Industrial Economics

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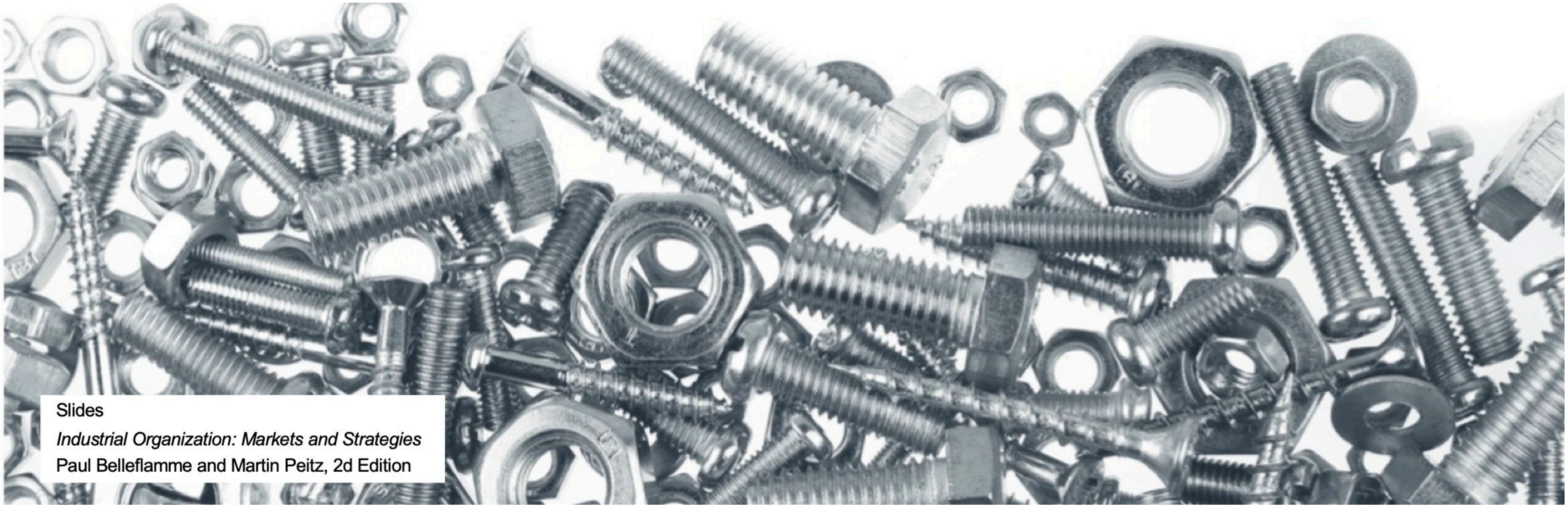
AUEB – Erasmus Program



Slides
Industrial Organization: Markets and Strategies
Paul Belleflamme and Martin Peitz, 2d Edition

Couse Outline

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2. Monopoly ✓
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4. Dynamic Oligopoly
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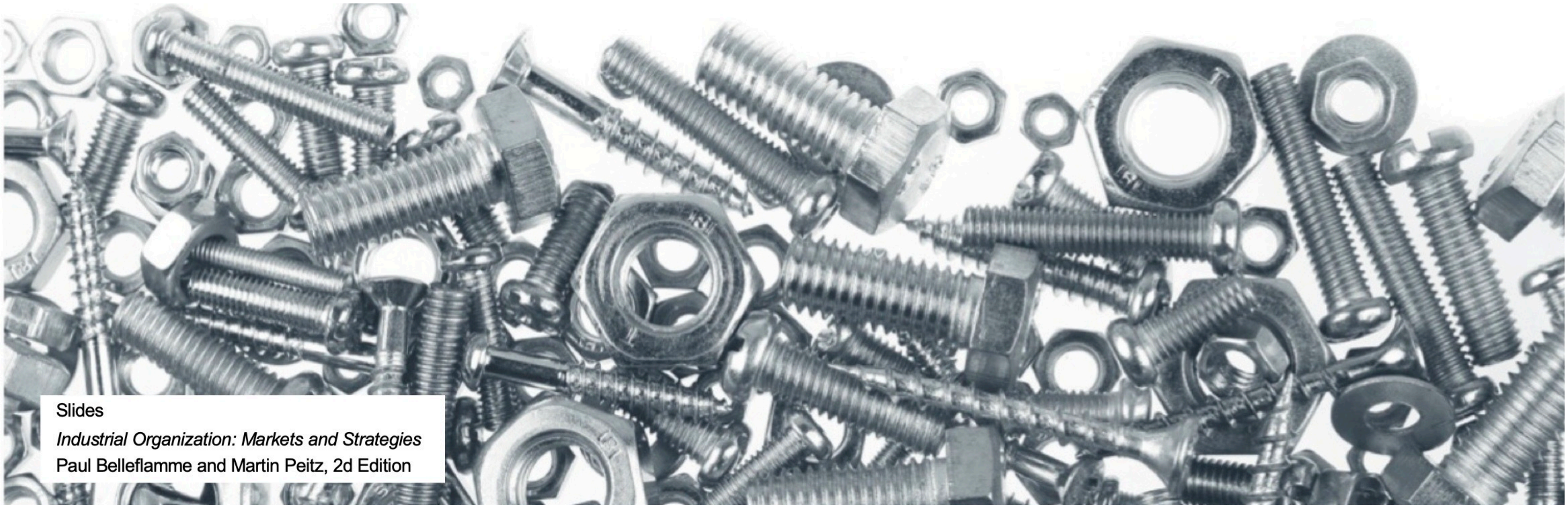

Slides

Industrial Organization: Markets and Strategies

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4.1 Sequential Choices

4.1.1 Stackelberg Model:
Sequential Choice of Quantities

Stackelberg model: Sequential Choice of Quantities

- **Model Assumptions:**
  - $n = 2$ firms
  - Homogeneous products with the following market demand function:
  $$P(q) = a - bq$$
  where total quantity $q = q_1 + q_2$
  - Cost function of firm i: $C_i(q_i) = cq_i$ with $a > c$ $\rightarrow$ constant symmetric MC: c
  - Dynamic game:

    Stage 1: Firm 1 ("Leader") chooses q_1.

    Stage 2: Firm 2 ("Follower"), after observing q_1, chooses q_2.
  - No capacity constraints.

Stackelberg model: Sequential Choice of Quantities

- **Model Solution – Equilibrium:**

Which quantities firms choose in the Subgame Nash equilibrium?

Solution by Backward Induction:

- <u>Stage 2</u>

Firm 2 observes q_1 and solves the following problem:

$$\max_{q_2} \pi_2 = q_2 P(q) - C_2(q_2) = q_2 (a - bq_1 - bq_2) - cq_2$$

FOC:

$$\pi_2' = \frac{\partial \pi_2}{\partial q_2} = a - 2bq_2 - bq_1 - c = 0$$

$$\rightarrow$$

$$BR_2(q_1) = q_2(q_1) = \frac{a - c - bq_1}{2b}$$

Best-response function of "Follower"

Stackelberg model: Sequential Choice of Quantities

- **Model Solution – Equilibrium** (cont.)**:**
  - Stage 1

  Firm 1 anticipates Follower's reaction – takes it into account – and solves:

$$\max_{q_1} \pi_1 = q_1 (a - bq_1 - bBR_2(q_1)) - cq_1 = q_1 (a - bq_1 - b \frac{a - c - bq_1}{2b}) - cq_1$$

$$= q_1 (\frac{a + c - bq_1}{2}) - cq_1$$

FOC:

$$\pi_1' = \frac{\partial \pi_1}{\partial q_1} = ½(a + c - 2bq_1) - c = 0$$

$$\rightarrow \; q_1^{SL} = \frac{a-c}{2b}$$

$$\rightarrow \; q_2^{SF} = \frac{a-c}{4b}$$

$$\rightarrow p^S = \frac{a+3c}{4} \qquad \pi_1^{SL} = \frac{(a-c)^2}{8b} \qquad \pi_2^{SF} = \frac{(a-c)^2}{16b}$$

Stackelberg model: Sequential Choice of Quantities

- **Leader vs. Follower:**
  - $q_1^{SL} = \frac{a-c}{2b} > q_2^{SF} = \frac{a-c}{4b}$ — Leader produces more
  - $\pi_1^{SL} = \frac{(a-c)^2}{8b} > \pi_2^{SF} = \frac{(a-c)^2}{16b}$ — Leader makes higher profits

"First-mover advantage"

- **Sequential (Stackelberg) vs. Simultaneous (Cournot) choices:**
  - $q_1^{SL} = \frac{a-c}{2b} > q_i^{C} = \frac{a-c}{3b}$
  - $q_2^{SF} = \frac{a-c}{4b} < q_i^{C} = \frac{a-c}{3b}$
  - $\pi_1^{SL} = \frac{(a-c)^2}{8b} > \pi_i^{C} = \frac{(a-c)^2}{9b}$
  - $\pi_2^{SF} = \frac{(a-c)^2}{16b} < \pi_i^{C} = \frac{(a-c)^2}{9b}$
  - $p^S < p^C \quad CS^S > CS^C \quad TS^S > TS^C$

Larger (lower) **quantity and profits for Leader** (Follower) **with respect to Cournot**

Why? Leader has stronger incentives to increase quantity – It knows that by increasing q_1, then the Follower will reduce q_2 (strategic substitutes).

Stackelberg model: Sequential Choice of Quantities

- **Paradox of commitment**:

  The assumption that the leader cannot revise its decision, i.e. that q_1 is irreversible, is crucial in the derivation of the Stackelberg equilibrium.

  Why? If it could change it after stage 2, firm 1 would produce then its best response to q_2, $BR_1(q_2)$. This flexibility, however, would hurt firm 1 since firm 2 would anticipate this reaction and the result could be no other but Cournot.

  This is a paradox since firm1 is better off if we reduce its alternatives: It is by limiting its own options that it can manage to influence the rival's course of actions in its own interest.

Case: *When Spanish Conquistador Hernando Cortez landed in Mexico in 1519, one of his first orders to his men was to burn the ships. Cortez was committed to his mission and did not want to allow himself or his men the option of going back to Spain.*

How to achieve irreversibility? Install production capacity (+ sunk costs)

Stackelberg model: Sequential Choice of Quantities

In a duopoly market with one firm (Leader) choosing its quantity before the other firm (Follower), the Subgame Perfect Nash equilibrium is such that:

- Leader enjoys a first-mover advantage
- Leader is better off and Follower is worse off than at the Nash equilibrium of the Cournot game.

4.1.2 Stackelberg Model:
Sequential Choice of Prices

Stackelberg model: Sequential Choice of Prices

Homogeneous Products

- **Model Assumptions:**

  Same assumptions as in the standard Bertrand model with the only difference that now firms choose their prices sequentially.

- **Model Solution - Equilibrium:**
  - Stage 2:

  Firm 2 observes p_1 and reacts optimally (best response):

$$p_2(p_1) = \begin{cases} p^m & \text{if } p_1 > p^m \\ p_1 - \varepsilon & \text{if } c < p_1 \leq p^m \\ c & \text{if } p_1 \leq c, \end{cases}$$

  - Stage 1:

  Firm 1 anticipates Follower's reaction – takes it into account.

  It has (weak) incentives to set $p_1 = c$.

  Thus, the Subgame Perfect Nash equilibrium is: $(p_1, p_2) = (c, c)$

Stackelberg model: Sequential Choice of Prices

Differentiated Products

- **Model Assumptions:**

  Same assumptions as in the Bertrand model with Differentiated products with the only difference that now firms choose their prices sequentially.

$$q_1 = a - bp_1 + dp_2$$

$$q_2 = a - bp_2 + dp_1$$

with $b > d \geq 0$

- **Model Solution - Equilibrium:**

  - Stage 2:

  Firm 2 observes p_1 and solves:

$$\max_{p_2} \pi_2 = (p_2 - c)(a - bp_2 + dp_1)$$

FOC:

$$\pi_2' = \frac{\partial \pi_2}{\partial p_2} = a - 2bp_2 + dp_1 + bc = 0$$

$$\rightarrow p_2 = (a + dp_1 + bc)/2b$$

Best-response function of "Follower"

Stackelberg model: Sequential Choice of Prices

Differentiated Products

- **Model Solution – Equilibrium** (cont.)**:**
  - Stage 1:

Firm 1 anticipates Follower's reaction – takes it into account – and solves:

$$\max_{p_1} \pi_1 = (p_1 - c)[a - bp_1 + d(a + dp_1 + bc)/2b]$$

Simplify:

$$\pi_1 = (p_1 - c)(A - Bp_1)$$

where $A = a(1 + d/2b) + cd/2$ and $B = b - d^2/2b$

FOC:

$$\pi_1' = \frac{\partial \pi_1}{\partial p_1} = A - 2Bp_1 + Bc = 0$$

$$\rightarrow p_1^* = (A + Bc)/2B$$

$$\rightarrow p_2^* = [a + d(A + Bc)/(2B) + bc]/2b$$

Stackelberg model: Sequential Choice of Prices

Differentiated Products

- **Leader vs. Follower:**
  - $p_1^{SL} > p_2^{SF}$ Follower charges a lower price (undercuts)
  - $\pi_1^{SL} < \pi_2^{SF}$ Follower makes higher profits
    ”Second-mover advantage”

Sequential Choice of Quantities vs. Prices

- **Conclusion:**

  Result depends on strategic substitutability/complementarity.

  - Under strategic substitutability (choice of quantities):

    Follower reacts to ↑ in Leader's quantity by ↓ its own quantity.

    → Preferable to be the Leader and to be able to commit to a larger quantity.

  - Under strategic complementarity (choice of prices):

    If Leader acts aggressively, the Follower reacts aggressively.

    → Preferable to be the Follower in order to set lower price than the Leader.

4.2 Free Entry

Free entry: Endogenous Number of Firms

- So far we have assumed that the number of firms in oligopoly markets is exogenous.

  Implicit assumption: entry prohibitively costly.

- Next, we will endogenize the number of firms.

  No entry and exit barriers other than entry costs -- Firms enter as long as profits can be reaped.

  We will analyse a two-stage game in which:

  Stage 1: Potential entrants decide to enter the market or not.

  Stage 2: Quantity competition.

Cournot model with Free Entry

- **Model Assumptions:**
  - n firms in the market (entrants) – infinite number of potential entrants
  - Homogeneous products with the following market demand function:

    $$P(q) = a - bq$$

    where total quantity $q = q_1 + q_2 + \ldots + q_n$
  - Cost function of firm i: $C_i(q_i) = cq_i$ with $a > c$ $\rightarrow$ constant symmetric MC: c
  - Dynamic game:

    Stage 1: Each potential entrant decides whether to enter in the market or not.

    Stage 2: The firms which have entered in the market choose their quantities simultaneously and separately.
  - Entry (fixed) cost: $e > 0$
  - No capacity constraints.

Cournot model with Free Entry

- **Model Solution – Equilibrium** (cont.)**:**
  - Stage 2:

Each firm i solves the following problem:

$$\max_{q_i} \; \pi_i = q_i P(q) - C_i(q_i) = q_i (a - bq_i - bq_{-i}) - c\, q_i - e$$

FOC

$$\pi_i' = \frac{\partial \pi_i}{\partial q_i} = a - 2bq_i - bq_{-i} - c = 0 \;\rightarrow\; BR_i(q_{-i}) = q_i(q_{-i}) = \frac{a - c - bq_{-i}}{2b}$$

Since firms are symmetric in equilibrium $q_1^* = \ldots = q_i = q_n^*$. Using this, we rewrite:

$$q_i = BR_i(q_{-i}) = \frac{a - c - b(n-1)q_i}{2b}$$

$$\rightarrow q_i^*(n) = \frac{a-c}{b(n+1)}$$

If $n\uparrow \rightarrow$ individual quantity $\downarrow$

"Business-stealing effect": $q(n+1) < q(n)$

$$\rightarrow \pi_i(n) = \frac{(a-c)^2}{b(n+1)^2} - e$$

If $n\uparrow \rightarrow$ individual profit $\downarrow$

Cournot model with Free Entry

- **Model Solution – Equilibrium:**

  - Stage 1:

Each potential entrant, decides to enter or not. It will enter if and only if:

$$\pi_i\,(n) = \frac{(a-c)^2}{b(n+1)^2} - e \geq 0$$

We solve for n that satisfies the above condition with equality:

$$\rightarrow (n^e + 1)^2 = \frac{(a-c)^2}{be} \qquad e\uparrow \;\rightarrow\; n^e \downarrow$$

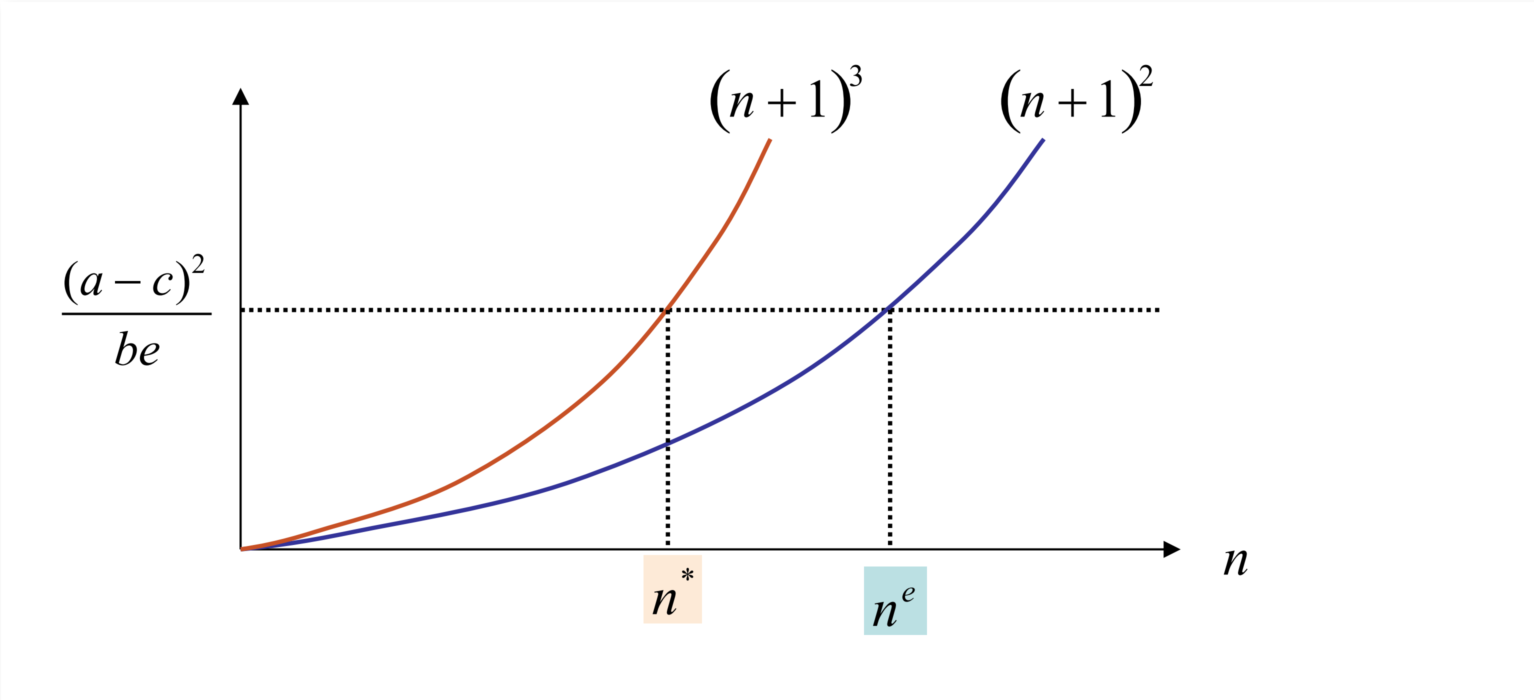
Important observation: The above number differs from the number of firms that would maximize welfare ($TS = PS + CS$).

$$W(n) = n\pi(n) + SC(n) = \frac{n(n+2)}{2b}\left(\frac{a-c}{n+1}\right)^2 - ne$$

$$W'(n^*) = 0 \Leftrightarrow \left(n^* + 1\right)^3 = \frac{(a-c)^2}{be}$$

$$\rightarrow \boldsymbol{n^e > n^*}$$

Cournot Model with Free Entry



Because of the business-stealing effect, the symmetric Cournot model with free entry exhibits socially excessive entry.

Case: **Entry in small cities in the U.S.**

Bresnahan & Reiss (1990,1991) estimate an entry model.

Use data from rural retail and professional markets in small U.S. cities.

Results:

- Firms enter if profit margins are sufficient to cover fixed costs of operating.
- Profit margins ↓ with additional entry.