Mikro II, lecture 5b

Adverse selection and environmental regulation

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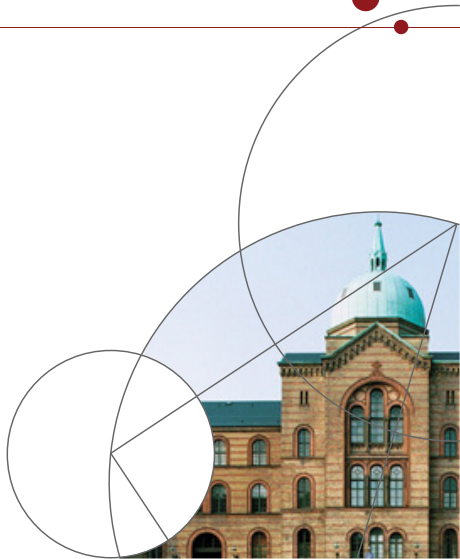

Plan for the lecture

1. Principal Agent model on the organization of environmental regulation when the policy-maker lacks information

Environmental regulation

- We now finish the subject asymmetric information, which included moral hazard, adverse selection and Principal Agent models
- Last topic: Environmental regulation, the principal is the government
- In our discussion of Pigou tax / Coase, we talked loosely about what information the government needed to design policy; now: formalize missing information via the Principal Agent setup
- We have spent a lot of time on the Principal Agent setup so we go a little faster over the details (see Sloth for thorough review)

Firms

- A firm must choose how much pollution it will allow; more pollution can allow higher profits
- Firm technology may vary, the index i indicates the type of firm; profit function for type i is:

$$\pi_i(e) = \pi^* - k_i(e^* - e)^2 \qquad , \quad \pi^* > 0, k_i > 0$$

- Optimal to pollute $e = e^*$, lowering e from this level will lower profits, different for different firms (k_i large/small)

The government

- The government wants to regulate the firm's pollution by demanding a (maximum) level of pollution and also taxing the firm
- Motivation: There is an externality cost of pollution at $C(e)$, where $C(0) = 0, C' > 0, C'' > 0$
- The government requires a tax payment of T and we allow the tax to provide an extra social return of g (e g public investments); the government wants to maximize social utility (measured in money):

$$(\pi(e) - T) - C(e) + T + gT = \pi(e) - C(e) + gT$$

The government as the principal

- Here, the government is the Principal and the firm is the agent
- The government must design a contract T, e (taxation and pollution control) that maximizes social utility
- The company can choose to close and get zero profit: outside option = 0, IR condition
- What does the government know? We start with the full information case, i.e. the government knows what the type of firm is when it imposes the tax and regulation

Optimal contract with full information

- The full information solution is fairly straightforward and very intuitive as long as you keep the social return to tax money g in mind (write down the formal problem for each type of firm the principal can face)
- The tax payment is set exactly such that the firm gets zero profit ($g > 0 \Rightarrow$ tax revenue is better than profit)

$$T = \pi_i(e)$$

- Substituting this into the expression for social utility and maximizing, we get that the level of pollution must meet the condition:

$$(1+g)\pi_i'(e) = C'(e)$$

- If $g = 0$, this is just the default "marginal return equals marginal cost"; $(1+g)$ shows up because profits are taxed and provide extra returns

Asymmetric information

- We now assume asymmetric information instead; the firm knows its own type (technology), but the government does not.
- As usual, we will include it in the model by leaving the firm type random (from the government's point of view).
- We assume two possible types: the probability is q for low cost, $i = L$, and $(1-q)$ for high cost, $i = H$, where $k_L < k_H$

$$\pi_L(e) = \pi^* - k_L(e^* - e)^2 \qquad \pi_H(e) = \pi^* - k_H(e^* - e)^2$$

Regulation with asymmetric information

- Standard Principal Agent problem: The government must now offer two "contracts" e_L, T_L and e_H, T_H

- An interpretation: Firms can register as two different types, which are subject to environmental regulation and taxation

  (We could imagine many other ways of designing regulation in practice when there is asymmetric information: check out the course *mechanism design*)

  Important result here is the *Revelation principle*: When looking for contracts that maximize social utility we can restrict ourselves to cases in which firms are willing to reveal their private information to the social planner (i.e. to report their true type/cost).

IC conditions and social utility

- The firm specifies its own type $\Rightarrow$ the contracts e_L, T_L and e_H, T_H should be designed such that the company will not try to fake its type
- Gives rise to Incentive Compatibility constraints as usual
- Uncertainty about the type of firm means that the principal maximizes *expected* social benefit:

$$q\left(\pi_L(e_L) - C(e_L) + gT_L\right) + (1-q)\left(\pi_H(e_H) - C(e_H) + gT_H\right)$$

The principal's problem, asymmetric information

$$\max_{e_L,T_L,e_H,T_H} \quad q\left(\pi_L(e_L) - C(e_L) + gT_L\right) + (1-q)\left(\pi_H(e_H) - C(e_H) + gT_H\right)$$

s.t.

$$\pi_H(e_H) - T_H \geq 0 \qquad (\text{IR}_H)$$

$$\pi_L(e_L) - T_L \geq 0 \qquad (\text{IR}_L)$$

$$\pi_H(e_H) - T_H \geq \pi_H(e_L) - T_L \qquad (\text{IC}_H)$$

$$\pi_L(e_L) - T_L \geq \pi_L(e_H) - T_H \qquad (\text{IC}_L)$$

Analysis of constraints I

- Mathematically, Sloth shows that if both IR_H and IC_L are met then IR $_L$ is also met

- Intuition:
  - If regulation of H is mild enough such that H does not prefer to close down ...
  - ..and if regulation of L is mild enough such that L does not prefer to pretend to be H
  - .. then L wants to submit to the regulation scheme rather than closing down.

Analysis of constraints II

- It follows from the previous slide that we can drop IR_L from the problem.
- Next: We (Sloth) make a (qualified) guess that IC_H doesn't bind (guess-and-check method):
  1. Suppose IC_H does not bind
  2. Solve the problem without IC_H
  3. Check that the solution actually complies with IC_H (turns out to be the case, see Sloth)

The principal's problem, simplified

$$\max_{e_L,T_L,e_H,T_H} \quad q\left(\pi_L(e_L) - C(e_L) + gT_L\right) + (1-q)\left(\pi_H(e_H) - C(e_H) + gT_H\right)$$

s.t.

$$\pi_H(e_H) - T_H \geq 0 \qquad (\text{IR}_H)$$

$$\pi_L(e_L) - T_L \geq \pi_L(e_H) - T_H \qquad (\text{IC}_L)$$

- We can quickly argue that both constraints will bind (otherwise raise T_H or T_L)
- Then the problem can be solved by Lagrange or by using the constraints and maximize

The optimal regulation I

- We omit the mathematics here (see Sloth) and just discuss the conclusions:
- If the company has high costs, it follows from IR_H that the entire profit must be taxed exactly as in the case with full information
- It further turns out that if the company has low costs then it should reduce pollution as much as with full information
- On these two points, the optimal contract (regulation) is thus not changed by the asymmetric information

The optimal regulation II

- In contrast, the pollution level of an H firm is higher than under full information and the taxation of a L firm is lower (inefficient).

- Low-cost firms pay only part of their profits in tax, i.e. they now get positive profits (information rents)

  The lower tax (positive profit) entices L firms to admit that they are L types and undertake major pollution reduction

- However, high-cost companies should not limit their pollution as much as under full information

  If H firms were imposed a greater pollution reduction, it would require their tax payment to be lowered (otherwise negative profits), but this would make it attractive for L firms to pretend to be H

Socrative Quiz Question

True or false: If the share of high cost firms gets close to one, the amount of pollution specified in their contract e_H will get closer to the full information benchmark.

What have we learned?

- Principal Agent models can be used to analyze information problems in policy design
- Get a general idea of how a Principal Agent model with two types of agents can be mathematically analyzed
- Asymmetric information may have the same distributional and efficiency consequences in policy design as we have seen elsewhere