Topic 2: Productivity, Output, and Employment

Lei Pan

School of Arts
Australian Catholic University

Chapter Outline

- The Production Function
- The Demand for Labour
- The Supply of Labour
- Labour 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 quantities of inputs (such as labour, 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 labour. We focus on the labour market in this topic. We first assume that the quantities of labour supplied and demanded are equal so that all labour resources are fully utilized, and later we introduce unemployment.

The Production Function

Production Function

- inputs (capital, labour, and raw materials)
- productivity (effectiveness of turning inputs to output)

The Production Function

- Factors of production (inputs):
  - Capital (K)
  - Labour (N)
  - Others (raw materials, land, energy)
  - Productivity of factors depends on technology and management (China's High-speed train tragedy 23/7/2011)
- The production function (the effectiveness with which capital and labour are used):

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

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

Application

- Cobb-Douglas

$$Y = AK^{\alpha}N^{1-\alpha}$$

  Constant return to scale
  α: share of capital in total production
  U.S. experience: $\alpha = 0.3$, $1 - \alpha = 0.7$

  The production function implies that, share of capital input is constant.

- Output, capital, and labour 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.

Production Function of the U.S., 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:
  - 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,

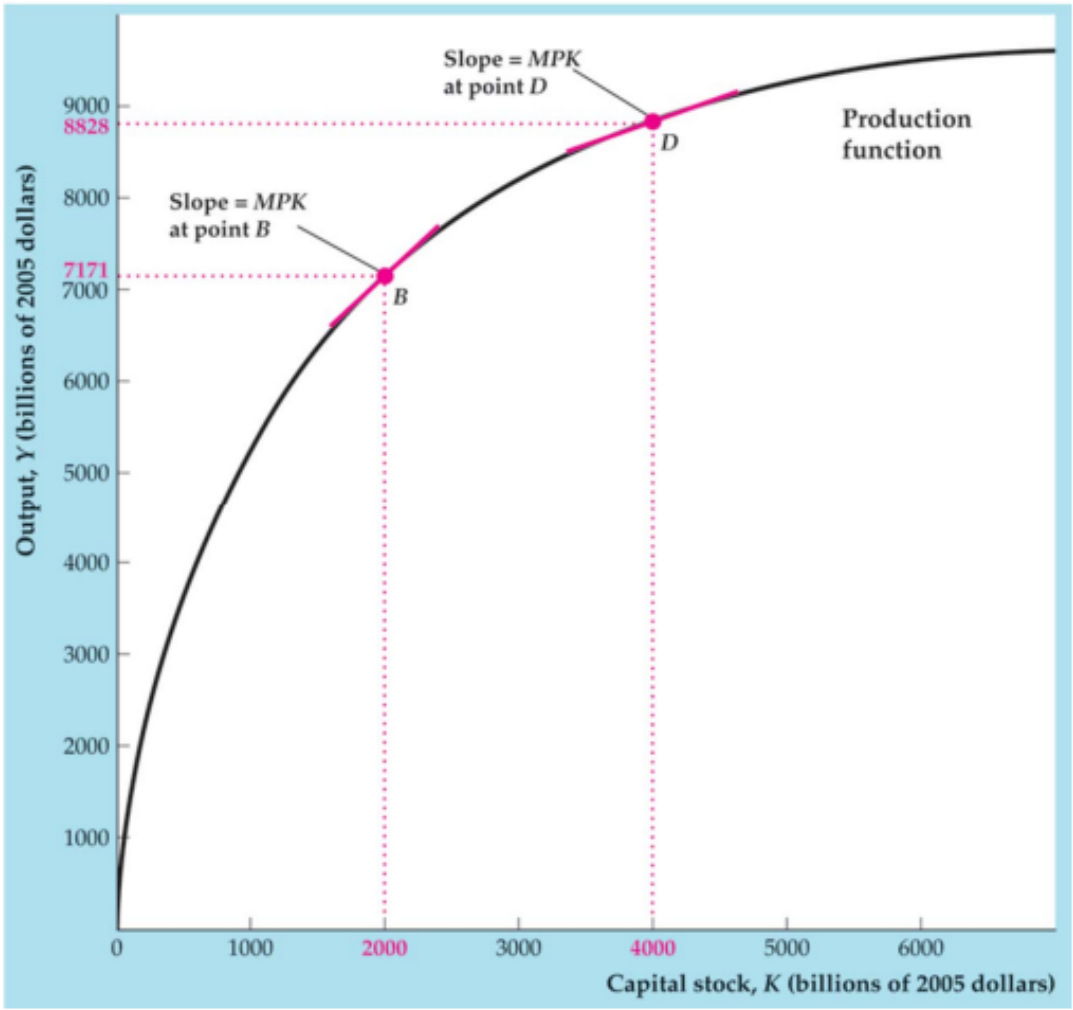
$$MPK = \Delta Y / \Delta K$$

    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 labour,

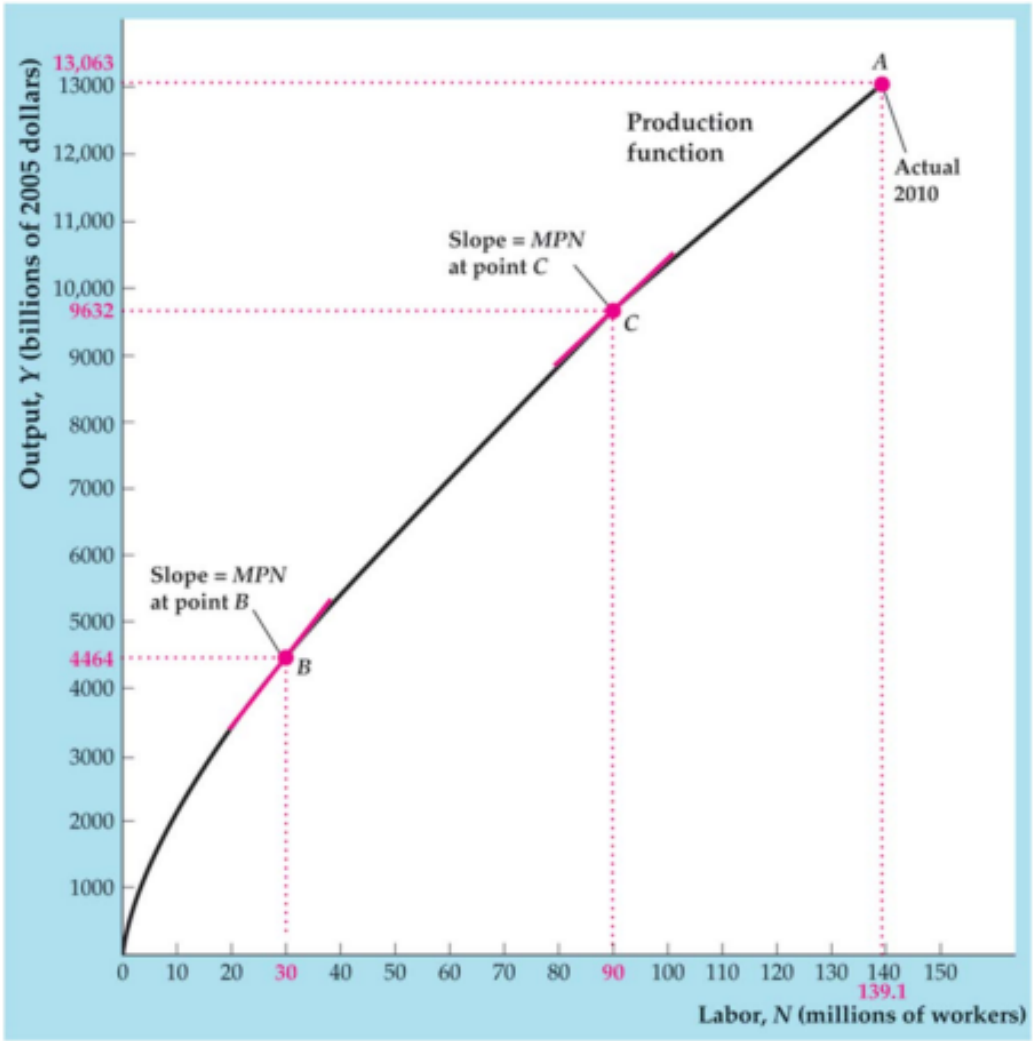
$$MPN = \Delta Y / \Delta N$$

    is the slope of production function graph (Y vs. N). MPN always positive. Diminishing marginal productivity of labour.

The marginal product of capital



The production function relating output and labour

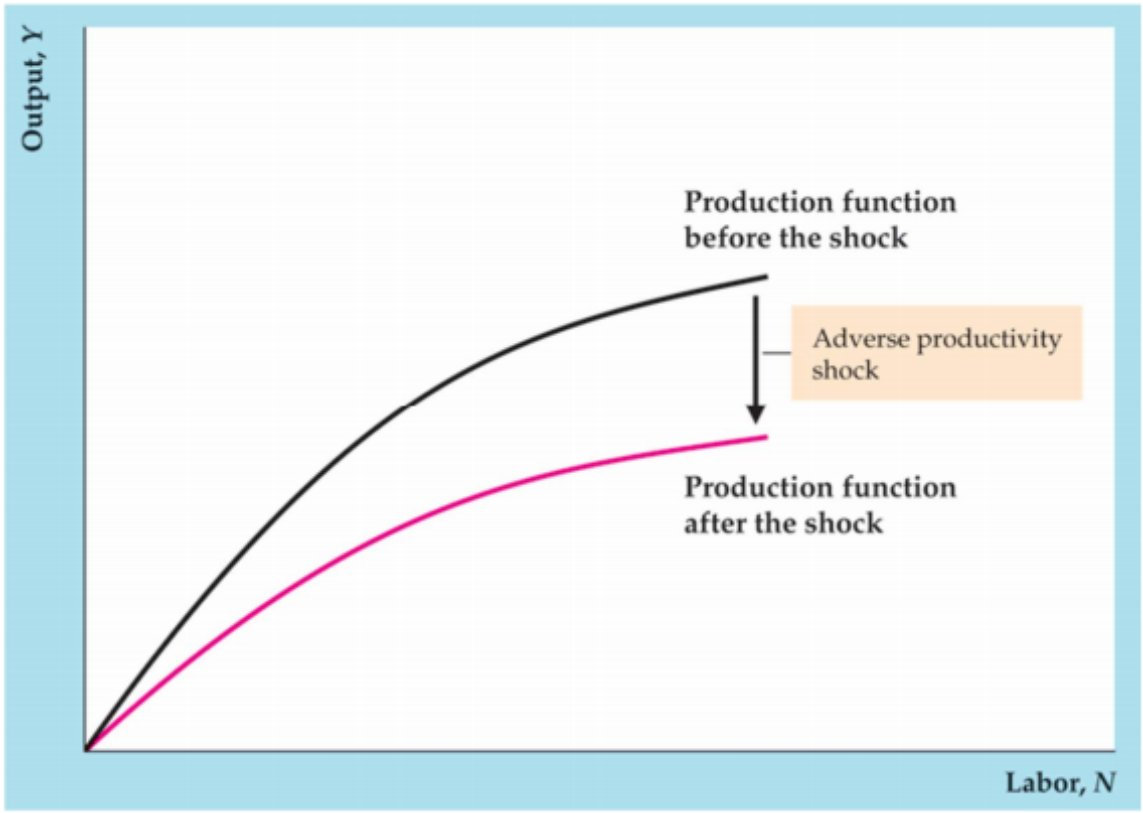


Supply shocks

- 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.
- Those factors which affect TFP are called *supply shocks*.
- 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
  - 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).

How supply shocks affect production

An adverse supply shock that lowers the *MPN*.



Labour demand

- The amount of labour employed in the economy can change fairly quickly.
- 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.
  - Labour market is competitive. Firms and worker take the wage rate determined in the competitive labour market as given.
  - Firms maximize profits. The firm will demand the amount of labour that maximizes its profit. Firms must compare the costs and benefits of hiring each additional worker.

Labour demand

- *MPN*: the benefit of employing an additional worker in terms of the extra *output* produced.
- *MRPN*: the benefit of employing an additional worker in terms of the extra *revenue* produced. To calculate *MRPN*, we need to know the price of the firm's output (P).
- Profit maximization – setting the nominal wage equal to the marginal revenue product of labour (*MRPN*):

$$MRPN = P \times MPN$$

  where $W = MRPN$ 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 $w = MPN$, since $W = P \times w$ and $MRPN = P \times MPN$.

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
  - If real wage (w) $>$ marginal product of labour (MPN), profit rises if number of workers declines.
  - If $w < MPN$, profit rises if number of workers increases.
  - Firms' profits are highest when $w = MPN$.

Firms' optimal decision

- In nominal terms

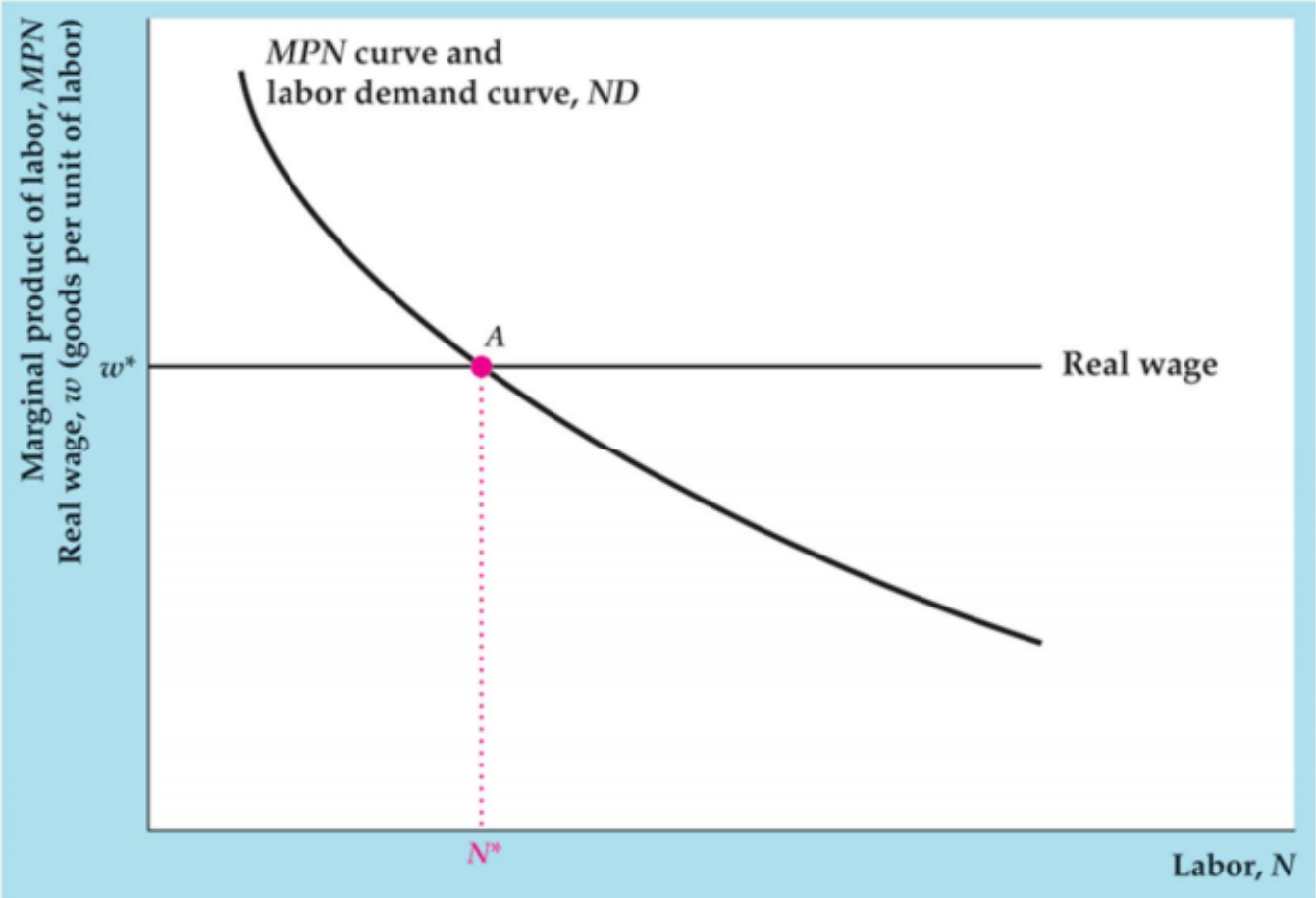
$$MRPN = W$$

- In real terms

$$MPN = w$$

where real wage $w = W/P$.

The determination of labour demand



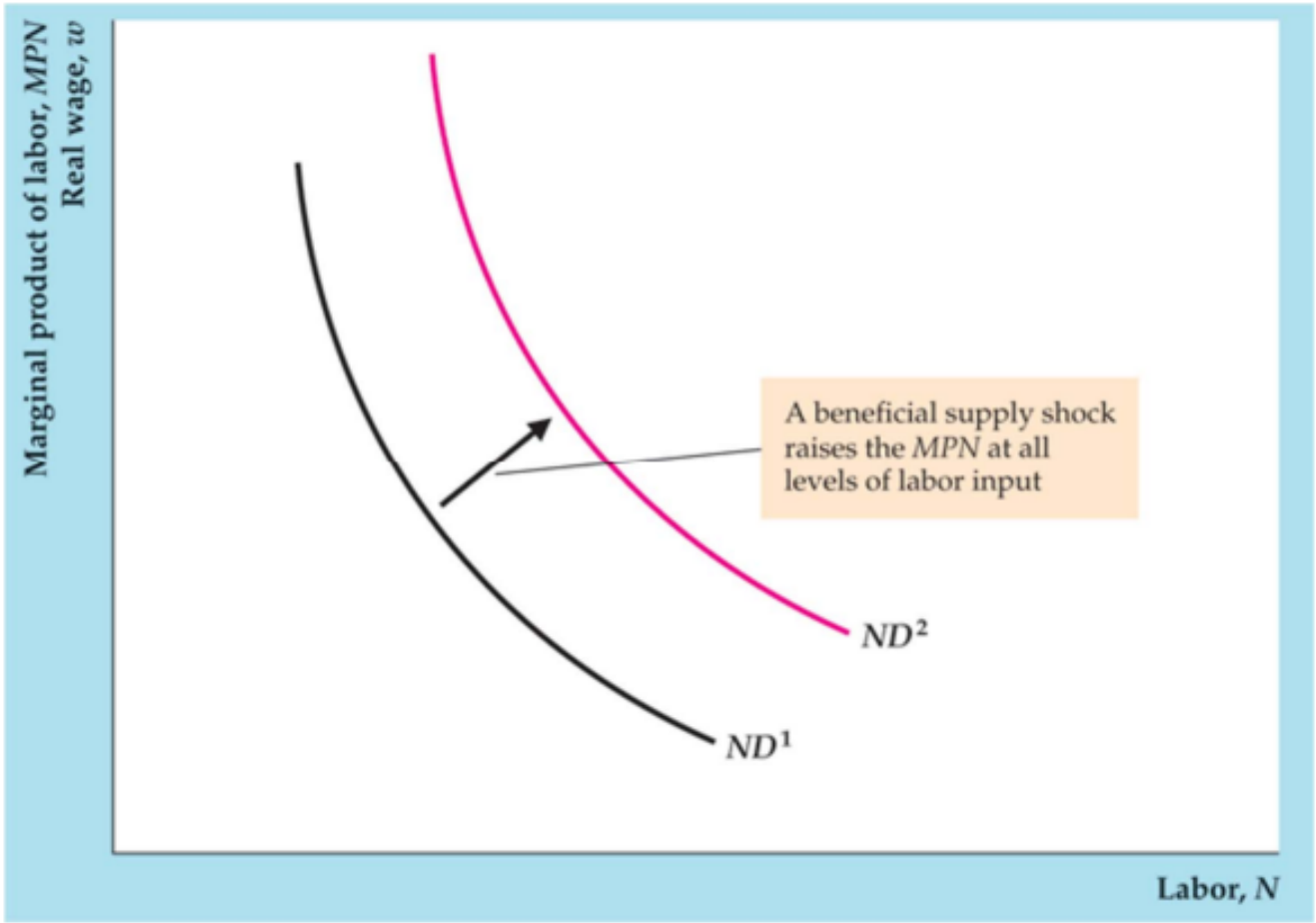
The marginal product of labour and the labour demand curve

- *Labour demand curve* shows relationship between the real wage rate and the quantity of labour demanded.
- It is the same as the *MPN* curve except that the vertical axis measures the real wage for the labour demand curve and measures the marginal product of labour for the *MPN* curve. Note that $w = MPN$ at equilibrium.
- So the labour demand curve is downward sloping; firms want to hire less labour as the real wage rises.

Factors that shift the labour demand curve

- Note: A change in the wage causes a movement *along* the labour demand curve, not a shift of the curve.
- Supply shocks: Beneficial supply shock raises *MPN at all levels of labour input*, so shifts labour 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 labour demand curve to the right; opposite for lower capital stock.

The effect of a beneficial supply shock on labour demand



Aggregate labour demand

- Aggregate labour demand is the sum of all firms' labour demand. The aggregate labour demand curve looks the same as the labour demand curve for an individual firm.
- Same factors (supply shocks, size of capital stock) that shift firms' labour demand cause shifts in aggregate labour demand.

The supply of labour

- Supply of labour 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 labour is the sum of individuals' labour supply.
- Labour 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.
- **marginal benefits** of working (additional labour income) vs. **marginal cost** of working (forgone leisure)
  - If benefits of working another day exceed costs, work another day.
  - Keep working additional days until benefits equal costs.

Real wages and labour supply

- What are factors affecting labour supply?
  - Real wage
- 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 labour.
  - Net effect: ambiguous
- 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.

Real wages and labour 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.
- 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 labour supply will increase by less or decrease by more than for a temporary reduction in the real wage.

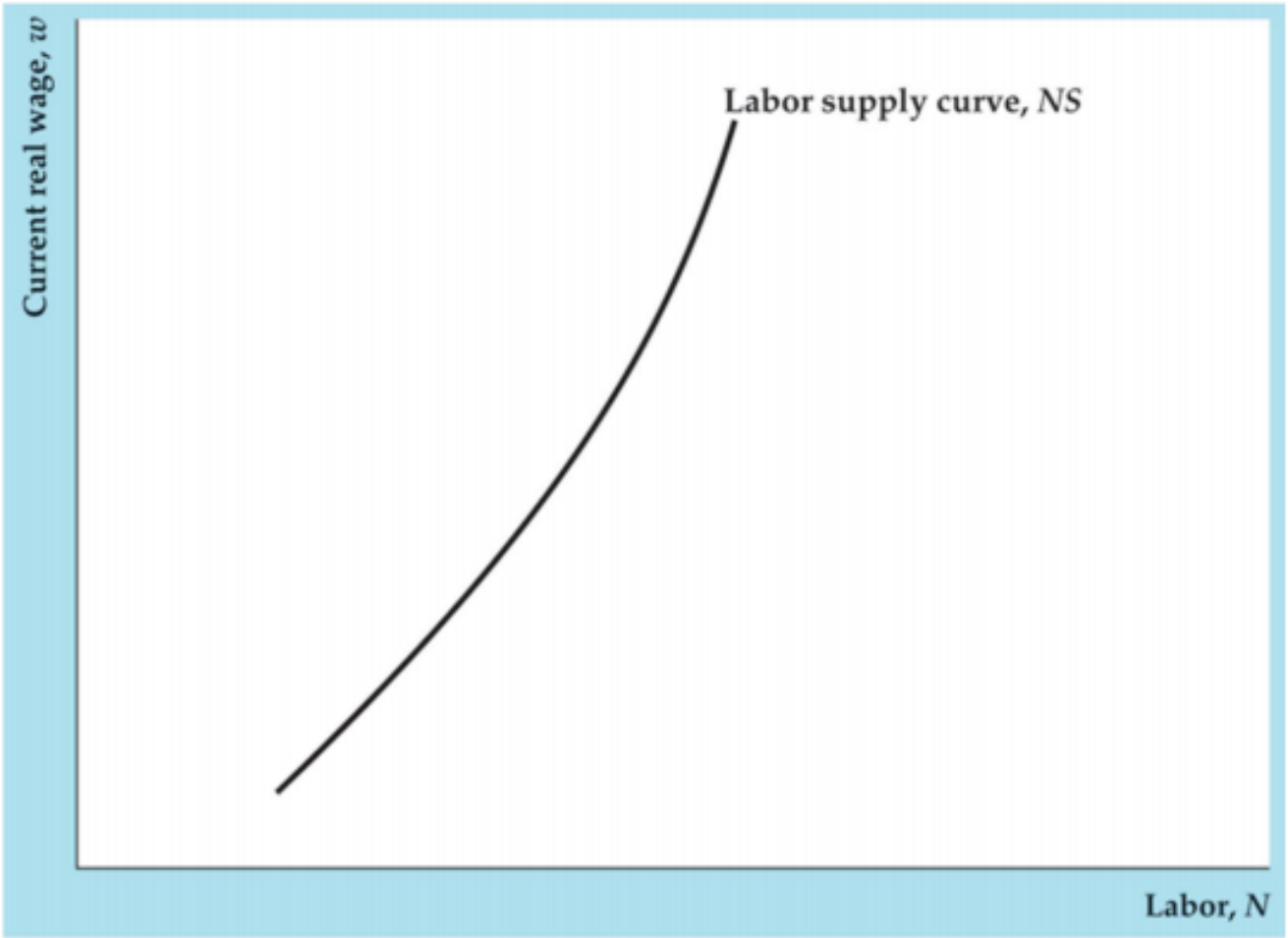
Real wages and labour supply

- Empirical evidence on real wages and labour supply:
  - Overall result: Labour supply increases with a temporary rise in the real wage.
  - Labour supply falls with a permanent increase in the real wage.

The labour supply curve

- Increase in the current real wage should raise quantity of labour supplied.
- *Labour supply curve* relates quantity of labour supplied to real wage, holding constant all other factors (including the expected future real wage rate) that affect the amount of labour supply.
- Labour supply curve slopes upward because higher wage encourages people to work more.
- Factors that shift the labour supply curve:
  - Wealth: Higher wealth reduces labour supply *at any real wage* (shifts labour supply curve to the left)
  - Expected future real wage: Higher expected future real wage is like an increase in wealth, so reduces labour supply (shifts labour supply curve to the left).

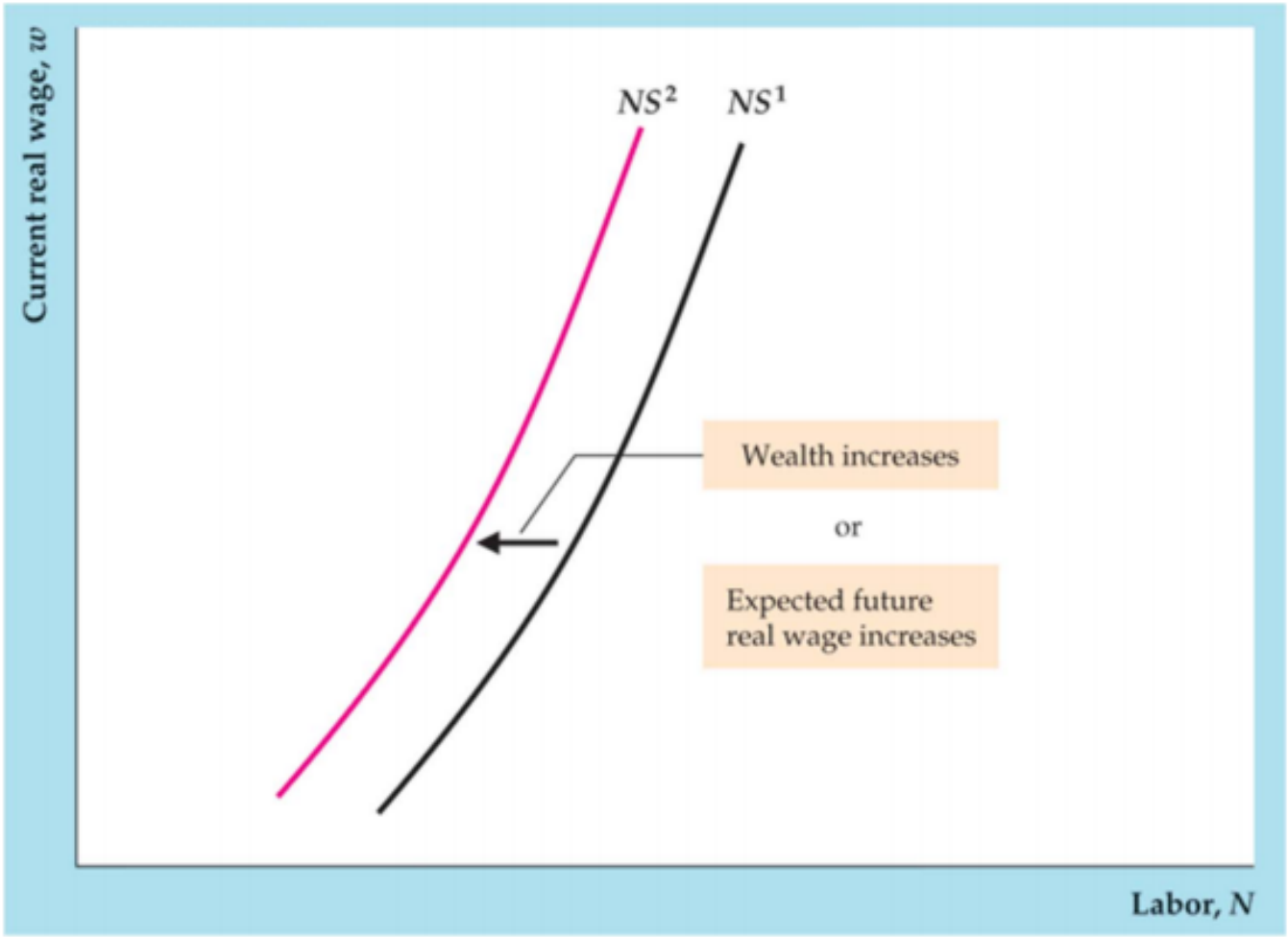
The labour supply curve of an individual worker



Aggregate labour supply

- Aggregate supply of labour is the total amount of labour supplied by everyone in the economy.
- Aggregate labour supply rises when current economywide real wage rises because:
  - Some people work more hours.
  - Other people enter labour force.
  - Result: Aggregate labour supply curve slopes upward.
- Factors increasing labour 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 labour force participation (increased female labour participation, elimination of mandatory retirement): increased number of people wanting to work.

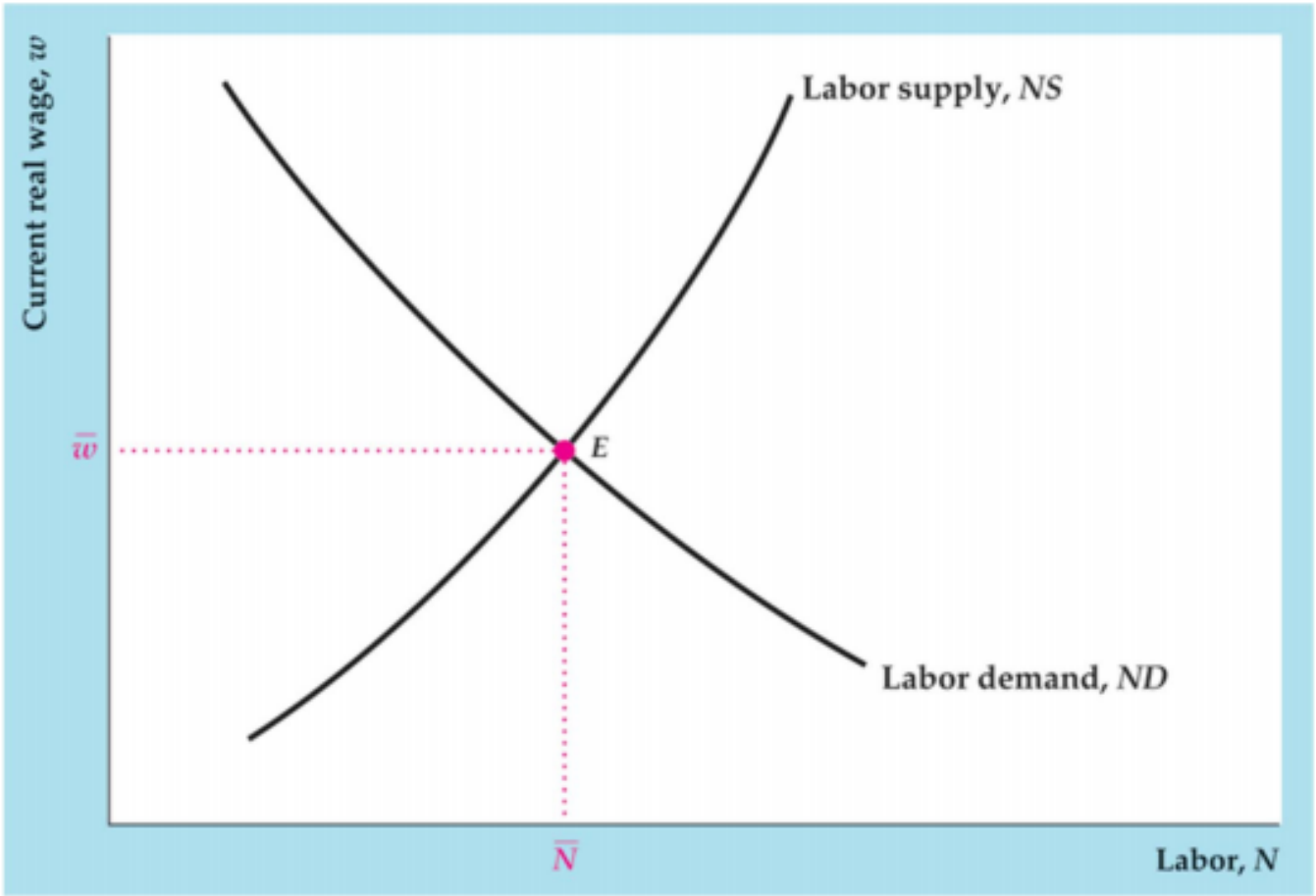
Effect on labour supply of an increase in wealth



Labour Market Equilibrium

- Equilibrium: aggregate labour supply equals aggregate labour demand. (Called "*the classical model of the labor market*".)
- Classical model of the labour market real wage adjusts quickly to equate labour supply and labour demand. If labour supply is less than labour 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 ($\bar{N}$) and market-clearing real wage ($\bar{w}$).
- Problem with classical model: can't study unemployment.

Labour Market Equilibrium



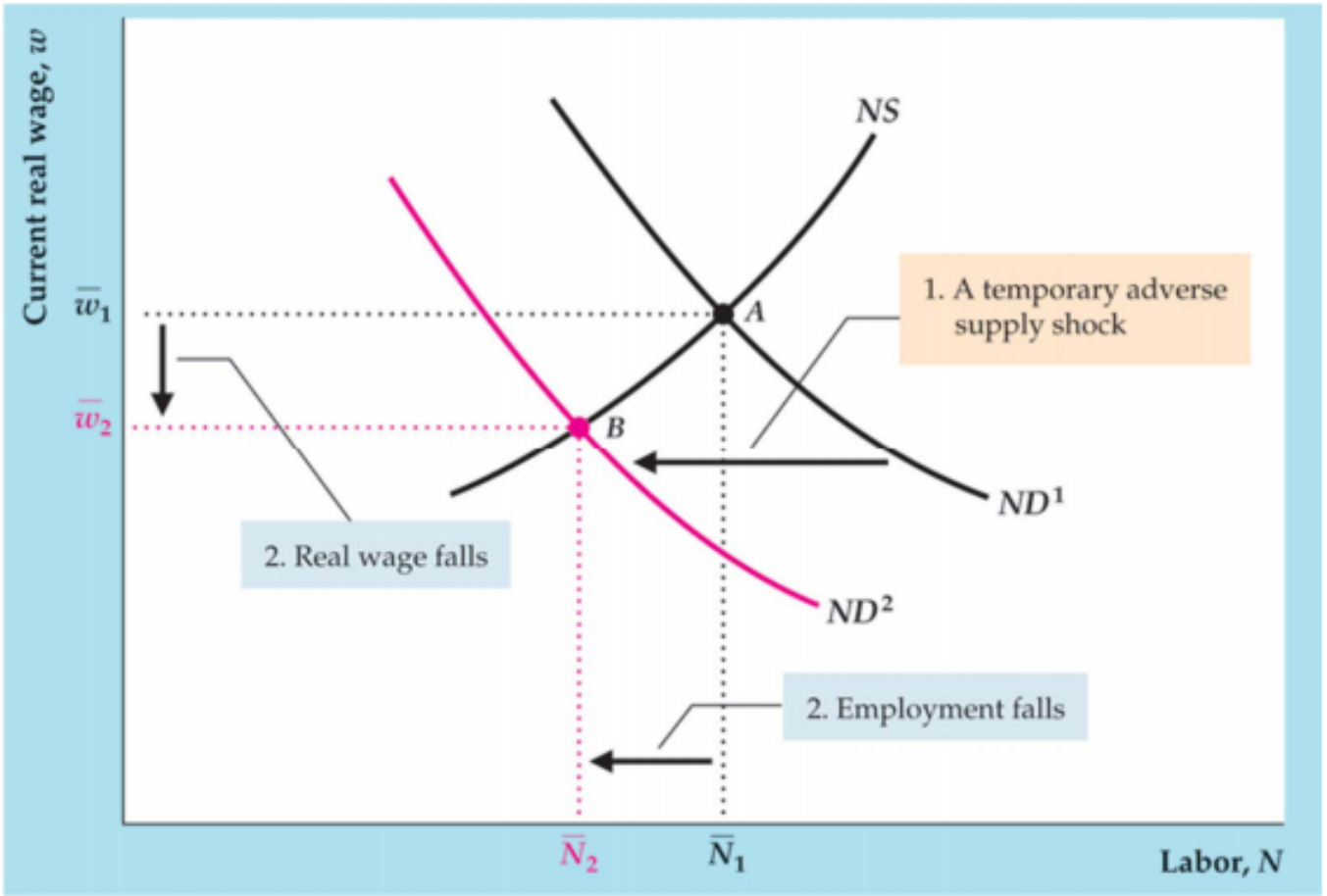
Labour Market Equilibrium

- Full-employment output
  - = potential output
  - = level of output when labour market is in equilibrium
  - = long run equilibrium output

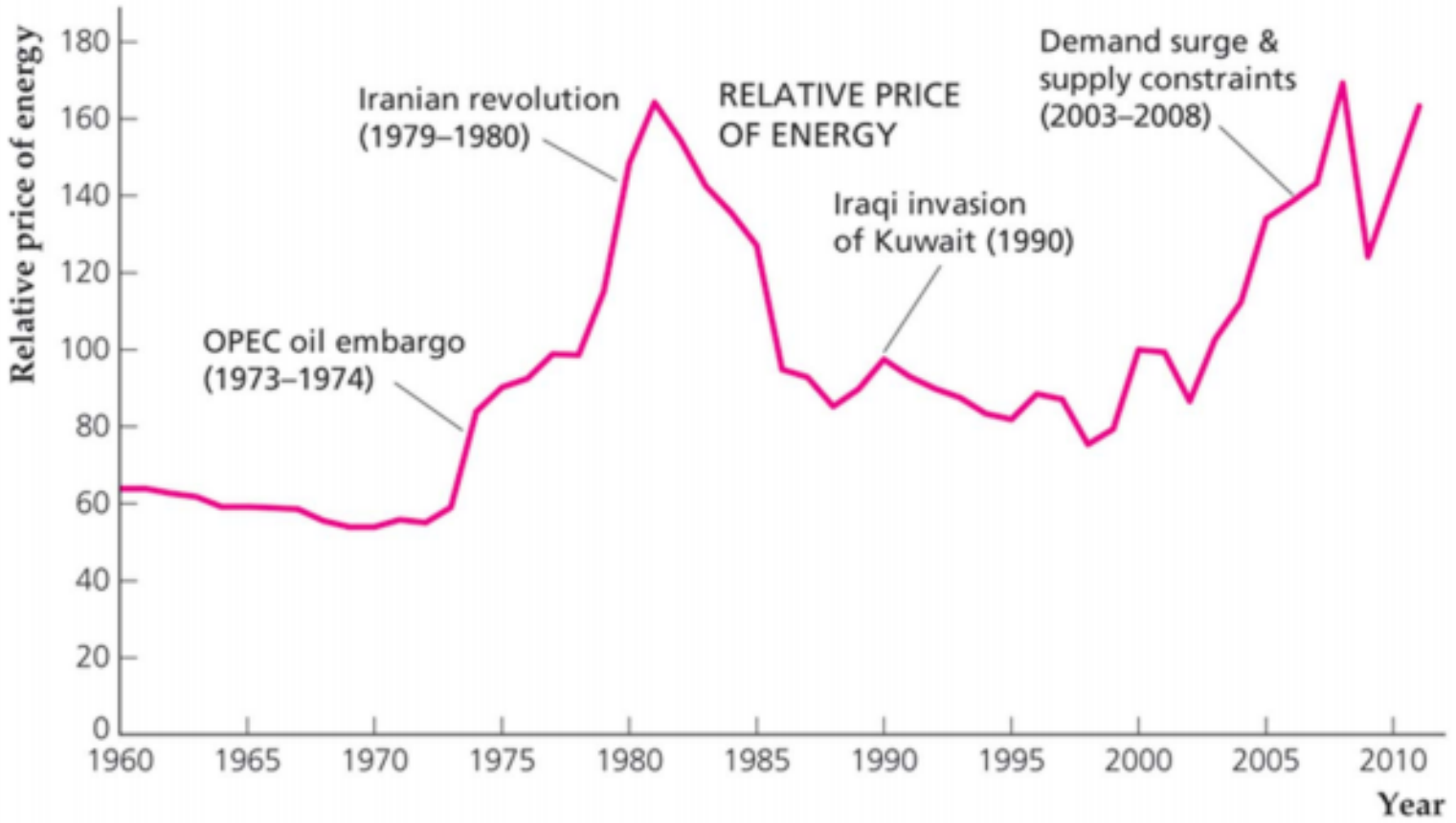
$$\bar{Y} = AF(K, \bar{N})$$

- It is affected by changes in full employment level or production function (example: supply shock).
- Application: output, employment, and the real wage during oil price shocks:
  - Sharp oil price increases in 1973-1974, 1979-1980, 2003-2008.
  - Adverse supply shock – lowers labour 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%.

Effects of a temporary adverse supply shock on the labour market



Relative price of energy, 1960-2011



Measuring unemployment

- In the real world, most countries cannot reach full-employment.
- 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).
- Labour Force = Employed + Unemployed.
- Unemployment Rate = Unemployed/Labour Force.
- Participation Rate = Labour Force/Adult Population.
- Employment Ratio = Employed/Adult Population.

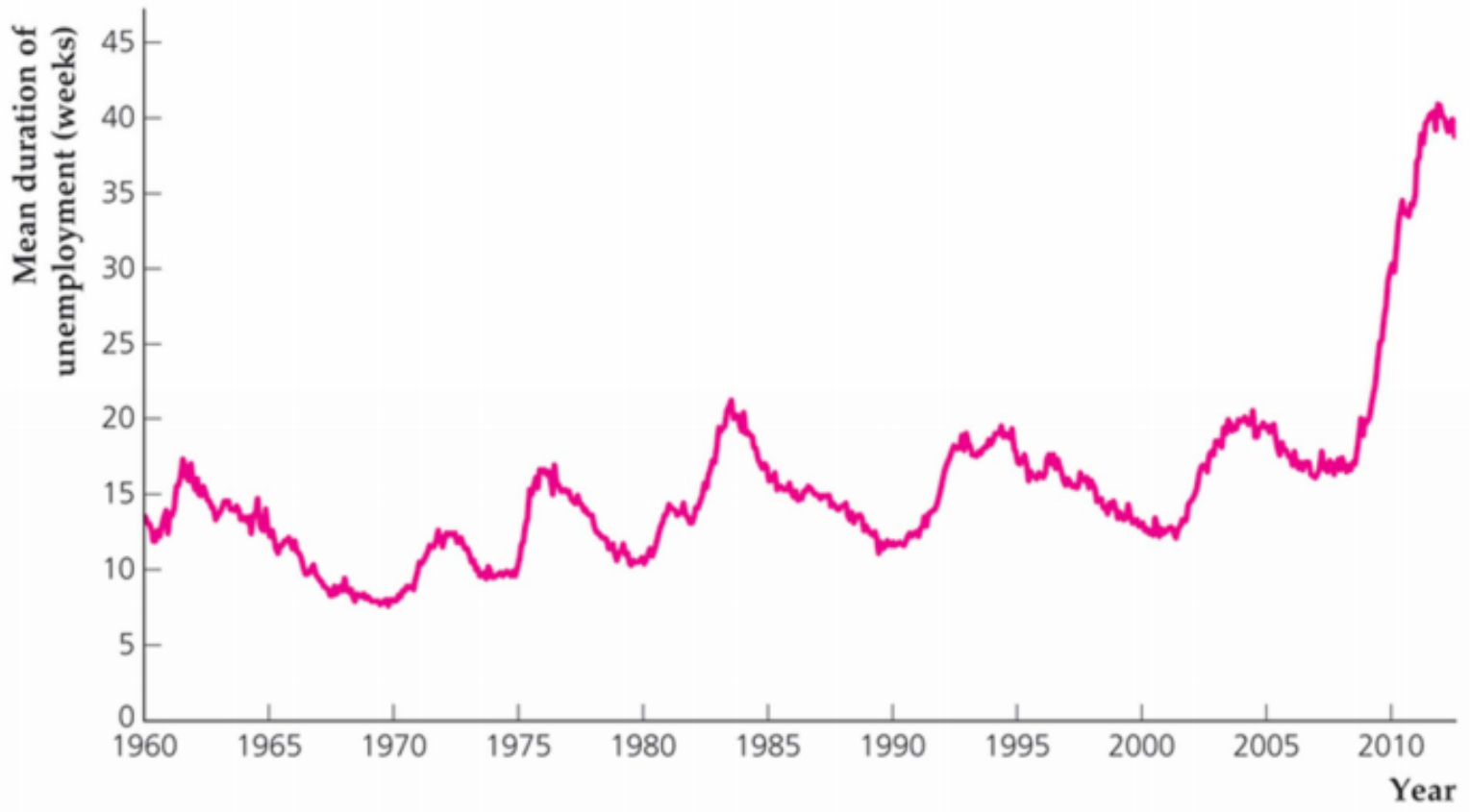
Changes in employment status

- Discouraged workers: people who have become so discouraged by lack of success at finding a job that they stop searching.
- Other unemployed workers leave the labour force to engage in some activity such as homemaking or going to school.

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.
- US facts:
  - short duration, two months or less
  - high job turnover rate
  - Pattern differs in other countries

Mean duration of unemployment, 1960-2012



Why there are always unemployed people

- Frictional unemployment
  - Search activity of firms and workers due to heterogeneity. In realty, 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 labour 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

$$u - \bar{u}$$

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

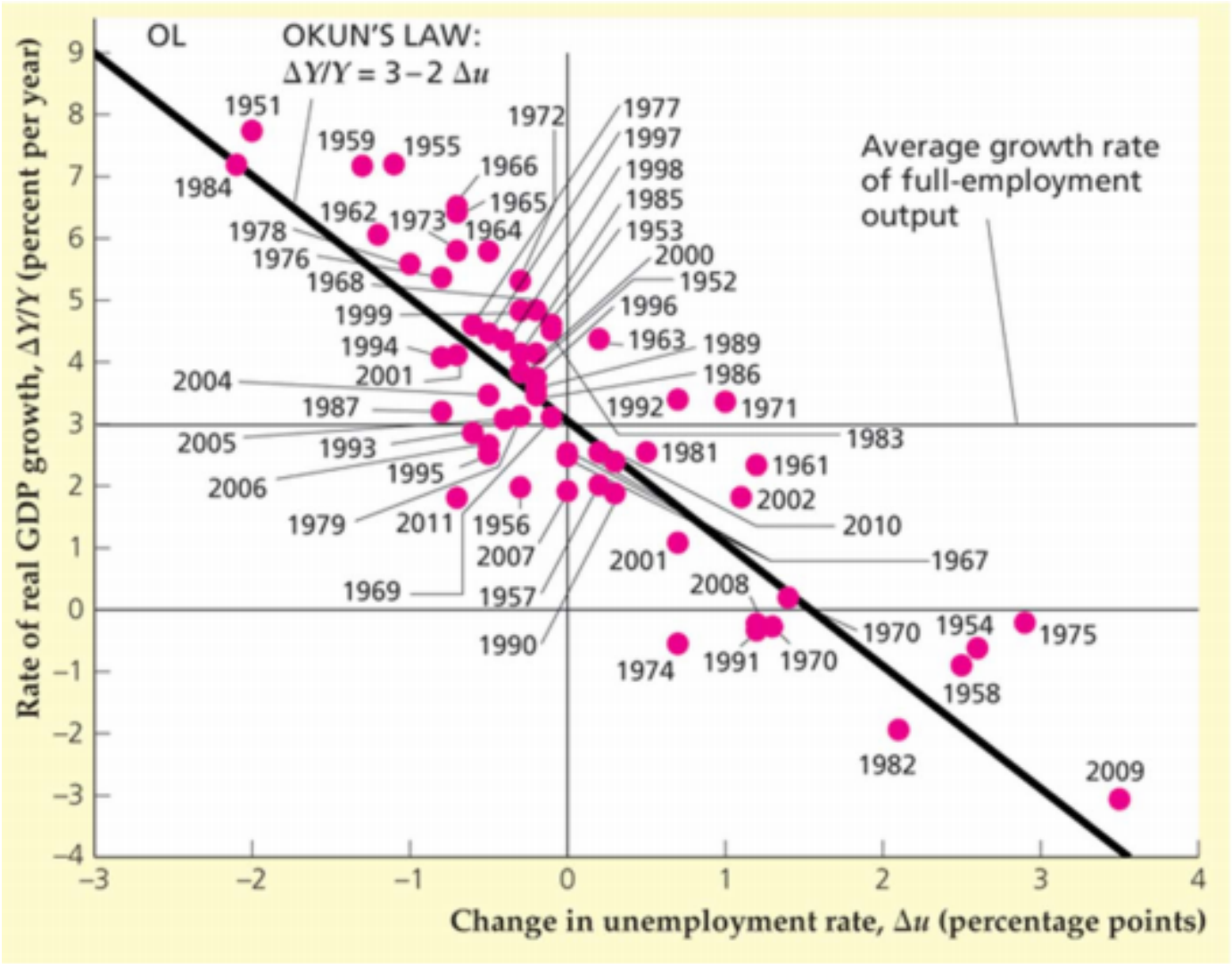
- Okun's Law: an empirically observed relationship relating unemployment to losses in a country's production

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

  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: Labour force falls, hours of work per worker decline, average productivity of labour 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%:

$$\frac{\Delta Y}{Y} = 3 - 2\Delta u$$

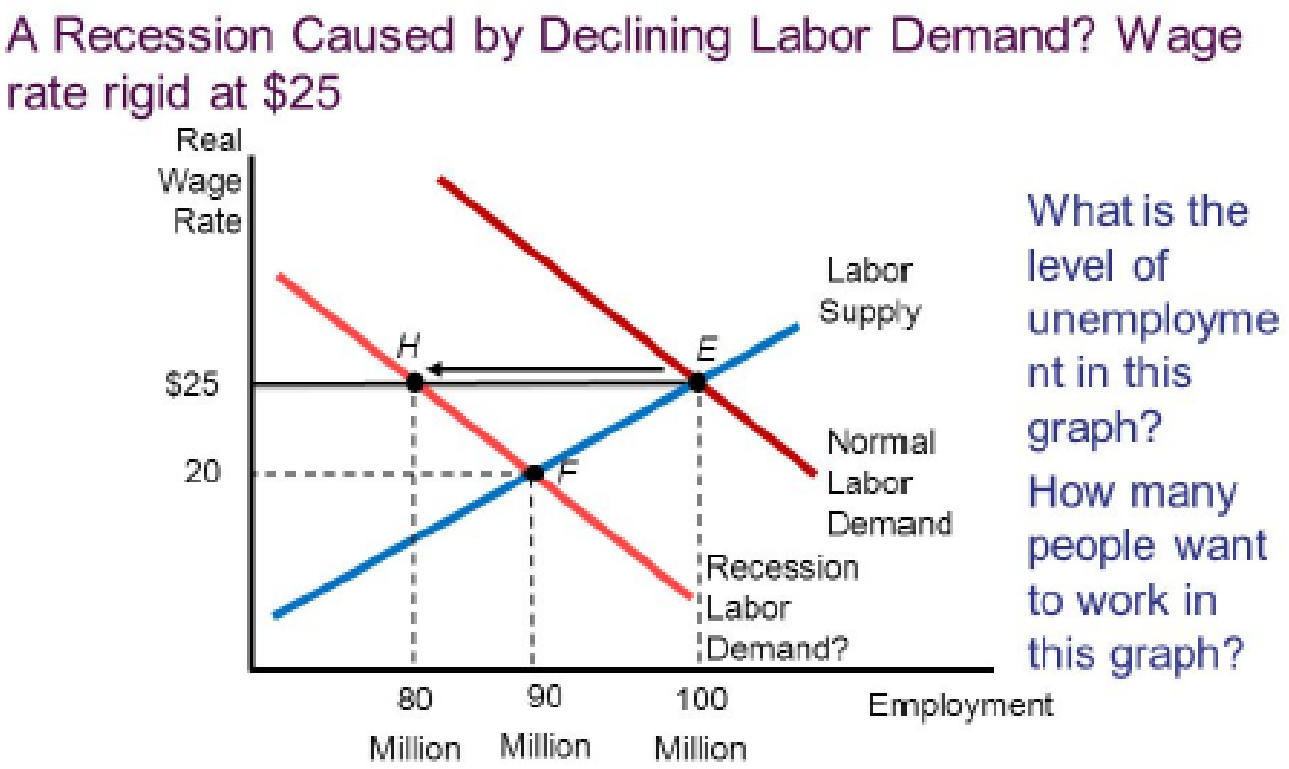
Okun's Law in the U.S., 1951-2011



Unemployment in Europe

High unemployment rate in Europe

- Labour market rigidity, employment protection



Downward wage rigidity prevents the labor market from clearing. This could, in theory, explain the rise in unemployment during a recession.