ECN 453: Cournot Competition 2

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Static Models of Oligopoly: Cournot Competition

- Today we will continue to study Cournot competition (competition on quantities)
- We will focus on extensions and applications of the basic Cournot model we saw last time.

Plan

1. Connection between Bertrand competition and Cournot competition
2. Cournot competition with many firms
3. Comparative statics: changes to input prices
4. Comparative statics: new technology
5. Comparative statics: exchange rates

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Cournot competition: Cournot vs Bertrand

- How is Cournot competition related to Bertrand competition?

- Remember the capacity constrained Bertrand competition from last week?
  - Then, we argued that if capacity constraints were q_1 and q_2 then the price under Bertrand competition was $p_1 = p_2 = P(q_1 + q_2)$.

  - (Note: before, we denoted the capacity constraints by k_i but now I'm denoting them by q_i)

- So, the setup to Cournot competition is equivalent to the choice of capacity in the following two stage game:
  1. Choose capacity constraints q_1 and q_2

  2. Given these capacity constraints, compete under Bertrand competition

- The above relationship between Bertrand and Cournot competition is known as the **Kreps and Scheinkman (1983)** result.

Cournot competition: Cournot vs Bertrand

- As economists, we choose which model best fits a particular industry.
- General way to choose between Cournot vs Bertrand:
  - If capacity/output can be adjusted easily $\rightarrow$ Bertrand
  - If capacity/output are hard to adjust $\rightarrow$ Cournot

Cournot competition: Cournot vs Bertrand

- Markets more suited to modeling with Bertrand competition:
  - Software, insurance, banking
- Markets more suited to modeling with Cournot competition:
  - Airlines
  - Many other industries that manufacture physical goods e.g. wheat, cement, steel, cars etc
  - Idea: capacity investments are long-run choices in these industries

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Cournot competition with many firms

- **Setup:**
- n firms
- Market demand: P(Q) = a-bQ where:
  - a,b are constants
  - total output: $Q = q_1 + q_2 + ... + q_n$
- Constant marginal cost: c
- **Question:** What are the Cournot equilibrium quantities?

Cournot competition with many firms

- **Question:** What are the Cournot equilibrium quantities?
- To solve, we will use our typical steps, starting with writing down the payoffs for each firm.
- Payoffs:

$$\pi_i = q_i P(Q) - c q_i$$

Cournot competition with many firms

- Next, we need to find the best response of firm i.

- First, expand profit:

$$\begin{aligned}\pi_i &= q_i P(Q) - cq_i \\ &= q_i(a - bQ) - cq_i \\ &= q_i(a - b(q_1 + q_2 + ... + q_n)) - cq_i \\ &= q_i a - q_i bq_1 - q_i bq_2 - ... - bq_i^2 - ... - bq_i q_n - cq_i\end{aligned}$$

- Take the derivative and set it equal to zero (to maximize profit):

$$\frac{d\pi_i}{dq_i} = -bq_i + a - bQ - c = 0$$

Cournot competition with many firms

- Finally, we need to compute the Nash equilibrium from the best responses.
- The trick is to observe that the firms are identical. Therefore, in equilibrium, the quantities will be identical with $q = q_1 = ... = q_n$ and so $Q = nq$.
- Therefore the best response of firm i is:

$$-bq + a - bnq - c = 0$$

- So, optimal quantity and price (getting price from substituting optimal quantity into the demand curve) is:

$$q = \frac{a - c}{(n+1)b}$$
$$p = \frac{a + nc}{n+1}$$

Cournot competition with many firms

- Let's see how prices change with the number of firms:

$$p = \frac{a + nc}{n + 1}$$

- As $n \to \infty$, $p \to c$.

- I.e. as the number of firms gets large, the market converges to the perfect competition price level.

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Comparative statics: changes to input prices

- We will now look at some **comparative statics**.
- **Comparative statics** means evaluating how the equilibrium changes when we change the parameters to the problem.
  - For example, in the entry deterrence midterm question, we evaluated how the equilibrium changed when we changed x.
- We will start by looking at an increase in input costs.
  - We are particularly in interested in computing **pass-through**: the change in the final price for a change in the input price (marginal cost).

Comparative statics: changes to input prices - carbon price example

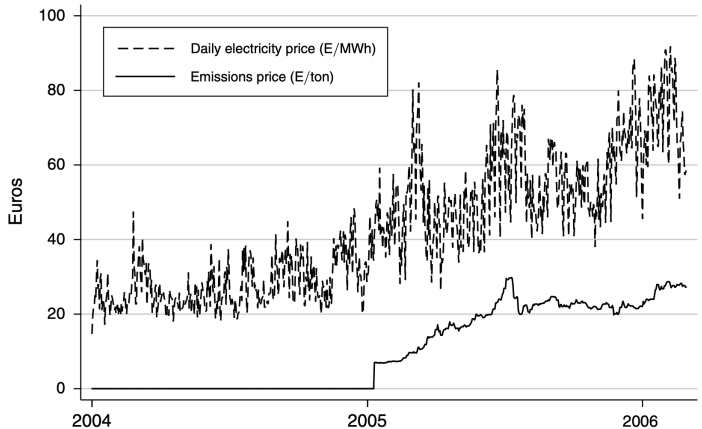

FIGURE 1. EVOLUTION OF THE ETS CARBON PRICE AND THE SPANISH WHOLESALE ELECTRICITY PRICE

- *'Pass Through of Emissions Costs in Electricity Markets'*: Fabra and Reguant (2014)

Comparative statics: changes to input prices - graph with example of 40% increase in costs

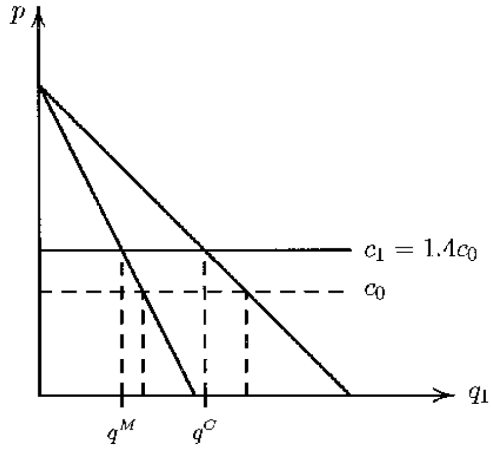

Figure 7.9 Optimal Solution after Increase in Marginal Cost: Two Extreme Cases.

Comparative statics: changes to input prices - graph with example of 40% increase in costs

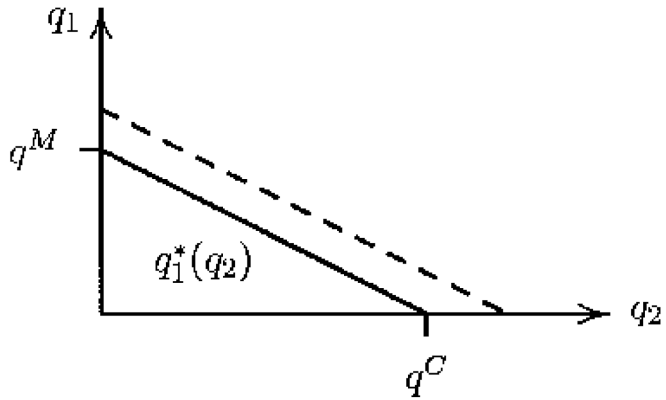

Figure 7.10 Shift in the Firm 1 Reaction Curve.

Comparative statics: changes to input prices - graph with example of 40% increase in costs

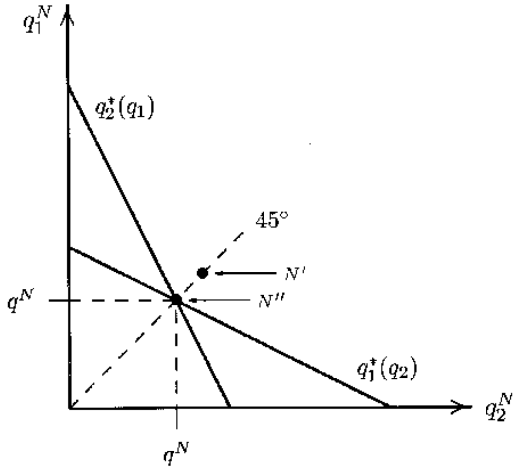

Figure 7.11 Cournot Equilibrium after Increase in Marginal Cost (N'').

Comparative statics: changes to input prices (math version)

- **Setup:** Cournot duopoly with total demand $p = a - bQ$ and two identical firms with marginal cost c.

- **Question:** Suppose that marginal cost increases by \$20. What is the change in output price p?

Comparative statics: changes to input prices

- **Solution:**

- With 2 firms, we saw before that equilibrium prices are given by:

$$p = \frac{a + 2c}{3}$$

- Finding the change in price for a change in c:

$$\frac{dp}{dc} = \frac{2}{3}$$

- So, model predicts price increases by 66% ($13.33) for a $20 increase in costs.

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Comparative statics: new technology

- **Setup**:
- Firm 1: old technology $c_1 = \$15$
- Firm 2: new technology $c_2 = \$12$
- Demand: p=30-Q
- Firms compete on quantities (Cournot competition)
- **Question**: How much would Firm 1 be willing to pay for the new technology?

Comparative statics: new technology

- **Solution**:
- Apply our 'usual steps' to solve for the Cournot equilibrium with and without the new technology.
- Without the new technology can show that the initial profit level for Firm 1 is: \$16. After the new technology is introduced, solving for the equilibrium, the profit for Firm 1 is: \$36.
- So, Firm 1 would pay \$20 for this new technology.

Comparative statics: new technology

- For problems like these with:
  - Asymmetric (i.e. different) constant marginal costs $c_1 \neq c_2$
  - Two firms
  - Cournot competition
  - Linear demand in the form $p = a - bQ$ where a,b are constants
- By exactly the same method from the previous slide (but more complicated algebra on p205) where a hat on the variables denotes the Cournot equilibrium values (see next slide):

Comparative statics: new technology

$$\hat{q}_1 = \frac{a - 2c_1 + c_2}{3b}$$
$$\hat{q}_2 = \frac{a - 2c_2 + c_1}{3b}$$
$$\hat{Q} = \hat{q}_1 + \hat{q}_2 = \frac{2a - c_1 - c_2}{3b}$$
$$\hat{p} = a - b\hat{Q} = \frac{a + c_1 + c_2}{3}$$

- **Caution**: although these formulas are useful, in many of the problems I will set some assumptions will not be satisfied and so you will need to go through the 'usual steps' to solve the Cournot equilibrium.

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Comparative statics: exchange rates

- **Setup**:
- Microprocessor duopoly; Cournot competition
- Two firms, Firm 1: in Japan Firm 2: in the US
- Initially, firms have the same cost, $c_1 = c_2 = \$12$
- Suppose we have a Yen devaluation so that $c_1 = \$8$
- Assume at the initial equilibrium $p = 24$.
- **Question:** How do firms' market shares change due to the devaluation?

Comparative statics: exchange rates

- **Solution:** Use 'calibration' (i.e. use data to determine values of parameters)
- Firm 1's market share (using the asymmetric equilibrium formulas):

$$s_1 = \frac{q_1}{q_1 + q_2} = \frac{a - 2c_1 + c_2}{2a - c_1 - c_2}$$

- At initial equilibrium (where costs = \$12 for both firms):

$$p = \frac{a + 2c}{3}$$

- Solving for a:

$$a = 3p - 2c = 3 * 24 - 2 * 12 = 48$$

- Substituting into the formula:

$$s_1 \approx 58\%$$

- So, Japan's market share goes from $50\% \rightarrow 58\%$

Summary of key points*

- Know the connection between Cournot and Bertrand competition and know how to choose between the two models to fit a particular industry.
- Know how to solve Cournot models with > 2 firms (and the 'trick' which is to set the equilibrium production level of identical firms to be the same value)
- Understand the three comparative statics examples:
  - Changes to input prices
  - New technology
  - Exchange rates
- Know the formulas for linear demand (n firms, asymmetric costs, etc...)

*To clarify, all the material in the slides, problem sets, etc is assessable unless stated otherwise, but I hope this summary might be a useful place to start when studying the material.