Part II. Market power

Chapter 4. Dynamic aspects of imperfect competition

Slides

Industrial Organization: Markets and Strategies

Paul Belleflamme and Martin Peitz, 2d Edition

Chapter 4. Learning objectives

- Understand how competition is affected when decisions are taken sequentially rather than simultaneously.
- Analyze entry decisions into an industry and compare the number of firms that freely enter with the number that a social planner would choose.
- Distinguish endogenous from exogenous sunk cost industries and analyze how market size affects market concentration.

Sequential choice: Stackelberg

- Chapter 3: ‘simultaneous’ decisions
  - Firms aren’t able to observe each other’s decision before making their own.
- Here: sequential decisions
  - Possibility for some firm(s) to act before competitors, who can thus observe past choices.
    - E.g.: pharma. firm with patent acts before generic producers
  - Better to be **leader** or **follower**?
    - Depends on nature of strategic variables & on number of firms moving at different stages.
  - First mover must have some form of **commitment**.
    - When and how is such commitment available?

One leader / One follower

- First-mover advantage?
  - Firm gets higher payoff in game in which it is a leader than in symmetric game in which it is a follower.
  - Otherwise, second-mover advantage.
- Quantity competition: **Stackelberg model**
  - Similar to Cournot duopoly
  - But, one firm chooses its quantity before the other.
  - Look for subgame-perfect equilibrium
  - Setting
    - $P(q_1,q_2) = a - q_1 - q_2$; $c_1 = c_2 = 0$
    - Firm 1 = leader; firm 2 = follower

One leader / One follower (cont'd)

- Solve by backward induction
  - Follower's decision
    - Observes q_1, chooses q_2 to $\max \pi_2 = (a - q_1 - q_2)q_2$
    - Reaction: $q_2(q_1) = (a - q_1)/2$
  - Leader's decision
    - Anticipates follower's reaction:
      $\max \pi_1 = (a - q_1 - q_2(q_1))\, q_1 = (1/2)(a - q_1)\, q_1$
- Equilibrium

$$q_1^L = a/2,\ q_2^F = q_2(q_1^L) = a/4,\ P(q_1^L, q_2^F) = a/4$$
$$\pi_1^L = a^2/8,\ \pi_2^F = a^2/16$$

One leader / One follower (cont'd)

- Results
  - Leader makes higher profit than follower. As firms are symmetric → **First-mover advantage**
  - Comparison with simultaneous Cournot
    - $q^C = a/3$ & $\pi^C = a^2/9$
    - **Larger** (lower) **quantity and profits for leader** (follower) **w.r.t. Cournot**
    - Intuition: leader has stronger incentives to increase quantity when follower observes and reacts to this quantity, than when follower does not.

One leader / One follower (cont'd)

- **Lesson**: In a duopoly producing substitutable products with one firm (the leader) choosing its quantity before the other firm (the follower), the subgame perfect equilibrium is such that
  - firms enjoy a first-mover advantage;
  - the leader is better off and the follower is worse off than at the Nash equilibrium of the Cournot game.

One leader / One follower (cont'd)

- Price competition
  - Previous result hinges on strategic substitutability
    - Follower reacts to ↑ in leader's quantity by ↓ its own quantity → leader finds it profitable to commit to a larger quantity.
  - Reverse applies under strategic complementarity
    - If leader acts aggressively, follower reacts aggressively.
    - Preferable to be the follower and be able to set lower price.

- **Lesson**: In a duopoly producing substitutable products under constant unit costs, with one firm choosing its price before the other firm, the subgame-perfect equilibrium is such that at least one firm has a second-mover advantage.

One leader / Endogenous number of followers

- E.g.: market for a drug whose patent expired
  - Leader: patent holder / Followers: generic producers
  - Observation: leader cuts its price, possibly to keep the number of entrants low
- Theoretical prediction
  - **Leader always acts more aggressively (i.e., sets larger quantity or lower price) than followers.**
  - Intuition: leader is also concerned about the effect of its own choices on the number of firms that enter; nature of strategic variables is less important.
  - Confirms the observations.

Commitment

- Implicit assumption so far:
  - Leader can **commit** to her choice.
- Schelling's analysis of conflicts
  - **Threat**: punishment inflicted to a rival if he takes a certain action. Goal: prevent this action
  - **Promise**: reward granted to a rival if he takes a certain action. Goal: encourage this action
  - But, threats and promises must be **credible** to be effective → they must be transformed into a **commitment**: *inflict the punishment or grant the reward must be in the best interest of the agent who made the threat or the promise*.
  - **How?** Make the action **irreversible.**

Commitment (cont'd)

- **Paradox of commitment**
  - It is by limiting my own options that I can manage to influence the rival's course of actions in my 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?
  - Quantities: install production capacity (+ sunk costs)
  - Prices: 'most-favoured customer clause', print catalogues

- **Dynamic Competition**
- Go to EconS 503's website, Chapter 8, slides 154-177
- Bertrand model with heterogeneous goods and simultaneous price competition, each firm i chooses p_i to solve $\max_{p_i \geq 0} p_i q_i - TC_i(q_i)$, that is

$$\max_{p_i \geq 0} \; p_i D_i(p_i, p_j) - TC_i(D_i(p_i p_j))$$

- FOC:

$$\frac{\partial \pi_i}{\partial p_i} = D_i(p_i, p_j) + p_i \frac{\partial D_i}{\partial p_i} - \frac{\partial TC_i}{\partial D_i} \frac{\partial D_i}{\partial p_i} = 0$$

$$\Rightarrow D_i(p_i, p_j) + \left(p_i - \frac{\partial TC_i}{\partial D_i} \right) \frac{\partial D_i}{\partial p_i} = 0$$

- If goods are substitutes in consumption, then $\frac{\partial D_1}{\partial p_2} > 0$, and $\frac{\partial p_2(p_1)}{\partial p_1} > 0. \Rightarrow p_1^{seq} > p_1^{sim}$.
- An example is $q_i = a - bp_i + cp_j$, where $b > c$.

- If goods are complements in consumption, then $\frac{\partial D_1}{\partial p_2} < 0$, and $\frac{\partial p_2(p_1)}{\partial p_1} < 0. \Rightarrow p_1^{seq} > p_1^{sim}$.
- An example is $q_i = a - bp_i - cp_j$, where $b > c$.

- Cournot model with heterogeneous goods and simultaneous price competition, each firm i chooses q_i to solve

$$\max_{q_i \geq 0} \; q_i p_i \underbrace{\left(q_i, q_j\right)}_{Q} - TC_i(q_i)$$

- FOC:

$$\frac{\partial \pi_i}{\partial q_i} = p_i(Q) + p'_i(Q) q_i - \frac{\partial TC_i}{\partial q_i} = 0$$

- **Endogenous Entry**
- Go to EconS 503’s website, Chapter 8, slides 193-209

Free entry: endogenous number of firms

- So far (with one exception), limited number of firms
  - Implicit assumption: entry prohibitively costly
- Here, opposite view
  - No entry and exit barriers other than entry costs.
  - Firms enter as long as profits can be reaped.
  - Two-stage game
    1. Decision to enter the industry or not
    2. Price or quantity competition
  - 3 models
    - Free entry in Cournot model
    - Free entry in Salop model
    - Monopolistic competition

Properties of free entry equilibria

- Setting
  - Industry with symmetric firms; entry cost $e > 0$
  - If n active firms, profit is $\pi(n)$, with $\pi(n) > \pi(n+1)$
  - Number of firms under free entry, n^e such that $\pi(n^e) > 0$ and $\pi(n^e+1) < 0$
  - $e\uparrow \rightarrow n^e\downarrow$

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

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

Cournot model with free entry

- Linear model (more general approach in the book)
  - $P(q) = a - bq,\ C_i(q) = cq,\ c < a$
  - Equilibrium: $q(n) = (a-c)/[b(n+1)]$
  - "Business-stealing effect": $q(n+1) < q(n)$
- Free-entry equilibrium

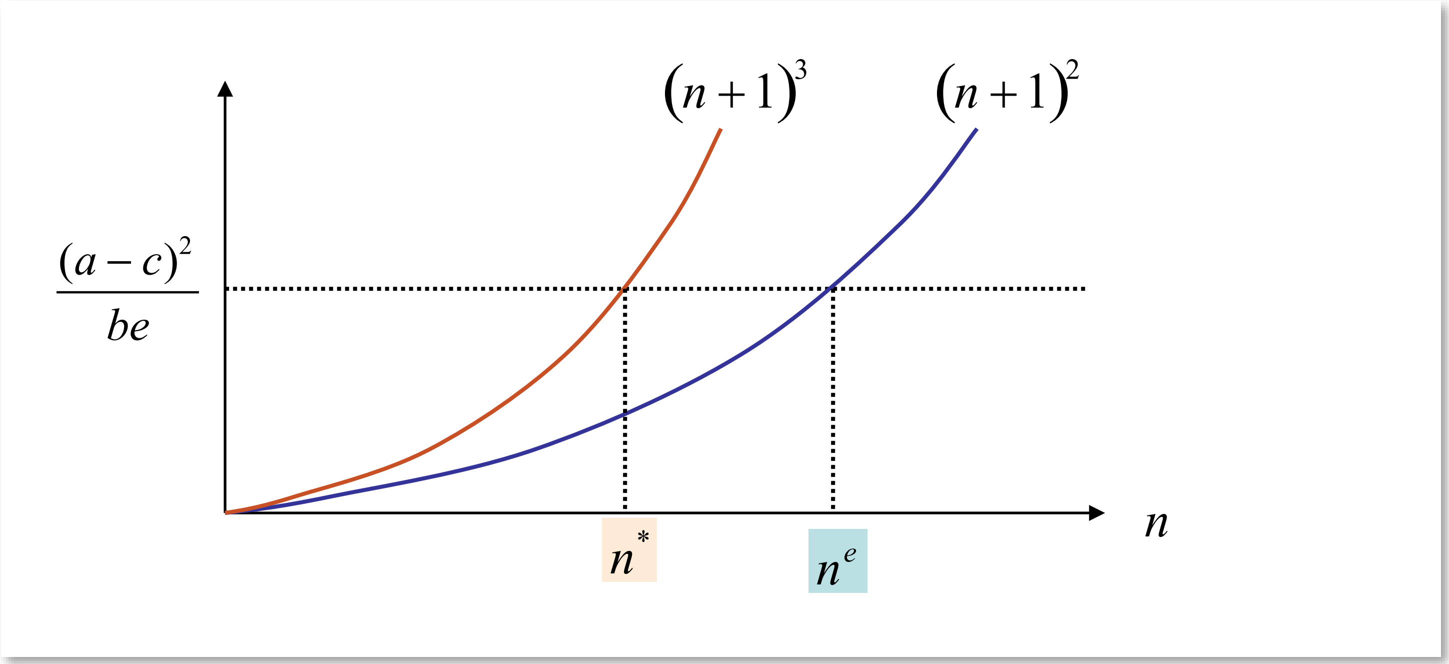
$$\pi(n^e) = \frac{1}{b}\left(\frac{a-c}{n^e+1}\right)^2 - e = 0 \Leftrightarrow \left(n^e+1\right)^2 = \frac{(a-c)^2}{be}$$

- Social optimum (second best)

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

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

Cournot model with free entry (cont'd)



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

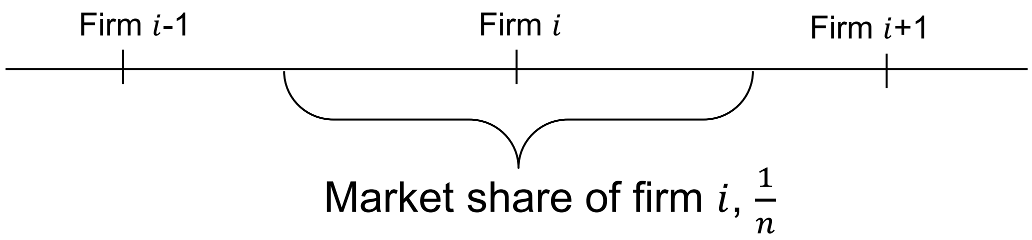
Price competition with free entry

- Salop (circle) model of Chapter 3
  - Firms enter and locate equidistantly on circle with circumference 1
  - Consumers uniformly distributed on circle
  - They buy at most one unit, from firm with lowest 'generalized price' (unit transportation cost, τ)
  - If n firms enter, equilibrium price: $p(n) = c + \tau / n$
- Free-entry equilibrium

$$\pi(n^e) = 0 \Leftrightarrow (p - c)\frac{1}{n^e} - e = 0 \Leftrightarrow \frac{\tau}{(n^e)^2} = e \Leftrightarrow n^e = \sqrt{\frac{\tau}{e}}$$

Price competition with free entry (cont'd)

- 1st stage, every firm i decides enter/not enter.
- 2nd stage, given n, every firm chooses p_i, $p(n) = c + \frac{\tau}{n}$.



- In the 2nd stage,

$$\pi(n^E) = (p - c)\frac{1}{n} - e$$

$$\Rightarrow \pi(n, p(n)) = \Big(\underbrace{c + \frac{\tau}{n}}_{P(n)} - c\Big)\frac{1}{n} - e = \frac{\tau}{n^2} - e$$

Price competition with free entry (cont'd)

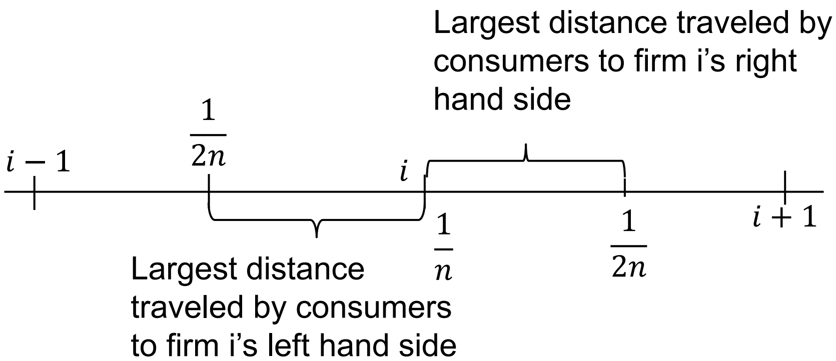
- In the 1st stage, n^E, the equilibrium number of firms, solves

$$\frac{\tau}{(n^E)^2} - e = 0 \Rightarrow n^E = \sqrt{\frac{\tau}{e}}$$

- $p(n^E) = c + \frac{\tau}{\sqrt{\frac{\tau}{e}}} = c + \sqrt{\tau e}$

Price competition with free entry (cont'd)

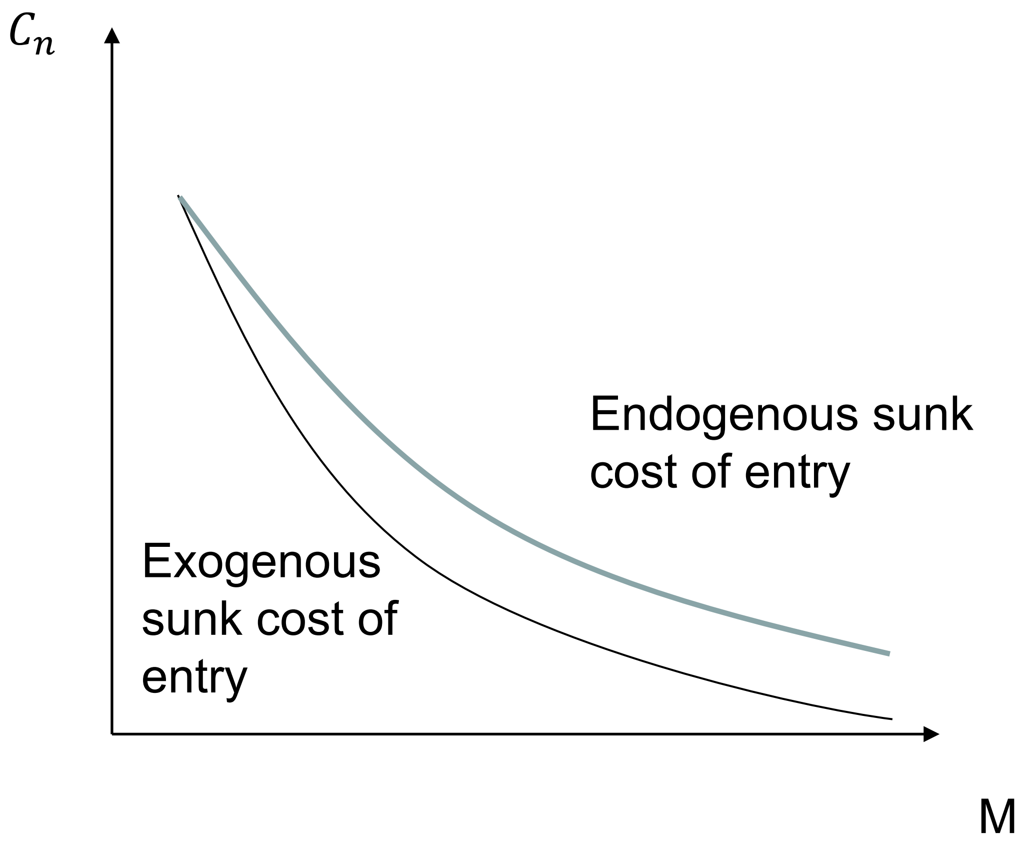
- To find the social optimum number of firms, the social planner chooses n^* to solve
$$\max_n W = CS + PS,$$



- which is equivalent to
$$\min_n ne + \tau\left(\underbrace{2n\int_0^{\frac{1}{2n}} s\,ds}_{\text{Expected distance traveled}}\right)$$

- FOC w.r.t n:
$$e - \frac{\tau}{4(n^*)^2} = 0 \Rightarrow n^* = \frac{1}{2}\sqrt{\frac{\tau}{e}} = \frac{1}{2}n^E$$

Price competition with free entry (cont'd)



Price competition with free entry (cont'd)

- Social optimum (second best)
  - Planner selects n^* to minimize total costs

$$\min_n TC(n) = ne + \tau\left(2n\int_0^{1/(2n)} s\,ds\right) = ne + \frac{\tau}{4n}$$

$$TC'(n^*) = 0 \Leftrightarrow e - \frac{\tau}{4(n^*)^2} = 0 \Leftrightarrow n^* = \frac{1}{2}\sqrt{\frac{\tau}{e}} = \frac{1}{2}n^e$$

- **Lesson**: In the Salop circle model, the market generates socially excessive entry.

  - Intuition: dominance of business-stealing effect
  - **Case.** Socially excessive entry of radio stations in the U.S.

Monopolistic competition

- 4 features
  - Large number of firms producing different varieties
  - Each firm is negligible
  - No entry or exit barriers → economic profits = 0
  - Each firm enjoys market power
- S-D-S model (Spence, 1976; Dixit & Stiglitz, 1977)
  - Rather technical → see the book

- **Lesson**: In models of monopolistic competition, the market may generate excessive or insufficient entry, depending on how much an entrant can appropriate of the surplus generated by the introduction of an additional differentiated variety.

Industry concentration and firm turnover

- So far, exogenous sunk costs
  - e = sunk cost, exogenous (i.e., not affected by decisions in the model); if $e\uparrow \rightarrow n^e\downarrow$
  - If market size $\uparrow \rightarrow n^e\uparrow$ & industry concentration $\downarrow$
- **Lesson**: In industries with exogenous sunk costs, industry concentration decreases and approaches zero as market size increases.
- Not verified empirically in all industries
  - $\exists$ industries with large increase of market demand over time **and** persistently high concentration
  - To reconcile theory with facts: endogenous sunk costs

Industry concentration and firm turnover (cont'd)

- **A model with endogenous sunk costs**
  - Quality-augmented Cournot model
  - 3-stage game (details in subsequent slides)
    1. Firms decide to enter
    2. Firms decide which quality to develop
    3. Firms decide which quantity to produce
  - Endogenous sunk costs arise from strategic investments that increase the price-cost margin
    - Improvements in quality, advertising, process innovations
    - Intuition: Market size ↑→ market more valuable → active firms invest more → some of extra profits are competed away → upper bound on entry (lower bound on concentration)

Industry concentration and firm turnover (cont'd)

- **Lesson**: In markets with endogenous sunk costs, even as the size of the market grows without bounds, there is a strictly positive upper bound on the equilibrium number of firms.

Case. **Supermarkets in the U.S.**

- Ellickson (2007): supermarkets concentration (U.S., 1998)
  - Identifies 51 distribution markets
  - All are highly concentrated (dominated by 4 to 6 chains), *independently of the size of the particular distribution market*.
- Due to endogenous sunk costs?
  - Quality dimension: available number of products
  - Can be increased by more shelf space and/or improved logistics
  - Average number or products has indeed increased
    - 14,000 (1980), 22,000 (1994), 30,000 (2004)
  - Investments are incurred within each distribution market.

Details: Quality-augmented Cournot model

- Effect of endogenous sunk costs on entry?
- 3-stage game
  1. Firms decide to enter
  2. Firms decide which quality to develop (s_i)
  3. Firms decide which quantity to produce (q_i)
- Consumers
  - Measure M, with Cobb-Douglas utility function

$$u(q_0, q) = q_0^{1-\gamma}(sq)^{\gamma}$$

  - Consumers spend a fraction γ of their income y on the good offered by Cournot competitors
  - Total consumer expenditure = $M\gamma y$

Details: Quality-augmented Cournot model (cont'd)

- 3rd stage
  - Price-quality ratio must be the same for all n firms:

$$p_i / s_i = p_j / s_j \equiv \lambda \text{ for all } i, j \text{ active}$$

  - Hence, industry revenues are such that

$$R = \sum p_i q_i = \lambda \sum s_i q_i \Leftrightarrow \lambda = R / \left(\sum s_i q_i \right)$$

$$\text{with } \frac{d\lambda}{dq_i} = -\frac{R s_i}{\left(\sum s_i q_i \right)^2} = -\frac{s_i}{R} \lambda^2$$

  - Firm maximizes $M\pi = (p_i - c) q_i = (\lambda s_i - c) q_i$

Details: Quality-augmented Cournot model (cont'd)

- 3rd stage (cont'd)
  - FOC: $$\frac{d\pi_i}{dq_i} = (\lambda s_i - c) + s_i q_i \frac{d\lambda}{dq_i} = 0 \Leftrightarrow s_i q_i = \frac{R}{\lambda} - \frac{cR}{\lambda^2 s_i}$$
  - Summing over *n* firms: $$\sum_i s_i q_i = \frac{nR}{\lambda} - \frac{cR}{\lambda^2} \sum_i \frac{1}{s_i}$$
  - As total revenues = total expenditure $$\sum_i s_i q_i = R/\lambda \Leftrightarrow \lambda = \frac{c}{n-1} \sum_i \frac{1}{s_i}$$
  - Plugging this value in FOC: $$q_i = \frac{R}{c} \frac{n-1}{s_i \sum_i \frac{1}{s_i}} \left(1 - \frac{n-1}{s_i \sum_i \frac{1}{s_i}} \right)$$

Details: Quality-augmented Cournot model (cont'd)

- 3rd stage (cont'd)
  - Positive sales for all firms ⇔ qualities not too different

$$\frac{1}{n-1}\sum_i \frac{1}{s_i} > \frac{1}{s_i}$$

  - Combine previous results to get

$$p_i - c = \left(\frac{s_i}{n-1}\sum_i \frac{1}{s_i} - 1 \right) c$$

$$\Rightarrow (p_i - c) q_i = \left(1 - \frac{n-1}{s_i \sum_i \frac{1}{s_i}} \right)^2 R$$

Details: Quality-augmented Cournot model (cont'd)

- Exogenous quality
  - Include entry costs, e, and fixed costs for producing quality, $C(s)$.
  - Symmetric equilibrium: $s_i = s$.
  - Firm's net profit:

$$\left(p^*(n) - c\right)q^*(n) - e - C(s) = R/(n^2) - e - C(s) = M\gamma y/(n^2) - e - C(s)$$

  - If market size M explodes, $n \to \infty$
  - Confirmation of result in 2-stage (entry-then-quantity-competition) model: no lower bound on concentration

Details: Quality-augmented Cournot model (cont'd)

- Endogenous quality: 2nd stage
  - If all other firms set quality $\hat{s}$, firm i's profit is

$$\left(1-\frac{n-1}{s_i\left(\frac{1}{s_i}+\frac{n-1}{\hat{s}}\right)}\right)^2 R - C(s_i) = \left(1-\frac{1}{\frac{1}{n-1}+\frac{s_i}{\hat{s}}}\right)^2 R - C(s_i)$$

  - Take $C(s_i) = \alpha s_i^{\beta}$
  - Symmetric equilibrium: $s_i = \hat{s} \equiv s^*$

$$2\left(1-\frac{1}{\frac{1}{n-1}+1}\right)\frac{\frac{1}{s^*}}{\left(\frac{1}{n-1}+1\right)^2} R = \alpha\beta\left(s^*\right)^{\beta-1} \Leftrightarrow s^* = \sqrt[\beta]{\frac{2R}{\alpha\beta}\frac{(n-1)^2}{n^3}}$$

    - Increases with $R = M\gamma y$
      $\Rightarrow$ market size $\uparrow \rightarrow$ firms compete more fiercely in quality

Details: Quality-augmented Cournot model (cont'd)

- Endogenous quality: 1st stage
  - Firm's net profit becomes

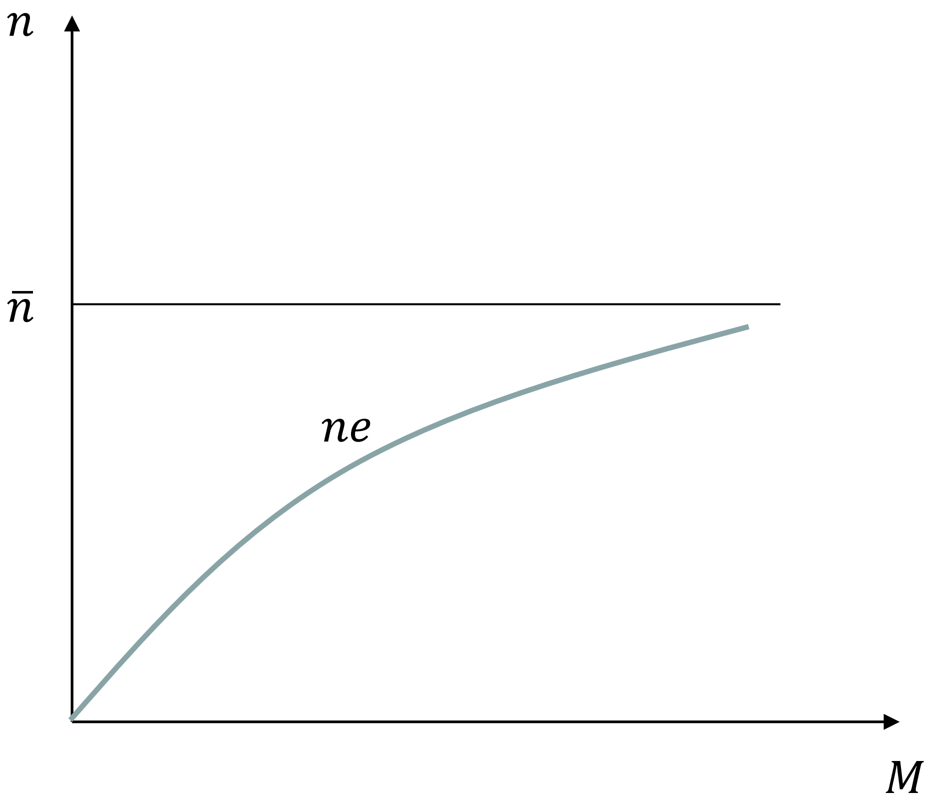
$$\frac{M\gamma y}{n^2} - e - \frac{2}{\beta}\frac{(n-1)^2}{n^3} M\gamma y = \frac{M\gamma y}{n^3}\left(n - \frac{2}{\beta}(n-1)^2\right) - e$$

  - Positive as long as

$$n - \frac{2}{\beta}(n-1)^2 > 0 \Leftrightarrow n \le \bar{n} \equiv 1 + \frac{1}{4}\left(\beta + \sqrt{\beta(\beta+8)}\right)$$

    - **Upper bound (independent of M) on number of firms**
    - <u>Example</u>: $\beta = 5 \Rightarrow \bar{n} = 4.27$
    - Natural oligopoly because only a small number of firms can be sustained, independently of market size

Price competition with free entry (cont'd)



- Let $\beta = 5, e = 0.2. \bar{n}$ is not a function of M

Details: Quality-augmented Cournot model (cont'd)

We state again:

- **Lesson**: In markets with endogenous sunk costs, even as the size of the market grows without bounds, there is a strictly positive upper bound on the equilibrium number of firms.

Industry concentration and firm turnover (cont'd)

- **Dynamic firm entry and exit**
  - So far, static models
    - OK to predict number of active firms in industries
    - But, unable to generate entry and exit dynamics
  - What do we expect?
    - Market entry (exit) in growing (declining) industries
  - What do we observe?
    - Simultaneous entry and exit in many industries
  - Explanation?
    - Firms are heterogeneous (e.g., different marginal costs)
    - Their prospects change over time (idiosyncratic shocks)
  - Model
    - More technical; to be read in the book

Industry concentration and firm turnover (cont'd)

- **Lesson**: In monopolistically competitive markets, market size ↑
  → total number of firms in the market ↑
  → only particularly efficient firms stay
  → turnover rate ↑
  ⇒ firms tend to be younger in larger markets.

Case. Hair salons in Sweden

- Asplund and Nocke (2006) compare age distribution of hair salons across local markets.
- Hypothesis: *estimated age distribution function of firms with large market size lies above estimated age distribution of firms with small market size.*
- Confirmed by the data.

Review questions

- Why is there generally a first-mover advantage under sequential quantity competition (with one leader and one follower) and a second-mover advantage under sequential price competition? Explain by referring to the concepts of strategic complements and strategic substitutes.
- When firms only face a fixed set-up costs when entering an industry, how is the equilibrium number of firms in the industry determined? Is regulation possibly desirable (to encourage or discourage entry)? Discuss.

Review questions (cont'd)

- What is the difference between endogenous and exogenous sunk costs? What are the implications for market structure?
- Which market environments lead to simultaneous entry and exit in an industry?