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:

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

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

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

Rate of return regulation (ROR)

model – Averch-Johnson effect

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

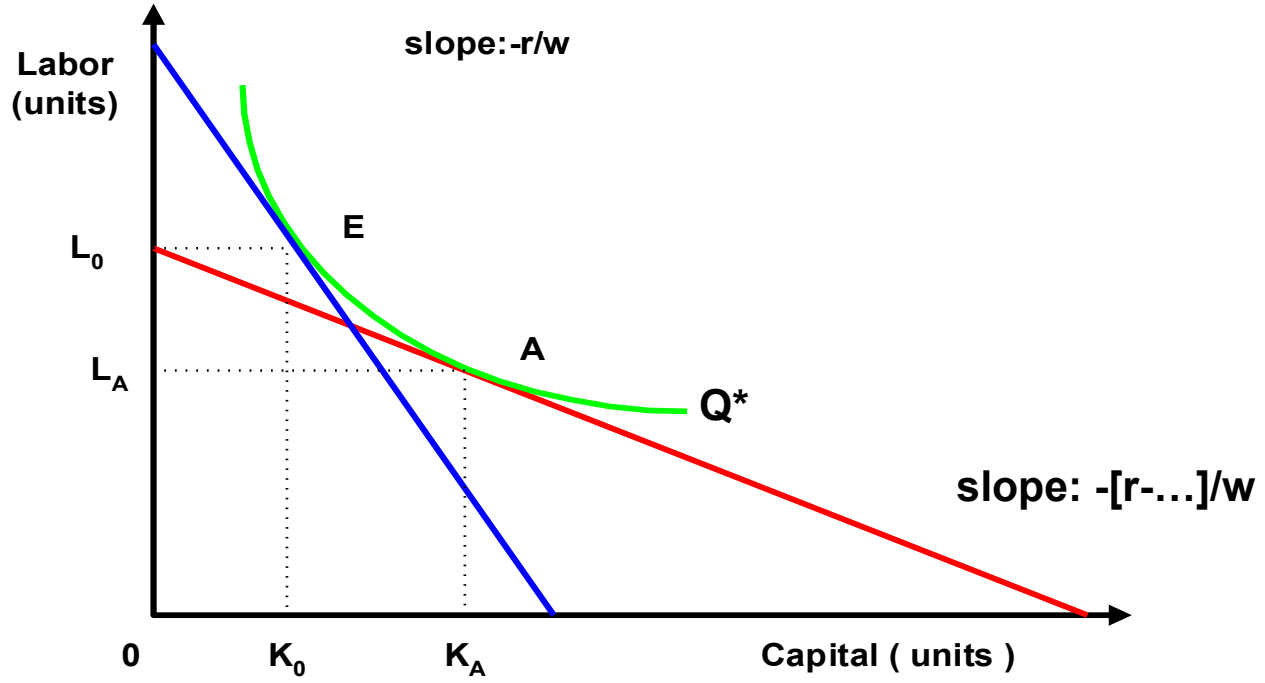
$$1.\ MR_q F_K = R_K = r - \frac{\lambda}{1-\lambda}(s - r)$$

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

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)

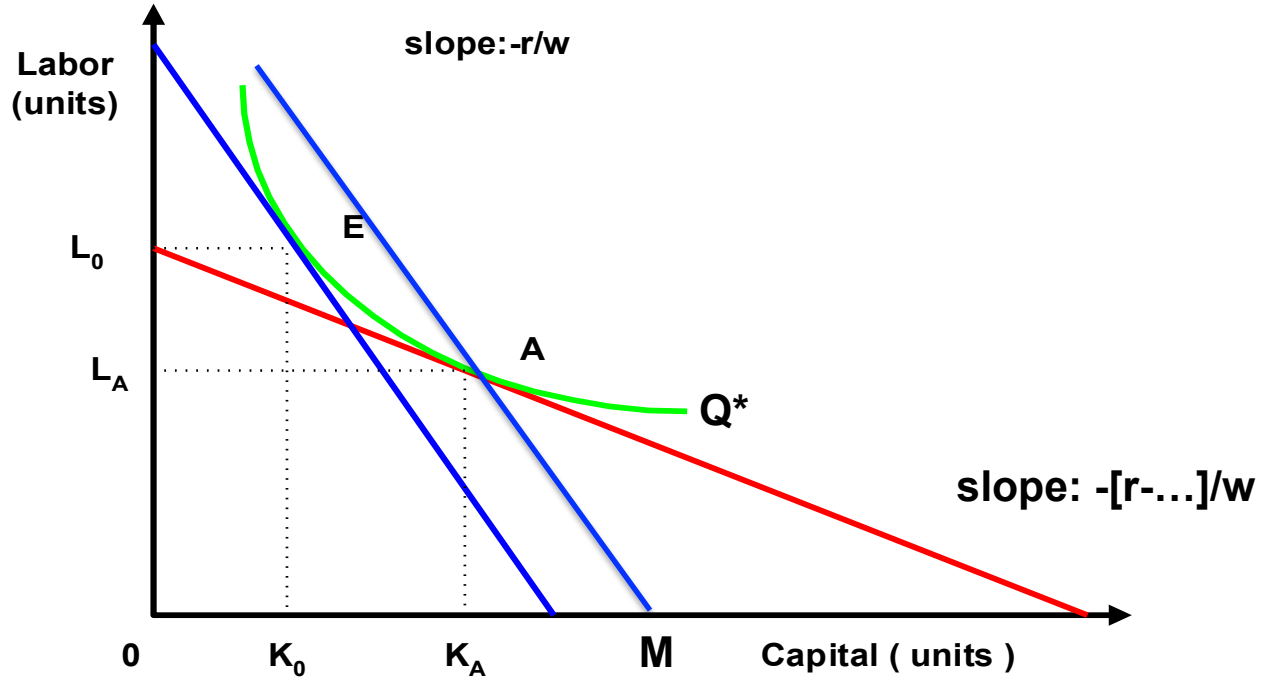
model – Averch-Johnson effect



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

Rate of return regulation (ROR)

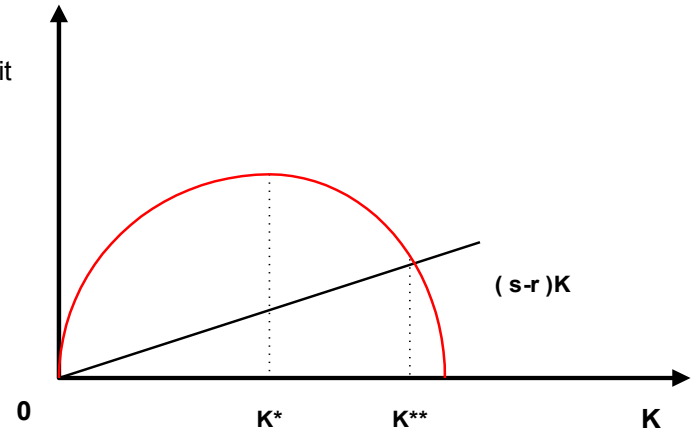
model – Averch-Johnson effect



- 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 also is 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 rate-of-return 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 ≤ stand-alone AC: P does not give an incentive for customers to produce the product by itself
  - the average incremental cost test
    - P ≥ 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 = $\frac{|C(X,Y)-C(0,Y)|}{X} = \frac{450+20X}{X}$

- 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

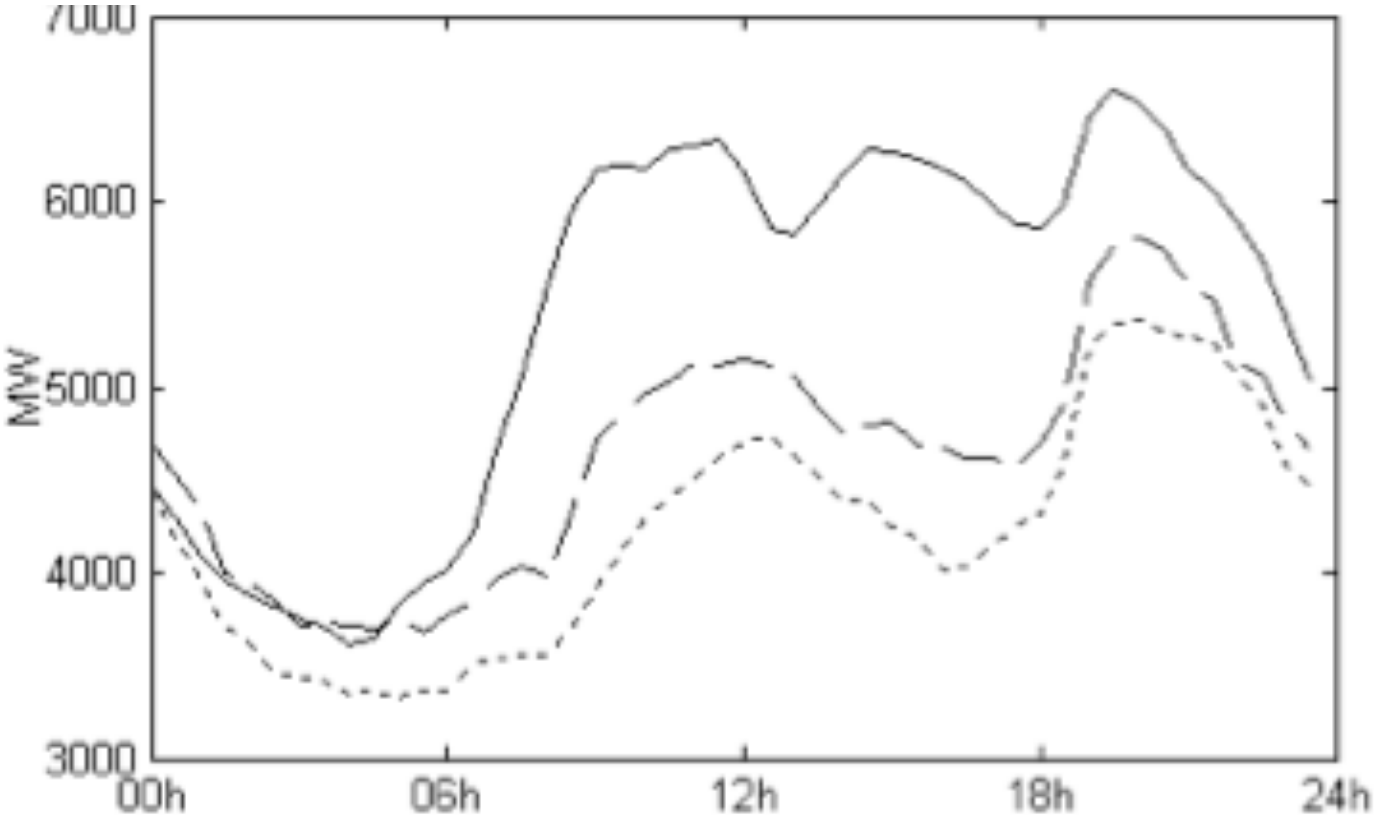
Discrimination

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 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