

Paris School of Economics

M2R APE

Environmental Economics

Part 1

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Duration : 2h00

No document allowed.

Problem (10/20)

We consider a polluting industry composed of firms that use the same polluting technology to produce a given good. They can install end-of-pipe devices to reduce their pollution but they are characterized by an unobservable environmental inefficiency θ that increases their abatement costs $C(e, \theta)$, with polluting emissions e . To keep things simple, we do not focus on the competition framework and only assume that their cost function is separable, one part depending only on output and the other part only on abatement costs. By assumption, all firms produce thus the same level of output. This allows to write their profit as follows, as the difference between π_0 standing for profit due to output, identical for all firms, and the abatement cost $C(e, \theta)$: $\pi(\theta) = \pi_0 - C(e, \theta)$. Therefore, the regulator only has to worry about pollution. The regulator only knows that θ is distributed accordingly to a repartition function $F(\theta)$, associated to the density function $f(\theta)$ defined on $[\underline{\theta}; \bar{\theta}]$.

In the greatest part of this problem, we will consider that the inefficiency affects only the variable abatement cost : $C(e, \theta) = F + \theta(\bar{e} - e)^2$ with $\bar{e} > 0$.

The damage caused by the polluting emissions is denoted by $D(e) = de^2$ with $d > 0$.

Under imperfect information, the regulator will propose to the firms a menu of contracts, characterized by different levels of taxes/subsidies depending on the efficiency degree $\{T(\theta)\}$. The subsidies are financed through an indirect tax bearing on households, with a cost of public funds denoted by α .

1. The framework

- (a) *Which kind of asymmetric information is depicted by these assumptions ?*

This is a typical case of hidden characteristic of the regulated firm : ex ante asymmetric information \equiv adverse selection.

- (b) *Which would be the level of polluting emissions of the firm θ in a decentralized equilibrium ?*

In the decentralized equilibrium, the firm maximizes its profit, taking account only of its private cost and ignoring the external cost caused by its activity :

$$\begin{aligned} \max_e \pi(e, \theta) &\equiv \min_e C(e, \theta) \Leftrightarrow e^d(\theta) = \arg \min C(e, \theta) \\ \text{s.c. } \pi(e, \theta) &\geq 0 \quad (\text{PC}) \end{aligned}$$

It should be noted here that the abatement cost increases with abatement, meaning that it decreases with the level of emissions released : $C_e(e, \theta) < 0$. The firm operates at zero marginal abatement cost, meaning that it does not make any effort of abatement.

- (c) Write the consumers' surplus S , which is assumed to depend only on $e(\theta)$, α and $T(\theta)$.

The transfer T is financed through distortionary taxes and α stands for the marginal cost of public funds (cost for increasing the public revenues), hence the welfare loss for consumers is $(1 + \alpha)T$. If we denote S_0 the market social welfare due to consumption, but assumed here not to depend on e and θ , the net consumers's surplus $S(e)$ is simply :

$$S(e) = S_0 - D(e(\theta)) - (1 + \alpha)T(\theta)$$

- (d) Under imperfect information, express the profit $\pi(\theta)$ of a firm θ according to $e(\theta)$ and $T(\theta)$.

The firm's profit is

$$\pi(e, \theta) = \pi_0 - C(e, \theta) + T(\theta)$$

- (e) Express the social welfare W , according to $e(\theta)$, α and $T(\theta)$. Write it now according $e(\theta)$, α and $\pi(\theta)$.

$$\begin{aligned} W &= S(e) + \pi(e, \theta) \\ &= [S_0 - D(e(\theta)) - (1 + \alpha)T(\theta)] + [\pi_0 - C(e, \theta) + T(\theta)] \\ \text{with } T(\theta) &= \pi(e, \theta) - \pi_0 + C(e(\theta), \theta) \\ \implies W &= S_0 - D(e(\theta)) - (1 + \alpha)C(e, \theta) - \alpha\pi(e, \theta) + \alpha\pi_0 \end{aligned}$$

2. Perfect information

- (a) Write the participation constraint for a firm θ and the regulator's program.

The firm will accept to participate only if its profit is positive or null :

$$\text{PC} : \pi(e, \theta) \geq 0 \Leftrightarrow \pi_0 - C(e, \theta) + T(\theta) \geq 0$$

- (b) Write the first order conditions of this program. Interpret them. Determine the first-best level for the polluting emissions e_{FB} : how does it depend on the marginal cost of public funds and on the abatement inefficiency of the firm ?

Under perfect information, the regulator knows the realization of θ . The first-order condition defining e_{FB} is :

$$\begin{aligned} \frac{\partial W}{\partial e} &= 0 = -D_e(e(\theta)) - (1 + \alpha)C_e(e, \theta) \\ &\Leftrightarrow -(1 + \alpha)C_e(e, \theta) = D_e(e(\theta)) > 0 \\ &\Leftrightarrow -C_e(e, \theta) = \frac{1}{1 + \alpha}D_e(e(\theta)) \end{aligned}$$

By contract, the regulator restricts the level of emissions $e_{FB} < e^d$ because the firm has to operate at a positive marginal cost of abatement. The higher α , and the lower the marginal damage that is internalized by the firm : because the regulating contract is socially costly, the regulator has to trade off between the environmental efficacy and the cost of the contract. Since the socially optimal level of pollution would have been e^* such that $-C_e(e^*, \theta) = D_e(e^*(\theta))$, $e_{FB} > e^*$. When the abatement inefficiency θ of the firm increases, e_{FB} increases.

3. Imperfect information

- (a) Express the profit $\pi(\theta, \hat{\theta})$ of a firm θ which announces $\hat{\theta}$.
- (b) What happens if one offers to a firm of type θ a contract designed for a less efficient firm, of type $\hat{\theta} > \theta$?
- (c) Compute the marginal informational rent of a firm θ . Is it positive or negative? How can you explain it?
- (d) Write the total informational rent, by expressing the profit $\pi(\theta)$ according to $\pi(\underline{\theta})$ or $\pi(\bar{\theta})$, depending on which one is the most relevant.
- (e) Write the participation constraint and the incentive constraint considered by the regulator. How writes then the regulator's program?
- (f) Solve this program and comment on the first order conditions and on the results.

4. Case of inefficiency affecting the fixed costs

- (a) How are the objective function and the constraints modified if the inefficiency affects only the fixed cost of installing a given depolluting device, the abatement cost becoming $C(e, \theta) = \theta F + (\bar{e} - e)^2$?
- (b) Write the first order conditions under perfect information and asymmetric information, and derive the contract for the firm in this case. Couldn't you explain intuitively this result?