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

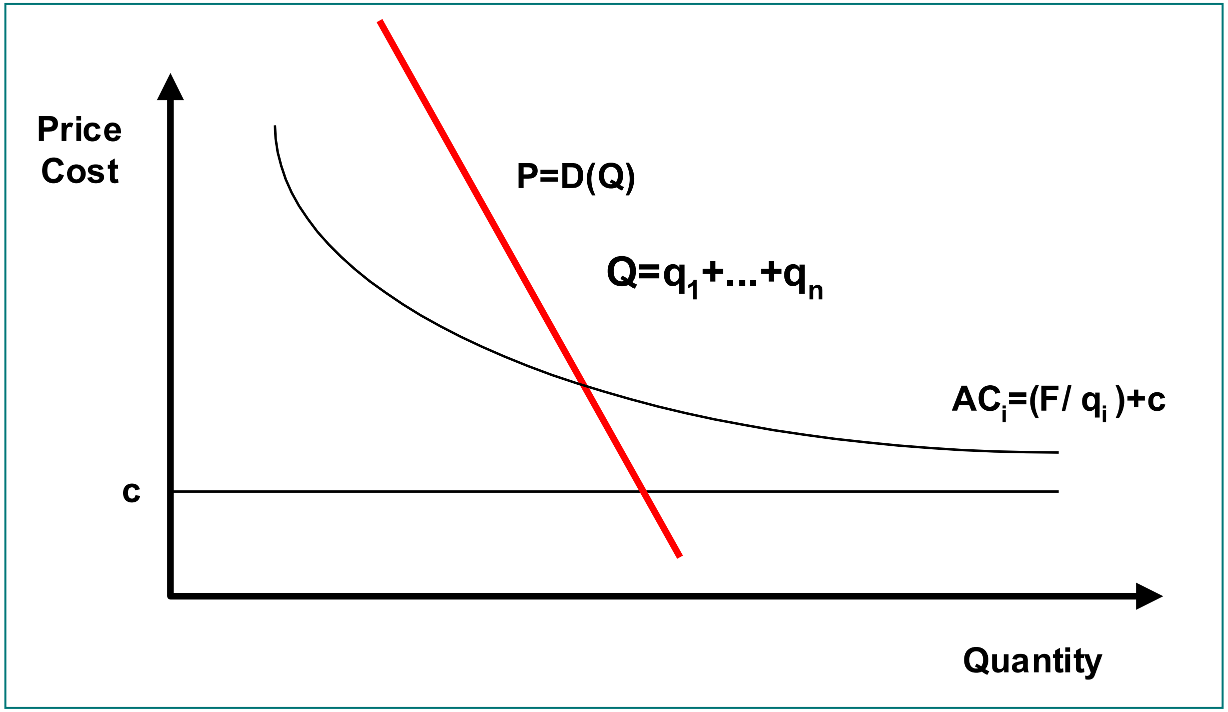
References

- Natural monopoly:
    - VHM, 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 (NM)

definition

- (cost-based or technology 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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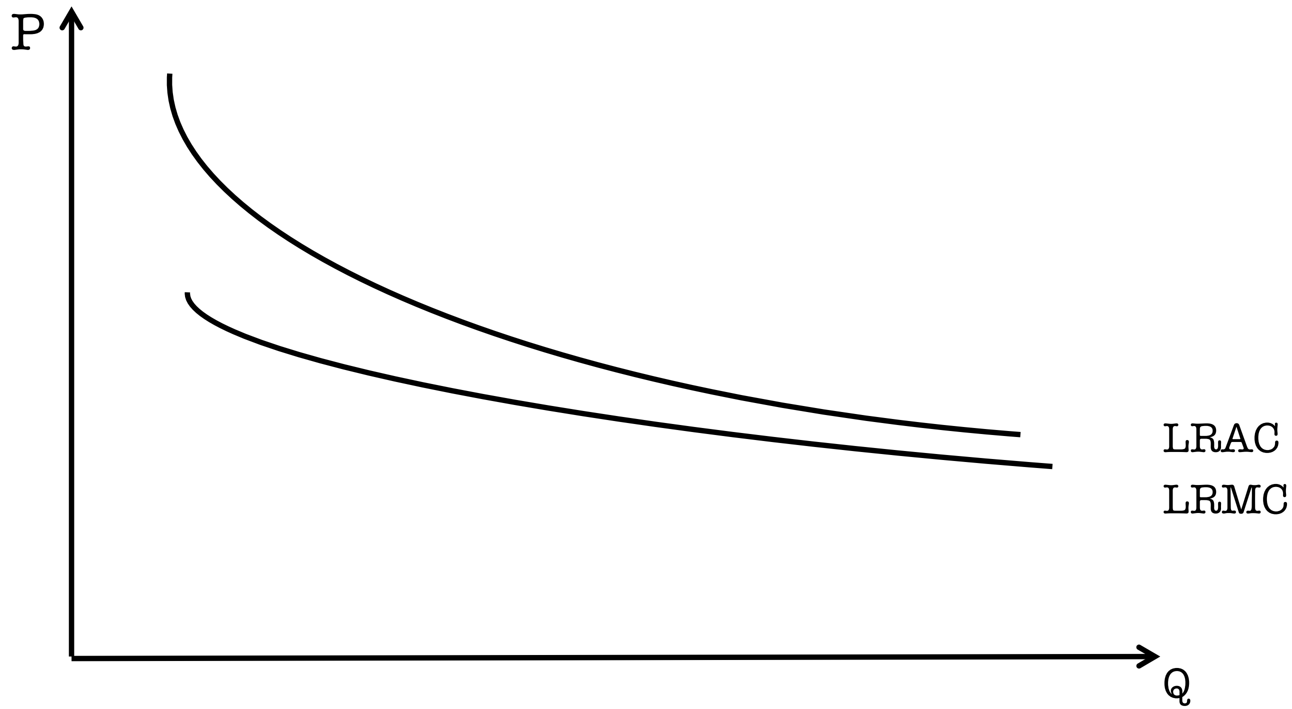
Economies of scale

- Definition: decreasing average long run 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



Economies of scale

with multiple outputs

Definitions (Baumol, Panzar, Willig):

1. Decreasing AC along a ray:

   $$C(tQ) < tC(Q),\ t > 1$$

2. Decreasing average incremental cost:

   $|C(q1,q2) - C(0,q2)|/q1$ decreasing with $q1$

3. Convex cost function along a transversal ray:

   $$C(tq1,(1-t)q2) < C(tq1) + C((1-t)q2)$$

   (similar to economies of scope – it's 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:

$$C(Q) < C(q_1) + C(q_2) + \ldots + C(q_k)$$

- 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_i=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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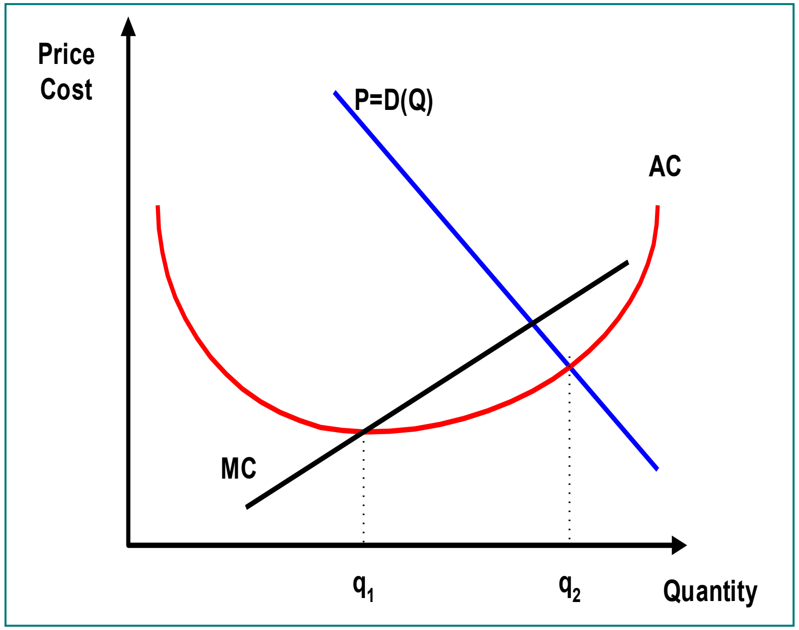
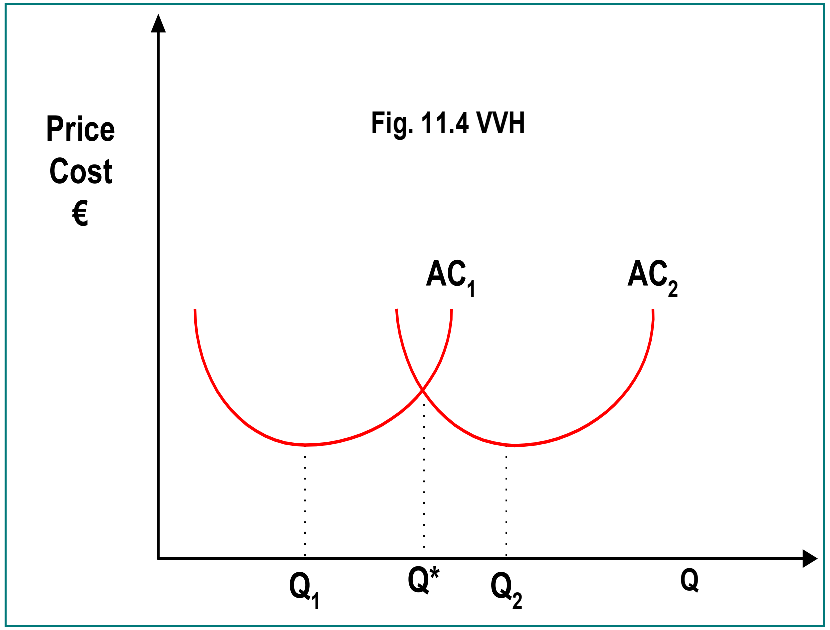
Subadditivity and economies of scale

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:

$$C(Q_1,Q_2) < C(Q_1,0) + C(0,Q_2)$$

- 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)

- Sufficient conditions for subadditivity:
  - economies of scope + declining average incremental cost for all products
  - Decreasing AC along a ray + convexity along a transversal ray

Natural monopoly

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

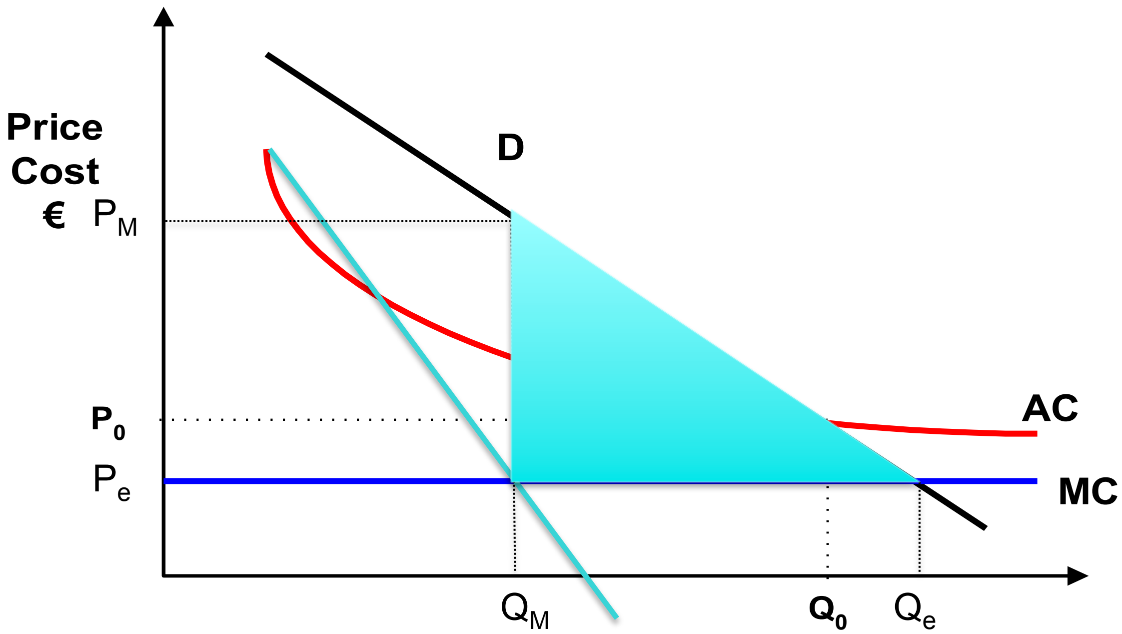
- Is a NM productive-efficient?
  - Usually yes, but not always: Productive efficiency requires cost to be minimized

- 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!

Contestable markets

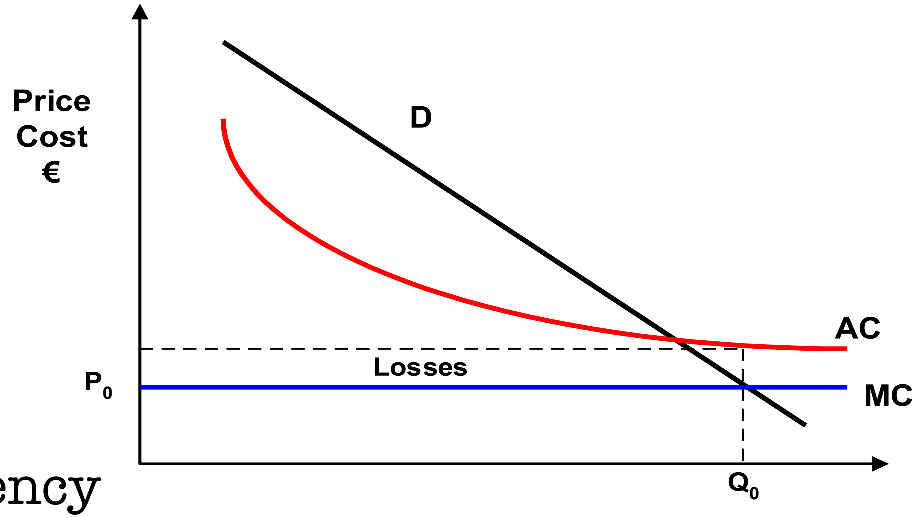
- Let there be N firms, of which *m* are producing
- The production vector is **admissible** iff there is market equilibrium and firms do not have losses
- The production vector is **sustainable** iff none of the N-*m* firms can enter the market with a lower price and have positive profit
- If a production vector is admissible + sustainable, then it's **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: $P_0 = C'(Q(P_0))$



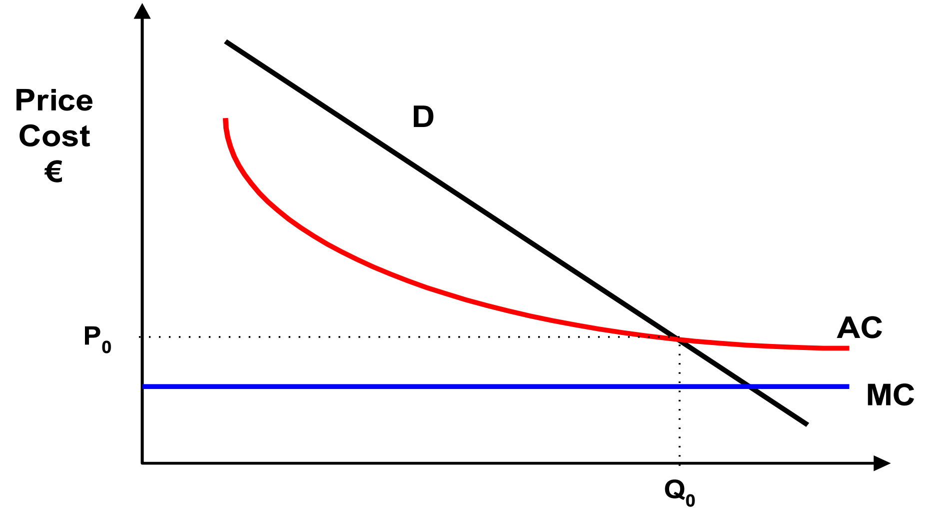
Advantage: allocative efficiency

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:

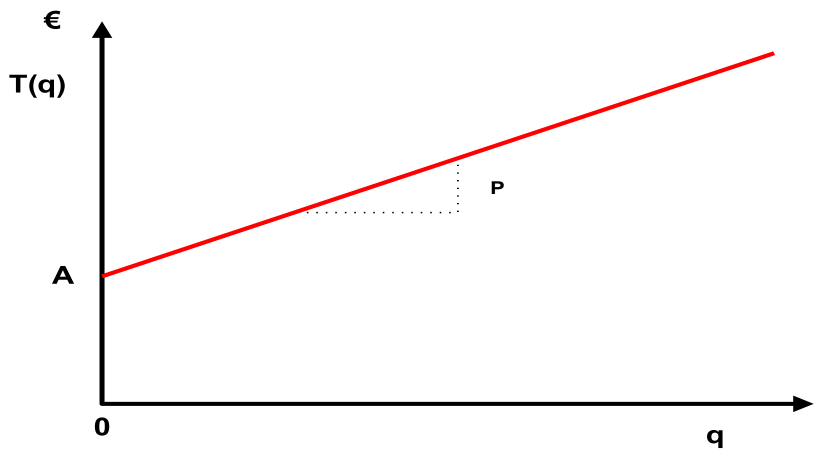
- information needed
- failure of allocative efficiency: less quantity and higher price than in MC pricing case (Deadweight loss)
- weak incentives to reduce costs

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

  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

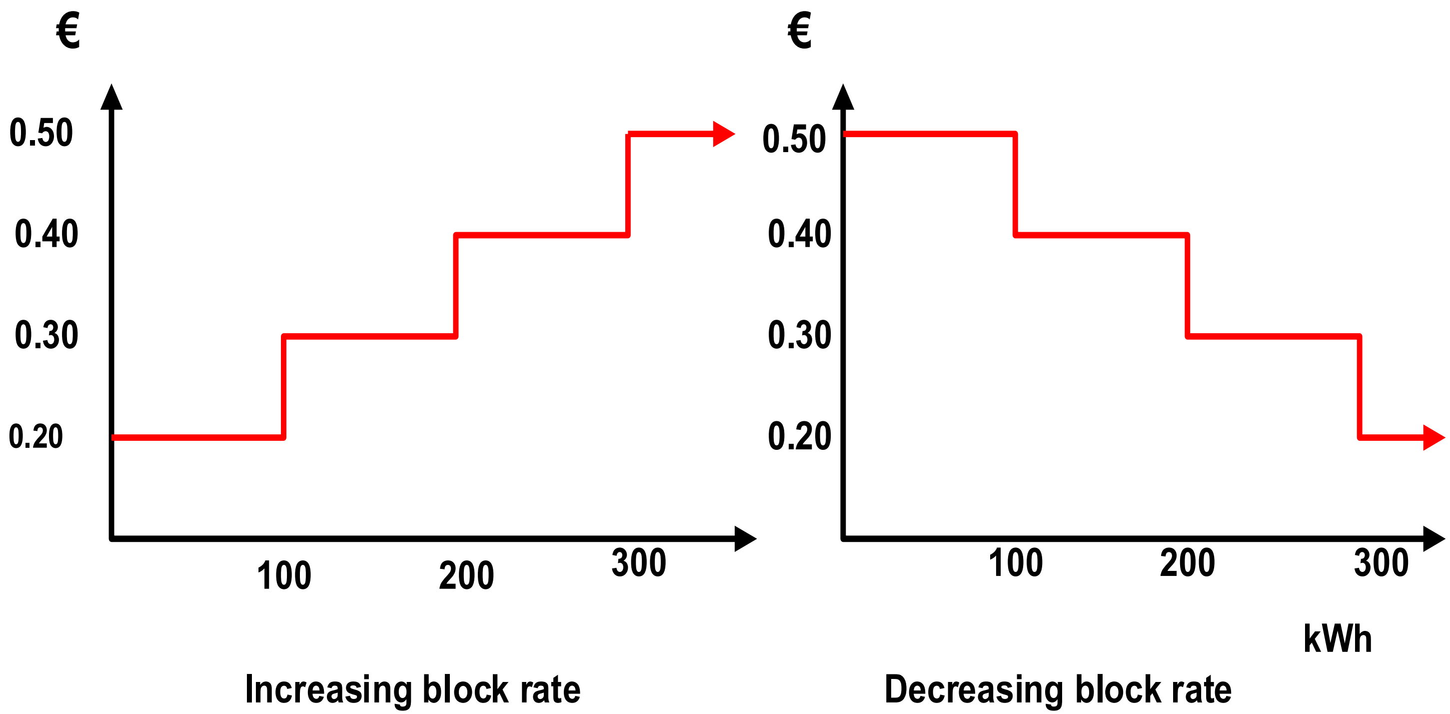
$$K/N>CS(c)$$

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

  (but discrimination may be forbidden….)

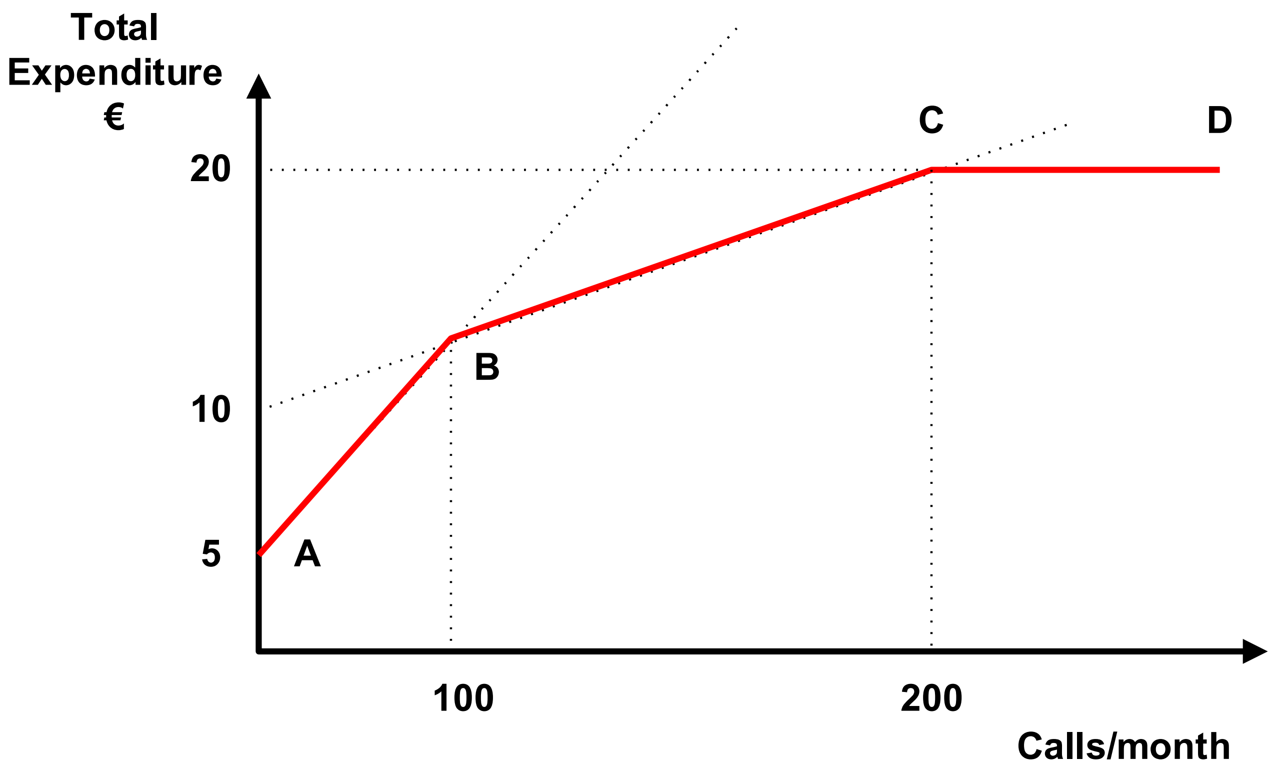
Nonlinear pricing

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))

- 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 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)

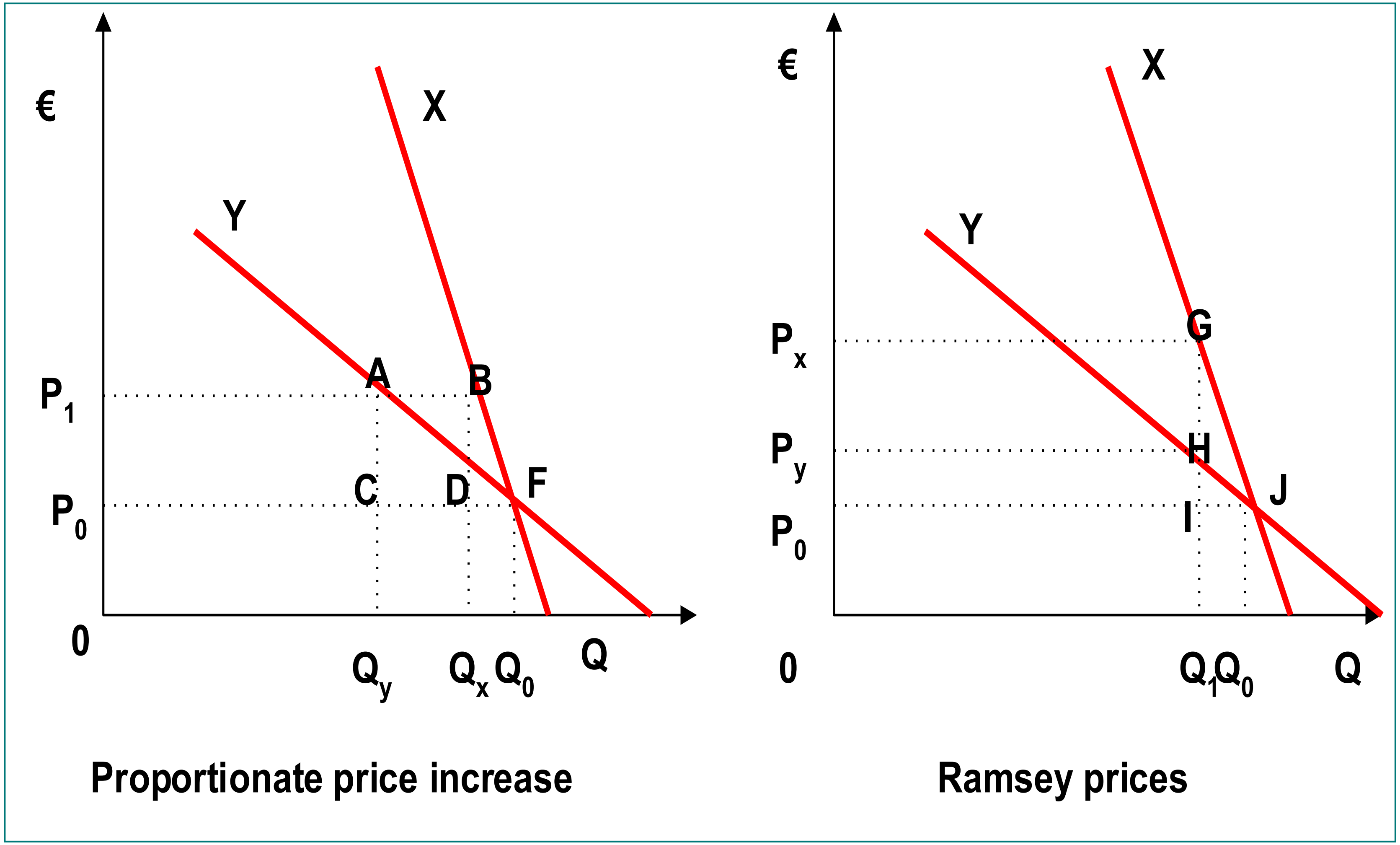
$$\frac{P_i - MC_i}{P_i} = \frac{\lambda}{\varepsilon_i}$$

- 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

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