Chapter 14

TRADITIONAL MODELS OF IMPERFECT COMPETITION

Pricing Under Homogeneous Oligopoly

- We will assume that the market is perfectly competitive on the demand side
  - there are many buyers, each of whom is a price taker
- We will assume that the good obeys the law of one price
  - this assumption will be relaxed when product differentiation is discussed

Pricing Under Homogeneous Oligopoly

- We will assume that there is a relatively small number of identical firms (n)
  - we will initially start with n fixed, but later allow n to vary through entry and exit in response to firms' profitability
- The output of each firm is q_i (i=1,…,n)
  - symmetry in costs across firms will usually require that these outputs are equal

Pricing Under Homogeneous Oligopoly

- The inverse demand function for the good shows the price that buyers are willing to pay for any particular level of industry output

$$P = f(Q) = f(q_1+q_2+\ldots+q_n)$$

- Each firm's goal is to maximize profits

$$\pi_i = f(Q)q_i - C_i(q_i)$$

$$\pi_i = f(q_1+q_2+\ldots q_n)q_i - C_i$$

Oligopoly Pricing Models

- The quasi-competitive model assumes price-taking behavior by all firms
  - *P* is treated as fixed
- The cartel model assumes that firms can collude perfectly in choosing industry output and *P*

Oligopoly Pricing Models

- The Cournot model assumes that firm *i* treats firm *j*'s output as fixed in its decisions
  - $\partial q_j / \partial q_i = 0$
- The conjectural variations (推测变化) model assumes that firm *j*'s output will respond to variations in firm *i*'s output
  - $\partial q_j / \partial q_i \neq 0$

Quasi-Competitive Model (skipped)

- Each firm is assumed to be a price taker
- The first-order condition for profit-maximization is

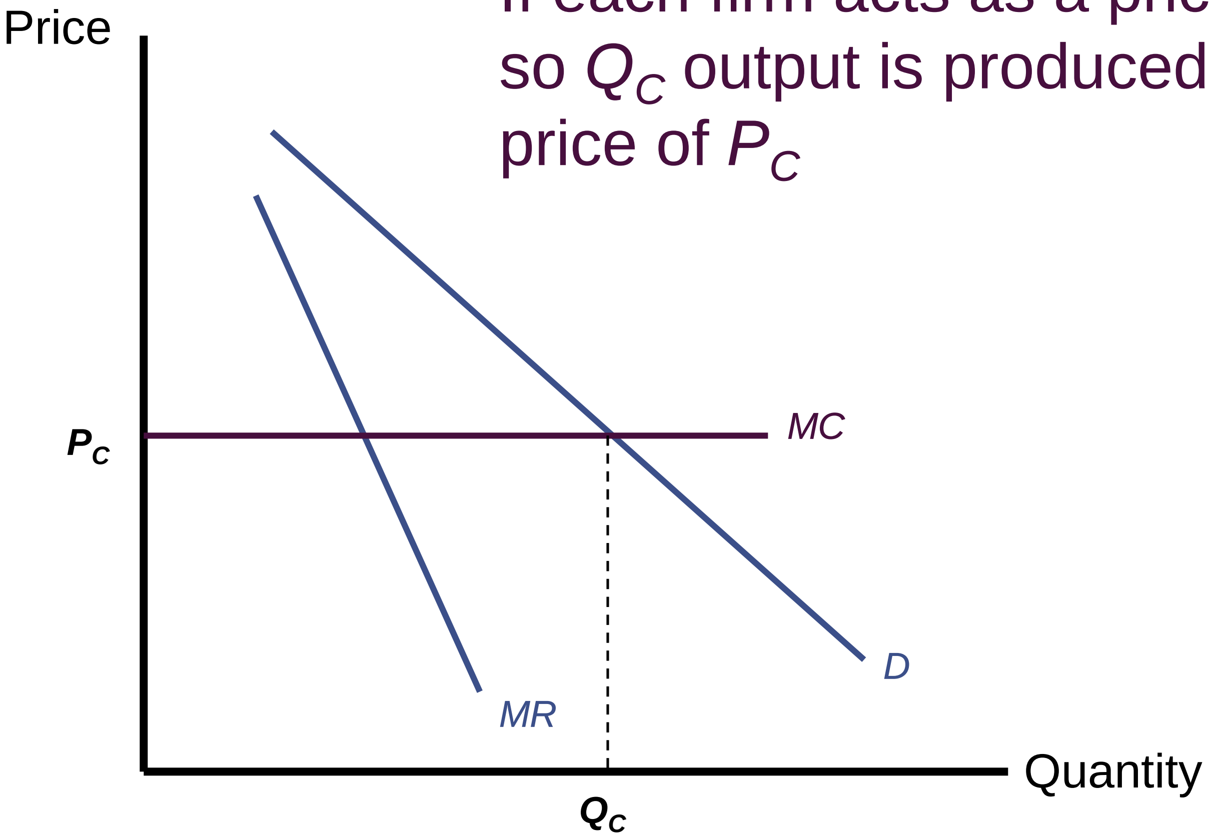
$$\partial \pi_i / \partial q_i = P - (\partial C_i / \partial q_i) = 0$$

$$P = MC_i(q_i) \quad (i=1,\ldots,n)$$

- Along with market demand, these *n* supply equations will ensure that this market ends up at the short-run competitive solution

Quasi-Competitive Model

If each firm acts as a price taker, $P = MC_i$ so Q_C output is produced and sold at a price of P_C



Cartel Model

- The assumption of price-taking behavior may be inappropriate in oligopolistic industries
  - each firm can recognize that its output decision will affect price
- An alternative assumption would be that firms act as a group and coordinate their decisions so as to achieve monopoly profits

Cartel Model

- In this case, the cartel acts as a multiplant monopoly and chooses q_i for each firm so as to maximize total industry profits

$$\pi = PQ - [C_1(q_1) + C_2(q_2) + \ldots + C_n(q_n)]$$

$$\pi = f(q_1 + q_2 + \ldots + q_n)[q_1 + q_2 + \ldots + q_n] - \sum_{i=1}^{n} C_i(q_i)$$

Cartel Model

- The first-order conditions for a maximum are that

$$\frac{\partial \pi}{\partial q_i} = P + (q_1 + q_2 + \ldots + q_n)\frac{\partial P}{\partial q_i} - MC(q_i) = 0$$

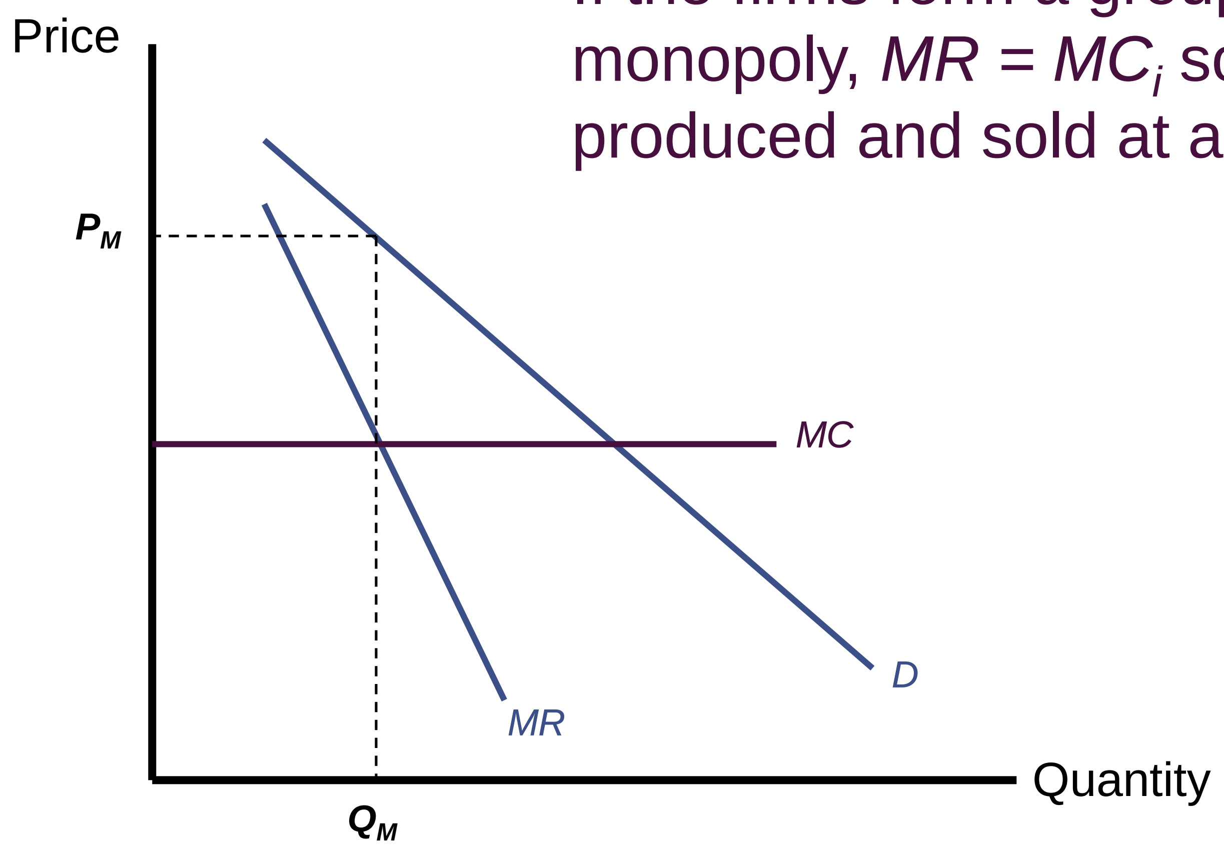
- This implies that

$$MR(Q) = MC_i(q_i)$$

- At the profit-maximizing point, marginal revenue will be equal to each firm's marginal cost

Cartel Model

If the firms form a group and act as a monopoly, $MR = MC_i$ so Q_M output is produced and sold at a price of P_M



Cartel Model

- There are three problems with the cartel solution
  - these monopolistic decisions may be illegal
  - it requires that the directors of the cartel know the market demand function and each firm's marginal cost function
  - the solution may be unstable
    - each firm has an incentive to expand output because $P > MC_i$

Cournot Model

- Each firm recognizes that its own decisions about q_i affect price
  - $\partial P / \partial q_i \neq 0$
- However, each firm believes that its decisions do not affect those of any other firm
  - $\partial q_j / \partial q_i = 0$ for all $j \neq i$

Cournot Model

- The first-order conditions for a profit maximization are

$$\frac{\partial \pi_i}{\partial q_i} = P + q_i \frac{\partial P}{\partial q_i} - MC_i(q_i) = 0$$

- The firm maximizes profit where $MR_i = MC_i$
  - the firm assumes that changes in q_i affect its total revenue only through their direct effect on market price

Cournot Model

- Each firm's output will exceed the cartel output
  - the firm-specific marginal revenue is larger than the market-marginal revenue
- Each firm's output will fall short of the competitive output
  - $q_i \cdot \partial P / \partial q_i < 0$

Cournot Model

- Price will exceed marginal cost, but industry profits will be lower than in the cartel model
- The greater the number of firms in the industry, the closer the equilibrium point will be to the competitive result

Cournot's Natural Springs Duopoly

- Assume that there are two owners of natural springs
  - each firm has no production costs
  - each firm has to decide how much water to supply to the market
- The demand for spring water is given by the linear demand function

$$Q = q_1 + q_2 = 120 - P$$

Cournot's Natural Springs Duopoly

- Because each firm has zero marginal costs, the quasi-competitive solution will result in a market price of zero
  - total demand will be 120
  - the division of output between the two firms is indeterminate
    - each firm has zero marginal cost over all output ranges

Cournot's Natural Springs Duopoly

- The cartel solution to this problem can be found by maximizing industry revenue (and profits)

$$\pi = PQ = 120Q - Q^2$$

- The first-order condition is

$$\partial\pi/\partial Q = 120 - 2Q = 0$$

Cournot's Natural Springs Duopoly

- The profit-maximizing output, price, and level of profit are

$$Q = 60$$

$$P = 60$$

$$\pi = 3{,}600$$

- The precise division of output and profits is indeterminate

Cournot's Natural Springs Duopoly

- The two firms' revenues (and profits) are given by

$$\pi_1 = Pq_1 = (120 - q_1 - q_2)\, q_1 = 120q_1 - q_1^2 - q_1q_2$$

$$\pi_2 = Pq_2 = (120 - q_1 - q_2)\, q_2 = 120q_2 - q_2^2 - q_1q_2$$

- First-order conditions for a maximum are

$$\frac{\partial \pi_1}{\partial q_1} = 120 - 2q_1 - q_2 = 0 \qquad \frac{\partial \pi_2}{\partial q_2} = 120 - 2q_2 - q_1 = 0$$

Cournot's Natural Springs Duopoly

- These first-order equations are called reaction functions
  - show how each firm reacts to the other's output level
- In equilibrium, each firm must produce what the other firm thinks it will

Cournot's Natural Springs Duopoly

- We can solve the reaction functions simultaneously to find that

$$q_1 = q_2 = 40$$

$$P = 120 - (q_1 + q_2) = 40$$

$$\pi_1 = \pi_2 = Pq_1 = Pq_2 = 1{,}600$$

- Note that the Cournot equilibrium falls between the quasi-competitive model and the cartel model

Conjectural Variations Model

- In markets with only a few firms, we can expect there to be strategic interaction among firms
- One way to build strategic concerns into our model is to consider the assumptions that might be made by one firm about the other firm's behavior

Conjectural Variations Model

- For each firm *i*, we are concerned with the assumed value of $\partial q_j / \partial q_i$ for $i \neq j$
  - because the value will be speculative, models based on various assumptions about its value are termed conjectural variations models
    - they are concerned with firm *i*'s conjectures about firm *j*'s output variations

Conjectural Variations Model

- The first-order condition for profit maximization becomes

$$\frac{\partial \pi_i}{\partial q_i} = P + q_i \left[\frac{\partial P}{\partial q_i} + \sum_{j \neq i} \frac{\partial P}{\partial q_j} \cdot \frac{\partial q_j}{\partial q_i} \right] - MC_i(q_i) = 0$$

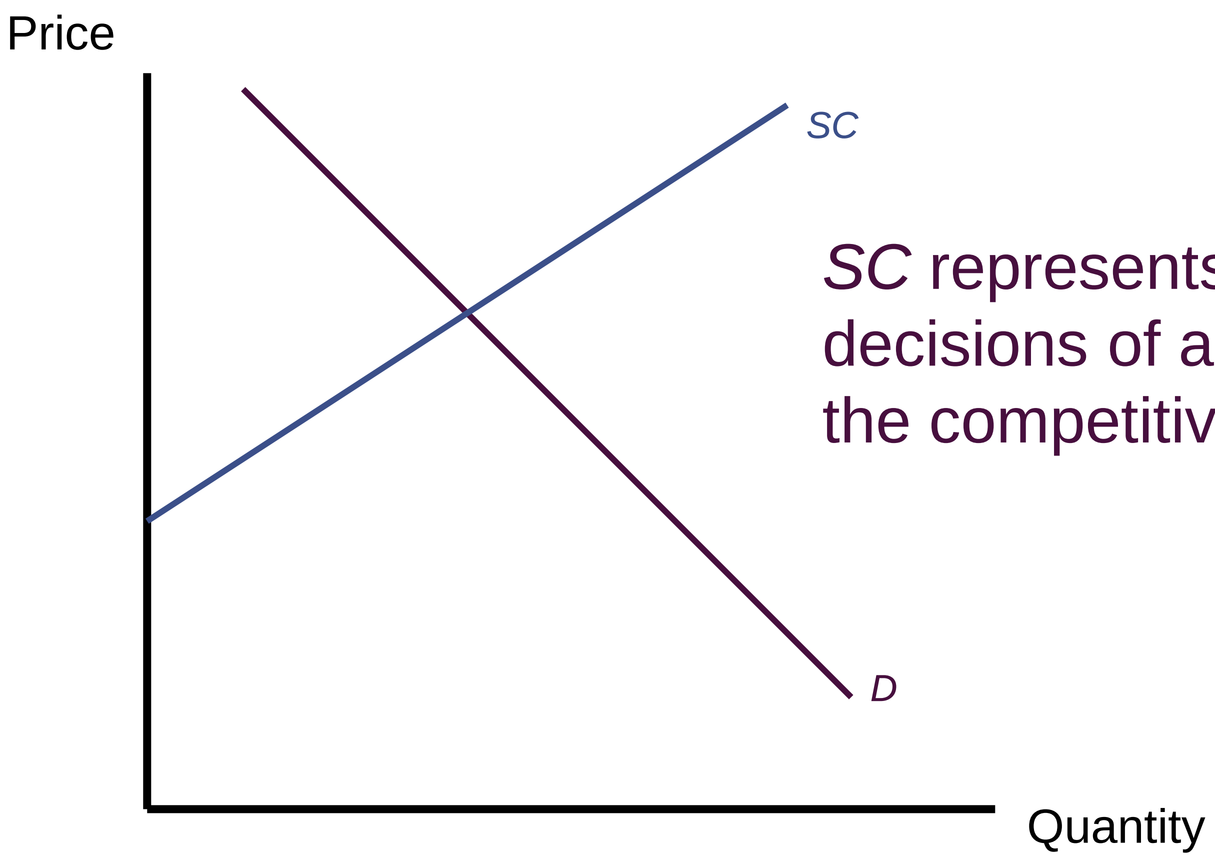
- The firm must consider how its output decisions will affect price in two ways
  – directly
  – indirectly through its effect on the output decisions of other firms

Price Leadership Model

- Suppose that the market is composed of a single price leader (firm 1) and a fringe of quasi-competitors
  - firms 2,…,n would be price takers
  - firm 1 would have a more complex reaction function, taking other firms' actions into account

Price Leadership Model

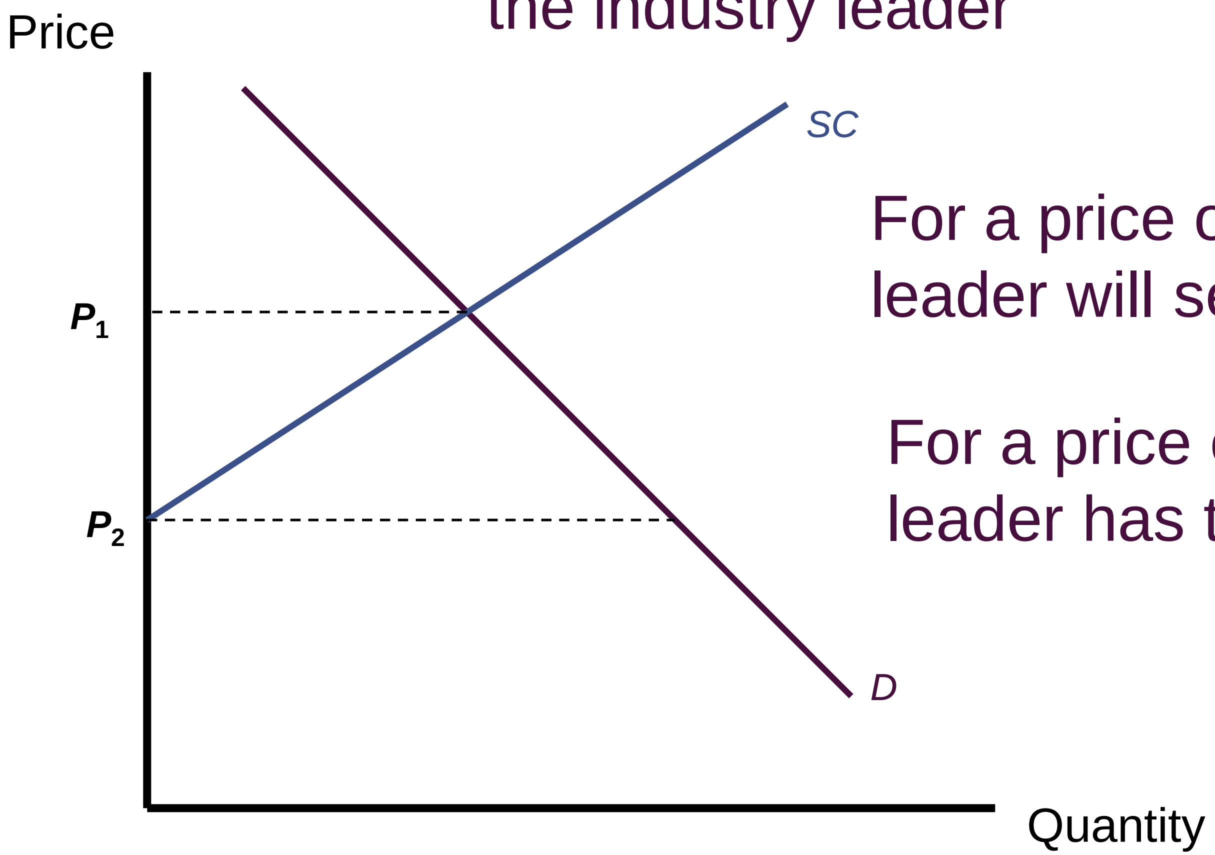
D represents the market demand curve



SC represents the supply decisions of all of the *n*-1 firms in the competitive fringe

Price Leadership Model

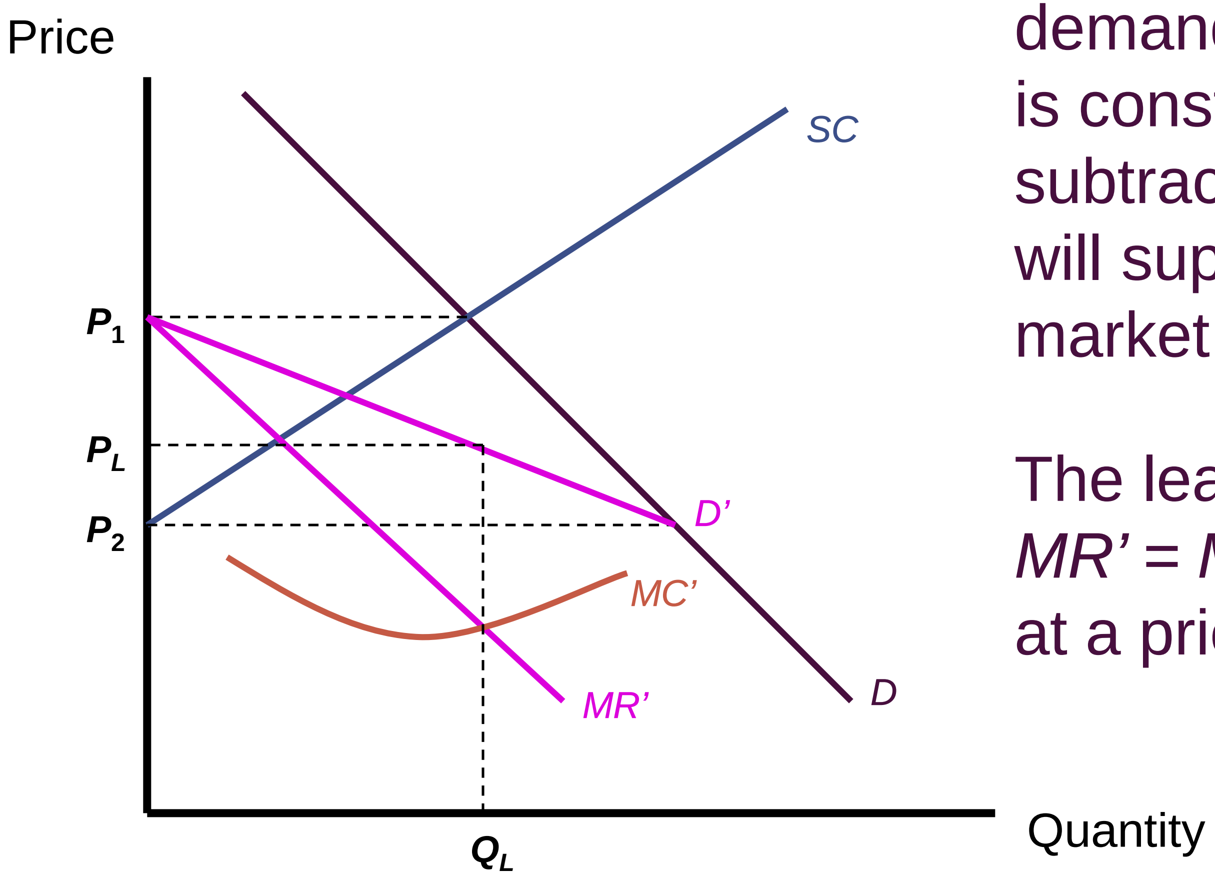
We can derive the demand curve facing the industry leader



For a price of P_1 or above, the leader will sell nothing

For a price of P_2 or below, the leader has the market to itself

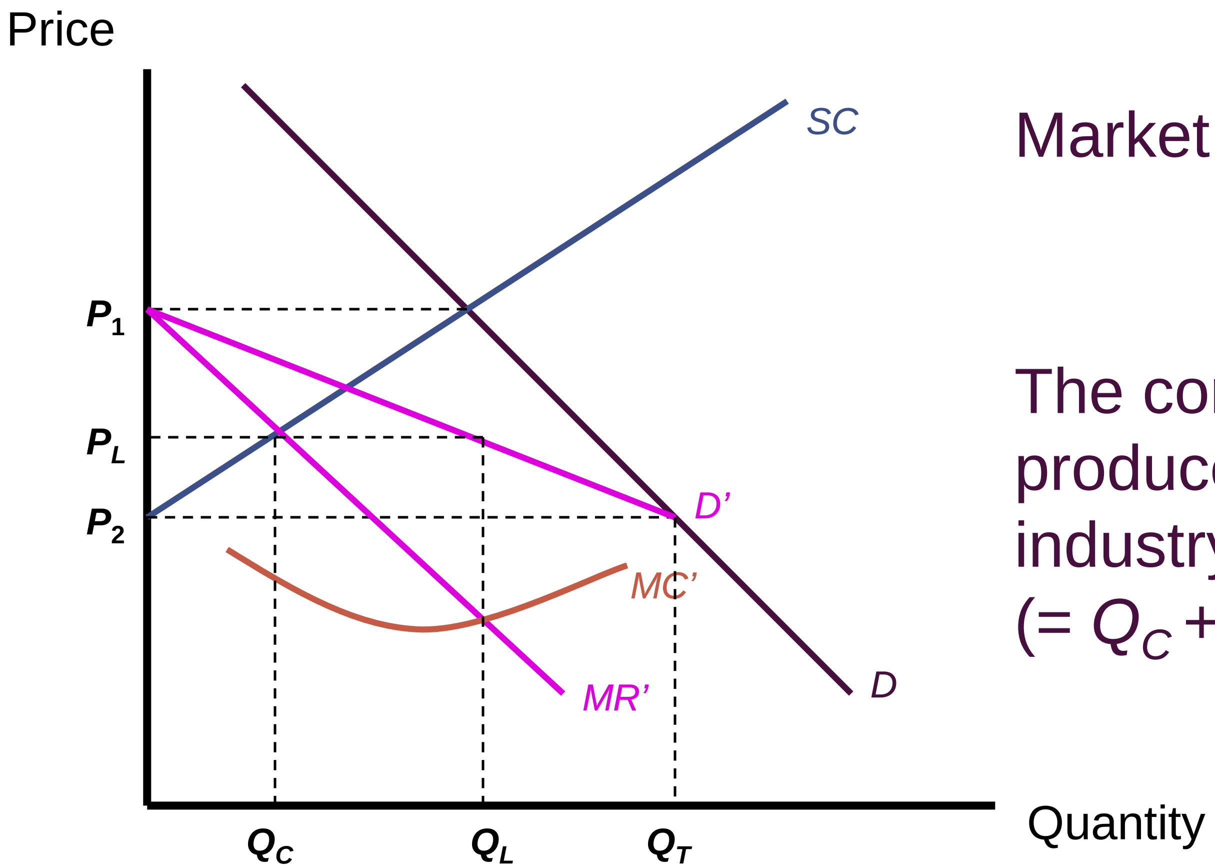
Price Leadership Model



Between P_2 and P_1, the demand for the leader *(D')* is constructed by subtracting what the fringe will supply from total market demand

The leader would then set *MR'* = *MC'* and produce Q_L at a price of P_L

Price Leadership Model



Market price will then be P_L

The competitive fringe will produce Q_C and total industry output will be Q_T ($= Q_C + Q_L$)

Price Leadership Model

- This model does not explain how the price leader is chosen or what happens if a member of the fringe decides to challenge the leader
- The model does illustrate one tractable example of the conjectural variations model that may explain pricing behavior in some instances

Stackelberg Leadership Model

- The assumption of a constant marginal cost makes the price leadership model inappropriate for Cournot's natural spring problem
  - the competitive fringe would take the entire market by pricing at marginal cost (= 0)
  - there would be no room left in the market for the price leader

Stackelberg Leadership Model

- There is the possibility of a different type of strategic leadership
- Assume that firm 1 knows that firm 2 chooses q_2 so that

$$q_2 = (120 - q_1)/2$$

- Firm 1 can now calculate the conjectural variation

$$\partial q_2/\partial q_1 = -1/2$$

Stackelberg Leadership Model

- This means that firm 2 reduces its output by ½ unit for each unit increase in q_1
- Firm 1's profit-maximization problem can be rewritten as

$$\pi_1 = Pq_1 = 120q_1 - q_1^2 - q_1q_2$$

$$\partial\pi_1/\partial q_1 = 120 - 2q_1 - q_1(\partial q_2/\partial q_1) - q_2 = 0$$

$$\partial\pi_1/\partial q_1 = 120 - (3/2)q_1 - q_2 = 0$$

Stackelberg Leadership Model

- Solving this simultaneously with firm 2's reaction function, we get

$$q_1 = 60$$

$$q_2 = 30$$

$$P = 120 - (q_1 + q_2) = 30$$

$$\pi_1 = Pq_1 = 1{,}800$$

$$\pi_2 = Pq_2 = 900$$

- Again, there is no theory on how the leader is chosen

Product Differentiation

- Firms often devote considerable resources to differentiating their products from those of their competitors
  - quality and style variations
  - warranties and guarantees
  - special service features
  - product advertising

Product Differentiation

- The law of one price may not hold, because demanders may now have preferences about which suppliers to purchase the product from
  - there are now many closely related, but not identical, products to choose from
- We must be careful about which products we assume are in the same market

Product Differentiation (skipped)

- The output of a set of firms constitute a product group if the substitutability in demand among the products (as measured by the cross-price elasticity) is very high relative to the substitutability between those firms' outputs and other goods generally

Product Differentiation

- We will assume that there are n firms competing in a particular product group
  - each firm can choose the amount it spends on attempting to differentiate its product from its competitors (z_i)
- The firm's costs are now given by

$$\text{total costs} = C_i(q_i, z_i)$$

Product Differentiation

- Because there are n firms competing in the product group, we must allow for different market prices for each $(p_1,...,p_n)$
- The demand facing the ith firm is

$$p_i = g(q_i,p_j,z_i,z_j)$$

- Presumably, $\partial p_i/\partial q_i \leq 0$, $\partial p_i/\partial p_j \geq 0$, $\partial p_i/\partial z_i \geq 0$, and $\partial p_i/\partial z_j \leq 0$

Product Differentiation

- The *i*th firm's profits are given by

$$\pi_i = p_i q_i - C_i(q_i, z_i)$$

- In the simple case where $\partial z_j/\partial q_i$, $\partial z_j/\partial z_i$, $\partial p_j/\partial q_i$, and $\partial p_j/\partial z_i$ are all equal to zero, the first-order conditions for a maximum are

$$\frac{\partial \pi_i}{\partial q_i} = p_i + q_i \frac{\partial p_i}{\partial q_i} - \frac{\partial C_i}{\partial q_i} = 0$$

$$\frac{\partial \pi_i}{\partial z_i} = q_i \frac{\partial p_i}{\partial z_i} - \frac{\partial C_i}{\partial z_i} = 0$$

Product Differentiation

- At the profit-maximizing level of output, marginal revenue is equal to marginal cost
- Additional differentiation activities should be pursued up to the point at which the additional revenues they generate are equal to their marginal costs

Product Differentiation

- The demand curve facing any one firm may shift often
  - it depends on the prices and product differentiation activities of its competitors
- The firm must make some assumptions in order to make its decisions
- The firm must realize that its own actions may influence its competitors' actions

Spatial Differentiation (skipped)

- Suppose we are examining the case of ice cream stands located on a beach
  - assume that demanders are located uniformly along the beach
    - one at each unit of beach
    - each buyer purchases exactly one ice cream cone per period
  - ice cream cones are costless to produce but carrying them back to one's place on the beach results in a cost of c per unit traveled

Spatial Differentiation

Ice cream stands are located at points *A* and *B* along a linear beach of length *L*

Suppose that a person is standing at point *E*

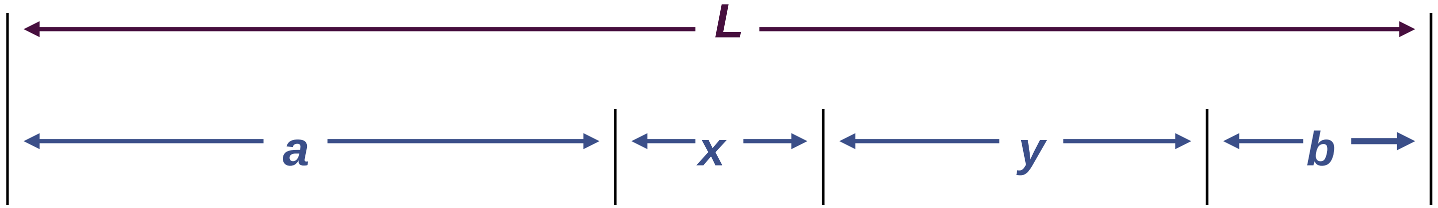
Spatial Differentiation

- A person located at point *E* will be indifferent between stands *A* and *B* if

$$p_A + cx = p_B + cy$$

where p_A and p_B are the prices charged by each stand, x is the distance from *E* to *A*, and y is the distance from *E* to *B*

Spatial Differentiation



$$a + x + y + b = L$$

Spatial Differentiation

- The coordinate of point *E* is

$$x = \frac{p_B - p_A + cy}{c}$$

$$x = \frac{p_B - p_A}{c} + L - a - b - x$$

$$x = \frac{1}{2}\left(L - a - b + \frac{p_B - p_A}{c}\right)$$

$$y = \frac{1}{2}\left(L - a - b + \frac{p_A - p_B}{c}\right)$$

Spatial Differentiation

- Profits for the two firms are

$$\pi_A = p_A(a + x) = \frac{1}{2}(L + a - b)p_A + \frac{p_A p_B - p_A^2}{2c}$$

$$\pi_B = p_B(b + y) = \frac{1}{2}(L - a + b)p_B + \frac{p_A p_B - p_B^2}{2c}$$

Spatial Differentiation

- Each firm will choose its price so as to maximize profits

$$\frac{\partial \pi_A}{\partial p_A} = \frac{1}{2}(L + a - b) + \frac{p_B}{2c} - \frac{p_A}{c} = 0$$

$$\frac{\partial \pi_B}{\partial p_B} = \frac{1}{2}(L - a + b) + \frac{p_A}{2c} - \frac{p_B}{c} = 0$$

Spatial Differentiation

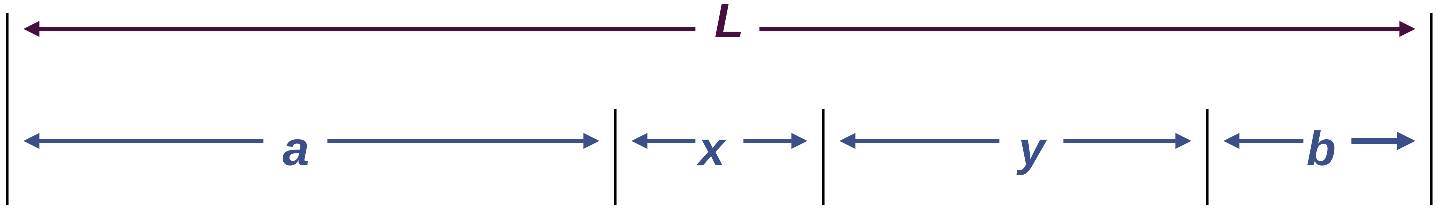
- These can be solved to yield:

$$p_A = c\left(L + \frac{a-b}{3}\right)$$

$$p_B = c\left(L - \frac{a-b}{3}\right)$$

- These prices depend on the precise locations of the stands and will differ from one another

Spatial Differentiation



Because *A* is somewhat more favorably located than *B*, p_A will exceed p_B

Spatial Differentiation

- If we allow the ice cream stands to change their locations at zero cost, each stand has an incentive to move to the center of the beach
  - any stand that opts for an off-center position is subject to its rival moving between it and the center and taking a larger share of the market
    - this encourages a similarity of products

Entry (skipped)

- In perfect competition, the possibility of entry ensures that firms will earn zero profit in the long run
- These conditions continue to operate under oligopoly
  - to the extent that entry is possible, long-run profits are constrained
  - if entry is completely costless, long-run profits will be zero

Entry

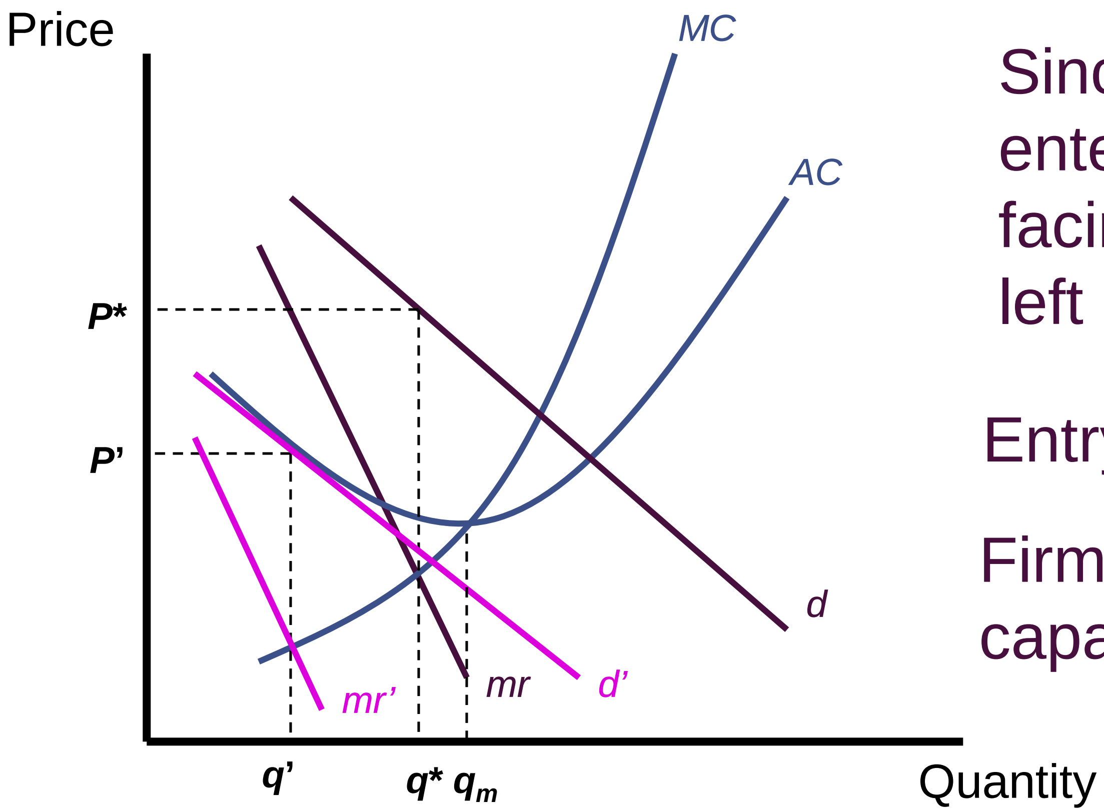
- Whether firms in an oligopolistic industry with free entry will be directed to the point of minimum average cost depends on the nature of the demand facing them

Entry

- If firms are price takers:
  - $P = MR = MC$ for profit maximization, $P = AC$ for zero profits, so production takes place at $MC = AC$
- If firms have some control over price:
  - each firm will face a downward-sloping demand curve
  - entry may reduce profits to zero, but production at minimum average cost is not ensured

Entry

Firms will initially be maximizing profits at q^*. Since $P > AC$, $\pi > 0$



Since $\pi > 0$, firms will enter and the demand facing the firm will shift left

Entry will end when $\pi = 0$

Firms will exhibit excess capacity = $q_m - q'$

Monopolistic Competition (skipped)

- The zero-profit equilibrium model just shown was developed by Chamberlin who termed it monopolistic competition
  - – each firm produces a slightly differentiated product and entry is costless
- Suppose that there are *n* firms in a market and that each firm has the total cost schedule

$$c_i = 9 + 4q_i$$

Monopolistic Competition

- Each firm also faces a demand curve for its product of the form:

$$q_i = -0.01(n-1)p_i + 0.01\sum_{j \neq i} p_j + \frac{303}{n}$$

- We will define an equilibrium for this industry to be a situation in which prices must be equal
  - $p_i = p_j$ for all i and j

Monopolistic Competition

- To find the equilibrium *n*, we must examine each firm's profit-maximizing choice of p_i
- Because

$$\pi_i = p_i q_i - c_i$$

the first-order condition for a maximum is

$$\frac{\partial \pi_i}{\partial p_i} = -0.02(n-1)p_i + 0.01\sum_{j \neq i} p_j + \frac{303}{n} + 0.04(n-1) = 0$$

Monopolistic Competition

- This means that

$$p_i = \frac{0.5\sum_{j \neq i} p_j}{n-1} + \frac{303}{0.02(n-1)n} + 2$$

- Applying the equilibrium condition that $p_i = p_j$ yields

$$p_i = \frac{30{,}300}{(n-1)n} + 4$$

- *P* approaches *MC* (4) as *n* gets larger

Monopolistic Competition

- The equilibrium n is determined by the zero-profit condition

$$p_i q_i - c_i = 0$$

- Substituting in the expression for p_i, we find that

$$\frac{30{,}300 \cdot 303}{n^2(n-1)} + \frac{4(303)}{n} = 9 + \frac{4(303)}{n}$$

$$n = 101$$

Monopolistic Competition

- The final equilibrium is

$$p_i = p_j = 7$$

$$q_i = 3$$

$$\pi_i = 0$$

- In this equilibrium, each firm has $p_i = AC_i$, but $p_i > MC_i = 4$
- Because $AC_i = 4 + 9/q_i$, each firm has diminishing AC throughout all output ranges

Monopolistic Competition

- If each firm faces a similar demand function, this equilibrium is sustainable
  - – no firm would find it profitable to enter this industry
- But what if a potential entrant adopted a large-scale production plan?
  - – the low average cost may give the potential entrant considerable leeway in pricing so as to tempt customers of existing firms to switch allegiances

Contestable Markets and Industry Structure (skipped)

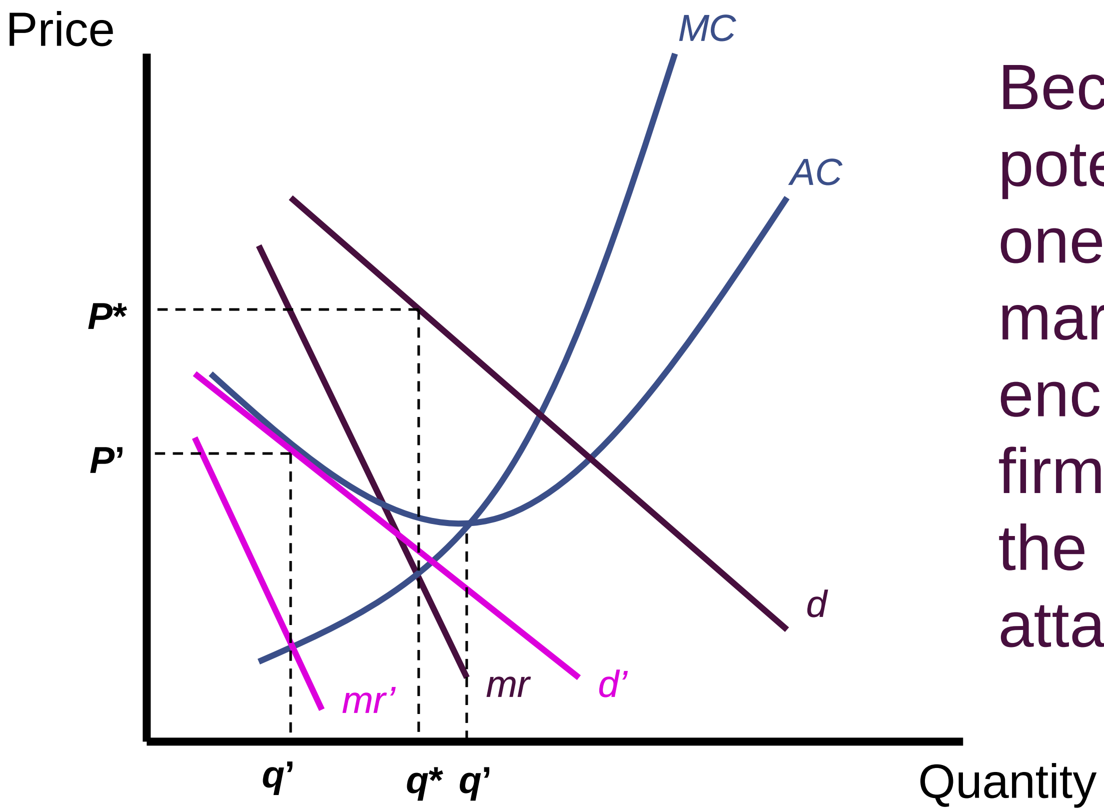
- Several economists have challenged that this zero-profit equilibrium is sustainable in the long run
  - the model ignores the effects of *potential entry* on market equilibrium by focusing only on actual entrants
  - need to distinguish between competition *in* the market and competition *for* the market

Perfectly Contestable Market

- A market is perfectly contestable if entry and exit are absolutely free
  - no outside potential competitor can enter by cutting price and still make a profit
    - if such profit opportunities existed, potential entrants would take advantage of them

Perfectly Contestable Market

This market would be unsustainable in a perfectly contestable market



Because *P* > *MC*, a potential entrant can take one zero-profit firm’s market away and encroach a bit on other firms’ markets where, at the margin, profits are attainable

Perfectly Contestable Market

- Therefore, to be perfectly contestable, the market must be such that firms earn zero profits and price at marginal costs
  - firms will produce at minimum average cost
  - $P = AC = MC$
- Perfect contestability guides market equilibrium to a competitive-type result

Perfectly Contestable Market

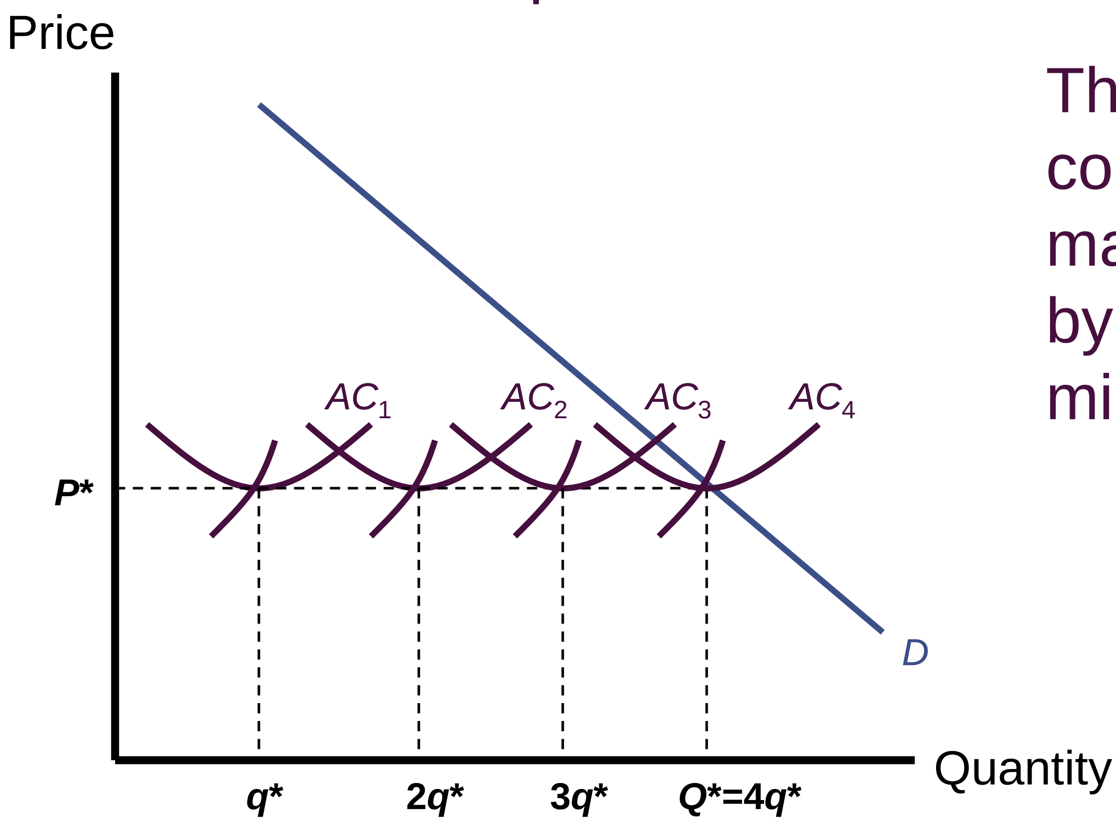
- If we let q^* represent the output level for which average costs are minimized and Q^* represent the total market demand when price equals average cost, then the equilibrium number of firms in the industry is given by

$$n = Q^*/q^*$$

  - this number may be relatively small (unlike the perfectly competitive case)

Perfectly Contestable Market

In a perfectly contestable market, equilibrium requires that $P = MC = AC$



The number of firms is completely determined by market demand (*Q**) and by the output level that minimizes *AC* (*q**)

Barriers to Entry

- If barriers to entry prevent free entry and exit, the results of this model must be modified
  – barriers to entry can be the same as those that lead to monopolies or can be the result of some of the features of oligopolistic markets
    - product differentiation
    - strategic pricing decisions

Barriers to Entry

- The completely flexible type of hit-and-run behavior assumed in the contestable markets theory may be subject to barriers to entry
  - some types of capital investments may not be reversible
  - demanders may not respond to price differentials quickly

A Contestable Natural Monopoly

- Suppose that the total cost of producing electric power is given by

$$C(Q) = 100Q + 8{,}000$$

  – since *AC* declines over all output ranges, this is a natural monopoly

- The demand for electricity is given by

$$Q_D = 1{,}000 - 5P$$

A Contestable Natural Monopoly

- If the producer behaves as a monopolist, it will maximize profits by

$$MR = 200 - (2Q)/5 = MC = 100$$

$$Q_m = 250$$

$$P_m = 150$$

$$\pi_m = R - C = 37{,}500 - 33{,}000 = 4{,}500$$

- These profits will be tempting to would-be entrants

A Contestable Natural Monopoly

- If there are no entry barriers, a potential entrant can offer electricity customers a lower price and still cover costs
  - this monopoly solution might not represent a viable equilibrium

A Contestable Natural Monopoly

- If electricity production is fully contestable, the only price viable under threat of potential entry is average cost

$$Q = 1{,}000 - 5P = 1{,}000 - 5(AC)$$

$$Q = 1{,}000 - 5[100 + (8{,}000/Q)]$$

$$Q^2 - 500Q + 40{,}000 = 0$$

$$(Q - 400)(Q - 100) = 0$$

A Contestable Natural Monopoly

- Only $Q = 400$ is a sustainable entry deterrent
- Under contestability, the market equilibrium is

$$Q_c = 400$$

$$P_c = 120$$

- Contestability increased consumer welfare from what it was under the monopoly situation

Important Points to Note:

- Markets with few firms offer potential profits through the formation of a monopoly cartel
  - such cartels may, however, be unstable and costly to maintain because each member has an incentive to chisel on price

Important Points to Note:

- In markets with few firms, output and price decisions are interdependent
  - each firm must consider its rivals' decisions
  - modeling such interdependence is difficult because of the need to consider conjectural variations

Important Points to Note:

- The Cournot model provides a tractable approach to oligopoly markets, but neglects important strategic issues

Important Points to Note:

- Product differentiation can be analyzed in a standard profit-maximization framework
  - with differentiated products, the law of one price no longer holds and firms may have somewhat more leeway in their pricing decisions

Important Points to Note:

- Entry conditions are important determinants of the long-run sustainability of various market equilibria
  - with perfect contestability, equilibria may resemble perfectly competitive ones even though there are relatively few firms in the market