Industrial Economics

Basic Constellations in Industrial Economics: Cournot competition, Stackelberg and Bertrand and the barriers to entry

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Outline

The Role of Investment Blocking Entry

- How can monopoly power be maintained over time?
- different variables have different time horizons (short term vs long term) and different levels of commitment
- difference between
  - fixed investment costs
  - fixed annual costs
  - long-term vs short-term variable costs
- commitment is needed to avoid competition

Different Forms of Competition

- Price competition (Bertrand competition)
- Quantity competition (Cournot competition) and the theory of limit pricing
- Capacity and investment in capital as irreversible (sunk) factors of production (Stackelberg)
- Information, reputation, the ability to generate beliefs as additional "sunk" capital.

In question is the credibility of the commitment. Capital must be irreversibly sunk in order to have commitment value. Limit pricing as such (that is to say without additional commitment) does nothing of the kind.

General points

- The role of capacity and investment with commitment value.
- The distinction between fixed costs (?capital?) on the one side and variable costs, prices, production on the other (long term vs. short term)
- Capital investment has two functions in this context:
  1. The usual function to enable production and to minimize the cost of production
  2. A strategic function to block the entry
- The term "capital" includes
  - Fixed physical facilities (buildings, machinery, assembly line etc.), but also
  - Know-how, technology, brand image, reputation, distribution networks, customer relationships, choice of geographic location etc. (whatever takes time to build and to undo).

General points

- The commitment value is essential and necessary for the formation of a barrier to entry. If not, one will end up in Cournot competition, the competitor taking production as input for own profit maximization);
    - We will essentially be evolving in a Stackelberg leader-follower model, where the "leader" has first-mover advantage;
    - In the original contribution by Stackelberg variable production is the strategic variable. This short-term notion without commitment value is no longer acceptable today);
    - The strategic variable is capital or capacity.

General points

- Remember: "the ability to constrain oneself is the necessary condition to constrain one's competitor or adversary", the notion of capital or fixed investment only formalizes this notion.
- Fixed capital has commitment value only if it cannot easily be sold on a secondary market separately from the firm. It must be in some sense intrinsic to the firm.
- This refers to the notions of indivisibility (which constitutes monopoly power), and hence to complexity and lack of codification as conditions for monopolistic competition.

Outline

The basic didactic model by Tirole (1989)

- This Cournot-Stackelberg model makes no distinction between quantity and capacity.
  1. Firm 1 chooses q_1 first (leader);
  2. Firm 2 choose q_2 as a function of q_1 (follower);
- The model is exceedingly simple for didactic purposes:
  1. Production is equal to capacity: $q_i = K_i$
  2. Variable cost is zero
  3. The demand function is $D(p) = q = q_1 + q_2 = 1 - p$
  4. The inverse demand function is $D^{-1}(q) = p = 1 - q_1 - q_2$.
  5. Profit functions are $\Pi_i(q_1, q_2) = q_i(1 - q_1 - q_2)$

Choice of optimal capacity (Cournot competition)

- Cournot version of setup: Firm 2 does not know the capacity q_1 firm 1 has *actually chosen*, but only has some beliefs about what capacity firm 1 might have chosen
- Firm 2 selects its capacity based on q_1 and thus determines its reaction curve in the Cournot model without a fixed cost of entry

$$\Pi_2(q_1, q_2) = q_2(1 - q_1 - q_2) = q_2 - q_1 q_2 - q_2^2$$

and

$$\frac{\partial \Pi_2}{\partial q_2} = 1 - q_1 - 2q_2 = 0 \text{ and } q_2 = \frac{1 - q_1}{2} \text{(Cournot response function)}$$

Observations:

$$\frac{\partial^2 \Pi_2}{\partial q_2^2} < 0 \text{ (maximum)}$$

$$\frac{\partial \Pi_2}{\partial q_1} < 0 \text{ (expansion of the competitior's capacity decreases profits)}$$

Choice of optimal capacity (Cournot competition)

- Firm 1 will do the same: $q_1 = \frac{1-q_2}{2}$
- Substituting (2) into (1) yields for the optimal quantities:

$$q_1 = \frac{1-q_2}{2} = \frac{1-\frac{1-q_1}{2}}{2} = \frac{1}{2} - \frac{1}{4} + \frac{q_1}{4}$$

and

$$\frac{3q_1}{4} = \frac{1}{4} \text{ and } q_1 = q_2 = \frac{1}{3}$$

- This yields for profits:

$$\Pi_1(q_1, q_2) = q_1(1 - q_1 - q_2) = \frac{1}{3} \times \frac{1}{3} = \frac{1}{9}$$

Firm 1 substitute into its profit function the reaction function of firm 2 rather than its quantity (Stackelberg result)

- Stackelberg setup: firm 2 knows the *actual quantity chosen* of firm 1 and reacts to it
- profits of firm 1

$$\Pi_1(q_1, q_2) = q_1(1 - q_1 - q_2) = q_1(1 - q_1 - \frac{1 - q_2}{2})$$
$$= q_1 - q_1^2 - \frac{q_1}{2} + \frac{q_1^2}{2} = \frac{q_1}{2} - \frac{q_1^2}{2}$$

- first-order condition

$$\frac{\partial \Pi_1}{\partial q_1} = 0 = \frac{1}{2} - q_1 \text{ and } q_1 = \frac{1}{2} \text{ (Stackelberg leader best response)}$$
$$q_2 = \frac{1 - q_1}{2} \text{ and } q_2 = \frac{1}{4} \text{ (Stackelberg follower best response)}$$

This yields for profits

- firm 1

$$\Pi_1(q_1, q_2) = q_1(1 - q_1 - q_2) = \frac{1}{2}\left(1 - \frac{1}{2} - \frac{1}{4}\right) = \frac{1}{8}$$

- firm 2

$$\Pi_2(q_1, q_2) = q_2(1 - q_1 - q_2) = \frac{1}{4}\left(1 - \frac{1}{2} - \frac{1}{4}\right) = \frac{1}{16}$$

- draw graph here

Credibility

- The problem is the credibility of the commitment. Why would Firm 1 insist on point [1/2; 1/4] with a profit of 1/8 if the profit is higher point [3/8; 1/8] with a profit of

$$\begin{aligned}
\Pi_1(q_1, q_2) &= q_1 \left(1 - q_2 - \frac{1 - q_2}{2}\right) \\
&= \frac{3}{8}\left(1 - \frac{1}{4} - 1 - \frac{1 - \frac{1}{4}}{2}\right) \\
&= \frac{3}{8}\left(1 - \frac{1}{4} - \frac{3}{8}\right) = \frac{3}{8} \times \frac{3}{8} = \frac{9}{64} > \frac{1}{8}.
\end{aligned}$$

- The problem is that firm 1 cannot durably fix Firm 2 at the point [3/8; 1/4] as Firm 2 would immediately play [3/8; 5/16]. However Firm 1 can fix it at [1/2; 1/4] by committing to a capacity which is equal to $CAP = q_1 = \frac{1}{2}$.

Outline

Limit pricing

- In simple limit pricing models, Firm 1 would also produce at $q_1 = \frac{1}{2}$ hoping that Firm will have a profit of zero when putting also $q_2 = \frac{1}{2}$ on the market. However this is not credible. Firm 2 will enter with $q_2 = \frac{1}{4}$ and Firm 1 will move to $\frac{3}{8}$. The result is again Cournot duopoly (Nash equilibrium). The "sunk" fixed cost of capacity is he only commitment Firm 1 can make.
- One way to interpret the game is in terms of a higher form of rationality or of a temporal asymmetry. Firm 1 is smarter or moves first. However, the question is who has committed first to a certain amount of capacity or production. This distinguishes the incumbent from the entrant.
- The commitment power of the incumbent increases when:
  - Capital depreciation is slow;
  - Capital is specific to the firm.

Outline

Choosing a cost fixed input (advertisement) to block entry

- In this game, Firm 1 wants to monopolise the market and establish a fixed barrier to entry (F) that would block the entry of Firm 2 by forcing it to make a negative profit if it would like to enter likewise (think of a massive advertising campaign as an example).
- In other words, the barrier of entry is a fixed cost that any entrant would also need to invest before being able to enter.
- Let us determine the least fixed cost for such a barrier of entry in order to keep out any competitors

$$\Pi_2(q_1, q_2) = q_2(1 - q_1 - q_2) - F = q_2 - q_1 q_2 - q_2^2 - F \leq 0$$

- Maximization:

$$\frac{\partial \Pi_2}{\partial q_2} = 01 - q_1 - 2q_2 \text{ and hence } q_2 = \frac{1 - q_1}{2}$$

Choosing a cost fixed input (advertisement) to block entry

- and thus $q_1 = 1/2$ (profit maximizing monopoly output), $q_2 = 1/4$
- resubstituting $q_2^* = 1/2$ into (1) yields

$$\Pi_2 = \frac{1}{4} - \frac{1}{4} \times \frac{1}{2} - \frac{1}{4} \times \frac{1}{4} - F = \frac{1}{16} - F \leq 0$$

- This means that in order to keep Firm 2 out of the industry while maximising profits, the initial fixed costs need to satisfy $F \geq \frac{1}{16}$

Choosing a cost fixed input (advertisement) to block entry

- Firm 1 will maintain its monopoly if it is able to compel the firm F2 to a fixed investment of at least $1/16$.
- In this case the profit of Firm 1 would be:

$$\Pi_1 = \frac{1}{2}\left(1 - \frac{1}{2}\right) - \frac{1}{16} = \frac{3}{16}.$$

- observation $\frac{3}{16} > \frac{1}{8}$
- Thus the profit with a sunk investment of $1/16$ to block entry completely is higher than the profit obtained with Stackelberg behaviour allowing the partial entry of Firm 2.

Choosing a cost fixed input (advertisement) to block entry

- With a fixed cost $F = 1/16$, Firm 1 blocks the entry of Firm 2 while producing the point of monopoly. The fixed cost in question needs to be sunk and irreversible! Otherwise there will be entry and adjustment.
- The very notion of F assumes an irreversible commitment. The notion of establishing an advertising reputational capital is an interesting concept in this context; the problem is that it leads us towards imperfect or monopolistic competition (Keppler (2009)).
- There is also the possibility of a war of attrition when both firms insist on providing the Stackelberg output even at negative profits. The idea is of course one of short run pain and long run gain in the hope that the competitor will leave the market. However, it can also be the result of irrational behaviour.

Strategic behaviour, barriers to entry and limit pricing

- Recall the logic of the Stackelberg model “I force my opponent by forcing myself” which requires an irreversible commitment.
- Such a commitment can take the form of physical capacity (the classic case).
- However it can also take the form of reputation, branding, advertising, technology etc. anything that is intrinsic and cannot be sold separately from the firm itself constitutes such an irreversible commitment.

Strategic behaviour, barriers to entry and limit pricing

- Consider the following game, where ADV refers to the irreversible fixed cost expenditure for an advertising campaign.
- This will show that the interest in blocking the complete entry of a competitor depends on the profits available under monopoly (i.e. the elasticity of the demand function).
- table below gives the pay-offs for the two firms' choices:

		Incumbent: Advertising Campain	Incumbent: NO Advertising Campain
Entrant	Enter	$\Pi_{\text{Duop}} - ADV$, $\Pi_{\text{Duop}} - ADV$	Π_{Duop}, Π_{Duop}
	Do NOT Enter	$\Pi_{\text{Monop.}} - ADV$, 0	Π_{Monop}, 0

Conditions for successfully blocking entry

1. For the incumbent to engage in anti-competitive behaviour it must be worth it: $\Pi_{\text{Monop}} - ADV > \Pi_{\text{Duop}}$
   If this is not the case, accommodation is preferable.
2. In order to block the entrant, it must hold that entering engenders negative profits: $ADV > \Pi_{\text{Duop}}$
   If this is not the case, the entrant will enter regardless.
3. Substituting condition (2) into condition (1) obtains : $\Pi_{\text{Monop}} - \Pi_{\text{Duop}} > \Pi_{\text{Duop}}$, which implies $\Pi_{\text{Monop}} > 2\Pi_{\text{Duop}}$

Blocking entry will be profitable and successful if $\Pi_{\text{Monop}} > 2\Pi_{\text{Duop}}$, i.e., if monopoly profits are at least twice as high as duopoly profits.

Outline

Bertrand Price Competition

- Two firms with the same marginal costs c engage in price competition:

$$\Pi_1(p_1, p_2) = (p_1 - c)D_1(p_1, p_2)$$

Each firm's demand is

$$D_1 = \begin{cases} D(p_1) & \text{if } p_1 < p_2 \text{ (“monopoly”)} \\ \frac{1}{2}D(p_1) & \text{if } p_1 = p_2 \\ 0 & \text{if } p_1 > p_2 \end{cases}$$

Bertrand Price Competition

- The maximum profit possible is the monopoly profit: $\Pi_M(p) = (p - c)D(p)$
- Defining a Nash-equilibrium in prices: $\Pi_i(p_i^*, p_j^*) \geq \Pi_i(p_i, p_j^*)$ for all p_i, where p_i^* and p_j^* are the optimal price strategies for the firm i and the firm j. In other words, each firm optimizes given the optimal strategy of the other firm.
- This however implies the paradox of Bertrand, which says that the only Nash-equilibrium in prices that exists is:

$$p_1^* = p_2^* = c \text{ with } \Pi_1 = \Pi_2 = 0$$

Bertrand Price Competition

- This happens since all other possibilities can be excluded as not being Nash equilibria.
  1. $p_1 > p_2$ is not a Nash equilibrium since $\Pi_1 = 0$ and $p_1 = p_2 - \epsilon$ would yield $\Pi_1 = (p_2 - \epsilon - c)D(p_2 - \epsilon) > 0$.
  2. $p_1 = p_2 > c$ is not a Nash equilibrium since $\Pi_1 = (p_1 - c)\frac{1}{2}D(p_1)$ and $p_1 = p_2 - \epsilon$ would yield $\Pi_1 = (p_2 - \epsilon - c)D(p_2 - \epsilon)$, which again is greater since for a small reduction in price, demand doubles.
- The only combination of strategies that cannot be improved on by either party is $p_1^* = p_2^* = c$, which is hence the only Nash equilibrium.

Four factors that help to avoid the Bertrand paradox

- There exist a number of possible solutions for the Bertrand paradox in the real world. They all rely on extending the "strategy space", i.e. introducing additional parameters.
  1. Capacity limits (suddenly increasing marginal costs),
  2. Transaction costs,
  3. Product differentiation,
  4. Cartelization.

Capacity limits and rationing

- The basic idea $\rightarrow$ draw graph here
- For $\text{Cap}_1 < D(c)$ and $p_2 = c + \epsilon$ it will hold that $\Pi_1 = \text{Cap}_1(p_1 - c) = 0$ and $\Pi_2 = (D(c+\epsilon) - \text{Cap}_1)(p_2 - c) > 0$
- $\Rightarrow$ Bertrand paradox is avoided

Outline

Efficient rationing

- Firm 1 produces Cap_1 at $p_1 = c$. This is where customers buy first. Firm 2 deals with the residual demand $D_2(p_2)$.
- draw graph here
- demand:

$$D_2(p_2) = \begin{cases} D(p_2) - \text{Cap}_1 & \text{if } D(p_2) > \text{Cap}_1 \\ 0 & \text{if } D(p_2) < \text{Cap}_1 \end{cases}$$

- This kind of rationing is called efficient, as it maximizes the consumer surplus. It yields the same outcome as a situation in which consumers can arbitrage between each other, i.e. those with low marginal utilities sell to those with high marginal utilities. It corresponds to a situation in which each one of n consumers can buy the quantity cap1/n at price $p_1 = c$.

Proportional rationing (the lottery)

- In this case, every customer has the same probability to have the opportunity to buy from Firm 1 but there are no arbitrage opportunities.
- The probability of having to buy the firm 2 is $\frac{D(p_1)-\text{Cap}_1}{D(p_1)}$
- This fixed factor determines the probability of having to buy at Firm 2 at any price p_2 and determines the probability of being able to take advantage of demand price $p_1 = c$. The residual demand of Firm 2 is:

$$D_2(p_2) = D(p_2)\frac{D(p_1) - \text{Cap}_1}{D(p_1)}$$

- That is total demand $D(p_2)$ times the probability that it will not be met by Firm 1 at $p_1 = c$.
- Firm 2 prefers this form of rationing because its price will be higher.

Proportional rationing (the lottery)

- draw graph here
- This form of rationing is not efficient since some customers only by because they are to get the good at $p_1 = c$, while others with higher marginal utility are unable to get anything. If arbitrage was allowed they would resell to them. (Important consideration: with costless arbitrage efficiency is always achieved.)

Waiting list

- This form of rationing is highly inefficient, as the consumer surplus dissipates in lost time and income.