

# lecture 5: natural monopoly – regulation as an agency relationship

# outline

- Natural monopoly
  - Regulation as an agency relationship  
(regulation under asymmetric information)

# outline

## Regulation under asymmetric information

### References

- LT, ch. 1
- Joskow, P. (2007) “Incentive Regulation in Theory and Practice: Electricity Distribution and Transmission Networks,” NBER Chapters, in: Economic Regulation and Its Reform: What Have We Learned? National Bureau of Economic Research, Inc.

# the story so far

## Natural monopoly:

- Definitions
- Ideal pricing solutions
- Regulation in practice

# overview

- We have looked at pricing solutions for regulated firms with subadditive costs (NM)
- IDEAL pricing: linear (MC and AC), Ramsey pricing, non-linear,...
- These solutions assume the regulator is informed about technology, costs and consumer demand AND can impose cost minimization obligations on firms
- But,
  - no concern in cost minimization or improvement in other dimensions of firm performance (quality,...)
  - the regulator has imperfect/incomplete information (so that the firm may use its informational advantage in the regulatory process to increase profits) and the firm can “capture” the regulator

## overview

- The evolution of traditional regulatory practices in the US reflected efforts to reduce the information asymmetry: laws and regulations require firms to adhere to a uniform system of capital and cost accounts, give regulators access to books and records of regulated firms, and right to request additional information, staff resources to evaluate information,...
- Some concern with incentives lead to the adoption of price-caps and sliding scales.
- Still, the mechanisms adopted did not use this information effectively: formal incentive regulation was infrequent in the US, Canada, Spain, Germany,...

# overview

- The discontent with price, quality, and cost performance of regulated firms and government contractors lead to a renewed theoretical interest on NM and oligopolies during the 80's
- Loeb and Magat (1979) confronted the asymmetric information problem focusing on demand data only
- The theoretical framework is by now reasonably developed and may help regulators (Laffont and Tirole, 1993; Armstrong, Cowan, and Vickers, 1994; Armstrong and Sappington, 2003)

# Asymmetric information

- Regulators cannot rely on contracts that are contingent on information held only by the firm (or more generally on information not verifiable by a court), e.g., information on costs, profits,...
- There are two types of informational constraints:
  - On actions/endogenous variables - “effort” - not observed by the agency; e.g., number of hours and intensity of work,... – **moral hazard**
  - On exogenous variables – “type”; e.g. technological possibilities, difficulty in implementing some tasks, demand,... – **adverse selection**



# Asymmetric information

- In general, adverse selection allows a firm to extract rents\*
- Moral hazard and adverse selection (and the loss of control of the regulator) create a demand for information gathering; e.g., audits in public firms and controls in private firms
- But most dimensions of asymmetric information do not show up in accounting statements!

# Regulation as an agency relationship

## Laffont-Tirole (LT) approach

- The Laffont-Tirole (LT) approach is to consider regulation as a Principal-Agent relationship (the firm has more information than the regulator)

# Regulation as an agency relationship

## problem's ingredients

- A firm's *cost opportunities* may be high or low
- The regulator does not know the firm's true cost opportunities, but has some information about its probability distribution
- The firm's *actual costs* depend on (i) its cost opportunities and (ii) decisions made by managers to exploit these opportunities
- Managers may exert more (or less) effort to get more (or less) out of cost opportunities (the  $>$  the effort, the  $<$  the actual costs)
- High effort is costly for managers
- The regulator cannot observe effort directly

# Regulation as an agency relationship problem's ingredients

- So, the firm wants to convince the regulator that it is a high cost firm, so that it is allowed to set too high prices (allegedly to ensure financial viability) obtaining high rents
- This is an **adverse selection problem**
- If the regulator can obtain reasonably good information on actual costs, ROR regulation (prices set to equal *ex post* costs) would solve the adverse selection problem
- But, if this loss of opportunity to earn rents reduces managers' incentives to make effort, costs may rise above efficient levels
- So, bad regulatory incentives may reduce effort; this is a **moral hazard problem**

# Regulation as an agency relationship

## problem's ingredients

- The regulator will then use a mechanism that takes both problems into account, subject to the firms' financial viability (individual rationality (IR) constraint)
- Two polar cases:
  - Setting a fixed price *ex ante* and forever (or a price cap adjusting with exogenous factors) gives high incentives for effort (and minimizes moral hazard); but, given IR, the regulator has to set high prices, so that rent extraction is poor (full cost of adverse selection)
  - Implement ROR (with no *ex post* negotiation) that reimburses cost *ex post*; if audits of expenses are accurate, the firm reveals if it's high or low cost (adverse selection disappears), but there may managerial slack (full cost of moral hazard)
- Trade-off: managerial efficiency *vs.* rent extraction

# Regulation as an agency relationship

## problem's ingredients

- The solution is somewhere in between as in a sliding scale
- But, LT show that the regulator can perform better by offering a menu of contracts
- Example: menu with two options: a price cap and a ROR contract; the price cap can be demanding because the ROR option exists (IR is not violated); but if the firm has low cost, choosing the price cap, more rent is conveyed to the consumer

# Regulation as an agency relationship

## aims and instruments

The optimal regulation of a monopoly is influenced by many factors:

1. Whether the regulator is benevolent or self-interested
2. The regulator's objective (when he is benevolent)  
$$S + \alpha R, \quad \alpha \in [0,1]$$
3. The cost of raising revenue from taxpayers (social cost of public funds)  $\lambda$
4. The range of policy instruments available (e.g., ability to use public funds/tax firms directly)
5. The regulator's bargaining power
6. The information available to the regulator and the firm
7. The regulator's ability to commit to long-term policies

# Regulation as an agency relationship

## aims and instruments

LT assume:

1. Whether the regulator is benevolent or self-interested:  
benevolent
2. The regulator's objective:  $S + R$
3. The cost of raising revenue from taxpayers (social cost of public funds)  $\lambda > 0$
4. The range of policy instruments available (e.g., ability to use public funds/tax firms directly): transfers are allowed
5. The regulator's bargaining power: all
6. The information available to the regulator and the firm: firm knows everything; regulator knows actual costs, but not cost opportunities and effort to reduce costs (*ex ante* knows probability distribution on cost opportunities)
7. The regulator's ability to commit to long-term policies: no need



# Regulation as an agency relationship taxonomy

<b>Power</b>	<b>Transfers?</b>	
	<b>Yes (Procurement)</b>	<b>No (Regulation)</b>
<b>High</b> (firm residual claimant)	Fixed-price contract	Price caps
<b>Intermediate</b> (cost or profit sharing)	Incentive contract	Incentive regulation
<b>Low</b>	Cost-plus	Rate-of-return (ROR) regulation

# Regulation as an agency relationship

## LT approach

- In a typical procurement contract, we assume that the government reimburses costs  $C$  and gives transfer  $t = a - bC$ ,  $0 < b < 1$
- So, the firm receives  $R = C + t = a + (1-b)C$
- “ $b$ ” is the power of the incentive scheme: the bigger “ $b$ ,” the bigger the firm’s incentives to decrease costs

# Regulation as an agency relationship taxonomy

<b>Power</b>	<b>Transfers?</b>	
	<b>Yes (Procurement)</b>	<b>No (Regulation)</b>
<b>High</b> (firm residual claimant)	Fixed-price contract ( $b=1$ , $a$ =assess. of efficient high costs)	<b>Price caps</b> (CPI-X)
<b>Intermediate</b> (cost or profit sharing)	Incentive contract ( $0 < b < 1$ , $0 < a < AEHC$ )	<b>Incentive regulation</b> (Performance Based Regulation - PBR)
<b>Low</b>	Cost-plus ( $a=b=0$ )	<b>Rate-of-return</b> (ROR) regulation

# Regulation as an agency relationship roadmap

- Model 1: cost reimbursement problem when  $q = 1$  (project with fixed dimension), two types of firms
- Model 2: cost reimbursement problem when  $q = 1$ , continuum of firms
- Model 3: cost reimbursement + pricing problem when  $q > 1$ , two types of firms
- Model 4: transfers are not allowed

# Model 1

## assumptions

- $C = \beta - e$  where  $\beta$  is the efficiency or adverse selection (AS) and  $e$  is the effort or moral hazard (MH) parameter
- $\beta$  is  $\beta_1$  (efficient) with probability  $v$  and  $\beta_h$  w. prob.  $1-v$
- $C$  is observable and verifiable (it's an AS problem)
- Firm's rent  $U = t - f(e)$ , where  $t$  are the regulator's transfers and  $f$  describes the disutility of effort;  $f' > 0$ ,  $f'' > 0$  (\*)
- $W = S - (1 + \lambda)(C + t) + U$ , where  $S$  is cons. surplus and  $\lambda$  represents distortions (\*\*)

# Model 1

complete information benchmark

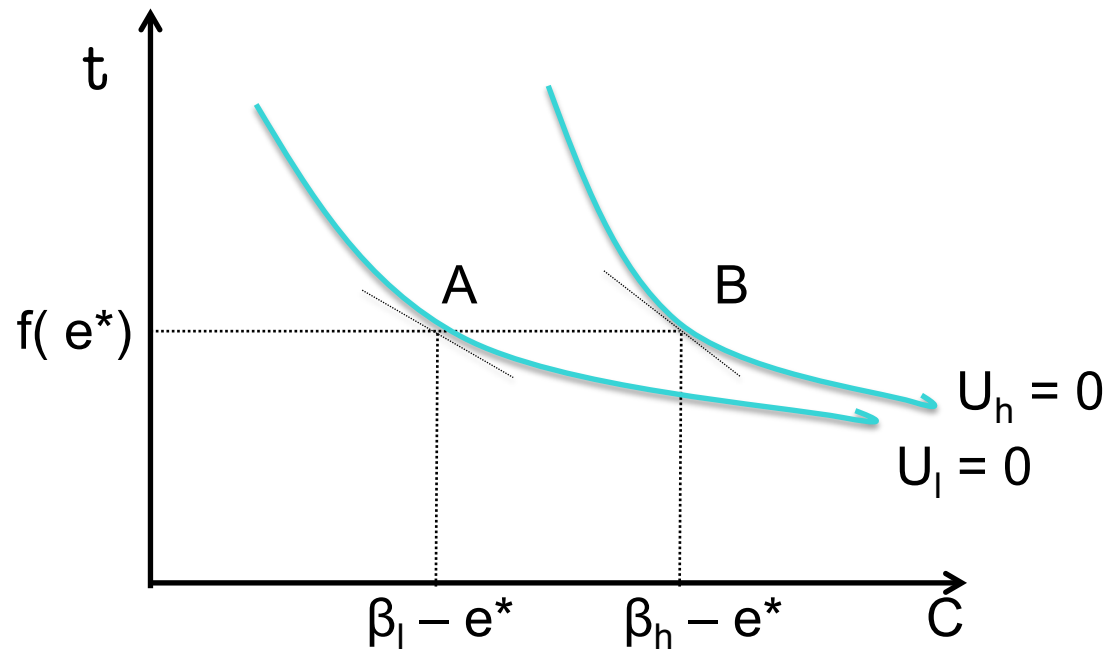
- $\beta$  is known, so that  $e$  is known
- Agency's problem:  $\text{Max}_{\{e,U\}} W$  s.t.  $U \geq 0$   
solution:  $U = 0$  and  $e^*$  s.t.  $f'(e^*) = 1$  (MC = MB)

Using a fixed-price contract ( $b = 1$ ):  $t = a - (\beta - e)$ , we obtain the first-best:

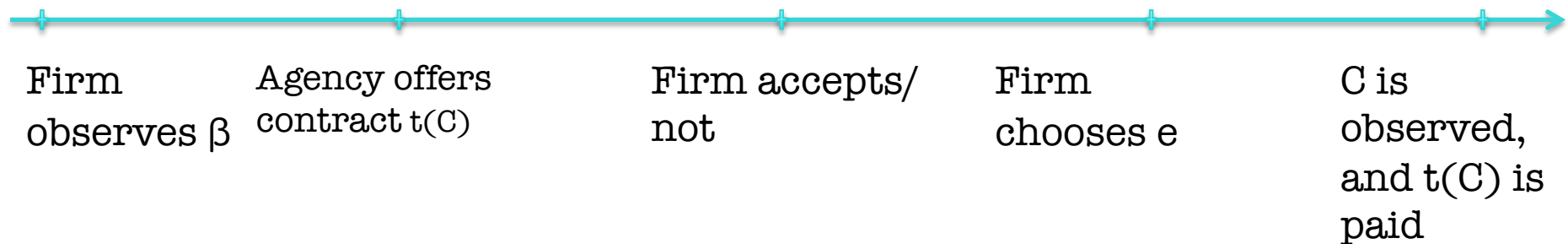
- The firm solves:  $\text{Max}_{\{e\}} U = a - (\beta - e) - f(e)$  to obtain  $e^*$  (the firm internalizes all cost reductions)
- And  $a = f(e^*) + (\beta - e^*)$

# Model 1

complete information benchmark



# Model 1 problem



- To find  $t(C)$ , we use a direct mechanisms  $[t(\beta), C(\beta)]$  (**Revelation Principle**)
- The agency offers contract  $[t(\beta), C(\beta)]$  when the firm announces  $\beta$  (ie, offers two contracts  $[t_l, C_l]$  and  $[t_h, C_h]$ )
- Rmk: the complete information contracts A and B cannot be offered as the efficient firm would pretend to be inefficient



# D-tour

## the revelation principle

- A regulatory mechanism induces a game in which the firm plays a strategy  $\sigma(\cdot)$
- Let  $\sigma^*(\beta)$  be  $\beta$ 's optimal strategy when faced with the mechanism that associates to each  $\sigma$  cost  $C(\sigma)$  and transfer  $t(\sigma)$
- Consider now the direct revelation mechanism that associates with the announcement of  $\bar{\beta}$  the pair  $[t(\sigma^*(\bar{\beta})), C(\sigma^*(\bar{\beta}))]$
- It is in the best interest of the firm to announce  $\bar{\beta} = \beta$

# Model 1 problem

- Agency's problem:

$$\text{Max}_{\{t_l, t_h, C_l, C_h\}} \mathbb{E}(W) \text{ s.t.}$$

$$U_l = t_l - f(\beta_l - C_l) \geq 0 \text{ (IR } \beta_l)$$

$$U_h = t_h - f(\beta_h - C_h) \geq 0 \text{ (IR } \beta_h)$$

$$t_l - f(\beta_l - C_l) \geq t_h - f(\beta_l - C_h) \text{ (IC } \beta_l)$$

$$t_h - f(\beta_h - C_h) \geq t_l - f(\beta_h - C_l) \text{ (IC } \beta_h)$$

- Remarks:

- (IR  $\beta_l$ ) is satisfied when (IR  $\beta_h$ ) and (IC  $\beta_l$ ) are
- $C_h \geq C_l$  (monotonicity)
- IR  $\beta_h = 0$  (othw th could be reduced and the condition would still be satisfied)
- IC  $\beta_l$  is also active (same argument)
- IC  $\beta_h$  to be ignored and checked later

# Model 1 problem

- Agency's problem:

$$\text{Max}_{\{t_l, t_h, C_l, C_h\}} \mathbb{E}(W) \text{ s.t.}$$

$$U_l = t_l - f(\beta_l - C_l) \geq 0 \text{ (IR } \beta_l)$$

$$U_h = t_h - f(\beta_h - C_h) = 0 \text{ (IR } \beta_h)$$

$$t_l - f(\beta_l - C_l) = t_h - f(\beta_l - C_h) \text{ (IC } \beta_l)$$

$$t_h - f(\beta_h - C_h) \geq t_l - f(\beta_h - C_l) \text{ (IC } \beta_h)$$

- Remarks:

- (IR  $\beta_l$ ) is satisfied when (IR  $\beta_h$ ) and (IC  $\beta_l$ ) are
- $C_h \geq C_l$  (monotonicity)
- IR  $\beta_h = 0$  (othw  $t_h$  could be reduced and the condition would still be satisfied)
- IC  $\beta_l$  is also active (same argument)
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# Model 1

## solution

$$(\text{IR } \beta_h): t_h = f(\beta_h - C_h) = f(e_h)$$

$$(\text{IC } \beta_l): t_l = t_h + f(e_l) - f[e_h - (\beta_l - \beta_h)]$$

Therefore:

- The efficient firm's rent is

$$U_1 = f(e_h) - f(e_h - \Delta\beta) = \Phi(e_h), \text{ with } \Phi > 0 \text{ and } \Phi' > 0$$

- And we have

$$t_h = f(e_h) \text{ and } t_l = f(e_l) + \Phi(e_h)$$

(So, increasing the inefficient firm's effort implies increasing the efficient firm's rent!)

# Model 1

## solution

To determine:  $e_h, e_l$

The agency's problem becomes:

$$\text{Max}_{\{e_h, e_l\}} \mathbf{E}(W) = v[S - (1 + \lambda)(f(e_l) + \beta_l - e_l) - \lambda\phi(e_h)] + \\ (1 - v)[S - (1 + \lambda)(f(e_h) + \beta_h - e_h)]$$

F.O.C. imply

$$f'(e_l) = 1 \Rightarrow e_l = e^*$$

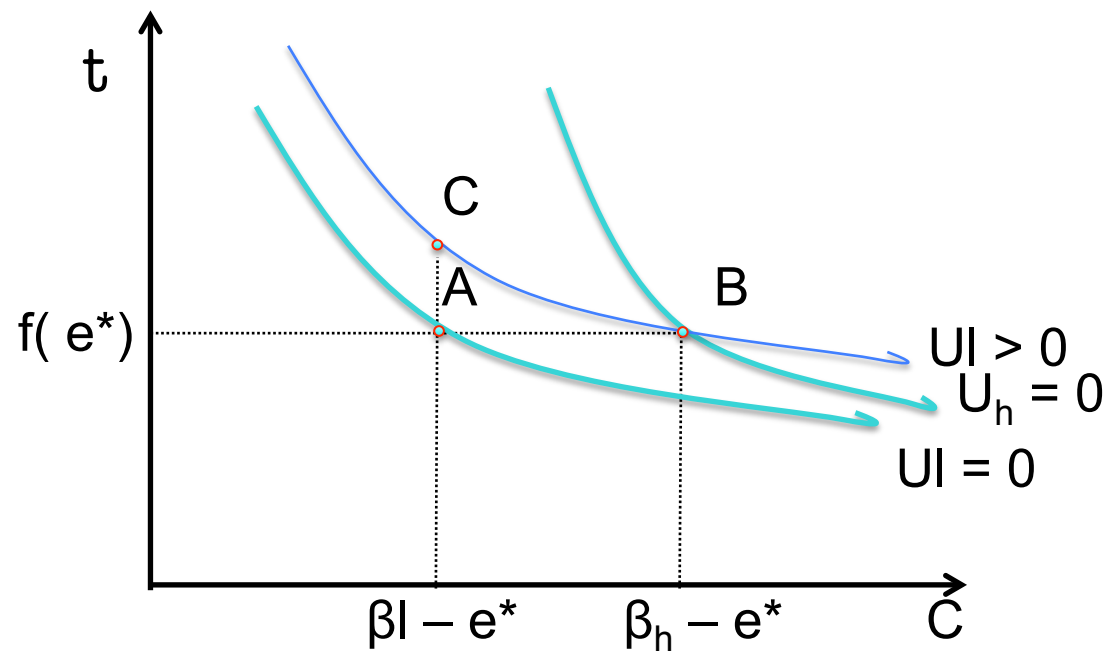
$$f'(e_h) = 1 - \frac{\lambda}{1 + \lambda} \frac{v}{1 - v} \Phi'(e) < 1 \Rightarrow e_h < e^*$$

Concluding: we have a menu of contracts with

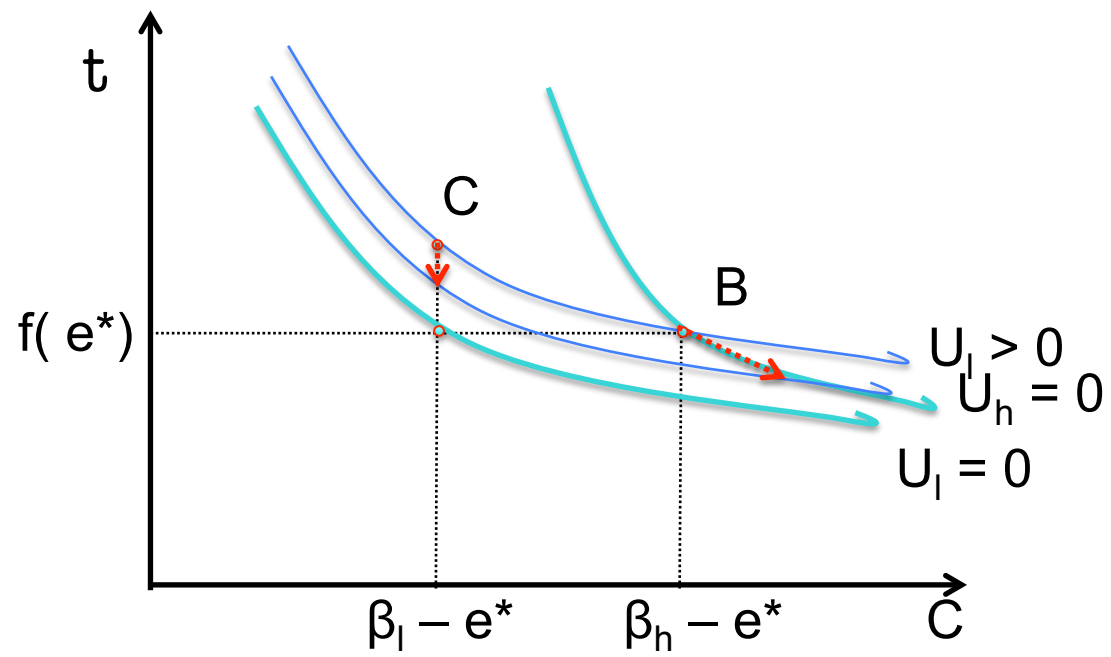
$$e_h < e^*; e_l = e^*; U_h = 0; U_l > 0$$

The distortion in  $e$  grows with  $\lambda$  and  $v$ .

# Model 1 solution



# Model 1 solution



# Model 1

## solution

- If only the efficient firm produces, the contract is such that:

$$f'(e_1^*) = 1 \text{ and } U_1^* = 0$$

- So, it is better to have just the efficient firm producing when

$$v[S - (1 + \lambda)(f(e_1^*) + \beta_1 - e_1^*)] >$$

$$v[S - (1 + \lambda)(f(e_1) + \beta_1 - e_1) - \lambda\Phi(e_h)] + \\ (1 - v)[S - (1 + \lambda)(f(e_h) + \beta_h - e_h)]$$



# Model 1

to sum up

- With complete information,
  - the agency can use a **fixed-price contract** with  $b = 1$
  - $e = e^*$
  - $U = 0$  (the agency extracts all the rent)
  
- With asymmetric information,
  - the agency offers a **menu of (two) contracts**
  - The efficient firm's effort is  $e^*$ , but the inefficient firm's effort is distorted
  - The efficient firm obtains positive rents, whereas the inefficient firm gets 0 utility
  - There's a **trade-off** between inducing effort and giving rent

## Model 2

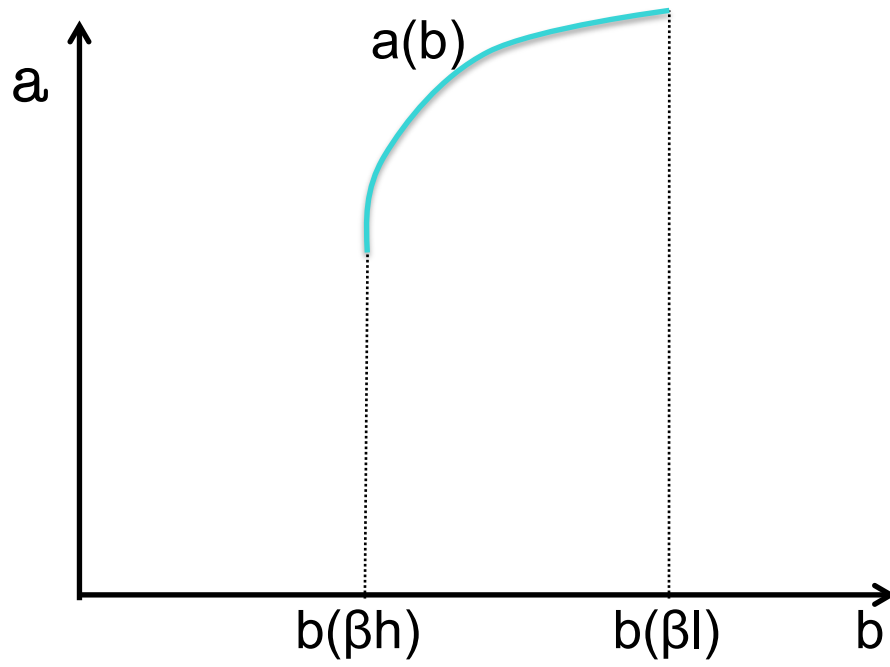
- With a continuum of types:
  - The lowest cost type exerts efficient effort and has positive rent
  - The highest cost type has greatest distortion and 0 rent
- LT show that these conditions can be implemented by offering a menu of linear contracts of the form:

$$t(\beta, c) = a(\beta) - b(\beta)c$$

Where  $a$  and  $b$  are decreasing in  $\beta$

- The lowest cost type chooses a fixed price contract; as  $\beta$  increases, the transfer is less sensitive to actual costs ( $b$  declines) and the rent is lower ( $a$  declines)

# Model 2



# Conclusion

- In the last 15 years incentive regulation theory has developed considerably, but practical implementation has lagged behind
- Price caps are the most common form of incentive regulation; but
  - Only seldom best instrument in theory
  - Include ratchets that reduce the power of incentives
  - Not simple: defining relevant capital and operating costs is difficult
  - Information burden is similar to that of ROR
  - Accompanied by other incentive schemes for quality
- Formal offers of menus are rare, though the give and take of regulatory negotiations may be a substitute

# General conclusions

- The regulator's task is to try to induce the firm to employ its superior information in the broader social interest
- How successful the regulator is depends upon many factors: the nature of a firm's private information, the environment in which the firm operates, the policy instruments, commitment power,...
- Technology, instruments, and institutions matter for design of regulatory policies
- So, even if we aim at general principles, the best policy varies across industries, across countries, and over time
- Carefully-structured options (that cede rent to those revealing a superior ability) are an important policy instrument