

No 05. Chapter 3

Productivity, Output, and
Employment



Introduction

- This chapter describes factors that determine the level of output produced in an economy.
- It also begins to develop our theory of the economy.



Over the Next Few Chapters ...

- Our strategy will be to develop theories for
 - the labor market
 - goods markets
 - asset markets
- We argue markets in these sectors tend to “equilibrate”
- We investigate what further implications can be derived from the theory



The Model

- Looking ahead, the Appendix to Chapter 9 presents a mathematical version of the model we are beginning to construct
 - In that Appendix, we can compactly summarize a theory we develop in several hundred textbook pages on a single sheet!
- Click to see the model sheet: [Model Sheet](#)



The Production Function

- Output produced in an economy depends on:
 - The amounts of inputs available, for example capital and labor, also raw materials
 - The effectiveness with which these inputs are used



The Production Function in Equation Form

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

where:

Y is real output produced in a given time period.

A is a parameter (a number) reflecting overall productivity.

K is the quantity of capital used in the time period.

N is the quantity of labor used in the time period.

F is a function relating output to inputs used.



A Production Function for the U.S.

- The following production function equation fits U.S. data well (See Table 3.1, next slide):

$$Y = AK^{0.3}N^{0.7}$$

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

Year	Y (Billions of Dollars)	K (Billions of Dollars)	N (Billions of Hours)	A
1979	2750	1000	100	1.0
1980	2800	1050	105	1.0
1981	2850	1100	110	1.0
1982	2900	1150	115	1.0
1983	2950	1200	120	1.0
1984	3000	1250	125	1.0
1985	3050	1300	130	1.0
1986	3100	1350	135	1.0
1987	3150	1400	140	1.0
1988	3200	1450	145	1.0
1989	3250	1500	150	1.0
1990	3300	1550	155	1.0
1991	3350	1600	160	1.0
1992	3400	1650	165	1.0
1993	3450	1700	170	1.0
1994	3500	1750	175	1.0
1995	3550	1800	180	1.0
1996	3600	1850	185	1.0
1997	3650	1900	190	1.0
1998	3700	1950	195	1.0
1999	3750	2000	200	1.0
2000	3800	2050	205	1.0
2001	3850	2100	210	1.0
2002	3900	2150	215	1.0
2003	3950	2200	220	1.0
2004	4000	2250	225	1.0

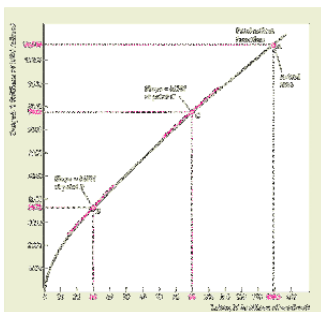
In the Table

- Note that K and N are directly measurable, but A is determined as a “residual” that changes over time.
- The productivity parameter, A , generally grows over time, but not always.
- Growth of productivity is a major driver of increasing standards of living.

Production Function Properties

- We normally plot output as a function of one input, holding other inputs conceptually fixed.
- The production function is upward sloping (as we plot output versus an input, e.g. capital).
- The production function becomes flatter as we move from left to right (increasing labor and output)

Figure 3.3 The production function relating output and labor



Marginal Products

The marginal product of capital is:

$$\frac{\Delta Y}{\Delta K}, \text{ for small increments } \Delta K.$$

Similarly, the marginal product of labor is:

$$\frac{\Delta Y}{\Delta L}, \text{ for small increments } \Delta L.$$

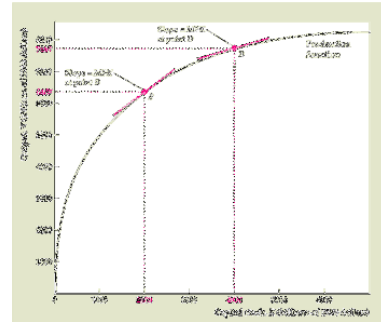
Marginal Products

- There is a geometric interpretation of the marginal product:
 - The slope of the production function at a point (showing output as a function of labor) is the marginal product of labor:

$$\frac{\Delta Y}{\Delta L}$$

- Properties of the production function, revisited:
 - The marginal product of labor is positive.
 - The marginal product of labor falls as the amount of labor increases (holding the capital stock fixed).

Figure 3.2 The marginal product of capital



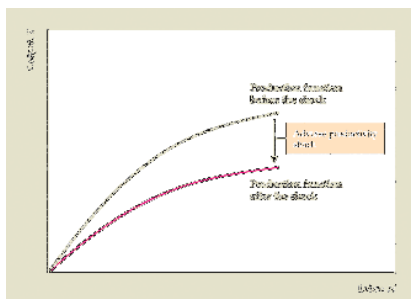
Supply Shocks

- Our production function shows that output is a function of capital and labor inputs
- However, this function is subject to change as a result of:
 - Technological change
 - Changes in regulatory environment
 - Changes in the supply of inputs other than capital and labor (e.g., energy)

Curve Shifts

- The production function is a multivariable function
 - Output depends on capital, labor, the productivity parameter, and (implicitly) other omitted variables
- So, if we plot output versus labor, we conceptually hold the other variables fixed
 - If any of those other variables change, our plot of the production function must shift

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



The Labor Market

- We now consider the labor market
- We will now assume that capital is fixed (in fact, the capital stock grows slowly over time)
- In a typical business cycle, capital varies little, but labor varies a lot

The Demand for Labor: Assumptions

- The capital stock is fixed.
- Workers are all alike.
- Wages are determined in competitive labor markets.
- Firms choose how much labor to employ in order to maximize profit.

Profit Maximization and Labor Demand

- A firm will hire an additional unit of labor so long as the value of the extra output produced by a worker is greater than (or just equal to) the cost of the additional unit of labor

Profit Maximization and Labor Demand (Equations)

Increase employment if the following condition holds (the condition can be written in several different ways):

$$P > MPN > W$$

$$MPN > W$$

$$MPN > \frac{W}{P}$$

$$MPN > w$$

Historians follow ...

Notation

P is the price of output

MPN is the marginal product of labor

W is the nominal wage rate (in dollars per unit of labor)

$w = \frac{W}{P}$ is the real wage (the wage in terms of units of goods per unit of labor).

Profit Maximum

A firm will be maximizing profit only when

$$MPN = w$$

As we have noted, the marginal product of labor depends on the quantity of labor employed. So we can rewrite this as:

$$MPN(N) = w$$

Summary

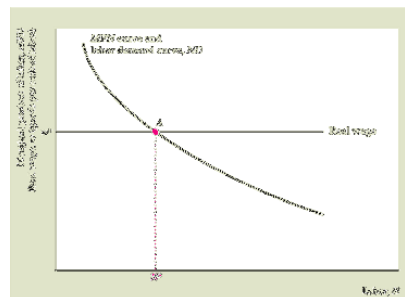
Comparing the Benefits and Costs of Changing the Amount of Labor		
Decision to hire the new worker	Decision to employ as if the new worker weren't there	Decision to employ as if the new worker were there
Benefit	$MPN > w$ ($MPN > W/P$)	$MPN > w$ ($MPN > W/P$)
Financial loss	$P \times MPN > W$ ($MPN > W/P$)	$P \times MPN > W$ ($MPN > W/P$)

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

Demand for Labor

- At any given real wage, what quantity of labor will a firm buy?
 - Answer: The quantity that makes the marginal product of labor equal the real wage.
 - See this illustrated for one real wage rate (on the next slide), but consider several different values for the real wage.
 - This reveals that the marginal product of labor schedule is the firm's labor demand schedule.

Figure 3.5 The determination of labor demand



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

Demand Shifters

- 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

The Economy's Demand for Labor

- Our preceding analysis has derived a firm's demand for labor function.
- Aggregate labor demand (the economy-wide demand for labor)
 - is the sum of all firms' labor demand
 - Is shifted by the same factors (supply shocks, size of capital stock) that shift firms' labor demand curves

Labor Supply

- We now consider the supply side of the labor market
 - In microeconomics, we think of individuals as utility maximizers
 - Essentially, this means that individuals:
 - have preferences that satisfy some plausible consistency conditions
 - make choices that leave them better off instead of worse off

Individual Decisions about Work

- Individuals must decide how much they wish to work
- More work means more income (which can be spent buying goods), but less leisure
- So when an individual decides how much to work, she is really making a consumption choice—she is choosing a bundle of consisting of both “goods” and “leisure”

Shall I Work Another Hour?

- That depends partly on the utility I get from the extra goods (purchased with extra labor earnings) versus the utility lost from foregone leisure
- It also depends partly on the real wage (the price of leisure in terms of goods)
 - Generally, if the real wage changes, this will change an individual's choice regarding goods (work) and leisure.

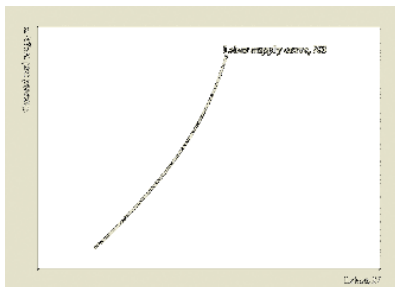
Income and Substitution Effects

- Does an increase in w (the real wage) cause an individual to work more or less?
 - An increase in w means that leisure is relatively more expensive, leading workers to consume less leisure (work more). This is a substitution effect.
 - However, increase in w means that workers have more purchasing power. Normally more income leads to more consumption of both items (more goods and more leisure, hence less work). This is an income effect.
- So the effect of an increase in w on hours worked for an individual is theoretically ambiguous.

The Economy-wide Labor Supply Curve

- Most evidence suggests that at least a short-term or temporary increase in the real wage (as in a business cycle fluctuation) leads to an increase in work effort by an individual.
 - Also, more individuals enter the labor force in periods when the real wage is high.
- So, we will normally draw the labor supply curve with an upward slope.

The Economy's Labor Supply Curve



Labor Supply Shifters

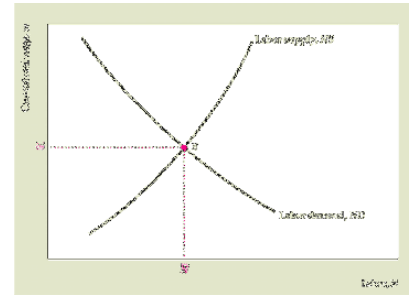
- Changes in wealth (or expected future wealth) will shift the labor supply curve.
 - More wealth may lead one to want both more goods and more leisure, so work effort would fall
 - If I had won the lottery last year, I might not be teaching this class!
- Changes in population or in preferences regarding work can also shift the labor supply curve. Increasing labor force participation rates of women may partly be a response to wages, but may also reflect changes in social norms (tastes).

Labor Market Equilibrium

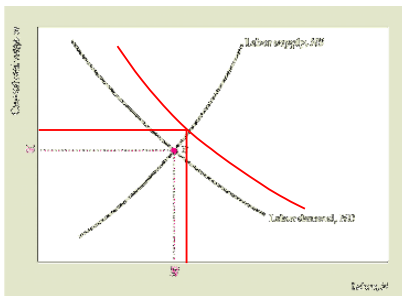
- The equilibrium condition: The real wage adjusts so that the quantity of labor demanded equals the quantity of labor supplied

$$NS(w) = ND(w)$$

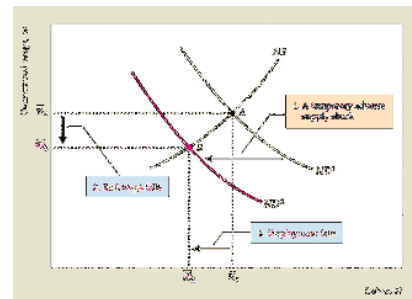
Labor Market Equilibrium



A Favorable Supply Shock



Effects of A Temporary Adverse Supply Shock



Full Employment

- In the labor market, the demand-supply equilibrium determines the quantity of labor, the number employed.
 - We consider this to be the “full-employment” quantity of labor.
- Also, if we use the production function to find the level of output produced when the labor input is at its full-employment level, we call that output the full-employment level of output:

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

Employment and Unemployment

- We have referred to the employment outcome at the demand-supply equilibrium in the labor market as a “full-employment” outcome.
 - At the same time, we know that some people are always unemployed – so unemployment is not zero when we are at full employment.
- Some turnover is normal even for a market in equilibrium:
 - If the number of job seekers and the number of vacancies are evenly matched, there is no tendency for the real wage to fall, even though positive unemployment exists.

Full-Employment Unemployment (The Natural Rate)



- We know that at full employment, unemployment is not at zero
- The unemployment rate prevailing at full-employment is sometimes termed the “natural rate” of unemployment

The End

