

Imperfectly Enforceable Pollution Tax with Asymmetric Information

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1. Introduction / Motivation

- General claim in environmental economics: taxes are superior to uniform emission standards in terms of cost-effectiveness.
- But to set a tax, the regulator needs to have at least some idea of the distribution of the marginal abatement cost (MAC) functions of the firms.

- One possibility: regulator asks firms to report their abatement costs
- Problem: firms may lie
- This concern is not new in the literature
- Kwerel (1977): firms will have an unbounded incentive to under-report its abatement costs under an emissions tax scheme

- Bulckaen (1997): incentive bounded if the regulator requires the firms to emit “consistently” with its report of abatement costs
- In other words, the incentive to under-report will be bounded if the regulator is able to perfectly enforce the resulting tax

- How does this result change in the more realistic situation in which the regulator is unable to perfectly enforce the resulting tax?

2. Objectives

- (1) Does the firm have an incentive to under-report? If it does, is this incentive bounded or unbounded?
- (2) If bounded, is the reported level of abatement costs larger or smaller than in the case of perfect enforcement?
- (3) Could the regulator design a penalty scheme based on emissions violations to bound under-reporting?

3. The Model

- N firms
- x_j be firm j 's level of emissions
- $X = \sum_j x_j$
- The regulator is able to estimate the aggregate damage function of pollution $D(X)$; $D'(X) > 0$ and $D''(X) > 0$.
- $C_j(x_j)$: the firm j 's abatement cost function

- $C_j' < 0$ and $C_j'' > 0$
- $C(X)$ is the aggregate abatement cost function
- $C_j(x_j)$ is privately known by firm j
- The regulator asks each firm j to report its abatement costs. It also declares that the information will be used to determine the optimal emission tax t

- To capture the decision of what to report and dropping subscript j , let
- $C(x) = C(x, \theta)$
- θ captures the truthfulness of the report
- $C_{\theta}(x, \theta) > 0$ and $-C_{x\theta}(x, \theta) > 0$
- $C(x, \theta^0)$: real abatement cost function

- $C(X) = C(X, \theta)$ is the aggregate reported abatement cost function
- $-C_{X\theta}(X, \theta) < 0$
- The regulator sets the tax so that $-C_X(X, \theta) = D'(X) = t$
- Therefore, $t = t(\theta)$

- Call $\bar{x} = x[t(\theta), \theta]$ the “consistent” level of emissions of the representative firm, determined by $t(\theta) = -C_x [x(t(\theta)); \theta]$
- The game between the firm and the regulator has three stages:
 - (1) The firm reports its abatement costs (θ);
 - (2) The regulator sets $t(\theta)$
 - (3) The firm chooses x and enforcement is applied.

- The firm is inspected with probability π and if found in violation of \bar{x} it pays a unit fine of $t(\theta) + \phi$, where ϕ is the constant marginal penalty
- The firm is going to comply with the consistent level of emissions ($x = \bar{x}$) if $-C_x\{\bar{x}, \theta^0\} \leq \pi[t(\theta) + \phi]$.
- If $-C_x\{\bar{x}, \theta^0\} > \pi[t(\theta) + \phi]$, then $x > \bar{x}$ and

$$C_x\{x, \theta^0\} + \pi[t(\theta) + \phi] = 0$$

- I call $x^0 = x^0[t(\theta), \theta]$ the solution to this equation.

- In stage (1) the firm chooses θ (the truthfulness of the report) so as to minimize its expected costs:

$$\min_{\theta} F(\theta) = C\{x^0, \theta^0\} + t(\theta) * \bar{x} + \pi[t(\theta) + \phi](x^0 - \bar{x})$$

$$s.t. (1) -C_x\{x^0, \theta^0\} \leq \pi[t(\theta) + \phi]$$

$$(2) C_x\{\bar{x}, \theta\} + t(\theta) = 0$$

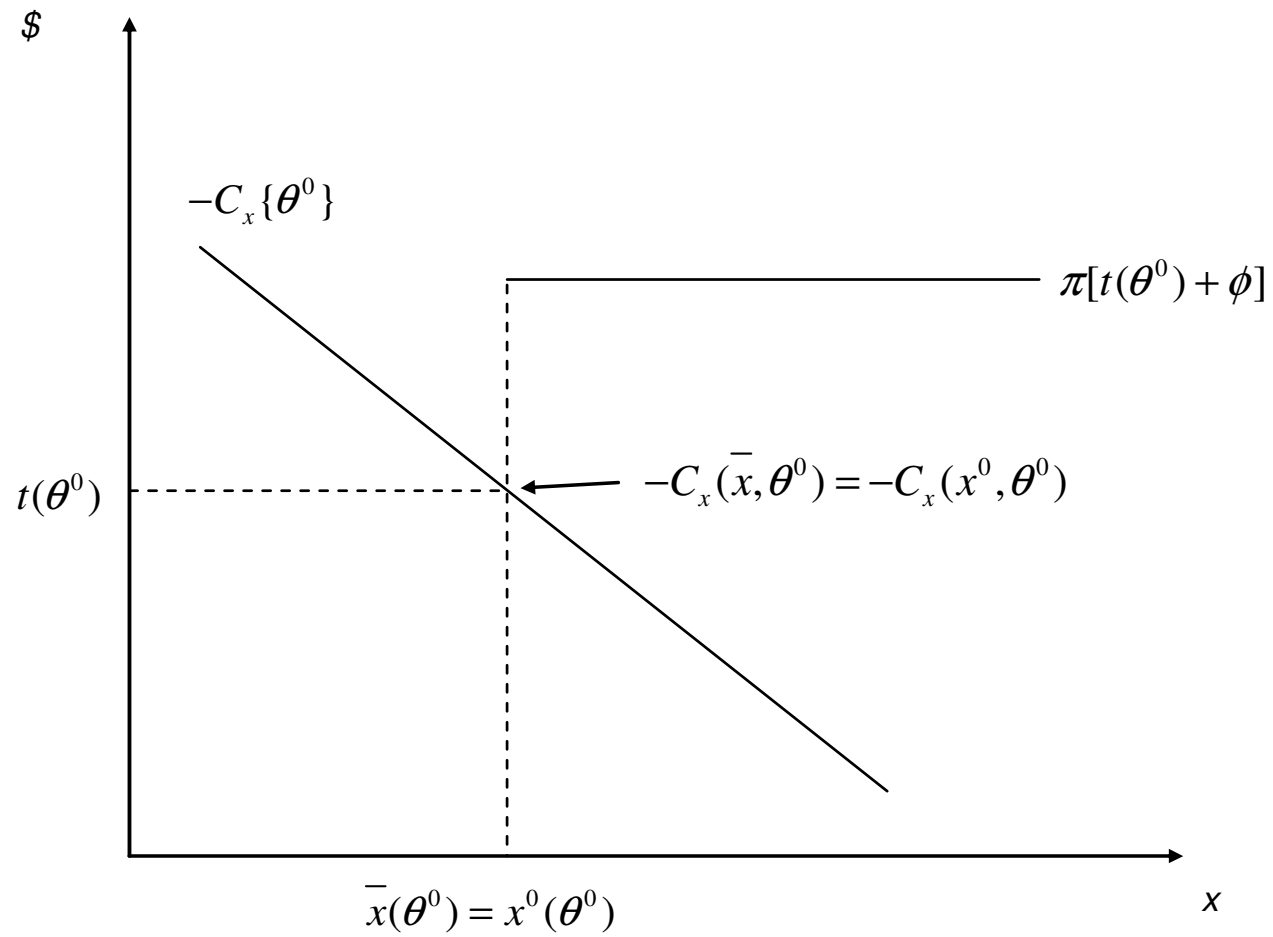
4. Incentives to Under-Report

- We evaluate $\frac{dF(\theta)}{d\theta}$ at θ^0 .
- We distinguish

Case 1:

- $-C_x\{\bar{x}(\theta^0), \theta^0\} \leq \pi[t(\theta^0) + \phi] \Rightarrow$ Initial level of enforcement is “high”

Figure 1: The initial level of the enforcement is high



- In this case $x^0(\theta^0) = \bar{x}(\theta^0)$, and

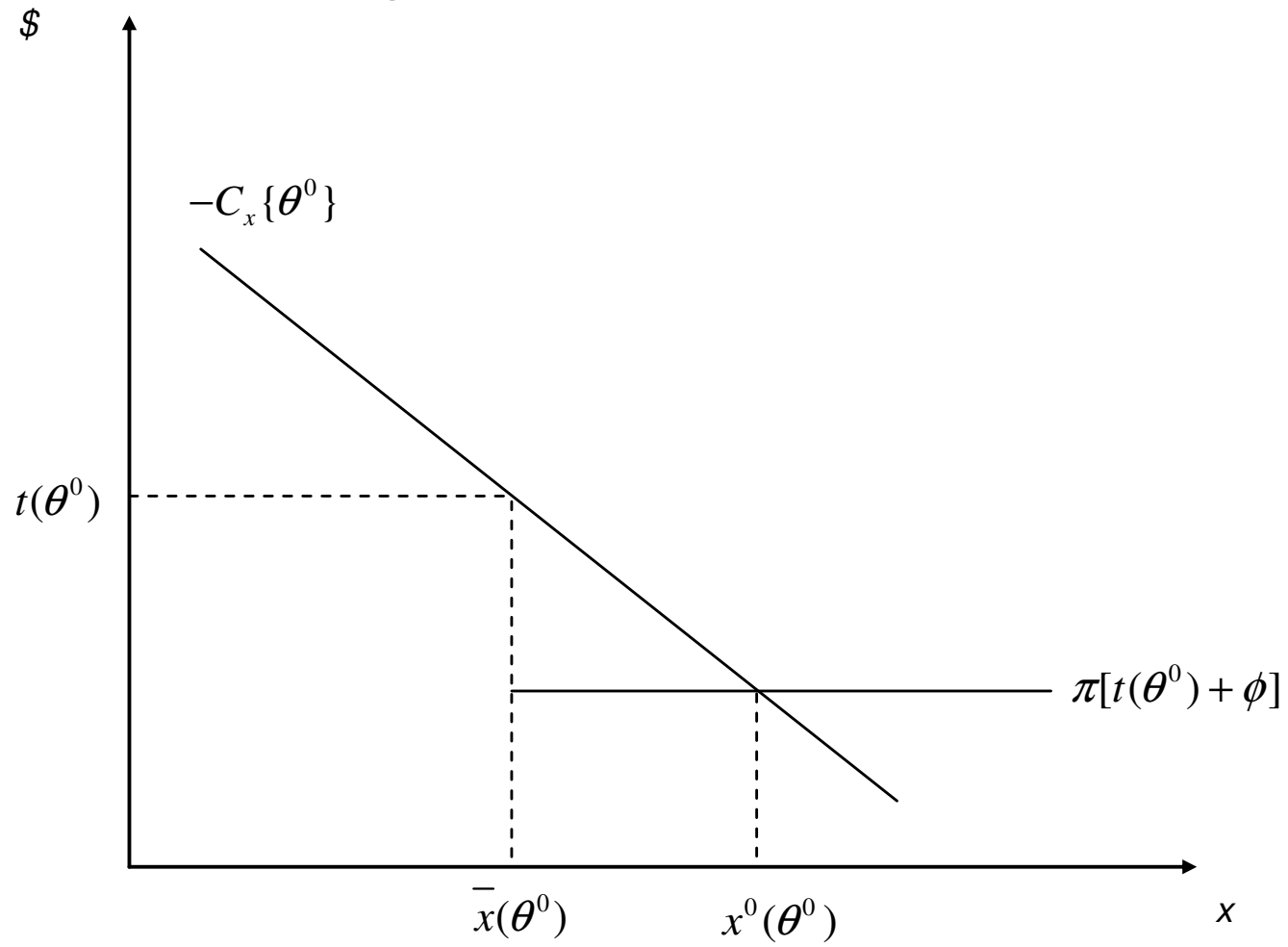
$$\frac{dF(\theta^0)}{d\theta} = \frac{dt(\theta^0)}{d\theta} x^0(\theta^0) > 0$$

- The firm is not going to report truthfully its abatement costs even if the expected marginal penalty is high enough to make it comply with the consistent level of emissions when it reports truthfully.

Case 2:

- $-C_x\{\bar{x}(\theta^0), \theta^0\} > \pi[t(\theta^0) + \phi] \Rightarrow$ The initial level of enforcement is “low”
- Now $x^0(\theta^0) > \bar{x}(\theta^0)$

Figure 2: The initial level of enforcement is low



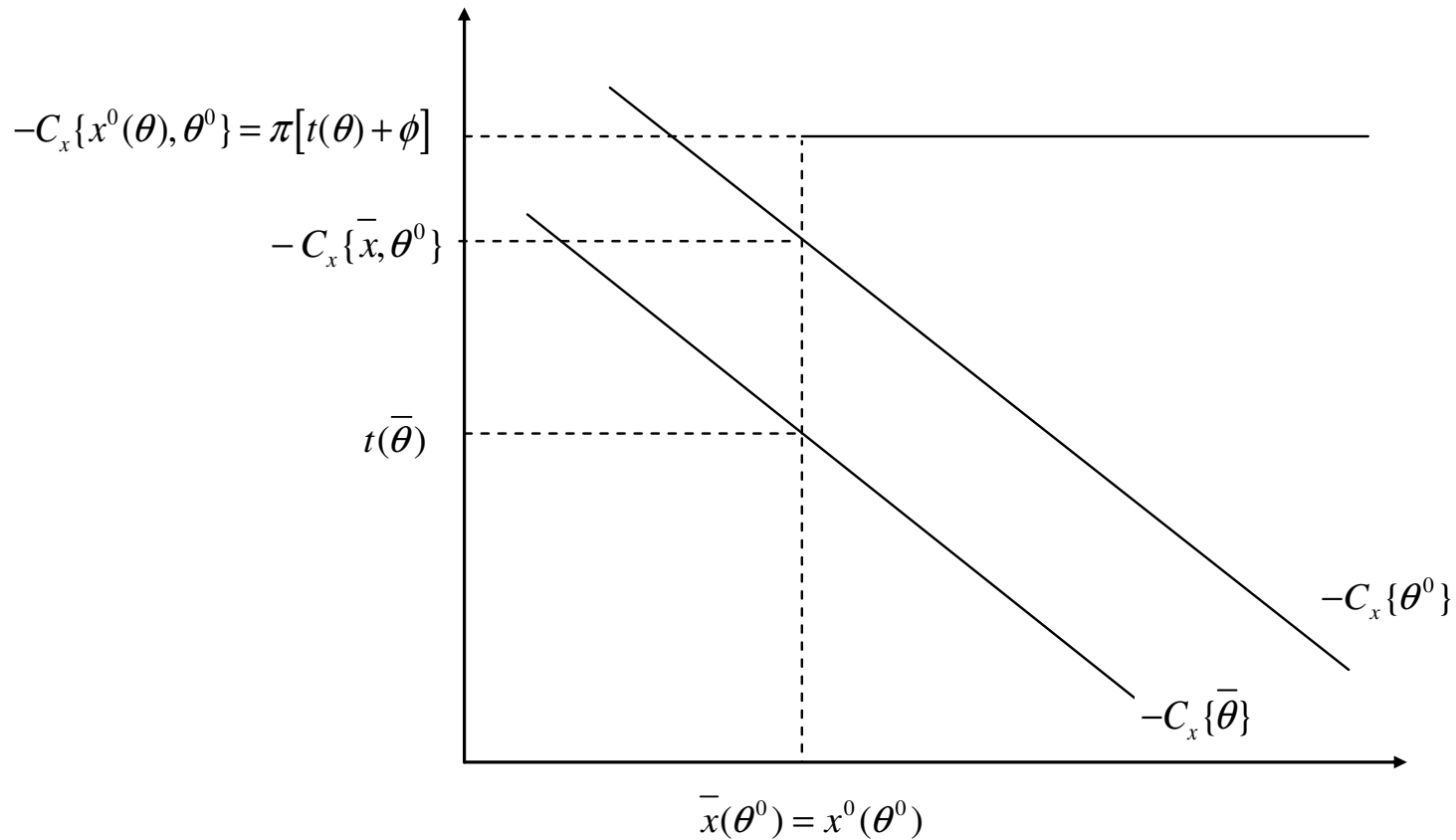
- Also in this case the firm has an incentive to under-report abatement costs.
- Result 1: *No matter the strictness of the level of enforcement of emissions the firm will never report its true level of AC.*

5. Bounded or Unbounded Incentives to Under-report?

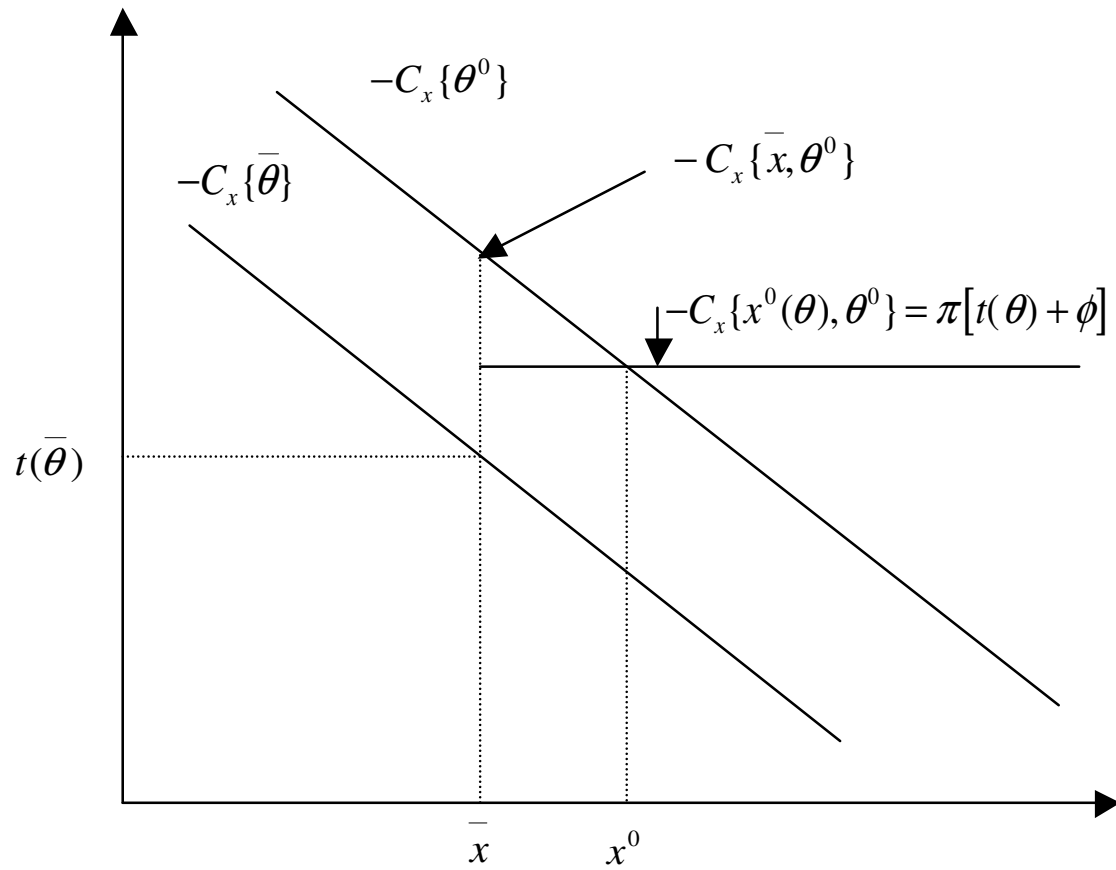
Case 1: $-C_x\{\bar{x}(\theta^0), \theta^0\} \leq \pi[t(\theta^0) + \phi]$

- Note that $-C_{x\theta}\{\bar{x}(\theta), \theta\} \frac{d\bar{x}}{d\theta} < 0 \forall \theta$ and $\frac{d\pi[t(\theta) + \phi]}{d\theta} = \pi \frac{dt(\theta)}{d\theta} > 0$
- This inequality cannot hold forever as long as θ decreases.
- We distinguish between two cases:

- **Case 1.a.:** $-C_x\{\bar{x}(\theta), \theta^0\} \leq \pi[t(\theta) + \phi]$ for all $\theta^* < \theta < \theta^0$, where θ^* is the level of θ that minimizes the total expected costs.



- Incentive to under-report is bounded. Bulckaen's case.
- **Case 1.b.:** $-C_x\{\bar{x}(\theta^0), \theta^0\} \leq \pi[t(\theta^0) + \phi]$, but at some $\theta < \theta^0$
 $-C_x\{\bar{x}(\theta), \theta^0\} > \pi[t(\theta) + \phi]$
- Then $x^0(\theta) > \bar{x}(\theta)$



- In this case the incentives of the firm to under-report abatement costs may be unbounded
- **Case 2:** $-C_x\{\bar{x}(\theta^0), \theta^0\} > \pi[t(\theta^0) + \phi] \Rightarrow$ The initial level of enforcement is “low”
- Same as Case 1.b,
- The firm’s incentives to under-report may be unbounded

- The incentives to under-report will be unbounded with certainty only if the marginal expected penalty for not complying with the consistent level of emissions is lower than the tax
- Result 2: *the incentive to under-report is bounded with certainty when the regulator is able to enforce the consistent level of emissions.*
- Result 3: *when the regulator is not able to enforce the consistent level of emissions for all levels of reported abatement costs, the incentive to under-report may be unbounded.*

6. Comparison with the case of perfect enforcement

- Result 4: *with imperfect enforcement of consistent emissions the firm always under-reports more than with perfect enforcement.*

7. Conclusions

- (1) No matter the strictness of the level of enforcement of emissions the firm will never report its true level of abatement costs.
- (2) The incentive to under-report is bounded with certainty only when the regulator is able to enforce the consistent level of emissions. Otherwise, the incentive to under-report may be unbounded.

- (3) With imperfect enforcement of consistent emissions the firm always under-reports more than with perfect enforcement.
- (4) Consistent penalties: Even in this case the incentive to under-report may be unbounded also.