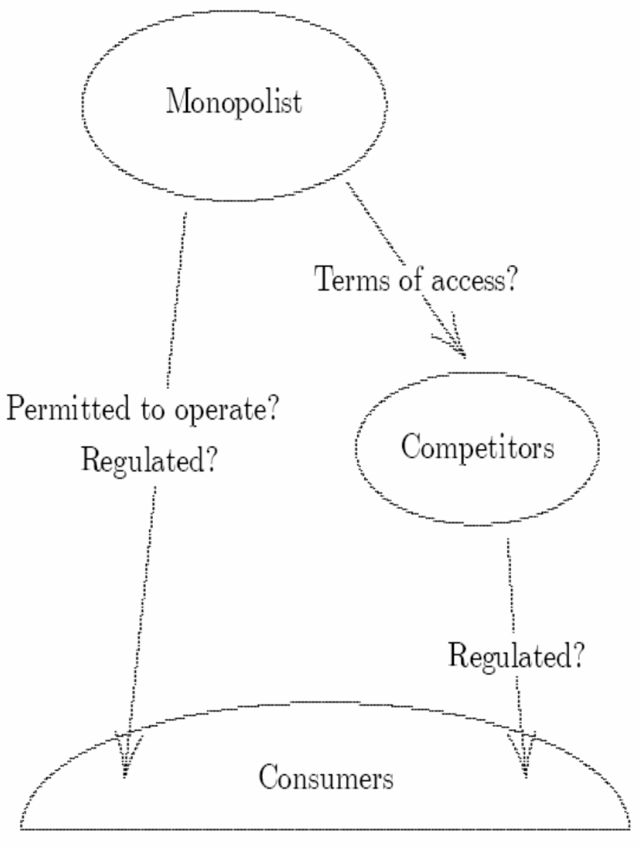
Lecture 5: Access Pricing

Armstrong, Doyle, and Vickers: "The Access Pricing Problem: A Synthesis," *Journal of Industrial Economics*, June 1996

Armstrong and Sappington pp. 93-102

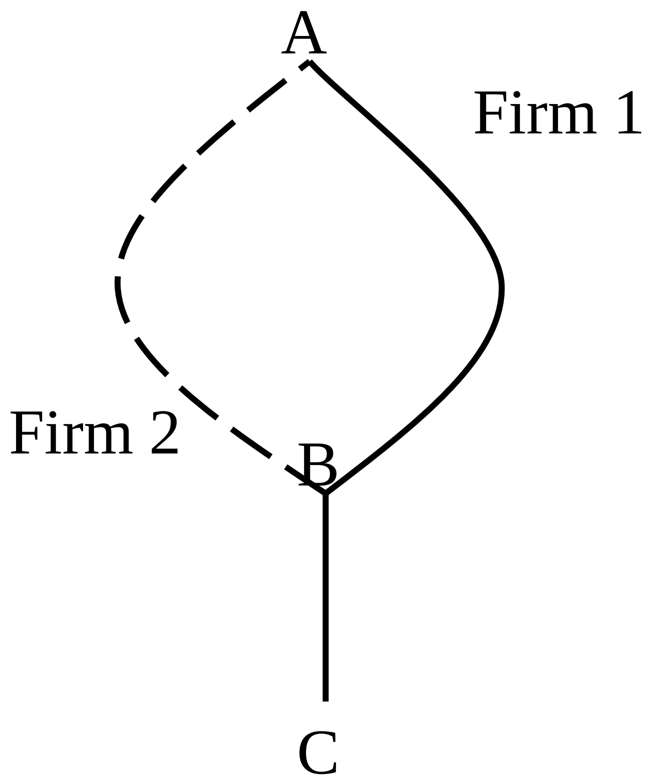
Introduction and Overview

- Traditional, VI monopoly structure replaced by *partial* competition.
  - Natural Monopoly characteristics limited to *upstream*, “bottleneck” stage.
- Examples of bottlenecks:
  - Telecom local exchange
  - Electricity distribution grid
  - Postal delivery network
  - Railroad tracks
  - Airports



Firms often have *access* rights to a competitor's *essential facilities*

- For nearly 100 years *(Terminal RR)*, railroads have been compelled to grant access to bottleneck facilities to competitors.
- Rationale:
  - To facilitate "end-to-end" competition
  - Other components competitive
- Competition in the AC market requires Firm 2 to have access to Firm 1's AC link
- But access at what price?



Modelling Access Regulation
Assumptions that must be made!

- Technology: Costs and Supply
  - Substitutability in production of downstream product: fixed or variable proportions between upstream and downstream products?
  - Is end-to-end “bypass” of the incumbent’s upstream network possible?
  - Do competitors have constant or decreasing returns to scale?
- Preferences: Demand for incumbent’s and competitors downstream products
  - Perfect Substitutes
  - Differentiated Products
- Firm Behavior: How do incumbent and competitors interact? E.g.,
  - Perfect competition
  - Dominant firm price leader
  - Cournot/Bertrand oligopoly

Regulatory assumptions that must be made!

- Goals of the Regulator: e.g.,
  - Total Surplus maximization
  - “Competition max”: i.e., minimizing the incumbent’s downstream market share
  - Productive efficiency: minimizing total costs of end-to-end production
- Instruments available to the Regulator
  - Retail price of incumbent
  - Access (wholesale) price
  - Retail margins
  - “taxes” on downstream output
  - Transfers to incumbent
- Constraints: Is the incumbent’s break-even constraint binding?
  - Ramsey pricing considerations

Basic access pricing problem and ECPR (efficient component pricing rule)

- Simple model:
  - "End-to-end" (AC) price p determined by competition or regulation.
  - Fixed proportions between upstream and downstream components
  - Constant "downstream" (AB) unit costs c_1 and c_2.
  - Upstream unit cost r_1

$$W(p,a,X_1,X_2) = CS(p) + \pi_1 + \pi_2$$

$$\pi_1 = (p - r_1 - c_1)X_1 + (a - r_1)X_2$$

$$\pi_2 = (p - a - c_2)X_2$$

$$\max W \quad s.t. \quad X_1 + X_2 \le D(p)$$

$$L = CS(p) + pD(p) - (r_1 + c_1)X_1 - (r_2 + c_2)X_2 + \lambda(X_1 + X_2 - D(p))$$

$$L_{X_1} = -(r_1 + c_1) + \lambda \le 0; \quad X_1 \ge 0; \quad X_1 L_{X_1} = 0$$

$$L_{X_2} = -(r_2 + c_2) + \lambda \le 0; \quad X_2 \ge 0; \quad X_2 L_{X_2} = 0$$

ECPR implements efficient outcome

- Profit maximization for firm 2:
  - $X_2 > 0$ iff $p \geq c_2 + a$
- Profit maximization for firm 1:
  - $X_1 > 0$ iff $a - r_1 \geq p - c_1 - r_1$
- Taken together, efficiency will be decentralized iff

$$p - c_2 \geq a \geq p - c_1$$

- For efficiency to be achieved for *any* c_2 requires $a = p - c_1$
- This is the Efficient Component Pricing Rule (ECPR)
- Does this have to be regulated? (HINT: Think of monopolist's "make or buy" decision.)

Limitations of basic model

- "All or nothing" character of solution results from:
  - Constant returns
  - Homogeneous products
  - Fixed proportions
- See Armstrong, Doyle, and Vickers (1996) for an analysis that relaxes these assumptions.
- These assumptions also reduce the problem to one of cost efficiency.
- Easy to establish that ECPR is the only way to implement cost minimization in fixed proportions case.

Expanded model

- Assumptions
  - Fixed proportions
  - Homogeneous product
  - Fringe supply: $S_f(p-a)$
- Case 1: Fixed p, maximize surplus wrt a.
- Case 2: Maximize surplus wrt p and a.
- Case 3: Profit max
- Case 4: Maximize surplus wrt p and a subject to a break-even constraint
- Case 5: Regulate mark-up.

$$W = S(p) + \pi^1(p,a) + \pi_f(p-a)$$

$$\pi^1 = (p-c-r)[D(p) - S_f] + (a-r)S_f$$

$$\pi^1_a = (p-c-r)S_f' + S_f - (a-r)S_f'$$

$$W_a = \pi^1_a - S_f = (p-a-c)S_f'$$

$$\pi^1_p = (p-c-r)[D' - S_f']$$

$$+[D - S_f] + (a-r)S_f'$$

$$W_p = \pi^1_p - [D - S_f]$$

$$= (p-c-r)D' - (p-a-c)S_f'$$

Analysis of cases: welfare maximization versus profit maximization

- As long as final price is fixed, efficiency requires ECPR
- Not surprisingly, unconstrained optimization yields marginal cost prices.
- Contrast this to unconstrained monopoly rule for access price.
  - Monopolist sets a>p-c
  - Gives up some cost efficiency to extract monopsony rents from fringe

$$W_a = (p - a - c)S_f' = 0$$

$$\Rightarrow a = p - c \text{ (ECPR)}$$

$$W_p = (p - c - r)D' - (p - a - c)S_f'$$

$$W_p \text{ and } W_a = 0$$

$$\Rightarrow p = c + r; \quad a = r$$

$$\pi_a^1 = 0$$

$$\Rightarrow a = p - c + S_f / S_f'$$

Optimal 2nd-Best Access Pricing Rules

- Ramsey-style rules emerge in the presence of a break-even constraint
- Mark-up m=p-a is related to the elasticity of fringe supply
  - In general, m<c and a> p-c
  - ECPR (m=c) obtains only for perfectly elastic fringe supply
- Given this, the usual inverse elasticity rule obtains for final product price

$$L = W + \lambda \pi^1 = S + \pi_f + (1+\lambda)\pi^1$$

$$L_a = W_a + \lambda \pi_a^1 = (1+\lambda)\pi_a^1 - S_f$$

$$L_a = 0 \Rightarrow (p - a - c) = -\frac{\lambda S_f}{(1+\lambda) S_f^{'}}$$

$$\frac{(m-c)}{m} = -\frac{\lambda}{(1+\lambda)\sigma_f}$$

$$L_p = (1+\lambda)\pi_p^1 - [D - S_f]$$

$$L_p = 0 \Rightarrow$$

$$(p - c - r)D' - (p - a - c)S_f^{'} = -\frac{\lambda [D - S_f]}{(1+\lambda)}$$

$$\frac{(p-c-r)}{p} = -\frac{\lambda D}{(1+\lambda) p D'} = \frac{\lambda}{(1+\lambda)\varepsilon}$$

Mark-up regulation: *m=p-a*

- Optimal monopoly price is unaffected by *m*.
- Mark-up can be independently set to maximize welfare given monopoly pricing downstream.
- Intuitively, requires productive efficiency and ECPR

$$\pi^1(m,p) = (p-c-r)D(p) + (c-m)S_f(m)$$

$$\pi^1_p = D(p) + (p-c-r)D'(p) = 0$$

$$\max_m W = S(p) + \pi_f(m) + \pi^1(m,p)$$

$$\Rightarrow S_f + (c-m)S_f' - S_f = 0 \Rightarrow m^* = c$$

Bypass considerations

- Traditional analysis assumes that there is *no* substitute for the dominant firm's access input.
- Often, however, the dominant firm's access price is regulated even when there are alternative sources of "essential facility" services.
- Now, access pricing must take into account another policy consideration:
  - Provide correct incentives for *facilities based competition.*
- Two ways to model:
  - Add a *vertically integrated fringe* with profits $\Pi_v(p)$; supply $S_v(p)$.
  - Add an *upstream fringe* with profits $\Pi_u(a)$ and supply $S_u(a)$.

Market with upstream bypass: Unconstrained Welfare maximization

$$\pi(p,a) = (p-c)[D(p) - S_f(p-a)]$$

$$+a[S_f(p-a) - S_u(a)] - r[D(p) - S_u(a)]$$

$$= (p-c-r)D - (p-a-c)S_f - (a-r)S_u$$

$$\pi_a = (p-c-a)S'_f + S_f - (a-r)S'_u - S_u$$

$$\pi_p = (p-c-r)D' + D - (p-a-c)S'_f - S_f]$$

$$W = S(p) + \pi(p,a) + \pi_f(p-a) + \pi_u(a)$$

$$W_a = \pi_a - \pi'_f + \pi'_u = (p-a-c)S'_f - (a-r)S'_u$$

$$W_p = -D + \pi_p + \pi'_f = (p-c-r)D' - (p-a-c)S'_f$$

- Retail and wholesale price equal marginal cost: i.e., p=c+r and a=r.
- Access price greater than marginal cost if retail price is greater than c+r

Constrained Welfare maximization with Bypass

$$L = W(p,a) + \lambda\pi(p,a) = S(p) + \pi_f(p-a) + \pi_u(a) + (1+\lambda)\pi(p,a)$$

$$L_a = (1+\lambda)\pi_a - \pi'_f + \pi'_u = (1+\lambda)[(p-a-c)S'_f - (a-r)S'_u] + \lambda[S_f - S_u]$$

$$L_p = -D(p) + (1+\lambda)\pi_p + \pi'_f = (1+\lambda)[(p-c-r)D' - (p-a-c)S'_f] + \lambda[D - S_f]$$

Solving these FONCs yields

$$(a-r) = \frac{-\lambda[S'_f(D-S_f) + (S_f - S_u)(D' - S'_f)]}{(1+\lambda)[D'(S'_f + S'_u) - S'_u S'_f]}$$

$$(p-a-c) = \frac{-\lambda[S'_u(D-S_f) + (S_f - S_u)D']}{(1+\lambda)[D'(S'_f + S'_u) - S'_u S'_f]}$$

Extensions to the basic model

- Differentiated products: I.e., fringe and incumbent’s downstream services are *not* perfect substitutes
  - What is the significance of ECPR in this case?
- Imperfect competition
  - Incumbent and fringe compete a la Cournot or Bertrand.
- Vertical separation; incumbent prevented from participating in downstream market
- Multiple downstream markets
  - Access price discrimination
- Sabotage! (Beard, Kaserman, and Mayo, *JIE* 2001)

"Sabotage" in the basic model

- Incumbent can (costlessly) raise the marginal costs of fringe by engaging in sabotage *s* so that $S_f(p\text{-}a\text{-}s)$.

  I.e., *s* is an access charge "increase" that doesn't generate revenues.
- Incentives for engaging in sabotage depend upon the level of access price.
- If access price is unregulated, there is no incentive to engage in sabotage
- If access price is set at ECPR, there is no incentive to engage in sabotage.

$$\pi^1 = (p-c-r)[D(p) - S_f(p-a-s)] + (a-r)S_f(p-a-s)$$

$$\frac{\partial \pi^1}{\partial s} = (p-c-a)S_f' = \frac{\partial \pi^1}{\partial a} - S_f$$

$$\text{sgn}\left(\frac{\partial \pi^1}{\partial s}\right) = \text{sgn}(p-c-a) \qquad \text{and} \qquad \frac{\partial \pi^1}{\partial a} = 0 \Rightarrow \frac{\partial \pi^1}{\partial s} < 0$$

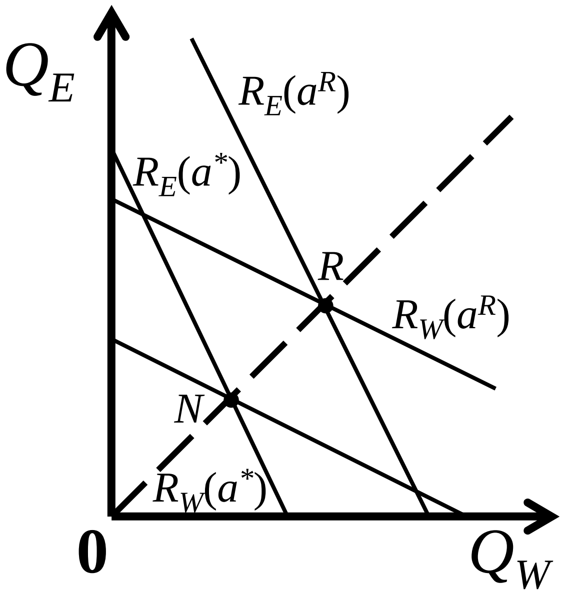
Interconnected networks: competition via negotiated "trackage rights"

- "Eastern" and "Western" railroads propose to introduce *competitive transcontinental service* by selling each other trackage rights.
- Each has marginal costs c per carload hauled over its own tracks.
- Inverse demand function for (directionless) transcontinental traffic $P(Q_E+Q_W)$
- Railroads capacity in carloads.
- Trackage rights granted at reciprocal unit access charge a

Negotiated, or regulated, access rates?

- Access charge increase raises each firm's perceived marginal cost
  - Shifts in their reaction functions
  - Results in lower equilibrium output, higher prices
- Negotiation leads to choice of the access charge that supports monopoly outcome
- Regulation would result in access rate supporting marginal cost pricing outcome
  - Might require negative access rate to achieve $P(Q(a))=2c$
  - Break-even constraint not an issue under symmetry

Analysis of negotiated and regulated access rates



Eq. effects of a

$$\pi_i = [P(Q_i + Q_j) - c - a]Q_i + (a - c)Q_j;\ \ i = E, W$$

$$\frac{\partial \pi_i}{\partial Q_i} = P - c - a + Q_i P' = 0;\ \ \Rightarrow Q_i(a) = Q_j(a)$$

$$\frac{\partial \pi_i}{\partial Q_i} + \frac{\partial \pi_j}{\partial Q_j} = 2(P - c - a) + QP' = 0 \Rightarrow Q(a) = 2Q_i(a)$$

$$Q'(a) = 2/(P' + MR') < 0$$

$$\Pi(a) = \pi_i + \pi_j = [P(Q(a)) - 2c]Q(a) \equiv \pi_I(Q(a))$$

$$\Pi'(a^*) = \pi_I{}'(Q(a^*))Q'(a^*) = 0 \Rightarrow Q(a^*) = \arg\max_Q \pi_I$$

$$\Rightarrow P(Q(a^*)) - 2c = -Q(a^*)P'(Q(a^*))$$

$$\Rightarrow 2a^* = 2c - Q(a^*)P'(Q(a^*)) > 2c$$

$$a^R = \arg\max_a CS[P(Q(a))] + \pi_I(Q(a))$$

$$\Rightarrow P(Q(a^R)) = 2c \Rightarrow 2(a^R - c) = QP'(Q(a^R)) < 0$$

Access Issues in Telecommunications: Introduction and Summary

- Goals of Access Pricing Policy
- Types of Local Exchange Access
- Desirability of Light-Handed Regulation (LHR) of access is limited to situations in which:
  - Access is for complementary (vertically related) products
  - End-to-end price is pegged by
    - Competition
    - Regulation
- Otherwise, letting firms negotiating access terms is like letting firms negotiate price fixing agreements!

What are the Goals of Access Pricing Policy?

- Facilitate end-to-end competition?
- Promote efficiency in competitive (downstream) segments?
- Facilitate product innovation?
- Encourage upstream bypass?
- Promote overall (Ramsey) efficiency?

Access categories (A minute is a minute is a minute?)

- Access categories:
  - Consumers (End Users)
  - Network extension
  - Network Interconnection
  - Originating and terminating
- Access prices can (and should) be different for all types
- Policy objectives vary as well

End User “Access” to the Local Exchange Network

- LHR possible, but not seriously discussed
- Advantages:
  - Efficient price discrimination
    - voice/data
  - Encourage facilities based entry
- Disadvantages:
  - Harm to End-Users
  - Monopoly rents
  - Deadweight loss

Network Extension: e.g., terminating access for international calls

- Classic case of *perfect complements*
- Bilateral bargaining reaches efficiency frontier
- Consumers benefit from:
  - Efficient provision
  - Absence of *double marginalization*
  - Absence of regulatory induced distortions
- Case for regulatory intervention
  - Counteract strategic intervention at “other end”
    - Credible “threat points” can influence bargaining outcomes
    - Bilateral inter governmental bargaining should yield LHR

Network Extension Model

- Demand for originating international calls: $D_i(p_i)$, $i = A, B$
- Costs:
  - Domestic network marginal costs: c_{i}
  - International segment marginal costs: t_i
  - International terminating access charge: a_i
- Profits: $\pi_i(p_i,p_j,a_i,a_j)=(p_i-c_i-t_i-a_j)D_i(p_i)+(a_i-c_i)D_j(p_j)$
- Two stage game, with access charges set first.
  - Define: $p_i^*(a_j)$ = argmax π_i;
    - Comparative statics yields: $\partial p_i^*(a_j)/\partial a_j > 0$.
  - Define first stage payoffs: $\Pi^i(a_i,a_j) = \pi_i(p_i{*}(a_j),p_j^*(a_i),a_i,a_j)$

Analysis of Network Extension model

- Non cooperative choice of terminating access rates results in "double marginalization"
  - Consumer prices above monopoly levels
- Joint profit-maximization yields marginal cost access charges
  - But, requires side payments if demands are "unbalanced"
- Suppose country *i* regulated to earn target profit level. What does country *j* do?

$$\frac{\partial \Pi^i}{\partial a_i} = D_j + (a_i - c_i) D_j' \frac{\partial p_j^*}{\partial a_i} = 0; \quad \Rightarrow (a_i - c_i) > 0$$

$$\Pi(a_i, a_j) = \Pi^i + \Pi^j = [p_i^*(a_j) - c_i - t_i - c_j] D_i(p_i^*(a_j)) + [p_j^*(a_i) - c_i - t_j - c_j] D_j(p_j^*(a_i))$$

$$\frac{\partial \Pi}{\partial a_i} = \left\{ D_j(p_j^*(a_i)) + [p_j^*(a_i) - c_i - t_j - c_j] D_j'(p_j^*(a_i)) \right\} \frac{\partial p_j^*}{\partial a_i} = 0$$

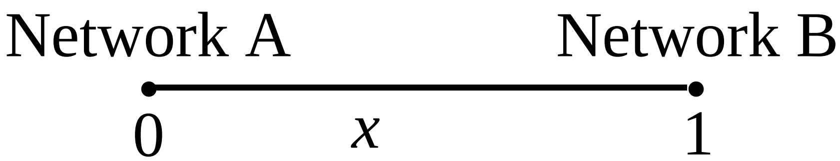
$$\Rightarrow \frac{\partial \pi_j}{\partial p_j} + (a_i - c_i) D_j'(p_j^*(a_i)) = 0; \quad \Rightarrow (a_i - c_i) = 0$$

Network Interconnection

- Both *horizontal* and *vertical* interaction
  - Networks are *rivals* competing for customers
  - Networks are *partners* in offering expanded services through interconnection.
- Problems with LHR:
  - Rivals may find it optimal *not* to interconnect
  - Bilateral negotiation of interconnection charge can be used to approach collusive outcome
  - Consumers an unrepresented "third party" to interconnection negotiations
  - No reason to expect negotiated outcomes to be in the public interest in the absence of competitive end-to-end market

Complications of interconnection models in telecommunications

- Customers choose network, then choose call volume
- Literature models network competition a la Hotelling: e.g.,
  - Laffont, Rey, and Tirole, *RAND* 1998
  - Armstrong, *Economic Journal* 1998
- But, models *very* special, and Hotelling framework gives rise to problems with existence of 2nd stage equilibrium



$$u_i = v(p_i);\;\; i = A, B$$

$$u_A + \alpha x^* = u_B + (1-\alpha)x^*$$

$$s_A = x^* = \frac{1}{2} + \frac{u_A - u_B}{2\alpha}$$