Price Competition Under Product Differentiation

**Introduction**

- In a wide variety of markets firms compete in prices
  - Internet access
  - Restaurants
  - Consultants
  - Financial services
- Without product differentiation competing in prices yields negative consequences for firms with market power
  - The Bertrand Paradox
- However, firms usually compete on product location and prices
- Hence we consider product differentiation under oligopoly
The Bertrand Paradox

- Take a simple example
  - two firms producing an identical product (spring water?)
  - firms choose the prices at which they sell their products
  - each firm has constant marginal cost of $c$
  - inverse demand is $P = A - BQ$
- Equilibrium is such that
  - $p_1 = p_2 = c$
  - Both firms make normal profits

Product differentiation

- The Bertrand Paradox is due to homogeneous products
- It creates incentives for firms to differentiate their products
  - to generate consumer loyalty
  - do not lose all demand when they price above their rivals
    - keep the “most loyal”
An example of product differentiation

Coke and Pepsi are similar but not identical. As a result, the lower priced product does not win the entire market. Econometric estimation gives:

\[ Q_C = 63.42 - 3.98P_C + 2.25P_P \]
\[ MC_C = 4.96 \]
\[ Q_P = 49.52 - 5.48P_P + 1.40P_C \]
\[ MC_P = 3.96 \]

There are at least two methods for solving this for \( P_C \) and \( P_P \)

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Bertrand and product differentiation

**Method 1:** Calculus

Profit of Coke: \( \pi_C = (P_C - 4.96)(63.42 - 3.98P_C + 2.25P_P) \)

Profit of Pepsi: \( \pi_P = (P_P - 3.96)(49.52 - 5.48P_P + 1.40P_C) \)

Differentiate with respect to \( P_C \) and \( P_P \) respectively

**Method 2:** \( MR = MC \)

Reorganize the demand functions

\[ P_C = (15.93 + 0.57P_P) - 0.25Q_C \]
\[ P_P = (9.04 + 0.26P_C) - 0.18Q_P \]

Calculate marginal revenue, equate to marginal cost, solve for \( Q_C \) and \( Q_P \) and substitute in the demand functions
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**Bertrand and product differentiation**

Both methods give the best response functions:

\[ P_C = 10.44 + 0.2826P_P \]
\[ P_P = 6.49 + 0.1277P_C \]

These can be solved for the equilibrium prices as indicated.

The equilibrium prices are each greater than marginal cost.

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**Bertrand competition and the spatial model**

- An alternative approach: spatial model of Hotelling
  - a Main Street over which consumers are distributed
  - supplied by two shops located at opposite ends of the street
  - but now the shops are competitors
  - each consumer buys exactly one unit of the good provided that its full price is less than \( V \)
  - a consumer buys from the shop offering the lower full price
  - consumers incur transport costs of \( t \) per unit distance in travelling to a shop

- Recall the broader interpretation
- What prices will the two shops charge?
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Bertrand and the spatial model

Assume that shop 1 sets price $p_1$ and shop 2 sets price $p_2$

Price

$p_1$

$p_2$

$x_m$ marks the location of the marginal buyer—one who is indifferent between buying either firm’s good

All consumers to the left of $x_m$ buy from shop 1

And all consumers to the right buy from shop 2

What if shop 1 raises its price?

$x_m$ moves to the left: some consumers switch to shop 2

$p_1'$

$p_1$

$x_m'$

$x_m$

Shop 1

Shop 2
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Bertrand and the spatial model

\[ p_1 + tx^m = p_2 + t(1 - x^m) \]

\[ \therefore 2tx^m = p_2 - p_1 + t \]

\[ \therefore x^m(p_1, p_2) = (p_2 - p_1 + t)/2t \]

How is \( x^m \) determined?

There are \( N \) consumers in total.

So demand to firm 1 is \( D^1 = N(p_2 - p_1 + t)/2t \).

\[ \text{This is the fraction of consumers who buy from firm 1.} \]

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Bertrand equilibrium

Profit to firm 1 is \( \pi_1 = (p_1 - c)D^1 = N(p_1 - c)(p_2 - p_1 + t)/2t \)

\[ \pi_1 = N(p_2p_1 - p_1^2 + tp_1 + cp_1 - cp_2 - ct)/2t \]

Differentiate with respect to \( p_1 \)

\[ \frac{\partial \pi_1}{\partial p_1} = \frac{N}{2t} (p_2 - 2p_1 + t + c) = 0 \]

\[ p^*_1 = (p_2 + t + c)/2 \]

This is the best response function for firm 1.

What about firm 2? By symmetry, it has a similar best response function.

\[ p^*_2 = (p_1 + t + c)/2 \]

This is the best response function for firm 2.
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Bertrand equilibrium 2

\[ p_{*1} = \frac{(p_2 + t + c)}{2} \]
\[ p_{*2} = \frac{(p_1 + t + c)}{2} \]
\[ 2p_{*2} = p_1 + t + c \]
\[ = \frac{p_2}{2} + \frac{3(t + c)}{2} \]
\[ \therefore p_{*2} = t + c \]
\[ \therefore p_{*1} = t + c \]

Profit per unit to each firm is \( t \)
Aggregate profit to each firm is \( Nt/2 \)

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Bertrand competition 3

- Two final points on this analysis
- \( t \) is a measure of transport costs
  - it is also a measure of the value consumers place on getting their most preferred variety
  - when \( t \) is large competition is softened
    - and profit is increased
  - when \( t \) is small competition is tougher
    - and profit is decreased
- Locations have been taken as fixed
  - suppose product design can be set by the firms
    - balance “business stealing” temptation to be close
    - against “competition softening” desire to be separate
Strategic complements and substitutes

- Best response functions are very different with Cournot and Bertrand
  - they have opposite slopes
  - reflects very different forms of competition
  - firms react differently e.g. to an increase in costs

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Strategic complements and substitutes

- suppose firm 2’s costs increase
- this causes Firm 2’s Cournot best response function to fall
  - at any output for firm 1 firm 2 now wants to produce less
  - firm 1’s output increases and firm 2’s falls
- Firm 2’s Bertrand best response function rises
  - at any price for firm 1 firm 2 now wants to raise its price
  - firm 1’s price increases as does firm 2’s
Strategic complements and substitutes 2

- When best response functions are upward sloping (e.g. Bertrand) we have strategic complements
  - passive action induces passive response
- When best response functions are downward sloping (e.g. Cournot) we have strategic substitutes
  - passive actions induces aggressive response
- Difficult to determine strategic choice variable: price or quantity
  - output in advance of sale – probably quantity
  - production schedules easily changed and intense competition for customers – probably price