LISBOA SCHOOL OF ECONOMICS & MANAGEMENT

ISEG SINCE 1911

lecture 3: natural monopoly – regulation in practice

outline

- Natural monopoly
  - Pricing solutions
    - Rate of return regulation
    - Incentive regulation:
      - Earnings sharing
      - Price caps
      - Yardstick regulation
  - Rate structure:
    - discrimination
    - peak-load pricing

outline

References

- VVH, ch. 12
- 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

the story so far

Natural monopoly:

- Definitions
- Pricing solutions
  - Linear:
    - MC pricing
    - AC pricing
  - Non-linear: two-part or multiple-part tariffs
  - Ramsey prices (for multiproduct NM)

Rate of return (or cost-of-service) regulation (ROR)

rationale

- Traditional method to regulate NM

- The underlying idea is that the monopoly's revenues must just equal its costs, so that economic profit is zero (no efficiency concern)

- The following equation describes this process:

$$R = E + sB ,$$

where: R-allowed revenue; E-expenses; s is the regulated rate of return (allowed cost of capital) and B is the regulatory asset base (or rate base)

Rate of return regulation (ROR)

problems and process

- Regulator's tasks:
  - Deciding on allowable profit, ie, finding s (rate level)
  - Finding B (rate base)
  - Selecting prices (rate structure) to discriminate among consumers or products ($R = \sum_{i=1}^{n} p_i q_i$)

Rate of return regulation (ROR)

setting s

- Aim: set s at the lowest level consistent with the firm's financial viability and existence of future investment*

- Process:

  - Firms usually apply for rate increases, initiating a rate hearing or rate case
  - Consumers and regulator may initiate hearing to reduce s
  - At a rate hearing, the firm presents financial exhibits (usually for the last accounting period) to show that s is too low

Rate of return regulation (ROR)

process – financial exhibits

- Monopoly company submits detailed cost breakdown of the regulated activities:

  TOTEX (Total Costs) =CAPEX (Capital expenditures)+ OPEX (Operating and maintenance expenditures)

Rate of return regulation (ROR)

setting s

- Aim: set s at the lowest level consistent with the firm's financial viability and existence of future investment*

- Process:
  - Firms usually apply for rate increases, initiating a rate hearing or rate case
  - Consumers and regulator may initiate hearing to reduce s
  - At a rate hearing, the firm presents financial exhibits (usually for the last accounting period) to show that s is too low
  - s is selected and prices are adjusted (D elasticities have to be known)
  - In principle firms can decide about their price structures (as long as s is not exceeded)
  - Prices unchanged until next rate case

Rate of return regulation (ROR)

setting s

- Since prices are unchanged until next rate case, firms have incentives to be production-efficient!

- So, incentives for efficiency are due to the regulatory lag!

Example

North Carolina Natural Gas Corporation Statement

	Year Ended Dec. 31, 19xx	Adjustments for Rate Increase	After Adjustments for Rate Increase
Revenues	$29,572,747	$2,832,332	$32,405,079
Expenses			
(1) Purchased gas	$19,411,430		$19,411,430
(2) Labor	2,968,387		2,968,387
(3) Depreciation	1,234,798		1,234,798
(4) Taxes	4,338,300	358,500	4,696,800
Total expenses	27,952,915	358,500	28,311,415
(5) *Net Operating Income*	1,619,832		4,093,664
Rate Base			
Plant less depreciation	41,871,387		41,871,387
Working capital	1,002,989		1,002,989
(6) Total	42,874,376		42,874,376
(7) Rate of return [(5)/(6)]	3.77%		9.54%

Rate of return regulation (ROR)

finding B

- Ideally prices should depend on (current) MC

- Approaches:

1. original value: original asset cost – depreciation
   - Problem: inflation

2. reproduction costs: How much would it cost to replace capacity with plants built today?

3. replacement costs: How much would it cost to replace capacity with plants built with the newest technology?
   - Problem: estimation of replacement costs, technological progress can reduce costs remarkably,

3. fair value cost: weighted value of the above

4. market prices: market-value (n. of shares times share price)
   - Problem: circularity (B is to define prices/returns, but here B is determined using prices/returns set in the past)

Rate of return regulation (ROR)

problems

- Need to determine s and B
- Strong relatedness between regulator and regulated monopoly creates loyalties (regulatory capture)
- Regulatory lags may harm consumers (when forced to wait for lower prices coming from cost reductions) and firms (when increases in input prices depress their rate of return)
- No incentives to minimize cost ('cost-plus' unless regulatory lag is big)
- Overinvestment (Averch-Johnson effect): under ROR, the firm chooses an allocative inefficient capital/labor ratio (still, this may stimulate innovation, as for most industries it occurs by substituting L for K)

Rate of return regulation (ROR)

model – Averch-Johnson effect

- Assumptions:
  - Neo-classical production function: $q = F(K, L)$; $F_i > 0$; $F_{ii} < 0$, $i = K, L$
  - Revenue: $R(K, L) = P(q)q$
  - Production factors : Labor L, capital K
  - Opportunity cost of capital r and wage w
  - Regulator determines fair rate of return, $s^* > r$ (othw the firm prefers to shut down or has no bite)

Rate of return regulation (ROR)

model – Averch-Johnson effect

- Unregulated monopoly:

$$Max\ \pi = R(K,L) - wL - rK$$

$$F.O.C. \Rightarrow \frac{F^*_K}{F^*_L} = \frac{r}{w}$$

where r is the cost of capital

This gives the combination of K and L that minimizes costs

- Monopoly under ROR:

$$Max\ \pi = R(K,L) - wL - rK$$

$$s.t.\ R(K,L) \leq wL + sK, \quad r < s$$

$$\Rightarrow Max\ \pi^* = R(K,L) - wL - rK - \lambda\left[R(K,L) - wL - sK\right]$$

Rate of return regulation (ROR)

model – Averch-Johnson effect

- It can be shown that (with $0 < \lambda < 1$):

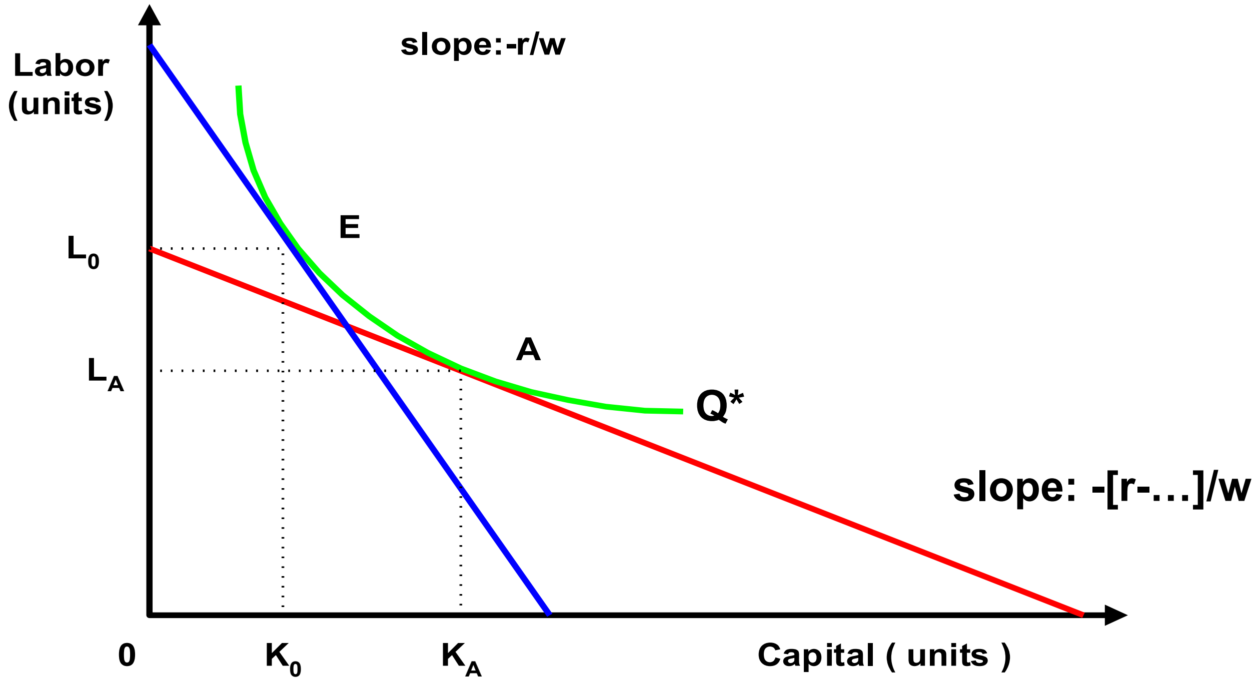
$$1.\ MR_q F_K = R_K = r - \frac{\lambda}{1-\lambda}(s - r)$$

$$2.\ MR_q F_L = R_L = w$$

Therefore, $$\frac{F_K}{F_L} = \frac{r}{w} - \underbrace{\frac{\lambda(s-r)}{(1-\lambda)w}}_{>0} < \frac{r}{w} = \frac{F_K^*}{F_L^*}$$

Rate of return regulation (ROR)

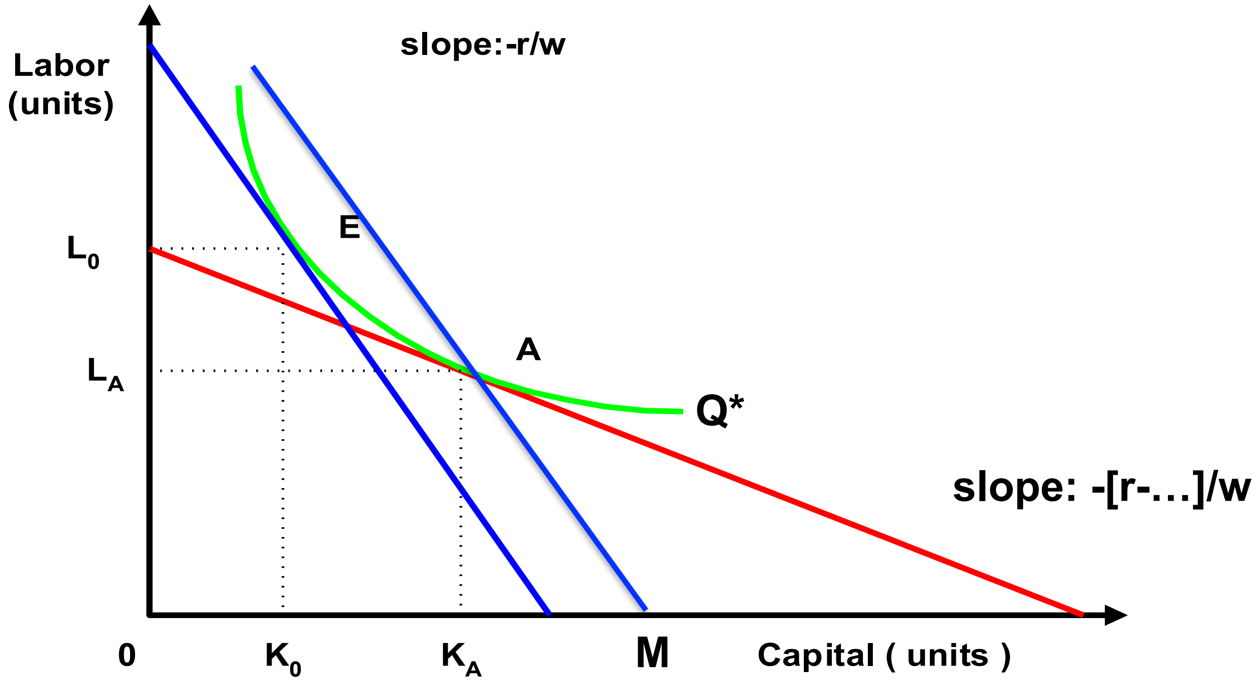
model – Averch-Johnson effect



- E: efficient point
- A: Averch-Johnson point

Rate of return regulation (ROR)

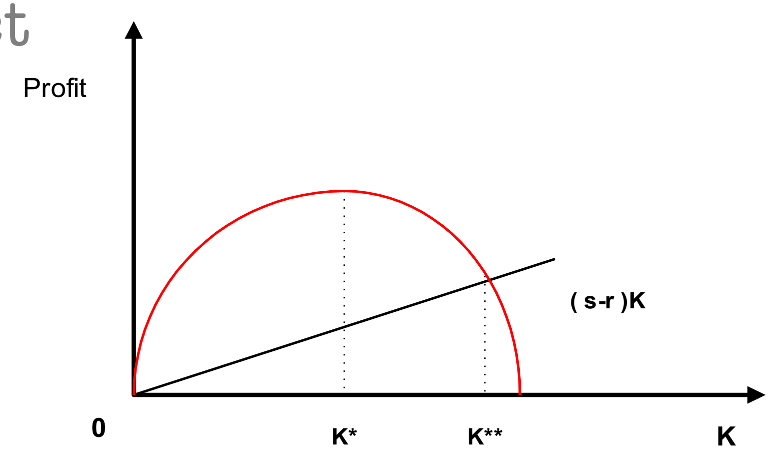
model – Averch-Johnson effect



- E: efficient point
- A: Averch-Johnson point
- **OM** is the cost of producing **Q*** in units of capital

Rate of return regulation (ROR)

model – Averch-Johnson effect



- So, $MRT_{KL} < r/w$

- For any given level of output the regulated firm uses too much capital relative to labor (overinvestment)

- Since input proportions are distorted, we have allocative inefficiency

- The larger the regulatory lag (decision – implementation), the smaller the A-J effect

Rate of return regulation (ROR)

final evaluation

- Where does s come from? Why don't we assume s =r to extract all the rent?
- No incentives to minimize cost; it's cost-plus regulation!
- If monopoly is also engaged in competitive markets, profits can be transferred into these business units (internal subsidies)
- Strong relatedness between regulator and regulated monopoly creates loyalties (regulatory capture)
- Averch-Johnson effect (overinvestment): under ROR, the firm chooses an allocative inefficient capital/labor ratio

Incentive regulation

- Designed to create incentives for the firm to lower costs, innovate, adopt efficient pricing, improve quality,...

- Gives the firm some discretion in setting prices and allows to share in profit increases

- Mostly used in telecommunications

- Exs:
  - Earnings sharing
  - Price-caps
  - Yardstick regulation (the least used)

Earnings sharing (sliding scale)

- The firm and consumers share any excess earnings (leaving it all to the firm amounts to no regulation) – constraint on profit
- So, firms retain part of the gains they create: there is incentive to innovate
- Ex: Pacific Bell in California: retain all profits if $r \leq 13\%$, rebate to consumers 50% of profits in excess of the 13% rate of return if $13\% \leq r \leq 16.5\%$; rebate all profits in excess of 16.5%

Earnings sharing (sliding scale)

- The firm's net rate of return is:

$$\begin{cases} r, & r \le \underline{r} \\ \underline{r} + \theta(r - \underline{r}), & \underline{r} \le r \le \bar{r} \\ \underline{r} + \theta(\bar{r} - \underline{r}), & \bar{r} < r \end{cases}$$

  Where $\underline{r} \le \bar{r}$ and $0 \le \theta \le 1$.

- In the example, $\underline{r} = 0.13$, $\bar{r} = 0.165$, and $\theta = 0.5$
- The higher $\bar{r}$ and θ, the stronger the incentives, but the higher the prices
- Traditional ROR has $\theta = 0$ and $\underline{r}$ is the allowed rate of return

Price caps – CPI-X

- The regulator specifies a maximum price, which is adjusted on a predetermined frequency according to a formula
- Firms have incentives to act efficiently and flexibility to adjust prices
- Used by the FCC and some US states; in Britain for industries as telephones, gas, water
- The formula has different parts:
  - An inflation factor: controls for general price changes and changes in input prices (+)
  - An X factor reflecting anticipated increases in productivity (-)

Price caps – CPI-X

- Example:

  The price-cap used by FCC is set so that AT&T can raise its price at 2% per year, the rate of inflation (5%) minus the expected growth in productivity (3%)

- The price cap is usually an average price; prices for individual services may be set by the firm

Mathios and Rogers, 1989

- This study finds evidence that favors price cap regulation in comparison with ROR regulation.
- They examined intrastate telephone service provided by AT&T and other companies in 39 states.
- It turns out that 28 of the 39 states moved to some form of price cap regulation of this long-distance service between 1984 and 1987.
- The authors found that "states that allowed pricing flexibility had lower 1987 prices than other states for all mileage bands."

Price caps – CPI-X

- The biggest challenge is to set X

- It should be set at the rate of productivity growth if the firm was subject to competitive pressures
  - If too low, prices will be too high relative to cost (dwl)
  - If too high, prices may be below cost

- Historical rates may be used, which should be low if ROR was used

- So, in many cases, a “stretch factor” – the gain in productivity growth from having price caps – is used

Price caps – CPI-X

- ROR: the regulator allows the firm to recover costs it has historically incurred; price cap: the regulator makes a projection of costs into the future, setting overall prices so that they will cover those expected costs

- The time path of a price cap has to be independent of the firm's costs (othw we have the "ratchet effect" and caps amount to ROR)

- Price caps were proposed in the 80's and applied in the UK; in the US, they replaced earnings sharing in the late 90's in telecom regulation; they are used in energy, communications, transports,…

Yardstick regulation

- If regulated firms serve different markets (eg, electric utilities in different areas), the regulator can use information on other firms' prices and performance to evaluate the performance of an individual firm

- The regulator determines the AC for comparable firms and sets the firm's price equal to AC
- So, a firm's prices are independent of its own costs and cost reductions lead to profit increases

- Problem: difficult to find comparable utilities (market conditions, past investment decisions,..)

Rate structure

- Up to here, the focus was on how the average price is set

- But, rate structure (how prices vary across consumers and products) is important:
  - Allocation of common costs across different consumer types (ex: fully distributed cost - FDC)
  - Variation of price with patterns in demand (ex: peak-load pricing)

Rate structure

Fully distributed cost - example

- a NM sells electricity to residential buyers (X) and industrial customers (Y)
- Costs are as follows:

$$C_X = 700 + 20X$$

$$C_Y = 600 + 20X$$

$$C_{XY} = 1050 + 20X + 20Y$$

(the joint production of X and Y is subadditive)

- The common fixed costs have to be distributed
- On the basis of: some common measure of utilization (minutes, kilowatt-miles,... employed or consumed by each) or in proportion to costs that can be directly assigned to the services

Rate structure

Fully distributed cost - example

- Assume a "reasonable" method leads to allocating 75% to X and 25% to Y. FDC AC's are:

$$AC_X = 787.5 / X + 20, \quad AC_Y = 262.5 / Y + 20$$

- And let

$$P_X = 100 - X, \quad P_Y = 60 - 0.5Y$$

- Setting $P = AC$, we obtain FDC prices and demands:

$$P_X = AC_X = 31.5, \quad P_Y = AC_Y = 23.6$$

$$X = 68.5, \quad Y = 72.8$$

- So, profit = 0, but there is no reason to expect these prices to be efficient; here, (linear) efficient prices would be Ramsey prices: $P_X = 30, \quad P_Y = 25$

$$X = Y = 70$$

Rate structure
Fully distributed cost

- So, FDC may lead to an efficiency problem
- But it may also raise a fairness problem: the fact that it's arbitrary may lead to disputes among consumer classes or hide undue discrimination

Rate structure

Discrimination

- Mainly fairness issue in the sense that one group may be subsidizing another

- To examine cross-subsidizing, the most logical tests are
  - the stand-alone AC
    - $P \leq$ stand-alone AC: P does not give an incentive for customers to produce the product by itself
  - the average incremental cost test
    - $P \geq$ AIC: each product contributes to TR an amount that at least covers the extra costs it causes; so, incremental revenue > incremental cost (and revenues from other products are reduced)

(the two methods give the same answers)

Rate structure

Discrimination - example

Stand-alone AC test for X:

- Since C_X = 700 + 20X, $AC_X(70)$=30. So, the Ramsey price of 30 for X=70 does not give incentives for the customers of X to break away and produce X separately; thus, Ramsey price 30 is subsidy-free

- Since C_X = 700 + 20X, $AC_X(68.5)$=30.21. So, the FDC price of 31.5 for X=68.5 is *not* subsidy-free

Rate structure

Discrimination - example

Stand-alone AC test for Y:

- Since $C_Y = 600 + 20Y$, $AC_Y(70)=28.6$. So, the Ramsey price of 25 for Y=70 does not give incentives for the customers of Y to break away and produce Y separately; thus, Ramsey price 25 is subsidy-free

Rate structure

Discrimination - example

Average incremental cost (AIC) test

- AIC of X = $\dfrac{|C(X,Y)-C(0,Y)|}{X} = \dfrac{450+20X}{X}$
- For X =70, this gives AIC (70)=26.4. So, the Ramsey price of 30 is subsidy-free
- The Ramsey price of Y also passes the test
- The FDC prices do not (the FDC price of 23.6 for Y=72.8 is smaller then its AIC of 24.8)

Rate structure
Discrimination

- Under some conditions of subadditivity of cost, Ramsey prices are subsidy-free (and no-one finds it profitable to enter)

- But, even with subadditive costs, subsidy-free prices may not exist!

- This is the case of an unsustainable NM: least-cost requires a single firm, but no prices can keep all of the monopolist products invulnerable to entry

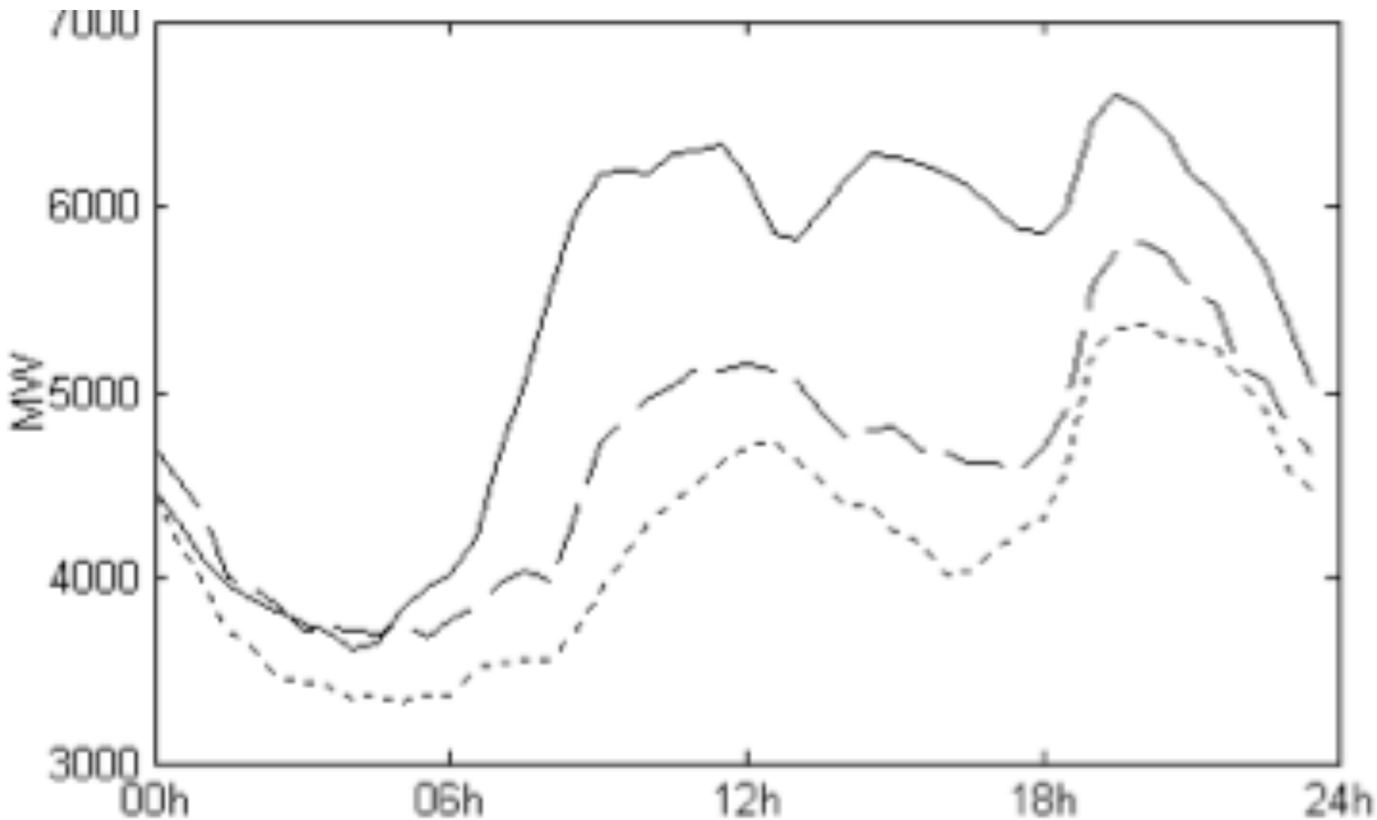
Discrimination

No subsidy-free prices - example

- Three towns need water supply
- Building a well that serves all costs 660 (P=220/ each town); serving 2 costs 400 (P=200/each); serving 1 costs 300
- The least cost solution is building a well for 3 (660 < 700 < 900).
- However, since P=220, (any) 2 towns have incentive to build a well for themselves
- It is as if, in the case the 660 well is built, (any) two towns are subsidizing the third town in an amount of 20 each

Peak-load pricing

- Variation in prices by time of use (eg, MC of electricity higher in the middle of the day than at night and prices vary accordingly)

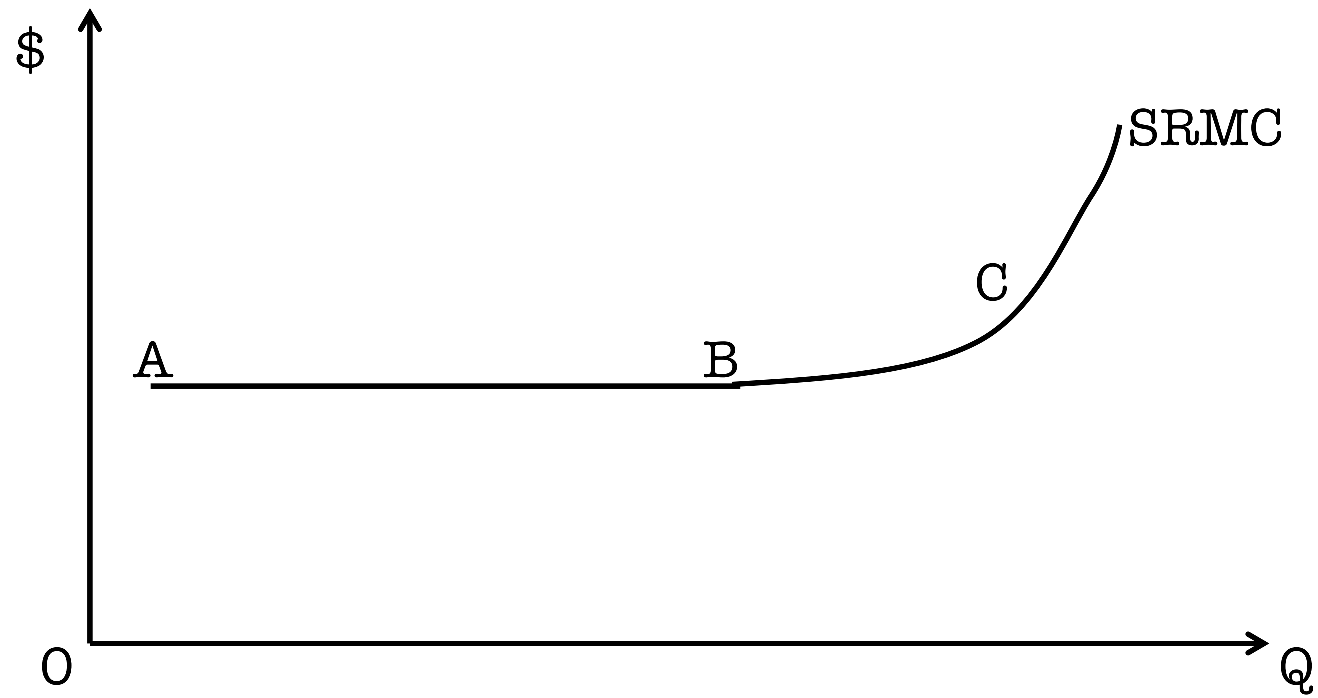


Load profiles from a working day (solid line), a Saturday (dashed), and a Sunday (dotted line) in Portugal, Oct. 2004
(Source: **Forecasting Daily Electricity Load Curves**
http://www.wseas.us/e-library/conferences/2005lisbon/papers/496-JCQ5.pdf)

Peak-load pricing

- Electricity:
  - Too costly to store; so, capacity is determined by the amount of peak demand
  - Demand has cyclical pattern (daily, weekly, monthly and seasonally): peak in the middle of the morning/end of the afternoon; weekends only 50%
  - An electric power system has different kinds of plants (nuclear plants, coal-fired plants, combustion turbines,... with decreasing FC/increasing VC); typically the short-run MC curve for the electric power system is a rising curve

Short-run MC cost curve for electric power system

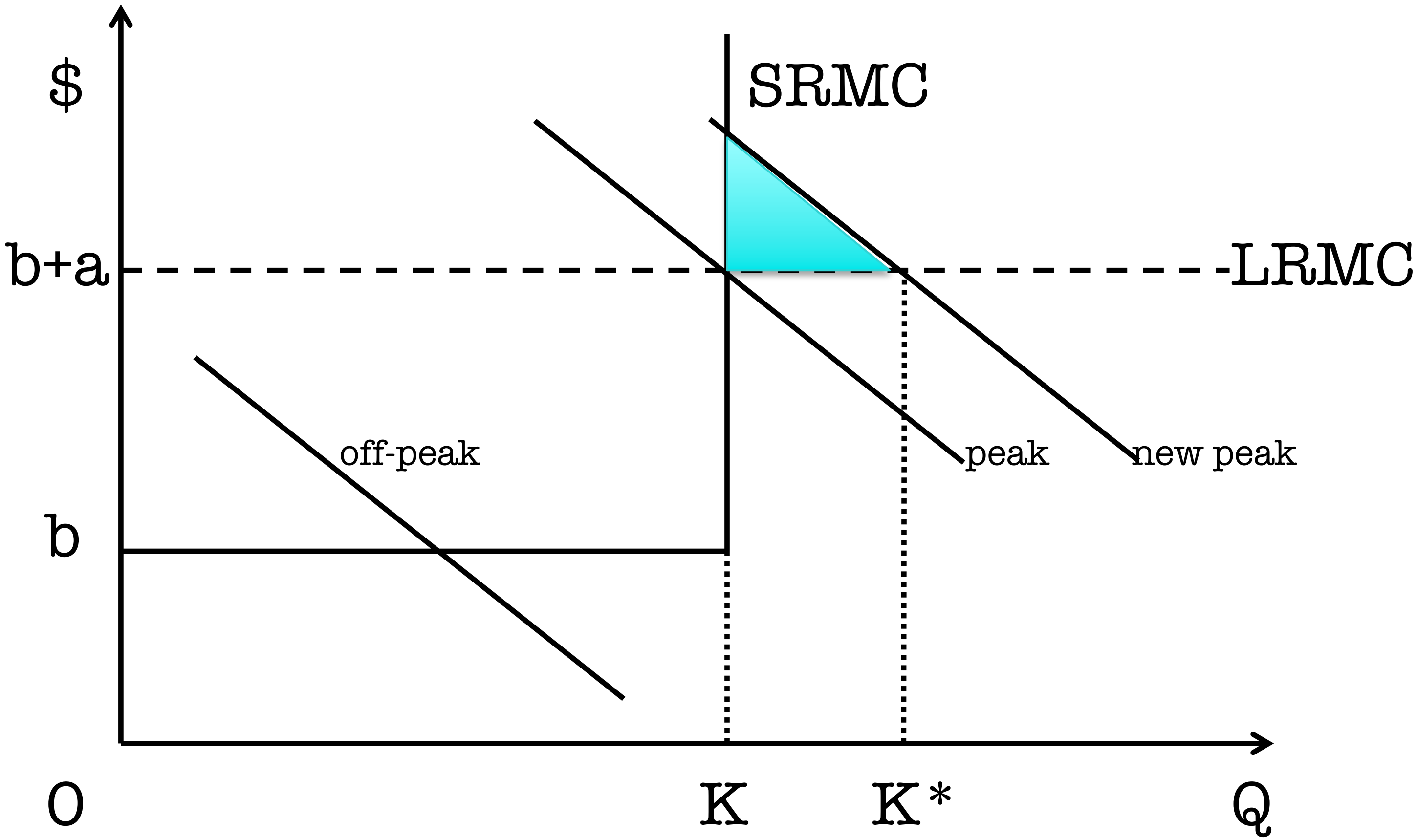


Since demand varies over time, P=SRMC would require a continuously changing price.

Peak-load pricing

- Simple model:
  - Peak demand for half the day; off-peak for the other half
  - Demands are independent (strong!)
  - VC = b until capacity K is reached; at K no more output is possible (approx. to smooth curve in slide 8)
  - *a* is the cost of 1 additional unit of capacity
  - Efficient solution P=SRMC
  - LRMC come into play to decide if K is optimal
  - Off-peak P = b; Peak P = b + a (=SRMC=LRMC, so that capacity is optimal!!)

Peak-load pricing

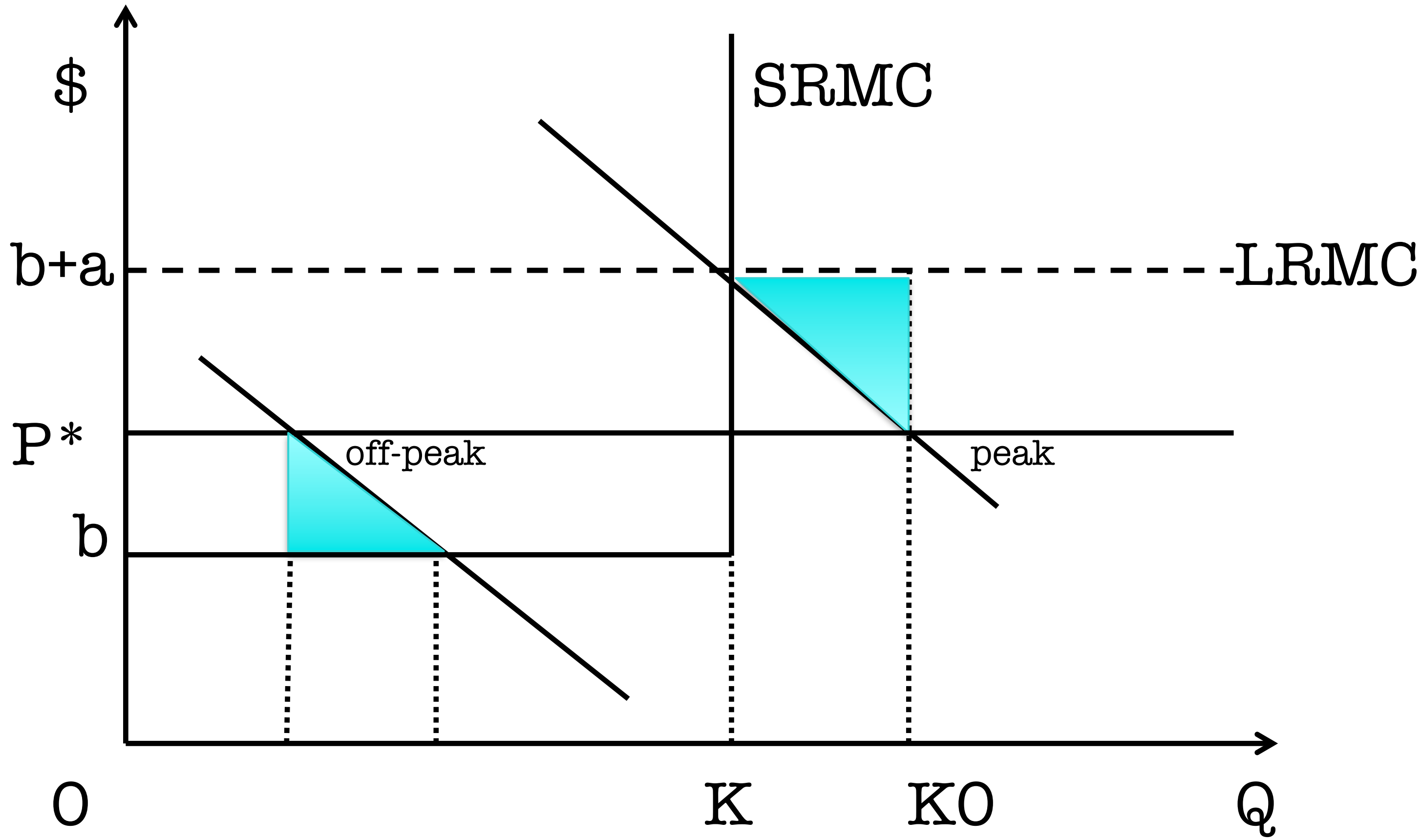


Peak-load pricing

- Solution: off-peak demanders pay b and off-peak pay b+a, i.e., peak demanders pay all capacity costs (and off-peak pay none)

- What if a single price is charged?

Peak-load pricing



Peak-load pricing

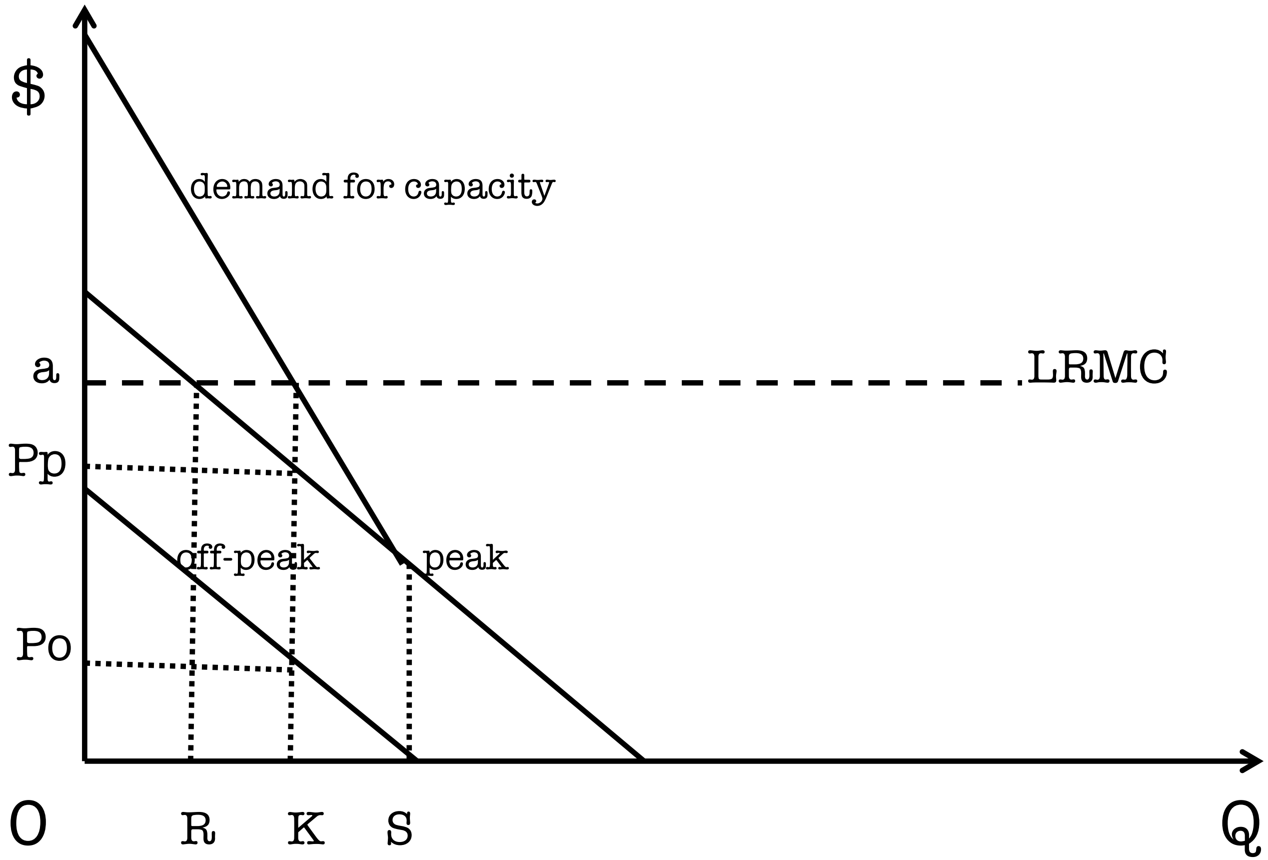
- Solution: off-peak demanders pay b and off-peak pay b+a, i.e., peak demanders pay all capacity costs (and off-peak pay none)

- (This is true for this extreme case, in which the two demands are too far apart)

- The next graph illustrates another example (with b=0)

Peak-load pricing

Shifting peak case



If P peak =a (and off-peak P=0), peak demanders consume less than off-peak!

Peak-load pricing

- Solution:
  - To obtain the optimal capacity, construct the demand for capacity (reflecting total willingness to pay for the plant)
  - In the graph, given optimal capacity K (at which Pcap=LRMC), the efficient prices are Pp and Po
  - So, the two groups of consumers share capacity costs