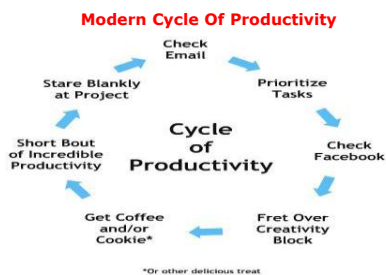


Chapter 3 Lecture - Productivity, Output, and Employment

Chapter 3 Lecture - Productivity, Output, and Employment



3-1

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

$$Y = AF(K, N)$$
 - Parameter A is "total factor productivity" (the effectiveness with which capital and labor are used)

3-2

Cobb-Douglas Production Function Characteristics (cont' d)

- The simplest production function is the Cobb-Douglas model. It has the following form.

$$Y = AK^\alpha N^\beta$$

where Y is real output, K is capital and N is labor. The parameters A , α and β are estimated from the empirical data.

If $\alpha + \beta = 1$, the production function has the particularly attractive characteristic of constant returns to scale.

3-3

Cobb-Douglas Production Function Characteristics (cont' d)

- Constant returns to scale can be shown by doubling both K and N into the previous production function so that

$$\begin{aligned} Y &= AF(2K, 2N) = A(2K)^\alpha (2N)^\beta \\ &= A(2^\alpha 2^\beta) \times K^\alpha N^\beta \\ &= A(2^{\alpha+\beta}) \times K^\alpha N^\beta \quad \text{we know } \alpha + \beta = 1 \\ &= 2 \times AK^\alpha N^\beta \end{aligned}$$

- Logarithmic form

$$\ln Y = \ln A + \alpha \ln K + \beta \ln N$$

3-4

Chapter 3 Lecture - Productivity, Output, and Employment

Cobb-Douglas Production Function Characteristics (cont'd)

- **Diminishing marginal product** means that as the amount of one factor input increases, holding other inputs constant, the increased amount of output from an extra unit of the input (its **marginal product**) declines

$$Y = AK^{0.5}(N)^{0.5}$$

$$MP_N = \frac{\delta Y}{\delta N} = 0.5AK^{0.5}N^{-0.5} = 0.5A \frac{K^{0.5}}{N^{0.5}}$$

3-5

Table 3.1 The Production Function of the United States, 1991-2010

Year	(1) Real GDP, Y (billions of 2005 dollars)	(2) Capital stock, K (billions of 2005 dollars)	(3) Labor, N (millions of workers)	(4) A ^a	(5) Growth in A (% change in A)
1991	8008	9388	117.7	18.29	
1992	8280	9521	118.5	18.74	2.5
1993	8516	9710	120.3	18.96	1.2
1994	8863	9932	123.1	19.29	1.7
1995	9095	10,216	124.9	19.41	0.6
1996	9426	10,544	126.7	19.75	1.8
1997	9846	10,924	129.6	20.09	1.7
1998	10,275	11,357	131.5	20.51	2.1
1999	10,771	11,821	133.5	21.02	2.5
2000	11,216	12,327	136.9	21.24	1.0
2001	11,338	12,691	136.9	21.25	0.2
2002	11,543	12,912	136.5	21.60	1.5
2003	11,836	13,108	137.7	21.91	1.4
2004	12,247	13,332	139.3	22.33	2.1
2005	12,623	13,584	141.7	22.66	1.3
2006	12,959	13,920	144.4	22.79	0.6
2007	13,295	14,297	146.0	22.86	0.3
2008	13,162	14,615	145.4	22.70	-0.7
2009	12,758	14,673	139.9	22.58	-0.5
2010	13,063	14,769	139.1	23.17	2.6

Note: ^aTotal factor productivity is calculated by the formula $A = Y/(K^{0.5}N^{0.5})$. 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/GDP; 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/va/fatables.asp; N is civilian employment in millions of workers from Bureau of Labor Statistics, Current Population Survey, bls.gov/cps/cpsarr01.htm.

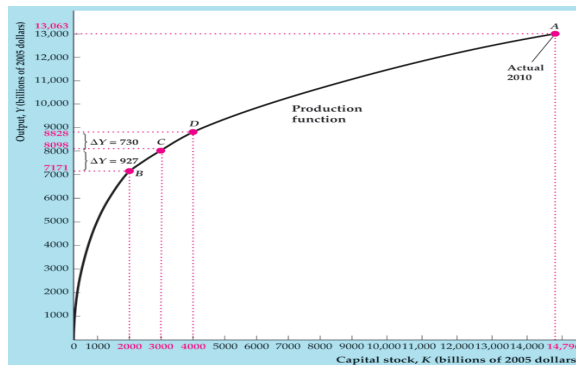
3-6

The Production Function

- 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
- 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

3-7

Figure 3.1 The Production Function Relating Output and Capital

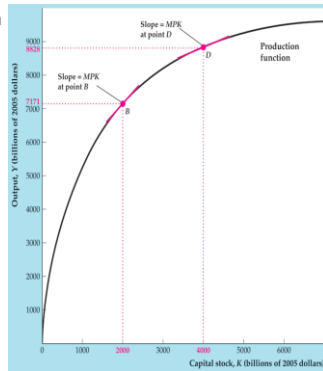


3-8

Chapter 3 Lecture - Productivity, Output, and Employment

Figure 3.2 The marginal product of capital

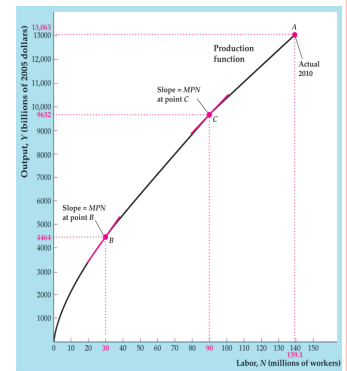
- The shape of the production function
 - Marginal product of capital, $MPK = \Delta Y / \Delta K$
 - Equal to slope of production function graph (Y vs. K)
 - MPK always positive
 - Diminishing marginal productivity of capital
 - MPK declines as K rises



3-9

Figure 3.3 The production function relating output and labor

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



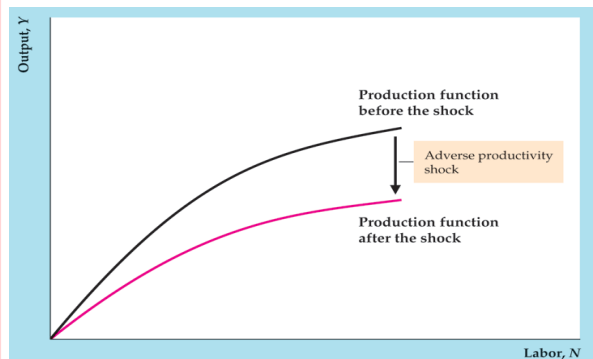
3-10

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
- 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)

3-11

Figure 3.4 An adverse supply shock that lowers the MPN



3-12

Chapter 3 Lecture - Productivity, Output, and Employment

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
- 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

$$MRP_N = P \times MP_N$$

$W = MRP_N$ is the same condition as $w = MP_N$
 since $W = P \times w$ and $MRP_N = P \times MP_N$

3-13

Table 3.2 The Clip Joint's Production Function

(1) Number of workers, N	(2) Number of dogs groomed, Y	(3) Marginal product of labor, MP_N	(4) Marginal revenue product of labor, $MRP_N = MP_N \times P$ (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		

3-14

The Demand for Labor

- The marginal product of labor and labor demand: an example
 - A change in the wage
 - Begin at equilibrium where $W = MRP_N$
 - A rise in the wage rate means $W > MRP_N$, unless N is reduced so the MRP_N rises
 - A decline in the wage rate means $W < MRP_N$, unless N rises so the MRP_N falls
- How much labor do firms want to use?
 - Analysis at the margin: costs and benefits of hiring one extra worker
 - If real wage (w) > marginal product of labor (MP_N), profit rises if number of workers declines
 - If $w < MP_N$, profit rises if number of workers increases
 - Firms' profits are highest when $w = MP_N$

3-15

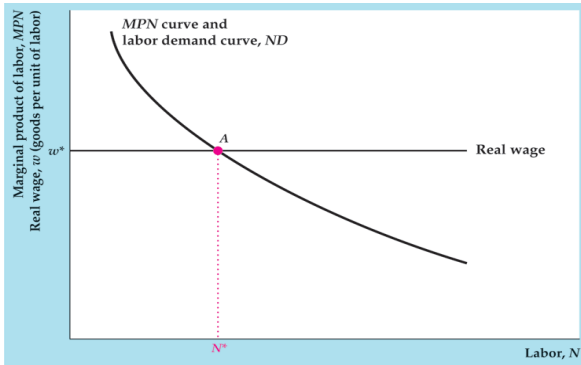
The Demand for Labor

- 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 MP_N curve, since $w = MP_N$ at equilibrium
 - So the labor demand curve is downward sloping; firms want to hire less labor, the higher the real wage

3-16

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Figure 3.5 The determination of labor demand



3-17

Summary

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

3-18

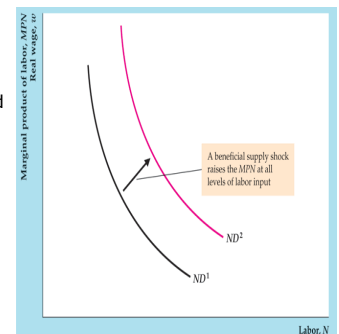
The Demand for Labor

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

3-19

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

- 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



3-20

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Summary

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 MPN and shifts MPN curve up and to the right.
Capital stock	Right	Higher capital stock increases MPN and shifts MPN curve up and to the right.

3-21

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
- 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

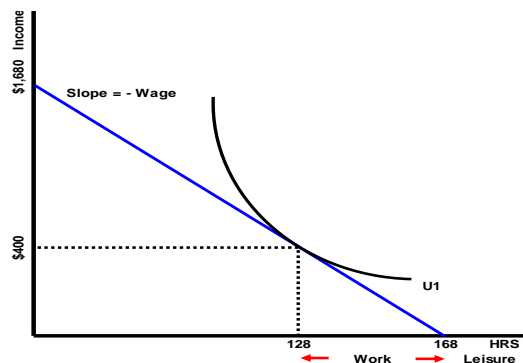
3-22

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

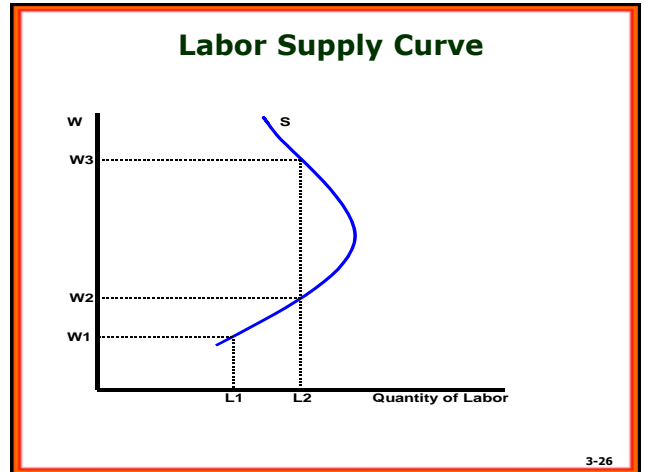
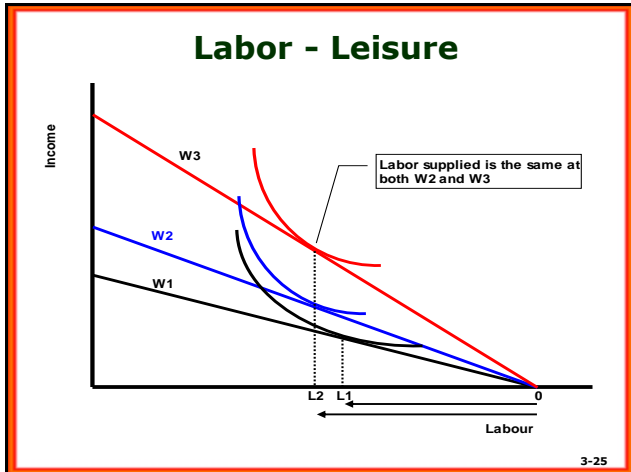
3-23

Labor - Leisure



3-24

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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
- 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

3-27

Figure 3.7 The labor supply curve of an individual worker

Real wages and labor supply

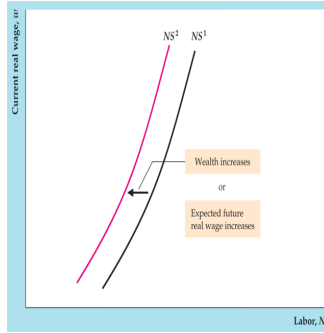
- The labor supply curve
 - Increase in the current real wage should raise quantity of labor supplied
 - Labor supply curve relates quantity of labor supplied to real wage
 - Labor supply curve slopes upward because higher wage encourages people to work more

3-28

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Figure 3.8 Factors that shift the labor supply curve

- Wealth: Higher wealth reduces labor supply (shifts labor supply curve to the left)
- 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)



3-29

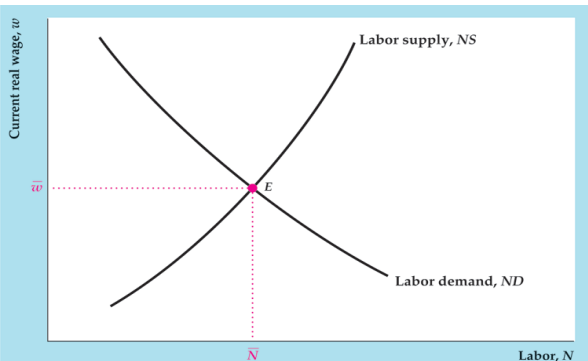
Summary

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.

3-30

Figure 3.9 Labor market equilibrium



3-31

Labor Market Equilibrium

- Classical model of the labor market—real wage adjusts quickly
- Determines full-employment level of employment and market-clearing real wage
- Full-employment output
- Full-employment output = potential output = level of output when labor market is in equilibrium

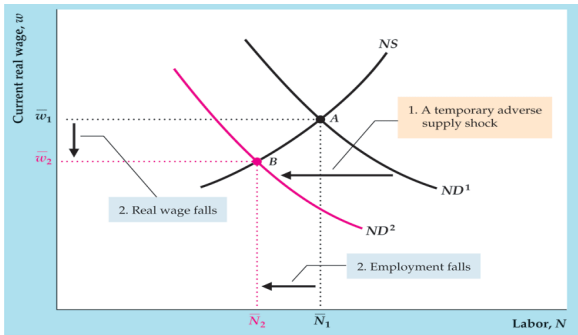
$$\bar{Y} = AF(K, \bar{N})$$

affected by changes in full employment level or production function (example: supply shock)

3-32

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Figure 3.10 Effects of a temporary adverse supply shock on the labor market



3-33

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

3-34

Unemployment

- Measuring unemployment
 - Categories: employed, unemployed, not in the labor force
 - Labor Force = Employed + Unemployed
 - Unemployment Rate = $\frac{\text{Unemployed}}{\text{Labor Force}}$
 - Participation Rate = $\frac{\text{Labor Force}}{\text{Adult Population}}$
 - Employment Ratio = $\frac{\text{Employed}}{\text{Adult Population}}$

3-35

Table 3.4 Employment Status of the U.S. Adult Population, July 2012

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

Note: Figures may not add up because of rounding.
Sources: The Employment Situation, July 2012, Table A-1.

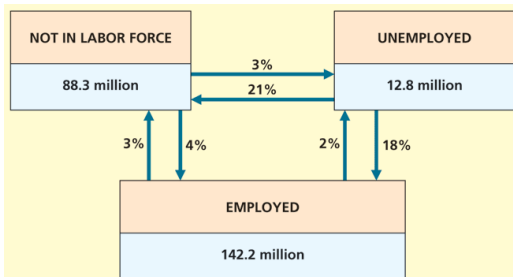
3-36

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Figure 3.12 Changes in employment status in a typical month (July 2012)

Changes in employment status

- Flows between categories
- Discouraged workers: people who have become so discouraged by lack of success at finding a job that they stop searching



3-37

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

- Numerical example:

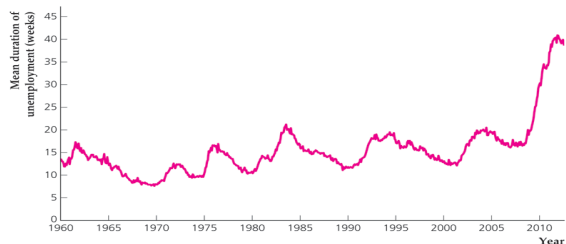
- Labor force = 100; on the first day of every month, two workers become unemployed for one month each; on the first day of every year, four workers become unemployed for one year each
- Result: 28 spells of unemployment during a year; 24 short (one month), four long (one year); so most spells are short
- 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

3-38

Figure 3.13 Mean duration of unemployment, 1960-2012

□ Unemployment Duration and the 2007-2009 Recession

- Four possible explanations for the increase in duration
 - measurement issues
 - the extension of unemployment benefits
 - very large job losses
 - weak economic recovery



3-39

Unemployment

• Why there are always unemployed people

- Frictional unemployment
 - Search activity of firms and workers due to heterogeneity
 - Matching process takes time
- 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

3-40

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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

$$u - \bar{u}$$

- BLS employment report
 - Household survey: unemployment, employment
 - Establishment survey: jobs

3-41

Employment and Unemployment

Marginally Attached Workers

- A **marginally attached worker** is a person who currently is neither working nor looking for work but has indicated that he or she wants and is available for a job and has looked for work sometime in the recent past.
- A **discouraged worker** is a marginally attached worker who has stopped looking for a job because of repeated failure to find one.

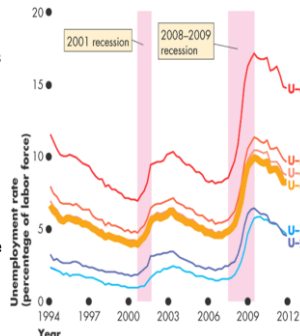
Part-Time Workers Who Want Full-Time Jobs

- Many part-time workers want to work part time, but some part-time workers would like full-time jobs and can't find them.
- In the official statistics, these workers are called *economic part-time workers* and they are partly unemployed.

3-42

Six Alternative Measures

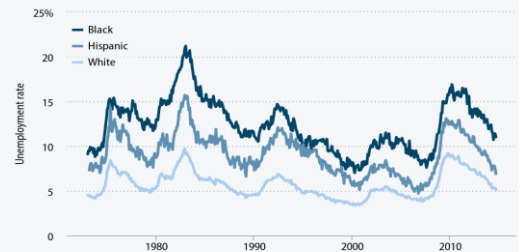
- U-1:** Those unemployed for 15 or more weeks
 - U-2:** Unemployed job losers
 - U-3:** The official unemployment rate
 - Broader measures are
 - U-4:** U-3 + Discouraged workers
 - U-5:** U-4 + Marginally attached workers
 - U-6:** U-4 + Part-time workers who want full-time jobs
- All measures increase together in recession.



3-43

Unemployment by Race

Unemployment rate of workers age 16 and older by race and ethnicity, 1973-2014



Source: Bureau of Labor Statistics' Current Population Survey, public data series

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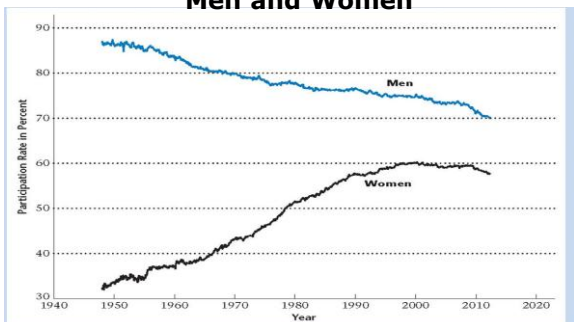
<http://www.stateofworkingamerica.org/charts/unemployment-by-race-and-ethnicity/>

<http://www.bls.gov/data>

3-44

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Labor Force Participation Rates of Men and Women



<http://data.bls.gov/timeseries/LNS1130000>

3-45

Relating Output and Unemployment: Okun's Law

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

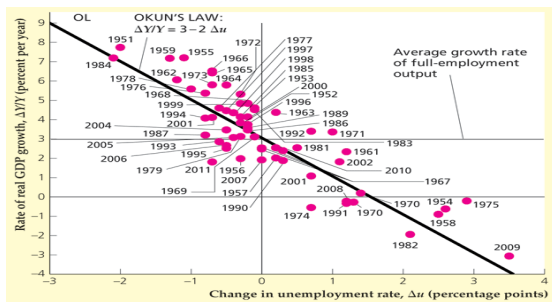
$$\frac{\bar{Y} - Y}{\bar{Y}} = 2(u - \bar{u})$$

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

$$\Delta Y/Y = 3 - 2 \Delta u$$

3-46

Figure 3.14 Okun's Law in the United States: 1951-2011



Sources: Real GDP growth rate from the Federal Reserve Bank of St. Louis FRED database, research.stlouisfed.org/fred2/series/GDPCA. Civilian unemployment rate for all civilian workers from Bureau of Labor Statistics Web site, data.bls.gov.

3-47

Outsourcing/Insourcing

- Outsourcing** is a process where business moves the production of goods outside the U.S. to benefit from lower costs, taxes, and fewer regulations. An example of outsourcing is when a consumer products company moves its telephone customer service agents to India to benefit from lower costs.
- Insourcing** is a process where business moves the production of goods to the U.S. to become closer to other manufacturers, consumers, and more beneficial costs. An example of insourcing occurs when a foreign parts supplier to the U.S. automotive industry builds a plant in the U.S. to be closer to the manufacturers.
- The issue with outsourcing relates to the loss of U.S. jobs to other countries. For many businesses facing increasing costs and competition, outsourcing lowers costs and keeps prices lower.
- However insourcing is a benefit to the U.S. economy in that the number of U.S. jobs increases. Companies build facilities here to be closer to their customers and save costs.

3-48