# Lecture 4: Incentive Regulation

Reading: Armstrong and Sappington "Recent Developments in the Theory of Regulation" pp. 3-72

(Chapter in vol. 3 of HB of IO)

# Regulatory Problem
# (Bayesian Approach)

To induce the regulated firm to produce

- The socially optimal level of output
- At lowest possible cost

Informational Constraints

- Moral hazard
  Unobservable “effort” affects costs
- Adverse Selection
  Firm knows more about cost than regulator

# Equivalent Model Structures

Revelation Principle Approach

- Regulator sets a payoff schedule T(θ)
- Firm:
  - Learns cost parameter
  - "Reports" θ (receives) permission to produce)
  - Produces output
  - Receives T(θ)

Menu of Contracts Approach

- Regulator offers a choice of cost-sharing contracts
- Firm:
  - Learns cost parameter
  - Chooses contract
  - Produces output
  - Receives payment

# Procurement-style model (Laffont and Tirole)

Design incentive scheme to maximize social welfare

- Single, fixed size, public project
- Value of project to consumers = $S$ (gross surplus)

Cost: $C = \beta - e$

- $e$: Manager's Effort (unobservable, can't contract on it)
- $\beta$: Technological efficiency parameter, private information

Regulatory Instruments:

$C$ : regulator reimburses firm for costs incurred (audited, verifiable)

$t$ : net monetary transfer to the firm (in addition to $C$)

Regulator sers "price" as

$P = C + t = C + (a - bC)$ where $b \in [0,1]$

Polar cases:

$b = 0$ is "low-powered"

firm bears none of its costs (like "cost plus")

$b = 1$ is "high-powered"

firm is residual claimant on cost savings (like "pure" price cap)

Questions: Optimal $a$?? Efficiency incentive? Size of rents going to firm?

# Welfare

Firm's Utility: $U = t - \psi(e)$

$\psi(e) =$ firm's disutility of effort

Individual Rationality: $t - \psi(e) \geq 0$

$\psi(0) = 0$ $\quad \lim_{e \to \beta} \psi(e) = \infty$

$\psi'(e) > 0$ $\quad \psi''(e) > 0$

Net surplus for consumers/taxpayers: $S - (1+\lambda)(t + \beta - e)$

Shadow price of public funds: $(1+\lambda)$

Cost: $(t + \beta - e)$

Social Welfare: $W = S - (1+\lambda)(t + \beta - e) + (t - \psi(e))$

cost to taxpayers — firm's utility

$$W = S - (1+\lambda)(\beta - e + \psi(e)) - \lambda U$$

Assume regulator is a Stackelberg leader

makes take-it-or-leave-it offer to the firm.

# Complete Information

Regulator chooses $(U, e)$, or, equivalently $(t, C)$) to solve

$$\max_{U,e} \; W = S - (1+\lambda)(\beta - e + \psi(e)) \text{ -}\lambda U \quad \text{subject to } U \geq 0.$$

$$L = S - (1+\lambda)(\beta - e + \psi(e)) \text{ -}\lambda U + \gamma U$$

$$L_U = \text{-}\lambda + \gamma \leq 0, \qquad UL_U = 0, \quad U \geq 0$$

$$L_\gamma = U \geq 0, \qquad \gamma L_\gamma = 0, \quad \gamma \geq 0$$

Know that at an optimum $U = 0$.
If $U > 0$, $L_U = 0 \Rightarrow \gamma < 0$. But K-T conditions require that $\gamma > 0$.

$$L_e = -(1+\lambda)(-1+\psi'(e)) = 0 \;\; \text{(when } e > 0) \Rightarrow \psi'(e) = 1$$

At first best: get level of effort $e^*$: $\psi'(e) = 1$ defines $e^*$
$U = 0$ (no rent for the firm)
first best transfer is $t = \psi(e^*)$

## Implementation (with Complete Information)

Many possible contracts that lead to $\psi'(e) = 1$ and $U = 0$

Example: Regulator gives firm $t = \psi(e^*)$
and requires $e^*$ (or, equivalently, sets cost target $C^* = \beta - e^*$)
If the firm accepts this contract and exerts $e < e^*$, it pays large penalty.

Example: Regulator offers firm a fixed price contract.
$t(C) = a - (C - C^*)$, where $a = \psi(e^*)$ and $C^* = \beta - e^*$

Here the firm is the residual claimant on its cost savings
$U = t(C) - \psi(e) = \psi(e^*) - (\beta - e - \beta + e^*) - \psi(e)$

$\max_e U = [\psi(e^*) - e^*] + e - \psi(e) \Rightarrow \psi'(e) = 1$

Firm chooses $e^*$, receives $U = 0$.

# Incomplete Information

Regulator observes $C$, but cannot observe $e$.
Common knowledge: Two types of firms, low cost $\underline{\beta}$ and high cost $\bar{\beta}$.
Define $\Delta\beta = \bar{\beta} - \underline{\beta}$.

Regulator offers contract based on jointly observable variables $C$ and $t$
Regulator observes $C$, makes net transfer payment $t$ to the firm.

contract intended for low cost type: $t(\underline{\beta}),\ C(\underline{\beta})$ notation: $\underline{t},\ \underline{C}$

contract intended for high cost type: $t(\bar{\beta}),\ C(\bar{\beta})$ notation: $\bar{t},\ \bar{C}$

Incentive Compatibility: $\underline{t} - \psi(\underline{\beta} - \underline{C}) \geq \bar{t} - \psi(\underline{\beta} - \bar{C})$ Eq 1

$\bar{t} - \psi(\bar{\beta} - \bar{C}) \geq \underline{t} - \psi(\bar{\beta} - \underline{C})$ Eq 2

Observation: IC requires that C($\beta$) is nondecreasing in $\beta$
Add 1 and 2: $\psi(\underline{\beta} - \bar{C}) + \psi(\bar{\beta} - \underline{C}) - \psi(\underline{\beta} - \underline{C}) - \psi(\bar{\beta} - \bar{C}) > 0$ Eq 3

Eq 3 rewritten: $\int_{\underline{C}}^{\bar{C}} \int_{\underline{\beta}}^{\bar{\beta}} \psi''(\beta - C)\, d\beta\, dC \geq 0$ Eq 4

When $\psi'' > 0$, then $\bar{\beta} > \underline{\beta} \Rightarrow \bar{C} > \underline{C}$ Eq 5

# Incomplete Information, continued…

Individual rationality: $\underline{U} \geq 0$ Eq 6 and $\bar{U} \geq 0$ Eq 7

Observation: Can ignore Eq 6.

$$\underline{U} = \underline{t} - \psi(\underline{\beta} - \underline{C}) \geq \bar{t} - \psi(\underline{\beta} - \bar{C}) \geq \psi(\bar{\beta} - \bar{C}) - \psi(\underline{\beta} - \bar{C}) \geq 0$$

(def) (IC low type) (IR high type) $(\psi' > 0)$

Ex Post Social Welfare when firm is of Type $\beta$:

$$W(\beta) = S - (1+\lambda)[t(\beta) + C(\beta)] + [t(\beta) - \psi(\beta - C(\beta)]$$

cost to taxpayers firm's utility

or

$$W(\beta) = S - (1+\lambda)[C(\beta) + \psi(\beta - C)] - \lambda U(\beta) \qquad \text{Eq 8}$$

Regulator's Prior on Firm Type: $\nu = \Pr(\beta = \underline{\beta})$

## Regulator's Problem

Design contracts to

$$\max_{\underline{C},\bar{C},\underline{U},\bar{U}} EW = (S-(1+\lambda)[\underline{C}+\psi(\underline{\beta}-\underline{C})] \text{ -}\lambda\underline{U}\}$$

$$+(1-\nu)\{(S-(1+\lambda)[\bar{C}+\psi(\bar{\beta}-\bar{C})] \text{ -}\lambda\bar{U}\}$$

Incentive Compatibility: $\underline{t}-\psi(\underline{\beta}-\underline{C}) \geq \bar{t}-\psi(\underline{\beta}-\bar{C})$ Eq 1

$\bar{t}-\psi(\bar{\beta}-\bar{C}) \geq \underline{t}-\psi(\bar{\beta}-\underline{C})$ Eq 2

Individual Rationality for Inefficient Firm: $\bar{U} > 0$ Eq 7

# Regulator's Problem: Solution Technique

Expect IC on efficient type (Eq 1)
and IR for inefficient type (Eq 7) to be binding.

Solve assuming these constraints are binding.
Then show that IC for inefficient type (Eq 2) is satisfied.

Consider IC on efficient type:

$$\underline{U} \geq \bar{t} - \psi(\underline{\beta} - \bar{C}) = \bar{t} - \psi(\bar{\beta} - \bar{C}) + \psi(\bar{\beta} - \bar{C}) - \psi(\underline{\beta} - \bar{C})$$

$$= \bar{U} + \psi(\bar{\beta} - \bar{C}) - \psi(\underline{\beta} + \bar{\beta} - \bar{\beta} - \bar{C})$$

$$= \bar{U} + \underbrace{\psi(\bar{e}) - \psi(\bar{e} - \Delta\beta)}_{\phi(\bar{e})}$$

$$\underline{U} \geq \bar{U} + \phi(\bar{e}) \qquad \text{Eq 10}$$

$\phi(\bar{e})$ is the informational rent accruing to the firm
with the more efficient technology.
Since $\phi(\bar{e}) > 0$, IR for efficient type not binding.

# Regulator's Problem - Restated

Design contracts to

$$\max_{\underline{C},\overline{C},\underline{U},\overline{U}} EW = \nu\{S-(1+\lambda)[\underline{C}+\psi(\underline{\beta}-\underline{C})] \text{ -}\lambda \overbrace{\underline{U}}^{\phi(\bar{\beta}-\bar{C})}\}$$

$$+(1-\nu)\{(S-(1+\lambda)[\overline{C}+\psi(\overline{\beta}-\overline{C})] \text{ -}\lambda \overbrace{\overline{U}}^{zero}\}$$

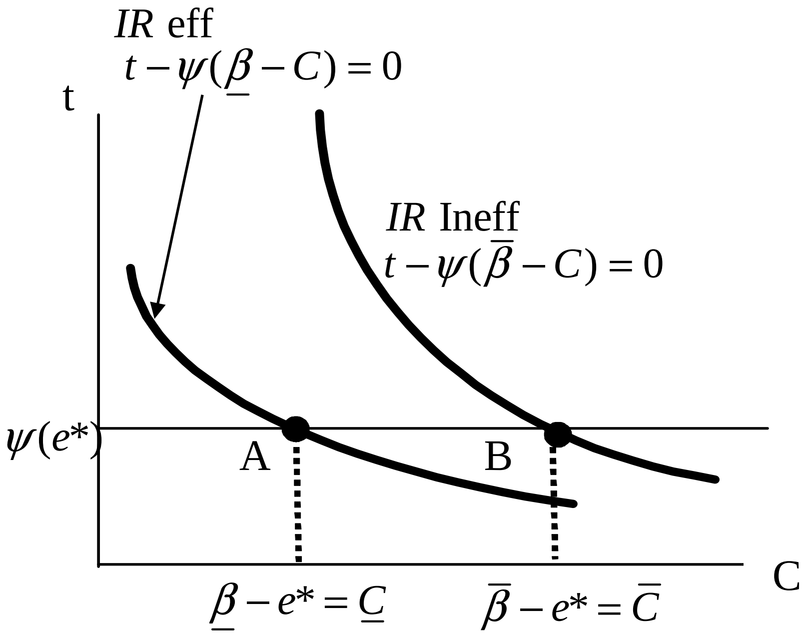
$$\frac{\partial EW}{\partial \underline{C}} = 0 \Rightarrow \psi'(\underline{\beta}-\underline{C}) = 1 \Rightarrow \underline{e} = e^*$$

Low cost firm: Efficient level of effort, and positive rent $\phi(\overline{e})$

$$\frac{\partial EW}{\partial \overline{C}} = 0 \Rightarrow \psi'(\overline{\beta}-\overline{C}) = 1-\left(\frac{\lambda}{1+\lambda}\right)\left(\frac{\nu}{1-\nu}\right)\phi'(\overline{\beta}-\overline{C}) < 1 \Rightarrow \overline{e} < e^*$$

High cost firm: Inefficiently low level of effort, and no rent.

# Optimal Contracts: Complete information




Indifference curve for firm of type $\beta$:

$U^0=t-\psi(\beta-C)$

$\frac{dt}{dC}=-\psi'(\beta-C)<0$ negative slope

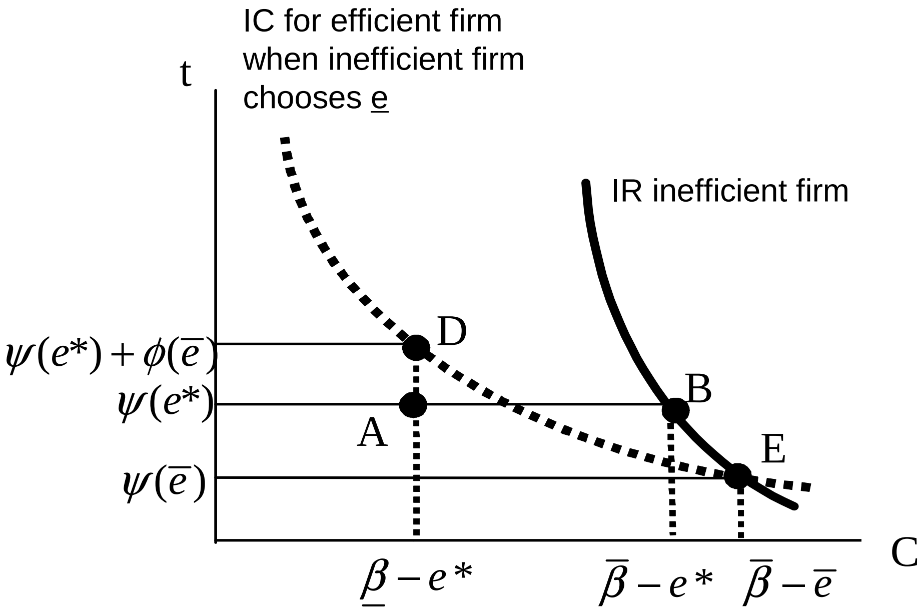
$\frac{d^2t}{dC^2}=\psi''(\beta-C)>0$ convex

With complete information: regulator offers inefficient firm ($\psi$(e*),$\overline{\beta}-e^*$), firm chooses B
regulator offers efficient firm ($\psi$(e*),$\underline{\beta}-e^*$), firm chooses A

Since the regulator know the firm's type, an efficient firm cannot imitate inefficient type.

Suppose regulator offers both firms the same two contracts with asymmetric information.
Both types prefer ($\psi$(e*),$\overline{\beta}-e^*$).
The contract is not incentive compatible.
The efficient firm takes the contract intended for the inefficent firm.

# Optimal Contracts: Incomplete information




Incentive compatibility constraint, efficient firm:

$\underline{U} = \bar{U} + \phi(\bar{e})$

$t - \psi(\bar{e}) = \phi(\bar{e})$ (recall, $\bar{U} = 0$)

Along IC curve

$\frac{dt}{dC} = -\psi'(\underline{\beta} - C) < 0$ negative slope

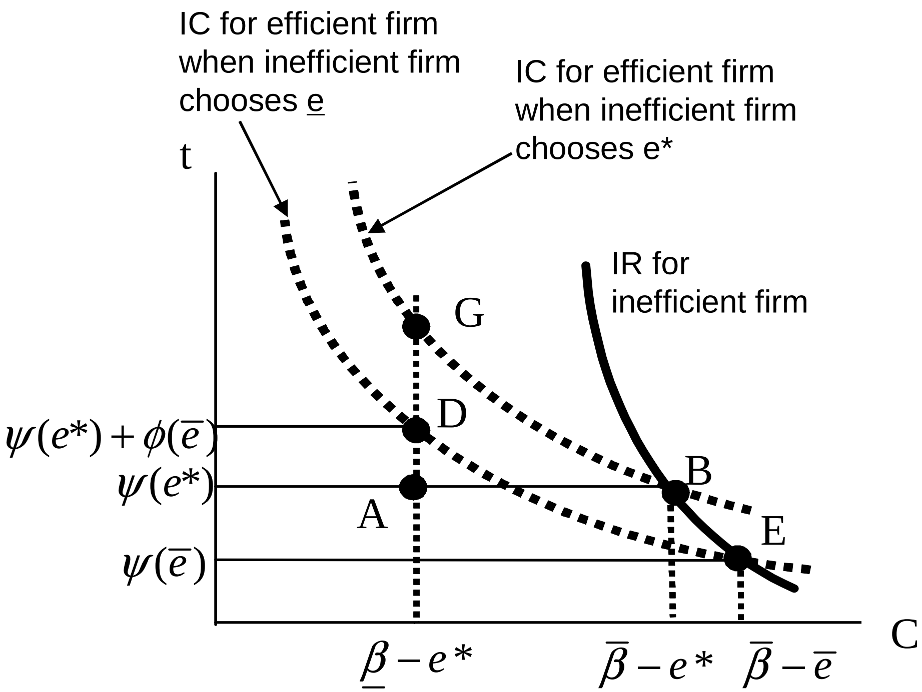
(flatter than IR because $\psi'=0$)

$\frac{d^2t}{dC^2} = \psi''(\underline{\beta} - C) > 0$ convex

Optimal contract for inefficient firm $(\bar{t}, \bar{C}) = (\psi(\bar{e}), \bar{\beta} - \bar{e})$, at E.
Optimal contract for efficient firm $(\underline{t}, \underline{C}) = (\psi(\underline{\beta} - C), \bar{\beta} - e^*)$, at D.

Efficient firm just indifferent betweeen D and E
Inefficient firm strictly prefers E to D, gets no rent.

# Why reduce the inefficient firm's effort below first-best level (e < e*)?




Suppose regulator designed contract for inefficient firm $(\bar{t},\bar{C}) = (\psi(e^*), \bar{\beta} - e^*)$, at B.
Inefficient firm still gets zero rents.

But now the efficent firm has a new incentive compatibility curve through B,
and would move from D to G, receiving higher rents.

Since expected rents rise, and rents enter welfare negatively, expected welfare falls.

Therefore, it is not optimal to design contract for efficient firm
that requires first-best level of effort.

# What happens if the shadow price of public funds is zero?

When $\lambda$=0, the regulators problem with asymmetric information becomes:

$$\max_{\underline{C},\bar{C},\underline{U},\bar{U}} EW = \nu(S-[\underline{C}+\psi(\underline{\beta}-\underline{C})]\} + (1-\nu)\{(S-[\bar{C}+\psi(\bar{\beta}-\bar{C})]\}$$

$$\frac{\partial EW}{\partial \underline{C}} = 0 \Rightarrow \psi'(\underline{\beta}-\underline{C}) = 1 \Rightarrow \underline{e} = e^*$$

$$\frac{\partial EW}{\partial \bar{C}} = 0 \Rightarrow \psi'(\bar{\beta}-\bar{C}) = 1 \Rightarrow \bar{e} = e^*$$

For both types of firms: Efficient level of effort.

Assuming S is large enough to satisfy IR constraint for both types of firms, one incentive compatible contract that would reach first best, is just to give the firm all the surplus, and let each type be an effort optimizer (e*).

Like Loeb and Magat (1979).

# Variable Scale, Single Product Firm, Private Good

Project has variable scale: $C = (\beta - e)q + \alpha$

Assume $\alpha$ is known, normalized to zero. $m \equiv (\beta - e)$ = marginal cost

Process: Cost is paid by government
Government receives revenues from sales
Government pays net transfer $t$ to the firm

Firm's Utility: $U = t - \psi(e)$ Individual Rationality: $t - \psi(e) \geq 0$

$\psi(e) =$ firm's disutility of effort $\psi(0) = 0$ $\lim_{e \to \beta} \psi(e) = \infty$ $\psi'(e) > 0$ $\psi''(e) > 0$

$S(q) =$ gross consumer surplus
$p(q) = S'(q) =$ price
$R(q) = qp(q) =$ revenue

Social Welfare: $W = S(q) - R(q)$ (consumer surplus) $+ (1+\lambda)R(q) -$ (revs for gov't help cover firm's cost and reduce need for taxing) $(1+\lambda)(C+t)$ (cost to taxpayers for funds raised from other sector) $+ U$ (firm's utility)

$$W = S(q) + \lambda R(q) - (1+\lambda)(C + \psi(e)) - \lambda U \quad \text{Eq 1}$$

(If $R(q) = 0$, like a pubic good project, with $S(q)$ = surplus associated with project of size q.)

# Full Information Benchmark

$$\max_{U,e,q} \; W = S(q) + \lambda R(q) - (1+\lambda)(C + \psi(e)) \; - \lambda \, U \quad \text{subject to } U \geq 0$$

Optimality:
As before, $U = 0$ (since U enters W negatively)

$$\frac{\partial W}{\partial e} = 0 \Rightarrow \psi'(e) = q$$

marginal disutility of effort = marginal saving in cost from another unit of effort

$$\frac{\partial W}{\partial q} = 0 \Rightarrow \left( \frac{p - m}{p} \right) = -\frac{\lambda}{1+\lambda} \frac{1}{E_{q,p}}$$

Not the usual Ramsey rule.
The firm has no budget constraint (firm receives t in addition to cost).
If $\lambda$=0, set $p = m$.
Government receipts are $R(q) = mq = (\beta - e)q$
Government expenditures are $t + (\beta - e)q$
Government pays out (subsidizes) net payment $-t$,
but induces first best level of effort e*

# Two-type case

Firm has either $\bar{\beta}$ (with $\bar{m} = \bar{\beta} - e$) or $\underline{\beta}$ (with $\underline{m} = \underline{\beta} - e$)

Optimal levels of variables are:

| | Efficient Firm | Inefficient Firm |
|---|---|---|
| Transfer | $\underline{t}$ | $\bar{t}$ |
| Output | $\underline{q}$ | $\bar{q}$ |
| Total Cost | $\underline{C}$ | $\bar{C}$ |
| Marginal Cost | $\underline{m}$ | $\bar{m}$ |
| Utility | $\underline{U}$ | $\bar{U}$ |

$\nu = \Pr(\beta = \underline{\beta})$

Regulator's Problem:

$$\max_{\bar{e},\underline{e},\bar{q},\underline{q}} \ \mathrm{E}W = \nu\{S(\underline{q}) + \lambda R(\underline{q}) - (1+\lambda)(\underline{\beta} - \underline{e}) \ -\lambda\ \phi(\bar{e})\}$$
$$+(1-\nu)\{S(\bar{q}) + \lambda R(\bar{q}) - (1+\lambda)(\bar{\beta} - \bar{e})\ \}$$

# Main Results with Incentive Compatible Contracts: Two-type case

1) High cost firm
   receives no rent
   undertakes less effort that the socially optimal amount

2) Low cost firm
   receives informational rent
   undertakes the socially optimal amount of effort

3) The prices charged are not distorted from their optimal levels, given firm type

$$\left(\frac{p-\overline{m}}{p}\right) = -\frac{\lambda}{1+\lambda}\frac{1}{E_{q,p}} \quad \text{and} \quad \left(\frac{p-\underline{m}}{p}\right) = -\frac{\lambda}{1+\lambda}\frac{1}{E_{q,p}}$$

The incentive and rent extraction issues are handled through the cost reimbursement payment

# Practicalities

Possible to extend to many types of firms

Temptation for regulator to renege once type is revealed by firm’s contract choice

Threat of renegotiation a bit artificial in the cases considered here,
but not in real world.

Regulators don’t use Laffont and Tirole
slow diffusion of complex theory into practice

Price cap regulation is quite common
Pure price caps have high-powered incentives (b=1)
BUT, actual application is not pure.

# Regulatory Problem
# Non-Bayesian Approach

To induce the regulated firm to produce

- The socially optimal level of output
- At lowest possible cost

Informational Constraints

- Firm knows more about its cost than the regulator
- Regulator can observe (verify) expenditures, but does not know whether the firm minimizes cost

Could have similar asymmetry with respect to demand

Non-Bayesian: no prior required on unknown parameter

# Examples of Non-Bayesian Mechanisms

- Price Caps
- Franchise Auctions (Demsetz Competition)
- Contestability
- Loeb and Magat
- Vogelsang and Finsinger (crawling Laspeyers index)
- Incremental Surplus Schemes
- Many others

General reference on Bayesian and Non-Bayesian literature:

Armstrong, M. and Sappington, D., "Recent Developments in the Theory of Regulation," *Handbook of Industrial Organization* (Volume III).

# Price Caps and Quality of Service

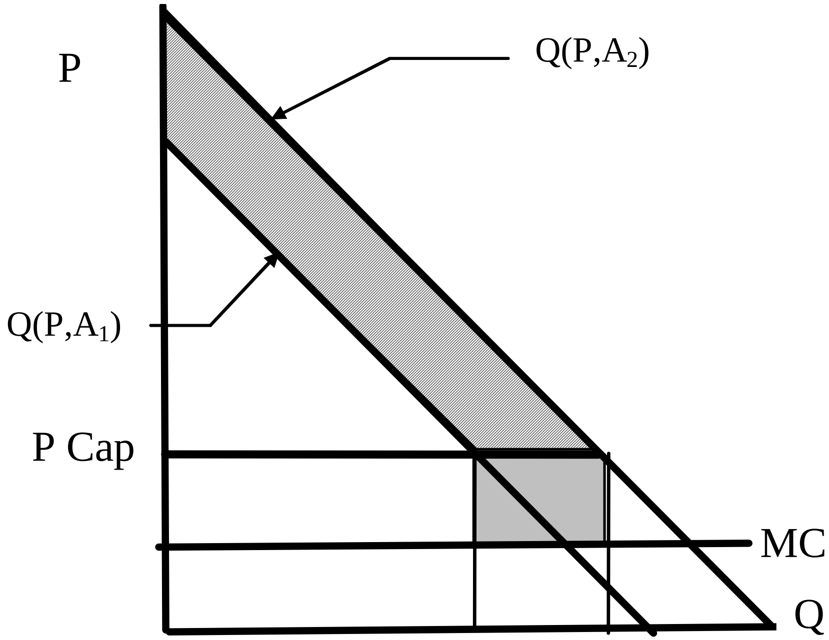
Suppose firm is contemplating improving quality of service.

A: fixed outlay on quality
Does not affect MC

Could be a gap between social incentives and private incentives

Example: Could have
Incremental profit <A <incremental CS

Won't necessarily get optimal quality



# Franchise Auctions (Demsetz Competition)

"Why Regulate Utilities?" *Journal of Law and Economics,* April, 1968.

Key Idea: It may be possible to have "competition for the market" even if "competition in the market" is not possible.

Franchise auctions may be used to introduce competition for the market even if there is a natural monopoly.

Auctions may be useful even if there are sunk costs.

Assumptions:

1) Inputs available to all bidders at prices determined in open markets.

2) Cost of colluding must be prohibitively high (so that bidding is competitive)

Example: Government owns essential facility or has a monopoly on the right to provide some service (local airport, pipeline, lock system for water carriers, CATV facilities, refuse collection)

Government auctions off the right to operate the facility for, e.g., 5 years.

A bid consists of the "fee" (i.e., "price") the franchise operator would charge to the customers:

- Subscription fee charged to CATV customers
- Landing/takeoff fee for aircraft at airport
- Usage fee for locks for water carriers
- Fee for collecting refuse

Government accepts lowest "price" offer.

What price would one expect to observe as the outcome of a Demsetz auction?

# Franchise Auctions (continued)

A few issues:

- Still have some deadweight loss.
- Government must specify all of the relevant dimensions of quality before the bidding.
- Need to define property rights carefully in the contract. Incentives to maintain the facilities?
- Must keep bidding simple to make bids comparable.

| | | Service 1 | Service 2 |
|---|---|---|---|
| • | Bidder 1 Fee | 8 | 10 |
| • | Bidder 2 Fee | 10 | 8 |

Multipart tariffs?

**Loeb And Magat. "A Decentralized Method For Utility Regulation," *Journal of Law and Economics*, 1979**

Use a subsidy scheme to achieve first best with a monopoly.

Demand is common knowledge to the regulator and the firm

Firm knows cost C(Q).    Regulator does not know cost.

Regulator sets a subsidy = consumer surplus

-- subsidy makes effective MR = Demand:

$$S(Q) = \int_0^Q P(q)dq - QP(Q)$$

# Loeb And Magat (continued)

Regulator chooses S(Q) knowing that the firm will pick Q to maximize profit.

$$\pi(Q) = QP(Q) - C(Q) + S(Q) = \int_0^Q P(q)dq - C(Q)$$

$$\pi_Q = P - C' = 0 \Rightarrow P = MC$$

Outcome:

First best.

Firms gets the whole surplus

Government pays big subsidy (= consumer surplus)

# Loeb And Magat (observations):

Can combine S(Q) with franchise tax to lessen the impact on government budget and drive profits toward zero

Query: How can combined subsidy and franchise tax be made operational?

- How are refunds from the firm to the government to the consumers?

Problem: Requires much confidence in knowledge of demand (<u>not</u> just local information).

Not very useful as a <u>practical</u> scheme.

As a first step in mechanism design - quite useful.

Gives a lot of informational rents to the firm if no franchise tax is implemented.

Might be able to mitigate these rents by holding an auction for cash for the right to have a franchise. Maximum bid limits producer profits to normal levels with first best outcome.

This combines Loeb and Magat with Demsetz auction, but with S(Q) as instrument get to first best instead of second best.

## Vogelsang,I., and J. Finsinger: "A Regulatory Adjustment Process for Optimal Pricing by Multiproduct Monopoly Firms," *Bell Journal of Economics*, 1979.

- Regulated firm is a multiproduct monopoly. Cost is C(**x**).

- A myopic, dynamic mechanism
  - similar to process regulators actually use.

- Requires no subsidy or tax scheme.

- First consider the mechanism for a firm producing a single product.

# V-F Mechanism, Single Product Firm

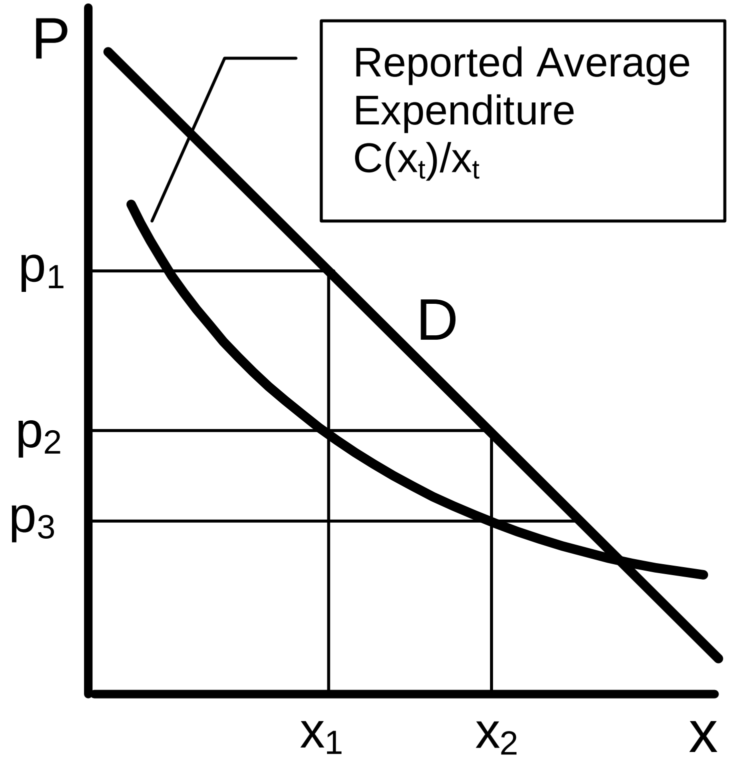
Regulator observes: $P_t$ , $x_t$ , $\pi(p_t)$, $C(x_t)$

$C(x_t)$ are expenditures, not necessarily efficient costs

Impose: $x_t P_{t+1} - C(x_t) \leq 0$

If $P_{t+1} = P_t$ , stop (have convergence)

Set t = t + 1




What's the eventual outcome of this process?

# V-F Mechanism, Multiproduct Firm

Claim: We can get to a Ramsey optimum in a multiproduct setting.

Suppose at each step, the (myopic) firms choose $P_{t+1}$ to:

$$\max_{P_{t+1}} \pi(P_{t+1}) \qquad \textit{subject to } P_{t+1} \in R_{t+1} = \{P_{t+1} \mid x_t P_{t+1} - C(x_t) \le 0\}$$

Lagrangian: $L = \pi(P_{t+1}) + \gamma[x_t P_{t+1} - C(x_t)]$

FONC: $\nabla\pi(P_{t+1}) + \gamma(x_t) = 0.$

At convergence, when $P_t = P_{t+1}$, then $\nabla\pi(P) = -\gamma(x)$
and the FONC for a Ramsey Optimum are satisfied.

Relate to Ramsey optimality:

$$\max_P S(P) + \pi(P) \text{ subject to } \pi(P) \ge 0$$

$$L = S(P) + (1+\lambda)\pi(P)$$

FONC: $\nabla S = -(1+\lambda)\nabla\pi, \ \textit{with} \ \nabla S = -x$

# V-F Mechanism, Multiproduct Firm (continued)

| Claim: Along the sequence of prices, consumer surplus $S$ rises, even if the firm is inefficient. |
|---|

Take first order expansion of $S$:

$$S(P_{t+1}) > S(P_t) + \nabla S(P_t) \bullet (P_{t+1} - P_t) = S(P_t) - x_t(P_t) \bullet (P_{t+1} - P_t) \qquad (1)$$

Rewrite the mechanism constraint

$$x_t P_{t+1} - x_t P_t \leq -x_t P_t + C(x_t) \Leftrightarrow x_t(P_t - P_{t+1}) \geq \pi_t. \qquad (2)$$

Substitute (2) into (1) yields

$$S(P_{t+1}) > S(P_t) - x_t(P_t) \bullet (P_{t+1} - P_t) \geq \mathrm{S}(P_t) + \pi_t$$

$$S(P_{t+1}) > S(P_t) + \pi_t \qquad (3)$$

$\Rightarrow$ Consumer surplus rises along the way and strictly so if $\pi_t > 0$.

| Claim: Total surplus $W$ rises along the way, too. |
|---|

Note by (3) that $S(P_{t+1}) > S(P_t) + \pi_t \equiv W_t$.

$\Rightarrow$ $S(P_{t+1}) + \pi_{t+1} > W_t \Rightarrow W_{t+1} > W_t$, so that total surplus rises too.

# V-F Mechanism Graphically

Iso-consumer surplus lines:

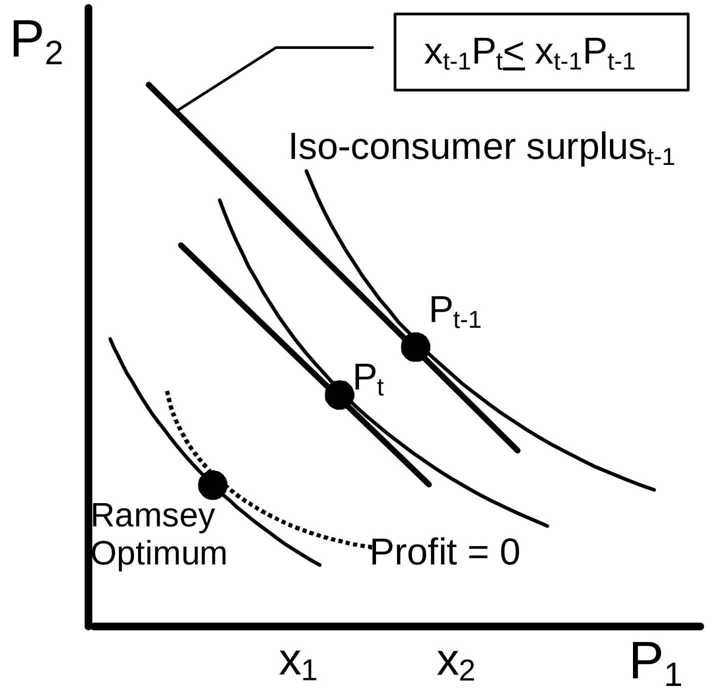
$$\text{slope:} \quad \frac{dP_2}{dP_1} = -\frac{x_{t-1}}{x_{t-2}}$$

Same slope as VF constraint

VF constraint in *t* inside of constraint in *t-1*

Consumer surplus increases monotonically over time.

Stop when profit = 0.



# Comments on VF

- Provides basis for determining weights for price caps in baskets
  - Weights: last period's quantities

- Some potential problems:
  - Waste
  - Myopic (assumes profit max in each period).
    If max PV profit, <u>if</u> converge, still get to Ramsey Optimum.
  - How fast will the process converge?
  - Process assumes stable demand, cost
  - Quality of service?

**Sappington and Sibley, "Regulating Without Cost Information: The Incremental Surplus Subsidy Scheme," *International Economic Review*, 1988.**

Instead of giving the firm the entire surplus (Loeb and Magat), implement a mechanism that gives the firm only the incremental surplus generated between (t-1) and (t).

Use *ex post* expenditure information to make the firm do what the regulator wants.

$P_t$ = price in period t
$Q_t$ = output in period t
$Q(P)$= demand schedule
$Q(P)$ is common knowledge

ß= discount factor (ß < 1)
$E_t$ = firm's expenditures in period t
$R_t$ = operating profit = $P_t Q_t - E_t$
$C(Q)$ = cost function (efficient)

In period t, the firm keeps the operating profit $R_t$ and is awarded a subsidy (+ or -) $S_t$

$$S_t = \int_{P_t}^{P_{t-1}} Q(p)dp - R_{t-1}$$

First term on RHS is the increment to consumer surplus in t
Second term on RHS "taxes away" last period's profits.

# Sappington and Sibley (continued)

The firm's problem $$\max_{E_t, P_t} \sum_{t=0}^{\infty} \beta^t \{R_t + S_t\}$$

$$\textit{subject to}: E_t - C(Q_t) \geq 0 \quad (\textit{firm may be inefficient})$$

$$S_t = \int_{P_t}^{P_{t-1}} Q(p)dp - R_{t-1} \qquad \forall t \geq 1$$

Let $P_0$ be exogenous and set under some prior regulatory scheme.

Firm's <u>profit is the increment to total surplus in time t</u>:

$$\pi_t = R_t + S_t = R_t + \int_{P_t}^{P_{t-1}} Q(p)dp - R_{t-1}$$

$$\pi_t = R_t + \int_{P_t}^{\infty} Q(p)dp - [R_{t-1} + \int_{P_{t-1}}^{\infty} Q(p)dp] = \Delta \textit{Total Surplus}$$

Total surplus in *t* Total surplus in (*t*-*1*)

# Sappington and Sibley: Incentives

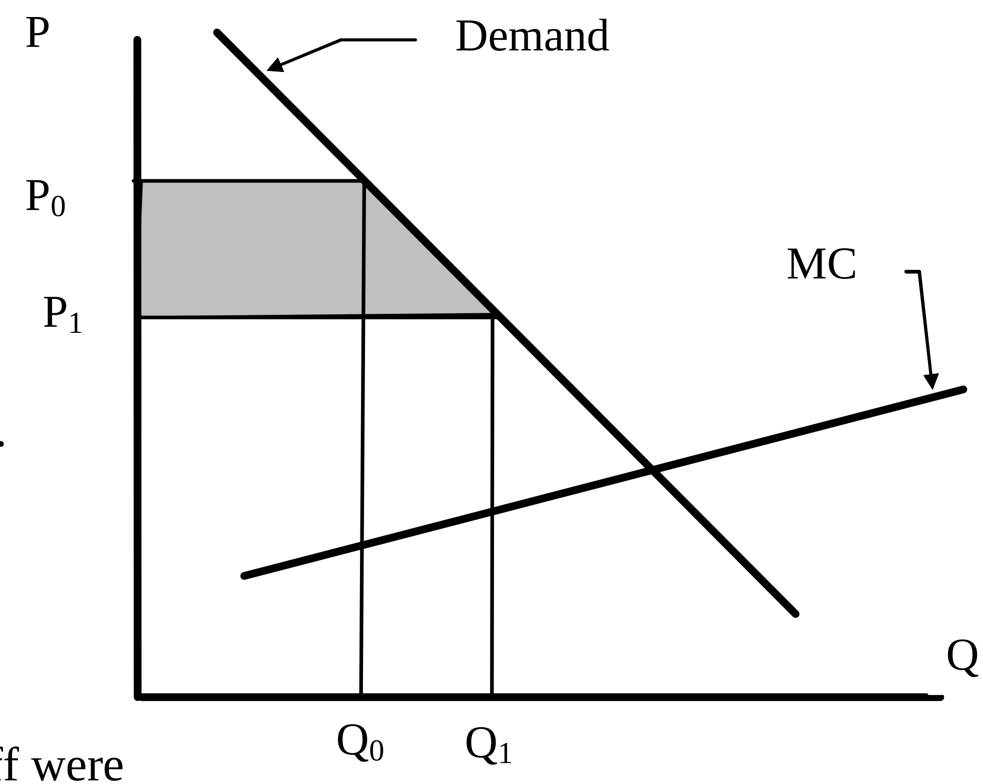
Why won't the firm stay at $P_0$ ?

$S_t = (CS_t - CS_{t-1}) - R_{t-1}$,
so the subsidy may be negative.

Profit = $(R_t - R_{t-1}) + (CS_t - CS_{t-1}) = 0$

Firm only gets profit by lowering price. Consequences:

- (1) $P$ goes to $MC$ immediately
- (2) Cost is minimized
- (3) For $t \geq 2$, $P = MC$, profit = 0.




"Intuitively, the firm acts as if its payoff were given by the total surplus in period t less a tax equal to the total surplus in t-1. From the standpoint of t, the tax is nondistorting, so the first best results are obvious." (p. 395 of paper)

"Compared with Loeb and Magat, the ability of the regulator to observe accounting profits vastly mitigates the firm's informational rents."

## Finsinger, J. and Vogelsang, I., "Strategic Management Behavior Under Reward Structures in a Planned Economy," *QJE* 1985.

Mechanism similar to Sappington and Sibley.
Difference: The market demand schedule is not assumed to be common knowledge, so the Incremental Surplus Subsidy of Sappington and Sibley cannot be computed.

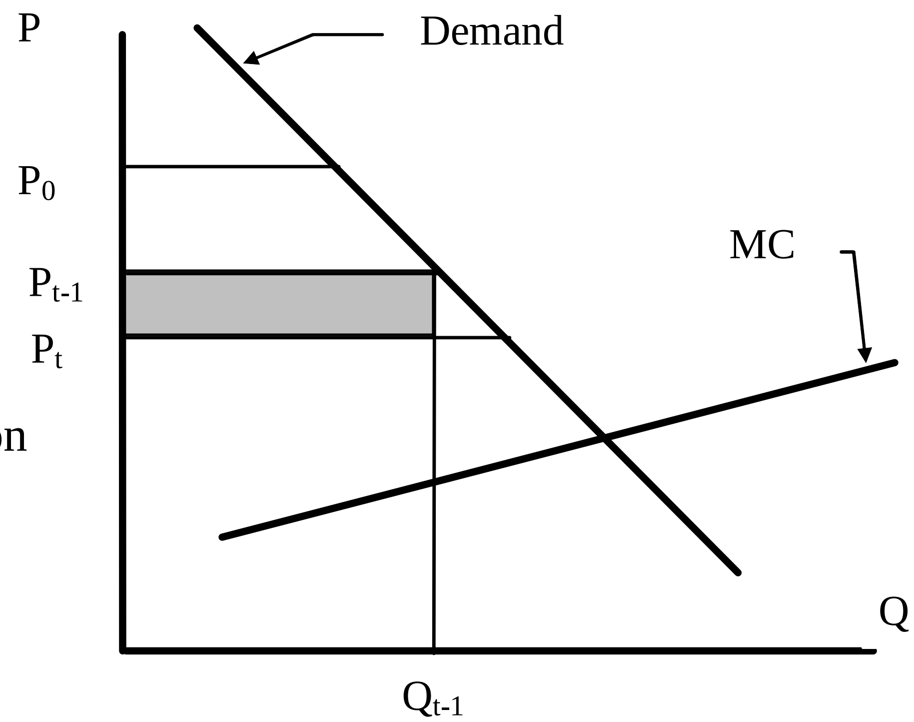
In period t, the firm sets $P_t$ and is given a subsidy $F_t$

$$F_t = Q_{t-1} (P_{t-1} - P_t) - R_{t-1}$$

As with Sappington and Sibley,
operating profit = $R_{t-1} = P_{t-1} Q_{t-1} - E_{t-1}$

$F_t$ is an approximation of $S_t$ in the Sappington and Sibley mechanism. Profit$_t$ = $R_t + F_t$

Firm's problem:
Choose $E_t$ and $P_t$ to max $\Sigma_t\{R_t + F_t\}ß^t$ .



# Finsinger and Vogelsang (continued)

Results:

(1) Firm minimizes cost in each period.

(2) Price declines monotonically to MC

(3) Firm earns informational rents in each period in which $P_t > MC$, but since $R_{t-1}$ is taxed away, rents earned in period t do not persist.

The firm is awarded a subsidy in each period which approximates the change in surplus, which is why P does not go to MC at once.

## Relation of Incremental surplus Schemes to Price Caps

If one assumes the number of consumers is fixed and totally inelastic, the subsidies $F_t$ (of Finsinger and Vogelsang) and $S_t$ (of Sappington and Sibley) could be thought of as being raised from the entry fee of a two part tariff.

Two parts of the tariff: $(F_t , P_t)$

- In period $t+1$, offer consumers $(F_{t+1} , P_{t+1})$ and $(F_t , P_t)$ as a choice.
- Since consumer surplus increases monotonically over time, consumers will select $(F_{t+1} , P_{t+1})$.
- $(F_{t+1} , P_{t+1})$ will play the role of a ceiling two part tariff in period $(t+2)$, and the firm offers $(F_{t+2} , P_{t+2})$, with still higher consumer surplus, etc.
- Regulators would be likely to allow this, since surplus increases.
- Regulators not only monitor $R_t$ , but require the firm to rebate $R_t$ in period $(t+1)$.
- Once $P_t$ falls below AC (in a single product setting), the firm receives a subsidy (not paying a tax). But consumers are willing to pay the tax to finance the subsidy since $P$ is moving toward $MC$. At steady state, $P=MC$ and the firm receives a subsidy = $-\pi_t$ , so the firm remains financially viable.