

EE211

Factor Markets

- **Demand for factor as a derived demand**
- **The firm's demand for a factor**
- **The supply of a factor**
- **Determination of factor prices**

Under the two scenarios:

- 1) Both factor market and output market are perfectly competitive.**
- 2) Factor market is perfectly competitive, but output market is under monopoly

Factors of Production

Factors of production:

- Inputs used to produce goods and services: labor, land, capital
- Prices and quantities are determined by supply and demand in factor markets.

Derived demand for a factor of production

- A firm's demand for a factor of production is derived from its decision to supply a good in another market.

Under the scenario:

Both factor market and output market are perfectly competitive.

The Competitive, Profit-Maximizing Firm

Labor market

- Governed by supply and demand

Labor demand is a derived demand



What determines a competitive firm's demand for labor?



How does labor supply depend on the wage?
What other factors affect labor supply?



How do various events affect the equilibrium wage and employment of labor?



How are the equilibrium prices and quantities of other inputs determined?

Two Assumptions

1. All markets are competitive

- The typical firm is a **price taker**
 - In the market for the good it produces
 - And in the labor market (factors of production)

2. Firms care only about maximizing profits

- Each firm's supply of output and demand for inputs are derived from this goal

Short-Run Factor Demand of a Firm

- A profit-maximizing firm's demand for a factor of a production is downward sloping: The higher the price of an input, the less the firm wants to buy.
- To understand what is behind a firm's factor demand, we examine a firm that uses capital and labor to produce output from factors.
- We show how the amount of an input the firm demands depends on the prices of the factors and the price of the final output.
- We start by considering the short-run factor demand for labor of a firm that can vary labor but not capital.

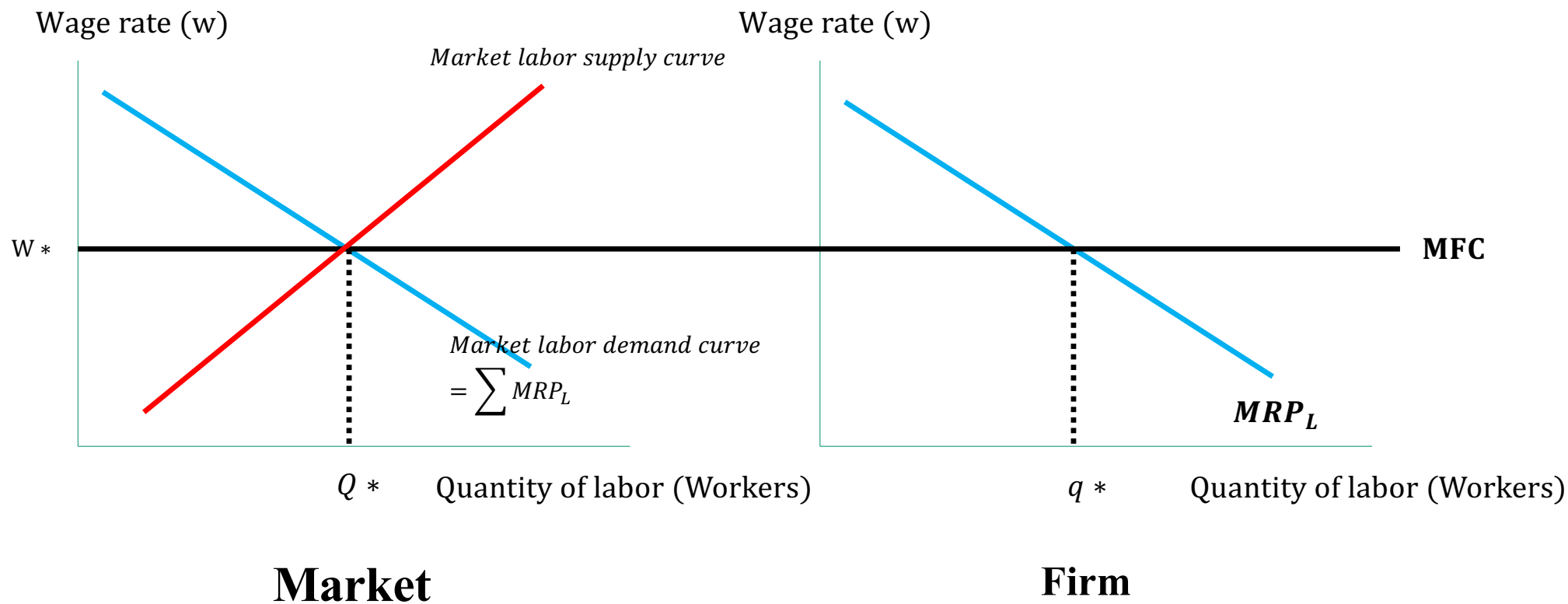
- In the short run, a firm has a **fixed amount of capital, $\bar{K}$** , and can **vary the number of workers, L** , it employs.
- **Will the firm's profit rise if it hires one more worker?**
- The answer depends on whether its revenue or labor costs rise more when output expands.
- **An extra worker per hour raises the firm's output per hour, q , by the marginal product of labor, $MP_L = \frac{\Delta q}{\Delta L}$.**
- How much is that extra output worth to the firm?
- **The extra revenue, R , from the last unit of output is the firm's marginal revenue, $MR = \frac{\Delta R}{\Delta q}$.**
- **As a result, the marginal revenue product of labor (MRP_L), the extra revenue from hiring one more worker, is**

$$MRP_L = MR \times MP_L$$

Example

Labor, L	Output, q	Marginal product of labor, MP_L	Marginal Revenue	Marginal revenue product of labor, $MRP_L = MR * MP_L$
1	7	7	3	21
2	13		3	
3	18		3	
4	22		3	
5	25		3	
6	27		3	

Example



- **Marginal factor cost (MFC)** is the increment to total costs paid for a factor of production resulting from a one-unit increase in the amount of the factor employed.
- It is expressed in currency units per incremental unit of a factor of production (input), such as labor, per unit of time.
- In the case of the labor input, for example, if the wage rate paid is unaffected by the number of units of labor hired, the marginal factor cost is identical to the wage rate.
- A firm that wants to optimize its profits hires each factor up to the point at which **its marginal factor cost equals its marginal revenue product (MFC=MRP)**

- For a firm that is a competitive employer of labor, the marginal cost of hiring one more worker per hour is the wage, w .
- Hiring an extra worker raises the firm's profit if the marginal benefit - the marginal revenue product of labor (MRP_L) - is greater than the marginal cost - the wage - from one more worker: $MRP_L > w$.
- If the marginal revenue product of labor (MRP_L) is less than the wage, $MRP_L < w$, the firm can raise its profit by reducing the number of workers it employs.
- Thus the firm maximizes its profit by hiring workers until the marginal revenue product of the last worker exactly equals the marginal cost of employing that worker, which is the wage: $MRP_L = w$.

- For now, **we restrict our attention to competitive firms**. A competitive firm faces an infinitely elastic demand for its output at the market price, p , so **its marginal revenue is p** , and its marginal revenue product of labor is

$$MRP_L = p \times MP_L$$

- **The marginal revenue product for a competitive firm is also called the value of the marginal product (VMP)** because it equals the market price times the marginal product of labor: the market value of the extra output.
- The competitive firm hires labor to the point at which its marginal revenue product of labor equals the wage:

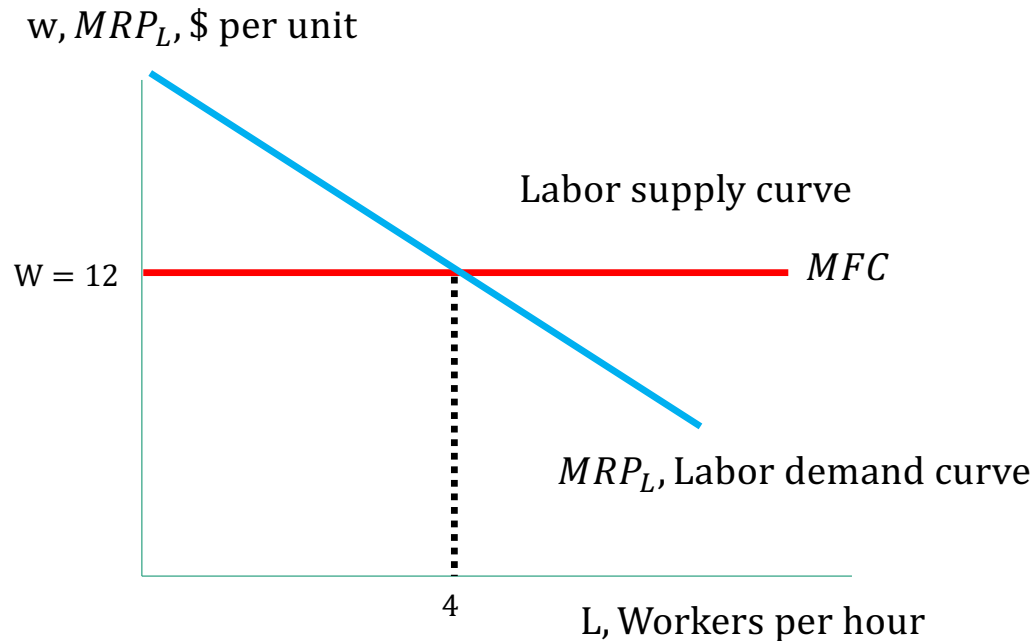
$$MRP_L = p \times MP_L = w$$

Marginal Product of Labor, Marginal Revenue Product of Labor, and Marginal Cost

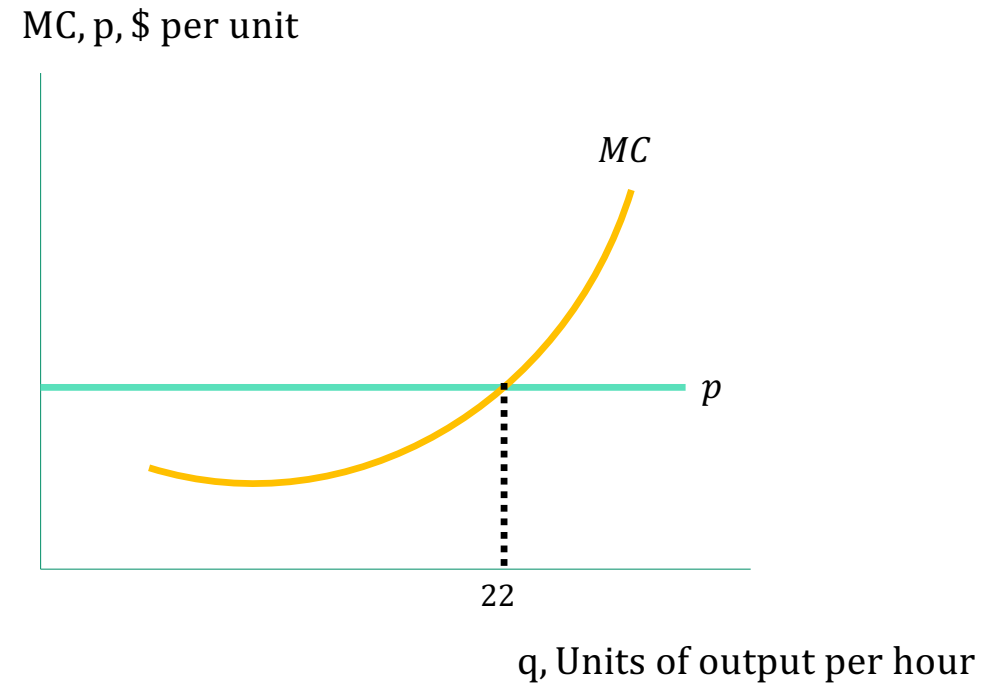
Labor, L	Output, q	Marginal product of labor, MP_L	Marginal revenue product of labor, $MRP_L = p * MP_L$	Marginal cost, $MC = w/MP_L$
2	13	6	\$18	\$2
3	18	5	\$15	\$2.4
4	22	4	\$12	\$3
5	25	3	\$9	\$4
6	27	2	\$6	\$6

Notes: **Wage, w , is \$12 per hour of work. Price, p , is \$3 per unit of output. Labor is variable, and capital is fixed.**

(a) Labor Profit-Maximizing Condition



(b) Output Profit-Maximizing Condition



The relationship between labor market and output market equilibria. (a) The firm's profit is maximized at $L=4$ workers per hour where the wage line, $w = \$12$, crosses the marginal revenue product of labor, MRP_L , curve, which is also the demand curve for labor.

(b) The firm's profit is maximized at 22 units of output (produced by 4 workers), for which its marginal cost, $MC = \frac{w}{MP_L}$, curve equals the market price, $p = \$3$.

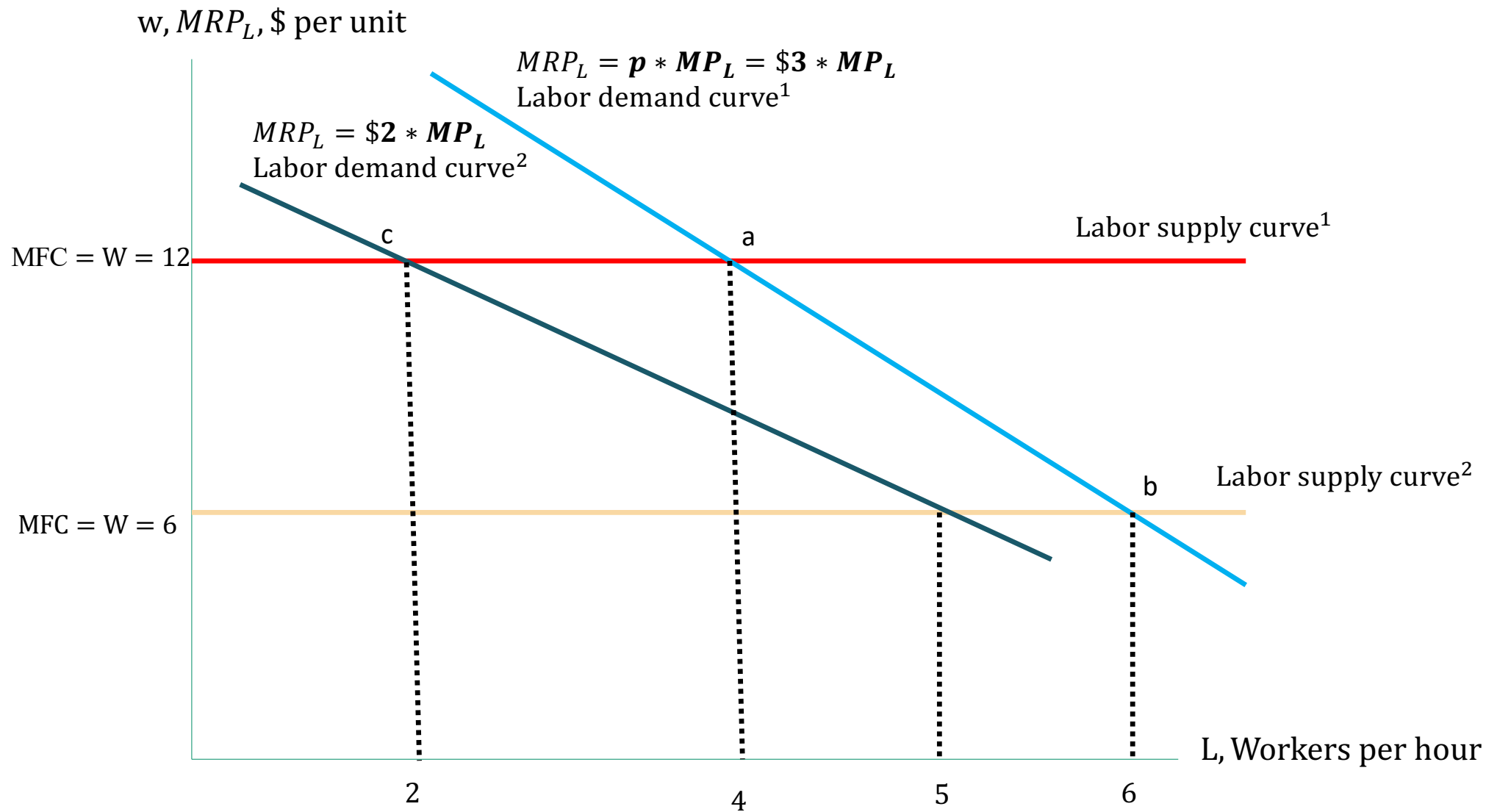
The two profit-maximizing equilibria give the same answer:

- The firm maximizes its profit by hiring 4 workers to produce 22 units of output.
- **Panel a** shows that the firm maximizes its profit by hiring 4 workers, for which the marginal benefit or marginal revenue product from the last worker, MRP_L , equals the marginal cost of that worker, w .
- **Panel b** shows that the firm maximizes its profit by producing 22 units of output, for which the marginal benefit or marginal revenue from the last unit of output, $p = \$3$, equals the marginal cost of the last unit of output, MC .

How changes in wages and prices affect factor demand.

- The number of workers a firm hires depends on the wage and the price of the final good.
- Suppose that the supply of labor shifts so that the wage falls from $w_1 = \$12$ to $w_2 = \$6$ while the market price remains constant at \$3. The firm hires more workers because the cost of more labor falls while the incremental revenue from additional output is unchanged.
- Figure shows that a fall in the wage due to a downward shift of the labor supply curve from labor supply curve¹ to labor supply curve² causes a shift along the labor demand curve¹ from point a, where the firm hires 4 workers, to point b, where the firm hires 6 workers per hour.

- If the market price falls from \$3 to \$2 , the demand curve for labor shifts downward from **the labor demand curve¹** to **the labor demand curve²**. If the wage stays constant at wage =\$12, the firm reduces its demand for workers from 4, point a, to 2, point c.
- Thus a shift in either the market wage or the market price affects the amount of labor that a firm employs.



- In **perfectly competitive markets**, VMPL and MRP are the same because price (P) equals marginal revenue (MR).
- VMPL (Value Marginal Product of Labor) is used in labor demand analysis, while MRP is used in determining optimal input levels for various factors of production.
- In summary: **While VMPL and MRP are closely related, they are not the same.**

VMPL is the value of the extra output, while MRP is the additional revenue generated by that extra output. The relationship between them depends on the market structure.

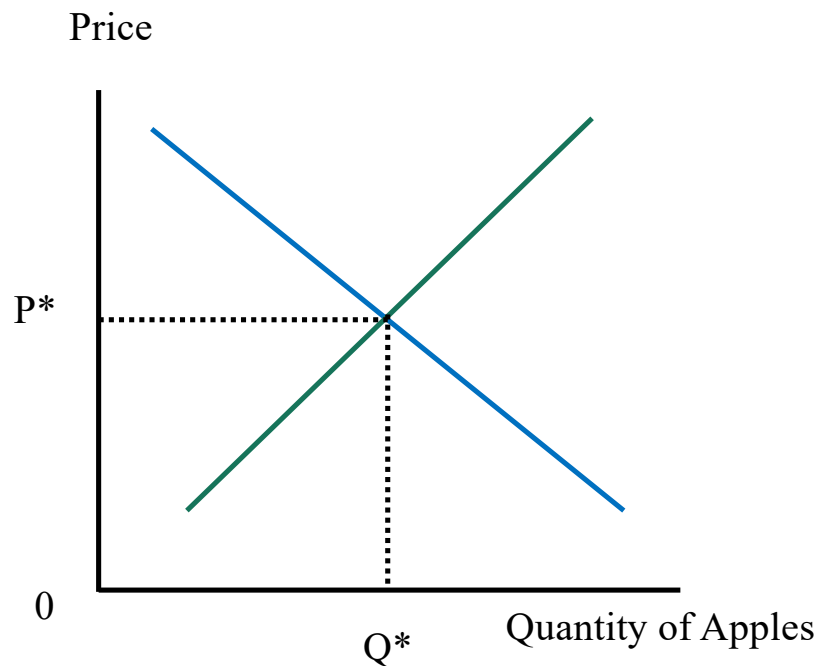
A group of colorful wooden human figures, including blue, green, red, yellow, and brown, are standing in a line on a light-colored surface. The figures are slightly out of focus in the background, creating a sense of depth. The text "The Demand for Labor" is overlaid in a white, serif font across the middle of the image.

The Demand for Labor

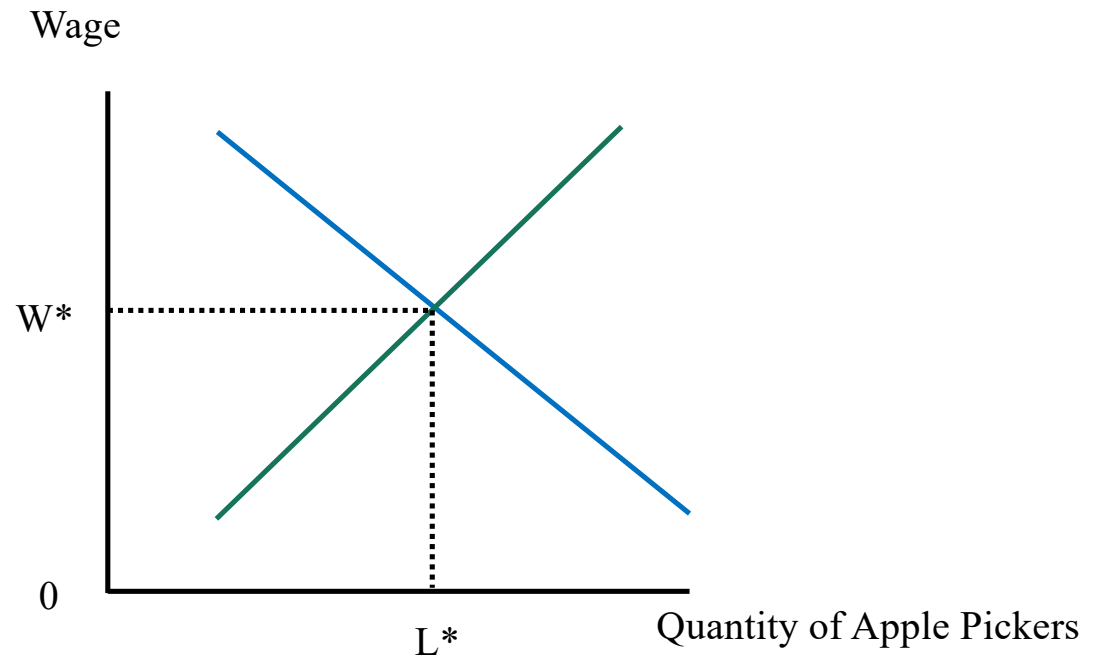
The Demand for Labor

- Labor demand is a **derived demand**
- Labor services are inputs into the production of other goods
- To understand labor demand, we focus on the firms that hire the labor and use it to produce goods for sale
- The link between the supply of goods and the demand for labor to produce them is crucial in determining equilibrium wages

(a) The Market for Apples



(b) The Market for Apple Pickers



(a) Shows how the supply and demand for apples determine the price of apples

(b) Shows how the supply and demand for apple pickers determine the wage of apple pickers.

Assumptions for the Firm

Firm is competitive in

- Market for apples (where it is a seller)
- Market for apple pickers (where it is a buyer)

Firm is profit-maximizing

- **Firm's supply of apples and demand for workers are derived from primary goal of maximizing profit**

The Production Function

Production function

- Relationship between the quantity of inputs used to make a good and the quantity of output of that good

Becomes flatter as the quantity of input increases

The Marginal Product of Labor

Marginal product of labor

- Increase in the amount of output from an additional unit of labor

Diminishing marginal product

- The marginal product of an input declines as the quantity of the input increases
- Explains the shape of the production function

How the Competitive Firm Decides How Much Labor to Hire

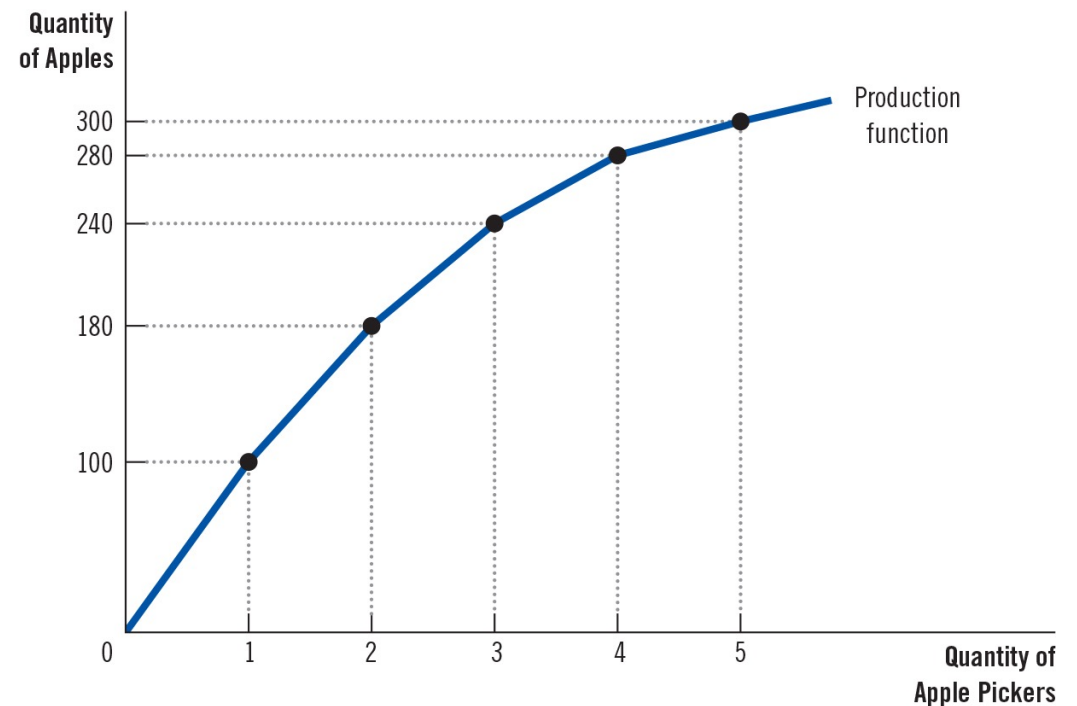
(1) Labor L	(2) Output Q	(3) Marginal Product of Labor $MPL = \Delta Q / \Delta L$	(4) Marginal revenue product of labor, $MRP_L = MR * MP_L$	(5) MFC or Wage W	(6) Marginal Profit $\Delta Profit = MRP_L - W$
0 workers	0 bushels				
1	100	100 bushels	\$1,000	\$500	\$500
2	180	80	800	500	300
3	240	60	600	500	100
4	280	40	400	500	-100
5	300	20	200	500	-300

How the competitive firm decides how much labor to hire

Labor (L)	Output (Q)	Marginal product of labor, $MPL = \Delta Q / \Delta L$	Marginal revenue product of labor, $MRP_L = MR * MP_L$ P=\$10 per bushel	MFC or Wage (w)	Marginal Profit $\Delta \text{profit} = MRP_L - w$
0 workers	0 bushels				
		100 bushels	\$1,000	\$500	\$500
1	100				
		80	800	500	300
2	180				
		60	600	500	100
3	240				
		40	400	500	-100
4	280				
		20	200	500	-300
5	300				

The Production Function

- The production function shows how an input into production (apple pickers) influences the output from production (apples).
- As the quantity of the input increases, the production function gets flatter, reflecting the property of **diminishing marginal product**.



Competitive, profit-maximizing firm

The competitive firm hires labor to the point at which its marginal revenue product of labor equals the wage:

$$MRP_L = MR \times MP_L = p \times MP_L = w$$

Active Learning 1: Xavier's Truck MPL and MRP_L

- The table which shows Xavier's popcorn truck input and output
- The price of popcorn is $P = \$5$ per bucket of popcorn
 - Calculate MPL and MRP_L
 - Graph a curve with MRP_L on the vertical axis, L on horizontal axis

Workers L	Buckets Q
0	0
1	30
2	55
3	75
4	90
5	100

Active Learning 1: Answers

Workers L	Buckets Q	$MPL = \Delta Q / \Delta L$	$MRP_L = MR * MP_L$
0	0		
1	30		
2	55		
3	75		
4	90		
5	100		



What Causes the Labor-Demand Curve to Shift?

Output price

- When the output price changes, **the marginal revenue product of labor (MRP_L)** changes, and the labor-demand curve shifts

Technological change

- Technological advance can raise MPL, shifting labor-demand curve to the right
- Labor-saving technology can reduce MPL, shifting labor-demand curve to the left

Supply of other factors

- Affect the marginal product of other factors

Recap: Costs and Benefits of One More Worker

- **Cost of hiring another worker:**

- The wage = the price of labor

- **Benefit of hiring another worker:**

- Produce and sell more output, increasing revenue.
- The size of this benefit depends on the **production function**: the relationship between the quantity of inputs used to make a good and the quantity of output of that good

The Production Function of the Marginal Product of Labor (MPL)

- The production function – the relationship between the quantity of inputs used to make a good and the quantity of output of that good
- **Marginal product of labor, $MPL = \Delta Q / \Delta L$**
 - **The increase in the amount of output from an additional unit of labor**
 - Where:
 - ΔQ = change in output
 - ΔL = change in labor
- **Diminishing marginal product**
 - **The marginal product of an input declines as the quantity of the input increases**

- Cost of hiring another worker (wage) is measured in dollars
- Benefit of hiring another worker (*MPL*) is measured in units of output
- Solution: convert *MPL* to dollars
- The marginal revenue product of labor (MRP_L)

As a result, the marginal revenue product of labor (MRP_L), the extra revenue from hiring one more worker, is

$$MRP_L = MR \times MP_L$$

A firm that wants to optimize its profits hires each factor up to the point at which **its marginal factor cost equals its marginal revenue product (MFC=MRP)**



The Supply of Labor

The Trade-Off between Work and Leisure

- People face trade-offs
- Trade-off between work and leisure
- Labor-supply curve
 - **Reflects how workers' decisions about the labor-leisure trade-off**
 - **Respond to a change in opportunity cost of leisure**

Labor-Supply Decision

Labor-supply decision

- The **income effect** reflects the response of hours worked due to a change in a person's level of economic well-being
- The **substitution effect** reflects the response of hours worked due to a change in the opportunity cost of leisure

The Supply of Labor

Trade-off between work and leisure:

- The more time you spend working, the less time you have for leisure.

Wage

- Is the opportunity cost of leisure
- When wage increases, the opportunity cost of enjoying leisure goes up



"I really didn't enjoy working five days a week, fifty weeks a year for forty years, but I needed the money."

Input Demand & Output Supply

The competitive firm's rule for demanding labor: $P \times MPL = W$

- Divide both sides by MPL : $P = W / MPL$
- Substitute $MC = W / MPL$ from previous slide: $P = MC$
- **This is the competitive firm's rule for supplying output.**

Hence: Input demand and output supply are two sides of the same coin.

Input Demand & Output Supply

Marginal Cost (MC): cost of producing an additional unit of output

$$MC = \Delta TC / \Delta Q, \text{ where } TC = \text{total cost}$$

In general: $MC = W / MPL$

To produce additional output

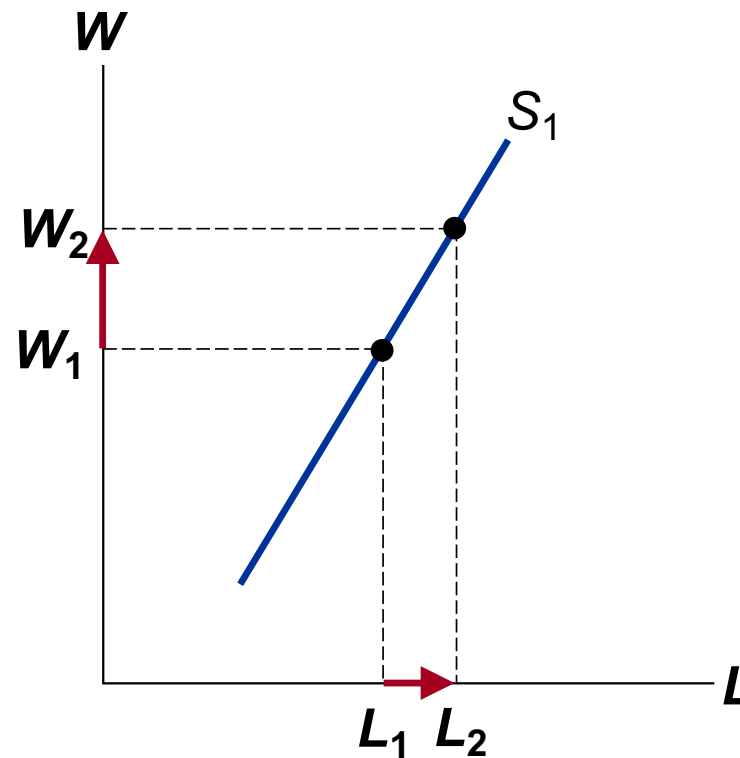
- Hire more labor. As L rises, MPL falls...
- causing W / MPL to rise...causing MC to rise.

Diminishing marginal product and increasing marginal cost are two sides of the same coin

The Labor Supply Curve

An increase in W is **an increase in the opportunity cost of leisure.**

People respond by taking less leisure and by working more.



What Causes the Labor-Supply Curve to Shift?

- **Changes in preferences**
 - Example: increase in labor force participation of women
- **Changes in alternative opportunities**
 - The supply of labor in any one labor market depends on the opportunities available in other labor markets
- **Immigration**
 - Movement of workers from region to region, or country to country

A complex, multi-tiered mechanical structure made of black spheres and rings. It features several horizontal bars supported by rings, with spheres of varying sizes placed at various points. The structure is set against a dark, gradient background with a reflective surface at the bottom. The text "Equilibrium in the Labor Market" is overlaid in white serif font.

Equilibrium in the Labor Market

Equilibrium Wage

Any event that changes the supply or demand for labor must change the equilibrium wage and **the marginal revenue product of labor (MRP_L)** by the same amount because these must always be equal

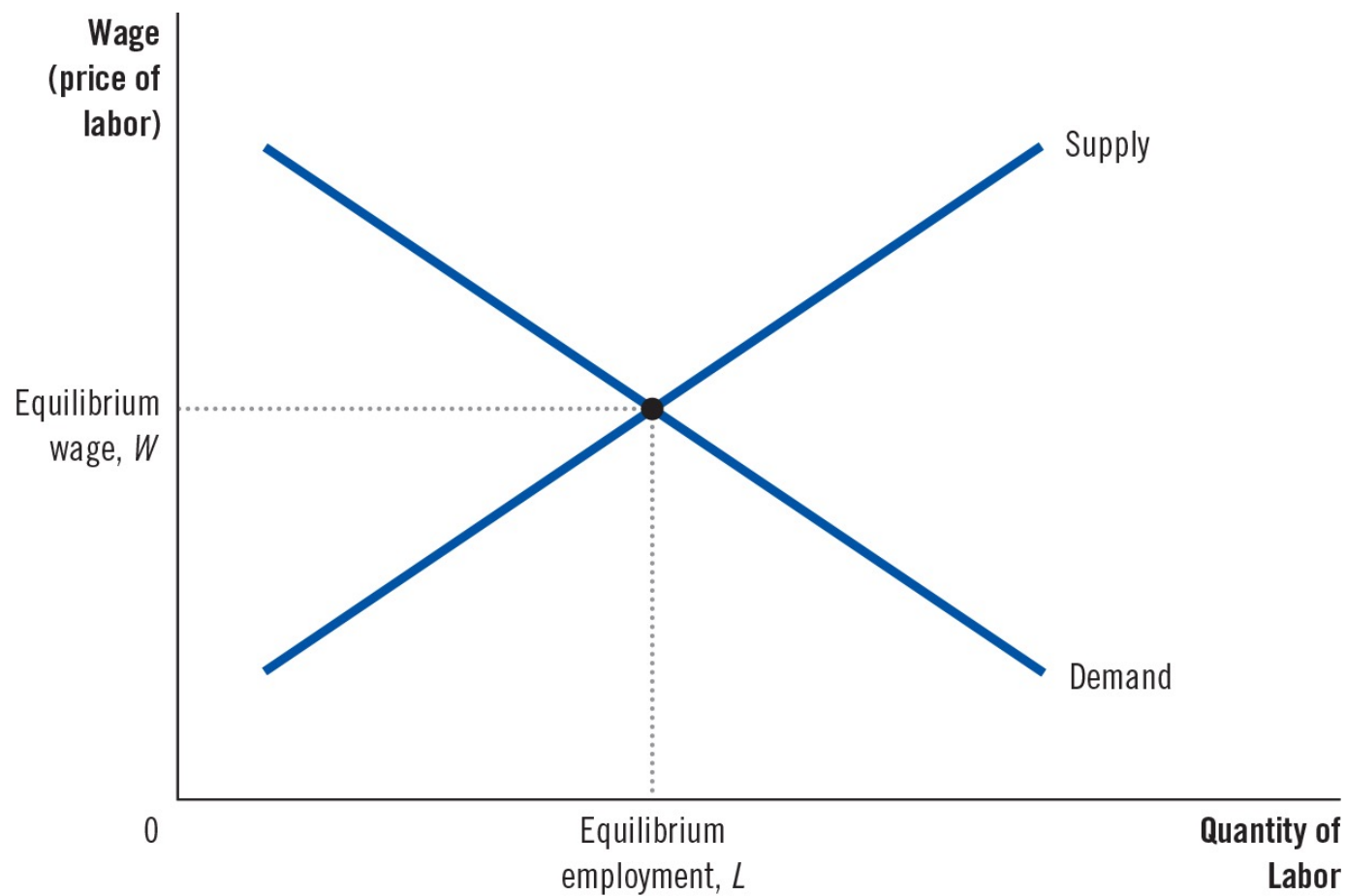
- The wage adjusts to balance the supply and demand for labor
- **The wage equals the marginal revenue product of labor (MRP_L)**

Shifts in Labor Supply

Increase in supply

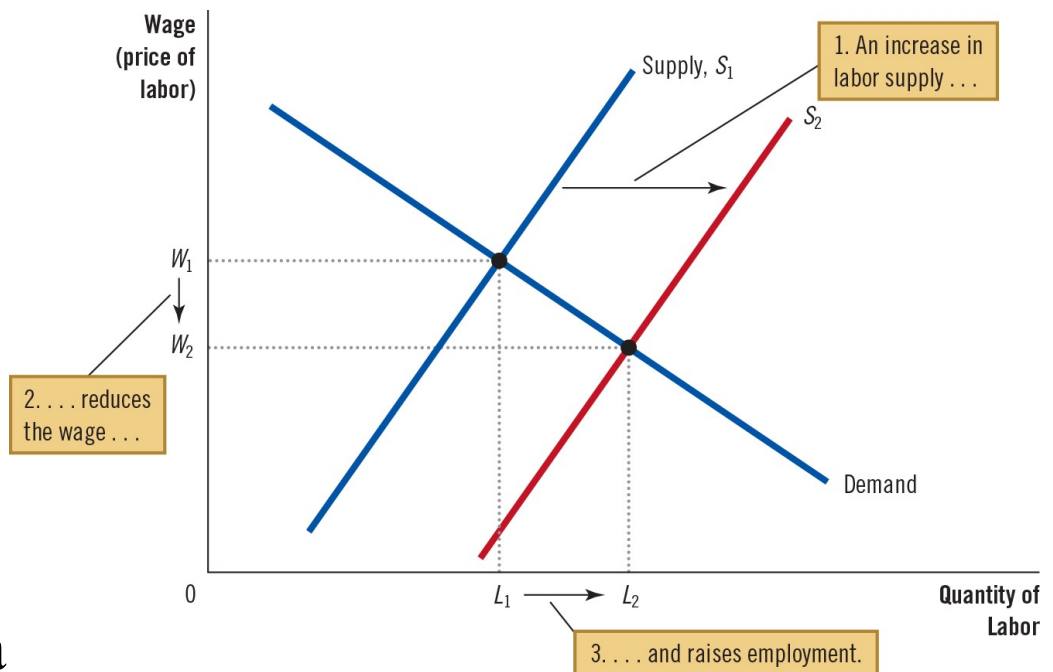
- Decrease in wage
- Lower marginal product of labor
- Lower MRP_L
- Higher employment

Equilibrium in a Labor Market



A Shift in Labor Supply

- When labor supply increases from S_1 to S_2 , perhaps because of an immigration wave of new workers, the equilibrium wage falls from W_1 to W_2 . At this lower wage, firms hire more labor, so employment rises from L_1 to L_2 .
- The change in the wage reflects a change in the **marginal revenue product of labor (MRP_L)** : With more workers, the added output from an extra worker is smaller.



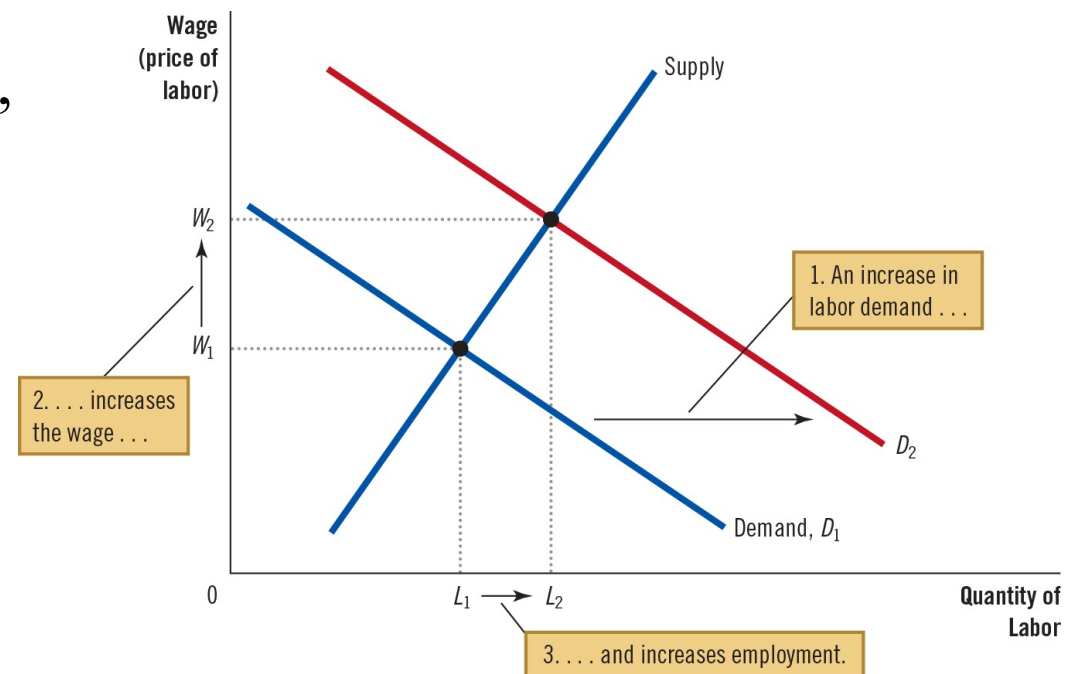
Shifts in Labor Demand

Increase in demand

- Higher wage
- No change in marginal product of labor
- Higher the marginal revenue product of labor (MRP_L)
- Higher employment

A Shift in Labor Demand

- When labor demand increases from D_1 to D_2 , perhaps because of an increase in the price of the firm's output, the equilibrium wage rises from W_1 to W_2 , and employment rises from L_1 to L_2 .
- The change in the wage reflects a change in the **the marginal revenue product of labor (MRP_L)** : With a higher output price, the added output from an extra worker is more valuable.



Active Learning 2: Changes in labor-market equilibrium

In each of the following scenarios, use a diagram of the market for (domestic) auto workers to find the effects on their wage and employment.

- A. Baby boomers who worked in the auto industry retire.
- B. Car buyers' preferences shift toward imported autos.
- C. Technological progress boosts worker productivity in the auto manufacturing industry.

The Other Factors of Production: Land and Capital



The Other Factors of Production: Land and Capital

- With land and capital, must distinguish between:
 - Purchase price: the price a person pays to own that factor indefinitely
 - Rental price: the price a person pays to use that factor for a limited period of time
 - The wage is the rental price of labor
- The determination of the rental prices
 - Analogous to the determination of wages

Equilibrium in the Markets for Land and Capital

Capital

- Equipment and structures used to produce goods and services

Purchase price

- Price a person pays to own that factor of production indefinitely

Rental price

- Price a person pays to use that factor for a limited period of time

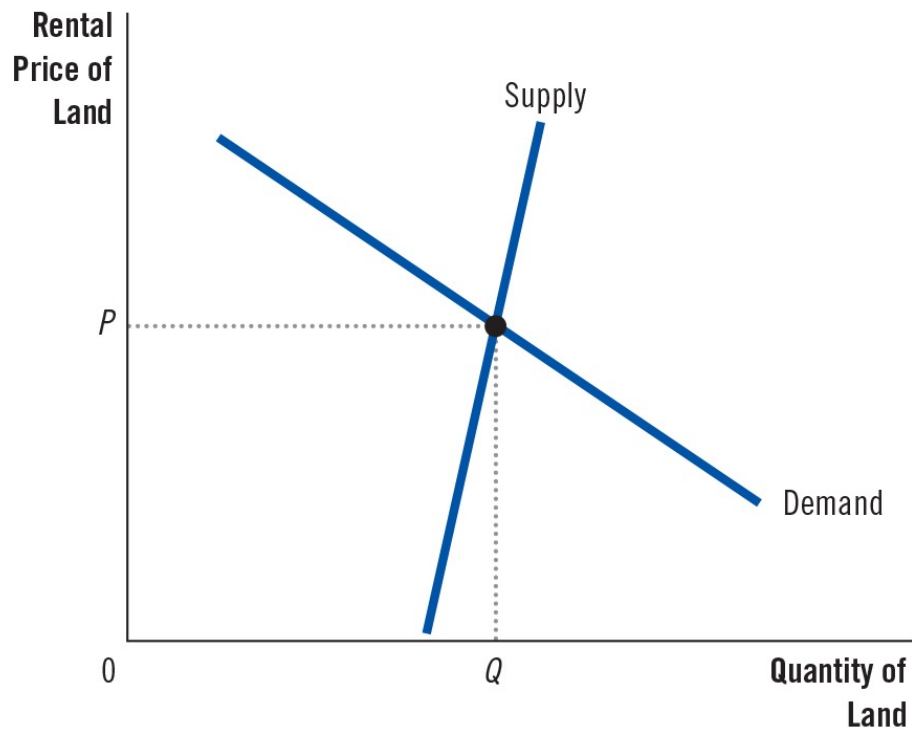
Equilibrium in the Markets for Land and Capital

- As long as the firms using the factors of production are competitive and profit-maximizing, each factor's rental price must equal **the marginal revenue product of capital (MRP_K)**
- Labor, land, and capital all earn the value of their marginal contributions to the production process
- Equilibrium purchase price depends on
 - Current value of **the marginal revenue product (MRP)**
 - **the marginal revenue product (MRP)** expected to prevail in the future

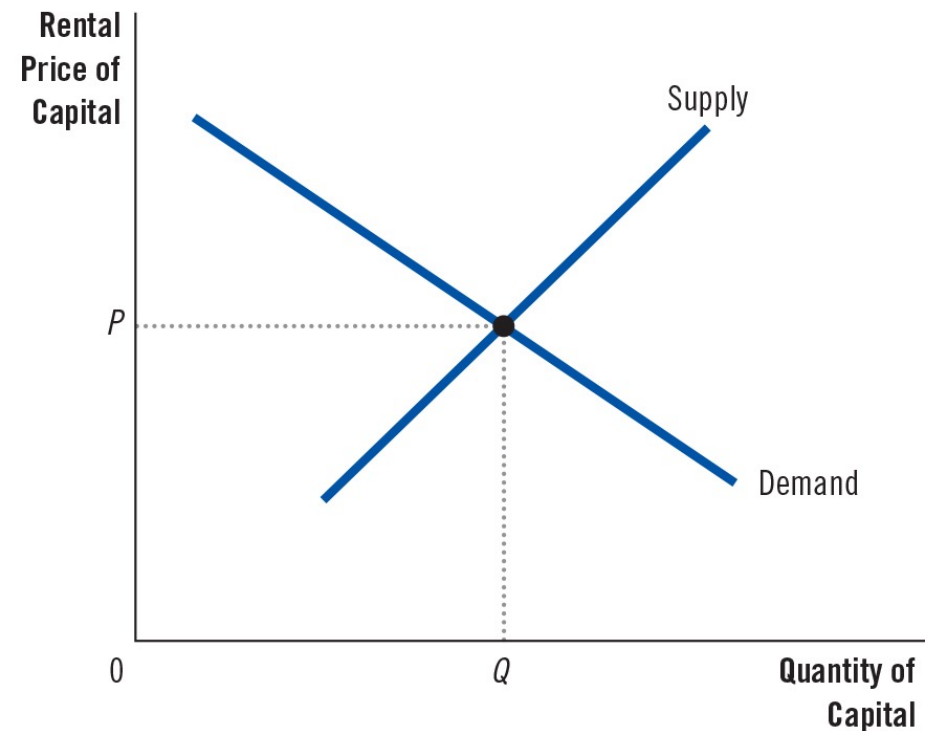
The Markets for Land and Capital

Supply and demand determine the compensation paid to the owners of land, as shown in panel (a), and the compensation paid to the owners of capital, as shown in panel (b). The demand for each factor, in turn, depends on the value of its marginal product.

(a) The Market for Land



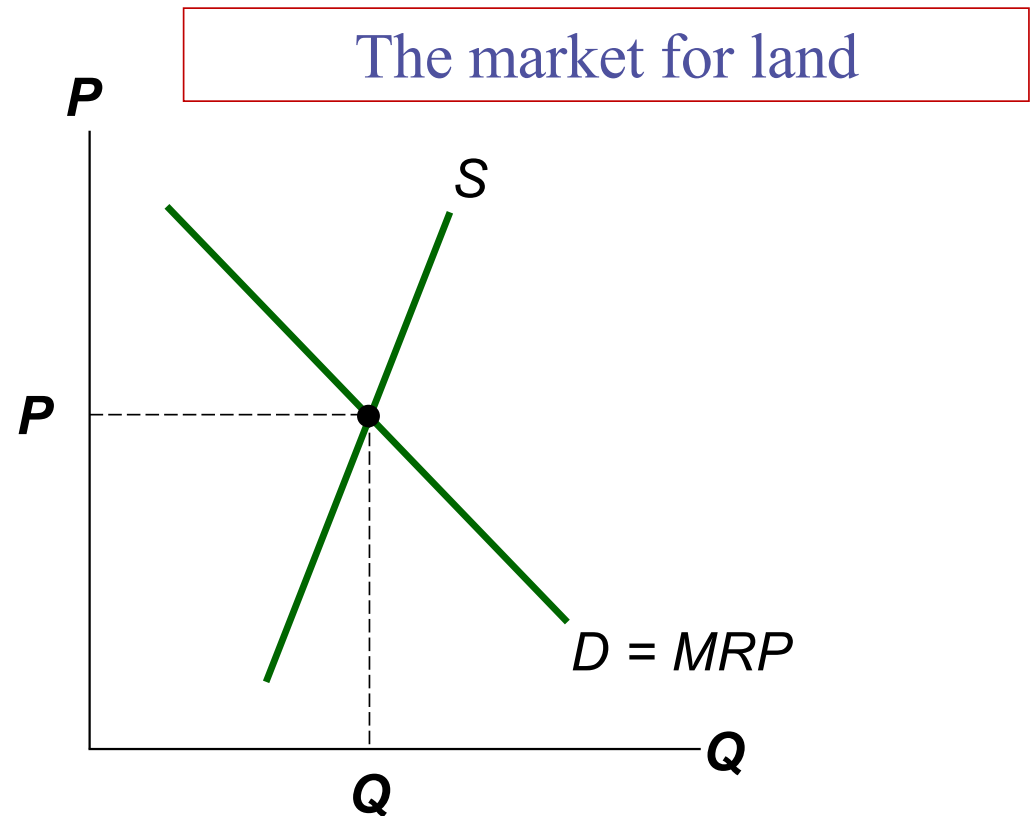
(b) The Market for Capital



How the Rental Price of Land is Determined

Firms increase the quantity of land to rent until **the marginal revenue product (MRP)** of land equals the land's rental price.

The rental price of land adjusts to balance supply and demand for land.

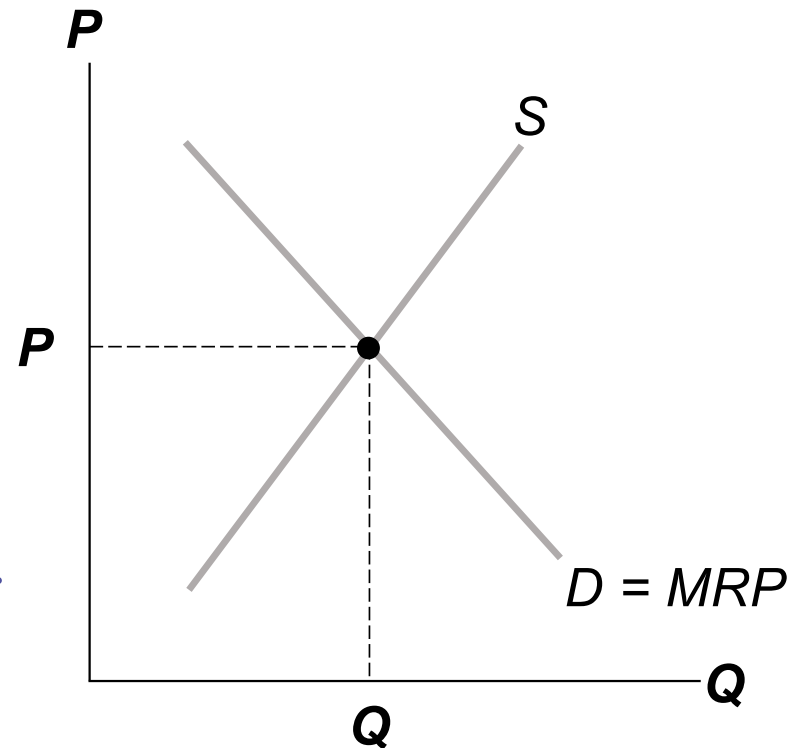


How the Rental Price of Capital is Determined

Firms increase the quantity of capital to rent until **the marginal revenue product (MRP)** of capital equals the capital's rental price.

The rental price of capital adjusts to balance supply and demand for capital.

The market for capital



Rental and Purchase Prices

- Buying a unit of capital or land
 - Yields a stream of rental income
- The rental income in any period
 - Equals **the marginal revenue product (MRP)**
- Hence, the equilibrium purchase price of a factor
 - Depends on both the current **MRP** and the **MRP** expected to prevail in future periods.

Linkages among the Factors of Production

- Factors of production are used together
 - In a way that makes each factor's productivity dependent on the quantities of the other factors
- Marginal product of any factor depends on
 - Quantity of that factor that is available
 - Diminishing marginal product
- An event that changes the supply of any factor of production can alter the earnings of all the factors

Conclusion

The theory developed in this chapter is called the neoclassical theory of distribution

- The amount paid to each factor of production depends on the supply and demand for that factor
- The demand, in turn, depends on that factor's marginal productivity
- In equilibrium, each factor of production earns the **the marginal revenue product (MRP)** contribution to the production of goods and services

References

Perloff, J.M., (2004) Microeconomics, 3th ed., Pearson Education, Inc.

Mankiw, N.G., (2024) **Principles of Microeconomics**, 10th ed.,
Cengage, (ISBN-13: 978-981-5119-30-5)

Class activity I

Smiling Cow Dairy can sell all the milk it wants for \$4 a gallon, and it can rent all the robots it wants to milk the cows at a capital rental price of \$100 a day. It faces the following production schedule:

Number of Robots	Total Product
0	0 gallons
1	50
2	85
3	115
4	140
5	150
6	155

- a. In what kind of market structure does the firm sell its output? How can you tell?
- b. In what kind of market structure does the firm rent robots? How can you tell?
- c. Calculate the marginal product and the the marginal revenue product (MRP) of each additional robot.
- d. How many robots should the firm rent? Explain.



Class activity II

Suppose that the president proposes a new law aimed at reducing healthcare costs: All Americans are required to eat one apple daily.

- a. How would this apple-a-day law affect the demand and equilibrium price of apples?
- b. How would the law affect the marginal product and the marginal revenue product (MRP) of apple pickers?
- c. How would the law affect the demand and equilibrium wage for apple pickers?