Industrial Economics

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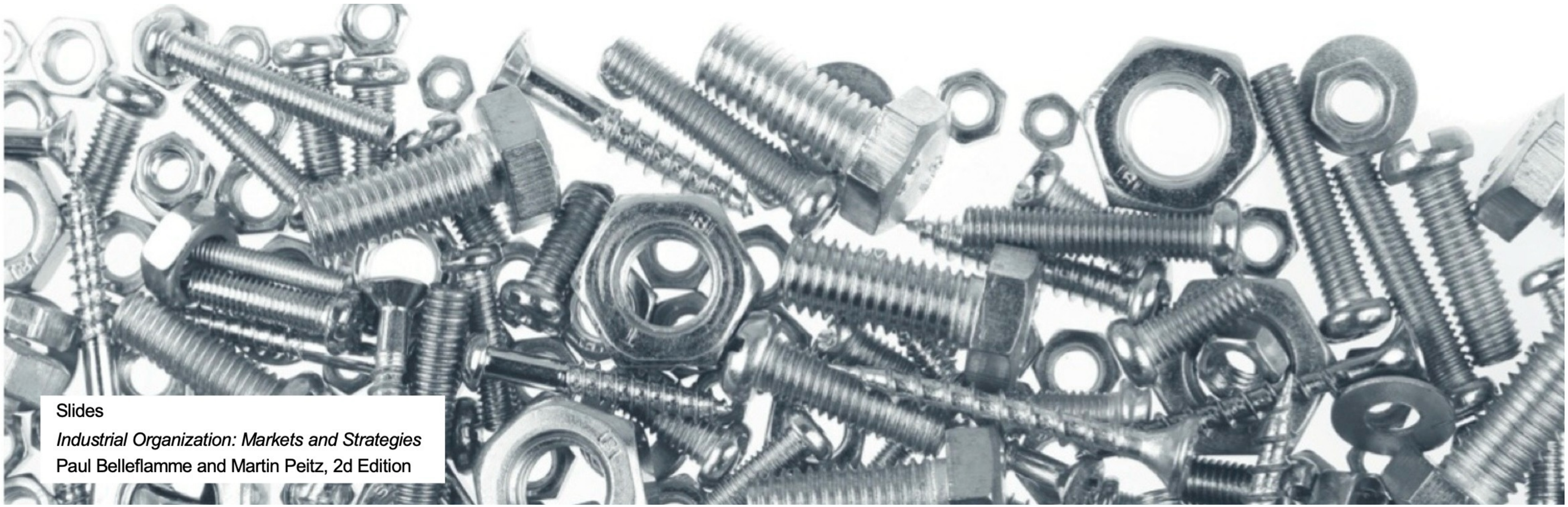
AUEB – Erasmus Program

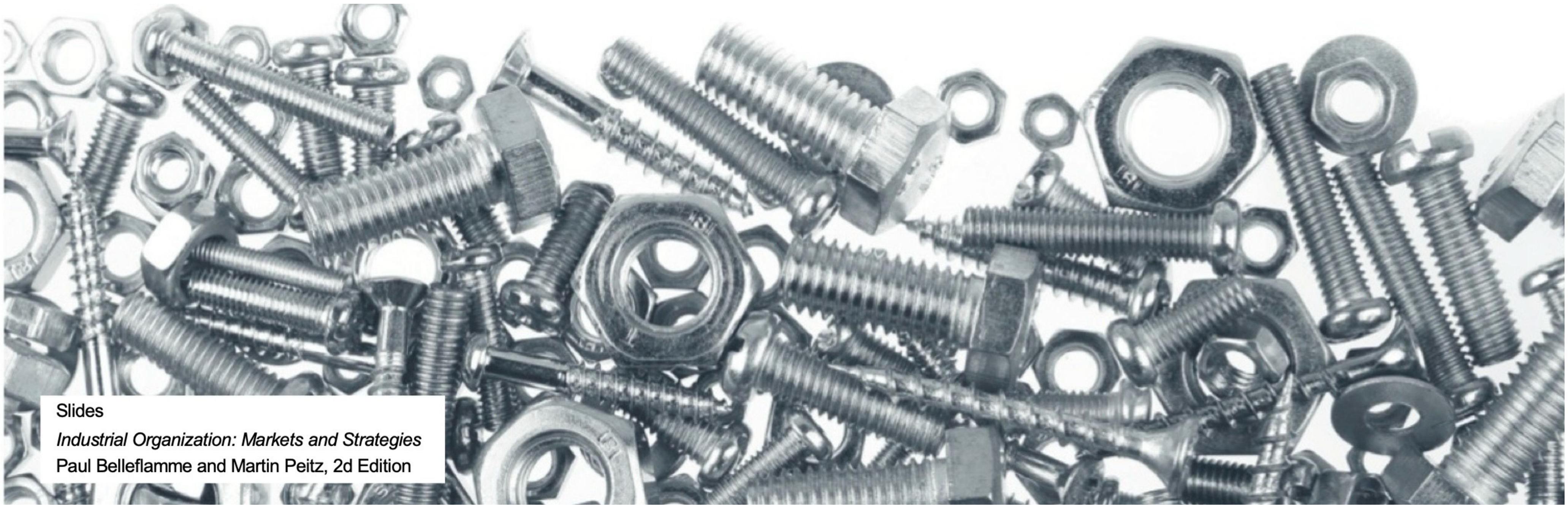


Slides

Industrial Organization: Markets and Strategies

Paul Belleflamme and Martin Peitz, 2d Edition

3. STATIC OLIGOPOLY



3.3 Price Competition

3.3.1 The Standard Bertrand Model

Standard Bertrand model

- **Model Assumptions:**
  - $n = 2$ firms ($i = 1, 2$)
  - Homogeneous products with market demand function: $Q(p) = (a - p)/b$, where Q is the total quantity. [It is the reverse of $P(Q) = a - bQ$]
  - Cost function of firm i: $C_i(q_i) = cq_i$ with $a > c$ $\rightarrow$ constant symmetric MC: c
  - Static game:
    Both firms choose simultaneously and separately the prices of their products, p_1 and p_2.
  - Each firm i faces demand for its own product:

$$q_i = \begin{cases} 0 & \text{if } p_i > p_j \quad \text{or } p_i > a \\ \frac{a-p}{2b} & \text{if } p_i = p_j = p < a \\ \frac{a-p}{b} & \text{if } p_i < \min(a, p_j) \end{cases} \qquad i, j = 1, 2 \text{ and } i \neq j$$

  - No capacity constraints

Standard Bertrand model

- **Model Solution – Equilibrium:**

Which prices firms choose in equilibrium?

[WATCH OUT!: We cannot solve the profit maximization problem through first order conditions because the demand function of each firm is discontinuous. Instead, we find the Nash equilibrium through logical reasoning.]

"There is a unique Nash equilibrium in which: $p_1^B = p_2^B = c$"

Proof:

The strategy profile $(p_1^B, p_2^B) = (c, c)$ satisfies:

- None of the firms has incentives to unilaterally deviate and change its price given the price of its rival (if it does it profit will not increase).
- For any other strategy profile (p_1, p_2), a profitable deviation exists.

Standard Bertrand model

- **Model Solution – Equilibrium** (cont.):

Step 1: Show there is no profitable unilateral deviation from $(p_1^B, p_2^B) = (c, c)$.

- If $p_1^d > p_2^B = c \rightarrow \pi_1^d = 0$
- If $p_1^d < p_2^B = c \rightarrow \pi_1^d < 0$

Thus firm 1 (and similarly firm 2) has no incentive to deviate.

Step 2: Show there is a profitable unilateral deviation from any other (p_1, p_2).

- $p_1^* = p_2^* > c \rightarrow \pi_1^* = \pi_2^* > 0$ (they share the demand)

  If $p_1^d = p_2^* - \varepsilon > c \rightarrow \pi_1^d > \pi_1^*$ Thus firm 1 has incentive to deviate.

- $p_1^* = p_2^* < c \rightarrow \pi_1^* = \pi_2^* < 0$

  If $p_1^d > c > p_2^* \rightarrow \pi_1^d = 0 > \pi_1^*$ Thus firm 1 has incentive to deviate.

- $p_1^* > p_2^* > c \rightarrow \pi_1^* = 0 < \pi_2^*$

  If $p_1^d = p_2^* - \varepsilon > c \rightarrow \pi_1^d > \pi_1^*$ Thus firm 1 has incentive to deviate.

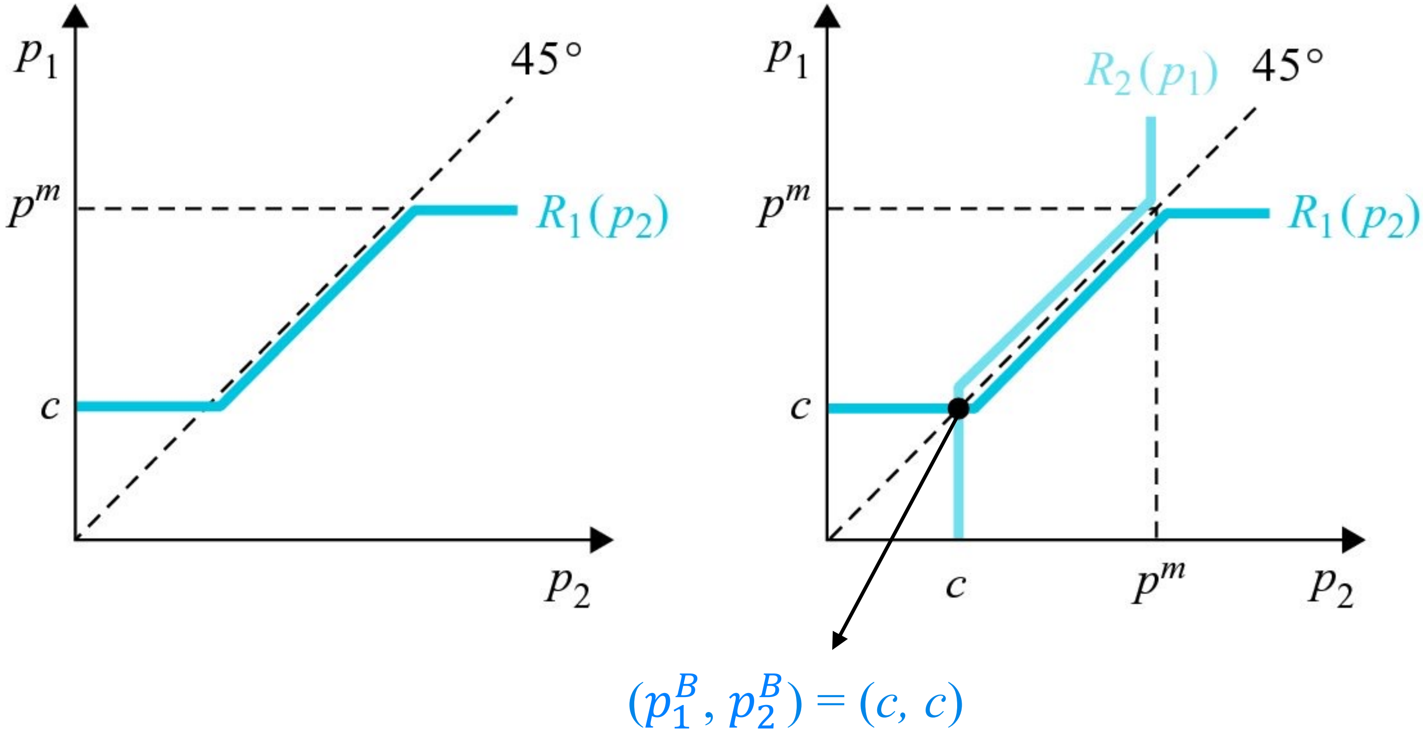
- $p_1^* > p_2^* = c \rightarrow \pi_1^* = \pi_2^* = 0$

  If $p_2^d = p_1^* - \varepsilon > c \rightarrow \pi_2^d > \pi_2^*$ Thus firm 2 has incentive to deviate.

Standard Bertrand model

- **Model Solution – Equilibrium** (cont.)**:**

  Or the strategy profile $(p_1^B, p_2^B) = (c, c)$ is the unique intersection of firms' *best-response functions*



Standard Bertrand model

- "Bertrand Paradox":

  Only 2 firms **but** perfectly competitive outcome.

In a homogeneous product Bertrand duopoly with identical and constant marginal costs, the equilibrium is such that firms set price equal to marginal cost; firms do not enjoy any market power.

The equilibrium of the Bertrand model can be "sensitive" to the assumptions of the model. Next we will examine variations - extensions of the Bertrand model.

Study the standard Bertrand model also from file in the eclass:

"Extra: 3.3 Price Competition: Standard & Asymmetric Costs"

3.3.2 Variations of the Bertrand Model

Bertrand model with Asymmetric Costs

- **Model Assumptions:**

Same assumptions as in the standard Bertrand model with only one difference:

  - Cost function of firm i: $C_i(q_i) = c_i q_i$ with $c_1 < c_2$ i.e., firm 1 is more efficient than firm 2.

- **Model Solution – Equilibrium:**

- If cost asymmetry is "small" – firm 1 is not much more efficient than firm 2, the Nash equilibrium is:

$(p_1, p_2) = (c_2 - \varepsilon, c_2)$ where ε is a very small number

- If cost asymmetry is "large", the Nash equilibrium is:

$$(p_1, p_2) = (p_1^m, c_2)$$

where p_1^m is the monopoly price for firm 1

In this case, firm 1 makes monopoly profits.

Different result than in standard Bertrand model – No Bertrand paradox.

Bertrand model with Asymmetric Costs

- Clarification:

  ”Small” cost asymmetry means that if the firm with the lower MC sets the price that a monopolist with the same MC would, this price is higher than the MC of its competitor.

  Thus, if it sets this price it will sell nothing and will make zero profits.

  $$\neq$$

  “Large” cost asymmetry means that if the firm with the lower MC sets the price that a monopolist with the same MC would, this price is lower than the MC of its competitor.

  Thus, if it sets this price it will make monopoly profits (which are the highest profits than a firm can make).

Study the Bertrand model with Asymmetric Costs also from file in the eclass:

“Extra: 3.3 Price Competition: Standard & Asymmetric Costs”

Bertrand model with n firms

- **Model Assumptions:**

  Same assumptions as in the standard Bertrand model with the following differences:

  - $n > 2$ firms, $i = 1, 2, 3, \ldots, n$

- **Model Solution – Equilibrium:**

  Marginal cost pricing by each firm *i* is a Nash equilibrium.

  Why?

  Same reasoning as in the standard Bertrand model with $n = 2$.

  Note: Here it is not the unique Nash equilibrium, but in all Nash equilibrium at least 2 firms sets their prices equal to MC and all the firms make zero profits.

Similar result as in standard Bertrand model.

Bertrand model with Differentiated Products

- **Model Assumptions:**

  Same assumptions as in the standard Bertrand model with only one difference:

  - Demand function for each firm:

$$q_1(p_1, p_2) = \bar{a} - \bar{b}p_1 + \bar{d}p_2$$
$$q_2(p_1, p_2) = \bar{a} - \bar{b}p_2 + \bar{d}p_1$$

with $\bar{a} = \frac{a}{b+d}$, $\bar{b} = \frac{b}{b^2-d^2}$, $\bar{d} = \frac{d}{b^2-d^2}$

Recall d/b is inverse measure of degree of (horizontal) product differentiation. When $d \to 0$ independent products; when $d \to 1$ perfect substitutes.

Cournot model with Differentiated Products

- **Model Solution – Equilibrium:**

Profit maximization of each firm i:

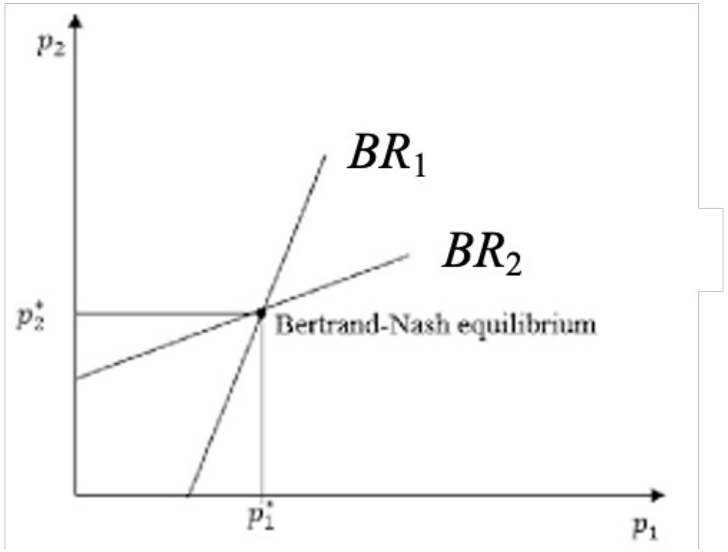
$$max_{p_i}\ \pi_i = (p_i - c)(\bar{a} - \bar{b}p_i + \bar{d}p_j)$$

The demand function is continuous, thus (in contrast to standard Bertrand model) we can use FOCs to find the Nash equilibrium:

$$\pi_i' = \frac{\partial \pi_i}{\partial p_i} = \bar{a} - 2\bar{b}p_i + \bar{d}p_j + c = 0$$

$$\rightarrow BR_i(p_j) = p_i(p_j) = \frac{\bar{a} + \bar{d}p_j + \bar{b}c}{2\bar{b}}$$

Best-response functions



$$\partial BR_i(p_j)/\partial p_j = \frac{\bar{d}}{2\bar{b}} > 0$$

Prices are "Strategic complements"

Price competition with Differentiated Products

- **Model Solution – Equilibrium** (cont.)**:**

Solution of the system of the two BR functions leads to:

$$p_1^* = \frac{\bar{a} + \bar{b}c}{2\bar{b} - \bar{d}} = p_2^*$$

Important observation:

$p_1^* > c$ No Bertrand paradox

➢ If $d \downarrow$ (higher differentiation) $\rightarrow$ price $\uparrow$, profit$\uparrow$

3.4 Price vs. Quantity Competition

Price versus Quantity competition

- Comparison of results in standard models:

  i.e, with $n = 2$, $p(q) = a - bq$, $c_1=c_2=c$

  - **Bertrand**: $p_1^B = p_2^B = c, \quad q_1^B = q_2^B = (a-c)/2b, \quad \pi_1^B = \pi_2^B = 0$
  - **Cournot:** $q_1^C = q_2^C = (a-c)/3b, \; p^C = (a+2c)/3, \; \pi_1^C = \pi_2^C = (a-c)^2/9b$

Homogeneous product case → higher price, lower quantity, higher profits under quantity than under price competition.

- Comparison of results in models with differentiated products:

  Same qualitatively conclusion as above.

Price as the strategic variable gives rise to a more competitive outcome than quantity as the strategic variable.

Capacity-then-price model (Kreps & Scheinkman)

- Model:
  Stage 1: Firms set capacities $\bar{q}_i$ and incur cost of capacity, c.

  Stage 2: Firms set prices p_i; cost of production is 0 up to capacity (and infinite beyond capacity); demand is $Q(p) = a - p$.

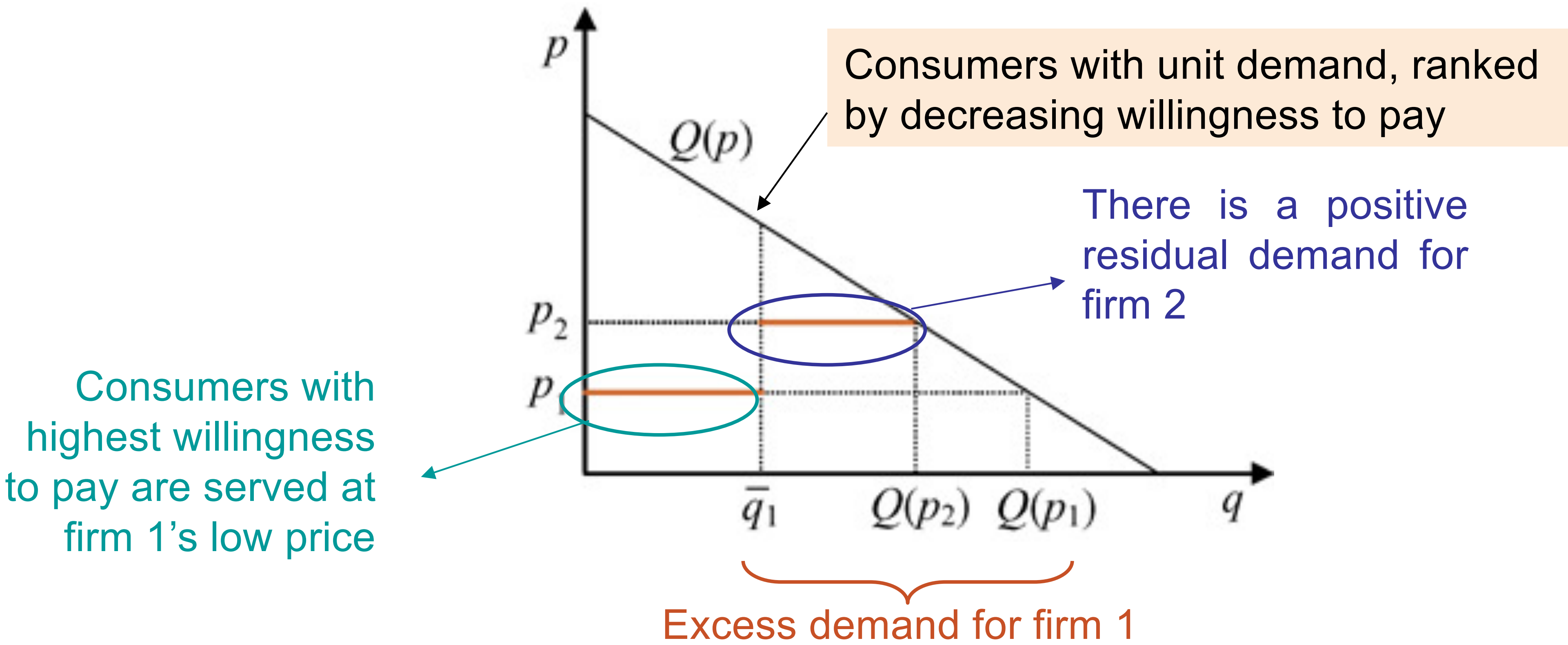
  Subgame-perfect Nash equilibrium; firms know that capacity choices may affect equilibrium prices

- Rationing:
  If quantity demanded to firm i exceeds its supply...
  ... some consumers have to be rationed...
  ... and possibly buy from more expensive firm j.

  Crucial question: *Who will be served at the low price?*

Capacity-then-price model

- Efficient rationing:
  - First served: consumers with higher willingness to pay.
  - Justification: queuing system, secondary markets



Capacity-then-price model

- **Equilibrium:**

Stage 2: If p_1 < p_2 and excess demand for firm 1, then demand for 2 is:

$$\hat{Q}(p_2) = \begin{cases} Q(p_2) - \bar{q}_1 & \text{if } Q(p_2) - \bar{q}_1 \geq 0 \\ 0 & \text{else} \end{cases}$$

Claim: if $c < a < (4/3)c$, then both firms set the market-clearing price:

$$p_1 = p_2 = p^* = a - \bar{q}_1 - \bar{q}_2$$

Stage 1: Same reduced profit functions as in Cournot:

$$\bar{\pi}_1(\bar{q}_1, \bar{q}_2) = (a - \bar{q}_1 - \bar{q}_2)\bar{q}_1 - c\bar{q}_1$$

In the capacity-then-price game with efficient consumer rationing (and with linear demand & constant marginal costs), the chosen capacities are equal to those in a standard Cournot market.

Appropriate modelling choice: Price or Quantity?

- How do firms behave in the market?
  - *Stick to a price and sell any quantity at this price?*
    → **Price competition**

    Appropriate choice when:
    - Unlimited capacity
    - Prices more difficult to adjust in the short run than quantities

    Example: mail-order business

  - *Stick to a quantity and sell this quantity at any price?*
    → **Quantity competition**

    Appropriate choice when:
    - Limited capacity (even if firms are price-setters)
    - Quantities more difficult to adjust in the short run than prices

    Example: package holiday industry