Optimal Regulation of Lumpy Investments

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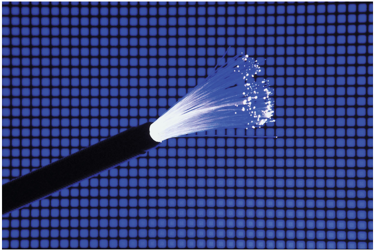
The problem



New network investment

- Need for large, one-off (lumpy) network upgrades
- to meet uncertain future demand

How to ensure optimal timing?

- Debate: strict price caps (efficiency)
- versus rents (investments)

Our aim

Real option theory

Investment under uncertainty

(Dixit & Pindyck, 1993)

Optimal regulation

Mechanism design

(Laffont & Tirole, 1993)

Optimal timing under uncertainty: Real options

higher demand

break-even demand

lower demand

invest now versus invest later

The value of waiting

Waiting with investment means preserving a valuable option

- Optimal investment delayed, take into account opportunity costs of option value
- McDonald-Siegel (1984), Dixit-Pindyck (1993)
- but monopolist: waits too long!

The regulator's two problems

1. make sure the monopolist invests at right moment
2. make sure that monopolist does not charge too much

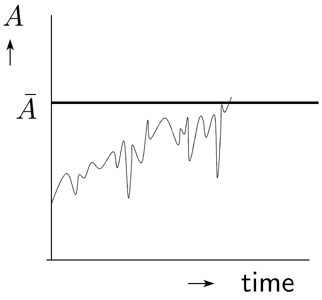
What is the optimal regulation?

- allowing monopolist to break even, at least

Mechanism design question!

Model

- Single lumpy investment (cost c)
- stochastic demand A



- with elasticity $\eta \Rightarrow$ measures deadweight loss

First-best: a benchmark

1. Set $p =$ marginal costs
2. Choose social surplus optimizing demand level $\bar{A}$ at which to invest:
    - Solve for the real options problem of finding the optimal investment threshold $\bar{A}$

    $$\bar{A}^{fb} > \text{breakeven value}$$

    (Delay grows as volatility grows.)
3. Instruct the monopolist to invest when demand $= \bar{A}^{fb}$

Second-best: monopolist has to recover costs

- make sure expected revenues cover monopolist's investment cost: $p > 0$
- but this reduces surplus upon investment (dead-weight loss)
- so optimal investment delayed

Choose demand level $\bar{A}$ and p jointly to maximize utility subject to $\Pi(\bar{A}, p) = c$:

$$\bar{A}^{sb} = \frac{\bar{A}^{fb}}{1 - \eta}$$

Note:

The regulator optimally sets both $\bar{A}$ and p
Setting only p delays investment (Dobbs, 2004)

Adverse selection

We now introduce asymmetric information on investment costs

- $c \in [c_L, c_H]$ with distribution $F(c)$

Second best is not incentive compatible

Recall second-best:

- higher costs means investment further delayed (i.e. higher $\bar{A}$)
- and higher revenues to compensate higher costs

Also attractive to low cost firms...

- So all firms have incentive to claim they have high costs

How to induce truth-telling?

Solution: pay people to tell the truth

- offer higher reward (higher price) for low cost types

But high prices are costly too: deadweight loss

Solution (continued):

- excessively delay high cost types' investment
- so that low cost firms prefer high price now to lower price (but greater demand) later

But this distorts high cost types' investment timing...

Optimal regulation: the trade-off

- higher reward p for low cost firms creates dead-weight loss
- higher $\bar{A}$ (delay) for high cost firms is inefficient

The optimization

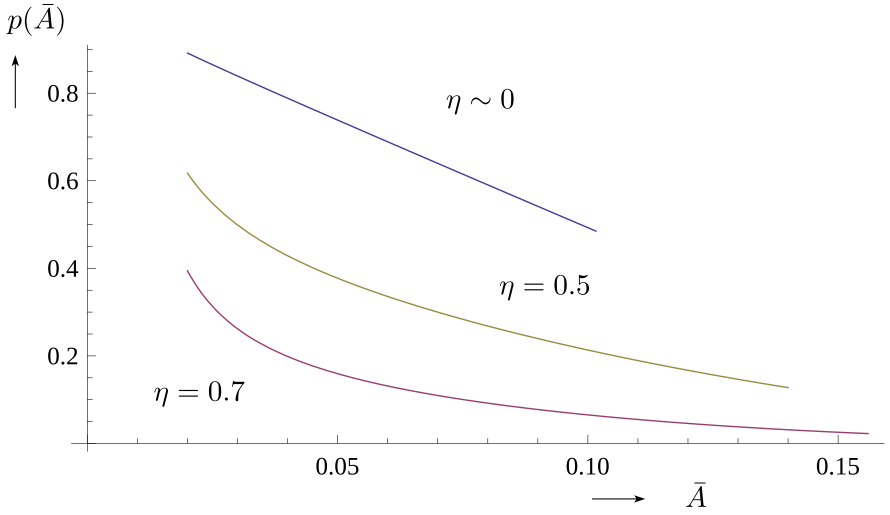
$$\max_{p(c),\bar{A}(c)} \underbrace{\mathbf{E}_c\mathbf{E}_{A(t)}}_{\text{expectation}} \left[\underbrace{V(p(c),\bar{A}(c))}_{\text{discounted cons surplus}} + \underbrace{\Pi(p(c),\bar{A}(c),c)}_{\text{discounted profits}} \right]$$

subject to incentive compatibility:

$$\text{condition on } \frac{d\Pi}{dc}$$

Optimal control problem!

Optimal regulation: Example Uniform distribution



Concluding remarks

If we worry about investment delay in network infrastructure

- instruct monopolist when to invest
- or give him the incentives to invest in timely manner!