

**Oligopoly**  
*Industrial Organization*

K. Graddy

Oligopoly 1

**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.

Oligopoly 2

**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

Oligopoly 3

**Overview of Topic**

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

Oligopoly 4

**Today's Outline (One-Shot Games)**

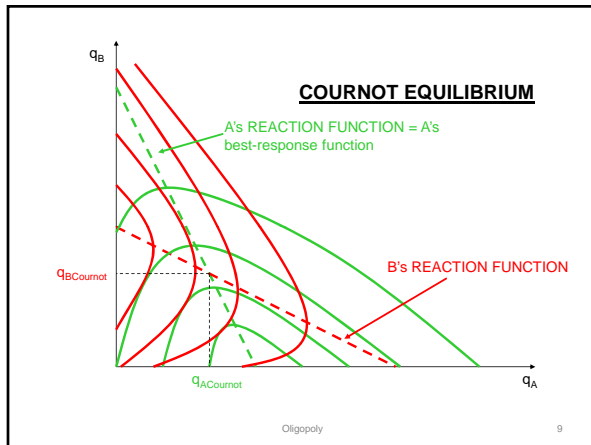
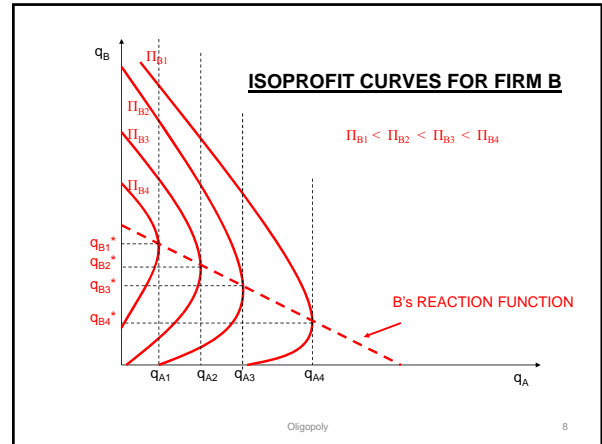
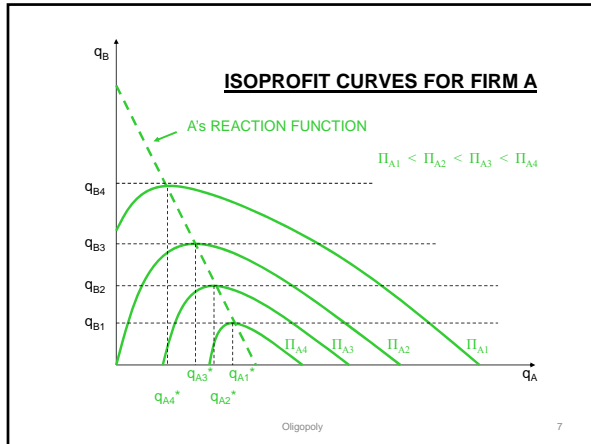
- Cournot
- Cournot vs. Collusion
- Von Stackelberg
- Bertrand
- Kreps and Scheinkman

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**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**

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- ### 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
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- ### 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
- Oligopoly 11

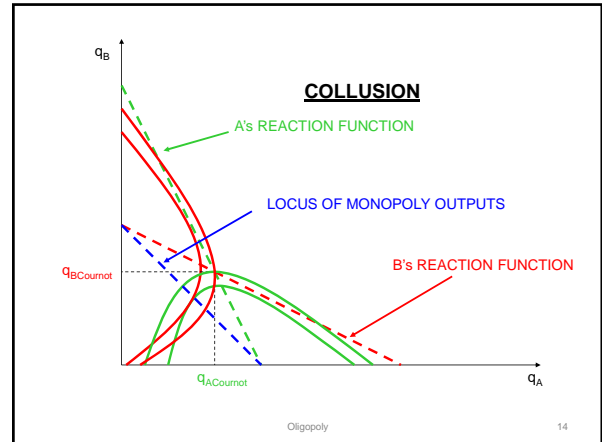
- ### Cournot Problems
- Firms are assumed to be naive: perhaps they should realise that their rivals' outputs are not given, but will react to their own output choices
  - Two possibilities:
    - **Collusion**: both firms recognise their interdependence
    - **Leadership**: only one firm moves first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

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### A Mathematical Example of Cournot

$$Q = A - P(Q)$$

$$C = kq$$

$$Q = q_1 + q_2$$

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

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### Cournot (cont.)

$$\Pi_1(q_1) = (A - q_2 - q_1)q_1 - kq_1$$

$$\frac{\partial \Pi_1}{\partial q_1} = A - q_2 - 2q_1 - k = 0$$

$$2q_1 = A - q_2 - k$$

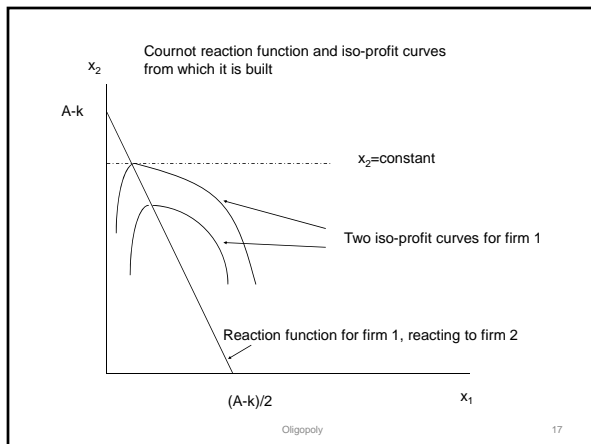
$$q_1 = \frac{A - q_2 - k}{2}$$

symmetrically,

$$q_2 = \frac{A - q_1 - k}{2}$$

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### Cournot Output

$$q_2 = \frac{A - \left(\frac{A - q_2 - k}{2}\right) - k}{2}$$

$$2q_2 = A - \frac{A - q_2 - k}{2} - k$$

$$4q_2 = 2A - A + q_2 + k - 2k$$

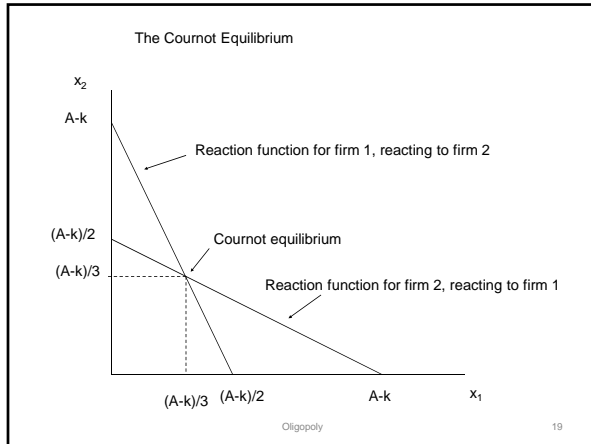
$$q_2 = \frac{A - k}{3} \quad q_1 = \frac{A - k}{3}$$

$$p = A - Q$$

$$= A - \frac{2(A - k)}{3} = \frac{A + 2k}{3}$$

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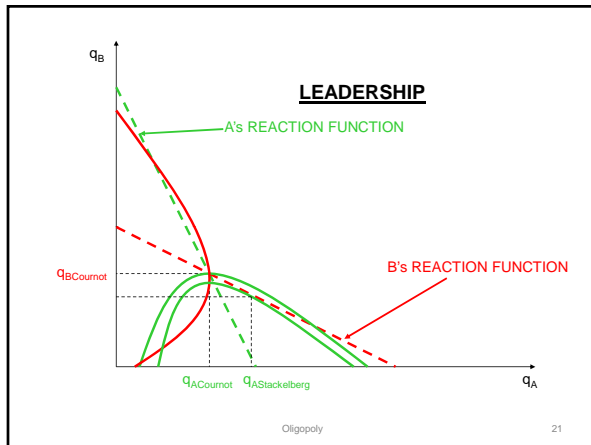
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### Leadership

- Von Stackelberg (1934)
- Firm A realises interdependence and becomes a “Stackelberg Leader”; Firm B does not, and remains a “Cournot Follower”
- Firm A realises 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.

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### 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

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### Stackelberg (cont.)

(1) Using firm 2's reaction function,

$$q_2 = \frac{A - q_1 - k}{2}$$

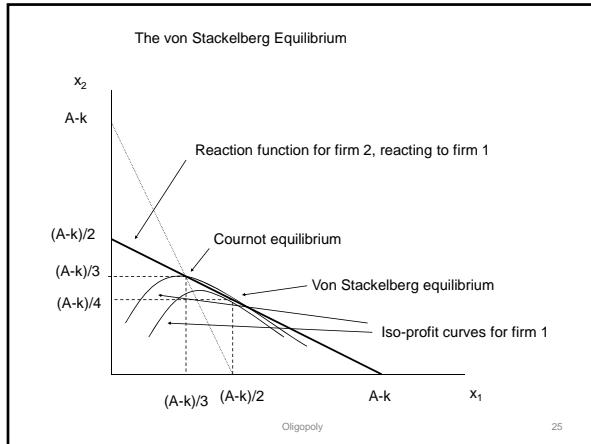
(2) Firm 1 maximizes profits, substituting in  $q_2$ 's reaction function for  $q_2$

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### Stackelberg (cont.)

$$\begin{aligned} \Pi_1(q_1) &= (A - q_2 - q_1)q_1 - kq_1 \\ &= \left( A - \frac{A - q_1 - k}{2} - q_1 \right) q_1 - kq_1 \\ \frac{d\Pi_1}{dq_1} &= A - \frac{A - q_1 - k}{2} - q_1 + \left( \frac{1}{2} - 1 \right) q_1 - k = 0 \\ \left( A - \frac{A}{2} \right) + \left( \frac{k}{2} - k \right) + \left( \frac{q_1}{2} - q_1 - \frac{1}{2} q_1 \right) \\ \frac{1}{2} A - \frac{k}{2} - q_1 &= 0 \\ q_1 &= \frac{A - k}{2} \end{aligned}$$

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### Bertrand Oligopoly

- Bertrand (1883)
- Two Firms: a Duopoly
- Homogeneous product
- Firms decide on **Prices** to quote
- Consumers buy from cheaper firm; quantity demanded determined by Market Demand
- Firms attempt to maximise their own profits, **assuming their rival's price is given**

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### 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:

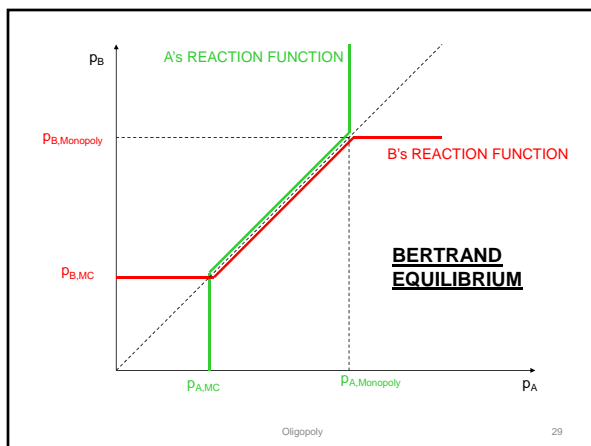
- if  $p_1 < p_2$ , then  $x_1 = A - p_1$  and  $x_2 = 0$
- if  $p_2 < p_1$ , then  $x_1 = 0$  and  $x_2 = A - p_2$
- if  $p_1 = p_2$ , then  $x_1 + x_2 = A - p_1$
- neither firm wishes to change, given Bertrand conjectures

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### 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.

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### 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

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## 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

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## 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)

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## 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, eg 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**)

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## 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 – therefore profits not reduced to zero
  - But if firms rationally foresee the ultimate profit consequences of their capacity choices, they will choose capacities equal to the Cournot Equilibrium quantities
  - Equilibrium is therefore both Cournot **and** Bertrand

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## Conclusion

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

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