Chapter 3: Productivity, Output, and Employment

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Chapter Outline

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

A Preview

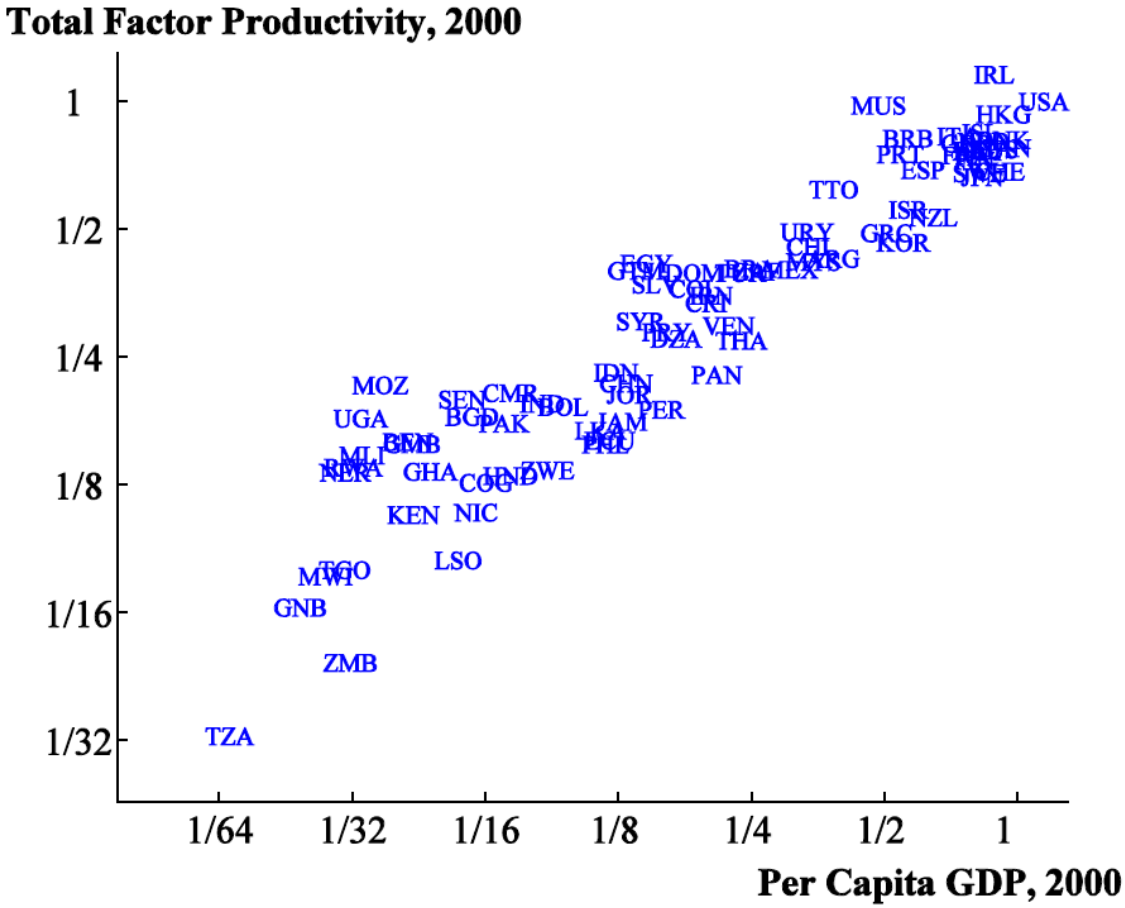
- The most fundamental determinant of economic well-being in a society: The economy's productive capacity.
- The amount of output an economy produces depends on two factors:
- The most important input to production is labor.

The Production Function

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

Productivity Differences across Countries

Large Income & TFP Differences between countries



Source: Jones and Romer (2012). US=1

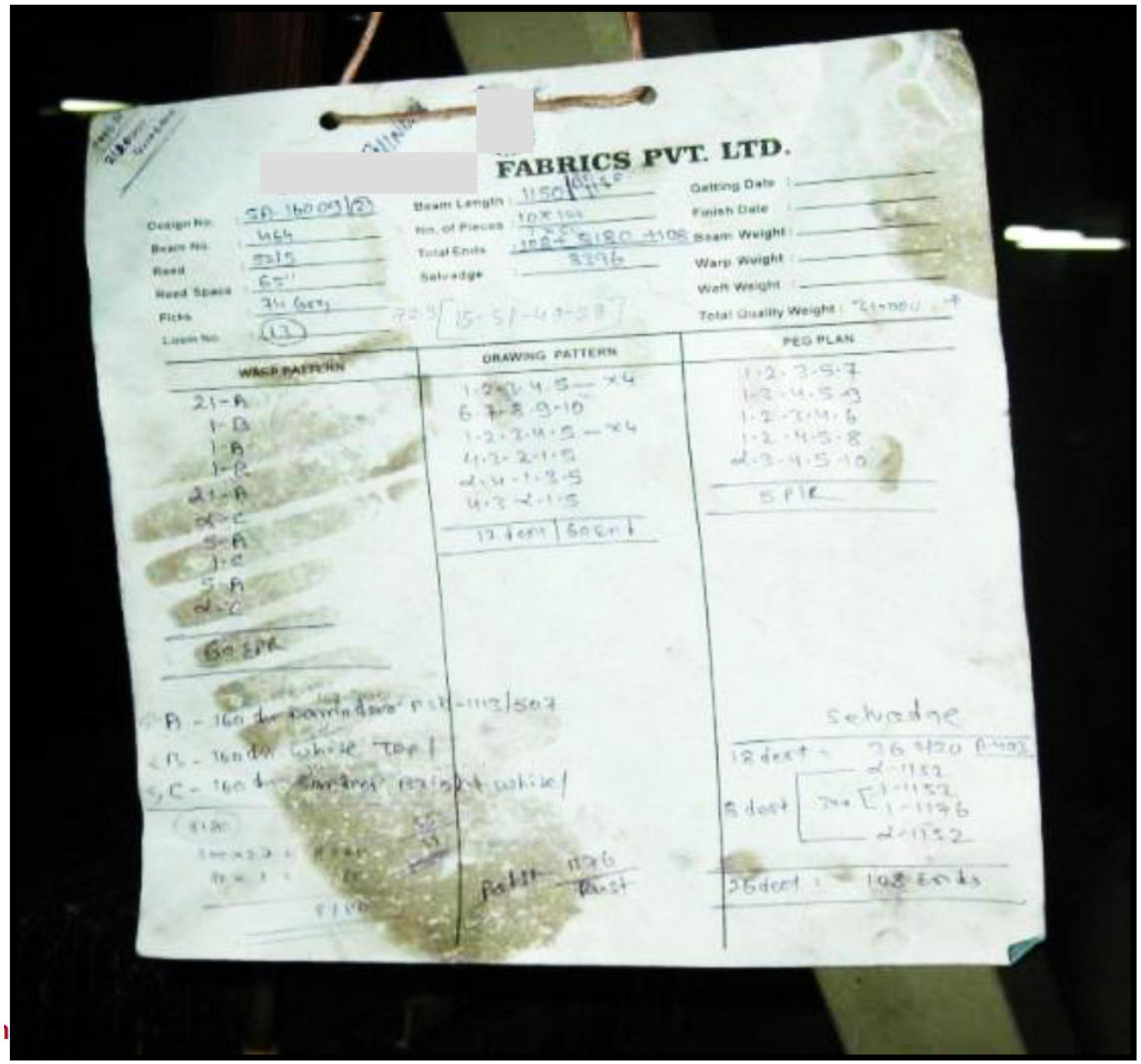
Examples of performance metrics – Toyota

Management in India

Inventory Control: Before

Management in India (Cont.)

Factory information: Before



The Production Function (Cont.)

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

$$Y = AF(K, N) \tag{1}$$

  Parameter A is "total factor productivity".
- Increases in A correspond...
- How to increase output? quantity, quality...

Application

- Cobb-Douglas production function:

$$Y = AK^{0.3}N^{0.7} \tag{2}$$

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:

Production Function of the U.S.

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	9086	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	21.28	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	22.38	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	13,206	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: [a]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...
- The shape of the production function. Graph production function (Y vs. one input; hold other input and A fixed).
  - Marginal product of capital,

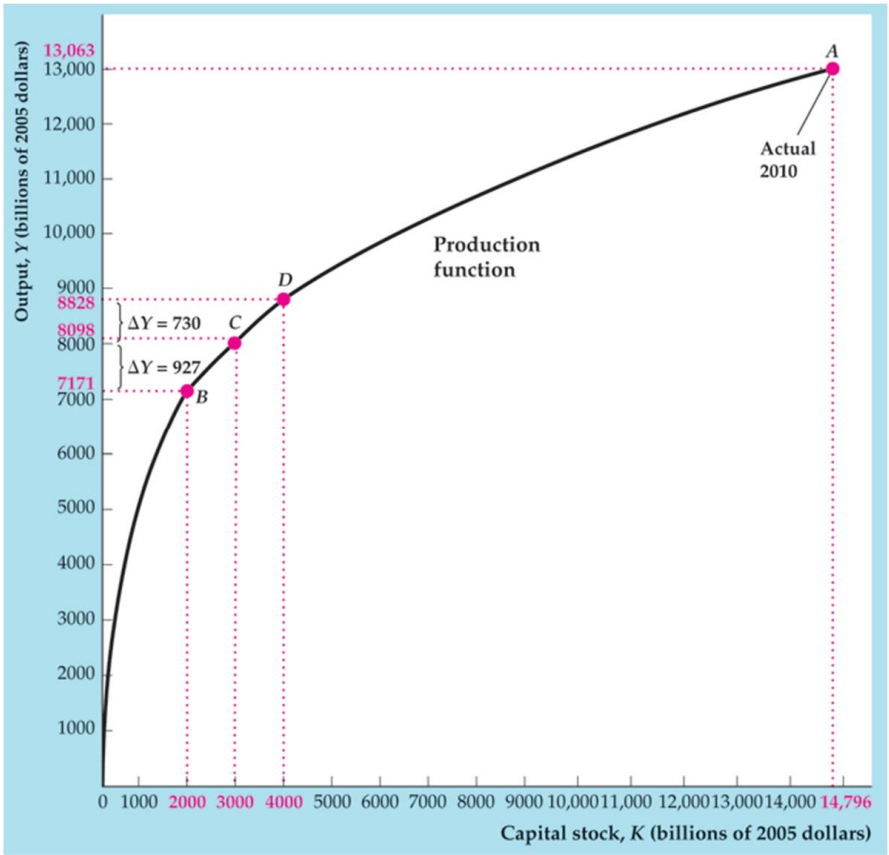
$$MPK = \Delta Y / \Delta K. \tag{3}$$

  - Marginal product of labor,

$$MPN = \Delta Y / \Delta N. \tag{4}$$

Capital and Output

Figure 3.1 The Production Function Relating Output and Capital



Marginal Product

Figure 3.2 The marginal product of capital

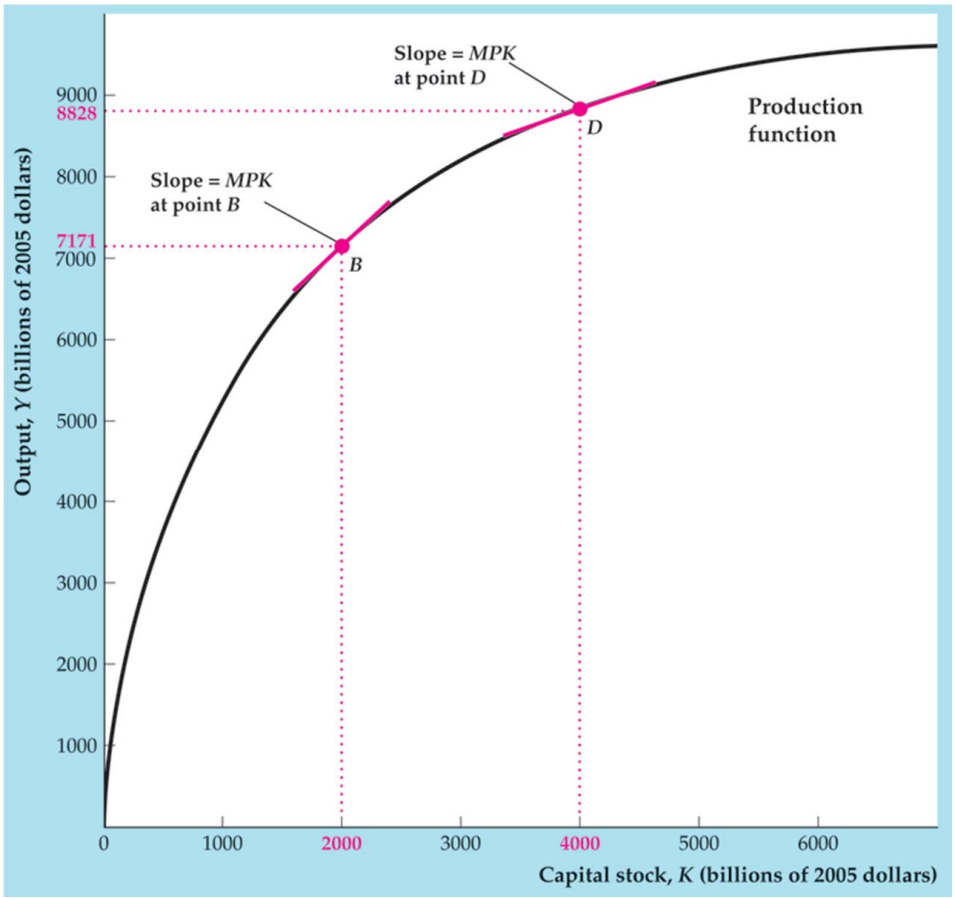
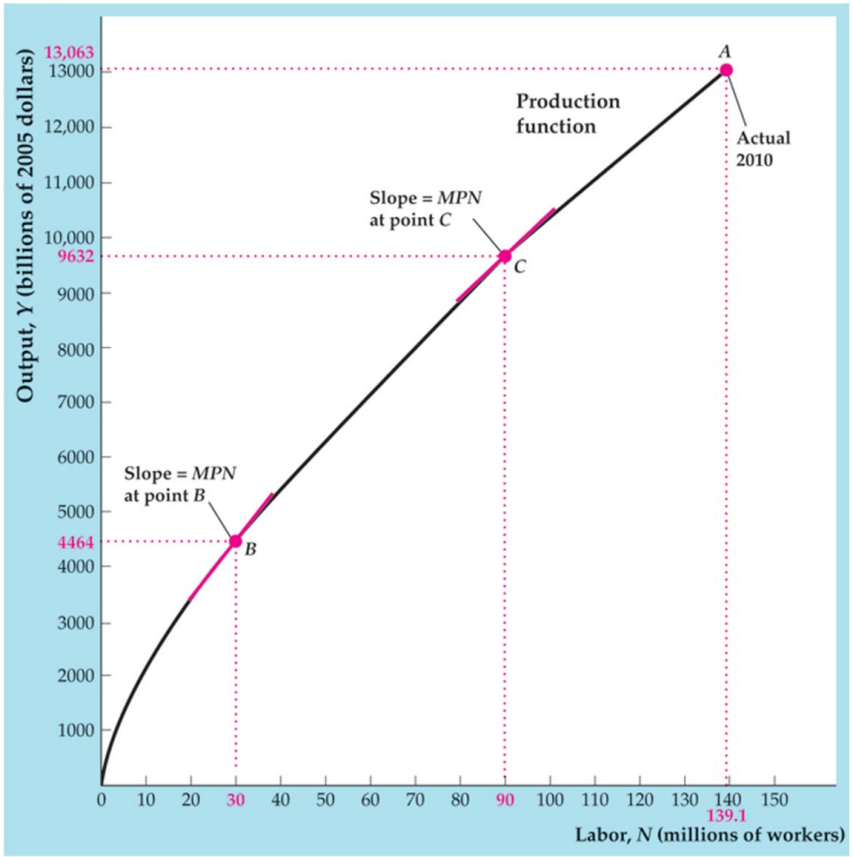
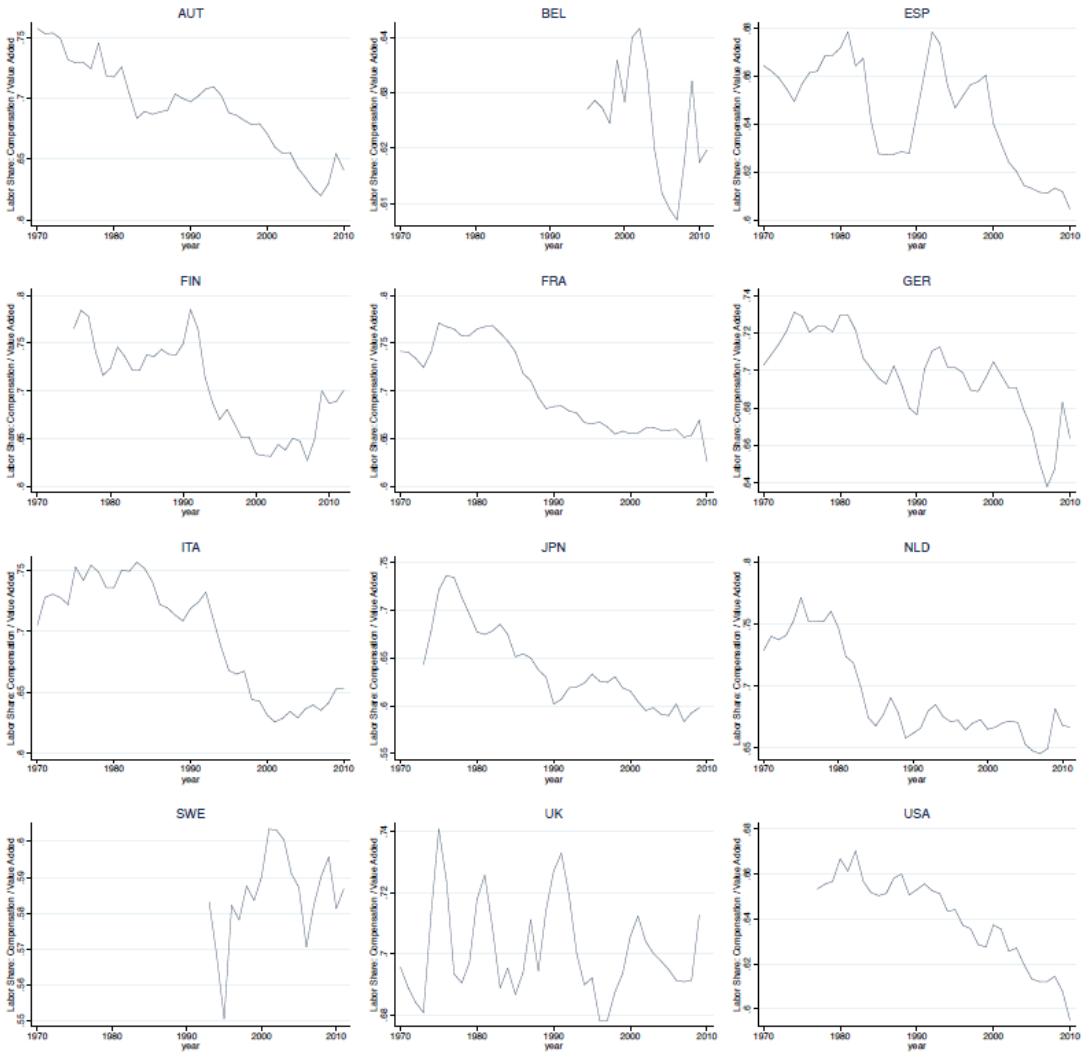


Figure 3.3 The production function relating output and labor



Is Labor Share Really Constant Over Time?

Figure 1: International Comparison: Labor Share by Country



Notes: Each panel plots the ratio of aggregate compensation over value-added for all industries in a country based on KLEMS data.

Possible Explanations

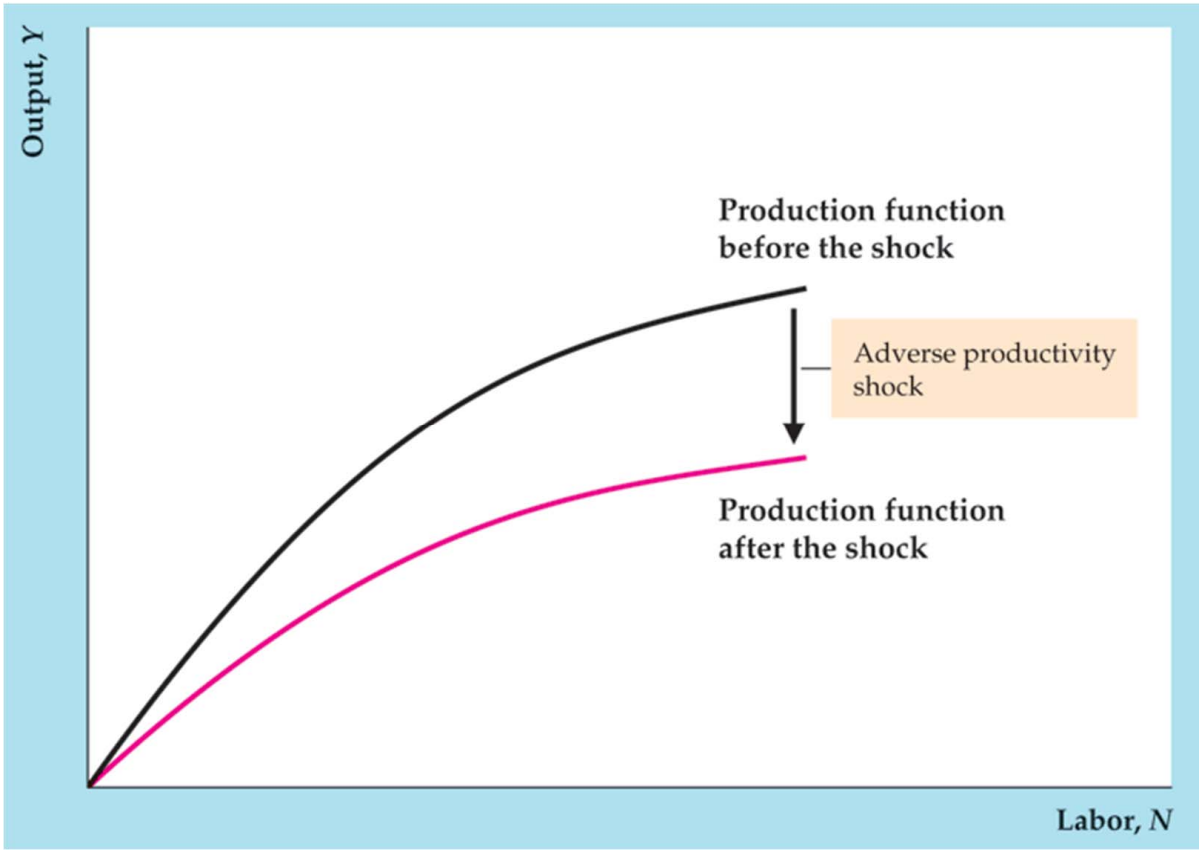
- Technology and price of goods based on ICT
- China shock and role of trade
- Superstar firms?

Supply shocks

- The production function of an economy does not usually remain fixed over time. Supply shock = productivity shock.
- 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...
- Supply shocks shift graph of production function (Fig. 3.4):
  - Negative (adverse) shock.
  - Positive shock.

Adverse Supply Shock

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.
  - Workers are all alike.
  - Labor market is competitive.
  - Firms maximize profits.
- *MPN*:
- *MRPN*:

- (Conti.) Example (Table 3.2): The Clip Joint:

$$MRPN = P \times MPN. \tag{5}$$

- Alternatively, we have $w = MPN$.
- Nominal and real variables.

Clip Joint's Production Function

Table 3.2 The Clip Joint's Production Function

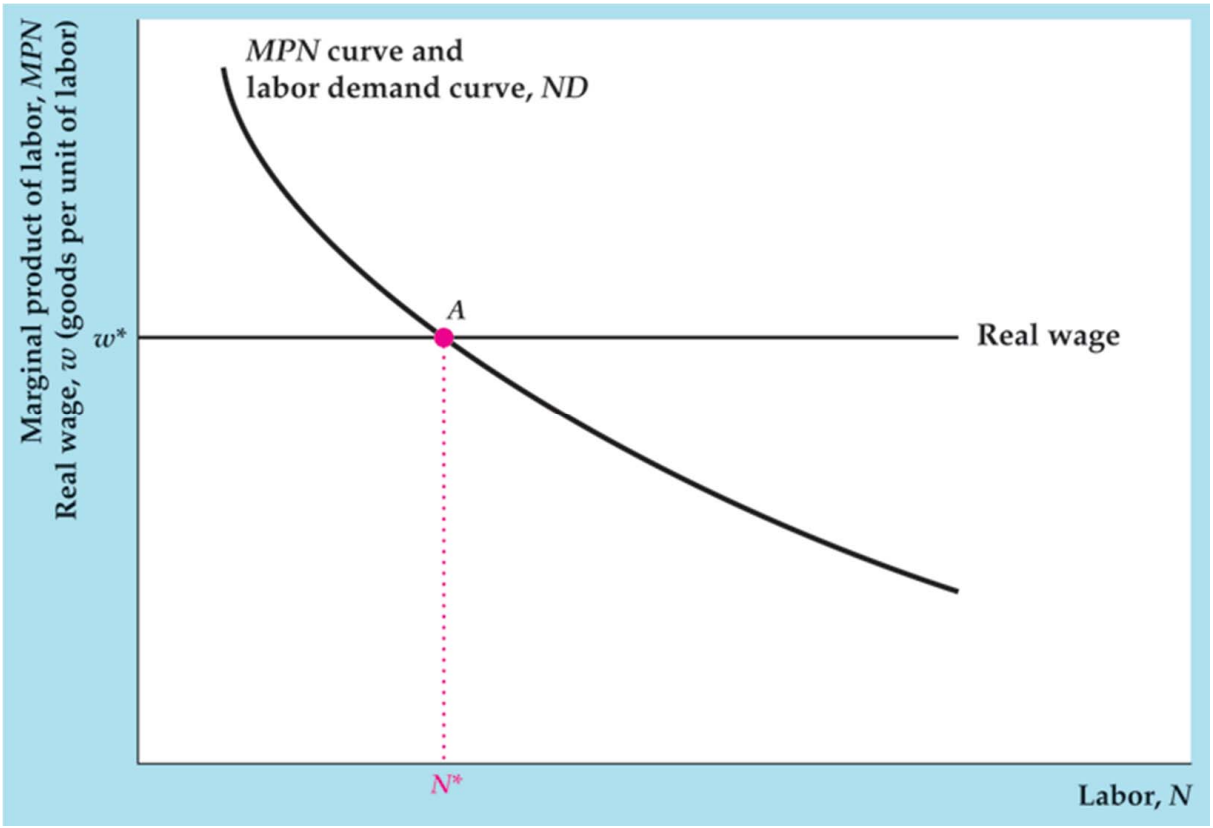
(1) Number of workers, *N*	(2) Number of dogs groomed, *Y*	(3) Marginal product of labor, *MPN*	(4) Marginal revenue product of labor, *MRPN* = *MPN* × *P* (when *P* = $30 per grooming)
0	0		
		11	$330
1	11		
		9	$270
2	20		
		7	$210
3	27		
		5	$150
4	32		
		3	$90
5	35		
		1	$30
6	36		

A change in the wage

- Begin at equilibrium where $W = MRPN$.
  - A rise in the wage rate means $W > MRPN$...
  - A decline in the wage rate means...
- Analysis at the margin: costs and benefits of hiring one extra worker (Fig. 3.5)

Determinant of Labor Demand

Figure 3.5 The determination of labor demand



The marginal product of labor and the labor demand curve

- *Labor demand curve* shows relationship between ... and ...
- It is the same as...
- So the labor demand curve is ... sloping; firms want to hire less labor as the real wage ...

Factors that shift the labor demand curve

- Note: A change in the wage causes a movement *along*..., not a shift...
- Supply shocks...
- Size of capital stock...

Clip Joint's Production Function

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

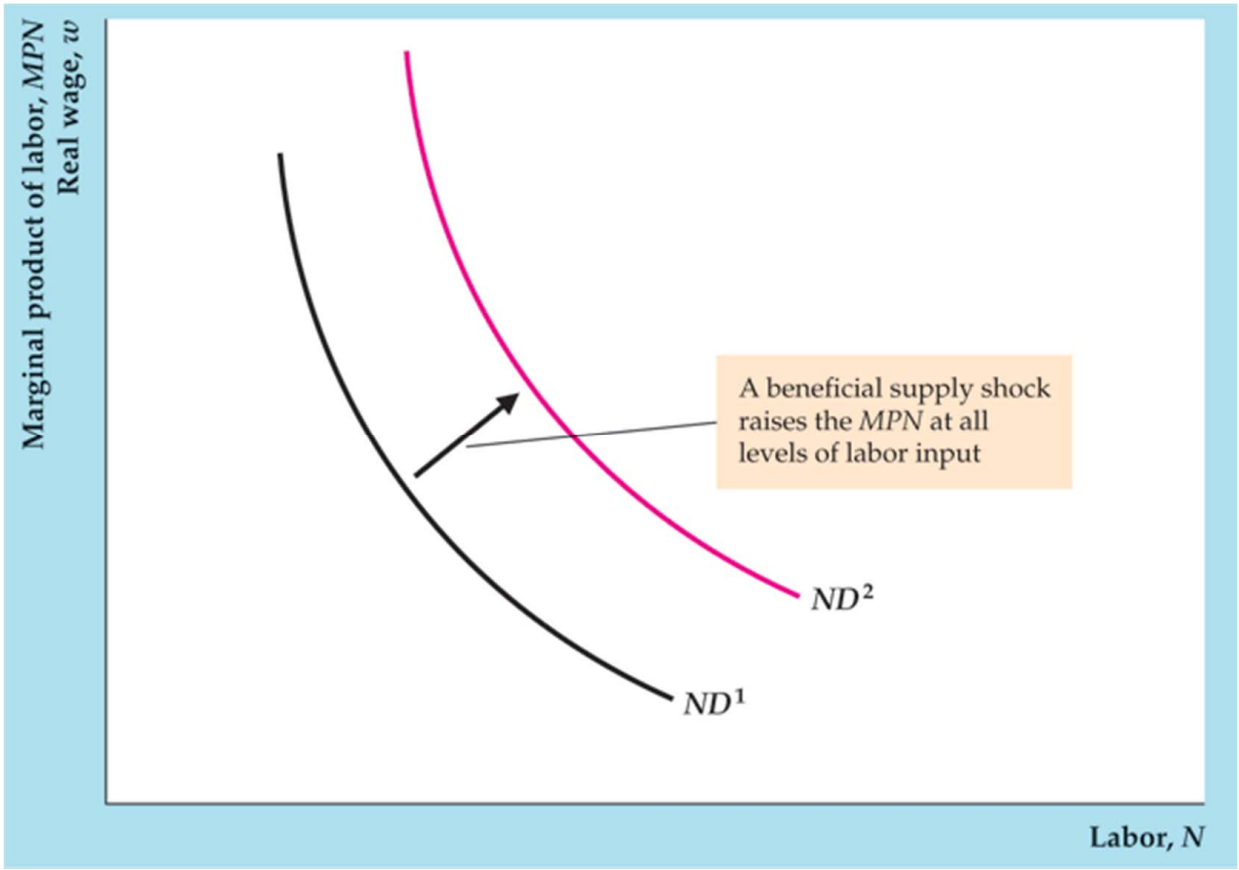
(1) Number of workers, *N*	(2) Number of dogs groomed, *Y*	(3) Marginal product of labor, *MPN*	(4) Marginal revenue product of labor, *MRPN* = *MPN* × *P* (when *P* = $30 per grooming)
0	0		
		22	$660
1	22		
		18	$540
2	40		
		14	$420
3	54		
		10	$300
4	64		
		6	$180
5	70		
		2	$60
6	72		

Aggregate labor demand

- Aggregate labor demand is the sum of ...
- Same factors (e.g.,...) that shift firms' labor demand cause shifts in ...

Positive Supply Shock

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



The supply of labor

- Supply of labor is determined by..
- Each person of working-age must decide between ... and ...
- Aggregate supply of labor is the sum of ...
- Labor supply of individuals depends on ... choice. It is called the ...!
- Labor-leisure choice during recession (Edward Prescott).
- Indivisible labor supply.

The income-leisure trade-off

- Utility depends on ... and ...
- Need to compare ... and ... of working another day:
  - Costs
  - Benefits
- If benefits of working another day exceed costs...
- Keep working additional days until ...

Real wages and labor supply

- The real wage is ...
- An increase in the real wage has offsetting ... and ... effects:
  - ...
  - ...
- A pure ... effect.
- A pure ...effect.

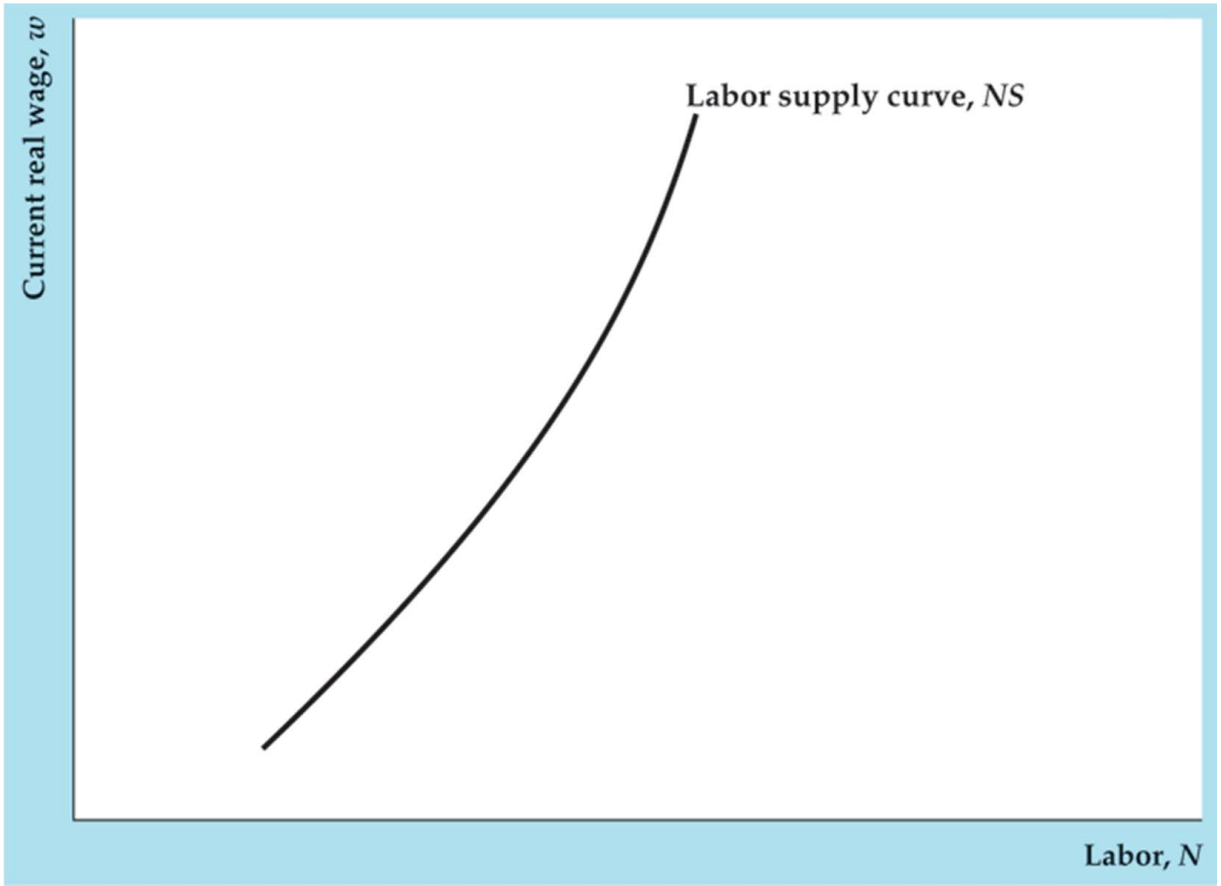
- (Conti.) The substitution and income effects together: a long-term increase in the real wage
- Empirical evidence on real wages and labor supply
  - Overall result.

The labor supply curve

- Increase in the current real wage should raise..
- *Labor supply curve* relates ... to ..., holding constant all other factors (including...) that affect the amount of labor supply.
- Labor supply curve slopes ... because ... (i.e., leisure is a normal good).
- Factors that shift the labor supply curve:
  - Wealth
  - Expected future real wage

Labor Supply Curve

Figure 3.7 The labor supply curve of an individual worker

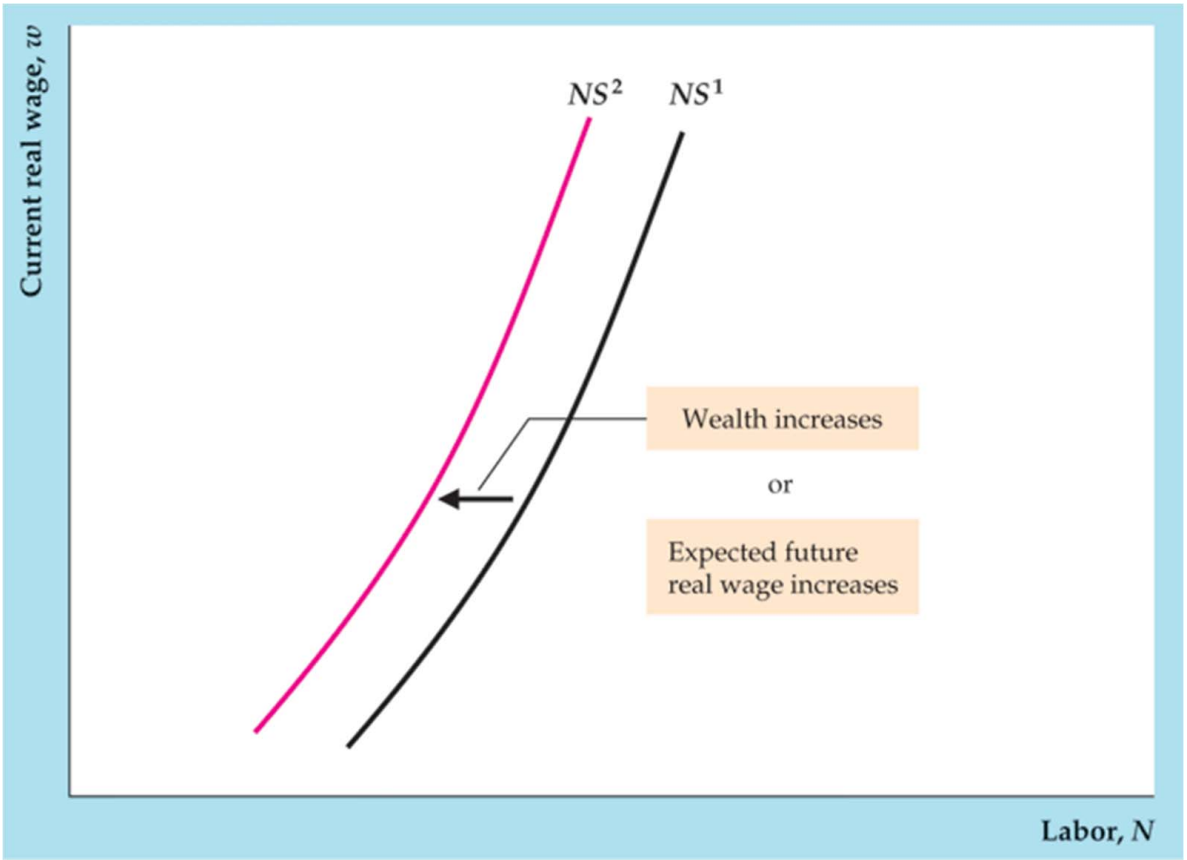


Aggregate labor supply

- Aggregate supply of labor is the total amount of...
- Aggregate labor supply rises when ...
  - Some people...
  - Other people...
  - Result...
- Factors increasing labor supply:
  - Decrease in wealth.
  - Decrease in expected future real wage.
  - Increase in working-age population.
  - Increase in labor force participation.

Labor Supply and Wealth

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



Summary 4

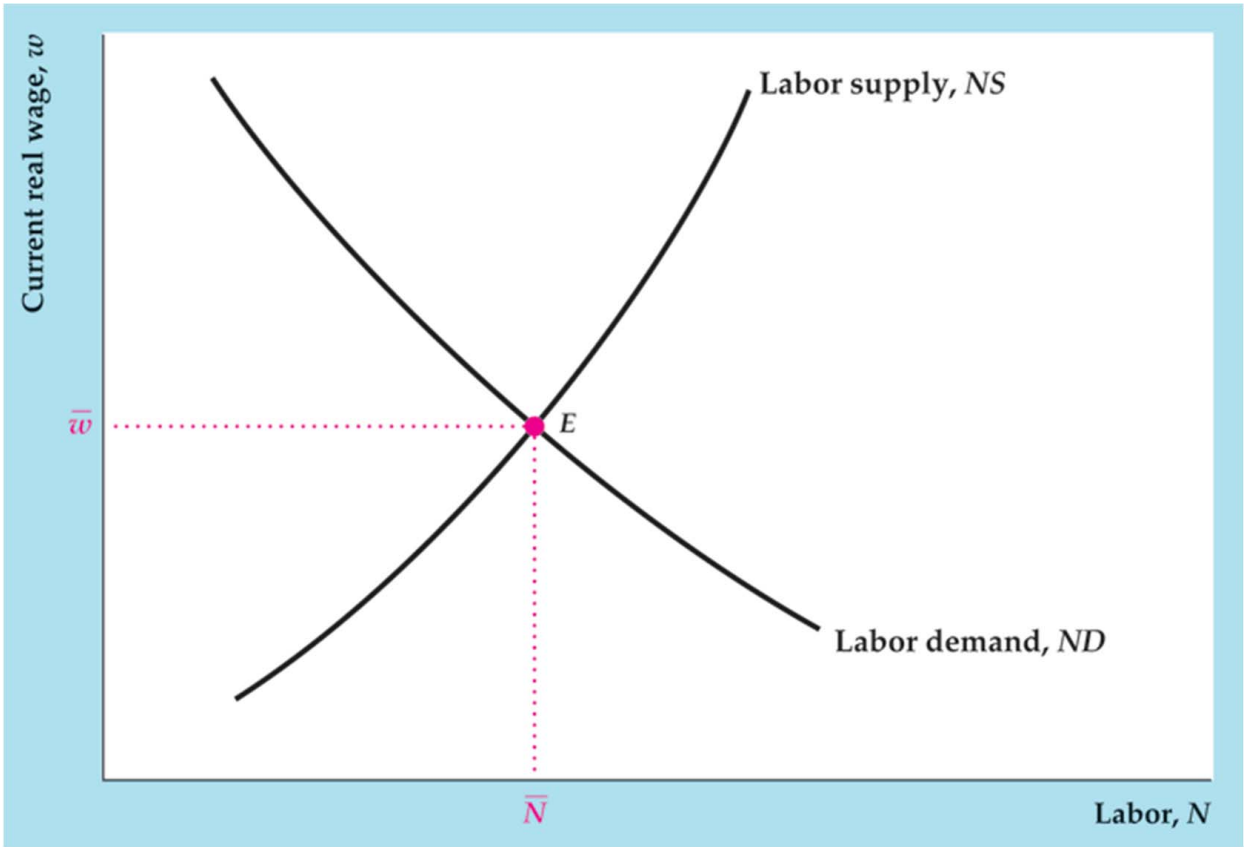
Factors That Shift the Aggregate Labor Supply Curve		
An increase in	**Causes the labor supply curve to shift**	**Reason**
Wealth	Left	Increase in wealth increases amount of leisure workers can afford.
Expected future real wage	Left	Increase in expected future real wage increases amount of leisure workers 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.

Labor Market Equilibrium

- 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 ....
- Determines full-employment level of employment $\left(\overline{N}\right)$ and market-clearing real wage $\left(\overline{w}\right)$.
- Problem with classical model: can't study...

Labor Market Equilibrium

Figure 3.9 Labor market equilibrium



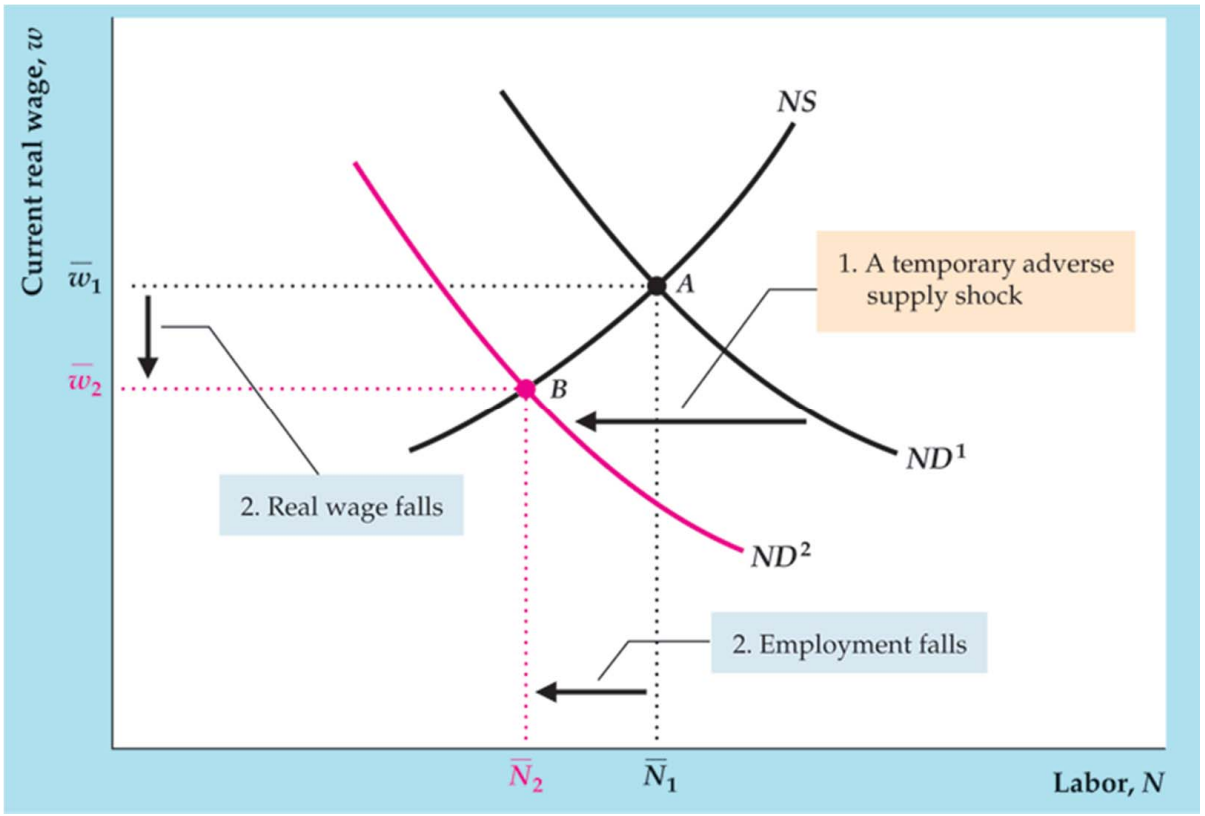
- (Conti.) Full-employment output = ...

$$\overline{Y} = AF\left(K, \overline{N}\right) \tag{6}$$

- It is affected by changes....
- Application: output, employment, and the real wage during oil price shocks:
  - Sharp oil price increases in...
  - Adverse supply shock...
  - First two cases: U.S. economy entered ...
  - Research result: 10% increase in price of oil reduces GDP by 0.4%.

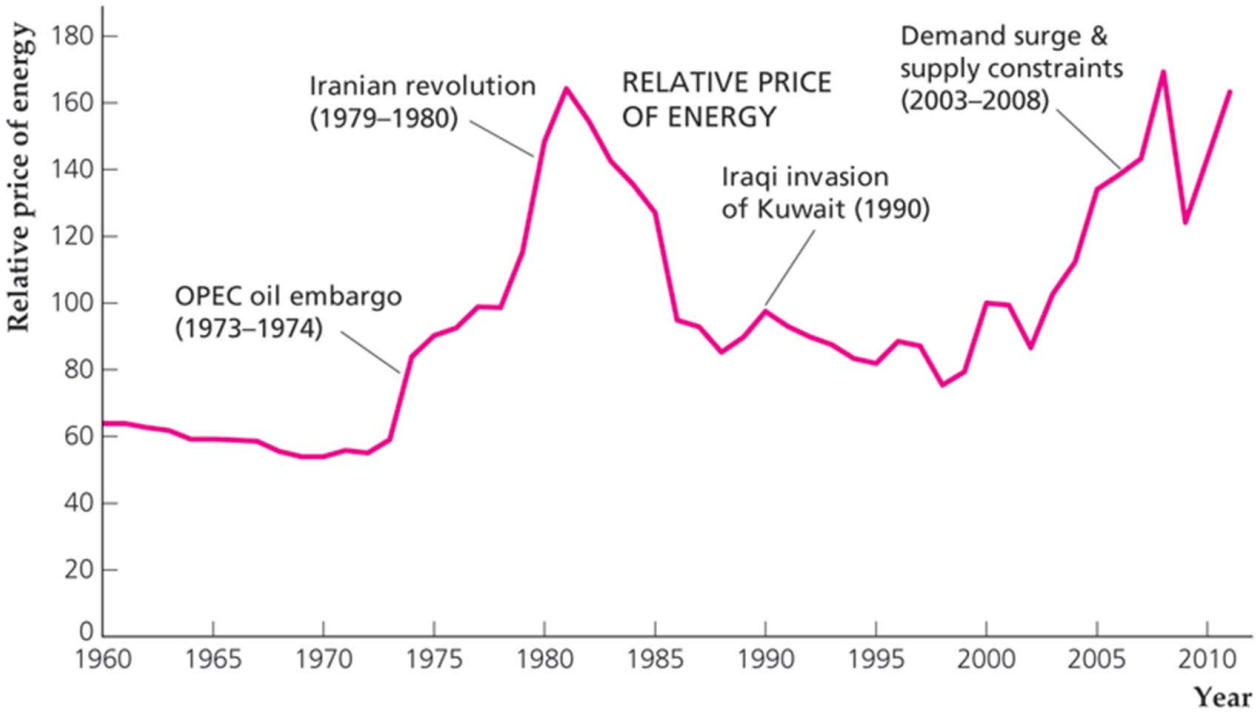
Temporary Adverse Shock

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



Relative Price of Energy

Figure 3.11 Relative price of energy, 1960-2011

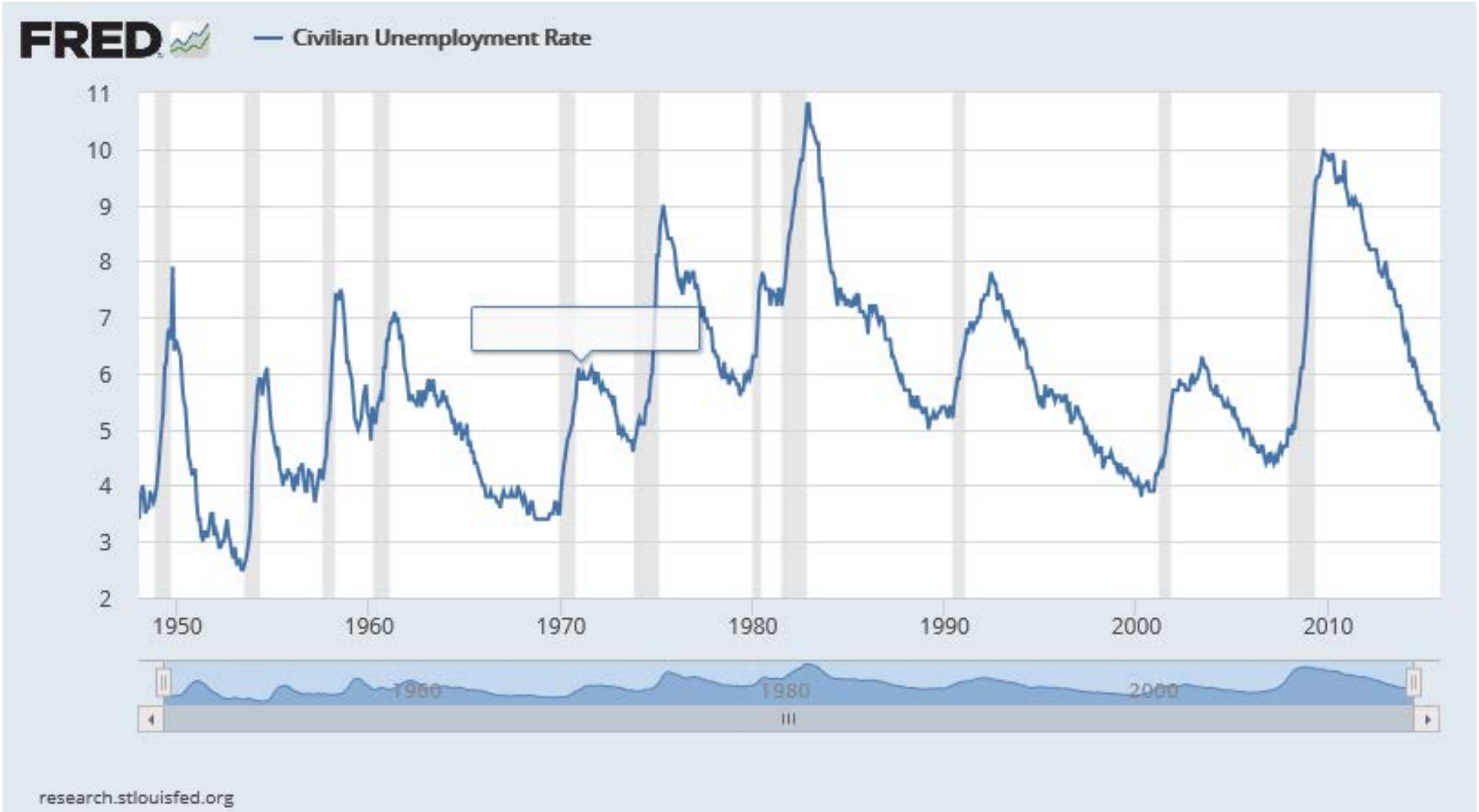


Sources: Producer price index for fuels and related products and power from research. stlouisfed.org/fred2/series/PPIENG; GDP deflator from research.stlouisfed.org/fred2/GDPDEF. Data were scaled so that the relative price of energy equals 100 in year 2000.

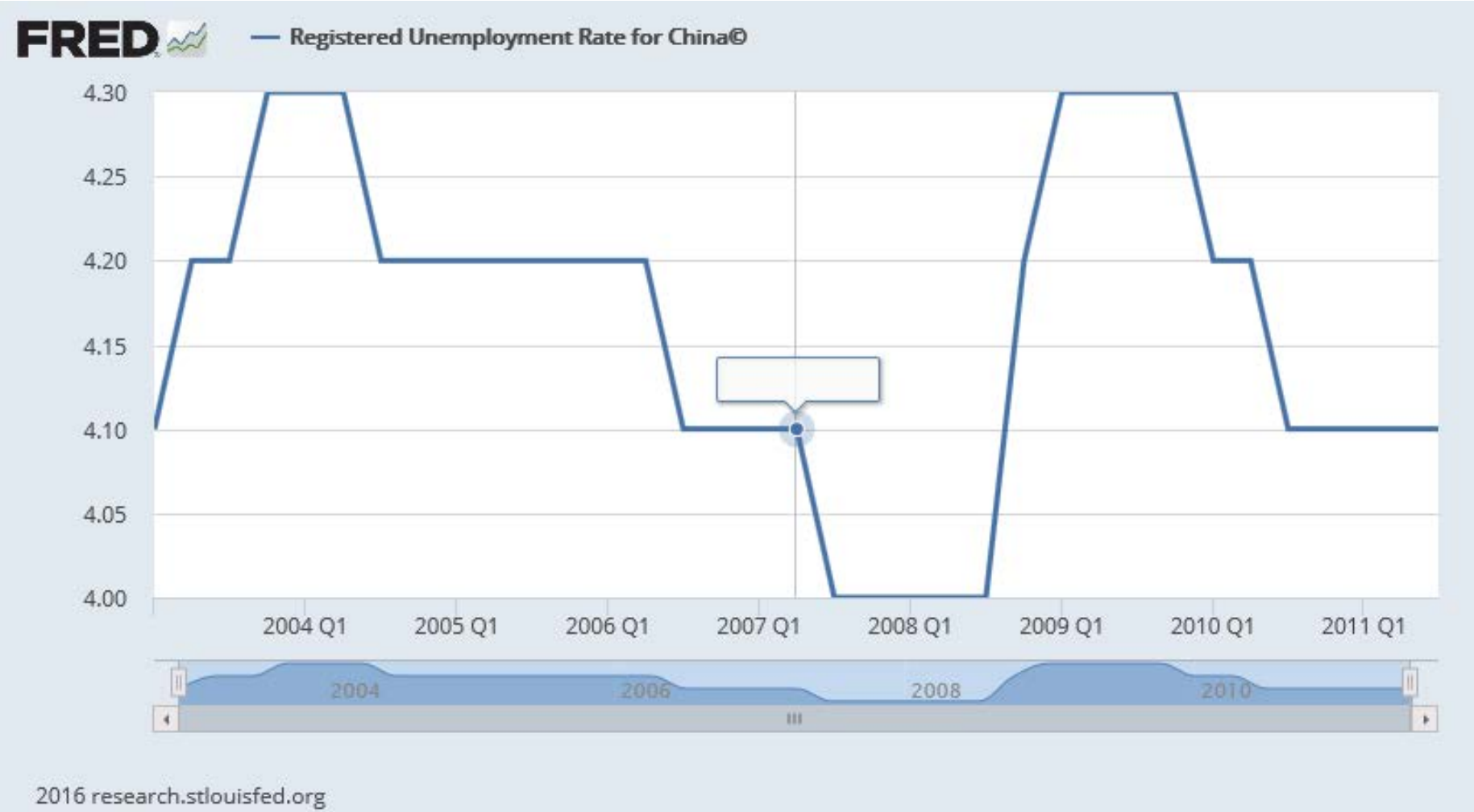
Measuring unemployment

- BLS Survey Categories:...
- Labor Force =
- Unemployment Rate =
- Participation Rate =
- Employment Ratio =
- Table 3.4 shows current data.

Unemployment Rate in U.S. (FRB at St. Louis)

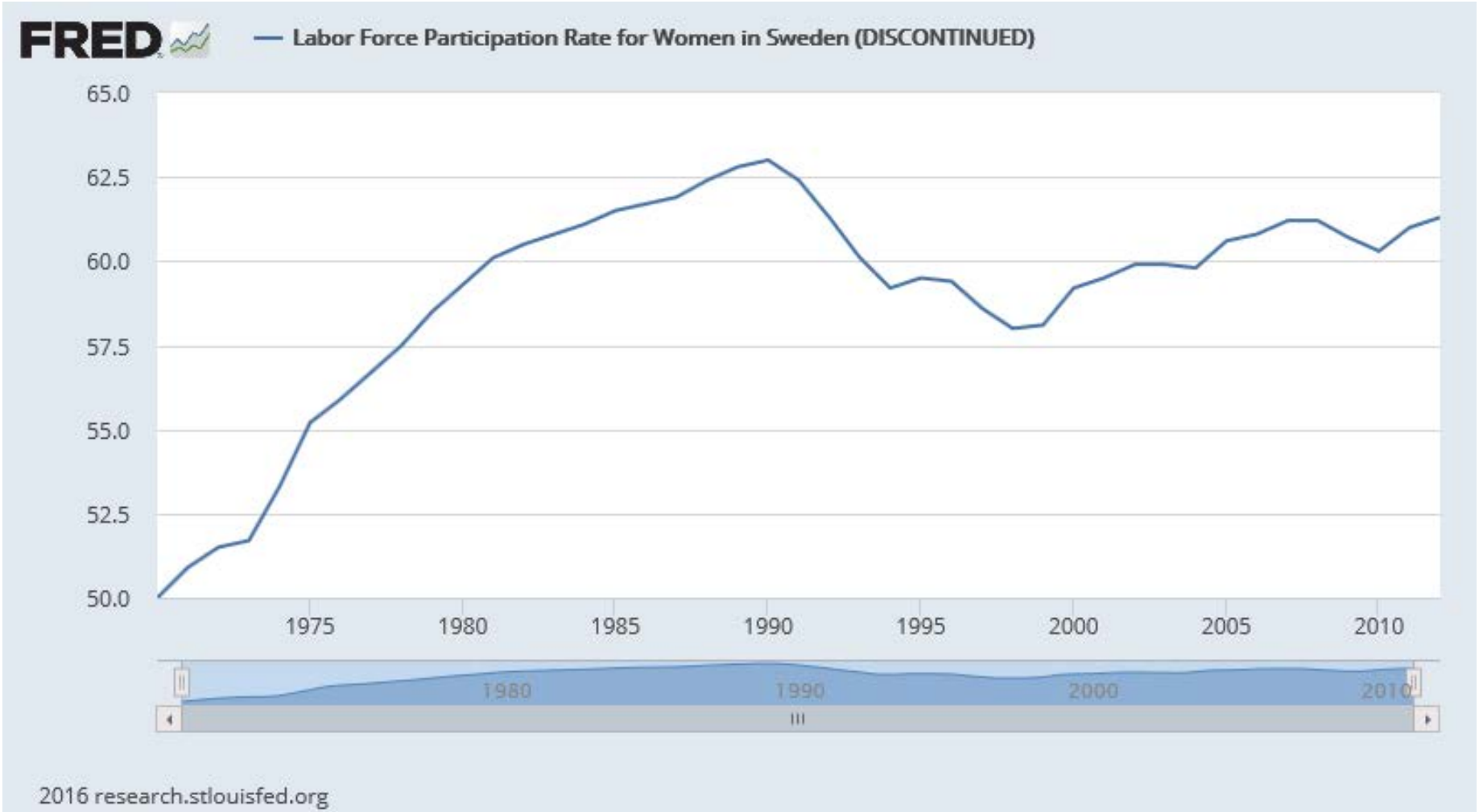


Unemployment Rate in China



Labor Participation Rate in U.S. (Financial Crisis)

Labor Participation Rate of Female in Sweden



Changes in employment status

- Flows between categories (Fig. 3.12).
- Discouraged workers: ...
- Other unemployed workers leave the labor force to engage in ...
- Major reason for drop in unemployment rate after 2011...

Employment Status

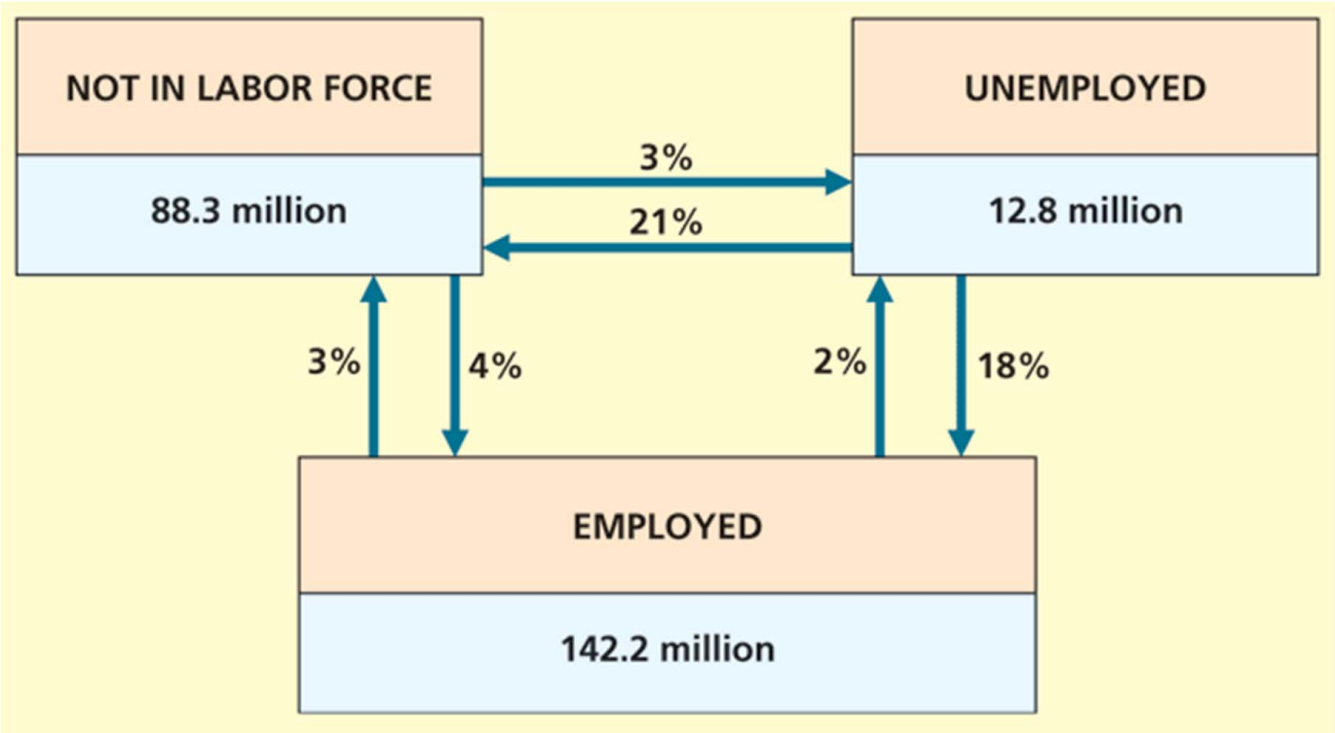
Table 3.4 Employment Status of the U.S. Adult Population, July 2012

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.

Change in Employment Status

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



How long are people unemployed? Two seemingly contradictory statements

- Most unemployment spells are of short duration...
  - Unemployment spell = ..
  - Duration = ...
- Most unemployed people on a given date are experiencing ...

Numerical Example

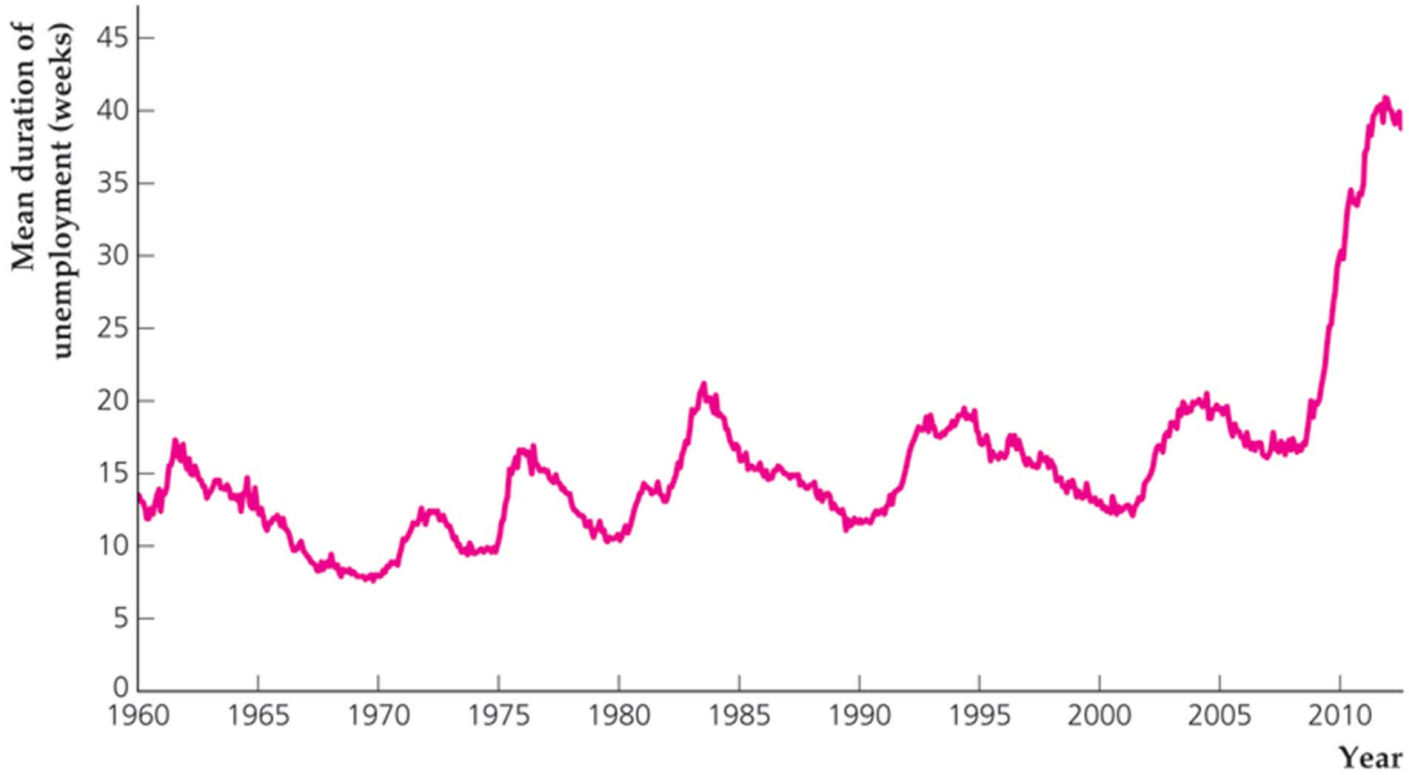
- Labor force = 100; ...
- Result: ... spells of unemployment during a year; ... short (one month), ... long (one year); so most spells are ...
- At any date, unemployment = ...

Application: Unemployment Duration and the 2007-2009 Recession

- 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
  - the extension of...
  - very large job losses.
  - weak economic recovery.
  - Much longer duration of ...

Mean Duration of Unemployment

Figure 3.13 Mean duration of unemployment, 1960-2012



Why there are always unemployed people

- Frictional unemployment (short run)
  - Search activity of firms and workers due to heterogeneity. In reality, neither jobs nor workers are ...
  - Matching process takes time (marriage market?).
  - As the economy is dynamic, ...
- Structural unemployment (long run)
  - Chronically unemployed:
  - Structural unemployment:
  - One cause: ...
  - Another cause: ...

The natural rate of unemployment

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

$$u - \overline{u}. \tag{7}$$

- In touch with data and research: labor market data
  - BLS employment report. Household survey: unemployment, employment.
  - Establishment survey: jobs.

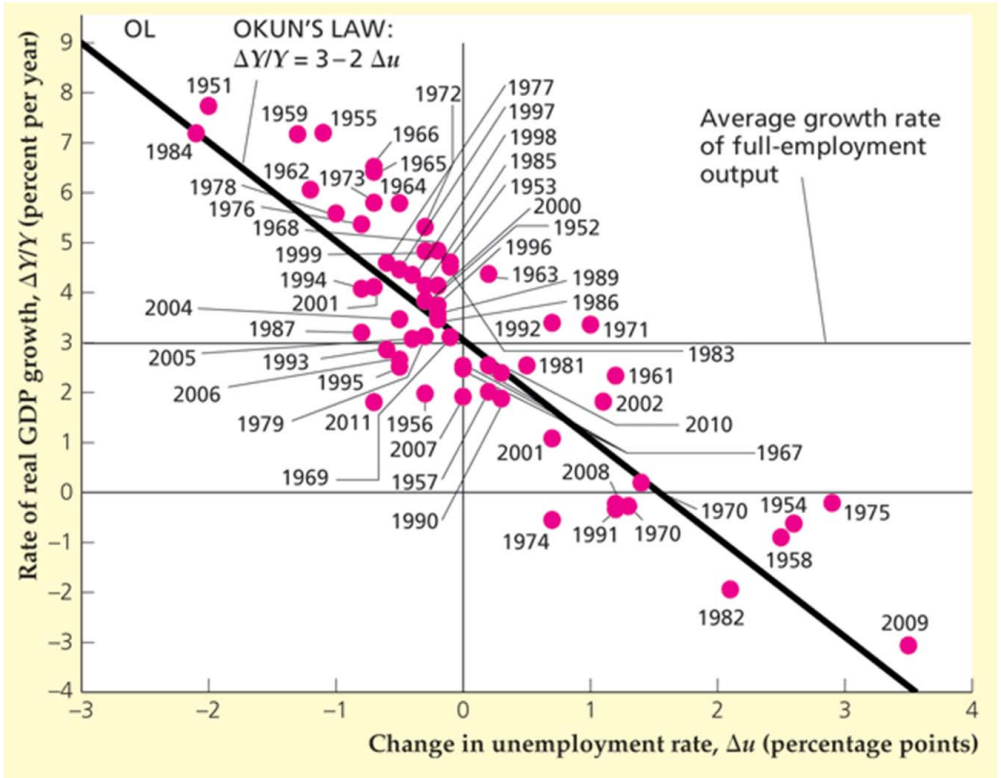
Relationship between output (relative to full-employment output) and cyclical unemployment

- $$\frac{\overline{Y} - Y}{\overline{Y}} = 2\left(u - \overline{u}\right), \tag{8}$$

  where Y is actual output and u is actual unemployment rate.
- Why is the Okun's Law coefficient 2, and not 1?
- Alternative formulation if average growth rate of full-employment output is 3%:

$$\Delta Y / Y = 3\% - 2\Delta u. \tag{9}$$

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.*