Industrial Organisation

Lecture 4: Will profits in reality be higher or lower than under Cournot?

Tom Holden
http://io.tholden.org/

Kreps Scheinkman exercise

- $Q(p) = 1 - p$.
- Two firms both with zero marginal costs.
- Proportional rationing:
  - Residual demand facing firm 2 if they price above firm 1 is: $Q(p_2)\left(\frac{Q(p_1)-\bar{q}_1}{Q(p_1)}\right)$.

- Claim to prove: $p^* = 1 - (\bar{q}_1 + \bar{q}_2)$ is an equilibrium in the second stage price game, providing $\bar{q}_1 < \frac{1}{4}$ and $\bar{q}_2 < \frac{1}{4}$.
  - Note that this threshold is lower than before.
  - With proportional rationing it is "harder" to get a Cournot-like outcome (and in general you won't).

Collusion (OZ 6.5)

- Recall the Davidson and Deneckere argument:
  - When firms run out of stock, it is not always the consumers with the lowest valuations who are left without the good.
  - This reduces the cost of being the higher priced firm, in terms of lost demand.
  - As a result, in the first period firms will be prepared to invest more in capacity.
  - So quantity ends up above the Cournot quantity (and profits end up below).

- But what if firms can collude?

- Collusion will tend to result in higher profits than under Cournot.

Outline

- Collusion
- Why collude?
  - Examples and types.
- Sustaining collusion in dynamic oligopoly.
- When is collusion easier?

Why collude?

- Under Cournot or Bertrand competition, the price is always below the monopoly one (and quantity is higher).
  - Since a monopolist could choose either the Cournot or Bertrand price if they really wanted, aggregate industry profits must be lower under Cournot or Bertrand.
  - So by agreeing to collude on a high price, all firms may increase their profits.

- The "business stealing effect" underlying oligopoly competition drives this.
  - A firm that increases its quantity does not internalise the negative impact it will have on the profits of other firms.
  - This externality means that (relative to the goal of maximising industry profits) firms will produce too much.
  - A bit like a "prisoner's dilemma". There is a Pareto-dominant outcome (featuring collusion), that cannot be sustained as an equilibrium.

Examples of collusion (1/2)

- Open agreements. (Analysed in OZ 5.4)
  - E.g. the OPEC cartel.
  - Generally just maximise joint profits, i.e. the cartel acts as if it was one firm not several.
  - Illegal in most developed countries.

- Secret agreements.
  - E.g. between Sotherby’s and Christie’s in the 90’s.
    - CEO’s of the two companies met in secret, and agreed on common commission charges. (Also shared client lists and removed the possibility of negotiating rates.)
    - Eventually Christie’s came forward with information, leading to a $65 million fine of Sotherby’s (combined US and EU), and a $7.5 million fine for the CEO of Sotherby’s along with one year in jail. The two auction houses also paid customers over $0.5 billion in compensation.

Examples of collusion (2/2)

- Secret agreements (continued).
  - Or the Vitamin cartel of the 90’s (Hoffman-LaRoche, BASF, Aventis, Solvay, Merck, etc.)
    - Regular exchange of sales data, price fixing.
    - Eventually prosecuted, $0.5 billion fine for Hoffman-LaRoche in the US and $225m for BASF, plus additional fines in the EU. Prison time and personal fines for the executives.

- Tacit agreements.
  - What we shall mostly focus on.
  - E.g. the fact that almost all shops selling Sony TV’s charge the same price (well above MC).

How is collusion possible?

- If my rival is selling vitamin C pills at £1 per 100 pills, no matter what informal agreement we might have in place, I will always be tempted to start selling them at 99p per 100.
- To sustain collusion then, my rival needs to be able to punish me for undercutting them.
  - E.g. by pricing at marginal cost for a prolonged period.
  - Collusion is thus always a dynamic phenomenon.

Finitely repeated games.

- Is having a finite number of sales periods enough to sustain $P > MC$?

- Consider any game with a unique Nash equilibrium (e.g. Prisoner's Dilemma, Cournot, Bertrand, etc.), and imagine it is to be played T times in succession, with final payoffs given by a (discounted) sum of payoffs from each period's game.
  - To find the SPNE, as usual we start at the final period and work backwards.
  - The final period is just the stage-game, so all players will play the Nash equilibrium of the stage-game.
  - Given everyone is playing the Nash equilibrium in the stage-game in the final period (independent of the history up to there), in the penultimate period everyone will also play the Nash equilibrium of the stage-game.
  - Etc.

- Thus finitely repeated symmetric marginal cost Bertrand competition results in $P = MC$ in each period.

Infinitely repeated symmetric Bertrand (1/4) (OZ 6.5.1 is similar)

- Infinitely many periods, indexed by $t = 0,1,2,\ldots$.
- n firms, each with constant marginal cost c.

- Market demand curve $Q(p)$, finite monopoly profits π_M, corresponding to a price p_M.
  - A monopolist would maximise $Q(p)(p-c)$, meaning $0 = Q'(p_M)(p_M - c) + Q(p_M)$.

- Each firm $i \in \{1, \ldots n\}$ simultaneously sets its price $p_{i,t}$ each period t, to maximise the discounted sum of their present and future profits:
$$\sum_{s=0}^{\infty} \beta^s \pi_{i,t+s} = \pi_{i,t} + \beta\pi_{i,t+1} + \beta^2\pi_{i,t+2} + \cdots$$
where $\pi_{i,t}$ is firm i's profits in period t.

Infinitely repeated symmetric Bertrand competition (2/4)

- Trivial equilibrium:
  - all firms set $p_{i,t} = c$ in each period t.

- Maximum-profit collusive equilibrium:
  - In the first period, all firms set $p_{i,1} = p_M$.
  - In subsequent periods t, all firms set $p_{i,t} = p_M$ unless they have ever observed another firm setting a price other than p_M, in which case they set $p_{i,t} = c$.
  - Thus if a firm ever deviates and sets a price below the monopoly one, from then on no firm makes a profit.
    - This is a "grim trigger strategy".

One-stage deviation principle

- A strategy is an SPNE if and only if there is no possible history up to a point t such that some player i would like to deviate from the strategy in period t only.

- Proof is omitted.

- Means we do not have to worry about complicated multi-period deviations.

Infinitely repeated symmetric Bertrand competition (3/4)

- Use one-stage deviation principle to prove that the collusive equilibrium is an SPNE:
  - If at some point a firm has ever set a price other than p_M, then all firms are pricing at cost, which means we are effectively in the trivial equilibrium (from which no firm wants to deviate).

Infinitely repeated symmetric Bertrand competition (4/4)

- Use one-stage deviation principle to prove that the collusive equilibrium is an SPNE:
  - If up to now all firms have priced at p_M, does a firm want to deviate?
    - Profits from now on from not deviating are $\frac{\pi_M}{n} + \beta \frac{\pi_M}{n} + \beta^2 \frac{\pi_M}{n} + \cdots = \frac{\pi_M}{n(1-\beta)}$.
    - Profits from deviating are π_M. (The deviating firm sets a price just below p_M, then all firms price at c from then on.)
    - So the proposed strategy is an SPNE if and only if $\frac{\pi_M}{n(1-\beta)} \geq \pi_M$, i.e. if and only if $1 \geq n(1-\beta)$, which is true if and only if $\beta \geq \frac{n-1}{n}$, i.e. if and only if firms are sufficiently patient.

How should we think of β? (1 / 3)

- Firms with rational owners will use $\beta = \frac{1}{1+r}$ where r is the real interest rate for a one period bond.
  - Could be months, years, etc.
  - Due to arbitrage between shares and bonds.
- The material in the next slide goes a bit beyond the textbook, but is still worth understanding.

How should we think of β? (2/3)

- Now suppose that demand was given by $Q_t(p) = (1+g)^t Q(p)$, so if $g > 0$ demand is growing.
  - A monopolist would maximise $(1+g)^t Q(p)(p-c)$ in period t, so the monopoly price is constant at p_M, and monopoly profits are $(1+g)^t \pi_M$.
- Also suppose that each period, a firm has a probability of h of being hit by a "death-shock" which would force it to exit the industry. (Assume exiting firms are immediately replaced.)
- Finally suppose that the discount factor was $\frac{1}{1+r}$.
- Then the expected profits from setting the monopoly price would be: $\frac{\pi_M}{n} + \frac{1}{1+r}(1+g)(1-h)\frac{\pi_M}{n} + \frac{1}{(1+r)^2}(1+g)^2(1-h)^2\frac{\pi_M}{n} + \cdots$
- Therefore behaviour in this model is the same as behaviour in our original model with $\beta = \frac{1}{1+r}(1+g)(1-h)$.

How should we think of β? (3/3)

- Putting the previous results together, setting the monopoly price is an SPNE in this richer model (with growing demand and death shocks) if and only if

$$\frac{1}{1+r}(1+g)(1-h) \geq \frac{n-1}{n}.$$

- So, the likelihood of observing collusion is:
  - Decreasing in the number of firms.
  - Increasing in the speed with which the market is growing.
  - Decreasing in the probability of a death shock.
  - Decreasing in real interest rates.

Free entry

- In a growing market, n fixed is implausible.

- Guess that $n_t = n(1+g)^t$. Then the profits from setting the monopoly price (in the set up of 2 slides ago) would be: $\frac{\pi_M}{n} + \frac{1}{1+r}(1+g)(1-h)\frac{\pi_M}{n(1+g)} + \frac{1}{(1+r)^2}(1+g)^2(1-h)^2\frac{\pi_M}{n(1+g)^2} + \cdots$.
  - Our guess is verified as profits are not growing over time, so this is consistent with constant entry cost.

- So this model is just like having $\beta = \frac{1}{1+r}(1-h)$ in our original model.
  - The $(1+g)$ terms cancel.

- So when there is free entry, growing demand neither makes collusion more nor less likely.

Are there equilibria other than the trivial and the maximal-profit one?

- Yes, because of: The Folk Theorem (Fudenburg and Maskin 1986):
  - Consider any infinitely-repeated n player game, with payoffs given by the discounted sum of payoffs from each period's stage-game.
  - For each player i, let π_i^* be the lowest payoff that players other than i can force on player i in the stage-game.
    - Everyone else gangs up on i to minimise their payoff.
  - Imagine that all of the players had instructions that told them what action they should take in every period.
  - And suppose that under these instructions, player i's average payoff would be v_i, with $v_i > \pi_i^*$.
  - Then providing a minor technical condition is satisfied, if players are sufficiently patient (i.e. discount factors are sufficiently high), there is an SPNE in which player i attain an average payoff off v_i (for all $i \in \{1, \ldots, n\}$).

Applying the Folk Theorem

- In symmetric Bertrand competition, the lowest payoff (profit) other players (firms) can force on a player is zero.
  - A firm can always set its price equal to c and either sell nothing, or sell at cost.

- In symmetric Cournot competition, the lowest payoff (profit) other players (firms) can force on a player is also zero, by producing the perfect competition quantity.
  - The remaining firm can always produce nothing.

- Highest possible profit that a single firm may make is π_M, when other firms make zero profits.

- Thus for any vector of firm profits $(\pi_1, \pi_2, \dots, \pi_n)$ with $\pi_i > 0$ for all i and $\pi_1 + \pi_2 + \cdots + \pi_n \leq \pi_M$:
  - for sufficiently patient firms, there is an SPNE of both repeated Bertrand and repeated Cournot in which average profits are given by the vector $(\pi_1, \pi_2, \dots, \pi_n)$.

Collusion over the business cycle

- Rotemberg and Saloner (1986) extend the repeated-Bertrand setting to allow for stochastic demand. ("booms and recessions")
  - In a boom, it is more tempting to deviate, so prices have to be lower in booms to remove this temptation.
    - Leads to counter-cyclical mark-ups.
- Green and Porter (1984) modify this model, supposing firms cannot observe aggregate demand.
  - Then firms do not know if demand is low because they have been undercut, or because of the aggregate state.
  - So they must punish for only a short period.
    - Leads to pro-cyclical mark-ups.
    - Agrees with Nekarda and Ramey (2010).
  - Nice evidence for this particular story is provided by the Porter (1983) case study of 19th century US railroad cartels.

Asymmetric shocks

- Rather than thinking about common business cycle shocks, we can also think about shocks that hit one firm and not another.
  - E.g. a firm's bank going bankrupt.
  - Or a vital machine breaking.
  - Or a new invention.

- Such shocks may lead a firm to have no alternative but to cut its price, so to punish them with $P = MC$ for ever cannot be optimal.

- But the less often such shocks arrive, plausibly the easier sustaining collusion will be.

Competition in multiple markets

- Evans and Kessides (1994) perform an empirical study of competition amongst US airlines.
  - Find that prices are higher on routes served by airlines that compete on a lot of other routes.
  - Deviating on one route may be punished by price cuts on all other routes on which the deviating airline flies.
    - If all routes were identical this would not make any difference, because the cost of deviation would exactly balance the benefits of it (you could deviate in several markets simultaneously, thus earning higher profits).
    - However, if airlines have natural cost advantages in some markets, then the maximal-profit collusive equilibrium would feature each airline serving the market in which it is most efficient, but ready to serve the other market should their rivals deviate.

Transparency

- Albraek et al. (1997) look at the consequences of the Danish Competition Council's 1993 decision to begin publishing the various prices charged by firms selling ready-mixed concrete.
  - Idea was that the increased transparency would make it easier for consumers to shop around.
  - Reality was that prices increased by 15%–20% within a year, and price dispersion fell.
    - Cannot be explained by e.g. the business cycle.
  - Natural explanation is that the public price information made it easier to detect firms deviating from collusive equilibria, and thus made collusion more likely.

Exercises

- OZ Ex. 6.8
  - Question 4

- OZ Extra exercises:
  - http://ozshy.50webs.com/io-exercises.pdf
  - Set #9

Conclusion

- Cournot competition is capacity constrained Bertrand.
  - Plausible rationing results in *lower* profits than standard Cournot.

- Collusion with monopoly profits is sustainable as an SPNE of Cournot or Bertrand competition.
  - As are many other profit levels, thanks to the Folk Theorem.

- We are more likely to observe $P \gg MC$ in dynamic oligopoly when:
  - There are few firms in an industry.
  - Markets are growing, but firm entry is blocked.
  - Firms rarely leave the market.
  - Real interest rates are low.
  - Demand is observable and low.
  - Demand is unobservable and high.
  - There are few asymmetric shocks.
  - Firms compete in multiple markets.
  - Prices are transparent.