Lecture 2 – Natural monopoly regulation

outline

- Natural monopoly
  - Definitions: economies of scale, economies of scope, subadditivity
  - Regulation
    - Optimal solutions:
      - Linear and nonlinear pricing
      - Ramsey pricing
    - Regulation in practice:
      - Rate of return regulation
      - price caps

outline

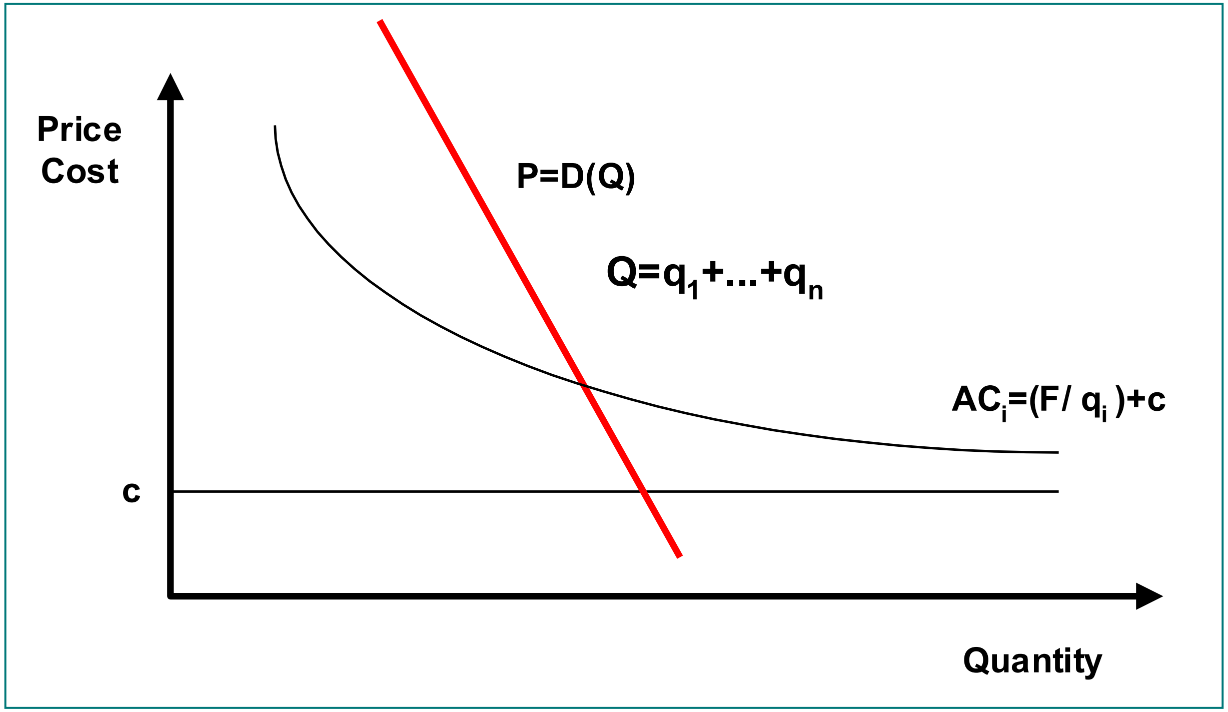
References

- Natural monopoly:
  - VVH, ch. 11
  - Baumol W. J. and D. F. Bradford, 1970, "Optimal Departures from Marginal Cost Pricing," *American Economic Review*, Vol. 60, No. 3, pp. 265-83
  - Ramsey, 1927, "A Contribution to the Theory of Taxation," *Economic Journal*, Vol. 37, No. 1, pp. 47-61

Natural monopoly

typical example

Let $C(q_i) = F + cq_i$. Then $AC_i = (F/q_i) + c$ is decreasing.



Natural monopoly

definition

- Cost or technology-based definition: An industry is a natural monopoly (NM) if the production of a particular good or service (or all combinations of outputs, in the multiple-output case) by a single firm minimizes cost
  - NM has been simply defined as existing when the AC curve is everywhere downward-sloping relative to market demand (**economies of scale**);
  - Baumol et al. (1970) introduced formally the notion of subadditive costs; a NM occurs when the cost function is subadditive.

- Tirole's definition does not depend solely on costs: a NM arises when market equilibrium yields a single firm.

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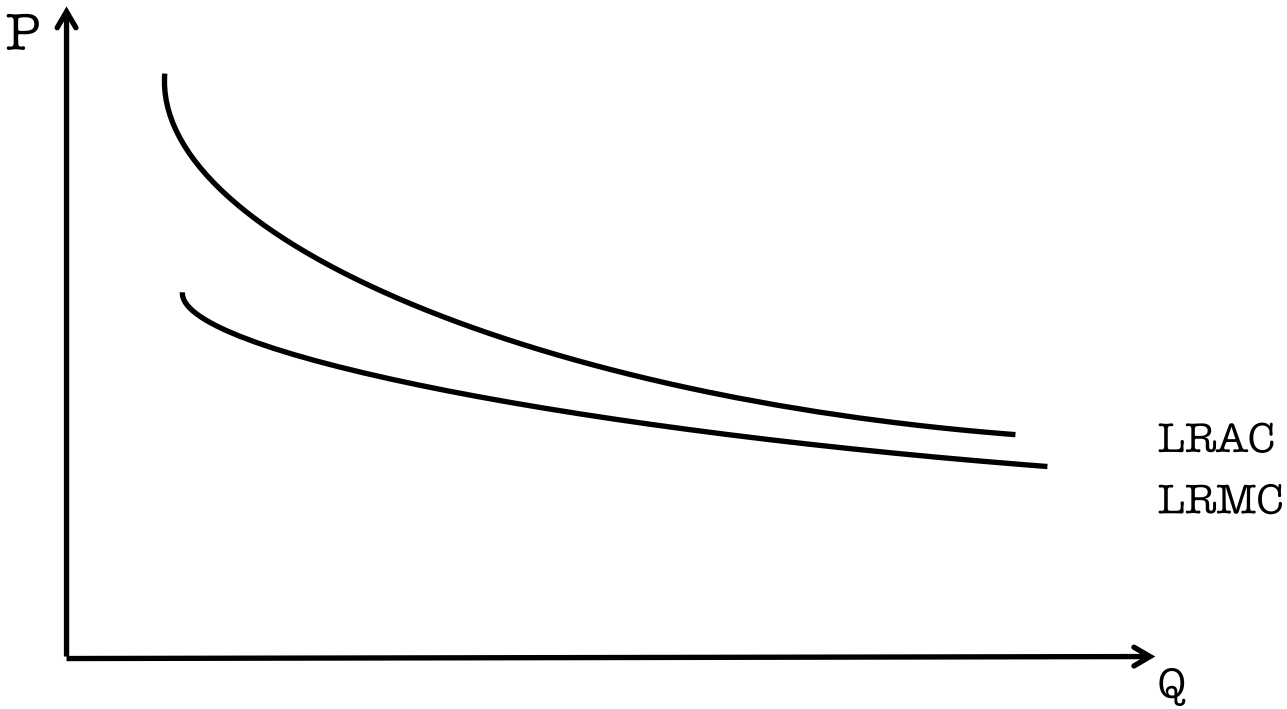
Economies of scale

- Definition: decreasing long run average cost as output increases.

- Why:
  - Existence of substantial fixed costs;
  - Opportunities for specialization in the deployment of resources;
  - Strong market position in factor inputs.

Economies of scale

single-product case



Economies of scale

multiproduct case

Definitions (Baumol, Panzar, Willig, 1982):

2–product case

1. Decreasing AC along a ray:

$$C(tq_1,tq_2) < tC(q_1,q_2),\, t > 1.$$

2. Decreasing average incremental cost:

$$\frac{|C(q_1,q_2) - C(0,q_2)|}{q_1}$$ decreasing with q_1.

3. Convex cost function along a transversal ray:

$$C(tq_1,(1-t)q_2) < C(tq_1,0) + C(0,(1-t)q_2),\, 0 < t < 1.$$

(Similar to economies of scope: it is cheaper to produce a convex combination of two goods in the same firm)

Subadditivity
definition

- In a market with k firms, where firm i has a cost function $C(q_i)$ and total output is Q, firms' cost functions are said to be subadditive at output level Q when:

$$C(Q) < C(q_1) + C(q_2) + ... + C(q_k)$$

- If this occurs for all values of Q, consistent with demand Q = D(p), then the cost function is said to be globally subadditive.

Subadditivity and economies of scale

single-product case

- In the single-product case, economies of scale up to Q is a sufficient* but not a necessary condition for subadditivity over this range or, by the cost-based definition, for NM.

- In fact, it may still be less costly for output to be produced in a single firm rather than multiple firms even if output of a single firm has expanded beyond the point where there are economies of scale.

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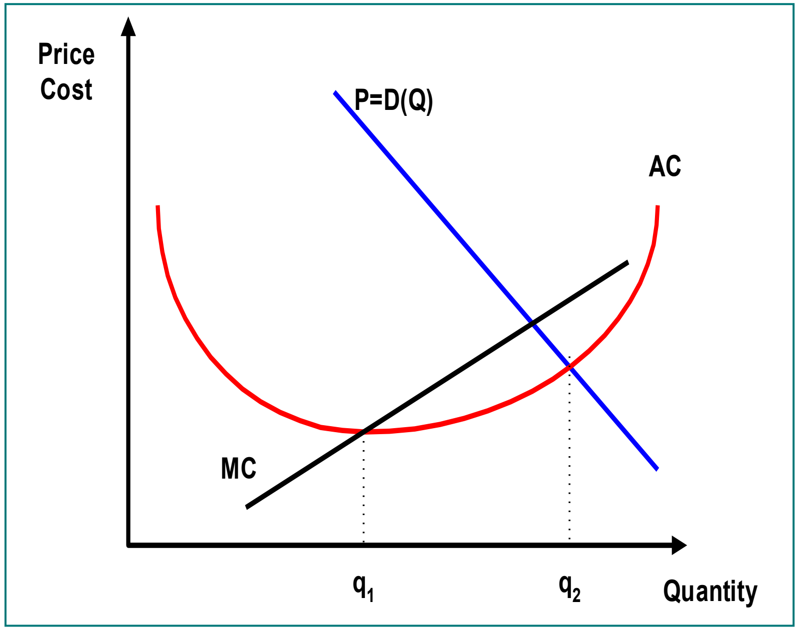
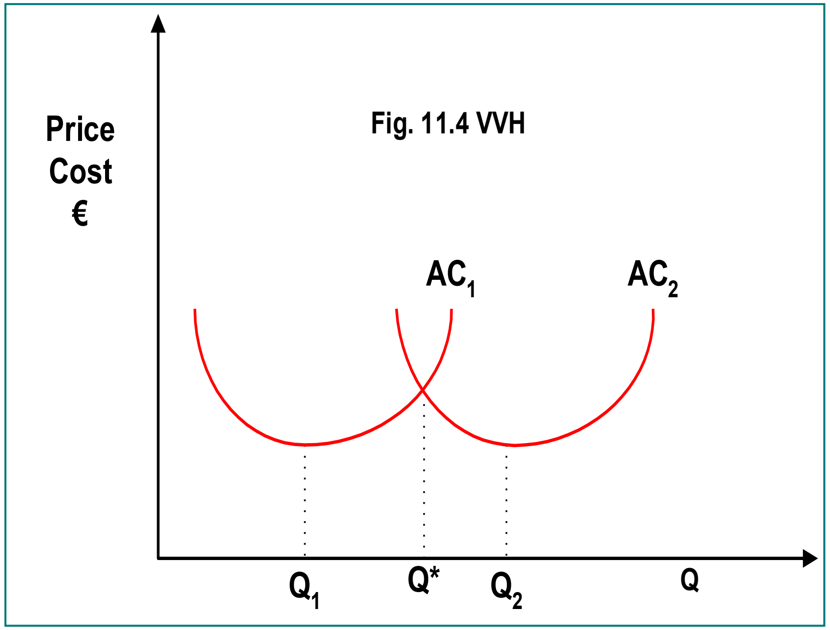
Subadditivity and economies of scale

One firm



Two firms



Economies of scale

Subadditivity

Economies of scope

- Most NM (public utilities) produce more than one product and there is interdependence among outputs.

- Economies of scope exist when it is cheaper to produce two products together (joint production) than to produce them separately:

$$C(q_1, q_2) < C(q_1, 0) + C(0, q_2).$$

- Example

- Sources:
  - shared inputs;
  - shared advertising creating a brand name;
  - cost complementarities (producing one good reduces the cost of producing another).

Subadditivity and economies of scope

multiproduct case

- Economies of scope is a necessary but not sufficient condition for subadditivity.

- In the multiproduct case, the existence of (product-specific) economies of scale in the production of any one product is neither necessary nor sufficient for subadditivity (because of economies of scope); example.

- Sufficient conditions for subadditivity:
  - Economies of scope + declining average incremental cost for all products;
  - Convexity along a transversal ray + decreasing AC along a ray.

Natural monopoly

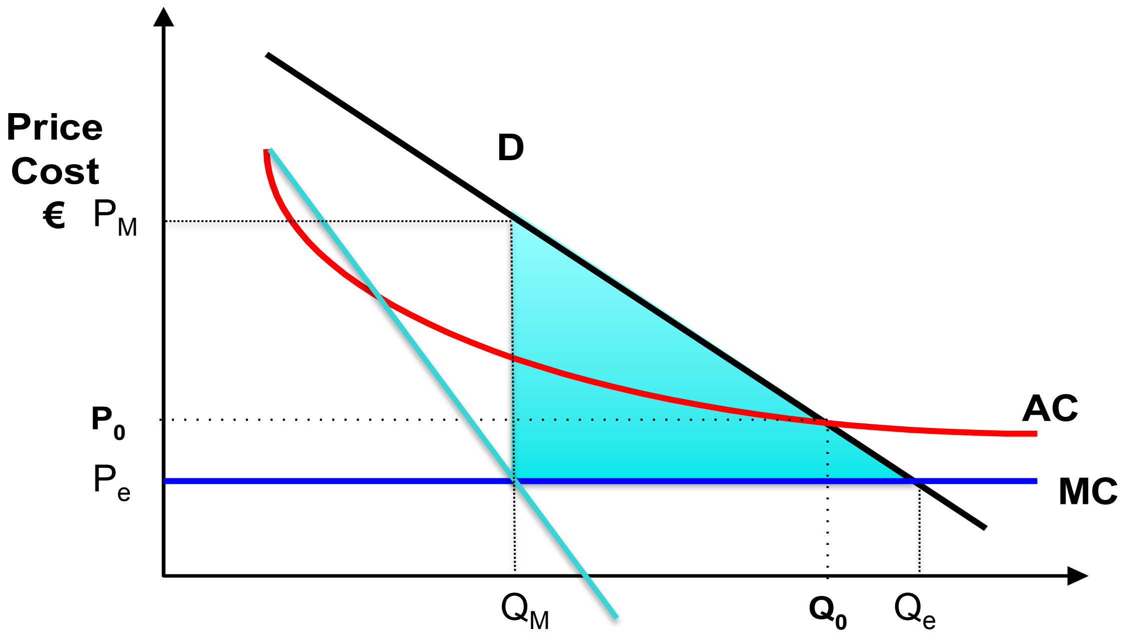
conflict: productive eff. *vs*. allocative eff.

- Is a NM productive-efficient?
    - Usually yes, but not always: Productive efficiency requires cost to be minimized.

- Is a NM allocative-efficient?
    - No: A monopolist generates a deadweight loss by restricting output below the competitive level, since $P_M > MC$.

Natural monopoly
efficiency

1. (Qe, Pe) first-best: P = MC
2. (QO, PO) second-best: P = AC



Natural monopoly

- Policy dilemma...
- Least-cost production requires a single-firm; but this leads to monopoly pricing – allocative inefficiency.
- Otherwise, competition results in productive inefficiency.

Natural monopoly

- Two-stage game
  - First stage: firms decide to enter (entry implies sunk cost of k)
  - Second stage: competition in prices
- Unique pure strategy equilibrium: a single firm enters and sets $P=P_M$ (earning monopoly profit – k)

Natural monopoly

solutions

- Doing nothing – why? Second-best obtained because of:
    - Contestable markets

Contestable markets

- Even if there a just a few firms in the market, there may be *potential* competition from firms who may enter the market

- This may lead to the second best pricing solution!

- Assumptions:
  - new firms have no disadvantage (input prices, technology, information,...);
  - no sunk costs;
  - entry lag is less than price adjustment lag.

Contestable markets

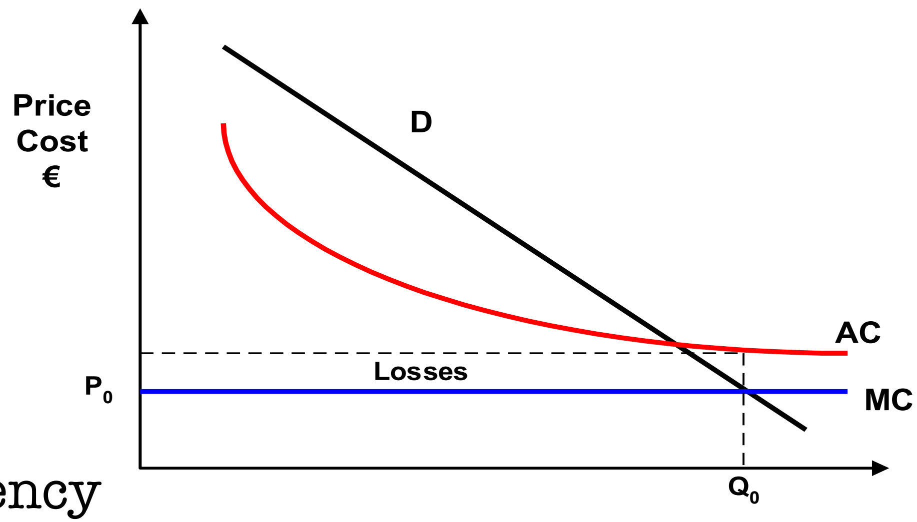
- Let there be N firms, of which *m* are producing
- The production vector is **admissible** iff there is market equilibrium and firms do not have losses
- The production vector is **sustainable** iff none of the N-*m* firms can enter the market with a lower price and have positive profit
- If a production vector is admissible + sustainable, then it is **contestable**

Natural monopoly
solutions

- Doing nothing – why? Second-best obtained because of:
  - Contestable markets
  - Auction bidding
  - Close substitutes for the product
- Regulation – *ideal* pricing solutions
  - Linear pricing
    - Marginal cost pricing
    - Average cost pricing
  - Non linear pricing or multipart tariff
  - Ramsey pricing (multiproduct case)

Marginal cost pricing

Efficient MC price: $P_0 = C'(Q(P_0))$



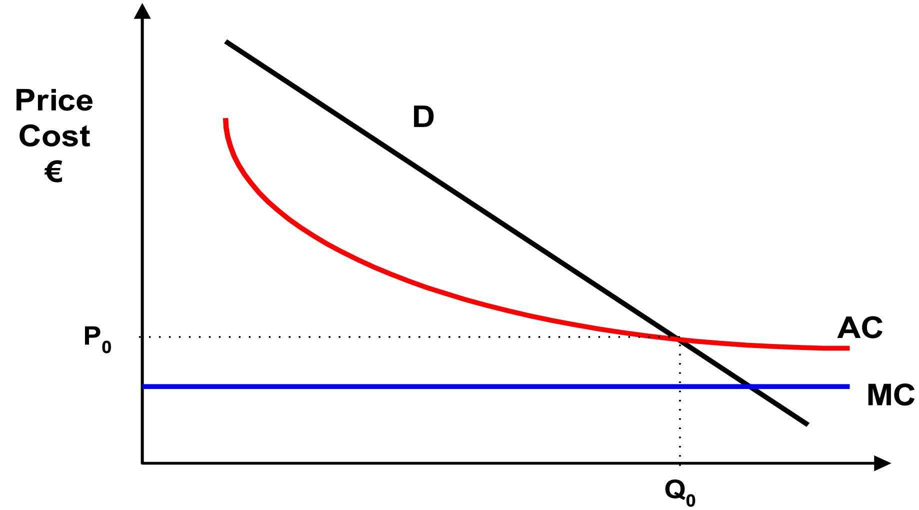
Advantage: allocative efficiency

Problems:

- information needed
- weak incentives to reduce costs
- NM is not able to break-even when economies of scale exist; use subsidy? This would imply raising funds (distortion) and the producer would know revenue gap would always be funded! Moreover, we may have CS < TC

Average cost pricing

Efficient AC price: $P_0 = C(Q(P_0))/Q(P_0)$



Advantage: maximizes total welfare s.t. break-even constraint

Problems:

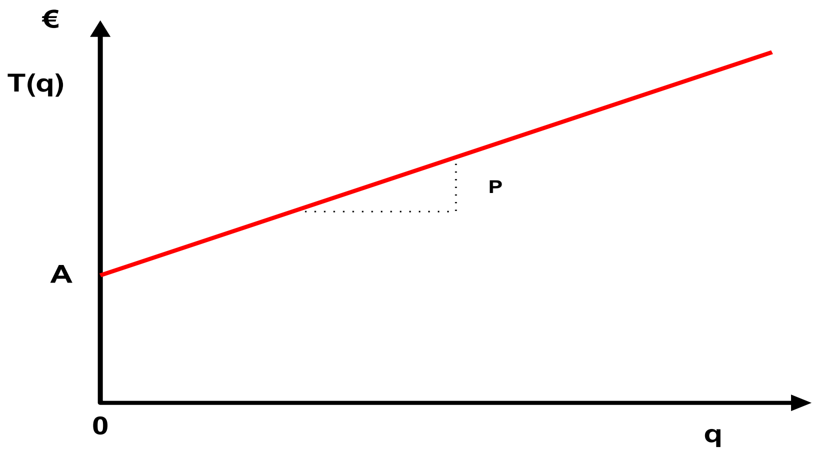
- information needed
- failure of allocative efficiency: less quantity and higher price than in MC pricing case (Deadweight loss)
- weak incentives to reduce costs

Nonlinear pricing

two-part tariffs

- Two-part tariffs include a fixed fee, regardless of consumption, plus a marginal cost price per unit

  $T(q) = A + Pq$



- If P = c, we may have efficient pricing and TR = TC for appropriate A!
- Nonlinear pricing is more efficient than linear tariffs above MC

  Often used in the utility industries (telecom., gas, water, electricity)

Nonlinear pricing

two-part tariffs

- If C(q)= K + cq and consumers are homogeneous, then it would be optimal to set a two-part tariff with

$$A^* = K/N \text{ and } P^* = c$$

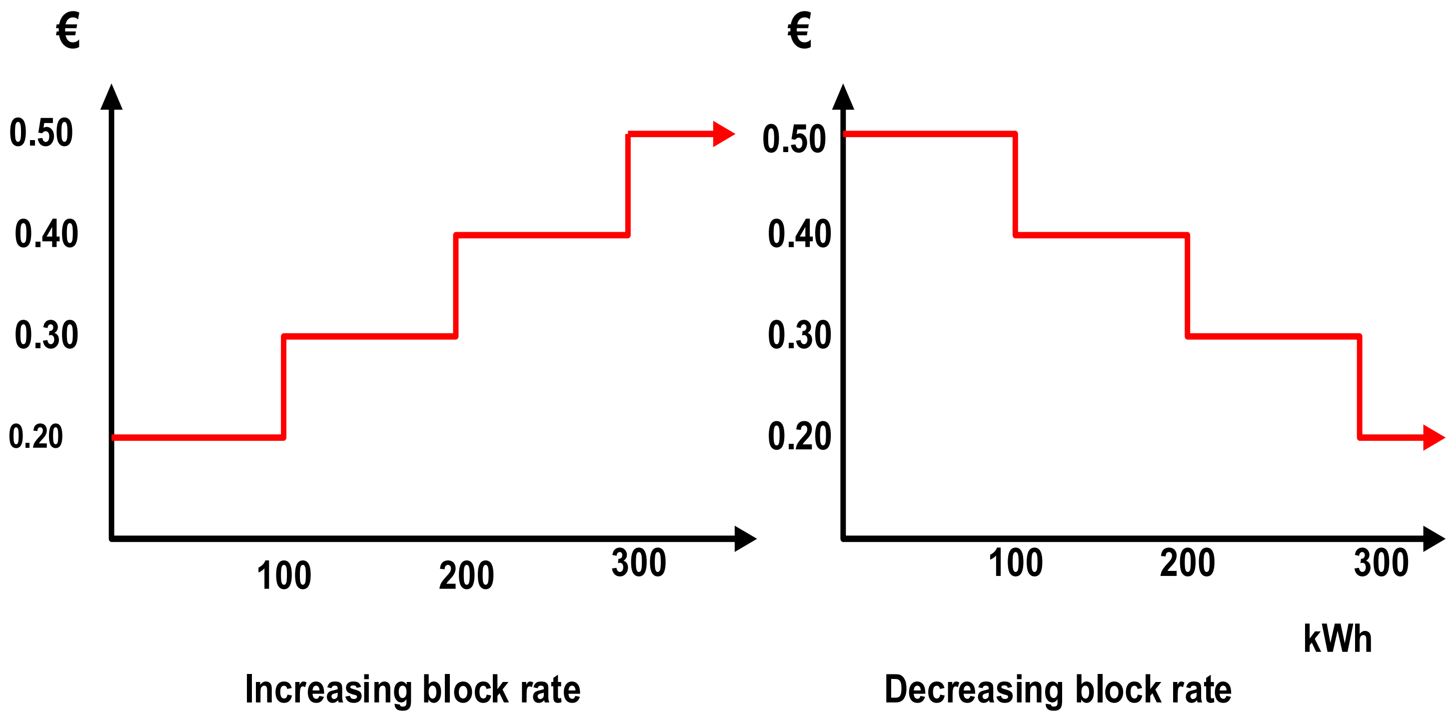
- But when consumers are heterogeneous, consumers with low willingness to pay drop out of the market if

$$K/N > CS(c)$$

- When consumers are hetereogeneous, welfare maximizing nonlinear tariffs will most likely involve the firm offering consumers discriminatory two-part tariffs:
  - Quantity discounts
  - Multipart tariffs

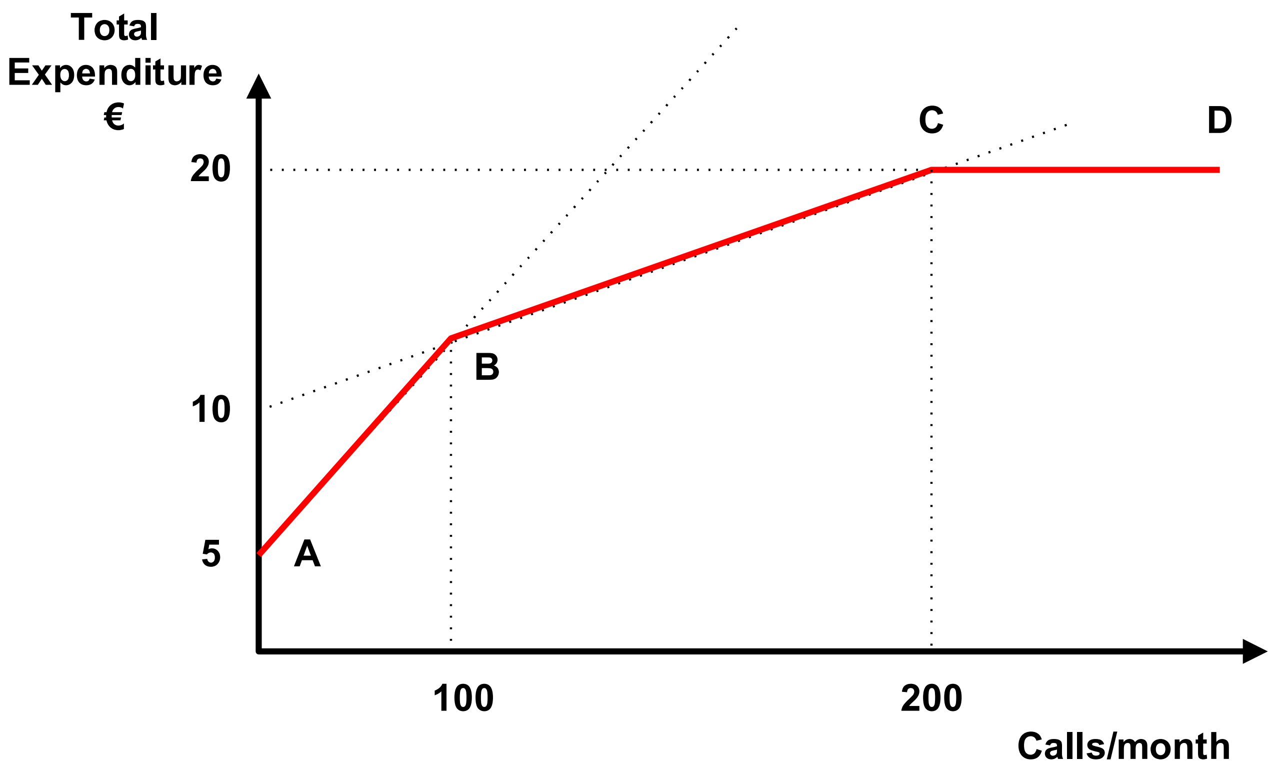
- As discrimination may be forbidden: Self-selecting tariffs

Nonlinear pricing
Increasing and declining block tariffs



Nonlinear pricing

Multi-part tariff or self-selecting two-part tariffs



Nonlinear pricing

optimal two-part tariff

- Trade-off:
  - Efficiency losses because of exclusion of additional consumers when A raises
  - Consumption losses as P increases above marginal cost.

- Start with A=0 and P=c: the loss must be compensated by higher A or P or both; balance efficiency losses (consumer exclusion) with consumption losses (reduction quantity).

- So, optimal two-part tariffs generally involve a P that exceeds MC (no allocative efficiency) and a fixed fee that excludes some consumers from the market (failure of universal service).

Multiproduct NM

- For a multiproduct natural monopolist, MC pricing leads to negative profits.

- But if price for each product exceeds MC it can cover this shortfall,

- By how much?

  - In the context of a multiproduct monopolist, each product would have a linear price, and the set of prices would minimize deadweight social losses subject to the zero profit constraint.

The Ramsey rule

- The Ramsey rule or Ramsey-Boiteux pricing applies to multiproduct NM that would obtain losses with MC pricing.
- Ramsey found the result before (1927) in the context of the theory of taxation. The rule was later applied by M. Boiteux (1956) to NM.
- Ramsey prices are linear prices that satisfy zero profit and maximize social welfare.

The Ramsey rule

- Assumptions:
  - natural monopoly
  - independent demands (0 cross-price elasticities)
  - linear demands.

- Ramsey-Boiteux pricing: the markup of each commodity is inversely proportional to the corresponding elasticity of demand (but it is smaller as the inverse elasticity of demand is multiplied by a constant lower than 1).

$$\frac{P_i - MC_i}{P_i} = \frac{\lambda}{\varepsilon_i}$$

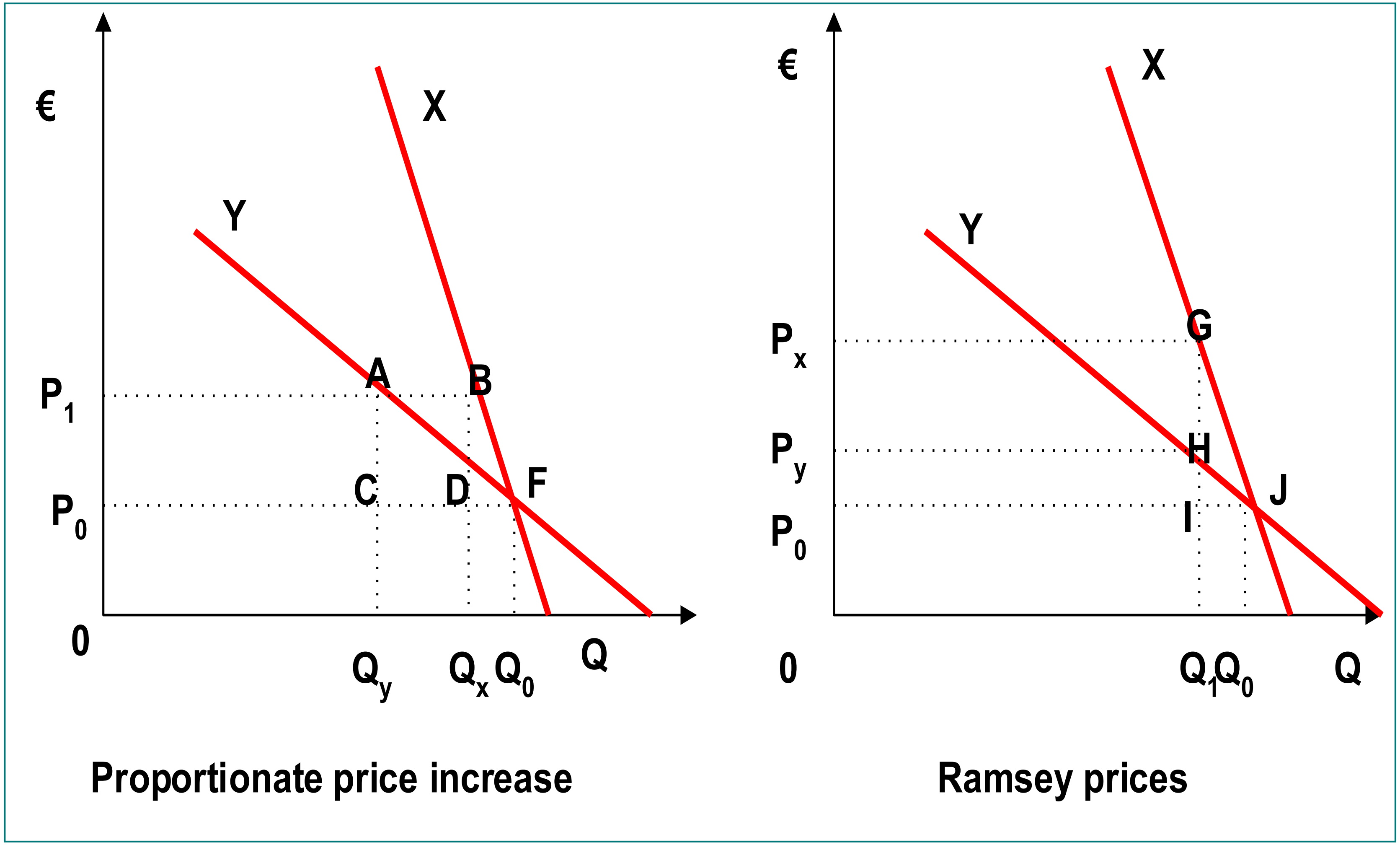
- The rule implies that the relative change in quantity is the same for all goods.

The Ramsey rule

example

- $C(X,Y) = 1800 + 20X + 20Y$
- Demands:
  - $Q_x = 100 - P_x$
  - $Q_y = 120 - 2P_y$
- MC pricing would imply $P_x = P_y = 20$; however, this implies losses.
- One way is to increase the two prices proportionally until 36.1; this leads to DWL of 130 + 260 = 390.
- An alternative is to raise the price of X (less elastic) more, so that the change in quantity is the same for the two products. We obtain $P_x = 40$ and $P_y = 30$.

The Ramsey rule



Examples

- Rail rates for shipping sand, potatoes or oranges are lower than those for liquor, cigarettes,... because elasticities of demand of shipping products that have low values per pound are higher.

- But, before 1984, even though the elasticity of long-distance calls was higher than for short-distance calls (0.5-2.5 vs. 0.05-0.2), AT&T priced short-distance calls way below long-distance! Profits in long-distance were used to subsidize losses on local service.