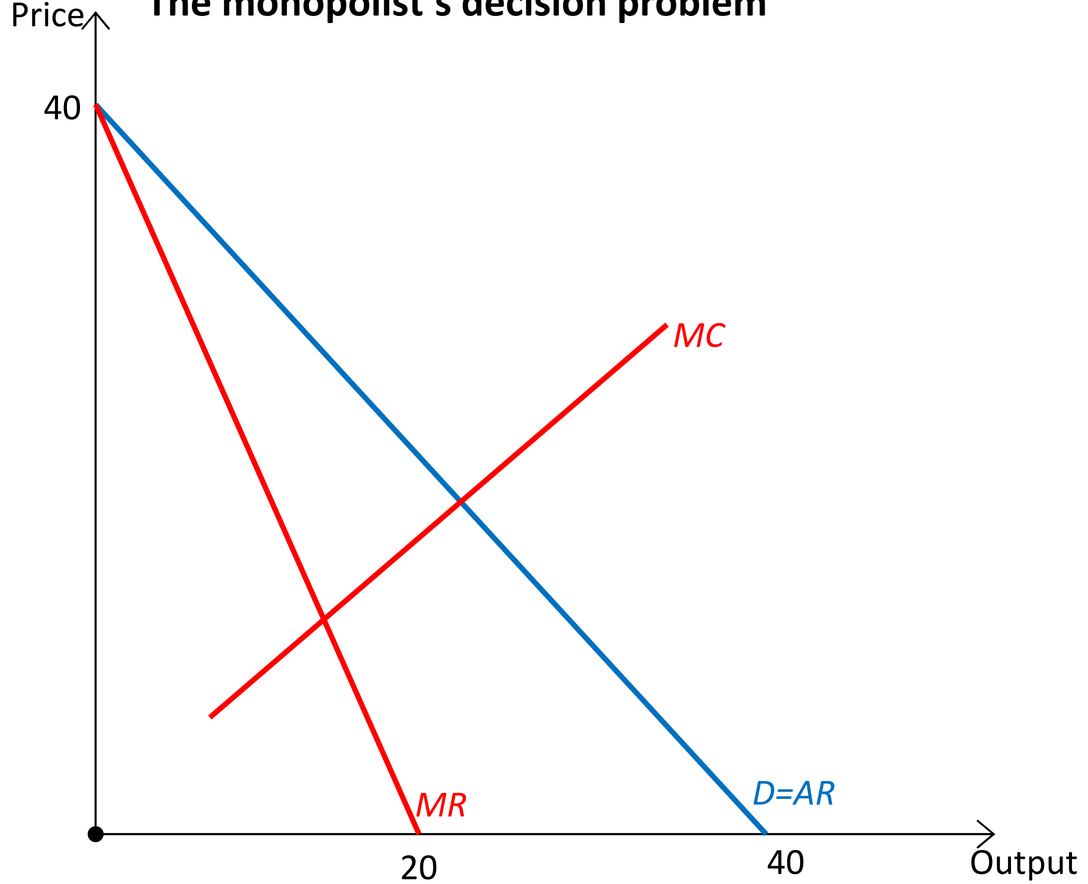
UC Berkeley
Haas School of Business
Economic Analysis for Business Decisions
(EWMBA 201A)
Fall 2013

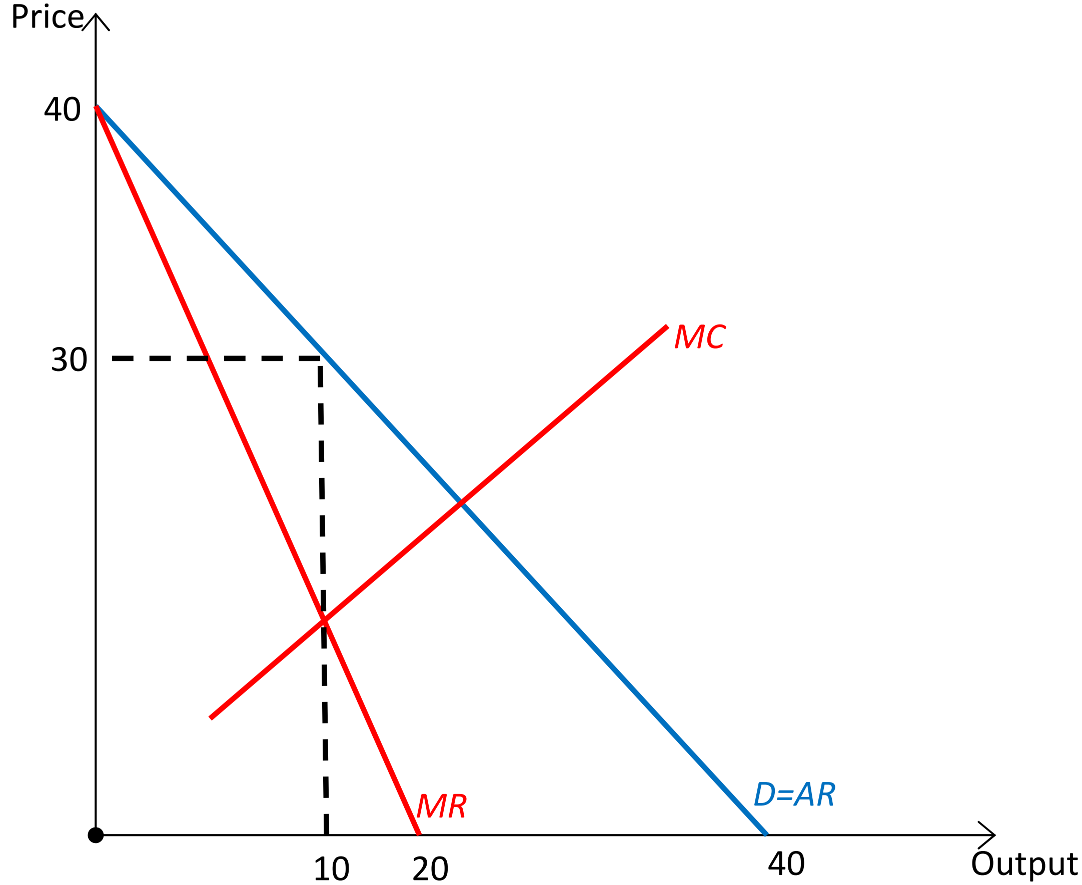
Pricing with market power and oligopolistic markets
(PR 11.1-11.4 and 12.2-12.5)

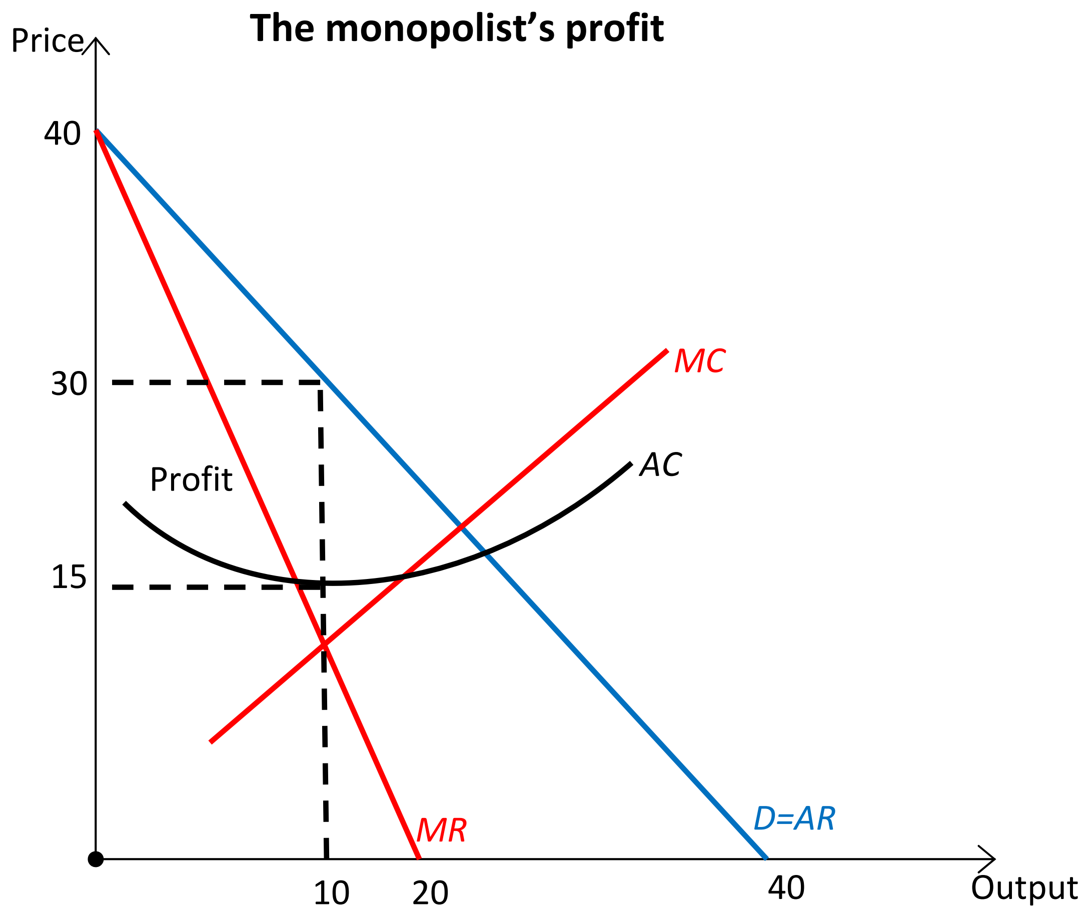
Module 4

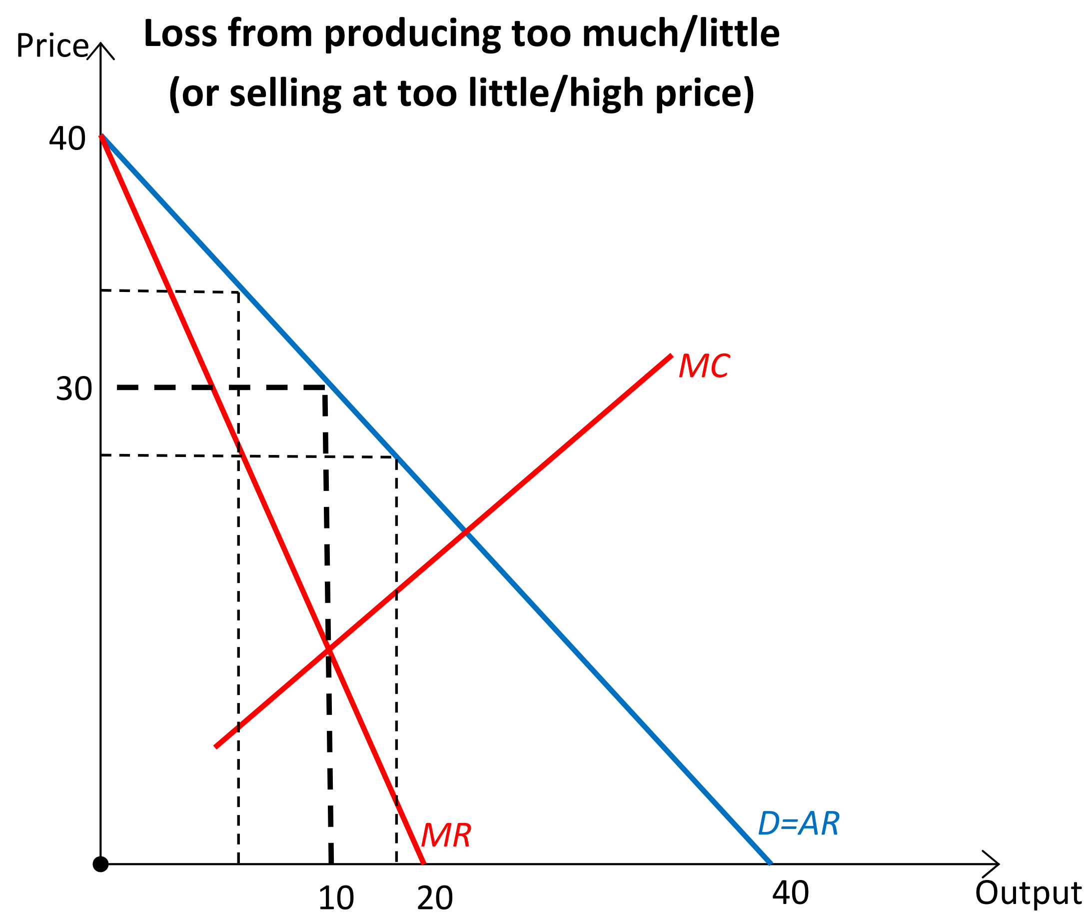
Sep. 28, 2013

The monopolist's decision problem

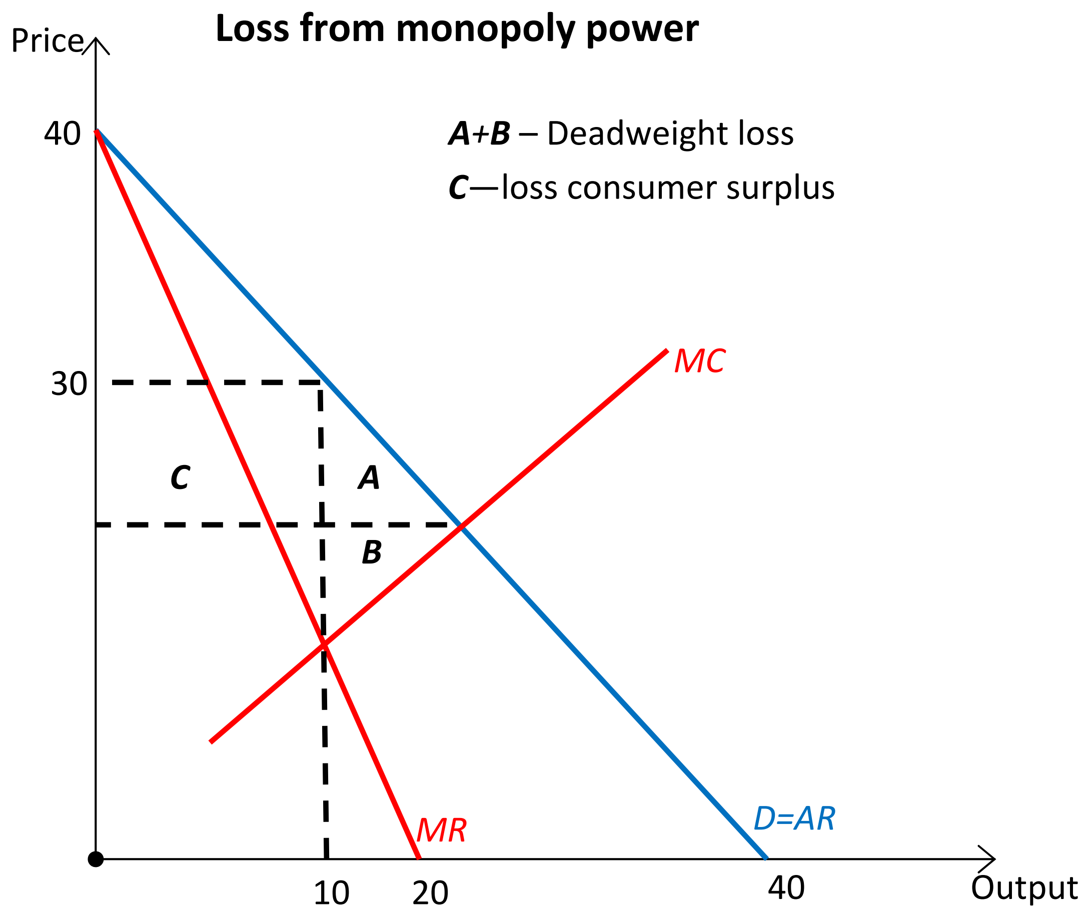



Price
40
30
MC
MR
D=AR
10
20
40
Output


The monopolist's profit
Price
40
30
15
Profit
MC
AC
MR
D=AR
10
20
40
Output



Loss from producing too much/little
(or selling at too little/high price)
Price
40
30
MC
MR
D=AR
10
20
40
Output

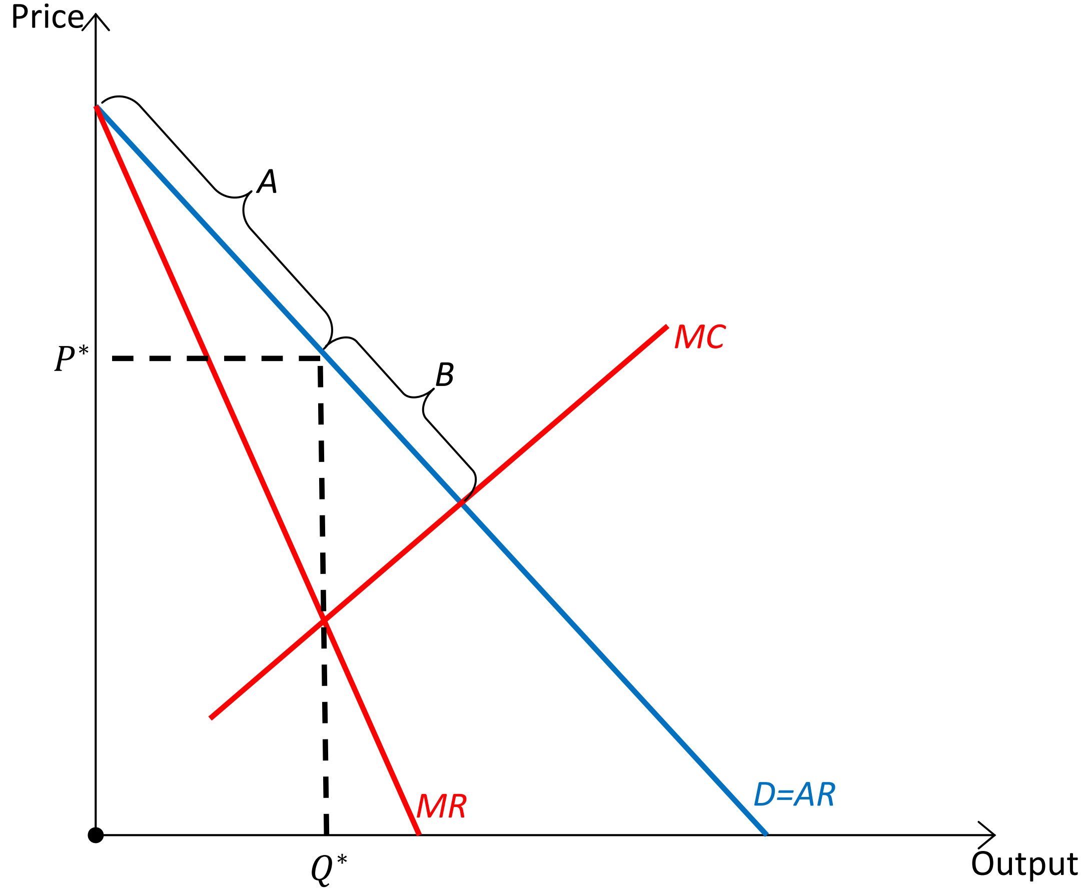


Loss from monopoly power
Price
40
30
C
A
B
A+B – Deadweight loss
C—loss consumer surplus
MC
MR
D=AR
10
20
40
Output

The deficiencies of simple pricing

[1] If the firm can charge only one price for all it consumers, to maximize profit, it would pick the price P^* and corresponding output Q^* where its marginal cost (MC) and marginal revenue (MR) curves intersect.

[2] But although *simple pricing* or *uniform pricing* is quite prevalent, it is neither the only nor the most desirable form of pricing. If the firm could sell different units of output at different prices, then we have another story.



Price
A
B
MC
P^*
MR
D=AR
Q^*
Output

What simple pricing loses?!

1. It leaves potential profit in the hands of consumers in the form of their consumer surplus (the surplus under region A of the demand curve).

2. It leaves "money on the table" (deadweight loss) due to the driving-down-the-price effect (the surplus under region B of the demand curve).

Two observations:

1. Under simple pricing, the firm cannot charge a price for the $Q^* + 1$ unit that is different than the price it charges for the other Q^* units. And the fact that it would, have to lower the price on all Q^* units in order to induce someone to buy the $Q^* + 1$ unit, makes selling that unit unprofitable.

2. The firm would like to charge a higher price to consumers willing to pay more than P^*. The firm would also like to sell to consumers willing to pay prices lower than P^*, but only if doing so does not entail lowering the price for the other consumers.

! This is the basis for price discrimination – charging different prices to different consumers.

Price discrimination

Economists typically consider three degrees of prices discrimination:

- 1^{st} The firm sells different units of output for different prices and these prices may differ from consumer to consumer.
- 2^{nd} The firm sells different units of output for different prices but every consumer who buys the same amount of the good pays the same price.
- 3^{rd} The firm sells output for different consumers at different prices, but every unit of output sold to a given consumer sells for the same price.

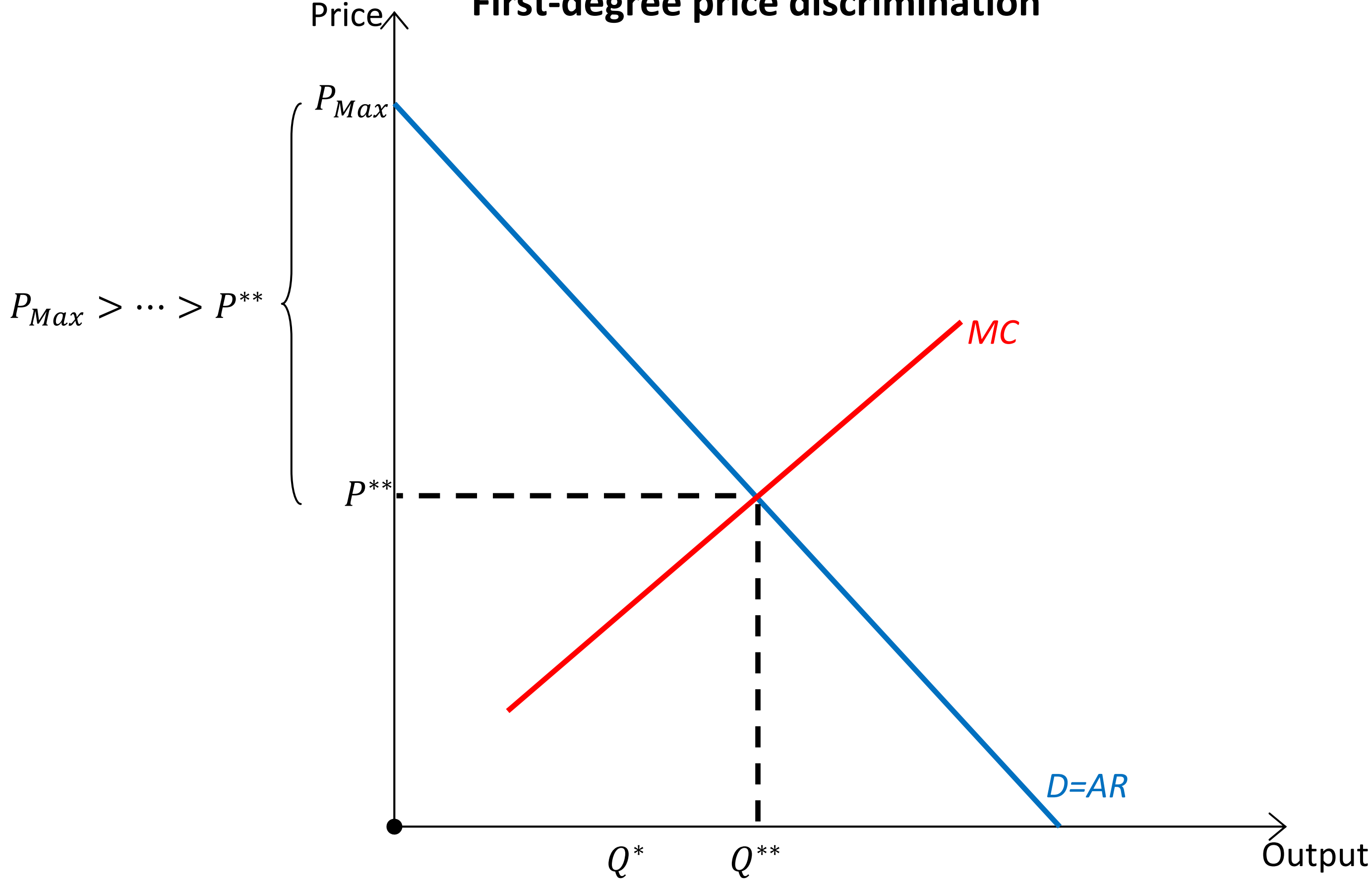
Next, we look at each of these types of prices discrimination to see what economics can say about how prices discrimination works!

First-degree (or perfect) price discrimination

$\Longrightarrow$ A firm that is able to perfectly price discriminate will sell each unit of output at the highest price it will command, that is, at each consumer's reservation price.

$\Longrightarrow$ Since the firm can capture all the welfare generated from selling any number of units, it will want to produce to the point at which demand intersects marginal cost Q^{**}.

First-degree price discrimination



- Producing Q^{**} units and capturing all of welfare is the very best the firm could ever do (the "Holy Grail" of pricing).

- Perfect price discrimination is an idealized concept but it is interesting theoretical because it achieves Pareto efficiency.

- Clearly, firms typically cannot know the reservation price of every consumer, but sometimes reservation prices can be roughly identified.

- There are very few real-life examples. Perhaps to closest example would be tuition rates in Ivy League colleges, based on ability to pay.

Second-degree price discrimination

- Under second-degree price discrimination the price per unit of output is not constant but depends on how much you buy (non-linear pricing).

- One form of second-degree price discrimination is via *quantity discounts* – liter bottle of Coke is less than twice as expensive as the half-liter bottle.

- Typically, each price-quantity package is targeted toward different consumers, giving consumers an incentive to self-select.

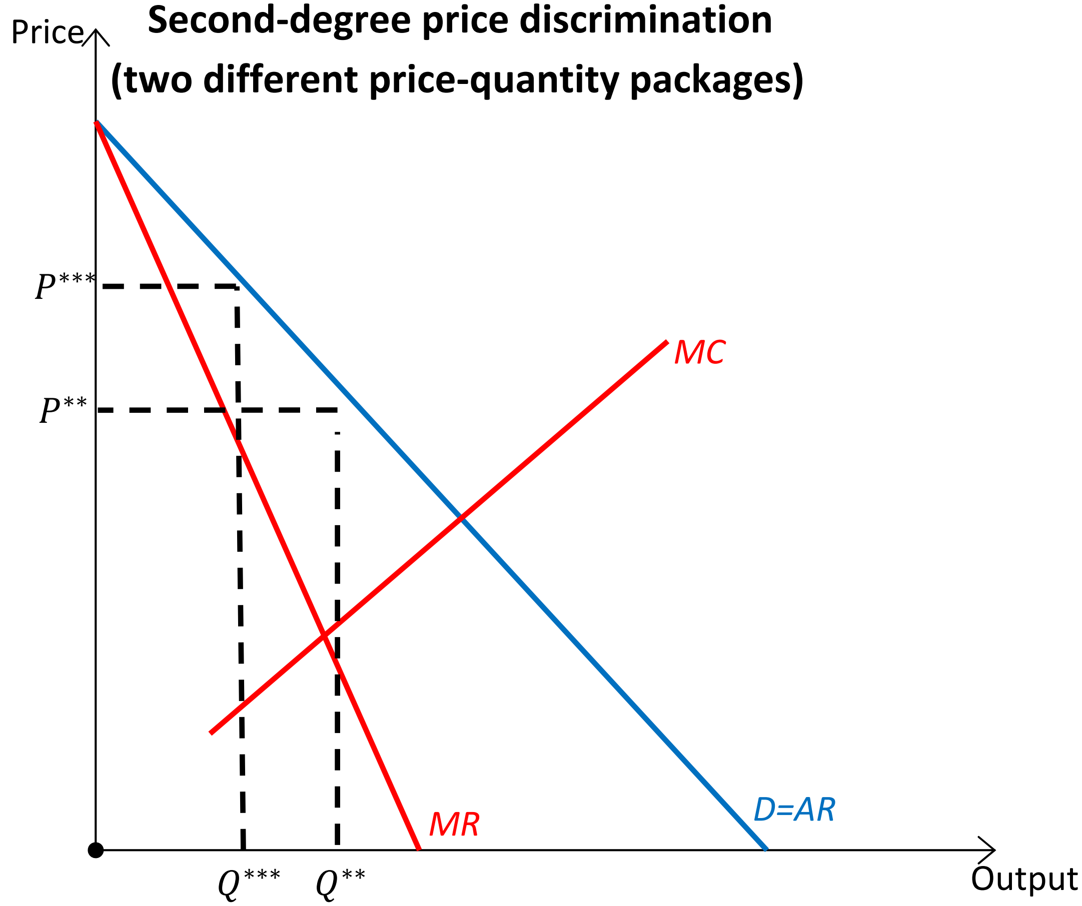
- In practice, firms often encourage this self-selection not by adjusting *quantity* of the good, but rather by adjusting the *quality* of the good.

The airline industry has been very successful in prices discrimination (the industry spokesperson prefer to use the term “yield management”):

[1] restricted and unrestricted fares
[2] first-class and couch-class travel
[3] Saturday night stayovers
[4] advance-ticketing

! In the 19$^{\text{th}}$ century, the French railroads removed the roofs from second-class carriages to create third-class carriages...

Second-degree price discrimination
(two different price-quantity packages)



Third-degree price discrimination

- Third-degree price discrimination means charging different prices to different consumers on the basis of *identifiable* characteristics.

- An example of third-degree discrimination is charging different prices on the basis of observed group membership (children, seniors, students, etc).

- Geography-based third-degree price discrimination is quite prevalent – in air travel, a round-trip SFO-JFK has a different price than JFK-SFO...

- Clearly, the market with the higher price must have a lower elasticity of demand.

An example

Let $P_1(Q_1)$ be the demand of students and $P_2(Q_2)$ be the demand of non-students where Q_1 and Q_2 are the amount sold to students and non-students, respectively. Let $C(Q_T)$ for $Q_T = Q_1 + Q_2$ be the firm's cost function.

The firm's profit is its revenue from each population less its costs is given by

$$\pi(Q_T) = P_1(Q_1)Q_1 + P_2(Q_2)Q_2 - C(Q_T).$$

The profit-maximizing quantity of output Q_1^* (resp. Q_2^*) is such that the marginal (incremental) profit resulting from a small increase in Q_1 (resp. Q_2) equals zero, that is,

$$\frac{\Delta \pi}{\Delta Q_1} = \frac{\Delta P_1 Q_1}{\Delta Q_1} - \frac{\Delta C}{\Delta Q_1} = 0,$$

and

$$\frac{\Delta \pi}{\Delta Q_2} = \frac{\Delta P_2 Q_2}{\Delta Q_2} - \frac{\Delta C}{\Delta Q_2} = 0,$$

Thus, at the profit-maximizing quantities Q_1^* and Q_2^*

$$MR_1(Q_1^*) = MR_2(Q_2^*) = MC(Q_1^* + Q_2^*).$$

To determine *relative prices*, we can write the marginal revenues in terms of elasticity of demand:

$$MR_1 = P_1(1 + 1/E_1)$$

and

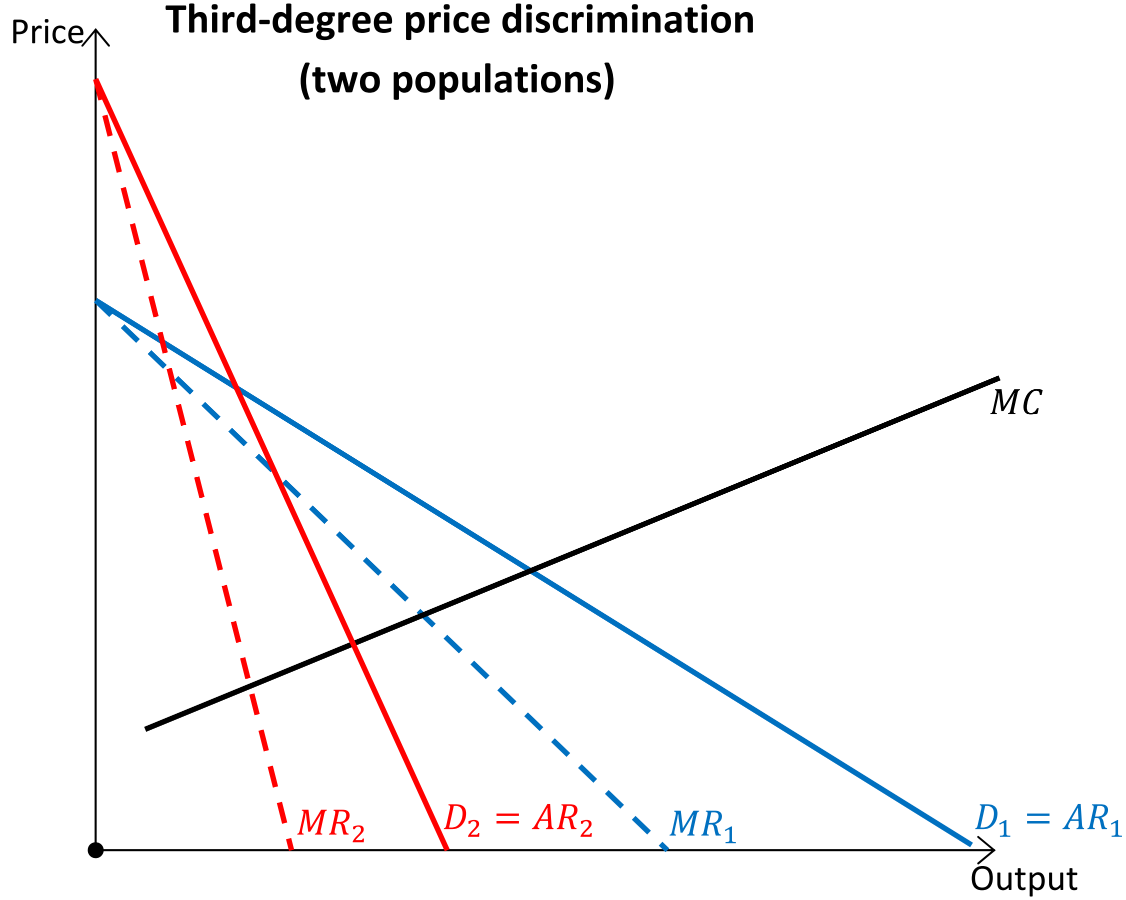
$$MR_2 = P_2(1 + 1/E_2).$$

By equating MR_1 and MR_2, we must have

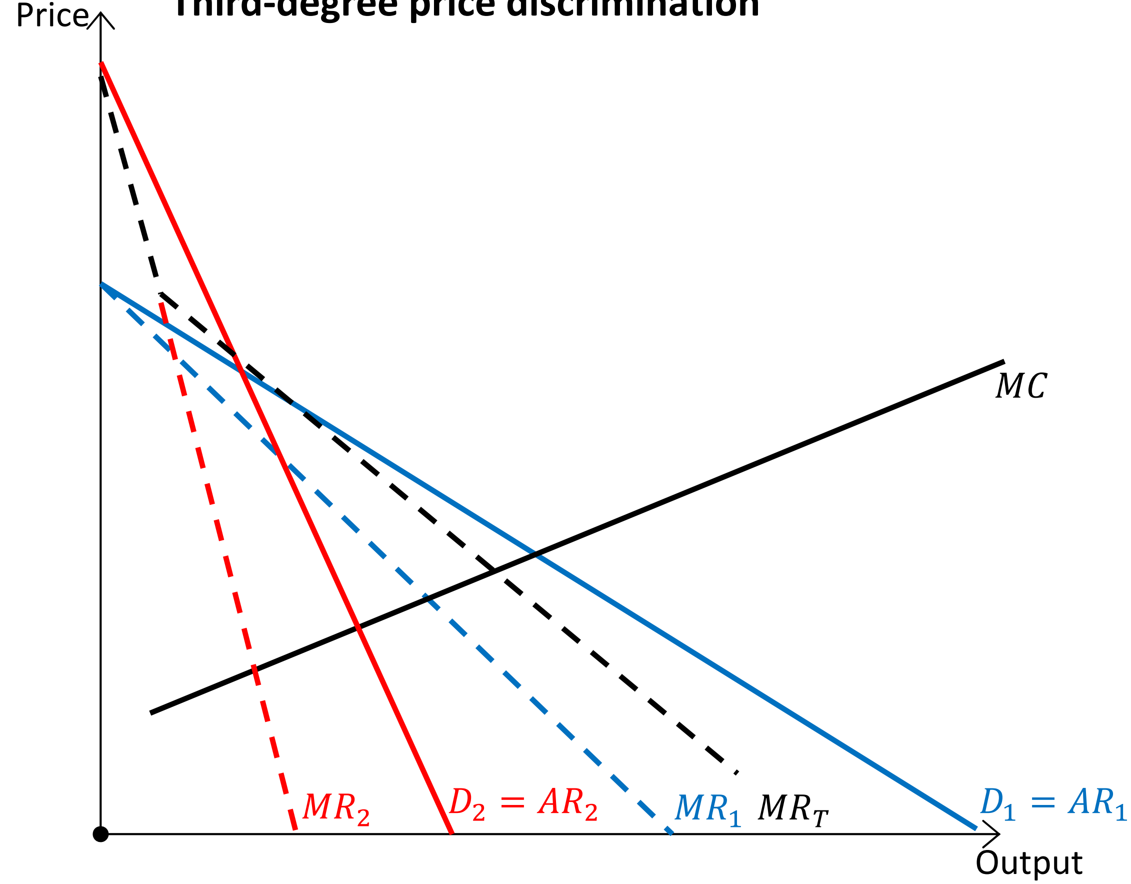
$$\frac{P_1}{p_2} = \frac{1 + 1/E_2}{1 + 1/E_1}.$$

! This analysis generalizes to any (finite) number of populations.

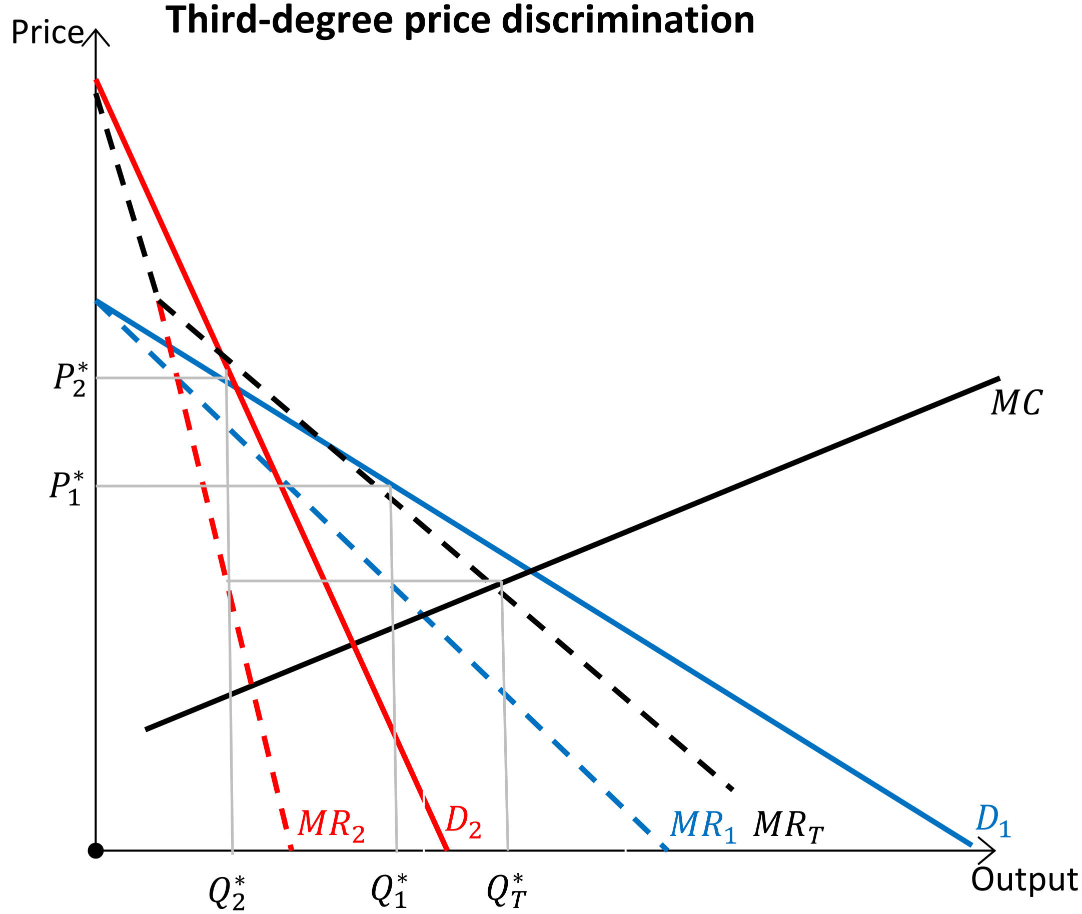
Third-degree price discrimination (two populations)



Third-degree price discrimination



Third-degree price discrimination



Two-part tariffs
(The Disneyland Dilemma)

A two-part tariff can help get a firm closer to the Grail than can simple pricing. It is a pricing scheme (tariff) with, as the name indicates, two parts:

I An entry fee – the amount that the consumer must pay before she can buy any units at all (overhead charge).

II A per-unit charge – the amount that the consumer must pay for each unit she chooses to purchase.

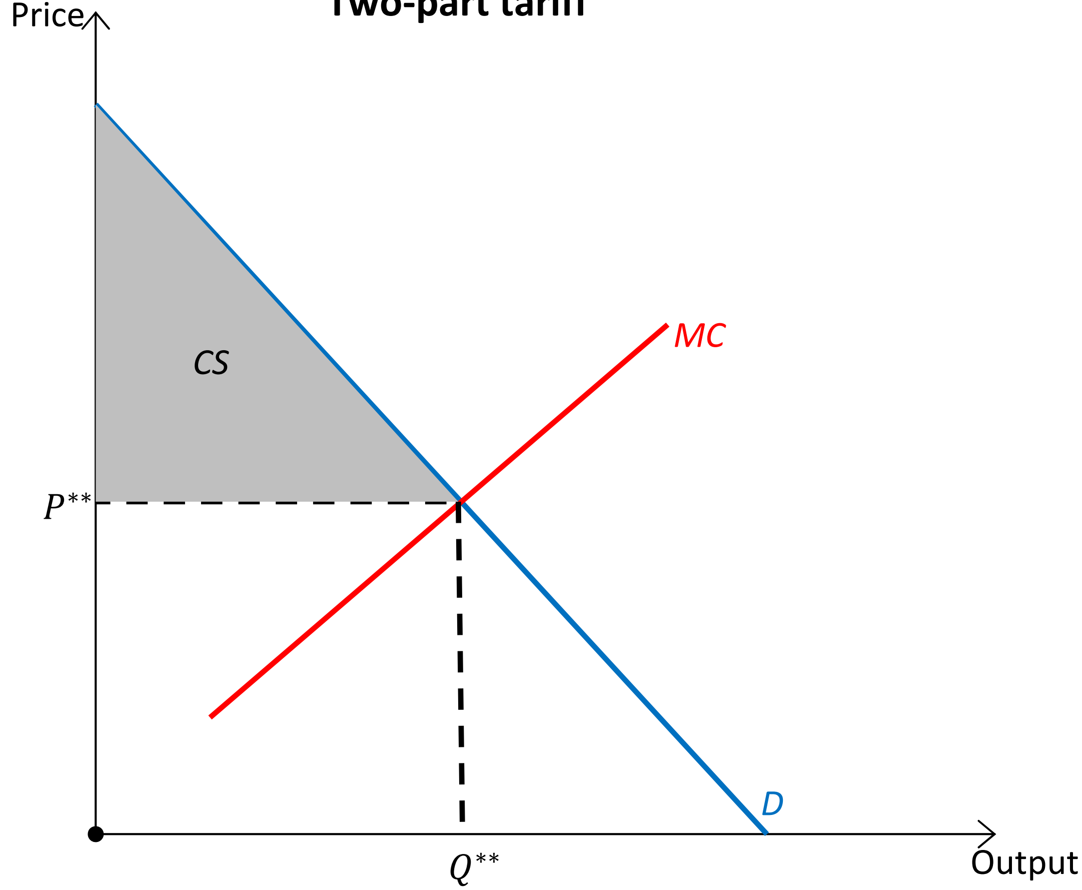
! In some instances, as with some – but not all – amusement parks, the per-unit charge might even be set to zero (so-called Disneyland pricing).

$\Longrightarrow$ **Identical consumers**

Suppose consumers have identical demands (are homogeneous). Under the profit-maximizing two-part tariff, the firm

- produces Q^{**} units, where $P(Q^{**}) = MC(Q^{**})$
- sets the per-unit charge equal $P(Q^{**})$
- sets an entry fee F to equal CS/N where N is the number of consumers.

Two-part tariff



$\Longrightarrow$ **Consumers are heterogeneous**

If consumers do not all have the same demand curves then designing the optimal two-part tariff becomes much more complicated.

One strategy would be to divide customers into homogeneous subgroups (third-degree price discrimination), and then employ the optimal two-part tariff on each group.

! Real-life use of two-part tariffs are hard to recognize initially – club stores, tech support (some has service-call charge), land-line phones, and more.

Takeaways

1. If all consumers are identical, then perfect price discrimination can be achieved by a two-part tariff. When consumers are not identical, then it is typically not possible to achieve perfect discrimination.

2. When consumers are heterogeneous it is sometimes possible to divide them into different populations that are more homogeneous. If so, then the firm can engage in third-degree price discrimination.

3. When the firm cannot freely identify consumers' types, it can try to induce them to reveal their types. This form of price discrimination is known as second-degree price discrimination.

4. Two prevalent forms of second-degree price discrimination are using quality distortions and quantity discounts.

5. Another method of price discrimination is *bundling*. Bundling allows the firm to take advantage of the correlations that exist between consumers' preferences for different products.

6. All discriminatory pricing is, in theory, vulnerable to *arbitrage* – the advantaged reselling to the disadvantaged. Firms seek to deter or reduce arbitrage.

Oligopoly
(preface to game theory)

- Another form of market structure is **oligopoly** – a market in which only a few firms compete with one another, and entry of new firms is impeded.

- The situation is known as the Cournot model after Antoine Augustin Cournot, a French economist, philosopher and mathematician (1801-1877).

- In the basic example, a single good is produced by two firms (the industry is a "duopoly").

Cournot's oligopoly model (1838)

- A single good is produced by two firms (the industry is a "duopoly").

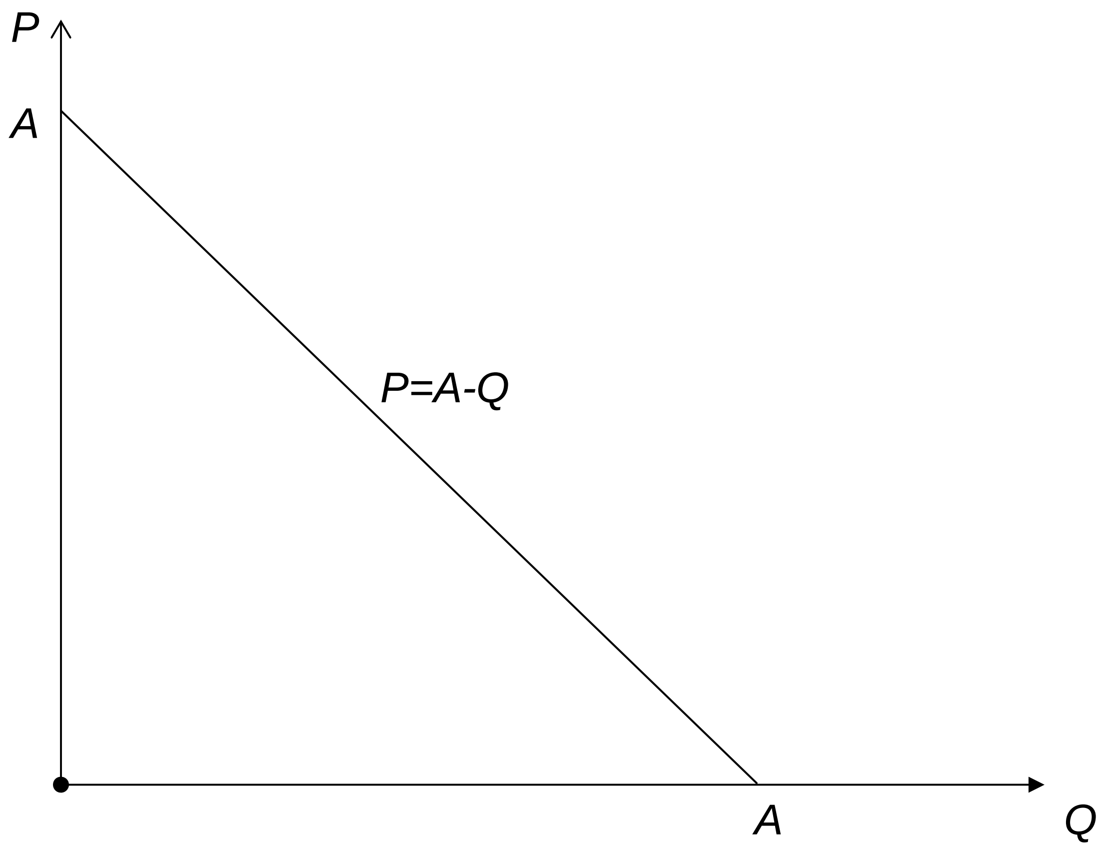
- The cost for firm $i = 1, 2$ for producing q_i units of the good is given by $c_i q_i$ ("unit cost" is constant equal to $c_i > 0$).

- If the firms' total output is $Q = q_1 + q_2$ then the market price is

  $$P = A - Q$$

  if $A \geq Q$ and zero otherwise (linear inverse demand function). We also assume that $A > c$.

The inverse demand function



To find the Nash equilibria of the Cournot's game, we can use the procedures based on the firms' best response functions.

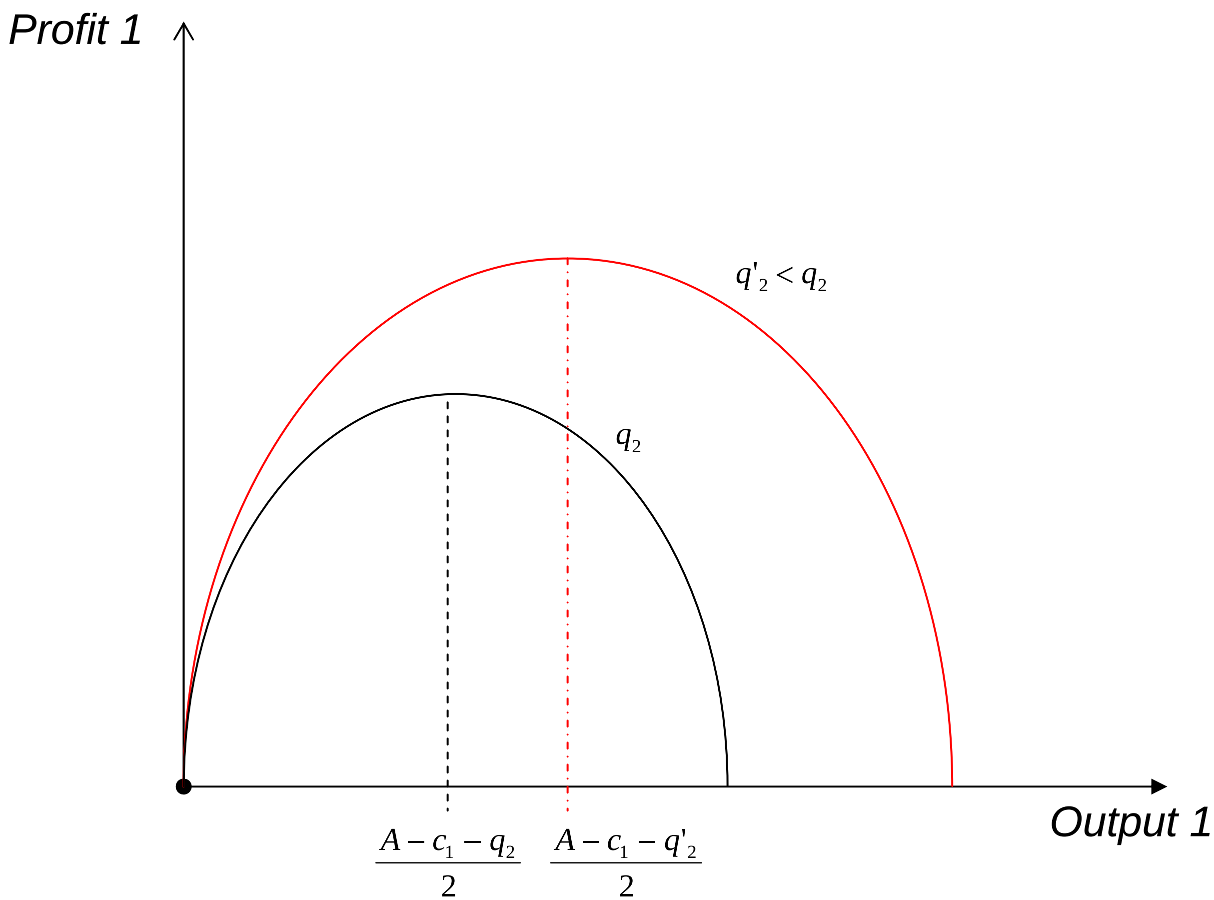
But first we need the firms payoffs (profits):

$$\begin{aligned} \pi_1 &= Pq_1 - c_1 q_1 \\ &= (A - Q)q_1 - c_1 q_1 \\ &= (A - q_1 - q_2)q_1 - c_1 q_1 \\ &= (A - q_1 - q_2 - c_1)q_1 \end{aligned}$$

and similarly,

$$\pi_2 = (A - q_1 - q_2 - c_2)q_2$$

Firm 1's profit as a function of its output (given firm 2's output)



To find firm 1's best response to any given output q_2 of firm 2, we need to study firm 1's profit as a function of its output q_1 for given values of q_2.

Using calculus, we set the derivative of firm 1's profit with respect to q_1 equal to zero and solve for q_1:

$$q_1 = \frac{1}{2}(A - q_2 - c_1).$$

We conclude that the best response of firm 1 to the output q_2 of firm 2 depends on the values of q_2 and c_1.

Because firm 2's cost function is $c_2 \neq c_1$, its best response function is given by

$$q_2 = \frac{1}{2}(A - q_1 - c_2).$$

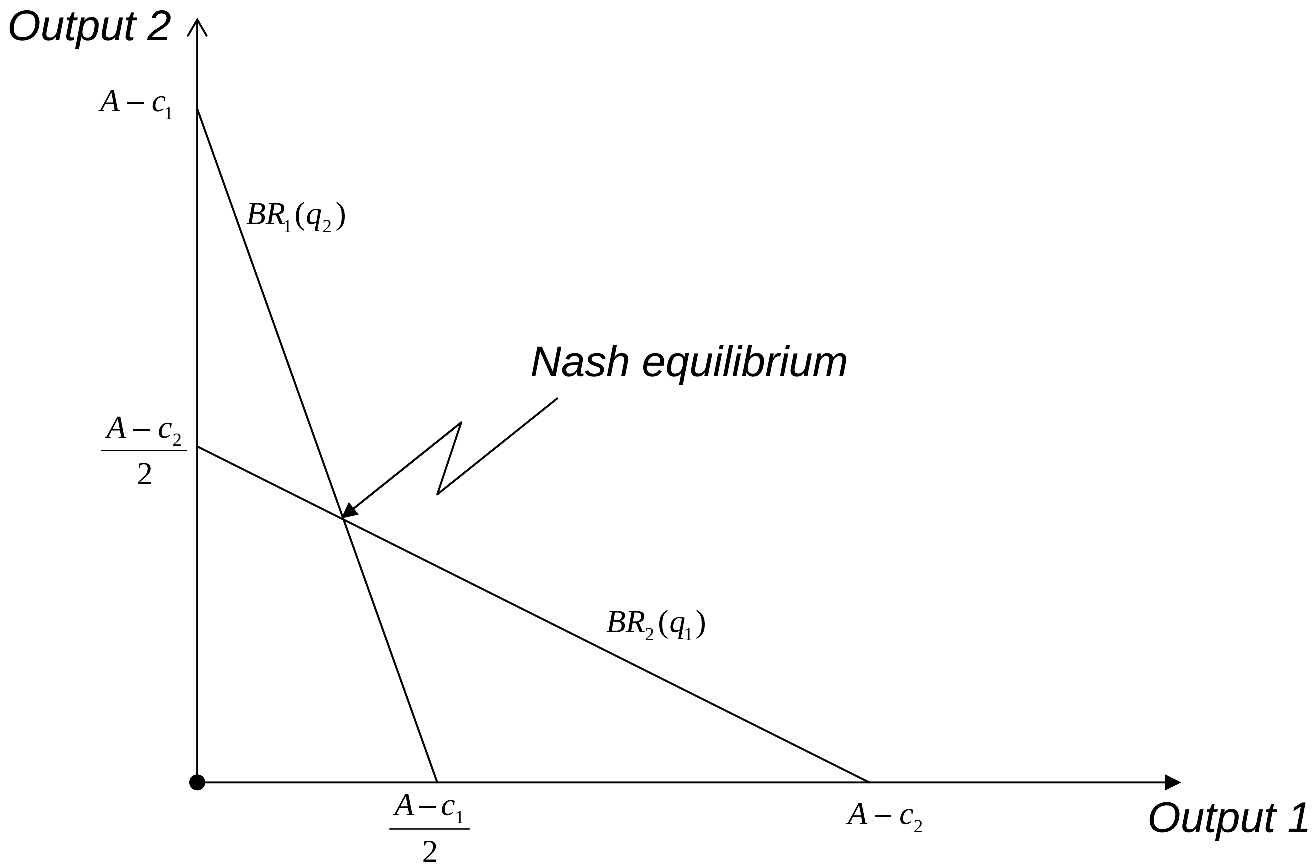
A Nash equilibrium of the Cournot's game is a pair (q_1^*, q_2^*) of outputs such that q_1^* is a best response to q_2^* and q_2^* is a best response to q_1^*.

From the figure below, we see that there is exactly one such pair of outputs

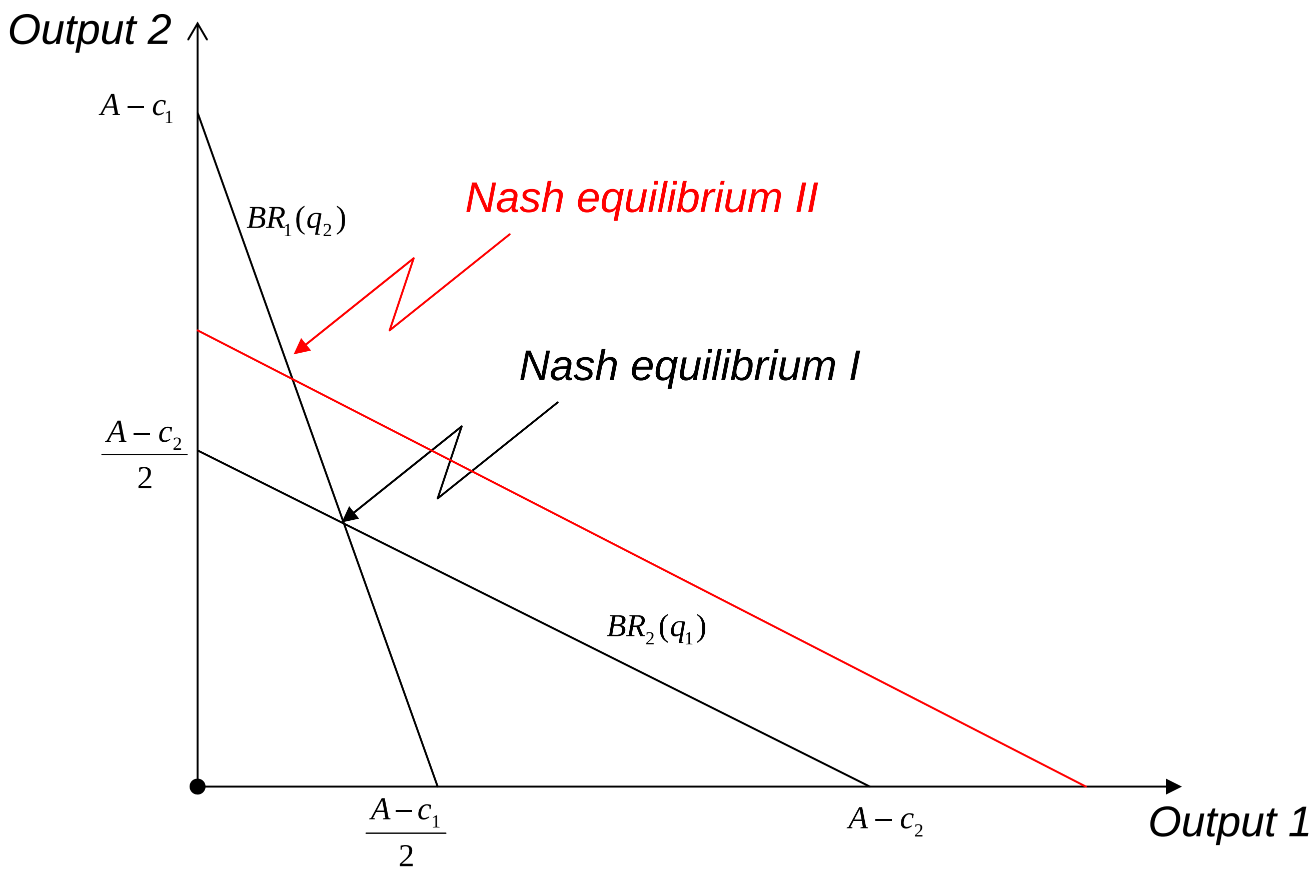
$$q_1^* = \frac{A+c_2-2c_1}{3} \quad \text{and} \quad q_2^* = \frac{A+c_1-2c_2}{3}$$

which is the solution to the two equations above.

The best response functions in the Cournot's duopoly game



Nash equilibrium comparative statics
(a decrease in the cost of firm 2)



A question: what happens when consumers are willing to pay more (*A* increases)?

In summary, this simple Cournot's duopoly game has a unique Nash equilibrium.

Two economically important properties of the Nash equilibrium are (to economic regulatory agencies):

[1] The relation between the firms' equilibrium profits and the profit they could make if they act collusively.

[2] The relation between the equilibrium profits and the number of firms.

[1] Collusive outcomes: in the Cournot's duopoly game, there is a pair of outputs at which *both* firms' profits exceed their levels in a Nash equilibrium.

[2] Competition: The price at the Nash equilibrium if the two firms have the *same* unit cost $c_1 = c_2 = c$ is given by

$$\begin{aligned} P^* &= A - q_1^* - q_2^* \\ &= \frac{1}{3}(A + 2c) \end{aligned}$$

which is above the unit cost c. But as the number of firm increases, the equilibrium price deceases, approaching c (zero profits!).

Stackelberg's duopoly model (1934)

How do the conclusions of the Cournot's duopoly game change when the firms move sequentially? Is a firm better off moving before or after the other firm?

Suppose that $c_1 = c_2 = c$ and that firm 1 moves at the start of the game. We may use backward induction to find the subgame perfect equilibrium.

– First, for *any* output q_1 of firm 1, we find the output q_2 of firm 2 that maximizes its profit. Next, we find the output q_1 of firm 1 that maximizes its profit, *given the strategy* of firm 2.

Firm 2

Since firm 2 moves after firm 1, a strategy of firm 2 is a *function* that associate an output q_2 for firm 2 for each possible output q_1 of firm 1.

We found that under the assumptions of the Cournot's duopoly game Firm 2 has a unique best response to each output q_1 of firm 1, given by

$$q_2 = \frac{1}{2}(A - q_1 - c)$$

(Recall that $c_1 = c_2 = c$).

Firm 1

Firm 1's strategy is the output q_1 the maximizes

$$\pi_1 = (A - q_1 - q_2 - c)q_1 \quad \text{subject to} \quad q_2 = \tfrac{1}{2}(A - q_1 - c)$$

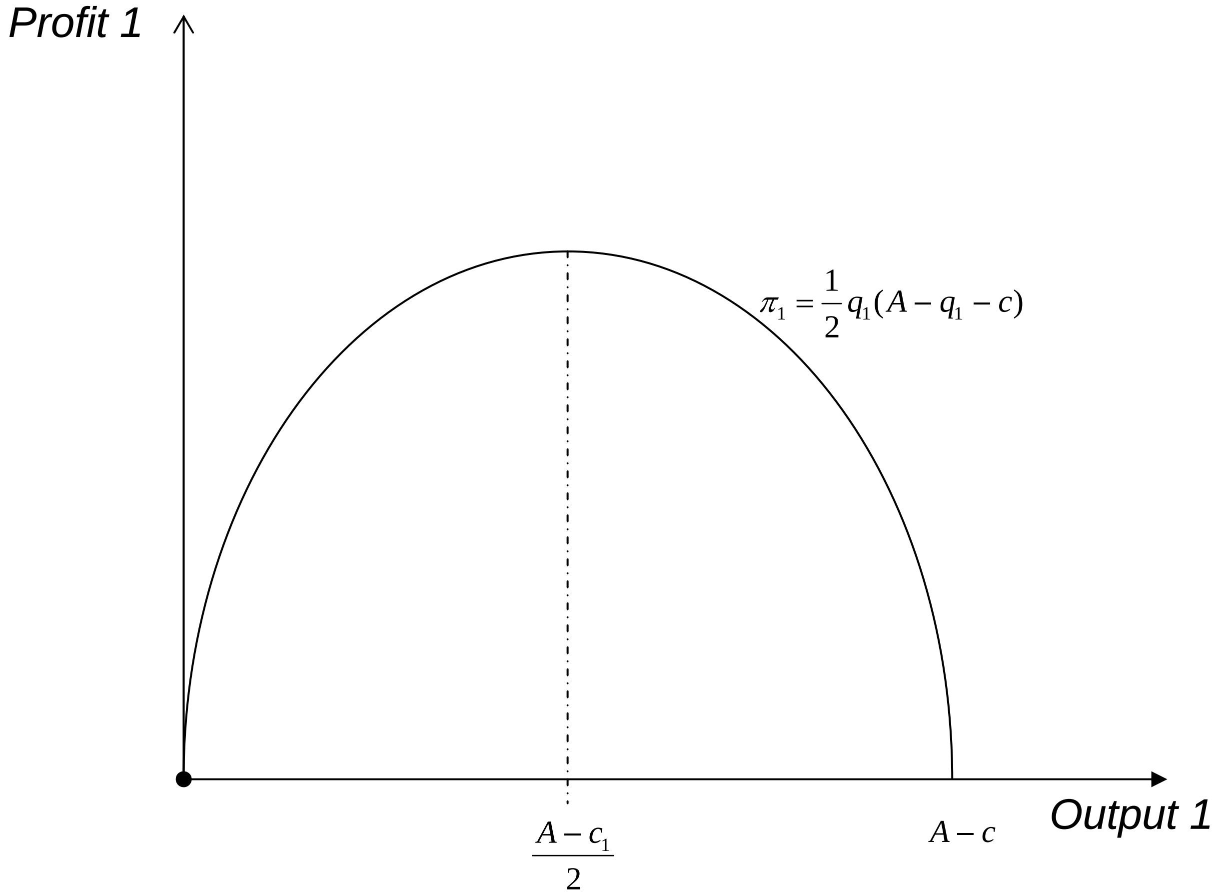
Thus, firm 1 maximizes

$$\pi_1 = (A - q_1 - (\frac{1}{2}(A - q_1 - c)) - c)q_1 = \frac{1}{2}q_1(A - q_1 - c).$$

This function is quadratic in q_1 that is zero when $q_1 = 0$ and when $q_1 = A - c$. Thus its maximizer is

$$q_1^* = \frac{1}{2}(A - c).$$

Firm 1’s (first-mover) profit in Stackelberg's duopoly game



We conclude that Stackelberg's duopoly game has a unique subgame perfect equilibrium, in which firm 1's strategy is the output

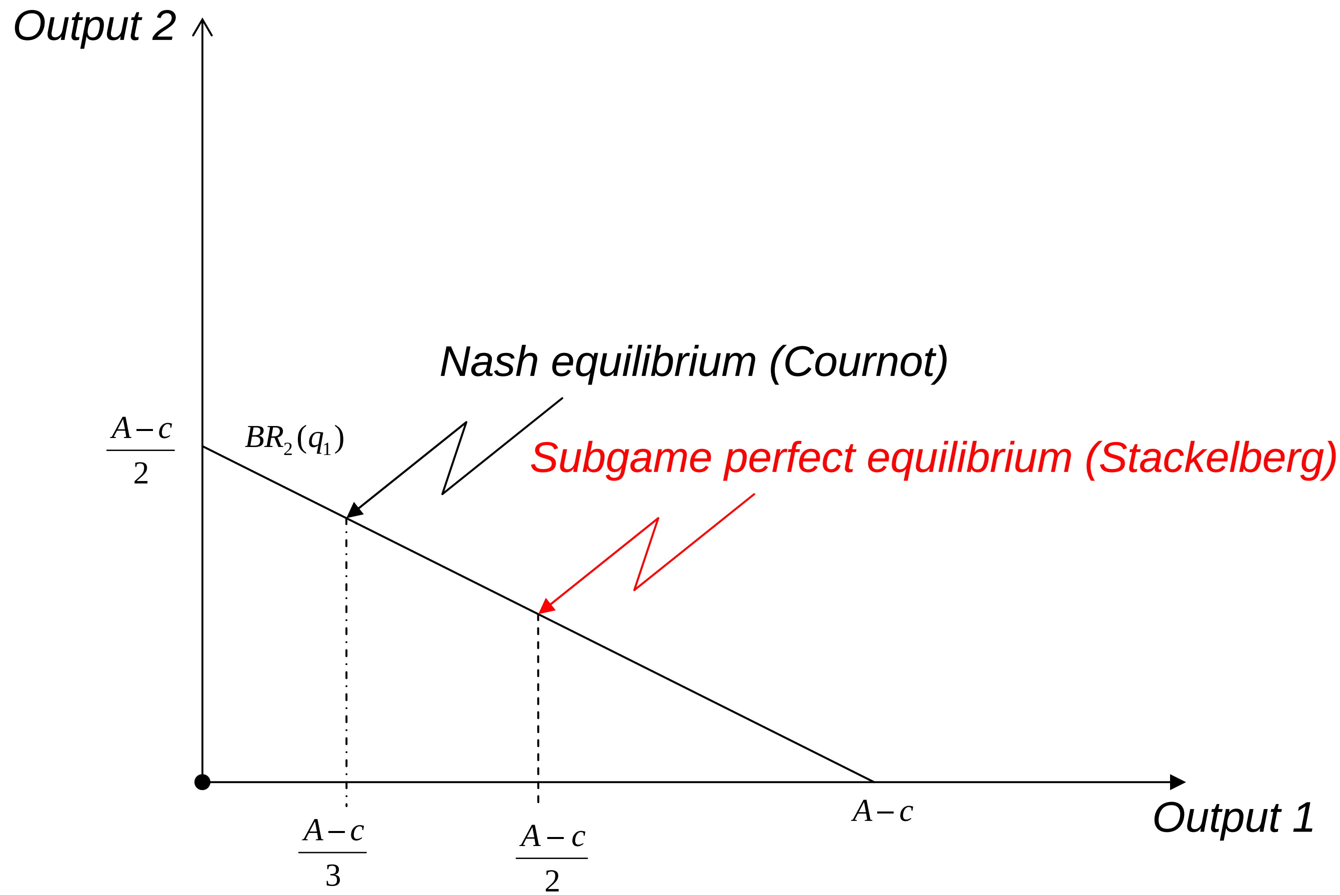
$$q_1^* = \frac{1}{2}(A - c)$$

and firm 2's output is

$$\begin{aligned} q_2^* &= \frac{1}{2}(A - q_1^* - c) \\ &= \frac{1}{2}(A - \frac{1}{2}(A - c) - c) \\ &= \frac{1}{4}(A - c). \end{aligned}$$

By contrast, in the unique Nash equilibrium of the Cournot's duopoly game under the same assumptions ($c_1 = c_2 = c$), each firm produces $\frac{1}{3}(A - c)$.

The subgame perfect equilibrium of Stackelberg's duopoly game



Bertrand's oligopoly model (1883)

In Cournot's game, each firm chooses an output, and the price is determined by the market demand in relation to the total output produced.

An alternative model, suggested by Bertrand, assumes that each firm chooses a price, and produces enough output to meet the demand it faces, given the prices chosen by *all* the firms.

$\Longrightarrow$ As we shell see, some of the answers it gives are different from the answers of Cournot.

Suppose again that there are two firms (the industry is a "duopoly") and that the cost for firm $i = 1, 2$ for producing q_i units of the good is given by cq_i (equal constant "unit cost").

Assume that the demand function (rather than the inverse demand function as we did for the Cournot's game) is

$$D(p) = A - p$$

for $A \geq p$ and zero otherwise, and that $A > c$ (the demand function in PR 12.3 is different).

Because the cost of producing each until is the same, equal to c, firm i makes the profit of $p_i - c$ on every unit it sells. Thus its profit is

$$\pi_i = \begin{cases} (p_i - c)(A - p_i) & \text{if} \quad p_i < p_j \\ \frac{1}{2}(p_i - c)(A - p_i) & \text{if} \quad p_i = p_j \\ 0 & \text{if} \quad p_i > p_j \end{cases}$$

where j is the other firm.

In Bertrand's game we can easily argue as follows: $(p_1, p_2) = (c, c)$ is the unique Nash equilibrium.

Using intuition,

- If one firm charges the price c, then the other firm can do no better than charge the price c.

- If $p_1 > c$ and $p_2 > c$, then each firm i can increase its profit by lowering its price p_i slightly below p_j.

$\Longrightarrow$ In Cournot's game, the market price decreases toward c as the number of firms increases, whereas in Bertrand's game it is c (so profits are zero) even if there are only two firms (but the price remains c when the number of firm increases).

Avoiding the Bertrand trap

If you are in a situation satisfying the following assumptions, then you will end up in a Bertrand trap (zero profits):

[1] Homogenous products

[2] Consumers know all firm prices

[3] No switching costs

[4] No cost advantages

[5] No capacity constraints

[6] No future considerations

Problem set V

PR 11 – exercises 4, 5, 7 and 8.

PR 12 – exercises 3-7.