MASTER OF COMMERCE IN COMPETITION AND ECONOMIC REGULATION

Quantitative Methods and Econometrics for application in Competition and Economic Regulation (QEC9X01)

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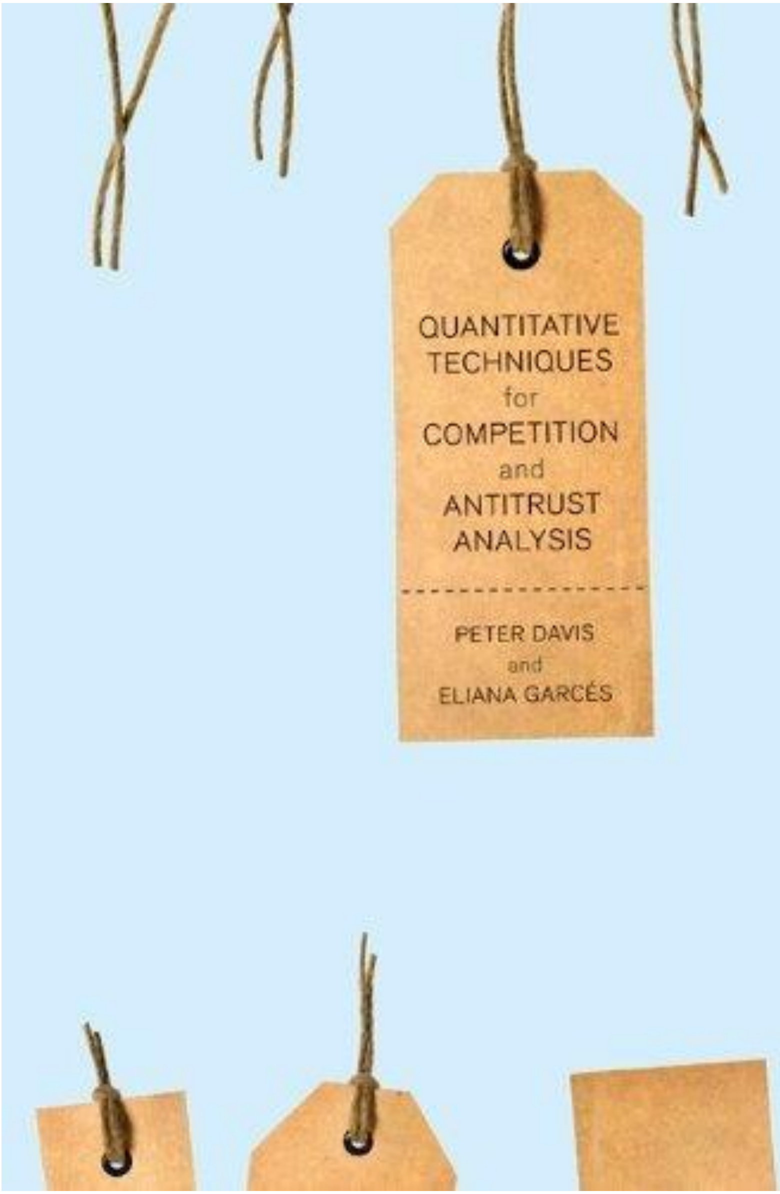
Lecture 2: Oligopolistic Competition



"Quantitative Techniques for Competition and Antitrust Analysis"
by Peter Davies and Eliana Garces

Chapter: 1

Outline

1. The Cournot Game
   – Quantity competition

2. Bertrand's Paradox
   – Price competition

3. Solutions to the Bertrand Paradox:
   – Price competition with differentiated products
   – Kreps-Scheinkman → firms first set capacities and then price competition (see Appendix)

Cournot duopoly (symmetric)

Demand:

- Assume that consumers' behaviour is summarized by linear inverse demand function: $P(Q) = a - bQ$.

Supply:

- Suppose there are two firms: Firm 1 and Firm 2 which produce homogenous good at a constant marginal cost of c (symmetry) and assume there are no fixed costs. (i.e. their per unit cost is c, cost function $C(q) = cq$, where $a>c$
- The firms are assumed to choose production quantities as strategic variables.

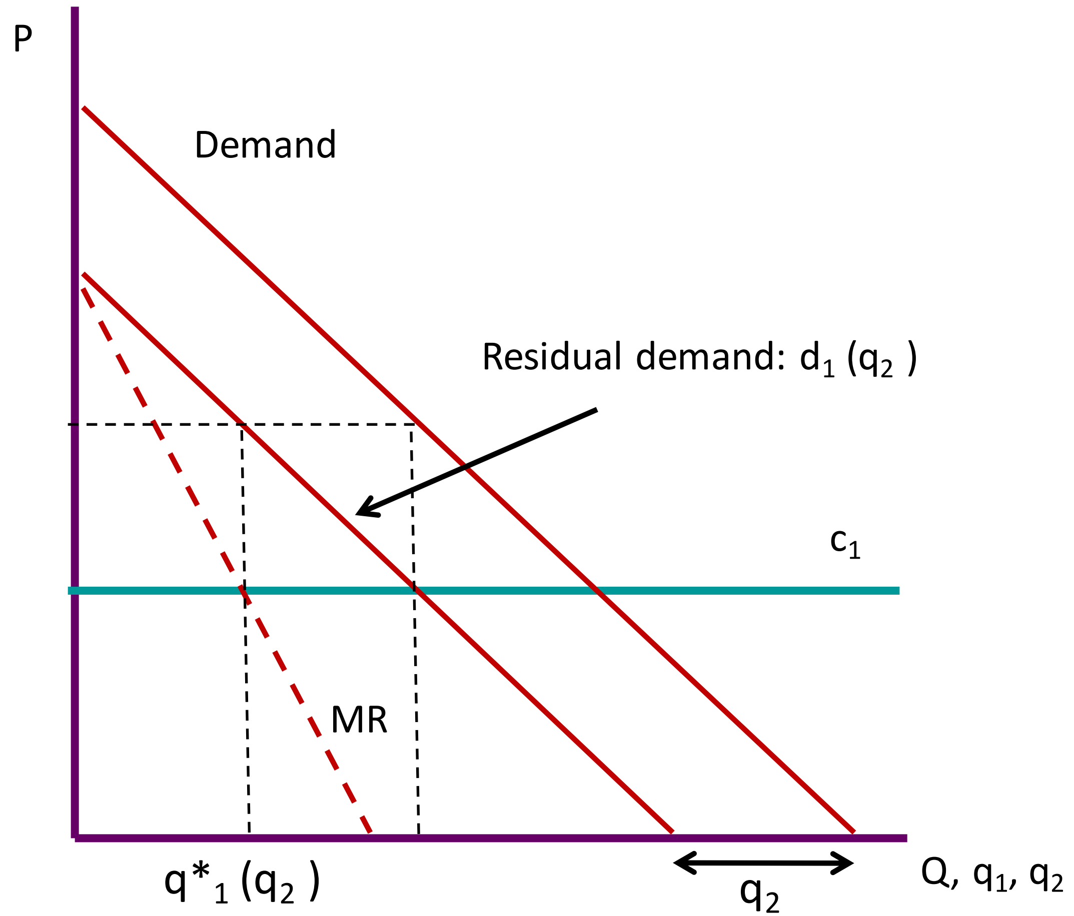
Cournot duopoly (symmetric)

Firms' profits can be written as:

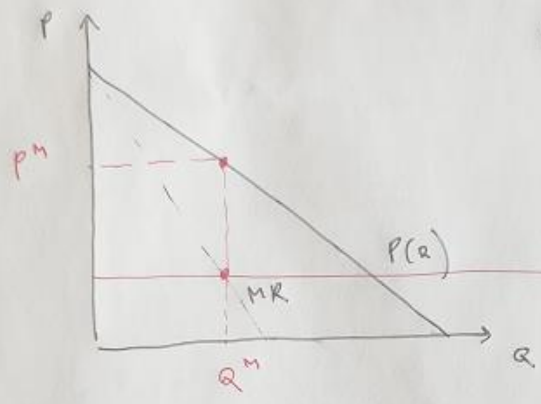
$$\begin{cases} \Pi_1 = (p(q_1 + q_2^c) - c_1)q_1 \\ \Pi_2 = (p(q_1^c + q_2) - c_1)q_2 \end{cases}$$

- Firm 1 decides how much to produce without knowing the production of competitor but knowing that his decision will have an effect on the quantity produced by Firm 2.
- Firm 1 forms expectations about quantity supplied by Firm 2.
- **Residual demand curve** of Firm 1 is the demand curve which is a portion of total market demand that is not supplied by Firm 2.
- To find the quantity which maximizes profits of Firm 1 we need to find the intersection point of marginal cost curve and marginal revenues derived for the residual demand curve.

Cournot duopoly (symmetric)



Monopoly



$$P(Q) = a - bQ$$

$$\Pi = P(Q) \cdot Q - C(Q) = (a - bQ)Q - C(Q)$$

$$\frac{\partial \Pi}{\partial Q} = \underbrace{\frac{\partial P}{\partial Q} Q + P(Q)}_{MR} - \underbrace{\frac{\partial C}{\partial Q}}_{MC} = 0$$

$$\boxed{MR = MC}$$

$$\frac{\partial \Pi}{\partial Q} = -b \cdot Q + a - bQ - \frac{\partial C}{\partial Q} = 0$$

$$-2bQ + a - mc = 0$$

$$\boxed{Q^M = \frac{a - mc}{2b}}$$

$$p^M = a - bQ^M = a - \cancel{b} \cdot \frac{a - mc}{2\cancel{b}} = \boxed{\overset{p^M \, \|}{\frac{a + mc}{2}}}$$

Cournot duopoly (symmetric)

Profit-maximization by Firm 1:

$$\Pi_1 = (p(q_1 + q_2^c) - c_1)q_1$$

$$\frac{\partial \Pi_1}{\partial q_1} = p(q_1 + q_2^c) - c_1 + p'(q_1 + q_2^c)q_1 = 0$$

$$\frac{\partial \Pi_1}{\partial q_1} = a - c_1 - 2bq_1 - bq_2^c = 0$$

Optimal production of Firm 1 as a function of expectations about quantity produced by Firm 2 (best-response function of Firm 1):

$$r_1(q_2^c) = q_1 = \frac{a - c_1 - bq_2^c}{2b}$$

Cournot duopoly (symmetric)

If Firm 1 expects that Firm 2 will not produce at all, it chooses monopoly quantity:

$$r_1(0) = \frac{a - c_1}{2b}$$

If Firm 1 were not interested to produce at all, we need to have:

$$a - c_1 - bq_2^c = 0 \Rightarrow q_2^c = \frac{a - c_1}{b}$$

This implies that price is equal to marginal cost (hence, there are no incentives to enter).

Firm 1 decides to supply $q_1 = 0$

$$P(Q) = a - b\,(q_1 + q_2)$$

$$= a - \cancel{b}\left(0 + \frac{a-c}{\cancel{b}}\right)$$

$$= a - (a-c) = \underline{\underline{c}}$$

Cournot solution

$$\begin{cases} q_1 = \dfrac{a-c-bq_2}{2b} \\ q_2 = \dfrac{a-c-bq_1}{2b} \end{cases}$$

$$q_1 = \frac{a-c-\cancel{b}\cdot\dfrac{a-c-bq_1}{2\cancel{b}}}{2b} \qquad / \cdot 2b$$

$$2b\,q_1 = \frac{\cancel{2}a-\cancel{2}c-\cancel{a}+\cancel{c}+bq_1}{2} \qquad / \cdot 2$$

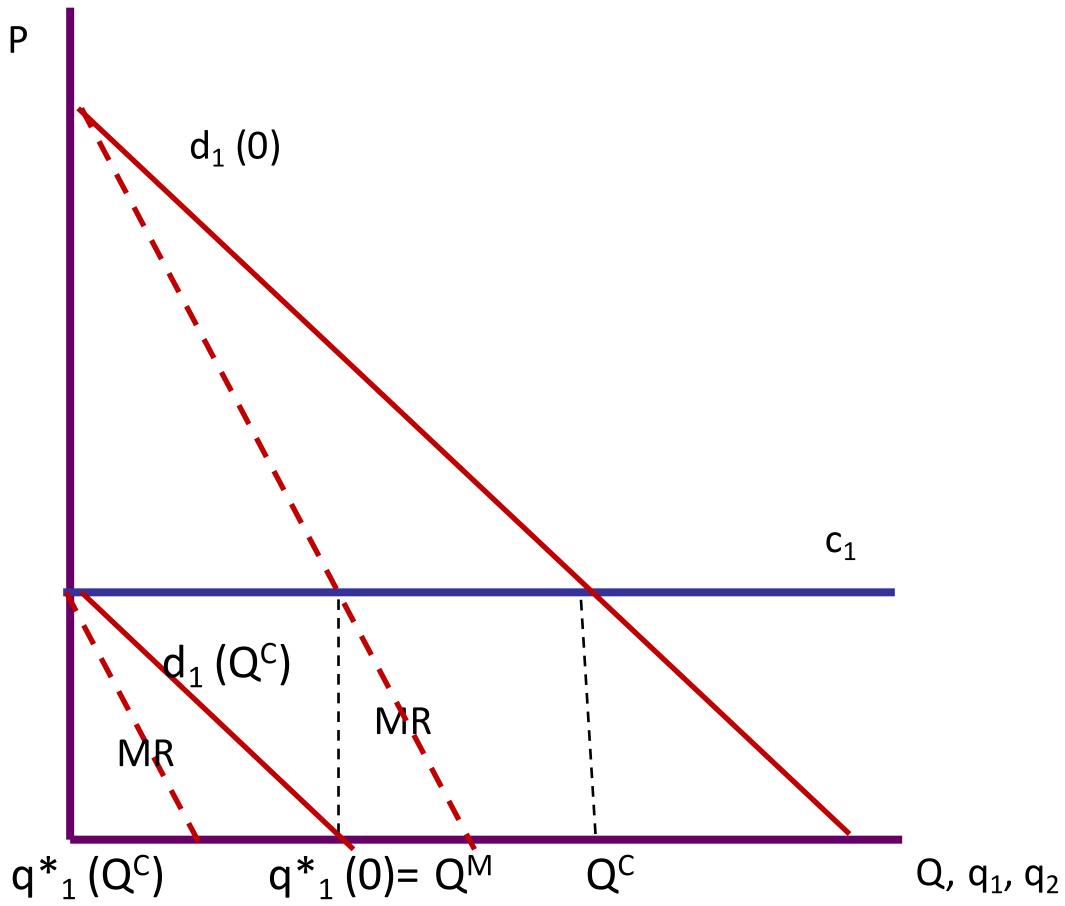
$$\overset{3}{\cancel{4}}bq_1 = a-c+\cancel{bq_1}$$

$$\boxed{q_1 = \frac{a-c}{3b}}$$

$$q_2 = \frac{a-c-\cancel{b}\cdot\dfrac{a-c}{3\cancel{b}}}{2b} = \frac{\overset{2}{\cancel{3}}a-\overset{2}{\cancel{3}}c-\cancel{a}+\cancel{c}}{6b}$$

$$\boxed{q_2 = \frac{a-c}{3b}}$$

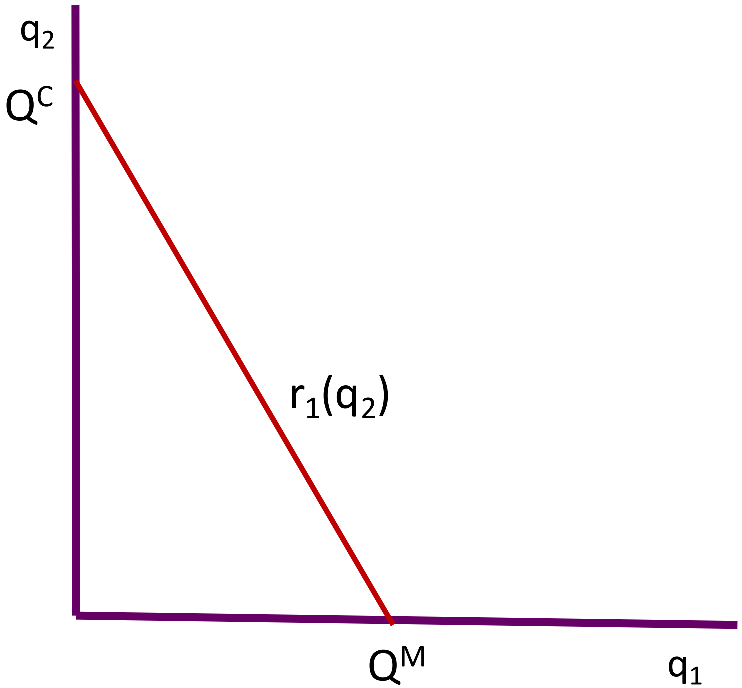
Cournot duopoly (symmetric)

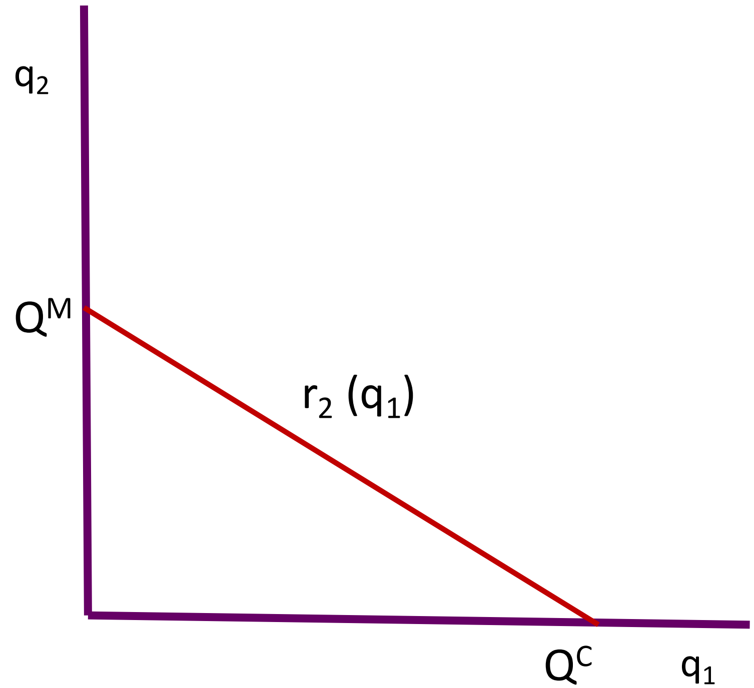


Cournot duopoly (symmetric)

Using similar reasoning we may derive and draw the best-response function for Firm 2.

$$r_1(q_2^c) = q_1 = \frac{a - c - bq_2^c}{2b} \qquad r_2(q_1^c) = q_2 = \frac{a - c - bq_1^c}{2b}$$





Cournot duopoly (symmetric)

- There are many pairs of production quantities which satisfy profit maximization condition of both firms => we need to find the one which represents equilibrium.

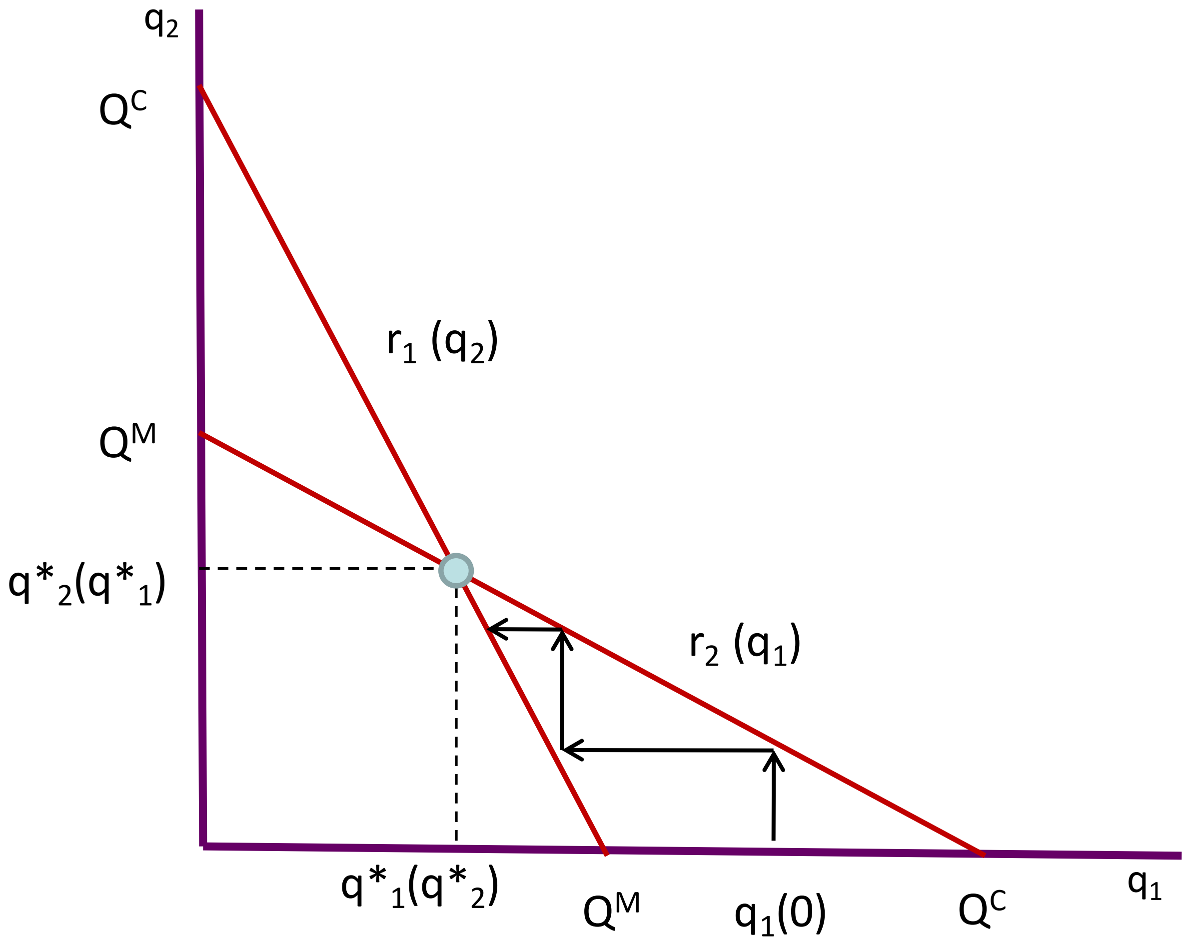
$$(q_1, q_2) = \left(\frac{a - c - bq_2^c}{2b}, \frac{a - c - bq_1^c}{2b} \right)$$

- Lets assume that when maximizing profits firms form correct expectations about the quantity produced by the competitor:

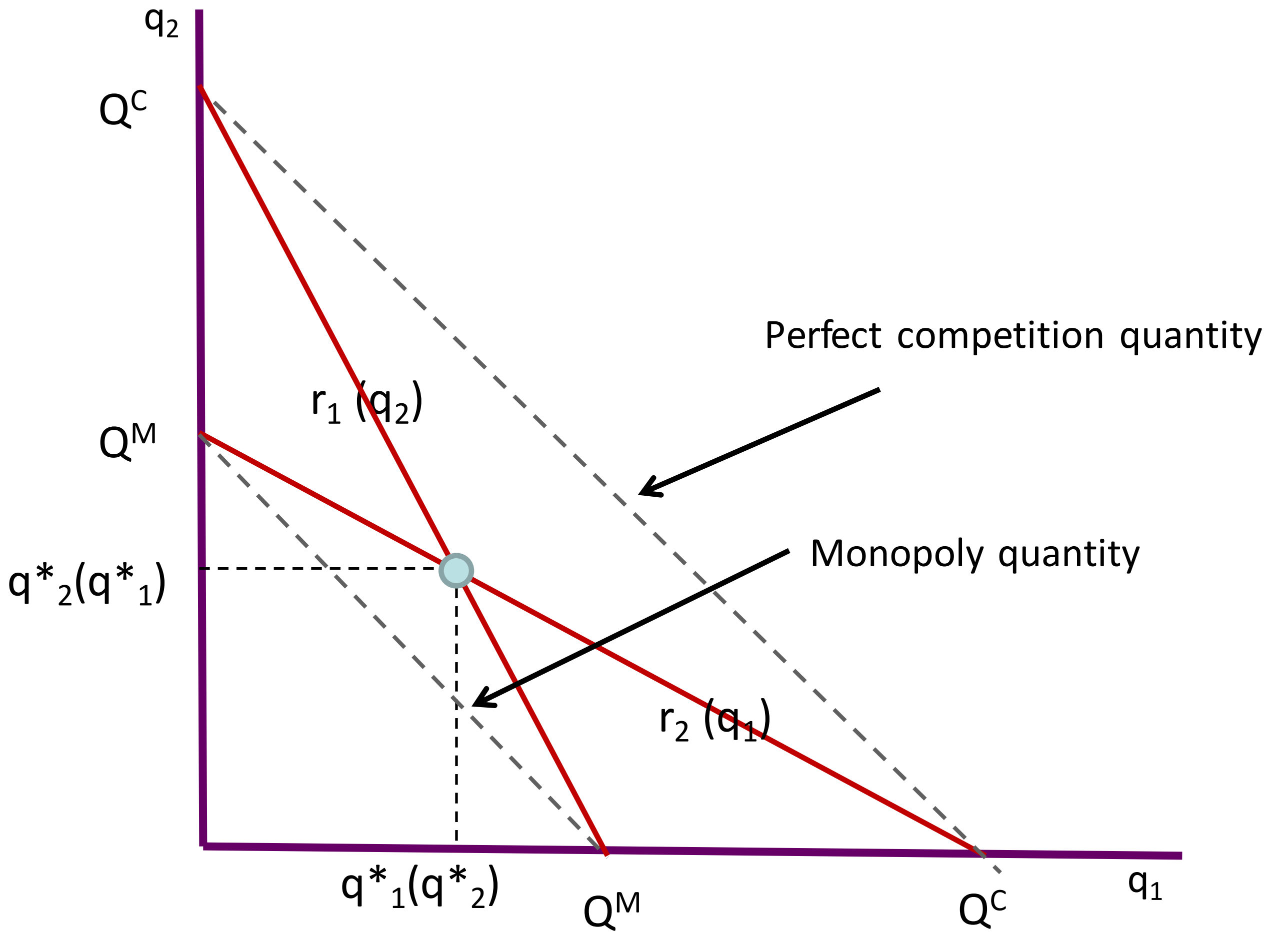
$$q_1^c = q_1 \quad q_2^c = q_2$$

- Production quantities which satisfy these conditions represent Nash-Cournot equilibrium. The equilibrium is in the intersection of the best-response functions.

Cournot duopoly (symmetric)



Cournot duopoly (symmetric)



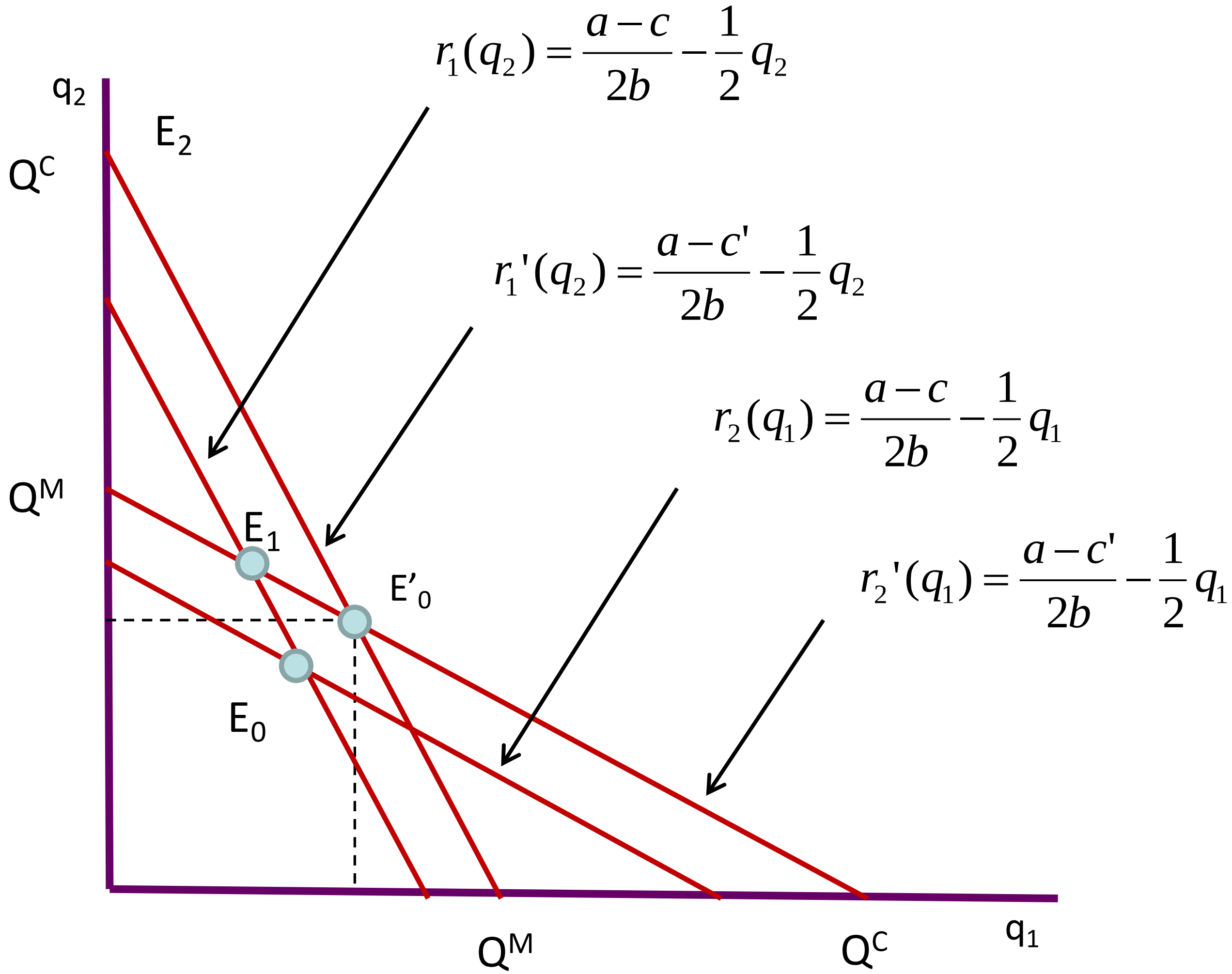
Cournot duopoly (asymmetric)

- If Firm 1 manages to achieve a technological advantage which allows it to reduce production cost from c to c', while Firm 2 maintains its production cost at c
→ the best-response function of Firm 1 is shifted upwards

- The equilibrium changes from point E_0 to point E_1
→ Firm 1 increases and Firm 2 decreases production quantity

- If both firms changed their m marginal costs from c to c', the equilibrium point would move to E'_0
→ both firms increase production quantities

Cournot duopoly (asymmetric)



Cournot duopoly (asymmetric)

- Firms are assumed to have different marginal costs.
- Let us take two firms i and j and compute the ratios of margins and market shares using their first order conditions:

$$\begin{cases} p - c_i = -\dfrac{\partial p(Q)}{\partial q_i} q_i \\ p - c_j = -\dfrac{\partial p(Q)}{\partial q_j} q_j \end{cases} \qquad \frac{(p-c_i)}{(p-c_j)} = \frac{\frac{q_i}{Q}}{\frac{q_j}{Q}} = \frac{s_i}{s_j}$$

- The ratio of shares increases when the ratio of margins increases
- The lower is the marginal cost => the greater is the market share => the greater is the margin and profits.

$$c_i > c_j \Rightarrow s_j > s_i \Rightarrow \Pi_j > \Pi_i$$

Asymmetric Cournot

$$\Pi_i = p(Q)q_i - c_i(q_i)$$

$$\frac{\partial \Pi_i}{\partial q_i} = \frac{\partial p}{\partial q_i} q_i + p(Q) - \frac{\partial c_i}{\partial q_i} = 0$$

$$p - mc_i = -\frac{\partial p}{\partial q_i} q_i$$

$$p - mc_j = -\frac{\partial p}{\partial q_j} q_j$$

$$\frac{p - mc_i}{p - mc_j} = \frac{-\frac{\cancel{\partial p}}{\partial q_i} q_i}{-\frac{\cancel{\partial p}}{\cancel{\partial} q_j} q_j} = \frac{q_i}{q_j} = \frac{\frac{q_i}{Q}}{\frac{q_j}{Q}} = \frac{s_i}{s_j}$$

$$mc_i > mc_j \Rightarrow p - mc_i > p - mc_j$$

$$\Downarrow$$

$$\frac{p - mc_i}{p - mc_j} > 1 \Rightarrow \frac{s_i}{s_j} > 1$$

$$\Leftarrow$$

$$s_i > s_j$$

Cournot duopoly: comparative statics

- Comparative statics predicts how market equilibrium will change in result of changes in various exogenous conditions => comparing the equilibria ex-ante and ex-post

- Example: changes in input costs due to technological progress, exchange rate fluctuations, changes in factors determining demand, etc.

Cournot: the case of N symmetric firms

The equilibrium exists when all firms j=1 ,..., N maximize profits with correctly formed expectations about quantities produced by the other firms:

$$\frac{\partial \Pi_i}{\partial q_i} = \frac{\partial p(Q)}{\partial q_i} q_i + p(Q) - \frac{\partial C(q_i)}{\partial q_i} = 0$$

where $Q = q_i + \sum_{j \neq i}^{n} q_j^c$

There is a unique symmetric equilibrium in which all firms produce the same quantity (take two FOCs and subtract sidewise to see this):

$$q_1 * = ... = q_n * = q *$$

$$\frac{\partial \Pi_i}{\partial q_i} = a - b \sum_{j=1}^{N} q_j^* - b q_i^* - c = 0$$

Cournot: the case of N symmetric firms

$$\pi_i = p(Q)\, q_i - c(q_i)$$

$$\frac{\partial \pi_i}{\partial q_i} = \frac{\partial p}{\partial q_i} q_i + p(Q) - \frac{\partial c}{\partial q_i} = 0$$

consider $p(Q) = a - b\,(q_1 + q_2 + \dots q_N)$

$$\frac{\partial \pi}{\partial q_i} = -b q_i + \left(a - b \sum_{k=1}^{N} q_k^e\right) - \frac{\partial c}{\partial q_i} = 0$$

$$= -2b q_i + \left(a - b \sum_{k \neq i} q_k^e\right) - \frac{\partial c}{\partial q_i} = 0$$

another FOC for j:

$$-2b j + \left(a - b \sum_{k \neq j} q_k^e\right) - \frac{\partial c}{\partial q_j} = 0$$

subtract sidewise

$$-2b q_i + 2b q_j + \left(\cancel{a} - b \sum_{k \neq i} q_k^e\right) - \cancel{mc_i} = 0$$

$$-\left(\cancel{a} - b \sum_{k \neq j} q_k^e\right) + \cancel{mc_j}$$

$\boxed{q_k = q_k^e}$ $\boxed{mc_i = mc_j}$

$$-\cancel{2}b q_i + \cancel{2}b q_j - b\cancel{q_j} + \cancel{b}q_i = 0$$

$$b q_i = b q_j$$

$\boxed{q_i = q_j}$ for any i and j

Cournot: the case of N symmetric firms

$$-2bq_i + \left(a - b\sum_{k\neq i}^{N} q_k^e\right) - \frac{\partial c}{\partial q_i} = 0$$

$$q_1 = q_2 = \dots = q_N = q^*$$

$$-2bq^* + \left(a - b\,(N-1)\,q^*\right) - mc = 0$$

$$a - b\,(N+1)\,q^* - mc = 0$$

$$\boxed{q^* = \frac{a - mc}{b\,(N+1)}}$$

$$p^* = a - b\sum_{i=1}^{N} q_i = a - bNq^*$$

$$p^* = a - \cancel{b}N \cdot \frac{a - mc}{\cancel{b}(N+1)}$$

$$= \frac{a\cancel{(N+1)} - \cancel{aN} - N \cdot mc}{N+1}$$

$$\boxed{p^* = \frac{a + N \cdot mc}{N+1}}$$

Cournot: the case of N symmetric firms

$$a - c - b(n+1)q^* = 0$$

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

$$p^* = \frac{a+nc}{n+1} \quad \Pi^* = \frac{1}{b}\left(\frac{a-c}{n+1}\right)^2$$

The equilibrium price decreases in the number of firms:

$$\frac{\partial p^*}{\partial n} = \frac{c(n+1) - a - nc}{(n+1)^2} = \frac{-a+c}{(n+1)^2} < 0$$

For infinite number of firms the price is equal to marginal costs.

Cournot: the case of N symmetric firms

- Cournot model illustrates causality between market structure and performance.

- Since firms are symmetric industry profits are equal to $n\Pi^*$

$$\frac{\partial n\Pi^*}{\partial n} = \frac{(a-c)^2}{b}\left(\frac{(n+1)^2 - 2n(n+1)}{(n+1)^4}\right) = \frac{(a-c)^2}{b}\left(\frac{-n^2+1}{(n+1)^4}\right) < 0$$

- When the number of firms increases (a change in structure) => industry profits decrease (a change in performance).

Cournot: the case of N symmetric firms

Deadweight loss in Cournot oligopoly rapidly decreases with an increase in the number of firms:

$$DL = \frac{1}{2}(P^* - P^C)(Q^C - Q^*) = \frac{1}{2}\left(\frac{a+nc}{n+1} - c\right)\left(\frac{a-c}{b} - \frac{n(a-c)}{b(n+1)}\right)$$

$$DL = \frac{1}{2b}\left(\frac{a-c}{n+1}\right)^2$$

Bertrand competition

Demand:

- Assume that consumers' behaviour is summarized by an inverse demand function: $P(Q) = a - bQ$, where $a>c$.

Supply:

- Suppose there are two firms: Firm 1 and Firm 2 which produce homogenous good at a constant marginal cost of c (symmetry) and assume there are no fixed costs, i.e., their cost function is $C(q) = cq$.

- The firms are assumed to simultaneously choose prices!

Proposition: If each firm has a constant marginal cost of production c, then the unique Nash equilibrium is

$$p_1^* = p_2^* = c$$

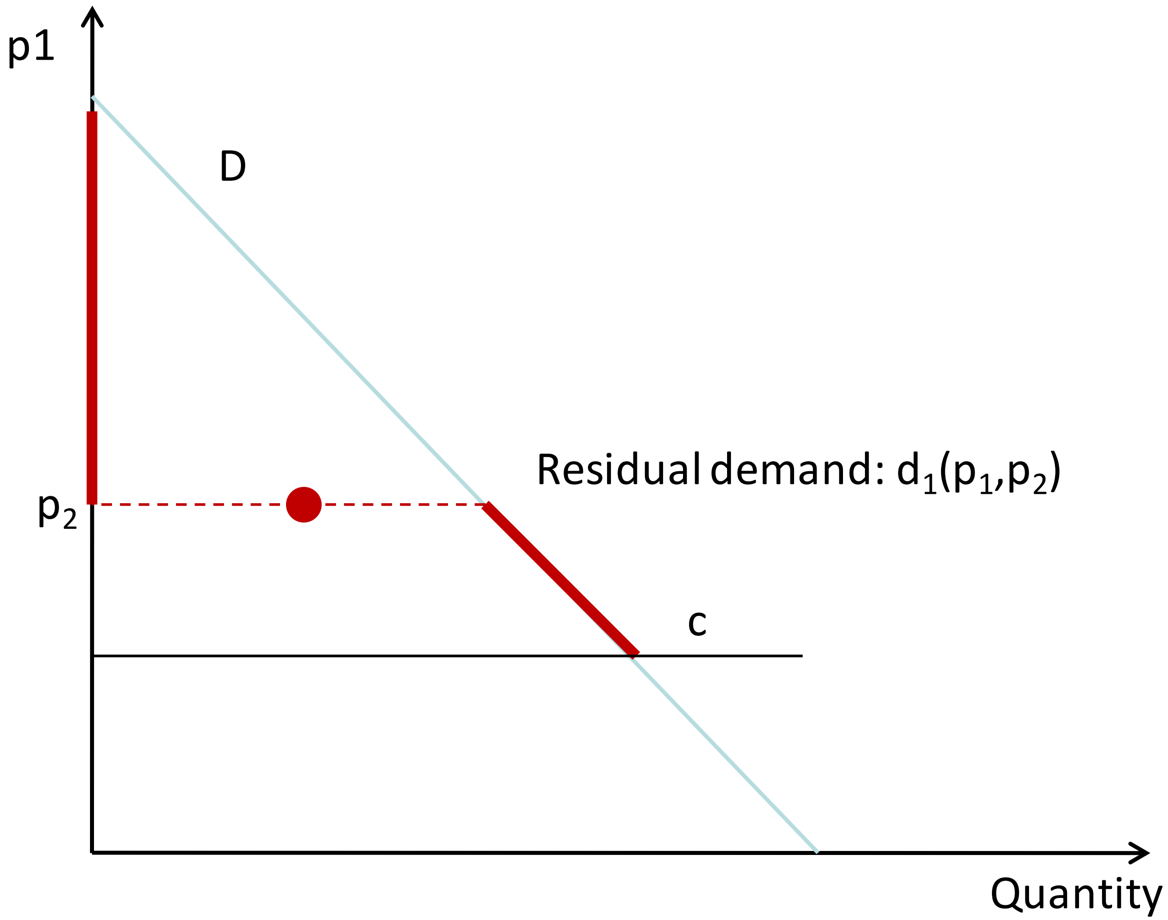
Bertrand competition

- The good is homogenous => competitors' products are perfect substitutes.
- Whichever firm sets the lowest price, it gets all of the demand.
- If each firm sets the same price, then they evenly split the demand.
- Residual demand function for Firm 1 is defined as follows (it is discontinuous at $p_1=p_2$):

$$d_1(p_1, p_2) = \begin{cases} D(p_1) & p_1 < p_2 \\ D(p_1)/2 & p_1 = p_2 \\ 0 & p_1 > p_2 \end{cases}$$

Bertrand competition: residual demand

Residual demand of Firm 1 at price $p_{2.}$



Bertrand competition

- Firm 1's optimal price depends on what it conjectures Firm 2's price will be, and vice versa:

- If Firm 1 expects Firm 2 to price above monopoly price, then Firm 1's optimal strategy is to price at the monopoly level.
  => Firm 1 gets all of the demand and makes monopoly profit.

- If Firm 1 expects Firm 2 to price below monopoly price but above marginal cost, then Firm 1 should set a price just below that of Firm 2: $p_1 = p_2 - \varepsilon$
- => Firm 1 gets all the demand and full profit instead of half of it.

$$\Pi_1(p_1 - \varepsilon, p_2) = D(p_2 - \varepsilon)((p_2 - \varepsilon) - c) \approx D(p_2)(p_2 - c) > \frac{D(p_2)}{2}(p_2 - c) > 0$$

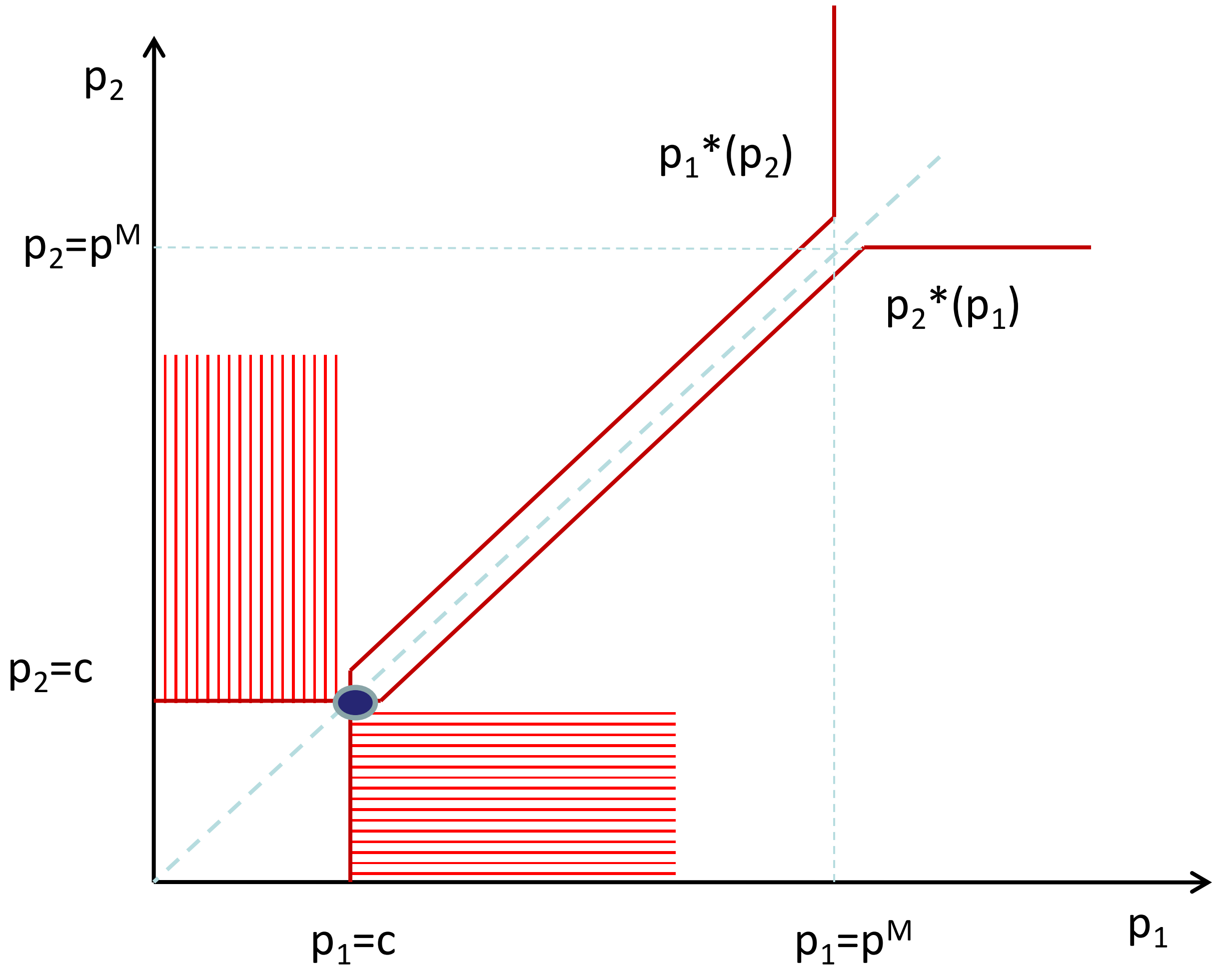
Bertrand competition

- But as long as Firm 1 sets price above marginal cost, then Firm 2 also has an incentive to undercut Firm 1, otherwise it makes zero profits.

- This price war occurs until each firm prices at marginal cost.
  => Both firms split the demand and make zero profit.

- If Firm 1 expects Firm 2 to price below marginal cost, then Firm 1's optimal price would be to price at marginal cost or above.
  => Firm 2 gets all the demand and makes negative profit, while Firm 1 gets no demand and makes zero profit.

Bertrand competition

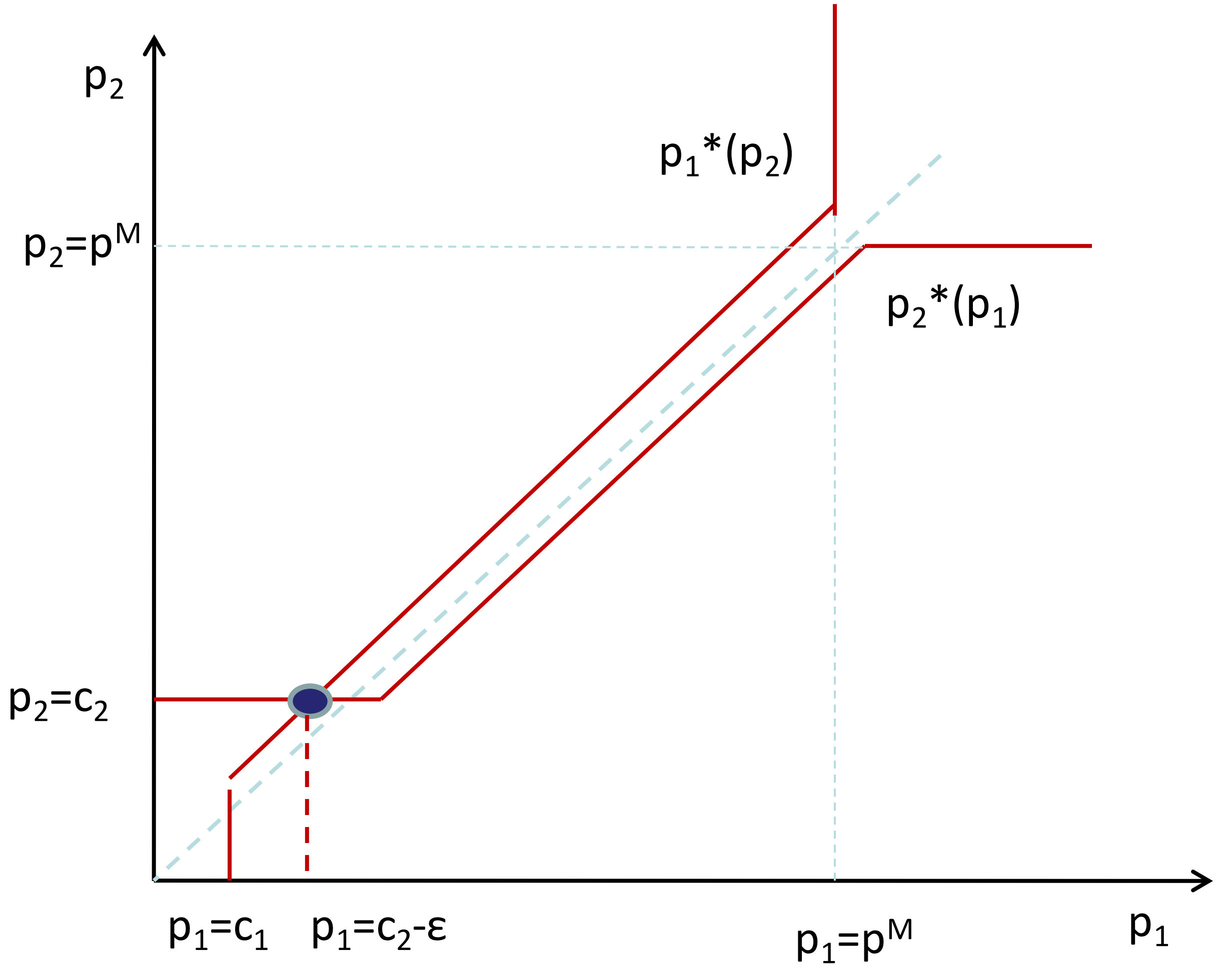


Bertrand competition

- In equilibrium both competitors set the same price at marginal cost.
- Why is this the only equilibrium? Because this is the only case where neither firm would profitably deviate.
- Setting price above marginal cost is not an equilibrium strategy.
  => the other firm has an incentive to undercut the price and capture the market and make a higher profit.
- Setting price below marginal cost is not an equilibrium strategy.
  => you capture all the demand, but you make a negative profit.

Bertrand competition

- When firms differ in marginal costs, only the low cost firm will sell. For instance, if Firm 1 is low cost, it will charge a price just under the marginal cost of the high cost Firm 2: $p_1 = p_2 - \varepsilon \rightarrow p_1 = c_2 - \varepsilon$



Summary – Bertrand Paradox

- Homogeneous product price competition with identical constant marginal costs

- The unique pure strategy Nash equilibrium is for firms to set price = mc and make zero profits!
  - Just two firms are sufficient to ensure p=mc.
  - This is very frustrating for the firms since increasing both their prices would make each of them better off!

- The result is interpreted as a paradox because we don't expect oligopoly pricing to yield the competitive outcome.
  - Theory seems to run directly counter to the data - observed lots of oligopolies who didn't seem to price at mc.

Bertrand Paradox ‘resolutions’

- “Resolutions” of the paradox:

  1. Differentiated products
  2. Repeated interaction
  3. Capacity constraints (Bertrand-Edgeworth model)
  4. Two stage game: first quantities, then prices (Kreps and Scheinkman, 1983):
     – Capacity chosen in the first stage are Cournot quantities
     – Prices chosen in the second stage with capacity constraints

  5. Search costs (Diamond, 1971): if consumers face a (however small) cost of searching for the lowest price, each firm charging the monopoly price is an equilibrium! This is called Diamond paradox.

Product differentiation model

- Suppose firms face a differentiated product linear demand system:

Demand for good 1: $$q_1 = a_1 - b_{11} p_1 + b_{12} p_2$$

Demand for good 2: $$q_2 = a_2 - b_{22} p_2 + b_{21} p_1$$

- Recall good 2 is a substitute for good 1 if an increase in the price of good 2 increases the demand for good 1

$$\frac{\partial q_1}{\partial p_2} = b_{12} > 0$$

Eg., Dell and Compaq computers

- And good 2 is a complement for good 1 if an increase in the price of good 2 decreases the demand for good 1

$$\frac{\partial q_1}{\partial p_2} = b_{12} < 0$$

Eg., MP3 files and MP3 players

Profit maximization

- Profit maximization with constant marginal costs

$$\pi_i(p_i, p_{-i}) = (p_i - c)D_i(p_i, p_{-i})$$

- FOC:

$$\begin{aligned}\pi_i^i(p_i, p_{-i}) &= D_i(p_i, p_{-i}) + (p_i - c)D_i^i(p_i, p_{-i}) \; = 0 \\ &= \left(a_i - b_{ii}p_i + b_{ij}p_j\right) + (p_i - c)(-b_{ii}) = 0\end{aligned}$$

- So that

$$\left(a_i + b_{ij}p_j\right) = (2p_i - c)b_{ii}$$

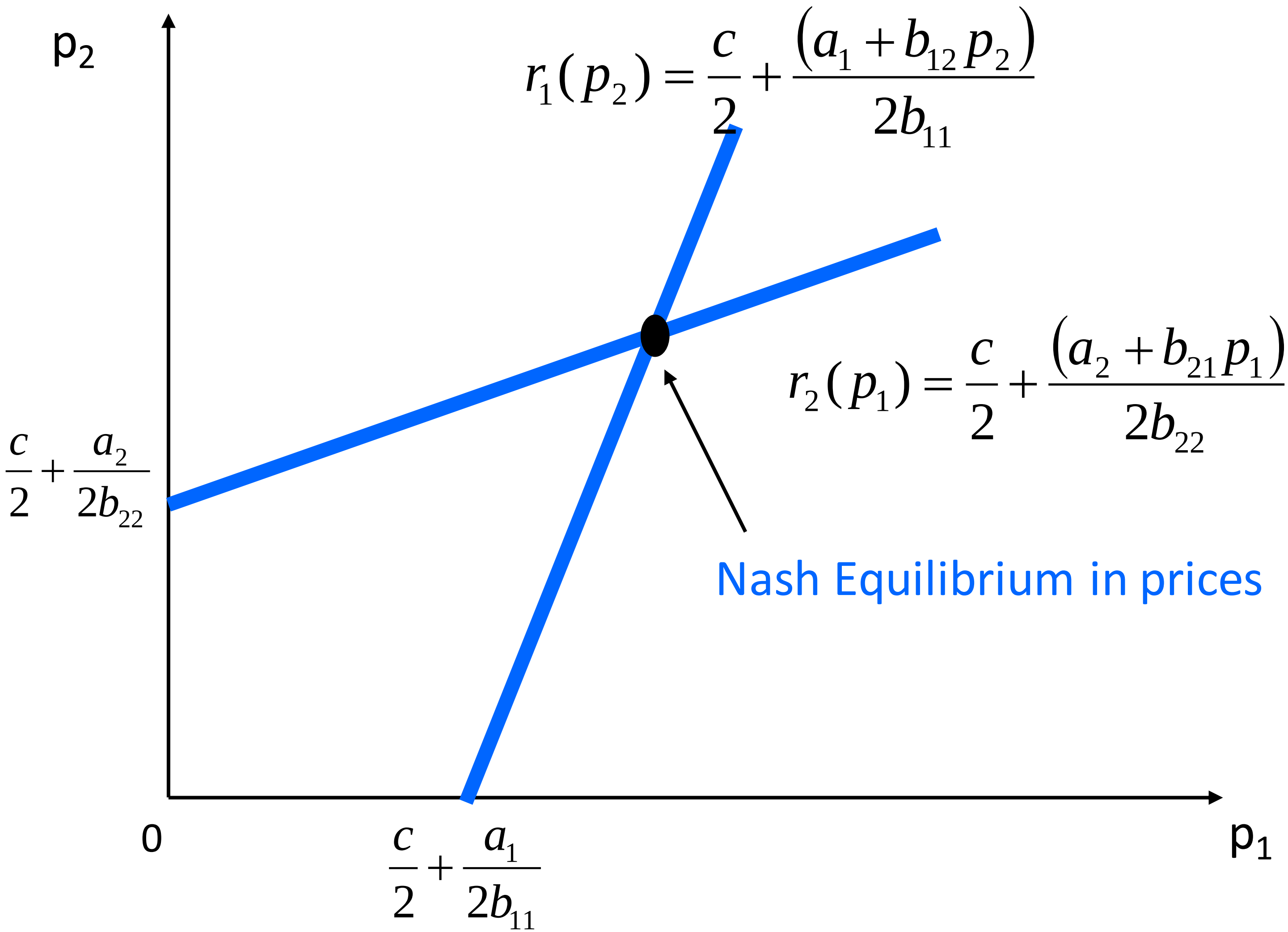
- And hence:

$$\boxed{r_i(p_{-i}) = p_i = \frac{c}{2} + \frac{\left(a_i + b_{ij}p_j\right)}{2b_{ii}}}$$

Slope of reaction function depends b_{ij}. In particular, whether slopes up or down depends on sign of b_{ij}.

Strategic complements

In differentiated product price game with demand substitutes (b_{ij}>0) prices are strategic complements (reaction curves slope up).



Substitute goods means prices are strategic complements

- We showed that the FOC are:

$$\frac{\partial \pi_i\,(p_i, p_{-i})}{\partial p_i} = \left(a_i - b_{ii}\,p_i + b_{ij}\,p_j\right) + (p_i - c)(-b_{ii}) = 0$$

- So that the cross derivative is

$$\frac{\partial^2 \pi_i\,(p_i, p_j)}{\partial p_j \partial p_i} = b_{ij}$$

- With linear demands, if products are substitutes ($b_{ij}>0$) then reaction curves in price games will slope upwards. If the goods are complements ($b_{ij}<0$) then reaction curves will slope downwards.

Take-away Points

- Competition in quantities and prices have very different Nash equilibria.

- Data usually indicates that oligopolists do not price at marginal cost and so do not often support the homogeneous product version of Bertrand's theory.

- Resolutions to the Bertrand paradox include among others:
  - Product differentiation
  - Capacity constraints (see Appendix)

Appendix

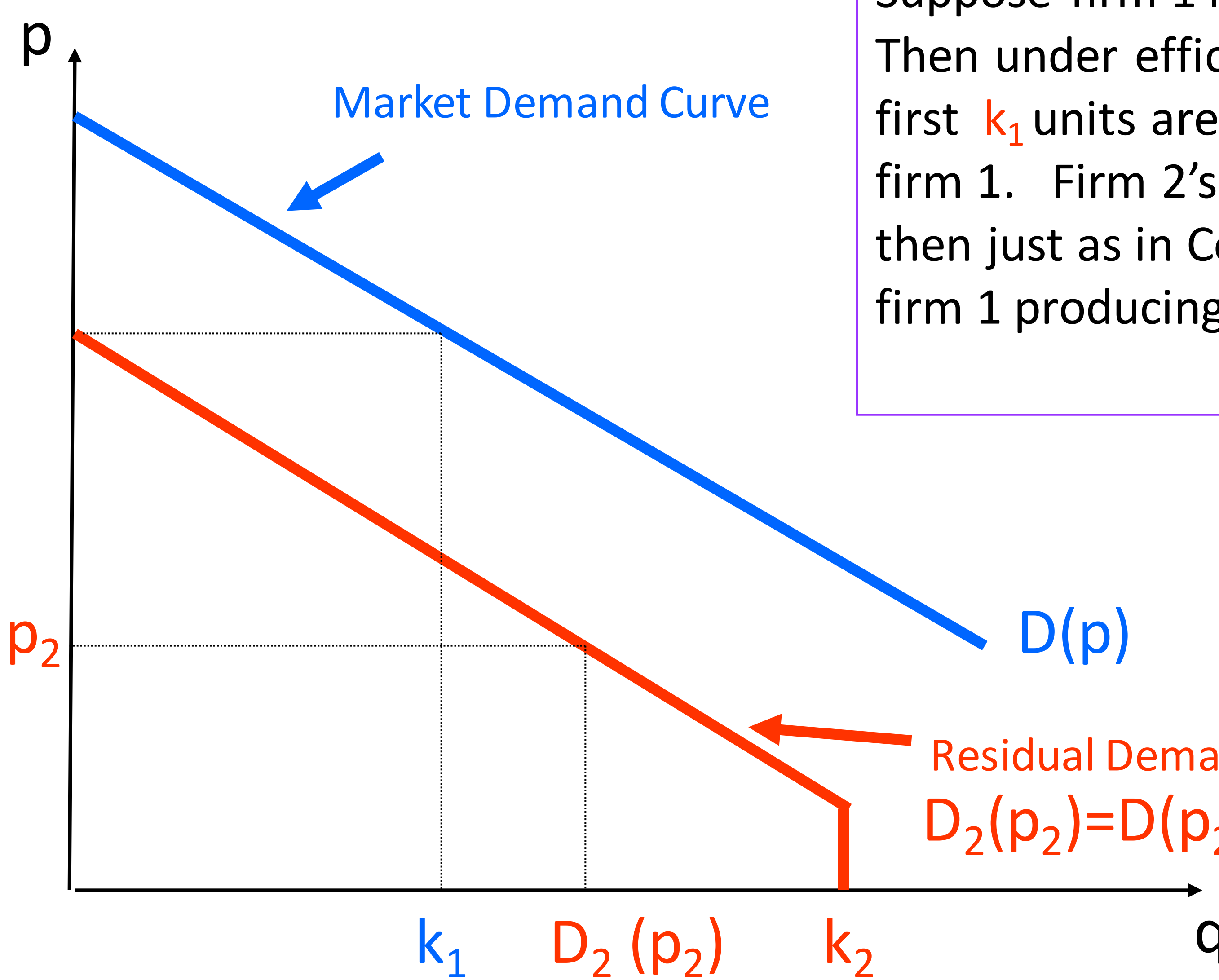
Price competition with capacity constraints

- Kreps-Scheinkman (Bell Journal, 1983) consider the two stage game:
  - Stage 1: Choose capacities
  - Stage 2: Bertrand price competition given capacities

- KS show that provided there is ‘efficient rationing’ at the second stage (given capacities) the sub-game perfect equilibrium of this two stage game can look a lot like the equilibrium in the one-shot Cournot quantity game.

- With capacity constraints, supply can be less than total demand for a given price (at least out of equilibrium) and so we have to know which consumers would get the good. Common assumptions are:
  1. Efficient Rationing: The consumers who value the good most are served first by the lowest price firm until capacity exhausted.
  2. Proportional (Random) Rationing: each consumer has an equal probability of being served.

Residual demand with efficient rationing



Suppose firm 1 is the low price firm. Then under efficient rationing, the first k_1 units are always bought from firm 1. Firm 2's demand curve is then just as in Cournot model with firm 1 producing at her capacity k_1.

Stage 2: Bertrand given capacities (k_1,k_2)

- Analytically, sales are therefore:

Low price firm gets all demand or sells capacity

$$q_i(p_i, p_j; k_i, k_j) = \begin{cases} \min\{D(p_i), k_i\} & \text{if} \quad p_i < p_j \\ \min\{k_i, \max\{D(p_i) - k_j, 0\}\} & \text{if} \quad p_i > p_j \\ \min\{k_i, (k_i/(k_i + k_j))D(p)\} & \text{if} \quad p_i = p_j \end{cases}$$

High price firm gets Residual demand if any and can sell upto capacity

Sharing rule if equal prices

- At stage 2, firm i chooses its price to solve:

$$r_i(p_j; k_i, k_j) = \underset{p_i}{\arg\max}\ \pi_i(p_i, p_j; k_i, k_j)$$

$$= \underset{p_i}{\arg\max}\ (p_i - c)q_i(p_i, p_j; k_i, k_j)$$

Case 1: capacities are large

- Capacities are not an effective constraint and so sales are:

$$q_i(p_i, p_j; k_i, k_j) = \begin{cases} D(p_i) & \text{if} \quad p_i < p_j \\ 0 & \text{if} \quad p_i > p_j \\ (k_i/(k_i + k_j))D(p) & \text{if} \quad p_i = p_j \end{cases}$$

- If prices are not equal then low price firm gets whole market. If prices are equal, the sharing rule applies.

- Firm's demand curve looks exactly as it does in the homogeneous product Bertrand game and p=mc is the unique equilibrium outcome to the sub-game.

Case 2: capacities are small

- If $$0 \le k_i \le D(p_i) - k_j \le D(p_i)$$

  and $$k_i \le \left(\frac{k_i}{k_i + k_j}\right) D(p_i) \Leftrightarrow k_i + k_j \le D(p_i)$$

- then capacity constraints bind and

$$q_i(p_i, p_j; k_i, k_j) = \begin{cases} k_i & \text{if} \quad p_i < p_j \\ \min\{k_i, D(p_i) - k_j\} = k_i & \text{if} \quad p_i > p_j \\ k_i & \text{if} \quad p_i = p_j \end{cases}$$

- And equilibrium price will equate industry supply (which is total capacity) to market demand:

$$k_i + k_j = D(p^*)$$

- Inverting gives the equilibrium price as a function to industry capacity:

$$p^* = D^{-1}(k_i + k_j) \equiv P(k_i + k_j)$$

Stage 1: capacity choices

- Substituting in the equilibrium price function

$$r_i(k_j) = \underset{k_i}{\arg\max}\ \pi_i(p_i^*, p_j^*; k_i, k_j)$$

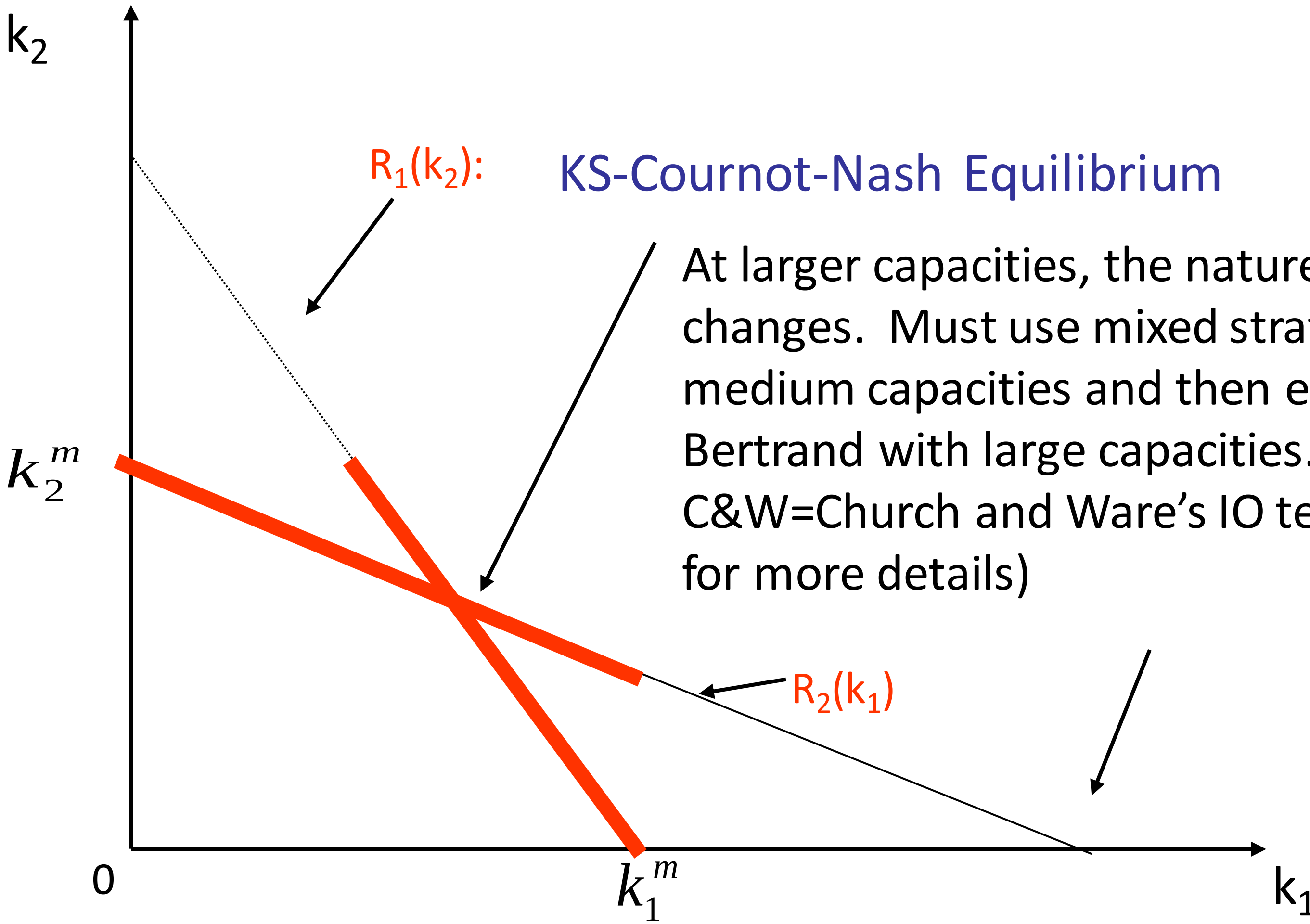
'Reduced form' profit function – with equilibrium prices substituted in

$$= \underset{k_i}{\arg\max}\ (p_i^* - c)q_i(p_i^*, p_j^*; k_i, k_j)$$

$$= \underset{k_i}{\arg\max}\ (P(k_i + k_j) - c)k_i$$

- Which looks exactly like the one-shot Cournot game profit function with choice variable capacity k_i instead of output, q_i and with the inverse demand function $P(k_i + k_j)$

Reaction curve diagram – KS's 'Cournot in capacities'



At larger capacities, the nature of equilibrium changes. Must use mixed strategies for medium capacities and then equilibrium is Bertrand with large capacities. (See C&W=Church and Ware's IO textbook and K-S for more details)

Davidson and Denekere (1986)

- Show that KS's result is sensitive to the exact rationing rule used. And they argue 'Efficient Rationing' isn't very likely.

- Recall, under efficient rationing, the most highly valued units must be bought from the low price firm, e.g., if consumers are randomly distributed between the two firms then this won't happen.

See: Deneckere, R., Davidson, C., 1986. "Long-run competition in capacity, short-run competition in price, and the Cournot model", *Rand Journal of Economics* 16, pp.404-415.