Chapter 13

Oligopoly and Monopolistic Competition

Chapter Outline

- Some Specific Oligopoly Models: Cournot, Bertrand and Stackelberg
- Competition When There are Increasing Returns to Scale
- Monopolistic Competition
- A Spatial Interpretation of Monopolistic Competition
- Historical Note: Hotelling’s Hot Dog Vendors
- Consumer Preferences and Advertising
Models of Oligopoly

• An **oligopoly** is a market with only a few important sellers.
  – A **duopoly** is an oligopoly with only two firms.
• Compared to perfect competition
  – Firms face downward sloping demand and thus can choose their price.
  – The market contains sufficiently few firms that each firm recognizes that the price it will receive for its output depends on how much output it chooses to produce.

Models of Oligopoly

• Compared to monopoly
  – An oligopoly has more than one firm. Hence, in an oligopoly, the optimal decision of one firm depends on the decision made by other firms in the market.
  – Such strategic interaction between firms does not occur in a monopoly since no other firms exist in the market (except interaction with a potential entrant).
Cournot Model

- **Cournot model**: oligopoly model in which each firm assumes that rivals will continue producing their current output levels.
  - Firms pick quantities simultaneously.
  - Each firm treats the other’s quantity as a fixed number, one that will not respond to its own production decisions.

Cournot Model

- Each firm chooses its quantity of output to maximize its profits, taking the other firm’s output as given.
- Given the rival’s quantity, the firm maximizes its profits by picking the quantity where marginal revenue equals marginal cost $MR = MC$ (like a monopolist facing the residual demand curve).
- Each firm’s quantity depends on the quantity of its rival, a relationship known as a reaction curve.
- The equilibrium quantities for the two firms occur at intersection of the two reaction curves, one for each firm.
Residual Demand Curve

• Figure 13.1 shows how to determine a Cournot duopolist’s optimal output, for a given output of the other firm, based on the residual demand curve.
• The residual demand curve is the portion of the market demand curve that remains for the first firm after the second firm has already sold its output.

Cournot Duopoly

• The residual demand curve facing the first firm is found by shifting the vertical axis over to the right by the amount of the second firm’s output $Q_2$.
• For the linear demand curve $P = a - bQ$, the residual demand curve facing the first firm would be

$$P = a - bQ$$
$$= a - b(Q_1 + Q_2)$$
$$= a - bQ_2 - bQ_1$$

where $a - bQ_2$ is the price intercept.
Cournot Duopoly

- The marginal revenue curve for the first firm is found as if the first firm were a monopolist facing the residual demand curve $P = a - bQ_2 - bQ_1$
  - marginal revenue has the same intercept but twice the slope. curve $MR = a - 2bQ_2 - 2bQ_1$
- Remember to double only the coefficient on the first firm’s output (not the output of the other firm).
- Graphically, the marginal revenue curve departs from the demand curve at the point $Q = Q_2$ and $P = a - bQ_2$, where the first firm produces no output.

Cournot Duopoly

- Figure 13.1 covers the special case of linear demand with zero marginal cost.
- To maximize profits, set $MC = MR$ and solve for $Q_1$:
  
  $0 = a - bQ_2 - 2bQ_1$
  $2bQ_1 = a - bQ_2$
  $Q_1 = \frac{a}{2b} - \frac{1}{2}Q_2$
Cournot Model

- **Reaction function**: a curve that tells the profit-maximizing level of output for one oligopolist for each amount supplied by another.
Cournot Duopoly

• For Cournot duopoly with linear demand and zero marginal costs, the reaction function for firm one is
  \[ R_1(Q_2) = Q_1 = \frac{a}{2b} - \frac{1}{2}Q_2 \]

• The reaction function for firm two is correspondingly
  \[ R_2(Q_1) = Q_2 = \frac{a}{2b} - \frac{1}{2}Q_1 \]

On a graph of output of firm one versus output of firm two, the reaction curve for firm one \( R_1(Q_2) = Q_1 = \frac{a}{2b} - \frac{1}{2}Q_2 \) has

– vertical intercept \( Q_1 = \frac{a}{2b} \) when \( Q_2 = 0 \) and
– horizontal intercept \( Q_2 = \frac{a}{b} \) when \( Q_1 = 0 \).

• And similarly for the reaction function for firm two.
Cournot Duopoly

- To find the equilibrium output of firm one and of firm two where the two reaction functions intersect, solve $Q_2 = \frac{a}{2b} - \frac{1}{2} Q_1$ for $Q_1 = \frac{a}{b} - 2Q_2$

then set equal to

$$Q_1 = \frac{a}{2b} - \frac{1}{2} Q_2$$

$$\frac{a}{b} - 2Q_2 = \frac{a}{2b} - \frac{1}{2} Q_2$$

$$\frac{3}{2} Q_2 = \frac{a}{2b}$$

$$Q_1 = Q_2 = \frac{a}{3b}$$

Cournot Duopoly

- Or alternatively insert $Q_2 = \frac{a}{2b} - \frac{1}{2} Q_1$ into

$$Q_1 = \frac{a}{2b} - \frac{1}{2} Q_2$$

$$Q_1 = \frac{a}{2b} - \frac{1}{2} \left( \frac{a}{2b} - \frac{1}{2} Q_1 \right)$$

$$\frac{3}{4} Q_1 = \frac{a}{4b}$$

$$Q_1 = Q_2 = \frac{a}{3b}$$
Cournot Duopoly

- With quantity of each firm $Q_1 = Q_2 = \frac{a}{3b}$
- Total quantity $Q = Q_1 + Q_2 = \frac{2a}{3b}$
- Price $P = a - bQ = a - b \left( \frac{2a}{3b} \right) = \frac{a}{3}$
- Profit $TR - TC = PQ - 0 = \frac{a}{3b} \left( \frac{a}{3} \right) = \frac{a^2}{9b}$
- Industry Profit $\frac{2a^2}{9b}$

Monopoly

- A monopoly facing the same linear demand with zero marginal costs would produce quantity $Q_m = \frac{a}{2b}$, charge price $P_m = \frac{a}{2}$, and profit $\frac{a^2}{4b}$.
- Compared to a shared monopoly where each firm would produce half of $Q_m$, a Cournot duopoly produces more, charges a lower price, and earns less profit.
Figure 13.2: Reaction Functions for Cournot Duopolists

Cournot Duopoly $P = 56 - 2Q$

- Suppose have linear demand curve $P = 56 - 2Q$ with constant marginal cost $MC = 20$.
- Firm one’s marginal revenue
  $$MR = 56 - 2Q_2 - 4Q_1$$
- Set marginal revenue equal to marginal cost and solve for firm one’s output in terms of firm two’s output (firm one’s reaction curve)
  $$20 = 56 - 2Q_2 - 4Q_1$$
  $$R_1(Q_2) = Q_1 = 9 - \frac{1}{2}Q_2$$
Cournot Duopoly $P = 56 - 2Q$

- By symmetry, firm two’s reaction curve is
  \[ R_2(Q_1) = Q_2 = 9 - \frac{1}{2}Q_1 \]
- Substitute firm two’s reaction curve into firm one's to find firm one’s optimal quantity
  \[ Q_1 = 9 - \frac{1}{2}Q_2 \]
  \[ Q_1 = 9 - \frac{1}{2}\left(9 - \frac{1}{2}Q_1\right) \]
  \[ Q_1 = Q_2 = 6 \]

Cournot Duopoly $P = 56 - 2Q$

- Quantity of each firm $Q_1 = Q_2 = 6$,
- Total quantity $Q = Q_1 + Q_2 = 12$
- Price $P = 56 - 2Q = 56 - 2(12) = 32$
- Profit $(P - c)Q = (32 - 20)6 = 72$
- Industry Profit $2(72) = 144$
Bertrand Model

• **Bertrand model**: oligopoly model in which each firm chooses its price simultaneously, assuming that rivals will continue charging their current prices.
Bertrand Model

• Strategy: If charging more than other firms, sales zero and need to lower price.
  – If charging the same as other firms, split the market so better to charge a tiny amount less and get the whole market.
• Results in all firms charging price equal to cost and earning no profits.

Bertrand Duopoly $P = 56 - 2Q$

• Price $P = MC = 20$
• Total quantity $20 = 56 - 2Q, Q = 18$
• Quantity of each firm $Q_1 = Q_2 = 9$
• Profit $(P - c)Q = (20 - 20)9 = 0$
• Industry Profit $2(0) = 0$
Stackelberg Model

- **Stackelberg model**: oligopoly model in which one firm (the leader) picks its quantity before the other firm (the follower).

Stackelberg Duopoly

- The leader firm 1 knows that follower firm two will pick output according to the Cournot reaction function.
  - For linear demand with zero marginal costs
    \[ Q_2 = \frac{a}{2b} - \frac{1}{2} Q_1 \]
Stackelberg Duopoly

- Residual demand facing the leader is
  \[ P = a - bQ_2 - bQ_1 \]
  \[ P = a - b \left( \frac{a}{2b} - \frac{1}{2} Q_1 \right) - bQ_1 \]
  \[ P = \frac{a}{2} - \frac{b}{2} Q_1 \]

- Marginal revenue
  \[ MR = \frac{a}{2} - bQ_1 \]

Stackelberg Duopoly

- Pick quantity to set marginal revenue for leader equal to zero marginal cost
  \[ 0 = \frac{a}{2} - bQ_1 \]
  \[ Q_1 = \frac{a}{2b} \]

- The follower firm 2 will respond by picking
  \[ Q_2 = \frac{a}{2b} - \frac{1}{2} Q_1 = \frac{a}{2b} - \frac{1}{2} \left( \frac{a}{2b} \right) = \frac{a}{4b} \]
Stackelberg Duopoly

- Total quantity $Q = Q_1 + Q_2 = \frac{a}{2b} + \frac{a}{4b} = \frac{3a}{4b}$
- Price $P = a - bQ = a - b \left(\frac{3a}{4b}\right) = \frac{a}{4}$
- Leader Profit $PQ_1 = \frac{a}{4} \left(\frac{a}{2b}\right) = \frac{a^2}{8b}$
- Follower Profit $PQ_2 = \frac{a}{4} \left(\frac{a}{4b}\right) = \frac{a^2}{16b}$

Industry Profit $\frac{3a^2}{16b}$

Figure 13.4: The Stackelberg Leader’s Demand and Marginal Revenue Curves
Stackelberg Duopoly $P = 56 - 2Q$

- Residual demand facing the leader is
  
  \[ P = 56 - 2Q_2 - 2Q_1 \]
  
  \[ P = 56 - 2 \left(9 - \frac{1}{2}Q_1\right) - 2Q_1 \]
  
  \[ P = 38 - Q_1 \]

- Marginal revenue
  
  \[ MR = 38 - 2Q_1 \]

- Pick quantity to set marginal revenue for leader equal to marginal cost
  
  \[ 20 = 38 - 2Q_1 \]
  
  \[ Q_1 = 9 \]

- The follower firm 2 will respond by picking
  
  \[ Q_2 = 9 - \frac{1}{2}(9) = 4.5 \]
Stackelberg Duopoly $P = 56 - 2Q$

- Total quantity $Q = Q_1 + Q_2 = 9 + 4.5 = 13.5$
- Price $P = 56 - 2Q = 56 - 2(13.5) = 29$
- Leader Profit $(P - c)Q_1 = (29 - 20)9 = 81$
- Follower Profit $(P - c)Q_2 = (29 - 20)4.5 = 40.5$
- Industry Profit $81 + 40.5 = 121.5$

Figure 13.5: The Stackelberg Equilibrium
Table 13.1: Comparison Of Outcomes

<table>
<thead>
<tr>
<th>Model</th>
<th>Industry output Q</th>
<th>Market price P</th>
<th>Industry profit II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared monopoly</td>
<td>Q_m = a/(2b)</td>
<td>P_m = a/(12)</td>
<td>( II_m = a^2/(4b) )</td>
</tr>
<tr>
<td>Cournot</td>
<td>(4/3)Q_m</td>
<td>(2/3)P_m</td>
<td>(8/9)II_m</td>
</tr>
<tr>
<td>Stackelberg</td>
<td>(3/2)Q_m</td>
<td>(1/2)P_m</td>
<td>(3/4)II_m</td>
</tr>
<tr>
<td>Bertrand</td>
<td>2Q_m</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Perfect competition</td>
<td>2Q_m</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

All four models assume a market demand curve of \( P = a - bQ \) and marginal cost equal to zero. (Of course, if marginal cost is not zero, the entries will be all different from the ones shown.)

Figure 13.6: Comparing Equilibrium Price and Quantity

[sloped graph showing comparison of equilibrium price and quantity across different models]
Comparison for $P = 56 - 2Q$

<table>
<thead>
<tr>
<th>MC = 20</th>
<th>Quantity Q</th>
<th>Price P</th>
<th>Industry Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monopoly</td>
<td>8</td>
<td>40</td>
<td>160</td>
</tr>
<tr>
<td>Cournot</td>
<td>12</td>
<td>32</td>
<td>144</td>
</tr>
<tr>
<td>Stackelberg</td>
<td>13.5</td>
<td>29</td>
<td>121.5</td>
</tr>
<tr>
<td>Bertrand, Perfect Competition</td>
<td>18</td>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>

Competition When There Are Increasing Returns To Scale

- In markets for privately sold goods, buyers are often too numerous to organize themselves to act collectively.
  - Where it is impractical for buyers to organize direct collective action, it may nonetheless be possible for private agents to accomplish much the same objective on their behalf.
The Chamberlin Model

• Assumption: a clearly defined “industry group,” which consists of a large number of producers of products that are close, but imperfect, substitutes for one another.

• Two implications:
  1. Because the products are viewed as close substitutes, each firm will confront a downward-sloping demand schedule.
  2. Each firm will act as if its own price and quantity decisions have no effect on the behavior of other firms in the industry.
Figure 13.8: The Monopolistic Competitor’s Two Demand Curves

Figure 13.9: Short-Run Equilibrium for the Chamberlinian Firm
Perfect Competition Versus Chamberlinian Monopolistic Competition

- Competition meets the test of allocative efficiency, while monopolistic competition does not.
- Monopolistic competition is less efficient than perfect competition because in the former case firms do not produce at the minimum points of their long-run average cost (LAC) curves.
- In terms of long-run profitability the equilibrium positions of both the perfect competitor and the Chamberlinian monopolistic competitor are precisely the same.
The Optimal Number of Locations

• The number of outlets that emerges from the independent actions of profit-seeking firms will in general be related to the optimal number of outlets in the following simple way:
  – Any environmental change that leads to a change in the optimal number of outlets (here, any change in population density, transportation cost, or fixed cost) will lead to a change in the same direction in the equilibrium number of outlets.
Figure 13.12: Distances with $N$ Outlets

Figure 13.13: The Optimal Number of Outlets
Figure 13.14: A Spatial Interpretation of Airline Scheduling

- Why not have a flight leaving every 5 minutes, so that no one would be forced to travel at an inconvenient time?
- The larger an aircraft is, the lower its average cost per seat is.
- If people want frequent flights, airlines are forced to use smaller planes and charge higher fares.

Figure 13.15: Distributing the Cost of Variety
Consumer Preferences And Advertising

• Because products are differentiated, producers can often shift their demand curves outward significantly by advertising.

• *The revised sequence:* the corporation decides which products are cheapest and most convenient to produce, and then uses advertising and other promotional devices to create demand for them.
Problem 1

1. The market demand curve for a pair of Cournot duopolists is given as $P = 36 - 3Q$, where $Q = Q_1 + Q_2$. The constant per unit marginal cost is 18 for each duopolist. Find the Cournot equilibrium price, quantity, and profits.

Solution 1

1. Linear demand curve $P = 36 - 3Q$ with constant marginal cost $MC = 18$. Firm one’s marginal revenue

   $MR = 36 - 3Q_2 - 6Q_1$

Set marginal revenue equal to marginal cost and solve for firm one’s output in terms of firm two’s output (firm one’s reaction curve)

   $18 = 36 - 3Q_2 - 6Q_1$

   $R_1(Q_2) = Q_1 = 3 - \frac{1}{2}Q_2$
Solution 1

By symmetry, firm two’s reaction curve is

\[ R_2(Q_1) = Q_2 = 3 - \frac{1}{2}Q_1 \]

Substitute firm two’s reaction curve into firm one's to find firm one's optimal quantity

\[ Q_1 = 3 - \frac{1}{2}Q_2 \]

\[ Q_1 = 3 - \frac{1}{2} \left( 3 - \frac{1}{2}Q_1 \right) \]

\[ Q_1 = Q_2 = 2 \]

Solution 1

Quantity of each firm \( Q_1 = Q_2 = 2 \)

Total quantity \( Q = Q_1 + Q_2 = 4 \)

Price \( P = 36 - 3Q = 36 - 3(4) = 24 \)

Profit \( (P - c)Q = (24 - 18)2 = 12 \)

Industry Profit \( 2(12) = 24 \)
Problem 2

2. The Zambino brothers enjoy a monopoly of the U.S. market for public fireworks displays for crowds above a quarter of a million. The annual demand for these fireworks displays is $P = 140 - Q$. The marginal cost is $20. A family dispute broke the firm in two. Alfredo Zambino now runs one firm and Luigi Zambino runs the other. They still have the same marginal costs, but now they are Cournot duopolists. How much profit has the family lost?
Solution 2

2. Linear demand curve \( P = 140 - Q \) with constant marginal cost \( MC = 20 \).
   Monopoly’s marginal revenue
   \[ MR = 140 - 2Q \]
   Set marginal revenue equal to marginal cost and solve for output
   \[ 20 = 140 - 2Q, Q_m = 60 \]
   \[ P_m = 140 - Q = 140 = 60 = 80 \]
   \[ (P - c)Q = (80 - 20)60 = 3600 \]

Solution 2

As separate Cournot duopolists, firm one’s marginal revenue
   \[ MR = 140 - Q_2 - 2Q_1 \]
   Set marginal revenue equal to marginal cost and solve for firm one’s output in terms of firm two’s output (firm one’s reaction curve)
   \[ 20 = 140 - Q_2 - 2Q_1 \]
   \[ R_1(Q_2) = Q_1 = 60 - \frac{1}{2} Q_2 \]
Solution 2

By symmetry, firm two’s reaction curve is

\[ R_2(Q_1) = Q_2 = 60 - \frac{1}{2} Q_1 \]

Substitute firm two’s reaction curve into firm one's to find firm one’s optimal quantity

\[ Q_1 = 60 - \frac{1}{2} Q_2 \]

\[ Q_1 = 60 - \frac{1}{2} \left( 60 - \frac{1}{2} Q_1 \right) \]

\[ Q_1 = Q_2 = 40 \]

Solution 2

Quantity of each firm \( Q_1 = Q_2 = 40 \)

Total quantity \( Q = Q_1 + Q_2 = 80 \)

Price \( P = 140 - Q = 140 - 80 = 60 \)

Profit \( (P - c)Q = (60 - 20)40 = 1600 \)

Industry Profit \( 2(1600) = 3200 \)

Profit loss \( 3600 - 3200 = 400 \)
Problem 3

3. The market demand for mineral water is given by $P = 15 - Q$. There are two firms that produce mineral water, each with a constant marginal cost of 3 per unit. Find the Cournot equilibrium price, quantity, and profits.

Solution 3

3. Linear demand curve $P = 15 - Q$ with constant marginal cost $MC = 3$. Firm one’s marginal revenue

$MR = 15 - Q_2 - 2Q_1$

Set marginal revenue equal to marginal cost and solve for firm one’s output in terms of firm two’s output (firm one’s reaction curve)

$3 = 15 - Q_2 - 2Q_1$

$R_1(Q_2) = Q_1 = 6 - \frac{1}{2}Q_2$
Solution 3

By symmetry, firm two’s reaction curve is
\[ R_2(Q_1) = Q_2 = 6 - \frac{1}{2}Q_1 \]
Substitute firm two’s reaction curve into firm one's to find firm one’s optimal quantity
\[ Q_1 = 6 - \frac{1}{2}Q_2 \]
\[ Q_1 = 6 - \frac{1}{2} \left( 6 - \frac{1}{2}Q_1 \right) \]
\[ Q_1 = Q_2 = 4 \]

Solution 3

Quantity of each firm \( Q_1 = Q_2 = 4 \)
Total quantity \( Q = Q_1 + Q_2 = 8 \)
Price \( P = 15 - Q = 15 - 8 = 7 \)
Profit \( (P - c)Q = (7 - 3)4 = 16 \)
Industry Profit \( 2(16) = 32 \)
Problem 4

4. How would the equilibrium price, quantity, and profits differ if instead the two mineral water firms behaved in a Bertrand fashion?
Solution 4

4. Price $P = MC = 3$
   Total quantity $3 = 15 - Q, Q = 12$
   Quantity of each firm $Q_1 = Q_2 = 6$
   Profit $(P - c)Q = (3 - 3)6 = 0$
   Industry Profit $2(0) = 0$