Deregulating Network Industries: Dealing with Price-Quality Tradeoffs

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Problem

There is consensus that deregulating network industries may bring about considerable welfare gains. Yet, the recent experience with deregulation is mixed.

Concern:
Deregulating an integrated monopoly is likely to lead to a *degradation of infrastructure quality* (e.g., Railtrack, Californian electric power).

Natural Questions:

- Do regulatory authorities face a *price-quality tradeoff* when deregulating network industries?
- Under what conditions will deregulation lead to a degradation of infrastructure quality or even welfare losses?

Related Literature

Provision of Quality under Integrated Monopoly:
The quality level provided by a profit-maximizing monopolist will generally deviate from the socially optimal level (Spence 1975, 1977).

Provision of Quality in Network Industries:
The provision of infrastructure quality in network industries is not very well understood:

- Institutional and regulatory details have subtle effects on investment incentives.
- Under bilateral monopoly, the incentives to invest in infrastructure quality are *smaller under vertical separation than under integration*, although there are counter-examples (Buehler et al. 2004).

Analytical Framework:
There is no canonical model to analyze investment incentives in network industries.

This Paper

Goes beyond the case of bilateral monopoly and extends previous research along the following dimensions: It ...

- ... examines the case of *liberalization* (plus integration and separation).
- ... allows for *varying degrees of (imperfect) downstream competition*.
- ... provides a *welfare analysis* dealing with potential price-quality tradeoffs.

Main Results:

1. Deregulating an integrated monopoly cannot simultaneously reduce the retail price and increase infrastructure quality.
2. There is scope for welfare-improving deregulation.
3. The realization of welfare gains crucially relies on the choice of the access charge.

Analytical Framework

General Setting:

- Consider an industry providing its final product using a network infrastructure.
- A provider of the final product must have network access.
- 1:1 technology.

Notation:

- $D(p, \theta)$ denotes demand for the final product, where $p \geq 0$ is the retail price and $\theta \geq 0$ is infrastructure quality.
- θ is observable but non-contractible (as in Laffont and Tirole 1993).
- $n \geq 1$ is the number of firms operating in the downstream market.
- $a \geq 0$ is the regulated access charge.

Assumptions

Assumption 1. The demand for the final product, $D(p, \theta)$, is twice continuously differentiable and satisfies $D_p(p, \theta) < 0$ and $D_\theta(p, \theta) > 0$. Let $P(q, \theta)$ denote inverse demand, with $P_Q(Q, \theta) < 0$ and $P_\theta(Q, \theta) > 0$.

Assumption 2. The revenue function satisfies

$$R_{p\theta}(p, \theta) = D_\theta(p, \theta) + pD_{p\theta}(p, \theta) \geq 0$$

for all (p, θ).

Assumption 3. Producing the quality level θ costs $K(\theta)$, with $K'(\theta) > 0$, $K''(\theta) > 0$, and $K'(0) = 0$.

The Regulator's Instruments

Market Structure Regulation:
The regulator may determine the preferred market configuration ρ, i.e.,

- the intensity of downstream competition (the number of downstream firms n),
- whether to break up the integrated monopoly.

Note: By selecting a market configuration ρ, the regulator chooses a *menu of feasible price-quality bundles*.

Access Charge Regulation:
By determining the level of the access charge a, the regulator selects a *particular* price-quality bundle from the menu.
Note: In an ideal world, this bundle would be chosen to maximize social welfare (contingent on the market configuration).

Welfare Optimum (Benchmark)

Let

$$W(p,\theta) = \int_p^\infty D(\tilde{p},\theta)d\tilde{p} + pD(p,\theta) - K(\theta)$$

denote the **social welfare function**.

The welfare-maximizing price quality bundle (p^*, θ^*) solves

$$W_p = pD_p \leq 0$$

$$W_\theta = \int_p^\infty D_\theta d\tilde{p} + pD_\theta - K' \leq 0.$$

- The welfare-maximizing price p^* is zero, as the marginal cost of output is zero.
- The socially optimal level θ^* is strictly larger than zero.

Vertical Integration

Under vertical integration ($\rho = I$), the monopolist solves

$$\max_{Q,\theta} \quad \pi(Q,\theta) = QP(Q,\theta) - K(\theta).$$

Assuming an interior solution, the integrated monopolist's choices p^I and θ^I solve

$$\pi_Q = P + QP_Q = 0$$
$$\pi_\theta = QP_\theta - K' = 0.$$

- For given θ, the retail price p^I is strictly larger than zero, causing the output to fall short of the optimal output.
- The equilibrium quality level θ^I is strictly larger than zero.

Vertical Separation (1)

Under vertical separation with n downstream firms competing à la Cournot $(\rho = S(n))$, firms play a **sequential game**.

Second Stage: Each downstream firm i chooses its output so as to

$$\max_{q_i} \quad \pi^D(q_i, Q_{-i}; \theta, a, n) = q_i \left(P(Q, \theta) - a\right),$$

where $Q_{-i} = \sum_{j \neq i} q_j$ is the sum of the competitors' outputs and $Q = q_i + Q_{-i}$ denotes aggregate output. The first-order condition is given by

$$\pi^D_{q_i} = (P - a) + q_i P_Q = 0.$$

Applying symmetry and letting $q^D(\theta; a, n)$ denote each downstream firm's equilibrium output (given quality level θ), aggregate output is given by $Q^D(\theta; a, n) = nq^D(\theta; a, n)$.

Vertical Separation (2)

First Stage: The upstream network monopolist chooses quality θ so as to

$$\max_{\theta} \quad \pi^U(\theta; a, n) = anq^D(\theta; a, n) - K(\theta).$$

At an interior solution, the monopolist's choice of quality as a function of a and n solves

$$\pi^U_\theta = anq^D_\theta - K' = 0.$$

Let $(p^{S(n)}, \theta^{S(n)})$ denote the equilibrium price-quality bundle attained under vertical separation.

Note: The equilibrium values $(p^{S(n)}, \theta^{S(n)})$ are functions of the (exogenous) access charge a. That is, the choice of a is crucial for comparing (p^I, θ^I) and $(p^{S(n)}, \theta^{S(n)})$.

Liberalization

Under liberalization with n downstream firms $(\rho = L(n))$, the integrated network monopolist competes with $n-1$ downstream firms.

Second Stage: As under separation.

First Stage: The integrated upstream monopolist selects θ so as to

$$\max_{\theta} \quad \pi^U(\theta; a, n) = P(Q, \theta) q_1^D + a Q_{-1}^D(\theta; a, n) - K(\theta),$$

where $Q_{-1}^D(\theta; a, n) = (n-1) q_{-1}^D(\theta; a, n)$ denotes the output of the firms operating at the downstream market only. The FOC is given by

$$\pi_\theta^U = \left(P_Q \left[(n-1) \frac{\partial q_{-1}^D}{\partial \theta} \right] + P_\theta \right) q_1^D + a(n-1) \frac{\partial q_{-1}^D}{\partial \theta} - K' = 0.$$

Let $(p^{L(n)}, \theta^{L(n)})$ denote the resulting equilibrium price-quality bundle.

Price-Quality Tradeoffs (1)

Proposition 1. *Suppose Assumptions 1-3 hold. Further assume that* $dp/dn \leq 0$ *and* $d\theta/dn \geq 0$ *under* $\rho \in \{S(n), L(n)\}, n \geq 1$. *Then a price-quality bundle* (p', θ'), *such that* $p' \leq p^I$ *and* $\theta' \geq \theta^I$, *with at least one inequality being strict, is not feasible under* $\rho \in \{S(n), L(n)\}$ *for* $n \geq 1$.

Implication: Deregulating an integrated monopoly cannot simultaneously reduce the retail price and increase infrastructure quality. That is, price reductions must come at the cost of sacrificing infrastructure quality (or vice versa).

Price-Quality Tradeoffs (2)

Proof of Proposition 1 (Sketch):

- With $n \longrightarrow \infty$, the network provider's revenues are given by $\widetilde{R}(\theta; a) \equiv aD(\theta; a)$.
- Differentiating yields $\widetilde{R}_{a\theta} = D_\theta + aD_{a\theta} \geq 0$, which is nonnegative by [A2].
- Perfect competition thus replicates (p^I, θ^I) for $p^I = a$, but cannot yield improvements in both dimensions.
- The claim follows from $dp/dn \leq 0$ and $d\theta/dn \geq 0$.

Welfare Effects of Deregulation (1)

Proposition 2. *Suppose Assumptions 1-3 hold. Consider regime* $\rho \in \{S(n), L(n)\}, n \geq 1$, *where the access charge* a *is such that the resulting price-quality bundle is* (p, θ). *Then marginally* ***decreasing the access charge*** *increases welfare if and only if*

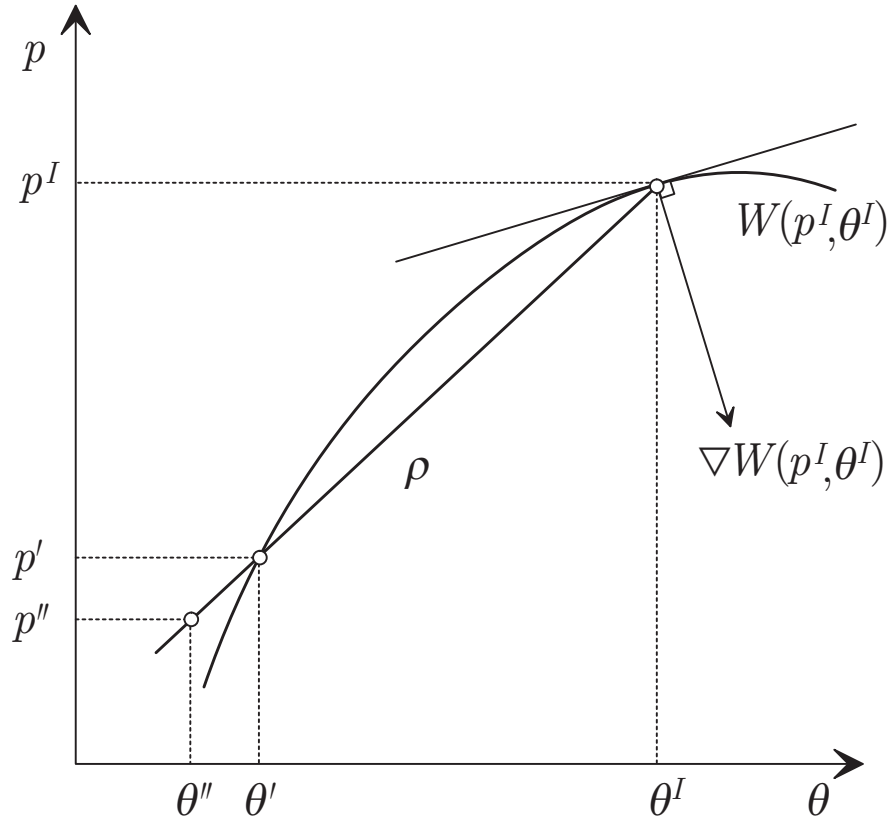
$$\left.\frac{dp}{d\theta}\right|^{\rho}_{(p,\theta)} > \left.\frac{dp}{d\theta}\right|^{W}_{(p,\theta)},$$

where

$$\left.\frac{dp}{d\theta}\right|^{W}_{(p,\theta)} \equiv -\frac{W_\theta}{W_p} = -\frac{\int_p^\infty D_\theta d\tilde{p} + pD_\theta - K'}{pD_p}.$$

Implication: Starting from an access charge resulting in (p, θ) under regime ρ, marginally reducing the access charge increases welfare iff the slope of the menu of feasible price-quality bundles ρ is larger than the slope of the welfare function.

Welfare Effects of Deregulation (2)



Welfare Effects of Deregulation (3)

Relevance of Proposition 2:

Useful for answering the question of whether there is scope for welfare-improving deregulation.

A Note of Caution:

- Proposition 2 can be used to evaluate the welfare effects of deregulation only *for regimes capable of reproducing* (p^I, θ^I).
- Analyzing the welfare effects of changes in access charges *within a given market configuration* is always possible.

Large Changes in Access Charges

Proposition 3. *Consider regime* $\rho \in \{S(n), L(n)\}, n \geq 1$, *where the access charge* a *is such that the resulting price-quality bundle is* (p, θ). *Suppose Assumptions 1-3 hold and marginally decreasing the access charge increases welfare. Then* ***decreasing the access charge*** *by a non-infinitesimal amount may reduce welfare.*

Implication: There is a risk of setting the access charge too low: Even if there is scope for improving welfare by reducing the access charge, reducing it by a large amount may yield welfare losses.

Intuition: Reducing the access charge discourages investment in network quality.

Linear Demand Model (1)

Suppose demand is given by

$$D(p, \theta) = \alpha - \beta p + \theta, \quad \alpha > 0, \beta > \tfrac{1}{2},$$

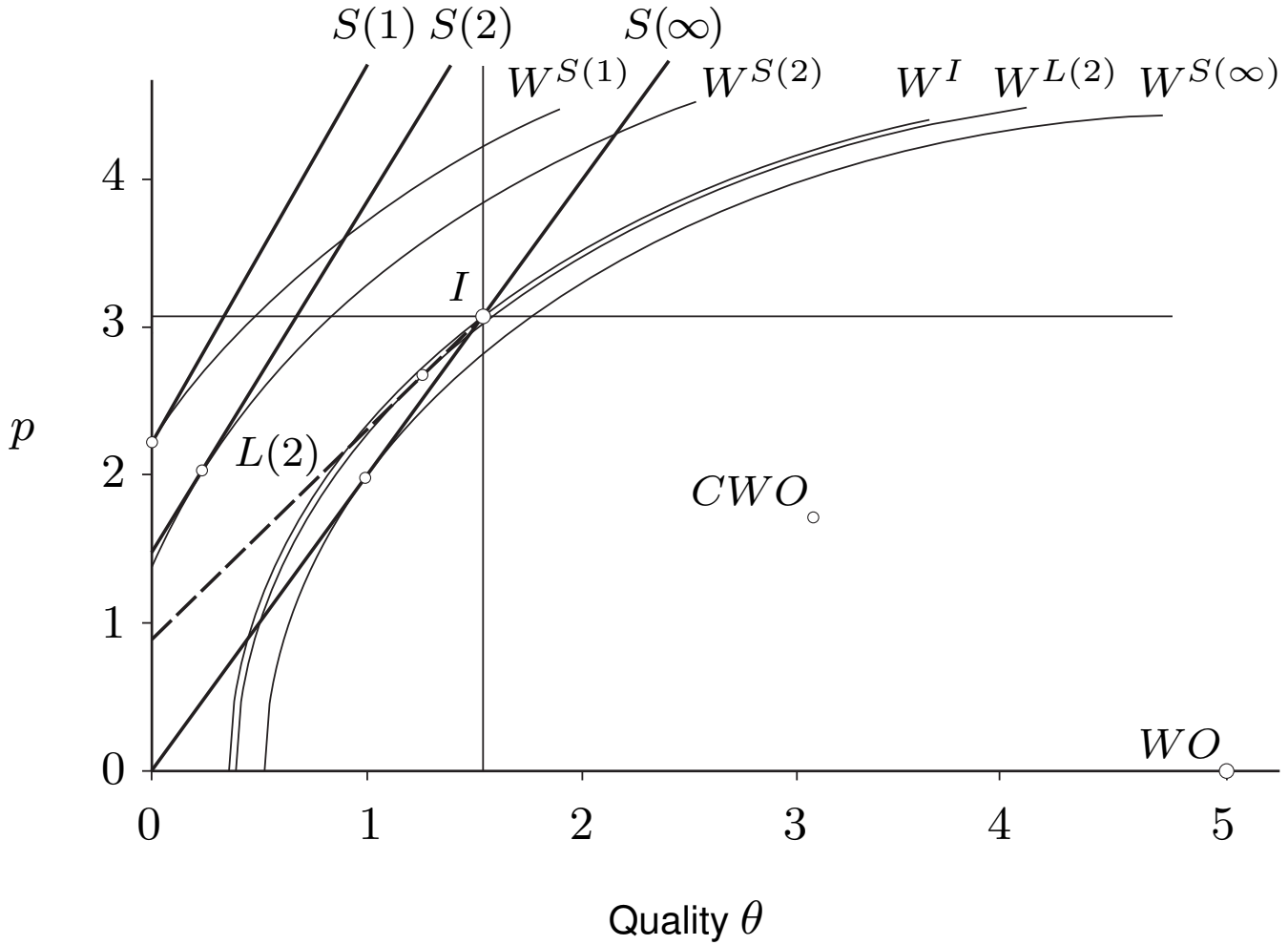
where α and β are exogenous parameters.

(Note: The linear demand model satisfies Assumptions 1-3.)

Advantage:
Closed-form solutions for p and θ.

In this presentation:
Graphical analysis.

Linear Demand Model (2)



Linear Demand Model (3)

Result 1. *A bundle* (p', θ') *such that* $p' \leq p^I$ *and* $\theta' \geq \theta^I$*, with at least only inequality being strict, is not feasible. For improvements in one dimension only, the following results hold:*

(i) ***Increasing quality*** *to any* $\theta' > \theta^I$ *is feasible under* $\rho = S(n), n \geq 2$ *only, and it comes at the cost of increasing the retail price to some* $p' > p^I$*.*

(ii) ***Reducing the retail price*** *to* $p' < p^I$ *is feasible for* $S(n), n \geq 1$ *and* $L(n), n \geq 2$*, but it comes at the cost of reducing quality to* $\theta' < \theta^I$*.*

Note: Liberalization will perform better than separation when deregulation aims at reducing retail prices (see Figure).

Linear Demand Model (4)

Result 2. *In the linear demand model, there is* ***scope for welfare-improving deregulation****. In particular, for suitable access charges, restructuring from* I *to* $L(2)$ *or* $S(\infty)$ *improves welfare.*

Result 3. *In the linear demand model, setting the access charge too low may reduce welfare relative to* $W(p^I, \theta^I)$*.*

Note: The linear demand model suggests that regulatory authorities have a lot of leeway when reducing the access charge.

Extensions and Limitations

Non-price Discrimination of Downstream Rivals:
The integrated monopolist may have incentives to discriminate against non-integrated downstream rivals ('**sabotage**', see, e.g., Economides 1998 and Weisman and Kang 2001).

- **Cost-Increasing Sabotage:** Does not affect our findings (see, e.g., Mandy and Sappington, forthcoming).
- **Demand-Reducing Sabotage:** Unclear.
  $\longrightarrow$ interesting subject for future research.

Downstream Quality:
Downstream firms may contribute to the provision of quality.
$\longrightarrow$ interesting subject for future research.

Conclusion

Key Findings:

- Deregulating an integrated monopoly **cannot simultaneously reduce the retail price and increase infrastructure quality**.
- There is **scope for welfare-improving deregulation**. Both liberalization and separation are capable of generating welfare improvements by trading off lower network quality against lower retail prices in a socially desirable way.
- The realization of welfare gains crucially relies on the choice of the **access charge**.

Policy Implication

If quality is contractible, regulators should consider the regulation of quality as a real alternative.