Increased number of people wanting to work increases amount of labor supplied.

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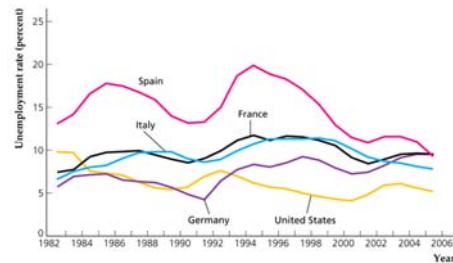
The Supply of Labor

- Application: comparing U.S. and European labor markets
 - Unemployment rates were similar in the U.S. and Europe in 1970s and 1980s, but are higher in Europe since then (Fig. 3.9)

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Figure 3.9 Unemployment rates in the United States and Europe



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The Supply of Labor

- Application: comparing U.S. and European labor markets
 - Research: three main reasons for higher unemployment rates in Europe (generous unemployment insurance systems, high tax rates, government policies that interfere with labor markets)

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The Supply of Labor

- Application: comparing U.S. and European labor markets
 - European countries: more generous unemployment insurance
 - Replacement rate = fraction of lost wages that a worker receives; higher in Europe than U.S.
 - European workers get unemployment benefits for longer, so have incentive to remain unemployed
 - The more turbulent economy of 1980s and 1990s led European job losers to take advantage of unemployment insurance system
 - Ireland and Netherlands reformed their unemployment insurance systems, and unemployment rates fell significantly

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The Supply of Labor

- Application: comparing U.S. and European labor markets
 - High income-tax rates in Europe also reduce incentive to work
 - Government interference in labor markets in Europe affects demand for labor and sometimes supply of labor

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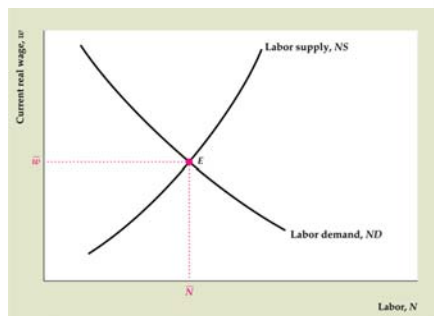
Labor Market Equilibrium

- Equilibrium: Labor supply equals labor demand
- Key Diagram 2
- Fig. 3.10

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Figure 3.10 Labor market equilibrium



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Labor Market Equilibrium

- Classical model of the labor market—real wage adjusts quickly
- Determines full-employment level of employment and market-clearing real wage
- Problem with classical model: can't study unemployment

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Labor Market Equilibrium

- Full-employment output
- Full-employment output = potential output = level of output when labor market is in equilibrium

(3.4)

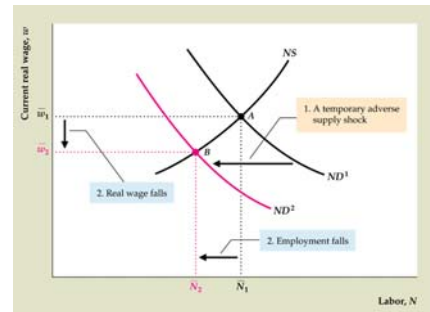
- affected by changes in full employment level or production function (example: supply shock, Fig. 3.11)

$$Y = AF(K, N)$$

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Figure 3.11 Effects of a temporary adverse supply shock on the labor market



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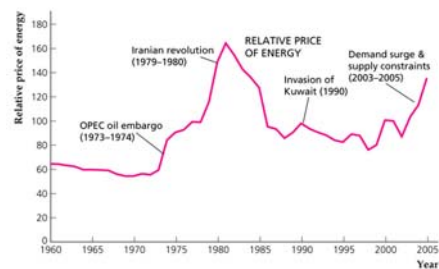
Labor Market Equilibrium

- Application: output, employment, and the real wage during oil price shocks
 - Sharp oil price increases in 1973–1974, 1979–1980, 2003–2005 (Fig. 3.12)

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Figure 3.12 Relative price of energy, 1960–2005



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Labor Market Equilibrium

- Application: output, employment, and the real wage during oil price shocks
 - 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 percentage points

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Labor Market Equilibrium

- Application: technical change and wage inequality
 - Two important features of U.S. real wages since 1970
 - Slowdown in growth of real wages
 - Increased wage inequality

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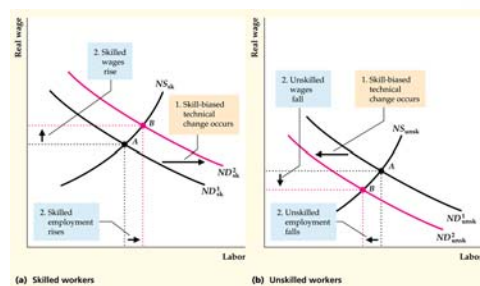
Labor Market Equilibrium

- Application: technical change and wage inequality
 - Slowdown in productivity growth combined with increased labor force participation has kept real wages from rising as much as they did before 1970
 - Skill-biased technical change (such as computerization) has increased real wages of highly educated workers, but reduced real wages of unskilled workers (Fig. 3.13)

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Figure 3.13 The effects of skill-biased technical change on wage inequality



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Unemployment

- Measuring unemployment
 - Categories: employed, unemployed, not in the labor force
 - 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

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Table 3.4 Employment Status of the U.S. Adult Population, May 2006

Category	Number (millions)	Share of labor force (percent)	Share of adult population (percent)
Employed workers	144.0	95.4	63.0 (employment ratio)
Unemployed workers	7.0	4.6 (unemployment rate)	3.1
Labor force (employed + unemployed workers)	151.0	100.0	66.1 (participation rate)
Not in labor force	77.4		33.9
Adult population (labor force + not in labor force)	228.4		100.0

Note: Figures may not add up because of rounding.
Source: The Employment Situation, May 2006, Table A.

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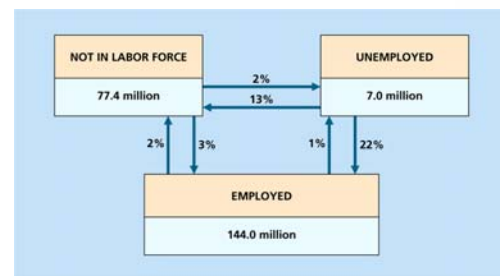
Unemployment

- Changes in employment status
 - Flows between categories (Fig. 3.13)
 - Discouraged workers: people who have become so discouraged by lack of success at finding a job that they stop searching

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Figure 3.14 Changes in employment status in a typical month



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Unemployment

- How long are people unemployed?
 - Most unemployment spells are of short duration
 - 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

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Unemployment

- How long are people unemployed?
 - 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

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Unemployment

- Why there are always unemployed people
 - Frictional unemployment
 - Search activity of firms and workers due to heterogeneity
 - Matching process takes time

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Unemployment

- Why there are always unemployed people
 - 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

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Unemployment

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

$$u - \bar{u}$$

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Unemployment

- In touch with the macroeconomy: labor market data
 - BLS employment report
 - Household survey: unemployment, employment
 - Establishment survey: jobs

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Relating Output and Unemployment: Okun's Law

- Relationship between output (relative to full-employment output) and cyclical unemployment

$$\frac{\bar{Y} - Y}{\bar{Y}} = 2(u - \bar{u}) \quad (3.5)$$

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Relating Output and Unemployment: Okun's Law

- 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
 - Result is 2% reduction in output associated with 1 percentage point increase in unemployment rate

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Relating Output and Unemployment: Okun's Law

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

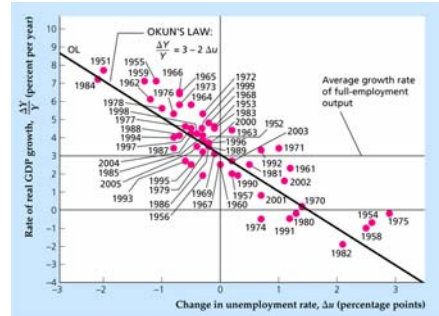
$$\Delta Y/Y = 3 - 2 \Delta u \quad (3.6)$$

- Fig. 3.15 shows U.S. data

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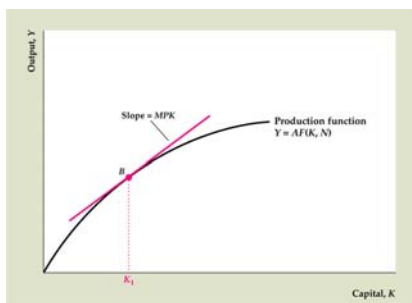
Figure 3.15 Okun's Law in the United States: 1951-2005



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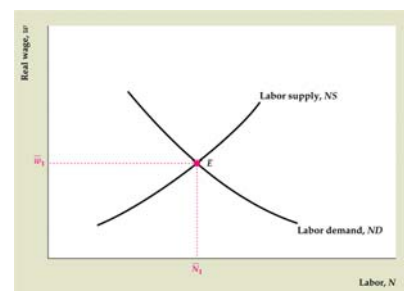
Key Diagram 1 The production function



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Key Diagram 2 The labor market



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