Intermediate Microeconomic
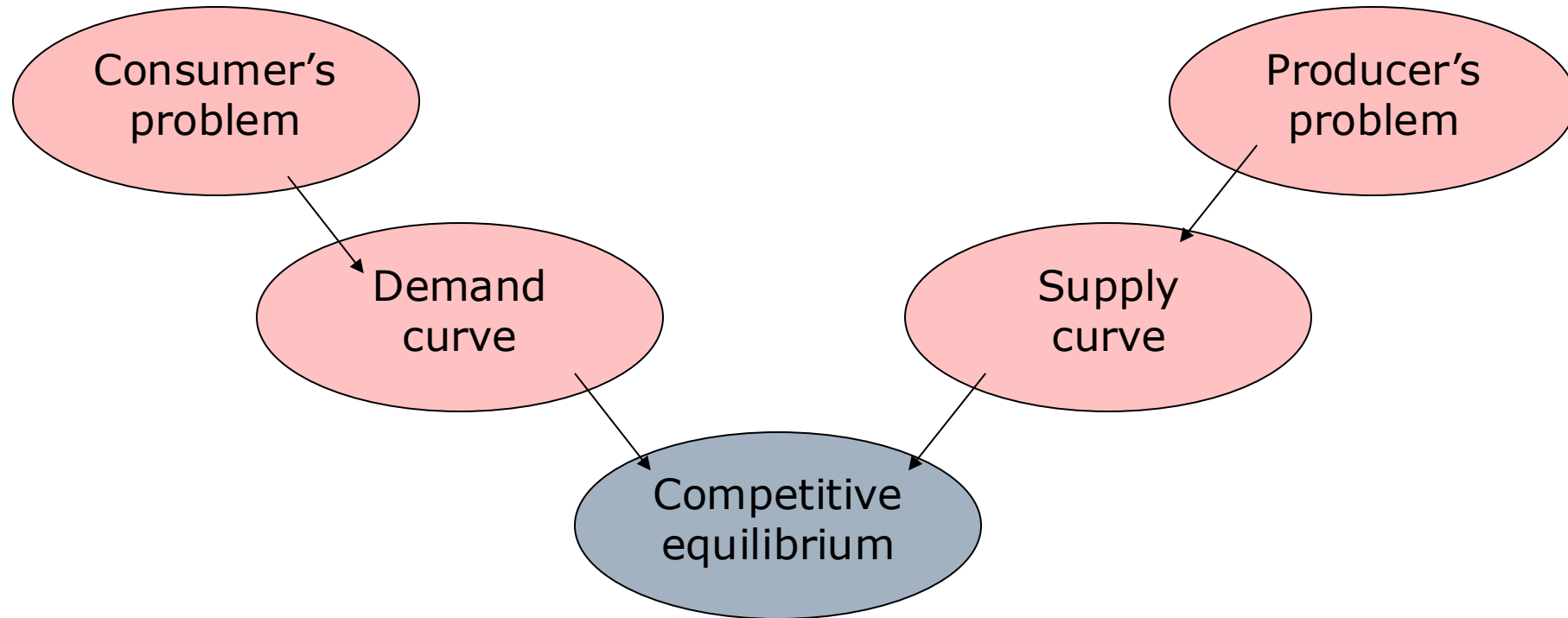## Spring 2025

Part four: Competitive markets
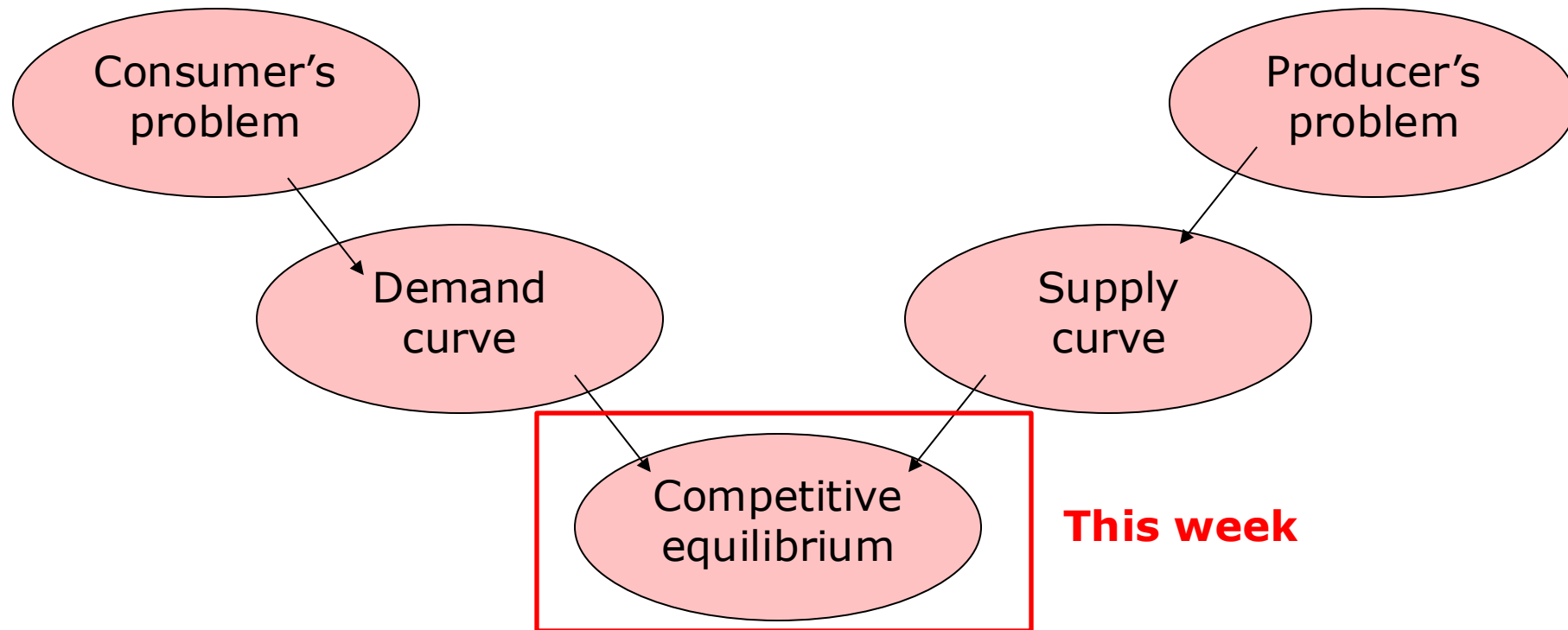
Week 6(a): Markets and efficiency (I)

Yuanning Liang

Big Picture

Big Picture

Consumer's problem → Demand curve → Competitive equilibrium ← Supply curve ← Producer's problem

This week

Competitive Equilibrium: Assumptions

1. Utility-maximizing consumers; profit-maximizing firms

2. Consumers and firms take prices as given (they both "looked outside the window and observe prices")

3. Perfect tradability
    - Complete market: there is a market for every commodity
    - Perfect information: no difficult-to-observe product characteristics
    - No transaction costs: buy price = sell price

4. Commodities are homogeneous and are private goods
    - My consumption of a product does not affect you directly

Competitive Equilibrium: Assumptions

- We begin with competitive markets NOT because we think these assumptions hold in reality, but because
  - They are the simplest to study;
  - They give rise to simple (but powerful) conclusions;
  - Thus, competitive markets serve as a good baseline (some people say "ideal") in microeconomics

- In later parts of the class, we'll see how violations of the competitive assumptions can lead to different outcomes

- From now on, I will use these terms interchangeably:
  - Competitive equilibrium
  - Competitive market equilibrium
  - Market equilibrium

Competitive Equilibrium: Roadmap

☐ Market demand and supply curve

☐ Compute competitive market equilibrium

☐ Properties of market equilibrium
- ■ Efficiency
- ■ Equity

☐ Three examples of government interventions and their welfare implications
- ■ Price controls
- ■ Minimum wages
- ■ Taxation

Competitive Equilibrium: Roadmap

- ☐ **Market demand and supply curve**

- ☐ Compute competitive market equilibrium

- ☐ Properties of market equilibrium
  - ■ Efficiency
  - ■ Equity

- ☐ Three examples of government interventions and their welfare implications
  - ■ Price controls
  - ■ Minimum wages
  - ■ Taxation

Market Demand

☐ Only two goods (*x* and *y*)

    ■ An individual's demand for *x* is

$$\text{Quantity of } x \text{ demanded} = x(P_x, P_y, I)$$

    ■ If we use *i* to reflect each individual in the market

$$\text{Market demand for } X = \sum_{i=1}^{n} x_i(p_x, p_y, I_i)$$

Market Demand Curve

□ Market demand curve for good X

- ■ p_X is allowed to vary
- ■ p_y and the income of each individual are held constant
- ■ If each individual's demand for x is downward sloping, the market demand curve will also be downward sloping

Construction of a Market Demand Curve from Individual Demand Curves

(a) Individual 1   (b) Individual 2   (c) Market demand
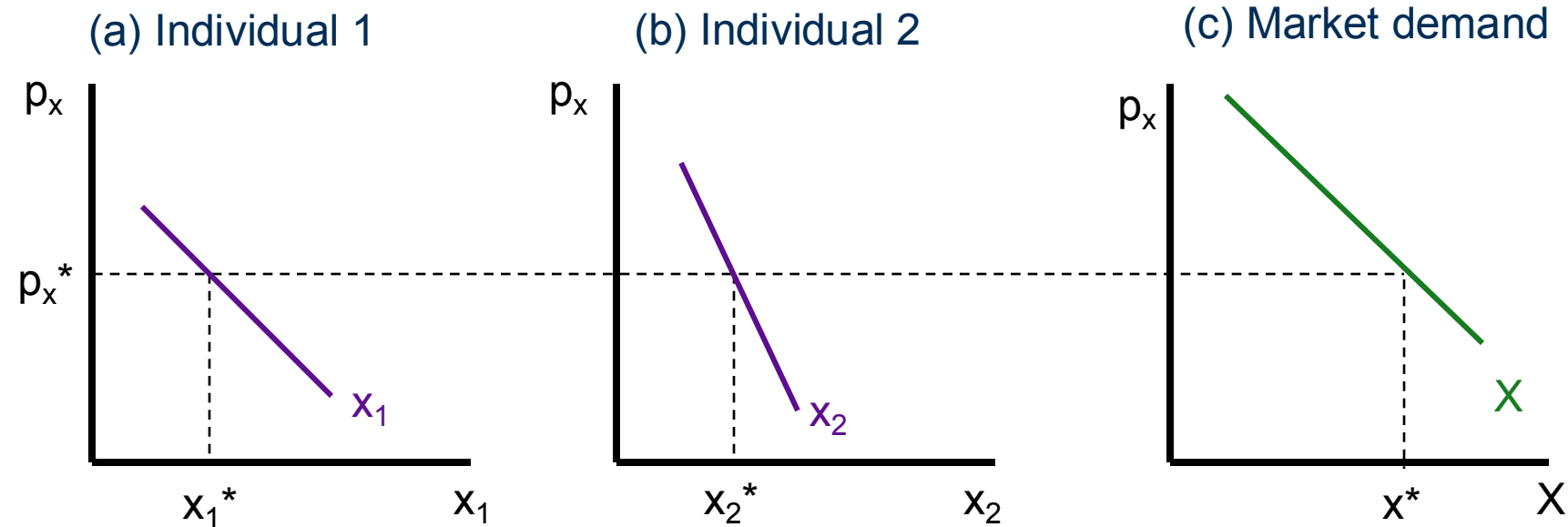
A market demand curve is the "horizontal sum" of each individual's demand curve. At each price the quantity demanded in the market is the sum of the amounts each individual demands. For example, at p^*_x the demand in the market is $x_1^* + x_2^* = x^*$

Shifts in the Market Demand Curve

☐ The market demand

  ■ Summarizes the *ceteris paribus* relationship between X and p_x

  ■ Changes in p_x result in movements along the curve (change in <u>quantity demanded</u>)

  ■ Changes in other determinants of the demand for X cause the demand curve to shift to a new position (change in <u>demand</u>)

Shifts in Market Demand

☐ Suppose that individual 1's demand for oranges is given by: $x_1 = 10 - 2p_x + 0.1I_1 + 0.5p_y$

  ■ p_x = price of oranges

  ■ I_1 = individual's 1 income

  ■ p_y = price of grapefruit

☐ and individual 2's demand for oranges is

$$x_2 = 17 - p_x + 0.05I_2 + 0.5p_y$$

☐ What is the market demand curve?

Shifts in Market Demand

☐ If p_y = 4, I_1 = 40, and I_2 = 20, the market demand curve becomes:

$$X = 27 - 3p_x + 4 + 1 + 4 = 36 - 3p_x$$

☐ If p_y rises to 6, the market demand curve shifts outward to:

$$X = 27 - 3p_x + 4 + 1 + 6 = 38 - 3p_x$$

  ■ Note that X and Y are substitutes

☐ If I_1 fell to 30 while I_2 rose to 30, the market demand would shift inward to

$$X = 27 - 3p_x + 3 + 1.5 + 4 = 35.5 - 3p_x$$

  ■ Note that X is a normal good for both buyers

Generalizations

☐ Suppose that there are n goods
  ◼ x_i, $i = 1,...,n$
  ◼ With prices p_i, $i = 1,...,n$
☐ Assume that there are m individuals in the economy
  ◼ The jth individual's demand for the ith good will depend on all prices and on I_j

$$x_{i,j} = x_{i,j}(p_1,...,p_n, I_j)$$

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Generalizations

□ The market demand function for x_i

- Sum of each individual's demand for that good

$$X_i(p_1,...,p_n,I_1,...I_m) = \sum_{j=1}^{m} x_{i,j}(p_1,...,p_n,I_j)$$

- The market demand function depends on the prices of all goods and the incomes and preferences of all buyers

Elasticity of Market Demand

- ☐ A simplified notation: the market demand function: $Q_D = D(P,P',I)$
- ☐ Define elasticities:

$$\text{Price Elasticity of Market Demand} = e_{D,P} = \frac{\partial D(P,P',I)}{\partial P} \cdot \frac{P}{Q_D}$$

$$\text{Cross Price Elasticity of Market Demand} = e_{D,P'} = \frac{\partial D(P,P',I)}{\partial P'} \cdot \frac{P'}{Q_D}$$

$$\text{Income Elasticity of Market Demand} = e_{D,I} = \frac{\partial D(P,P',I)}{\partial I} \cdot \frac{I}{Q_D}$$

Short-Run Market Supply

- ☐ Quantity of output supplied
  - ■ To the entire market in the short run
  - ■ Is the sum of the quantities supplied by each firm
    - ☐ The amount supplied by each firm depends on price
- ☐ Short-run market supply curve
  - ■ Upward-sloping: each firm's short-run supply curve has a positive slope

Short-Run Market Supply Curve

(a) Firm A   (b) Firm B   (c) The market
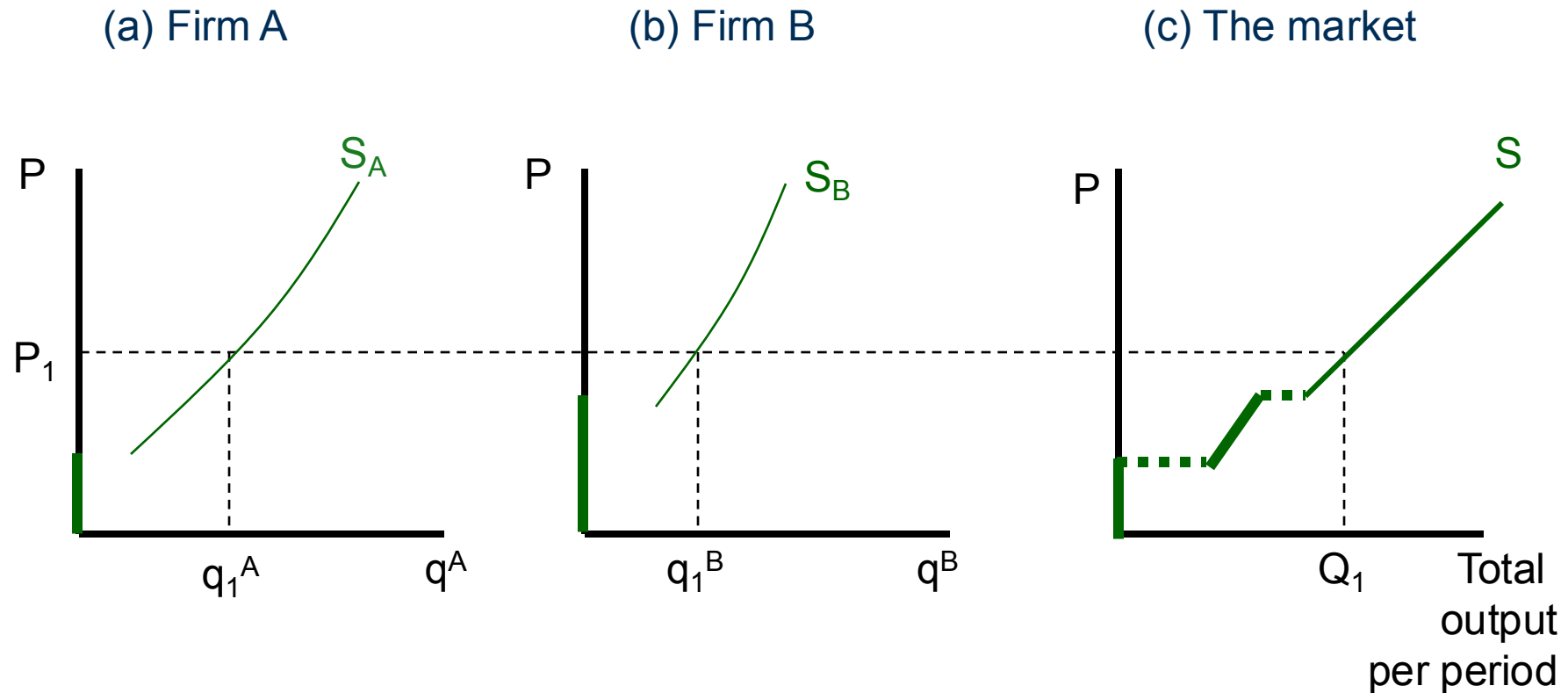
- The supply (marginal cost) curves of two firms are shown in (a) and (b).
- The market supply curve (c) is the horizontal sum of these curves.
- For example, at P_1 firm A supplies q^A_1, firm B supplies q^B_1, and total market supply is given by $Q_1 = q^A_1 + q^B_1$.

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Short-Run Market Supply Function

Short-run market supply function

- Shows total quantity supplied by each firm to a market

$$Q_s(P, v, w) = \sum_{i=1}^{n} q_i(P, v, w)$$

- Firms are assumed to face the same market price and the same prices for inputs

Short-Run Market Supply Function

☐ Short-run market supply curve

- ■ Shows the two-dimensional relationship between *Q* and *P*
- ■ Holding *v* and *w* (and each firm's underlying technology) constant
- ■ If *v, w*, or technology were to change, the supply curve would shift

Short-Run Supply Elasticity

□ Short-run supply elasticity

■ Describes the responsiveness of quantity supplied to changes in market price

$$e_{S,P} = \frac{\% \text{ change in } Q \text{ supplied}}{\% \text{ change in } P} = \frac{\partial Q_S}{\partial P} \cdot \frac{P}{Q_S}$$

■ Because price and quantity supplied are positively related, $e_{S,P} > 0$

A Short-Run Supply Function

☐ Cobb-Douglas production function:

$$q_i(P, v, w, k_1) = \left(\frac{w}{\beta}\right)^{-\beta/(1-\beta)} k_1^{\alpha/(1-\beta)} P^{\beta/(1-\beta)}$$

$$\text{Let } \alpha = \beta = 0.5, w = 12, k_1 = 80$$

☐ What is the single firm's supply function?
☐ 100 identical firms
  ■ Each with the same short-run supply function
☐ Short-run market supply function:
☐ Short-run elasticity of supply:

Competitive Equilibrium: Roadmap

- ☐ Market demand and supply curve

- ☐ **Compute competitive market equilibrium**

- ☐ Properties of market equilibrium
  - ◼ Efficiency
  - ◼ Equity

- ☐ Three examples of government interventions and their welfare implications
  - ◼ Price controls
  - ◼ Minimum wages
  - ◼ Taxation

Market Equilibrium

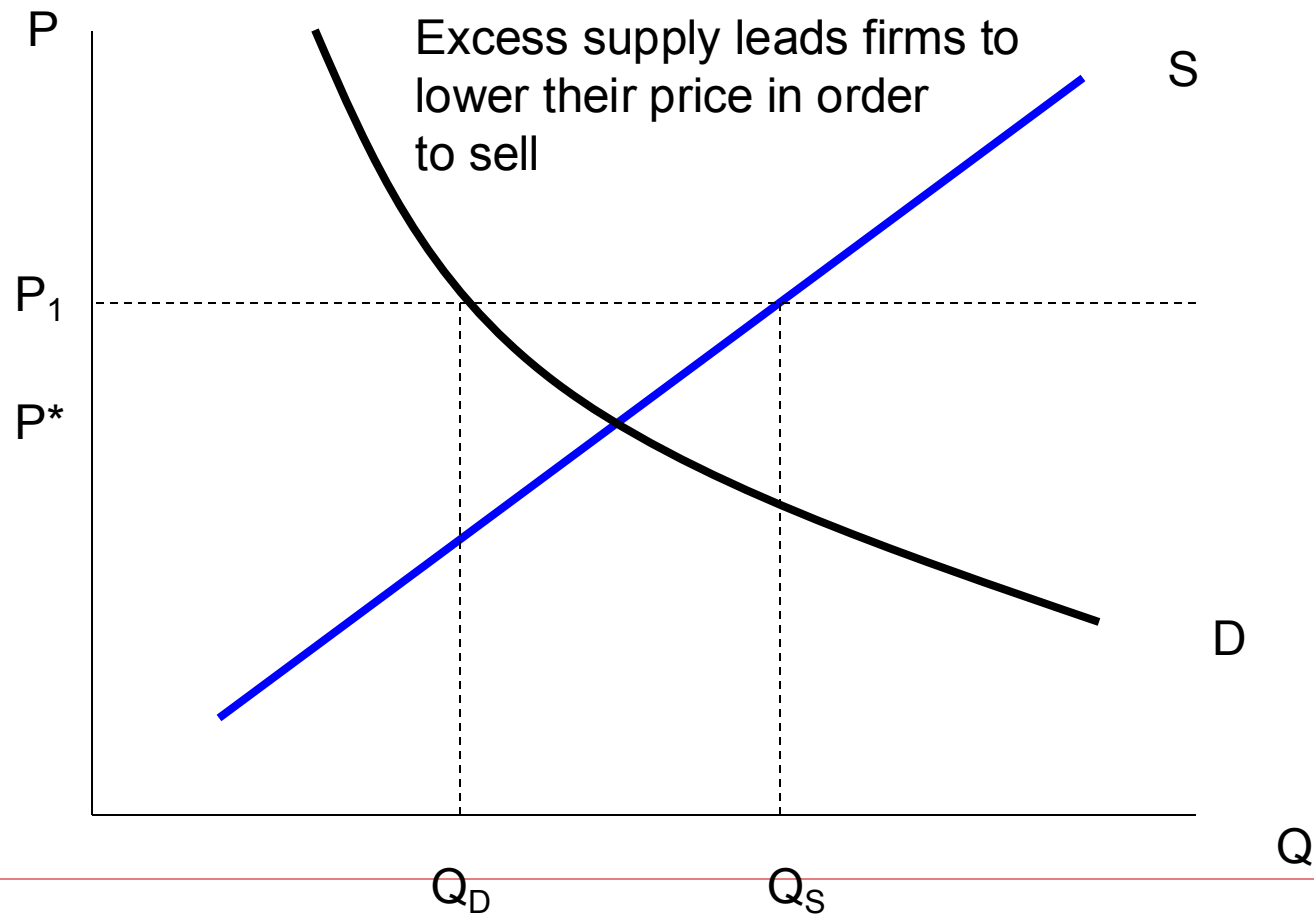An **equilibrium** is a pair (Q^*, P^*) such that, at P^*:

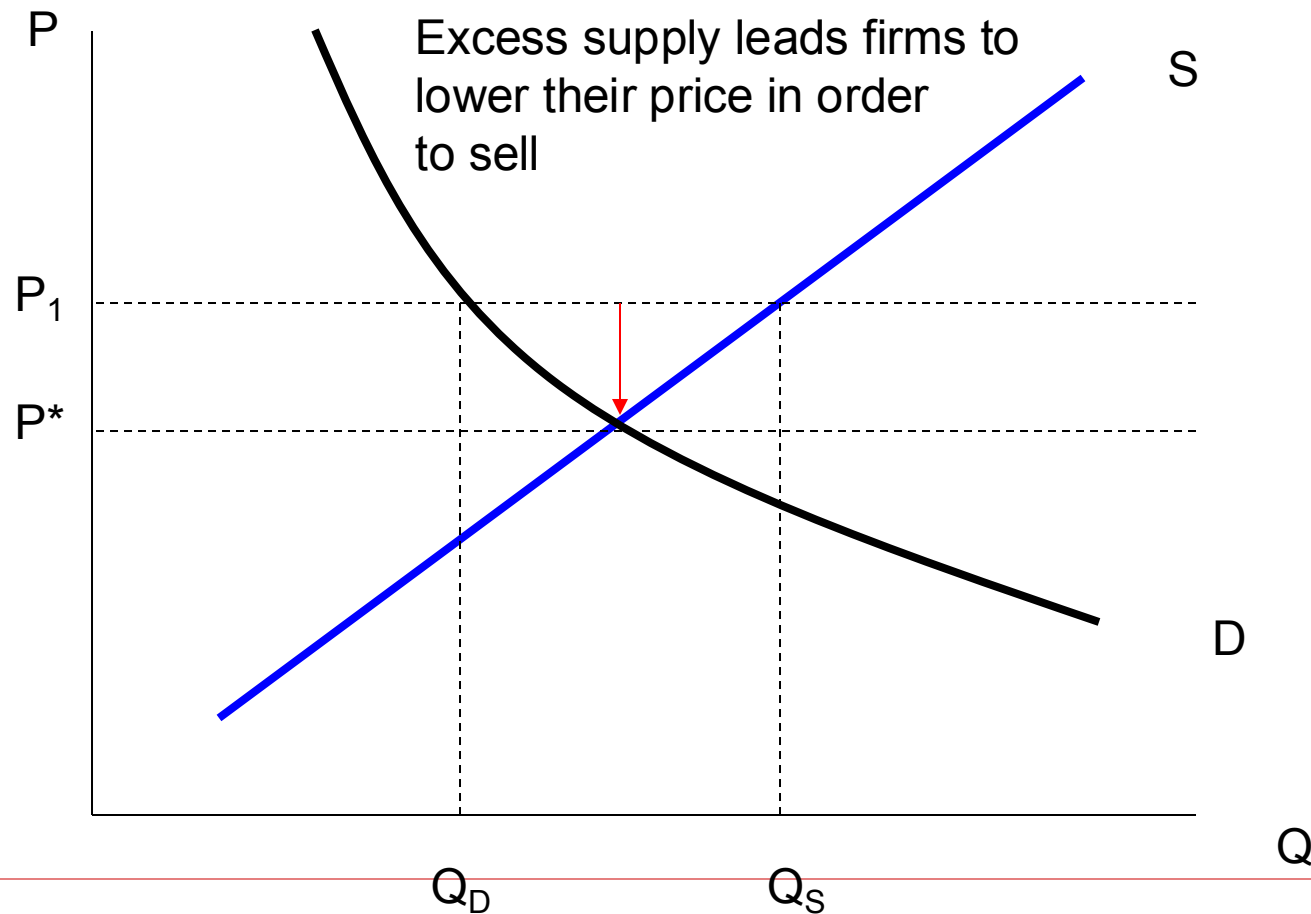$$S(P^*) = D(P^*) = Q^*.$$
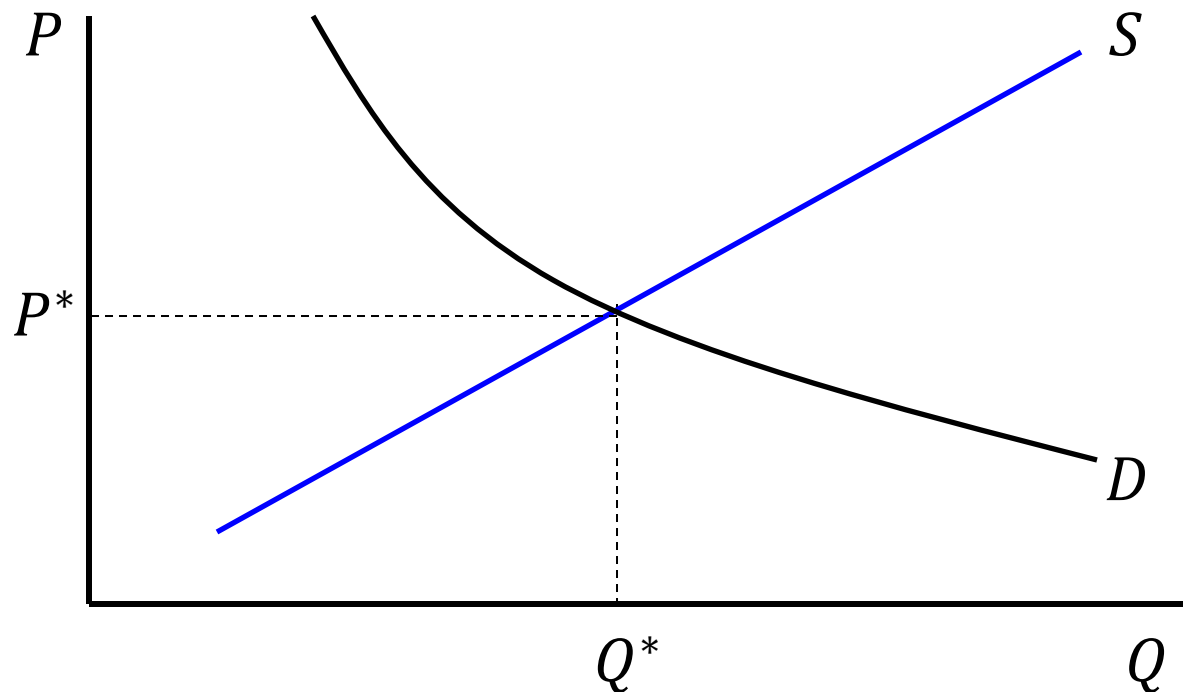
Why is (Q^*, P^*) an "equilibrium"?

At P^*:
1. Consumers are willing to buy Q^*.
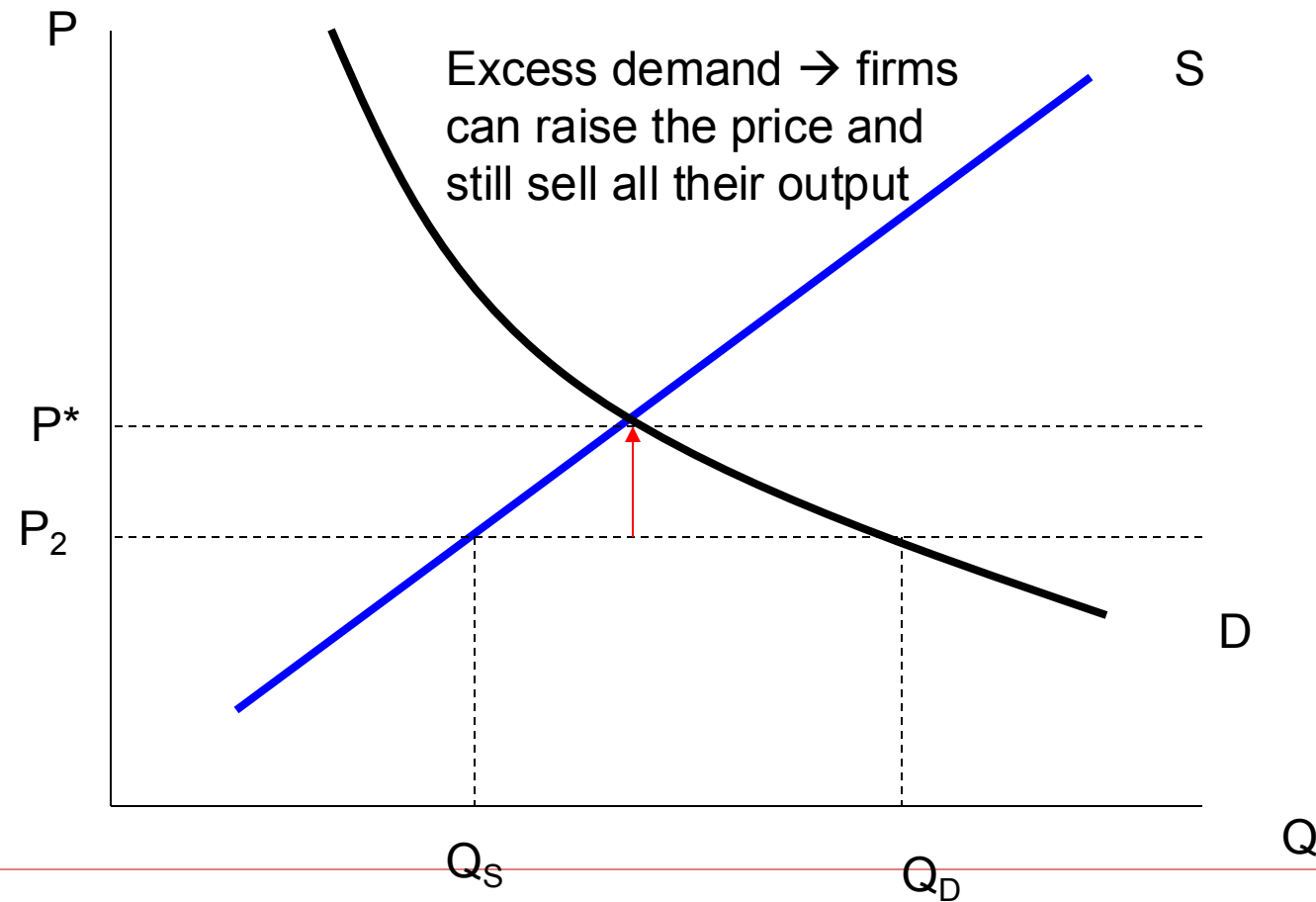2. Producers are willing to sell Q^*.
3. Markets clear.

What if we are out of equilibrium?

Excess supply leads firms to lower their price in order to sell

What if we are out of equilibrium?

Excess supply leads firms to lower their price in order to sell

What if we are out of equilibrium?

Excess demand → firms can raise the price and still sell all their output

Reasons for Shifts in Demand or Supply Curves

Demand Curves Shift Because	Supply Curves Shift Because
Incomes change	Input prices change
Prices of substitutes or complements change	Technology changes
Preferences change	Number of producers changes

When either a supply curve or a demand curve shift
- Equilibrium price and quantity will change
- The relative magnitudes of these changes depends on the shapes of the supply and demand curves
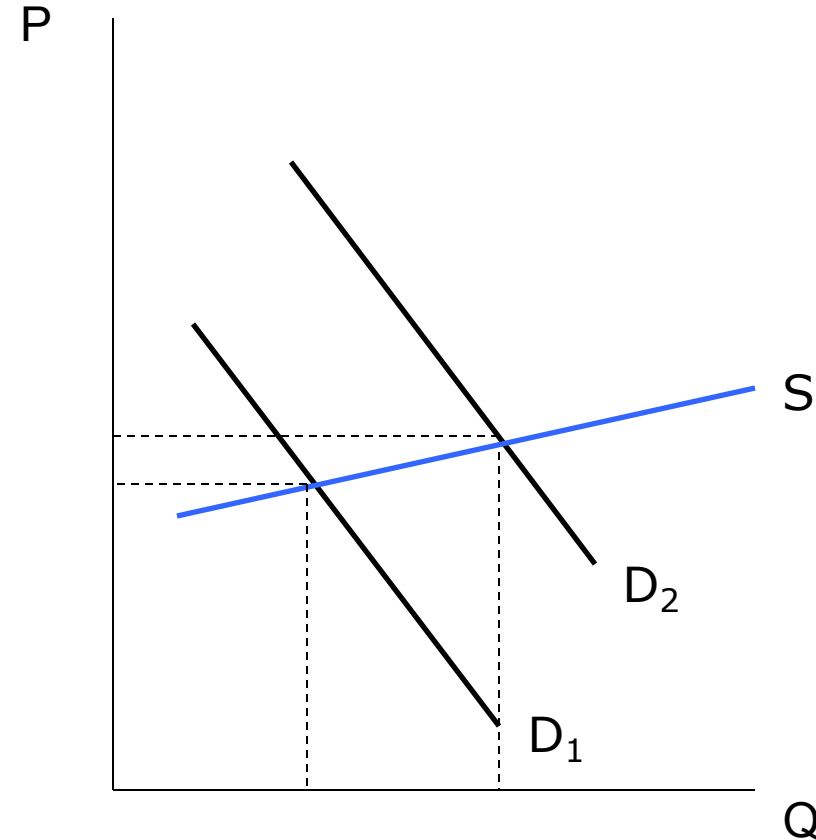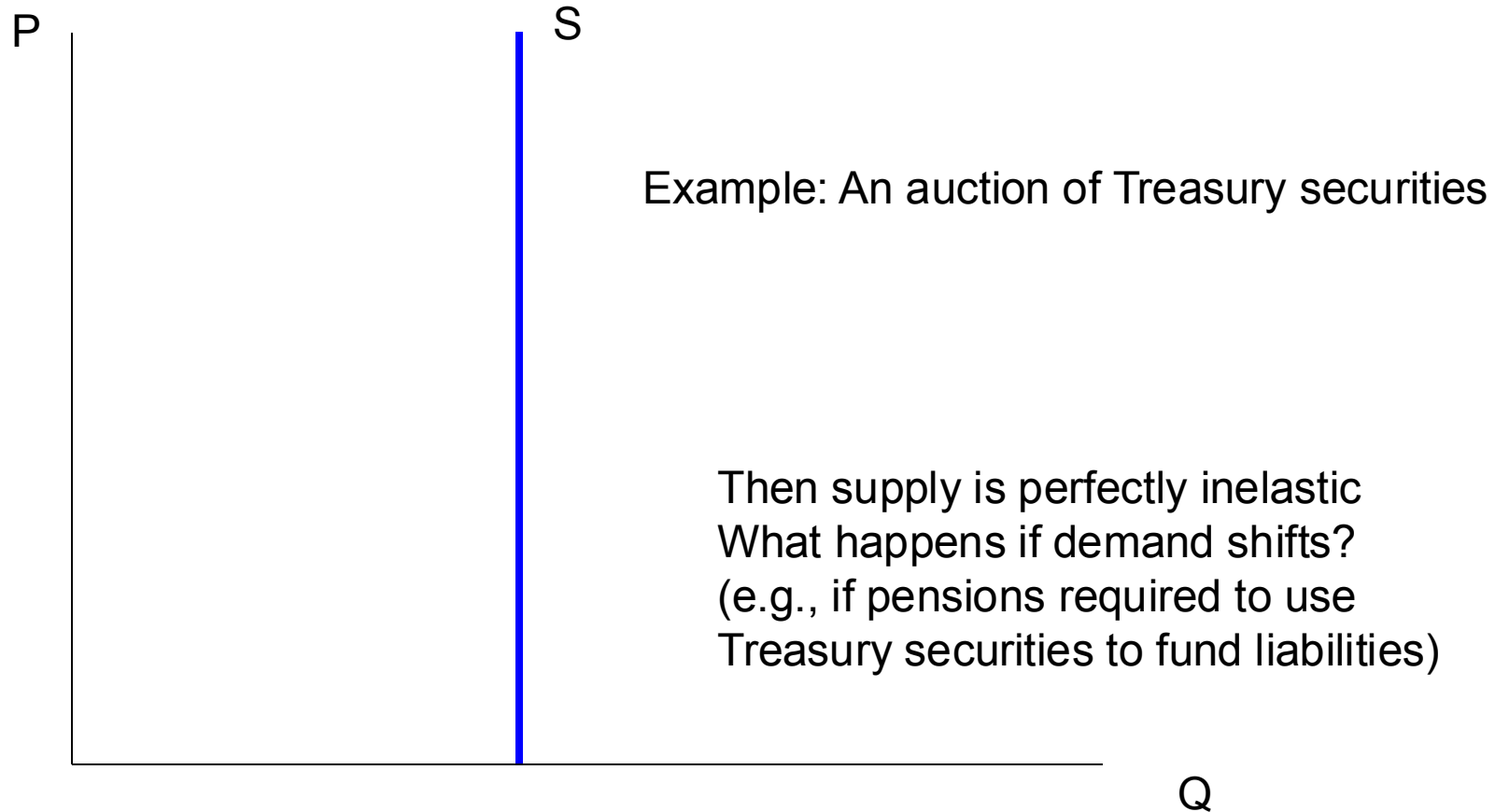
Equilibrium and Shifts in Demand

- [ ] When demand shifts, effect on P* and Q* depends on the shape of the supply curve

- [ ] Demand shifts from D_1 to D_2.

- [ ] With relatively inelastic (steep) supply, large change in P, small change in Q.
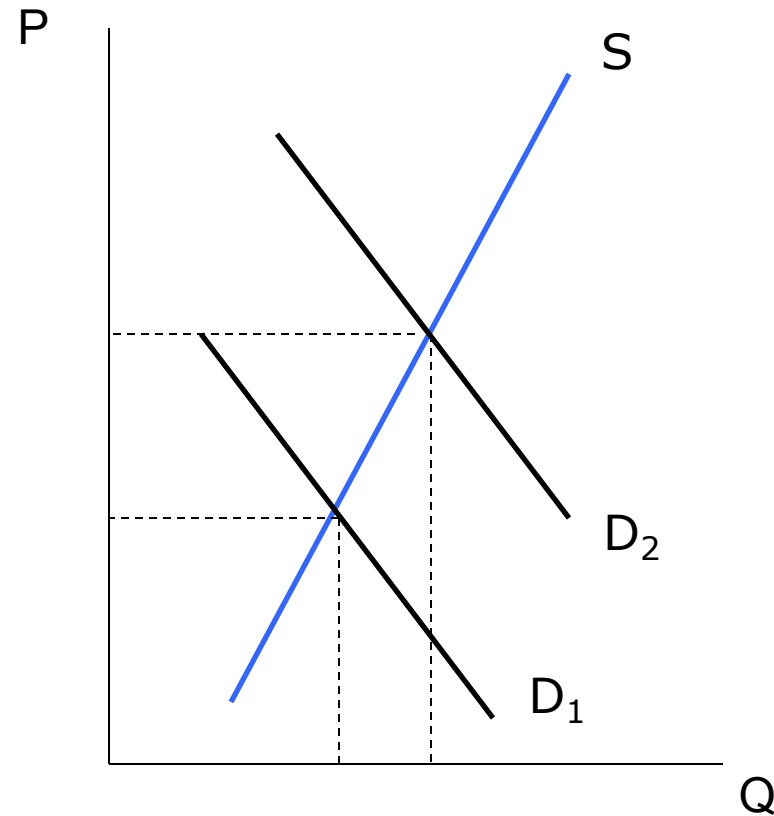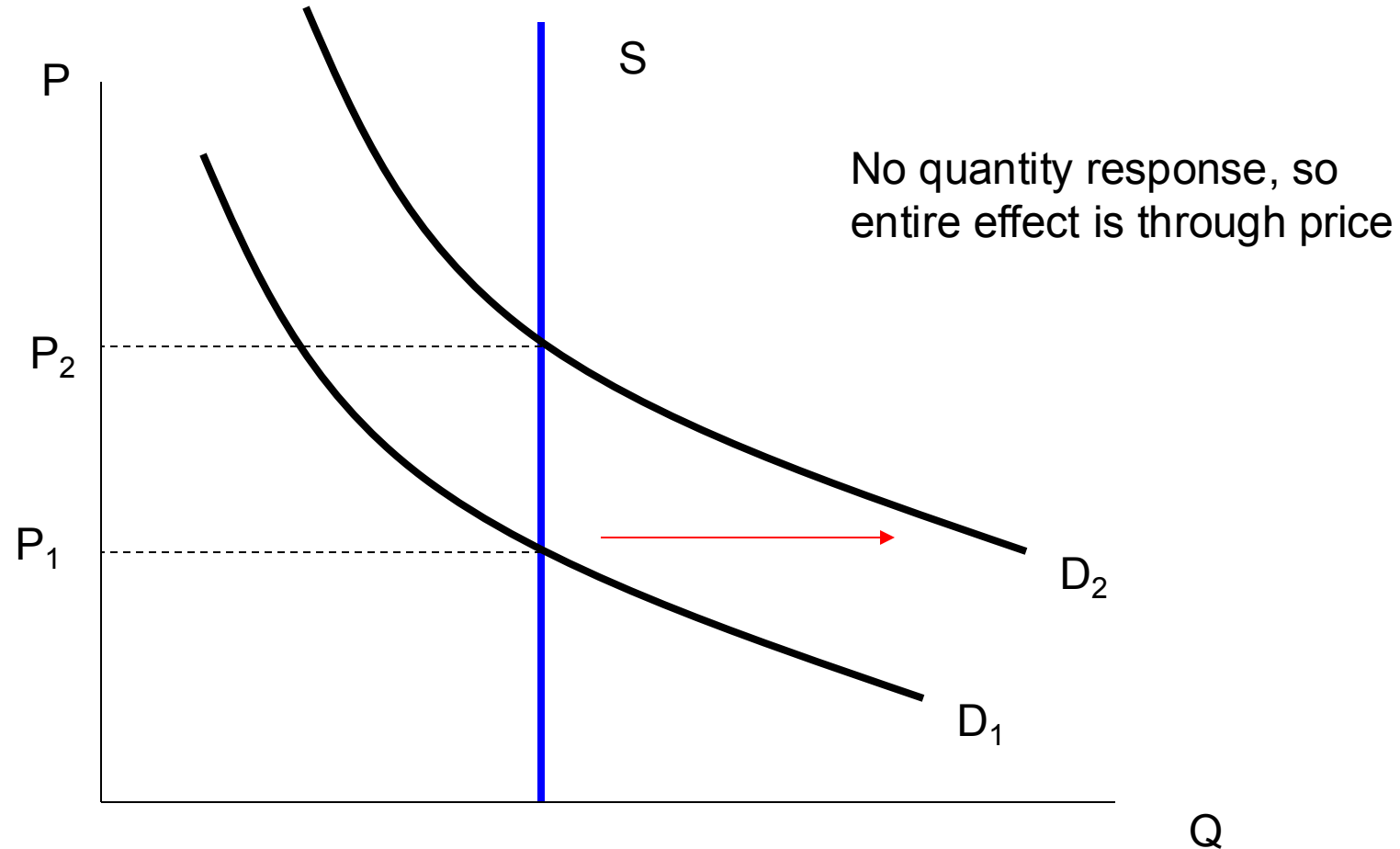
Equilibrium and Shifts in Demand

- [ ] When demand shifts, effect on P* and Q* depends on the shape of the supply curve

- [ ] Demand shifts from D_1 to D_2.

- [ ] With relatively elastic (flat) supply, small change in P, large change in Q.

# What if the supply of a particular security is fixed in the short-run?

P   S

Example: An auction of Treasury securities

Then supply is perfectly inelastic
What happens if demand shifts?
(e.g., if pensions required to use
Treasury securities to fund liabilities)

Q

What if the supply of a particular security is fixed in the short-run?

No quantity response, so entire effect is through price

Equilibrium and Shifts in Supply

- [ ] When supply shifts, effect on P* and Q* depends on the shape of the demand curve

- [ ] Supply shifts from S_1 to S_2.

- [ ] With relatively inelastic (steep) demand, large change in P, small change in Q.
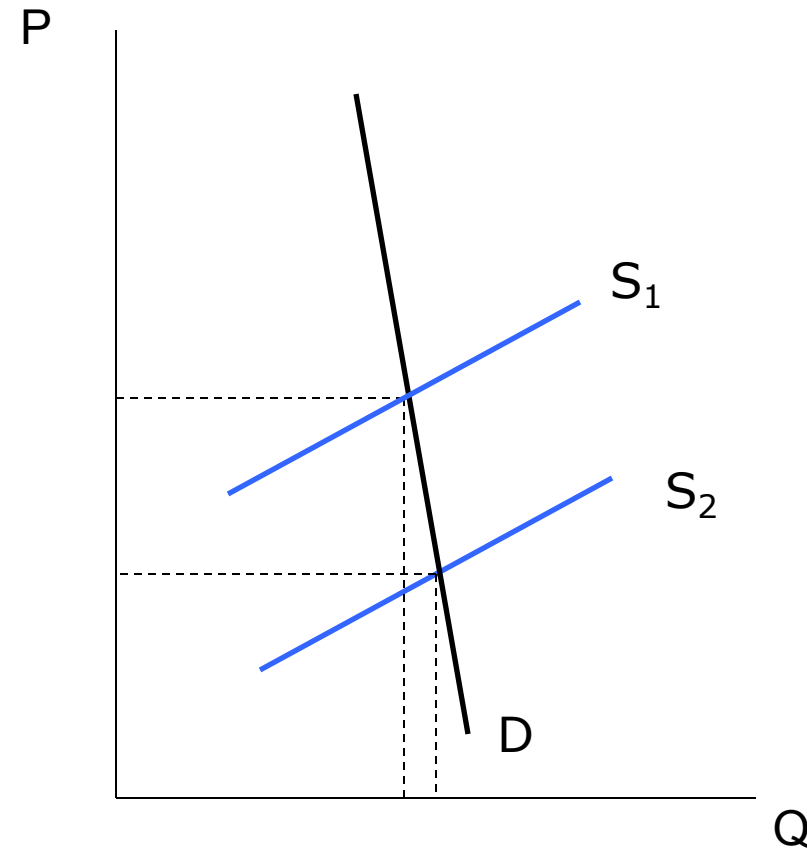
Equilibrium and Shifts in Supply

- ☐ When supply shifts, effect on P* and Q* depends on the shape of the demand curve

- ☐ Supply shifts from S_1 to S_2.

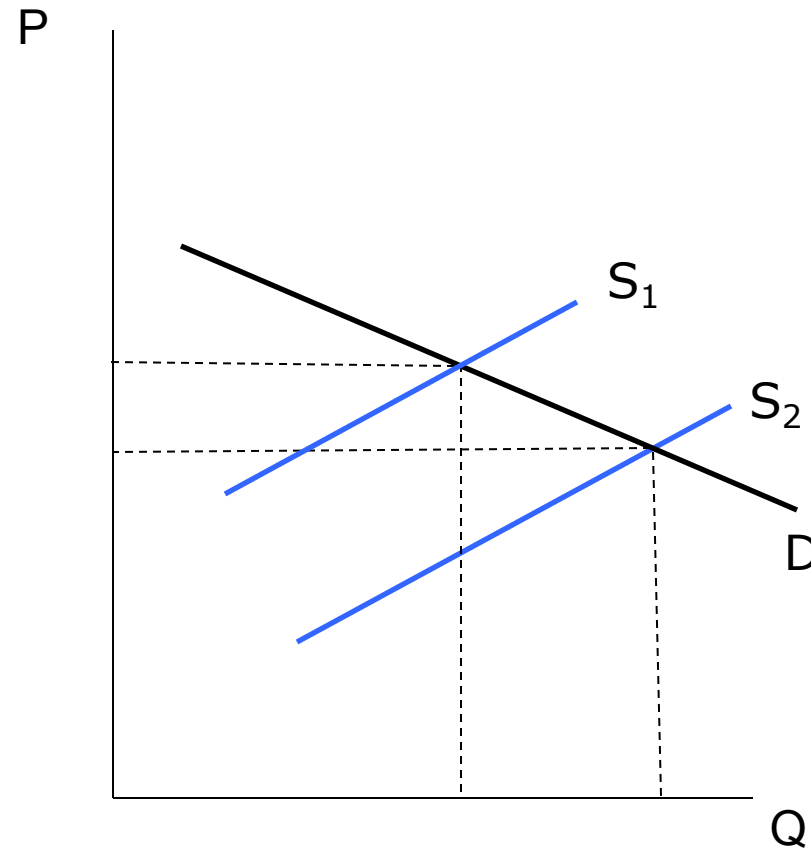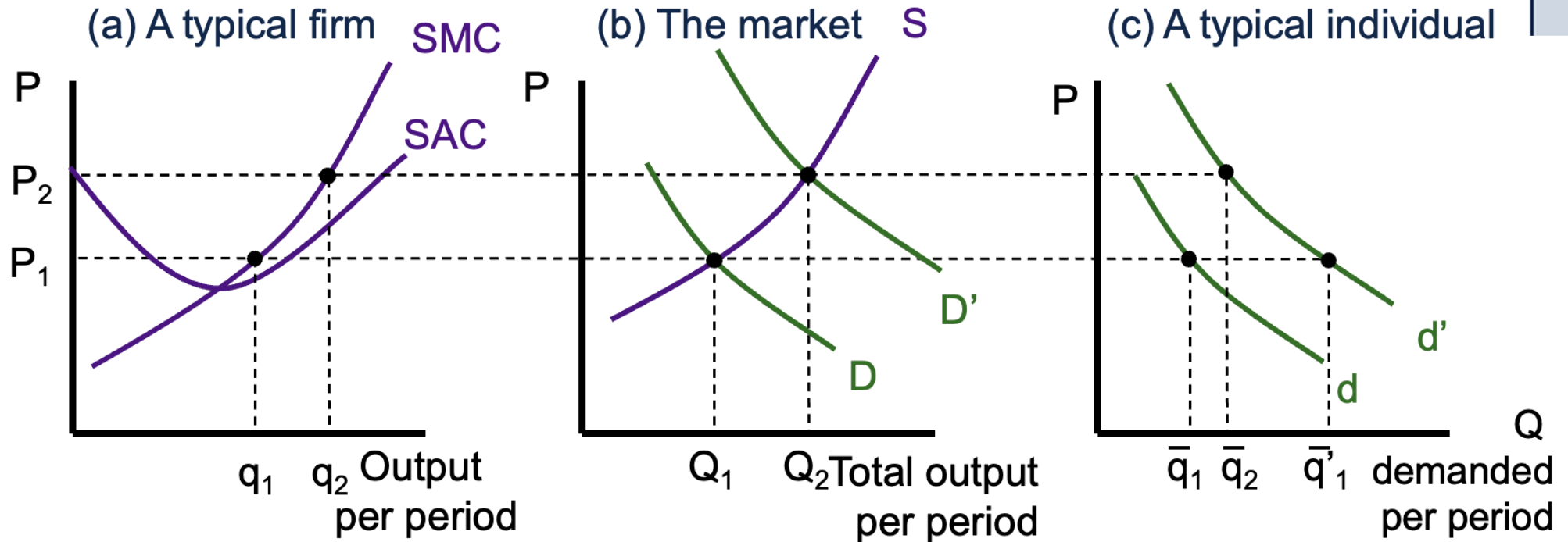- ☐ With relatively elastic (flat) demand, small change in P, large change in Q.

FIGURE 12.4 Interactions of Many Individuals and Firms

Determine Market Price in the Short Run

(a) A typical firm — SMC, SAC, P, P_2, P_1, q_1, q_2 Output per period

(b) The market — S, P, Q_1, Q_2 Total output per period, D', D

(c) A typical individual — P, Q, $\bar{q}_1$, $\bar{q}_2$, $\bar{q}'_1$ demanded per period, d', d

Market demand curves and market supply curves are each the horizontal sum of numerous components. These market curves are shown in (b). Once price is determined in the market, each firm and each individual treat this price as a fixed parameter in their decisions. Although individual firms and persons are important in determining price, their interaction as a whole is the sole determinant of price. This is illustrated by a shift in an individual's demand curve to d'. If only one individual reacts in this way, market price will not be affected. However, if everyone exhibits an increased demand, market demand will shift to D'; in the short run, price will increase to P_2.

Short-run vs long-run market equilibrium

☐ When we draw supply-demand chart, what we are looking for is "short-run" equilibrium

  ■ Short-run: there are fixed number of firms in the market

  ■ Each firm may earn positive economic profit

☐ A short-term equilibrium almost surely cannot sustain in the long run

  ■ If some firm's making positive economic profit, then in the long run, new firms will keep entering the market, more goods become available on the market, price goes down

  ■ This keeps happening until the price of the good is driven down to the point where profitability in the market is exhausted

Long-Run Analysis

☐ Long run

- A firm may adapt all of its inputs to fit market conditions
- Profit-maximization for a price-taking firm:
  - ☐ Price is equal to long-run *MC*
- Firms can also enter and exit an industry
- Perfect competition: there are no special costs of entering or exiting an industry

Long-Run Analysis

☐ New firms will be lured into any market

- ◼ Where economic profits are > 0
  - ☐ The short-run industry supply curve will shift outward
  - ☐ Market price and profits will fall
  - ☐ The process will continue until economic profits are zero

Long-Run Analysis

- ☐ Existing firms will leave any industry
  - ■ Where economic profits are negative
    - ☐ The short-run industry supply curve will shift inward
    - ☐ Market price will rise and losses will fall
    - ☐ The process will continue until economic profits are zero

# Long-Run Competitive Equilibrium

☐ Assumptions
- ■ All firms in an industry have identical cost curves
  - ☐ No firm controls any special resources or technology
- ■ The equilibrium long-run position requires that each firm earn zero economic profit
  - ☐ $P = MC$ (profit maximization)
  - ☐ $P = AC$ (zero profit)

Long-Run Competitive Equilibrium

☐ A perfectly competitive industry is in long-run equilibrium

■ If there are no incentives for profit-maximizing firms to enter or to leave the industry

■ When the number of firms is such that

☐ *P = MC = AC*
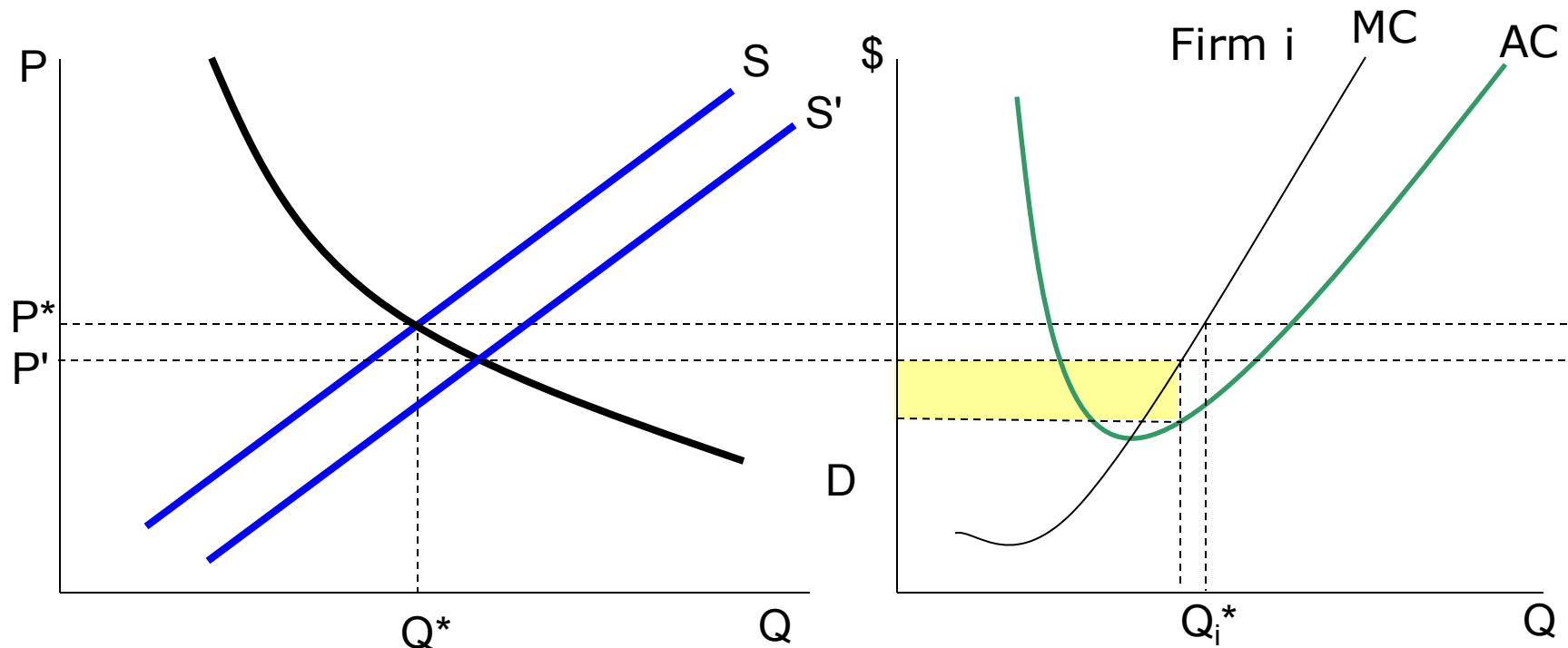
☐ And each firm operates at minimum *AC*

Short Run Equilibrium and Profit

☐   In the short run, the number of firms is fixed.

☐   Firms may earn an economic profit.

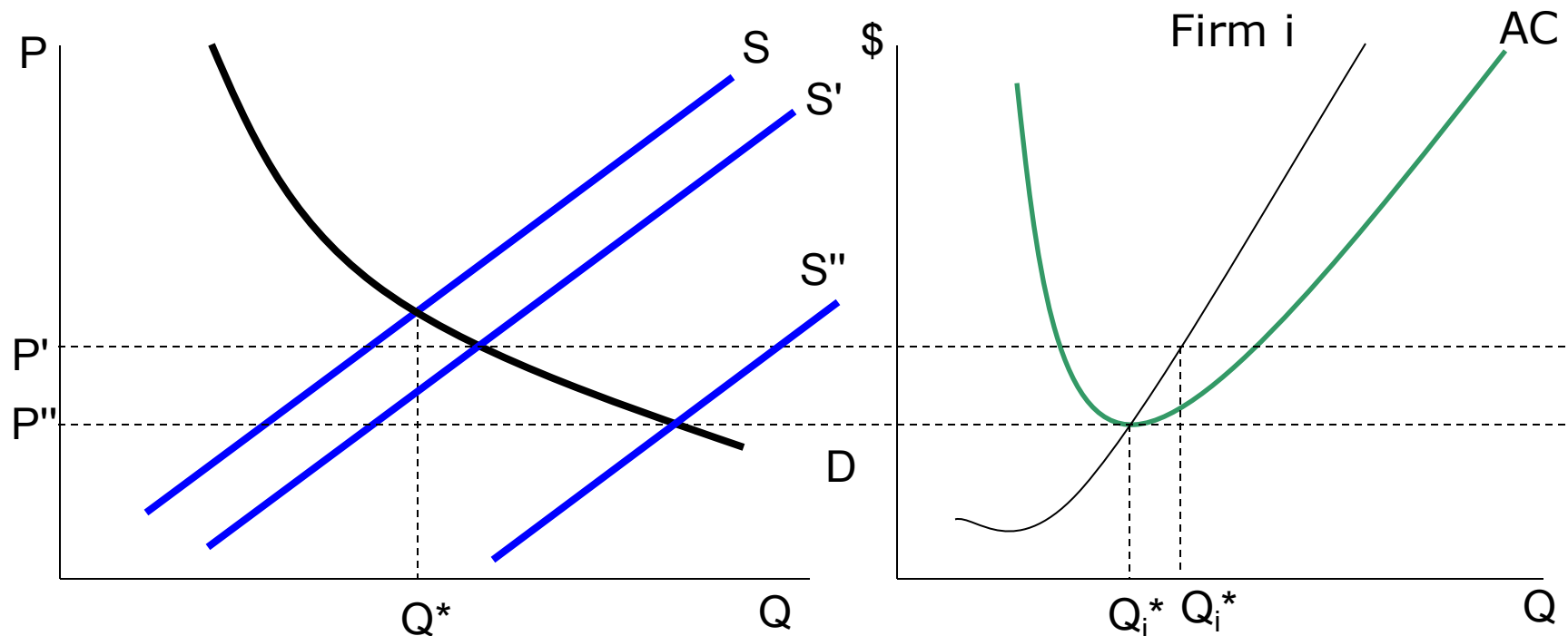☐   This will lead additional firms to enter the industry.
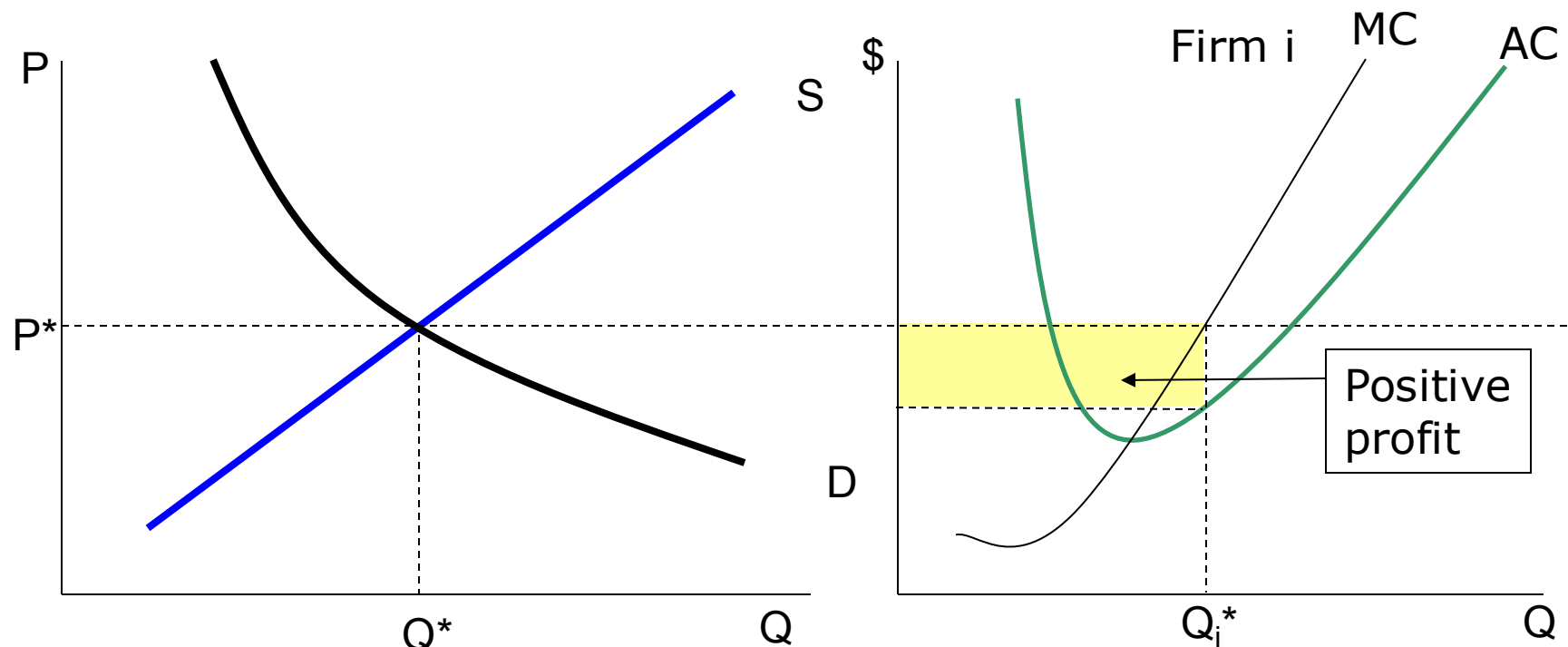
Entry and Profit

- ☐ Entry shifts the supply curve to the right.
- ☐ SR equilibrium price falls.
- ☐ Profit decreases.

Entry and Profit

- Entry continues until profit is zero.
- Profit is zero when P = min AC.

Long Run Equilibrium

☐ If all firms are identical, a long run equilibrium is a point where

■ Market price $P^* = \min AC$

■ There are N firms on the market, such that $Q_S(P^*) = Q_D(P^*) = Q^*$

☐ Note that because $P^* = \min AC$, every firm in the long run equilibrium is earning **zero profit**

■ This is because we assumed identical firms (same cost function)

Long Run Equilibrium - Example

☐ Suppose that firms have cost function:

$$C(Q) = 108 + 10Q + 1/3\ Q^2.$$

☐ Initially, there are 10 firms in the market.

☐ Market demand is given by Q = 1450 – P.

Questions:
1. What is the short-run equilibrium?
   1. Equilibrium price=? Quantity=?
   2. each firm's profit=?
2. What is the long-run equilibrium?
   1. Each firm's supply=? Price=?
   2. Long-run number of firms in the market=?

$$Q_D = 1450 - P$$
$$C(Q) = 108 + 10Q + 1/3\ Q^2$$

Long Run Equilibrium - Example

☐ **What is the short run equilibrium?**

☐ **Follow the steps:**

■ First, find each firm's supply function:

■ Then, find aggregate supply.

  If there are 10 firms, at a price of P, total supply is $10*Q_i$.

■ In the short run, equilibrium is where quantity supplied = quantity demanded.

■ In the short run, firms earn positive profits = ?

■ So, there will be entry in the long run.

$$Q_D = 1450 - P$$
$$C(Q) = 108 + 10Q + 1/3\ Q^2$$

Long Run Equilibrium - Example
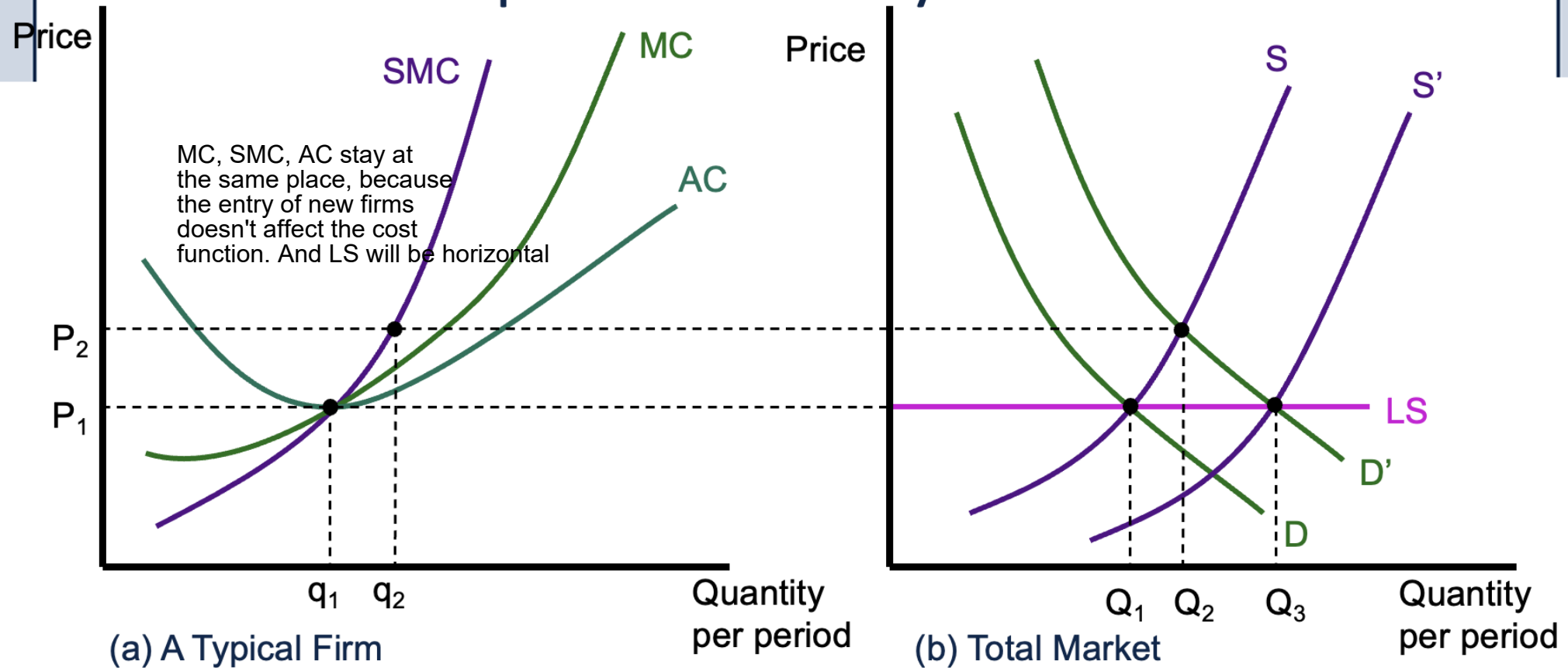
- ☐ **What is the long run equilibrium?**

- ☐ In the long-run equilibrium, P = min AC. Compute min AC:

- ☐ What is total quantity demanded?

- ☐ How many firms are there in the market?

Long-Run Equilibrium: Constant-Cost Case

☐ Constant-cost industry

  ■ The entry of new firms in an industry has no effect on the cost of inputs

    ☐ No matter how many firms enter or leave an industry, a firm's cost curves will remain unchanged

FIGURE 12.7 Long-Run Equilibrium for a Perfectly

Competitive Industry: Constant Cost Case

MC, SMC, AC stay at the same place, because the entry of new firms doesn't affect the cost function. And LS will be horizontal

(a) A Typical Firm

(b) Total Market

An increase in demand from D to D' will cause price to increase from P_1 to P_2 in the short run. This higher price will create profits in the industry, and new firms will be drawn into the market. If it is assumed that the entry of these new firms has no effect on the cost curves of the firms in the industry, then new firms will continue to enter until price is pushed back down to P_1. At this price, economic profits are zero. Therefore, the long-run supply curve (LS) will be a horizontal line at P_1. Along LS, output is increased by increasing the number of firms, each producing q_1.

EXAMPLE 12.4 Infinitely Elastic Long-Run Supply

- Total cost curve for a typical firm in the bicycle industry: $C(q) = q^3 - 20q^2 + 100q + 8{,}000$

- Demand for bicycles: $Q_D = 2{,}500 - 3P$

- What are the long-run equilibrium quantity and price?

Shape of the Long-Run Supply Curve

- **Shape of the long-run cost curve**

  - Determined by the zero-profit condition

  - Horizontal - if average costs are constant as firms enter

  - Upward sloped - if average costs rise as firms enter
   limited input.
    inputs' prices increase as firms entering.

  - Negatively sloped - if average costs fall as firms enter

Long-Run Equilibrium: Increasing-Cost Industry

- **The entry of new firms**
  - May cause the average costs of all firms to rise
  - Prices of scarce inputs may rise
  - New firms may impose "external" costs on existing firms
  - New firms may increase the demand for tax-financed services

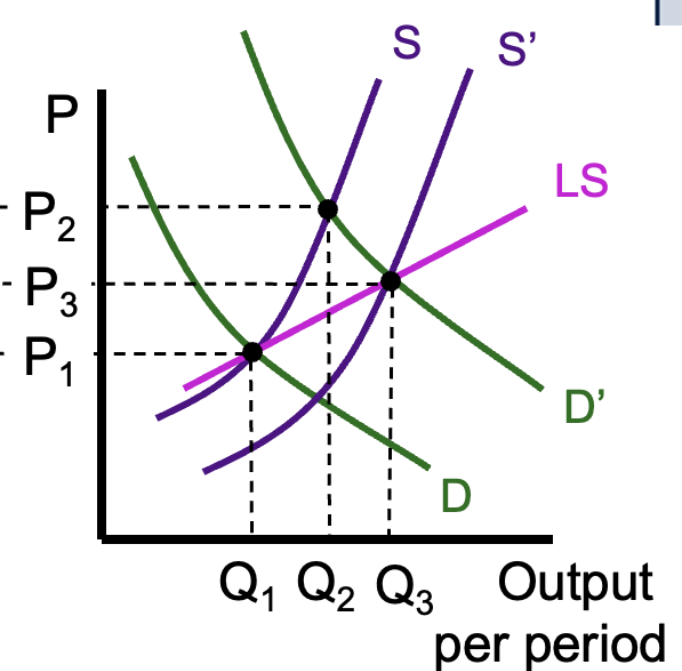**FIGURE 12.8 An Increasing Cost Industry Has a Positively Sloped Long-Run Supply Curve**

(a) Typical firm before entry   (b) Typical firm after entry   (c) The market
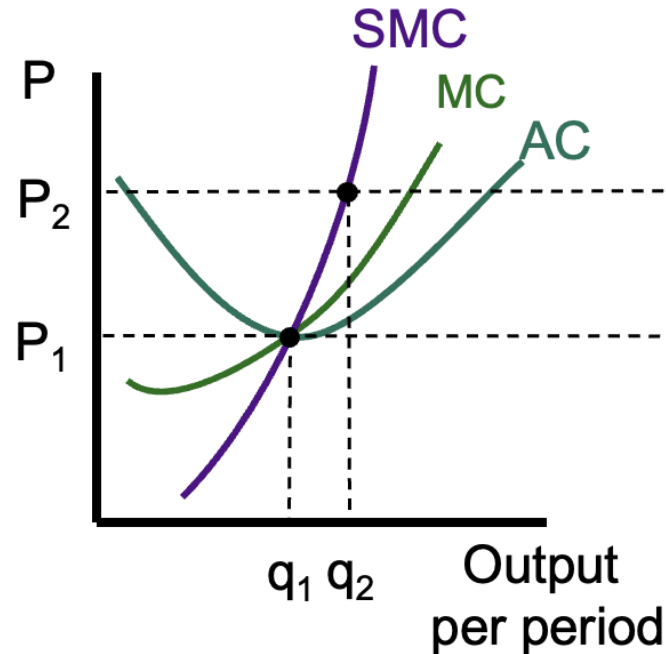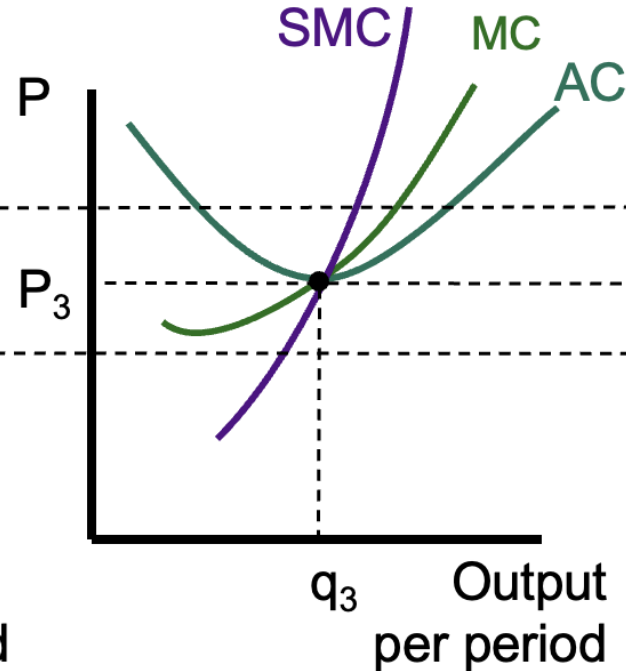
Initially the market is in equilibrium at P_1, Q_1.

An increase in demand (to D') causes price to increase to P_2 in the short run, and the typical firm produces q_2 at a profit. This profit attracts new firms into the industry.

The entry of these new firms causes costs for a typical firm to increase to levels shown in (b). With this new set of curves, equilibrium is re-established in the market at P_3, Q_3. By considering many possible demand shifts and connecting all the resulting equilibrium points, the long-run supply curve (LS) is traced out.
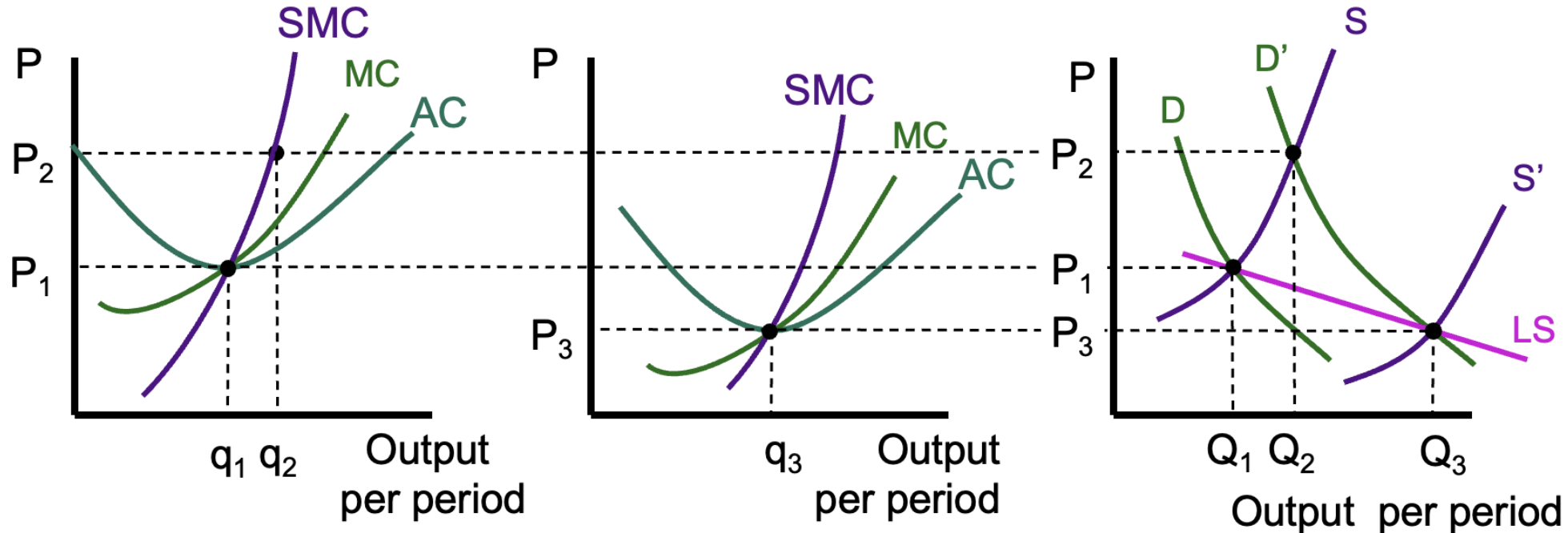
- The entry of new firms
  - May cause the average costs of all firms to fall
  - New firms may attract a larger pool of trained labor
  - Entry of new firms may provide a "critical mass" of industrialization
    - Permits the development of more efficient transportation and communications networks

(a) Typical firm before entry   (b) Typical firm after entry   (c) The market

Initially the market is in equilibrium at P_1, Q_1. An increase in demand (to D') causes price to increase to P_2 in the short run, and the typical firm produces q_2 at a profit. This profit attracts new firms into the industry. If the entry of these new firms causes costs for the typical firm to decrease, a set of new cost curves might look like those in (b). With this new set of curves, market equilibrium is re-established at P3, Q_3. By connecting such points of equilibrium, a negatively sloped long-run supply curve (LS) is traced out.

Classification of Long-Run Supply Curves

- **Constant Cost**
    - Entry does not affect input costs
    - Horizontal long-run supply curve at the long-run equilibrium price
- **Increasing Cost**
    - Entry increases inputs costs
    - Positively sloped long-run supply curve
- **Decreasing Cost**
    - Entry reduces input costs
    - Negatively sloped long-run supply curve

Long-Run Elasticity of Supply

- **Long-run elasticity of supply ($e_{LS,P}$)**

  - Records the proportionate change in long-run industry output to a proportionate change in price

  - Can be positive or negative

    - The sign depends on whether the industry exhibits increasing or decreasing costs

$$e_{LS,P} = \frac{\% \text{ change in } Q}{\% \text{ change in } P} = \frac{\partial Q_{LS}}{\partial P} \cdot \frac{P}{Q_{LS}}$$

Comparative Statics Analysis of Long Run Equilibrium

- **Assume: a constant-cost industry**
  - Initial long-run equilibrium
    - Industry output is Q_0
    - Typical firm's output is $q*$ (where AC is minimized)
    - Equilibrium number of firms in the industry (n_0) is $Q_0/q*$

Comparative Statics Analysis of Long Run Equilibrium

- ## A shift in demand

  - That changes the equilibrium industry output to Q_1

  - Changes the equilibrium number of firms to $n_1 = Q_1/q*$

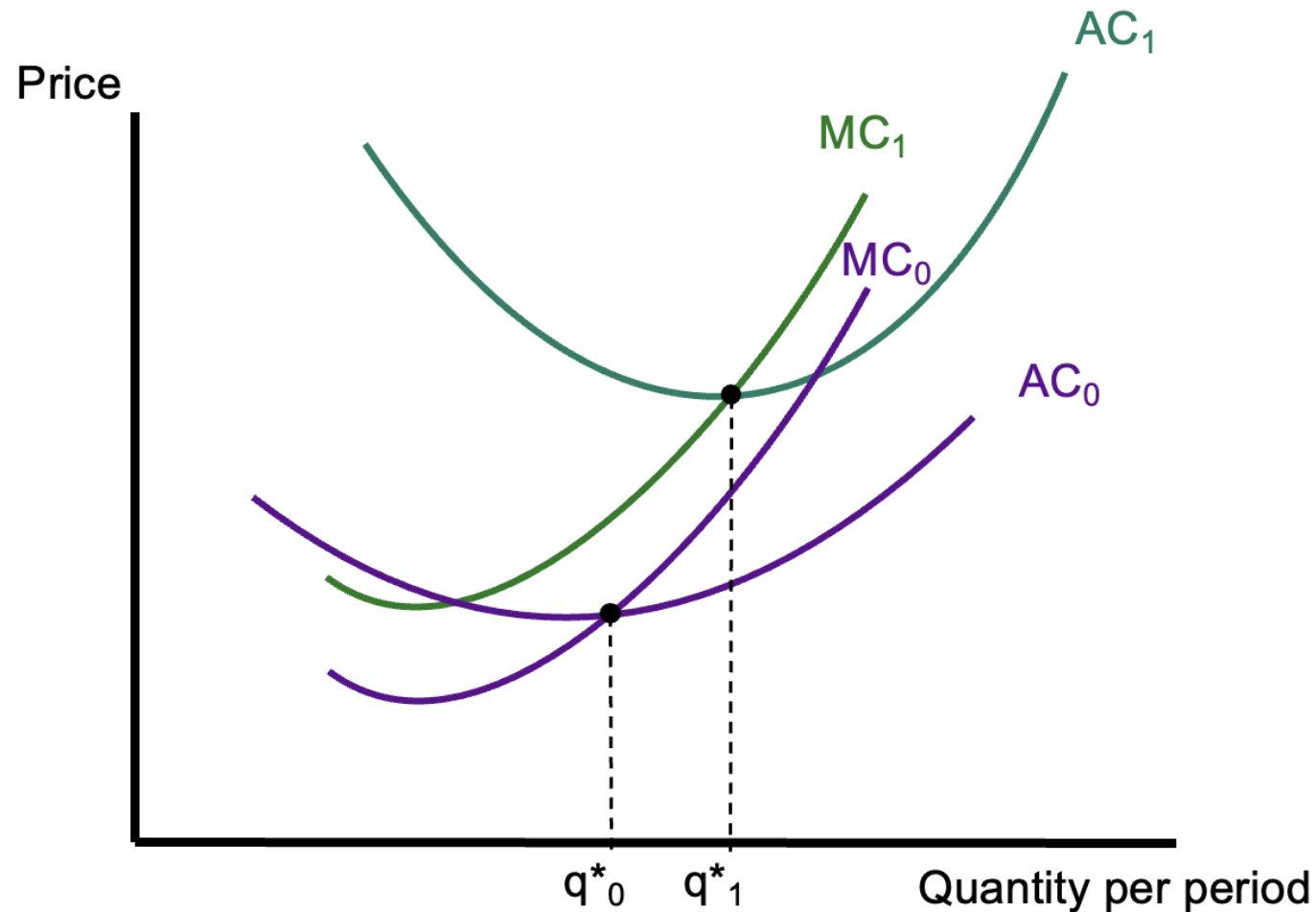 - Change in the number of firms is

$$n_1 - n_0 = \frac{Q_1 - Q_0}{q*}$$

Comparative Statics Analysis of Long Run Equilibrium

- The effect of a change in input costs
  - More complicated
  - Affects minimum average cost
  - Affects the quantity demanded
  - Affects the optimal level of output for each firm
  - Change in the number of firms:

$$n_1 - n_0 = \frac{Q_1}{q_1^*} - \frac{Q_0}{q_0^*}$$

An increase in the price of an input will shift average and marginal cost curves upward. The precise effect of these shifts on the typical firm's optimal output level (q*) will depend on the relative magnitudes of the shifts.

EXAMPLE 12.5 Increasing Input Costs and Industry Structure

- Total cost curve for a typical firm in the bicycle industry:

$$C(q) = q^3 - 20q^2 + 100q + 8{,}000$$

  - Then rises to: $C(q) = q^3 - 20q^2 + 100q + 11{,}616$

- (1) What is the optimal scale (q*) of each firm in the long run?

- (2) What is the long-run equilibrium price?

- (3) $Q_D = 2{,}500 - 3P,$

  What is the long-run number of firms in the industry?

Producer Surplus in the Long Run

- **Short-run producer surplus**
  - The return to a firm's owners in excess of what would be earned if output was zero
  - Sum of short-run profits and fixed costs

- **In the long-run**
  - All profits are zero and there are no fixed costs
  - Owners are indifferent about whether they are in a particular market

Producer Surplus in the Long Run

- ## Constant-cost industry
  - Input prices are assumed to be independent of the level of production
  - Inputs can earn the same amount in alternative occupations
- ## Increasing-cost industry
  - Entry will bid up some input prices
  - Suppliers of these inputs will be made better off

Producer Surplus in the Long Run

- **Long-run producer surplus**
  - Extra return producers make by making transactions at the market price
    - Over and above what they would earn if nothing were produced
  - Area above the long-run supply curve and below the market price

Ricardian Rent

- **Many parcels of land**
  - Ranges from very fertile land (low costs of production) to very poor land (high costs)
- **Long-run supply curve for the crop**
  - At low prices only the best land is used
  - As output increases, higher-cost plots of land are brought into production
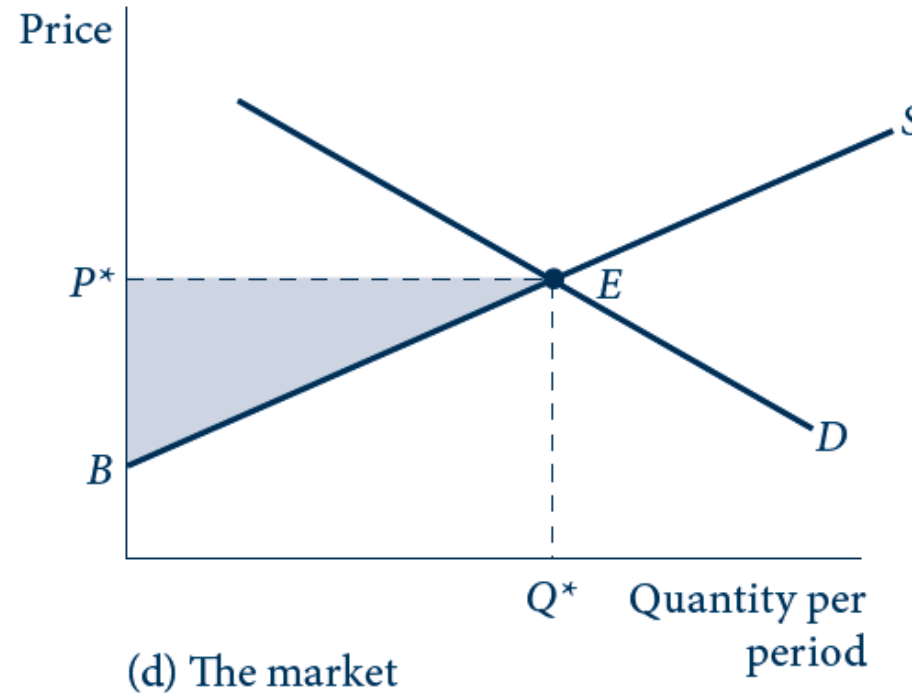 - Positively sloped - increasing costs associated with using less fertile land

(a) Low-cost firm

(b) Medium-cost firm

(c) Marginal firm
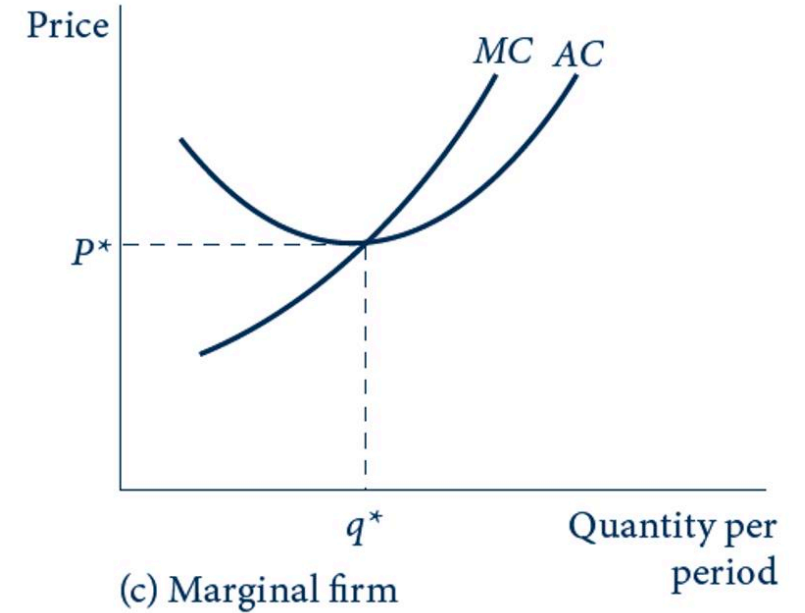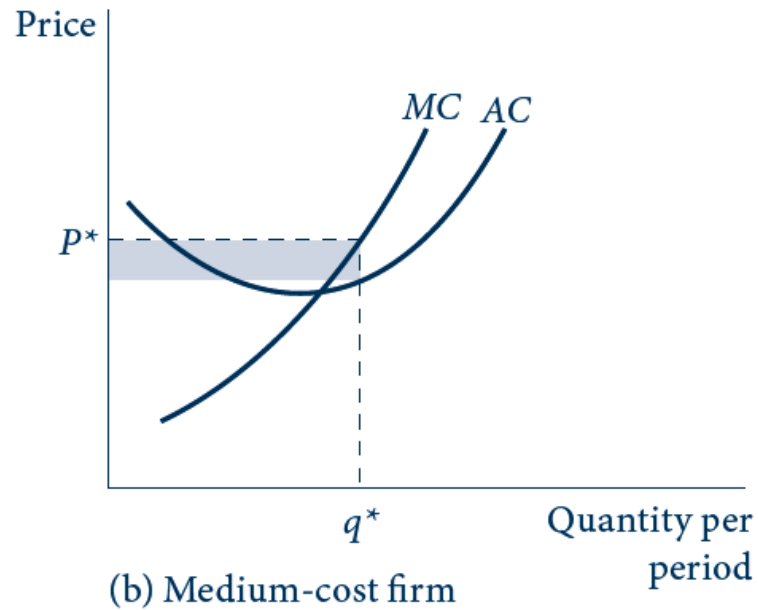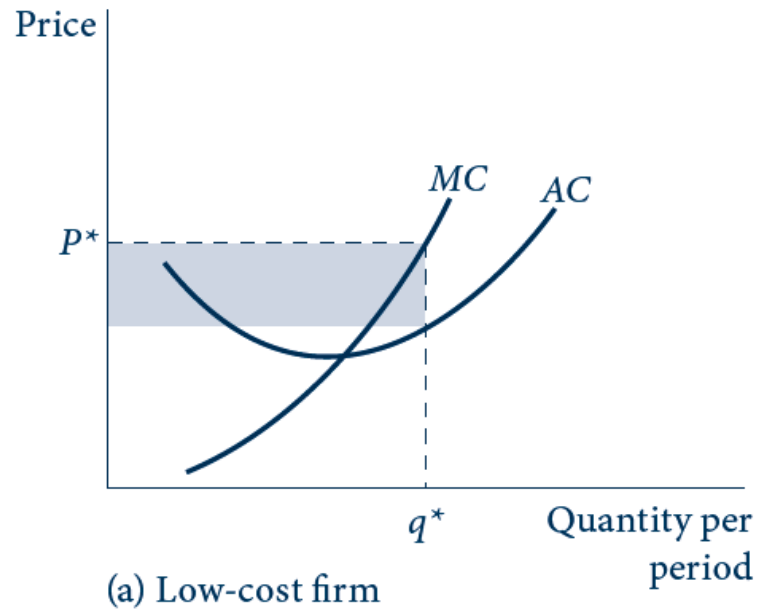
Owners of low-cost and medium-cost land can earn long-run profits.

(d) The market

Long-run producers' surplus represents the sum of all these rents—area PEB in (d).

Ricardian Rent

- ## Firms with higher costs
  - Will stay out of the market
  - Would incur losses at a price of *P**
- ## Profits earned by intramarginal firms
  - Can persist in the long run
  - Reflect a return to a unique resource
- ## Long-run producer surplus
  - The sum of these long-run profits

Ricardian Rent

- Long-run profits for the low-cost firms
  - May be reflected in the prices of the unique resources owned by those firms
    - The more fertile the land is, the higher its price
- Profits are capitalized into inputs' prices
  - Reflect the present value of all future profits

Ricardian Rent

- Scarcity of low-cost inputs
  - Creates the possibility of Ricardian rent
- Industries with upward-sloping long-run supply curves
  - Increases in output
    - Raise firms' costs
    - Generate factor rents for inputs

The Impact of Global Warming on Agriculture: A Ricardian Analysis

- By Robert Mendelsohn, William D. Nordhaus, And Daigee Shaw

- American Economic Review, 1994

- They measure the economic impact of climate on land prices.

- They find that higher temperatures in all seasons except autumn reduce average farm values, while more precipitation outside of autumn increases farm values.

The Impact of Global Warming on Agriculture:
A Ricardian Analysis

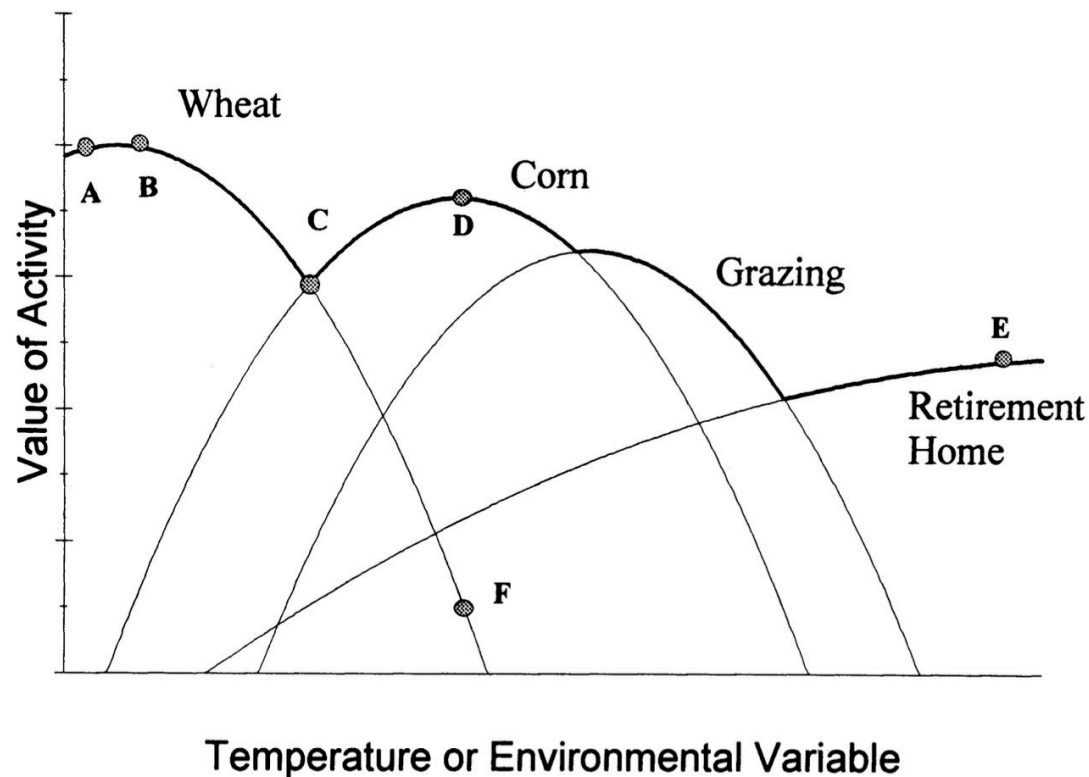• The *Ricardian approach* implies that, under competitive markets, the land rent will be equal to the net yield of the highest and best use of the land.

FIGURE 1. BIAS IN PRODUCTION-FUNCTION STUDIES