Oligopoly and Game Theory

- Extreme market structures: Monopoly and perfect competition. No need to consider rivals’ reactions.
- Oligopoly: An intermediate market structure consisting of only a few firms. Need to consider rivals’ reactions.
- Strategic interdependence is the essence of oligopoly.

Two Approaches

- Business is war
  “It is not enough to succeed. Others must fail.”
  -- Gore Vidal
- Cooperation
  “You don’t have to blow out the other fellow’s light to let your own shine”
  -- Bernard Baruch

Overview of Topic

1) One-Shot Games
2) The Lysine Cartel
3) Repeated Games and Cooperation
4) Facilitating Practices

Today’s Outline (One-Shot Games)

- Cournot
- Cournot vs. Collusion
- Von Stackelberg
- Bertrand
- Kreps and Scheinkman

Cournot Oligopoly

- Augustin Cournot (1838)
- Two Firms: a “Duopoly”
- Homogeneous product
- Firms decide on Quantities to supply
- Market price determined by total Quantity Supplied equal to Market Demand
- Firms attempt to maximise their own profits, assuming their rival’s quantity is given
Oligopoly

Cournot conclusions

- At the intersection of the reaction functions, Firm A is maximizing profits given Firm B's output, and vice versa
- This is an equilibrium
- Total output in Cournot Equilibrium is greater than monopoly output but smaller than perfectly competitive output. Therefore price is similarly between monopoly and perfectly competitive levels
- As number of firms increases, total output converges to the perfectly competitive level

Cournot extensions

- Analysis can be extended to
  - more than two firms
  - firms with differing costs
  - free entry, where new firms enter until the equilibrium profits fall to zero
- What happens out of equilibrium?
  - Text-books will give you simple dynamic stories, but these are logically flawed – the Cournot model is a "one-shot game" with no possibility of reaction

Cournot Problems

- Firms are assumed to be naïve: perhaps they should realise that their rivals’ outputs are not given, but will react to their own output choices
- Two possibilities:
  - Collusion: both firms recognise their interdependence
  - Leadership: only one firm moves first and takes advantage of the other
Collusion

- Isoprofit curves show that both firms could make more profit than in the Cournot equilibrium
- Combined Cournot output > Monopoly output; therefore combined Cournot profits < Monopoly profit
- If both firms agree to cut output, they could split monopoly profit between them
- But making such an agreement stick is not so easy! (For next class)

A Mathematical Example of Cournot

\[ Q = A - P(\bar{Q}) \]
\[ C = kq \]
\[ \bar{Q} = q_1 + q_2 \]

Firm’s maximize profits given their rival’s output quantity

Cournot (cont.)

\[ \Pi_1(q_1) = (A - q_2 - q_1)q_1 - kq_1 \]
\[ \frac{\partial \Pi_1}{\partial q_1} = A - q_2 - 2q_1 - k = 0 \]
\[ 2q_1 = A - q_2 - k \]
\[ q_1 = \frac{A - q_2 - k}{2} \]

Symmetrically,
\[ q_2 = \frac{A - q_1 - k}{2} \]

Cournot Output

\[ q_2 = \frac{A - (A - q_1 - k) - k}{2} \]
\[ 2q_2 = A - \frac{A - q_1 - k}{2} - k \]
\[ 4q_2 = 2A - A + q_1 + k - 2k \]
\[ q_2 = \frac{A - k}{3} \]
\[ q_1 = \frac{A - k}{3} \]
\[ p = A - \bar{Q} \]
\[ = A - \frac{2(A - k)}{3} A + 2k \]
Oligopoly

Leadership

• Von Stackelberg (1934)
  • Firm A realizes interdependence and becomes a “Stackelberg Leader”;
  • Firm B does not, and remains a “Cournot Follower”
• Firm A realizes Firm B will operate on its reaction function, and
  maximize profits given this assumption
• A’s output and profits are larger than Cournot levels; B’s are smaller.
  Total output rises, combined profits fall.

Von Stackelberg Equilibrium

• Suppose that firm 1 realizes that firm 2 will operate on its reaction function, and chooses
  its optimal quantity
• Knowing this, firm 1 acts as a leader

Stackelberg (cont.)

1) Using firm 2’s reaction function,
   \[ q_2 = \frac{A - q_1 - k}{2} \]
2) Firm 1 maximizes profits, substituting in \( q_1 \)’s reaction function for \( q_2 \)

Stackelberg (cont.)

\[
\Pi_1(q_1) = (A - q_1 - q_2)q_1 - kq_1
= \left( A - \frac{A - q_1 - k}{2} - q_1 \right)q_1 - kq_1
\]
\[
\frac{d\Pi_1}{dq_1} = A - \frac{A - q_1 - k}{2} - q_1 \left( \frac{1}{2} \right) q_1 - k = 0
\]
\[
\frac{\left( A - \frac{A - q_1 - k}{2} \right)}{q_1} = \frac{k}{2}
\]
\[
q_1 = \frac{A - k}{2}
\]
A Bertrand Equilibrium

Linear Demand: \( X = A - P \)

- \( P \) is price, \( X \) is total quantity demanded and \( A \) is a constant
- Constant marginal costs, \( k \), and no fixed costs
- An equilibrium consists of a pair of prices \((p_1, p_2)\) and a pair of quantities \((x_1, x_2)\) where:
  a) if \( p_1 < p_2 \) then \( x_1 = A - p_1 \) and \( x_2 = 0 \)
  b) if \( p_1 > p_2 \) then \( x_2 = A - p_2 \) and \( x_1 = 0 \)
  c) if \( p_1 = p_2 \) then \( x_1 + x_2 = A - k \)
  d) neither firm wishes to change, given Bertrand conjectures

Proof

- Could there be an equilibrium where the prices are unequal and the smaller of the two prices is more than \( k \)? Where the smaller of the two prices is less than or equal to \( k \)?
- Could there be an equilibrium where the prices are equal to each other and equal to something less than \( k \)? Where there are equal to something more than \( k \)?
- Only possibility left is where \( p_1 = p_2 = k \). ANY division of market demand between the two firms at those prices is an equilibrium.

Bertrand Conclusions

- Bertrand’s assumptions make “just undercutting” a compulsive strategy!
- Firms will not price above the monopoly price, or below MC
- Mutual undercutting drives price right down to MC – the perfectly competitive level
- Therefore Bertrand equilibrium is the perfectly competitive one, even though there are only two firms
- All profits disappear
Bertrand Criticisms

- Extreme conclusions depend on extreme assumptions, particularly:
  - Homogeneous product
  - No capacity constraints
- Incentive to undercut may be limited by:
  - Product differentiation – undercutting will take some, but not all, of the rival's market
  - Capacity constraints – no incentive to undercut if you can't supply the additional demand
- In these cases, price competition might stop before profits are completely exhausted
  - Firms might therefore purposely differentiate their products and limit capacity as a quasi-collusive device

Bertrand – Collusion and Leadership

- As in Cournot, firms may recognise interdependence:
  - They could collude and agree to each set the monopoly price and share the market (but again it is difficult to keep the agreement together)
  - Or one firm could be a “price leader” (although this can only be worthwhile if there is product differentiation or capacity constraints)

Cournot vs Bertrand

- Two models with very similar assumptions lead to very different conclusions. Which is “better”?
- Bertrand argued it was more realistic to have firms set prices.
  - But this is not always true, e.g. international commodity markets
  - And it all depends on your time-scale: Colgate and Macleans sell toothpaste by setting prices (looks like Bertrand), but in the longer term they have to decide the size of their factories against each other (looks more like Cournot)

Kreps and Scheinkman

- Kreps and Scheinkman (1983) combine the two:
  - A two-stage process:
    - First firms choose capacities
    - Then they sell the output from those capacities in a Bertrand competition
    - Resulting equilibrium is a capacity-constrained Bertrand
  - Equilibrium is therefore both Cournot and Bertrand

Conclusion

- Traditional Oligopoly Models
  - Cournot
  - Stackelberg
  - Bertrand
  - Very important: you can see firms producing above “marginal cost” and they could be competing