C34 Lecture 7

Regulation of Natural Monopoly
**Goals and challenges of natural monopoly regulation**

**Objectives**
- Allow firm to recover its costs
- Provide incentives for productive efficiency
- Provide price signals for efficient resource utilization
- Provide correct incentives for entry

**Difficulties**
- Public utilities require long-lived, sunk investments
- Multiple products
- Increased competition at industry “boundaries”
- Technological change
The “simple” regulatory rule: $P = AC$

**BASIC MONOPOLY MODEL (Declining ATC)**

- $D(Q) = a - bQ$, $MR(Q) = a - 2bQ$, $ATC = (F/Q) + c$, $MC = c$.  

- $MR = MC \Rightarrow P^M \Rightarrow DWL^{MONOPOLY}$
- $P = MC \Rightarrow DWL = 0$ but $\Pi < 0$
- $P = ATC \Rightarrow DWL^{REGULATE}$

- $DWL^M > DWL^R > DWL^C = 0$
- $Q^M < Q^R < Q^C$
- $P^M > P^R = ATC > P^C = MC$.  

Price

![Diagram showing price, demand, cost, and profit for a basic monopoly model.](image)
The Rate Case: ensuring cost recovery

- The fundamental rate case equation:
  \[ RR_t = sRB_{t-1} + OE_t + D_t \]
  revenue requirement = fair rate of return on rate base value + operating expense + depreciation expense

- Operating Expenses include the usual variable costs of the firm: i.e., items that an accountant would *expense*
  - Labor
  - Materials
  - Etc.
Depreciation expense: Recovering the costs of long-lived assets

- Prices recover investment costs over time
- What does “average cost” mean in this situation?
- Traditional accounting rules
  - Depreciation charges recover asset costs
  - Time pattern of depreciation charges
    - Straightline: \( D_t = \frac{V_0}{T} \)
    - Accelerated: \( D_t < D_s \) for \( t > s \)
- Example: \( V_0 = $1000; \ T=2; \ Q_1=60 \) and \( Q_2=40 \)
- What’s “AC” of this machine?
  - \( \frac{10}{1000}/(60+40) \)?
- Straight-line depreciation:
  - \( D_1=D_2=500 \)
    - “AC\_1” = $500/60 = $8.33
    - “AC\_2” = $500/60 = $12.50
- Accelerated depreciation: e.g., \( D_1=600>D_2=400 \)
  - “AC\_1” = $600/60 = $10.00
  - “AC\_2” = $400/40 = $10.00
Determining the fair rate of return

• Average of “debt” and “equity” costs of capital
  – But the firm chooses its debt/equity ratio
• Cost of debt capital relatively easy to measure
• Issues in determining cost of equity capital
  – Appropriate adjustment for “risk”
    • But regulatory process influences risk
  – Measuring investors’ expectations of future performance; i.e., implementing
    • \( k = \frac{\text{Div}}{\text{Price}} + g \)
  – A bonanza for Finance professors!
Rate structure: raising the revenue requirement

• With 2 or more products, there are typically an infinite number of ways to satisfy the revenue requirement
• Which prices should be “high” or “low” a major source of controversy in regulatory proceedings
  – Regulatory statutes typically contain “fairness” provisions and prohibit “undue discrimination”
• What are the economic principles that should be used?
  – Ramsey pricing principles (Chapter 11) provide answer based upon surplus maximization and presumption of monopoly
Fully distributed cost pricing

- FDC attempts to determine the costs of individual services
- Each service recovers the costs unambiguously assigned to it plus an allocated “fair share” of overhead costs
- Allocation rules base upon “objective criteria”
  - Volume
  - Attributable costs
- Example:
  - Output: $Q_1=Q_2=100$
  - Attributable costs per unit: $c_1=5$, $c_2=10$.
  - Overhead costs:
    - $F_1 = 700$ if only service 1
    - $F_2 = 500$ if only service 2
    - $F = 900$ if both provided
  - Allocation using relative volume:
    - $C_1 = c_1 Q_1 + Q_1 F/(Q_1 + Q_2) = 950$
    - $C_2 = c_2 Q_2 + Q_2 F/(Q_1 + Q_2) = 1450$
  - Allocation using relative attributable costs:
    - $C_1 = c_1 Q_1 + c_1 Q_1 F/(c_1 Q_1 + c_2 Q_2) = 800$
    - $C_1 = c_2 Q_2 + c_2 Q_2 F/(c_1 Q_1 + c_2 Q_2) = 1600$
Economically meaningful multiproduct cost concepts

- *Total costs* of the enterprise (C) depend on all output levels
- *Marginal cost* of any service *i* (MC$_i$) is the cost of producing *one more unit* of that service
- *Stand-alone costs* of a service *i* (SAC$_i$) are the costs of providing *only* that service
- *Incremental costs* of any service *i* (IC$_i$) are the *added* costs incurred because a service is provided
  - IC$_i$ = C - SAC$_{\text{others}}$
- AVERAGE COSTS do not exist!

- **Example:**
  - Total and marginal costs are
    \[ C = F + c_1 Q_1 + c_2 Q_2 = 900 + 500 + 1000 = 2400 \]
    \[ MC_1 = c_1 = 5 \]
    \[ MC_2 = c_2 = 10 \]
  - Stand-alone costs are
    \[ SAC_1 = F_1 + c_1 Q_1 = 700 + 500 = 1200 \]
    \[ SAC_2 = F_2 + c_2 Q_2 = 500 + 1000 = 1500 \]
  - Incremental costs are
    \[ IC_1 = C - SAC_2 = F - F_2 + c_1 Q_1 = 400 + 500 = 900 \]
    \[ IC_2 = C - SAC_1 = F - F_1 + c_2 Q_2 = 200 + 1000 = 1200 \]
Cross-subsidization: When is a rate structure “subsidy free?”

- Total revenues equal total costs
  - If not, the *firm* is either providing or receiving a subsidy
- Revenues from a service must not exceed the *stand-alone costs* of the service
  - If they do, the service is *providing* a subsidy
- Revenues from a service must not be less than *incremental costs* of providing that service
  - If they are, the service is *receiving* a subsidy

\[
\begin{align*}
\text{Total revenues equal total costs} & \quad p_1 Q_1 + p_2 Q_2 = F + c_1 Q_1 + c_2 Q_2 = 2400 \\
& \quad p_1 + p_2 = 24 \\
\text{Stand-alone cost tests} & \quad p_1 Q_1 \leq \text{SAC}_1 = 1200 \\
& \quad p_1 \leq 12 \\
& \quad p_2 Q_2 \leq \text{SAC}_2 = 1500 \\
& \quad p_2 \leq 15 \\
\text{Incremental cost tests} & \quad p_1 Q_1 \geq \text{IC}_1 = 900 \\
& \quad p_1 \geq 9 \\
& \quad p_2 Q_2 \geq \text{IC}_2 = 1200 \\
& \quad p_2 \geq 12
\end{align*}
\]
Efficiency of the rate structure: Peak-load pricing

- The “Peak-Load” Problem
  - Demand varies cyclically (e.g., daily, monthly, yearly)
  - Capacity cannot be varied over the cycle
  - Output cannot be stored

- Economic efficiency issues
  - How are marginal costs defined?
  - Should prices be set equal to short-run or long-run marginal costs?
  - How to recover capacity costs?

- Basic Model:
  - Independent demands
    \[ D_{\text{peak}} = D_1(p) > D_2(p) = D_{\text{off peak}} \]
  - Capacity K must be sufficient to meet demand
    \[ K \geq D_1(p_1) \geq D_2(p_2) \]
  - Per unit capacity costs = \( \beta \)
  - Per unit variable costs = \( b \)
  - LRMC = \( b + \beta \)
  - SRMC = \( b \)
  - Total costs
    \[ C = \beta K + b(D_1 + D_2) \]
Case I: Firm Peak

- Peak period price equals long-run marginal costs
  \[ p_1 = b + \beta \]
- Off-peak price equals short-run marginal cost
  \[ p_2 = b \]
- Peak-period users “pay” for all capacity costs
  \[ (p_1 - b)D_1 = \beta D_1 = \beta K \]
- Uniform pricing
  - Results in deadweight loss
  - Does not involve cross-subsidy
Case II: Shifting Peak

- Output in both periods fully utilizes capacity
  \[ D_1(p_1) = D_2(p_2) = K \]

- Unequal prices:
  \[ \beta + b > p_1 > p_2 > b \]
  \[ (p_1-b) + (p_2-b) = \beta \]

- Note that
  - Both prices above SRMC
  - Both prices below LRMC
  - Both period contribute toward covering capacity costs
A Cookbook for solving peak-load pricing problems

- Identify peak and off-peak periods
- *Try* setting peak price equal to $b + \beta$, off-peak price equal to $b$
  - If “peak” quantity greater than “off-peak” quantity at those prices, you’re done. If not,
- Construct the *demand for capacity* schedule by adding together the *inverse* demand schedules (less variable cost) for each period:
  - $P_K(K) = (P_1(K) - b) + (P_2(K) - b)$
  - (Remember, you’re now in the *shifting peak* case, so $K = Q_1 = Q_2$)
- Solve for the intersection of the demand for capacity schedule with the marginal cost of capacity: i.e., set $P_K(K) = \beta$ and solve for $K$
- Plug this value of $K$ back into the inverse demand functions $p_1 = P_1(K)$ and $p_2 = P_2(K)$