Lecture 3: Regulatory Commitment and Rate of Return Regulation

Readings: Braeutigam HB Chapter

Chapter 2 in David Newberry, *Privatization, Restructuring and Regulation of Network Utilities*, MIT Press 2000

Summary and Overview: Network Characteristics and Policy Issues

- Characteristics of Network Infrastructure Industries
  - Economies of scale and scope
  - Long-lived, sunk assets
  - Vertical integration of “monopoly” and “competitive” components
  - Multiple services and/or customer classes
  - Network externalities
- Resulting Policy Problems
  - Mark-ups over cost required to break-even
  - Recovering capital investments
  - “Unbundling” (vertical disintegration) and Access pricing
  - Price discrimination and Cross-subsidization
  - Universal Service funding

Issue 2: Network industries have long-lived (sunk) investments

- Creates commitment problems:
  – Government cannot commit *not* to regulate the price of activities *affected with the public interest*
- Once investment is sunk, regulator has incentive to regulate price to average variable cost
  – *Ex post,* firm accepts this rather shut down
  – *Ex ante,* firm won’t invest at all
- In the US, Rate of Return Regulation (RORR) evolved to solve this problem and to recover sunk costs over time through rates.

A simple model of regulatory commitment (Newberry, *Privitization, Restructuring and Regulation of Network Utilities,* MIT 2000)

- Investment sunk before prices set and revenues realized
- Costs and demand:
  - Capacity K costs r per unit
  - Variable costs b per unit
  - "Outside" costs c per unit
  - Demand inelastic and uncertain: $D \in \{1, 1-\sigma\}$; Prob{D=1} = ρ
  - Sales $Q = \min\{K, D\}$
  - Allowed revenues $R = R(K,Q)$
  - Profits: $\pi = R - bQ - rK$
- Regulator maximizes consumers' surplus: $CS = cD-R$, subject to firm's participation constraint $\pi \geq 0$.

Time line for investment cycle without regulatory commitment

- Firm chooses sunk investment, $K \in \{0, 1-\sigma, 1\}$
- Demand level revealed, $D \in \{1-\sigma, 1\}$
- Regulator chooses Revenue rule: $R(K,Q) \in \{R_K, R_Q, R_{var}\}$
  - Rate of return: $R_K = (r+\varepsilon)K + bQ$
  - "Used and useful": $R_Q = (r+\varepsilon+b)Q$
  - Variable cost: $R_{var} = bQ$
- Firm chooses output level: $Q \in \{0, \min[D,K]\}$
- Payoffs realized
  - Firm profit: $\pi = R(K,Q) - rK - bQ$
  - Consumers' surplus: $CS = Dc - R(K,Q)$

Inefficiency of subgame perfect Nash equilibrium without commitment

- Under command decision, planner would maximize

  $\rho(c - b)\min\{1,K\} + (1-\rho)(c - b)\min\{1-\sigma,K\} - rK$
- Assume that $\rho(c-b) > r$, so that $K = 1$ is the optimal investment policy.
- Any of the payoff outcomes in which $K = 1$ are socially optimal.
- Optimal choice for regulator is always R_{var}
  - Firm has incentive to produce, but sunk investment is expropriated.
- Therefore, firm chooses $K = 0$.

Subgame Perfect Equilibrium *with* regulatory commitment

- Suppose the regulator can commit to a pricing rule *before* the firm makes its investment decision.
- Changes the "order of moves" and information structure of the "game."
- Threat of firm to not invest is credible
- Allows social optimum to be sustained as a SPE:
  - i.e., $R = R_K$ and $K = 1$.
- What about *repeated* interactions between investors and regulator?

Basic structure of investor - regulator interaction is a Prisoners' Dilemma

- Stylized oligopolistic interaction:
  - Payoff structure: $c > a > b > d$
    - Joint "high price" strategy: *a*
    - Joint "low price" strategy: *b*
    - Cheating: *c*
    - Being cheated on: *d*
  - Leads to "low price" Nash equilibrium
- But suppose the firms played this game over and over again, "forever?"

Firm 2 Firm 1	Low price	High price
Low price	(*b*,*b*)	(*c*,*d*)
High price	(*d*,*c*)	(*a*,*a*)

A brief introduction to *infinitely repeated games* (i.e., Supergames)

- Player strategies become extraordinarily complex
  - Spell out actions at each date based on all possible histories of the game
- Consider two relatively simple strategies
  - Strategy 1 (Myopic Nash): Set a low price, regardless of history
  - Strategy 2 (Trigger):
    - Set high price until cheated upon
    - Once cheated upon, set low price *forever*
- What payoffs result from interactions of these strategies?

Math review: Discounted Present Values (DPVs)of infinite sums

- What is the DPV at interest rate r of an income stream of x received *next* period, and every period thereafter?

$$\text{DPV} = x/(1+r) + x/(1+r)^2 + x/(1+r)^3 + \ldots$$

$$(1+r)\text{DPV} = x + x/(1+r) + x/(1+r)^2 + x/(1+r)^3 + \ldots$$

$$r\text{DPV} = x$$

$$\text{DPV} = x/r$$

- Use this formula to fill in (part of) the payoff matrix of the oligopoly supergame.
- There are 4 payoff values to determine, associated with the strategy pairs: {Myopic, Myopic}, {Myopic, Trigger}, {Trigger, Myopic}, and {Trigger, Trigger}.

(Part of) the Supergame payoff matrix

- If both firms play Trigger, each receives *a* this period and forever; DPV = $a+a/r$.
- If both firms play Myopic, each receives *b* this period and forever; DPV = $b+b/r$.
- Suppose Firm 1 plays Myopic and Firm 2 plays Trigger:
  - Firm 1 receives *c* this period (as a cheater), then *b* forever: DPV = $c+b/r$
  - Firm 2 receives *d* this period (as a victim), then *b* forever: DPV = $d+b/r$
- Lower left entry of payoff matrix is the reverse.

Firm 2 / Firm 1	Myopic	Trigger
Myopic	$b+b/r, b+b/r$	$c+b/r$, $d+b/r$
Trigger	$d+b/r$, $c+b/r$	$a+a/r$, $a+a/r$

The Supergame may have two Nash equilibria

- {Myopic, Myopic} will be a Nash equilibrium.
- Requires that the DPV of starting out with a high price is less than the DPV of a low price forever:

  $d + b/r \leq b + b/r$

  $d \leq b$
- This condition is satisfied in any oligopoly situation.
  - (Being cheated on is the worst possible outcome.)

- Can {Trigger, Trigger}, which involves high prices and profits *forever,* be a Nash equilibrium?
- Necessary that DPV of cheating next period be less than the DPV of maintaining high price:

  $c + b/r \leq a + a/r$

  $(c-a) \leq (a-b)/r$
- That is, the one time gain from cheating must be less than the DPV of the difference between the high profit and low profit payoffs forever.

Circularity in the valuation process

- 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 (return OF capital)

- Fundamental circularity:

Value of rate base $\Rightarrow$ Costs $\Rightarrow$ Revenue $\Rightarrow$ Rates $\Rightarrow$ Discounted PV of cash flow $\Rightarrow$ Value of rate base

Depreciation as a Cost

- Two components of depreciation "cost:"
  - Reduction in productive capability of asset in place
  - Recovery OF capital investment over time
- Useful to separate these conceptually:
  - Maintenance Expense: Costs incurred to maintain productive power of asset
    - Actually incurred on a yearly basis
  - Depreciation Expense:
    - Portion of Common Cost arbitrarily allocated to each year

Depreciation: Accounting/Regulatory versus Economic

- Accounting depreciation *allocates* costs of sunk facilities over their "useful life"
- Economic depreciation measures asset value changes from period to period

$$\mathbf{D} = (D_1, D_2, \ldots, D_T) \geq \mathbf{0}$$

$$\sum_{t=1}^{T} D_t = P$$

$$N_t \equiv RR_t - OE_t$$

$$V_t = \sum_{\tau=t+1}^{T} \beta^{\tau-t} N_\tau$$

$$E_t \equiv V_{t-1} - V_t$$

$$\sum_{t=1}^{T} E_t = V_0 - V_T = P$$

How to break the valuation cycle?

- In competitive markets, asset values and economic depreciation charges are determined by the market
- But, under regulation, depreciation determines per period costs, which determine rates and values!
- For the resolution of this problem see:
  - Greenwald, B., "Rate Base Selection and the Structure of Regulation," *The Rand Journal of Economics*, *15,* Spring 1984, pp. 85-95.
  - Schmalensee, R., "An Expository Note on Depreciation and Profitability under Rate-of-Return Regulation," *Journal of Regulatory Economics*, *1,* September 1989, pp. 293-298.

$$\text{Choose}(D_1, D_2, ..., D_T)$$

$$s.t. \sum_{t=1}^{T} D_t = P$$

Set

$$s = r = (1-\beta)/\beta$$

$$RB_0 = P$$

$$RR_t = sRB_{t-1} + D_t + OE_t$$

$$\text{Then}, \forall t,$$

$$RB_t = V_t$$

$$D_t = E_t$$

Competition limits regulatory options and accelerates economic depreciation

- Simple 2 period example:
  - Constant marginal cost
  - Inelastic demand
  - s = r = 0 $\Rightarrow \beta = 1$
- Wide range of regulatory options w/o competition
- Suppose competition limits 2nd period price
- Cost recovery requires accelerated depreciation

$$RR_t = p_t Q = cQ + D_t$$
$$D_1 + D_2 = P$$
$$p_t = c + D_t / Q$$
$$e.g., p_{sl} = c + P / 2Q$$
$$(p_1 - c)Q + (p_2 - c)Q \equiv N_1 + N_2 = P$$

$$\text{comp.per.2 price} = \rho < p_{sl}$$
$$\Rightarrow p_2 \leq \rho \Rightarrow D_2 \leq (\rho - c)Q < P / 2$$
$$V_1 = (\rho - c)Q$$
$$RB_1 \leq V_1 \Rightarrow D_1 \geq P - (\rho - c)Q$$

Depreciation important for *any* application of cost-based pricing

- Forward-looking cost models (FLCM) increasingly used to set maximum rates for
  - access
  - interconnection
  - Universal Service Obligations
  - as well as basic rates
- FLCM give rise to a flow of costs overtime
  - Must be *annualized* for use in rate-setting
    - Creates problems for capital recovery

FLCM and falling investment costs

- Provider obligated to provide service beginning in period 1
- Price in *each* period limited by annualized per unit FLC, based upon *current* asset prices
- Asset prices falling over time
- Implications:
  - Provider incurs a capital loss upon investment
  - Investment not recovered under forward-looking prices

- Even simpler 2 period example

  $c = 0$

  P_0 = initial purchase price

  $P_1 < P_0$ price of asset beginning of period 2
- Maximum period 1 rate:

  $p_1 = P_0/2Q$
- Similarly, max per 2 rate is

  $p_2 = P_1/2Q$
- DPV of investment is

  $Q(p_1+p_2)-P_0=(P_1-P_0)/2<0$

Economic depreciation principles can neatly resolve this dilemma

- Solution 1: *Economic Depreciation Approach*
- Incorporate capital loss into annualized unit cost
- Initial investment cost is augmented by period 1 Economic Depreciation and *then* annualized:

  $p_1 = P_0/2Q + (P_0 - P_1)/2Q$

  $p_2 = P_1/2Q$
- Now

  $DPV=Q(p_1+p_2)-P_0 = P_0 - P_0 = 0$

- Solution 2: *Real Option Approach*
- Compensate the firm for giving up the option *not* to invest at time zero.
- $DPV_0 = (P_1 - P_0)/2$
- $DPV_1 = p_2Q - P_1 = 0$
- Value of the *real option* given by

$OV = DPV_1 - DPV_0 = (P_1-P_0)/2 > 0$

- Include OV as part of costs to be annualized.

Price Cap regulation

- Practice ahead of theory
- Introduced to correct the poor incentives associated with traditional “cost plus” RORR.
  - British Telecom privatisation
  - State regulators in US, one by one
  - “Enshrined” by US Telecom Act of 96
- Compared to RORR:
  - Improved incentives for cost efficiency.
  - Lower information costs
  - Poorer control of firm profits

Price cap regulation in practice

- Essential ingredients
  - Price index: $P = \Sigma_j p_{jt} Q_{jt-1}$
  - Cost index: $I = 1 + \Delta CPI$
  - Productivity offset factor: X
- Typical formula: $P_t \leq (I - X)P_{t-1}$
- Optional features
  - Bands
    - Limits on change in prices of individual services
  - Baskets
    - Separate calculations for various service categories: e.g., monopoly/competitive; basic/nonbasic; etc.

CPI – X Issues

- What services are subject to the cap?
  - Often imposed on a basket of services
    - Allows variation subject to an index constraint
    - May not span all of the firm’s activities
- What is the initial price, P_0 ?
  - Requires cost study, just like traditional ones
- What should X be?
- For how long should this X apply?
  - i.e. what is the regulatory lag?

Designing a Price Cap: Policy choices

- Pricing flexibility
  - Aggregate index allows firms to make efficient adjustments in rate structure (towards Ramsey)
  - *Bands* and *baskets* protect interest groups and may limit cross-subsidization
- Cost adjustments: Exog index versus input “pass through”
  - CPI is exogenous, but may not reflect *industry* conditions
  - Input cost pass through (e.g., *fuel adjustment clauses*) dampen incentives
  - Ideally, use an *exogenous* index of *industry-level* input costs
- X factor: Exog or industry specific productivity offset

Dynamic Effects of P-C Regime choices

- Price Cap in place for N years, then parameters all get reset
  - On what basis are they reset?
    - Experience!
- When t <<N cost cutting v. attractive
- As t $\rightarrow$ N, firm gets ready for Cap review
  - rate of cost decline slips
  - firm mimics a high cost operation
- Trade-off involving time to review
  - Large N favors high powered incentives
  - Small N keeps profits and losses in balance

Earnings sharing (sliding scale) regulation

- Firm keeps all profits until minimum rate of return is achieved
- Firm shares profits for intermediate rates of return
- Firm returns all profits above some maximum rate of return
- Sharing occurs through rebates rather than rate reductions
- Advantage: Provides mix of “cost plus” and “fixed price” contracts
- Disadvantage: Requires as much information as RORR