Lecture 5

ECON 4910, Environmental Economics
Spring 2011

Instrument choice under uncertainty
(Perman et al., Ch.8)
Enforcement (Heyes 1998)

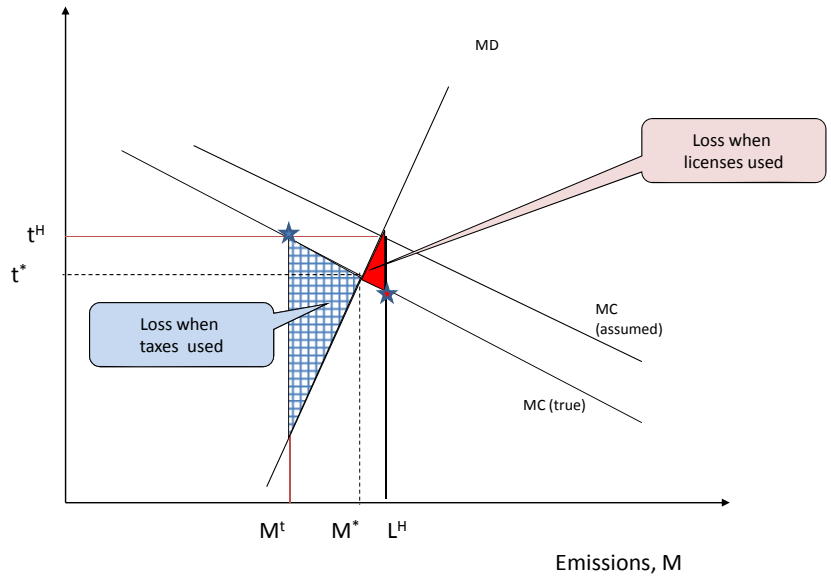
Instrument choice with uncertain B'(M)

- Regulator:
  - Goal: Max net benefits (PO) ⟶ B'(M) = D'(M)
  - Choose instrument: tax or tradable permits
- Firms:
  - Goal: Max profits ⟶ f' = τ (unit price of em.)
- Consumers: Passive
- Genuine uncertainty:
  - Marginal abatement costs are uncertain
  - Uncertainty realized *after* regulator acts, *before* firms act
- Asymmetric information:
  - Firms, not the regulator, know abatement cost functions
  - Firms act *after* the regulator

Price or quantity instruments?

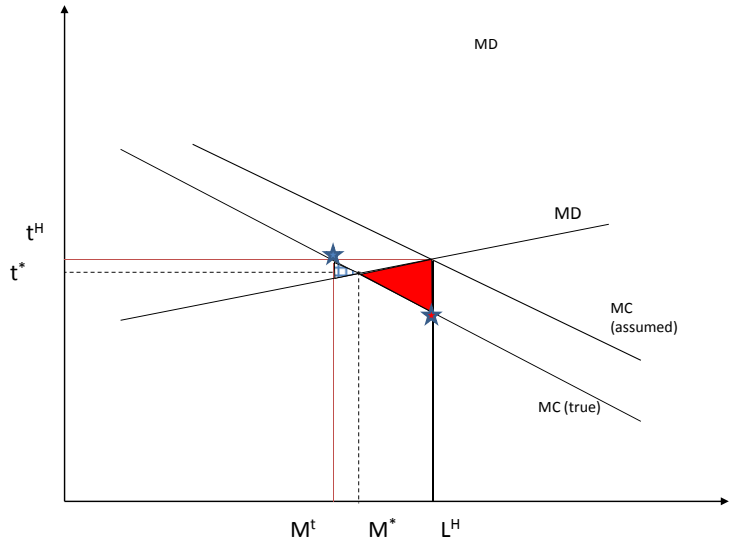
- Price instruments
  - Keep control of values (marginal abatement costs)
- Quantity instruments
  - Keep control of quantities (emission levels)
- What is worst:
  - To lose control of abatement costs?
  - To lose control of emission levels?

Figure 8.3 Uncertainty about abatement costs – costs overestimated.



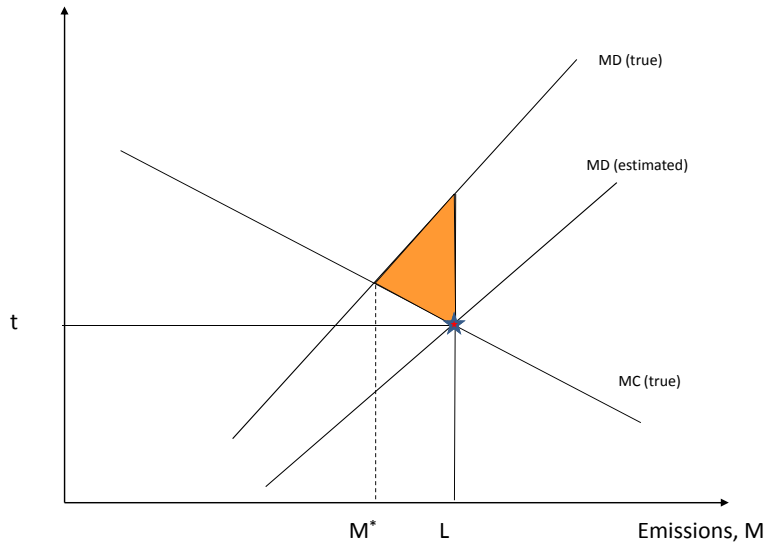
Target mistake: Costs of setting the ”wrong” target is *larger* with tax than permits

Figure 8.5 Uncertainty about abatement costs – costs overestimated.



Target mistake: Costs of setting the ”wrong” target is *smaller* with tax than permits

Figure 8.7 Uncertainty about damage costs – damages underestimated.



Damage uncertainty does not matter!

Reason: Only firms act; firms relate to MC curve, not MD curve

Prices versus quantities (Weitzman 1974)

- **Taxes** (prices): Good when B' is steep
  - Preferred when marginal abatement costs change faster than marginal damages
  - **B' curve steeper** (absolute slope is greater) **than D' curve**
- **Permits** (quantities): Good when D' is steep
  - Preferred when marginal abatement costs change slower than the marginal damages
  - **B' curve is flatter** (absolute slope is lower) **than D' curve**
- Intuition:
  - Marg. **abatement costs** vary a lot: wrong tax has large consequences for firms' costs
  - Marg. **damages** vary a lot: wrong emissions have large consequences for the environment
- Assumption: Uncertainty about level, not slope
- Damage uncertainty does not matter for instrument choice

Enforcement

- Readings: Heyes (1998), Perman et al. 8.4
  - Classical paper: Becker (1968): Crime and Punishment: An Economic Approach, *J.Pol.Econ*. 76
- Enforcement:
  - Monitoring/detection: Are firms violating?
  - Sanctioning: Punishment of confirmed violators
- Question 1: Will firms comply?
  - For simplicity: Consider the case of emission cap
  - Profit max. firm complies only if expected penalty of violating exceeds the firm's compliance cost
- Question 2: What should the regulator do about it?

Firms' compliance choice

- "Binding" emission cap: $m^{max} < \hat{m}$
  - disregard difference between firms
- Violate? If yes: How much?
- Assume risk neutral firms: Maximize expected profits
- Assume perfect monitoring
  - *If* inspected, violations are revealed with certainty
- Enforcement policy (known by firm):
  - Fixed monitoring probability *q*
  - Penalty P(m) if inspected (note notation):
    If $m \leq m^{max}$: P(m) = 0
    If $m > m^{max}$: P(m) ≥ 0, P' ≥ 0
- E(P(m)) = qP(m)

Profit maximizing compliance levels

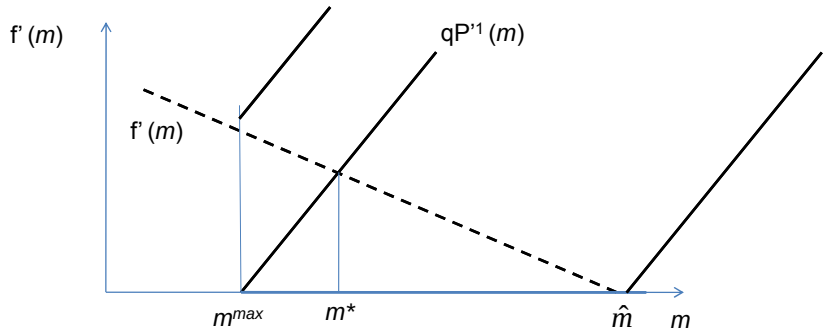
- Before: assumed that firms took $m \leq m^{max}$ as given
- Now: Firms decide m by maximizing expected profits
- Max E(π) = $f(m) - b$ – E(P(m)) (with respect to m)
  = $f(m) - b - q$P(m)
- First order condition for interior solution:
  ∂E(π) /∂m = $f' - qP' = 0$ -> $f' = qP'$
- The firm pollutes until marginal abatement cost equals *marginal expected penalty*
  - interior solution
- Corner solutions:
  - No violation if $f'(m^{max}) < qP'(m^{max})$
  - Full violation (no abatement) if $f'(\hat{m}) \geq qP'(\hat{m})$

Equivalent to Heyes (1998), but notation & formalization slightly different:

- abatement costs vs. income from pollution
- cost minimization vs. profit max
- penalty as a function of emissions or violations

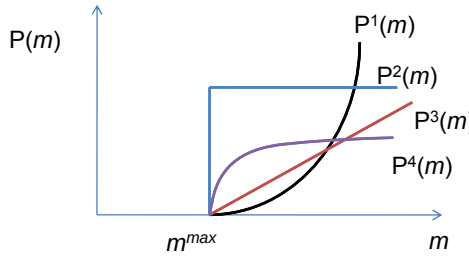
The importance of marginal penalties

- F.o.c.: $f' = qP'$
- f' decreasing in m (because f is concave)
- Increasing marginal penalties ($P'^{1}(m)$ increasing):
  - Profit max. emissions m^*



The penalty function

- Is the marginal penalty increasing in the degree of violation?
- All of these P functions impose a penalty for violations:



P^{1}''>0

P^{2}''=0 (for $m \neq m^{max}$)

P^{3}'' =0

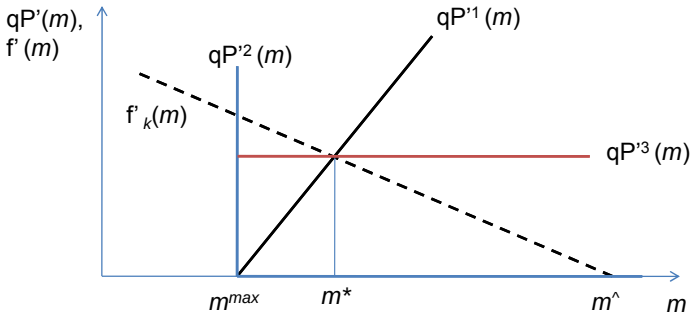
P^{4}'' < 0

- but their effects on emissions are very different!

- *F.o.c.:* $f'(m) = qP'(m)$
- If qP' is *not* increasing in m : May get corner solutions

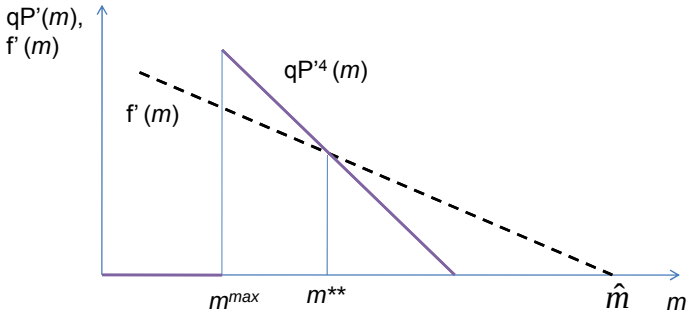
The importance of marginal penalties

- F.o.c.: $f' = qP'$
  - f' decreasing in m (because f is concave)
- Increasing or fixed marginal penalties ($P^{1}(m)$, $P^{3}(m)$):
  - Interior solution: m^*
- High absolute, but zero marginal penalties ($P^{2}(m)$):
  - Corner solution: either m^{max} or $m^{\wedge}$



The importance of marginal penalties, cont.

- Decreasing marginal penalties ($P^4(m)$):
  - at m^{**}, f.o.c is fulfilled
  - But: If emissions increase marginally, revenue will increase more than expected penalty
  - Corner solution: either m^{max} or $\hat{m}$
  - Area below f': Gain of violating; area below qP': Exp. cost of violating



Firms' compliance

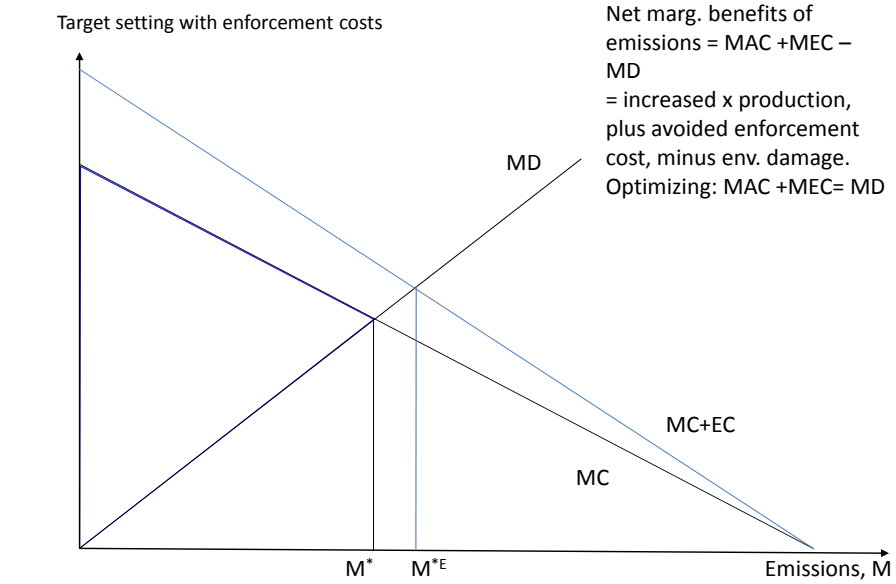
- Profit maximizing firms:
  - **Violate** when cost of compliance exceeds expected penalty
  - **Degree of violation:** depends on *marginal* expected penalty (and marg. abatement cost)
  - Decreasing marginal penalty may encourage full violation!
- Note:
  - If violation is profitable, and *q* and *P* independent of compliance history, firm will violate "forever" (even after it is caught).
  - Ex: q = 1, $P = P^1(m)$, $f'(m^{max}) > P^{1\prime}(m^{max})$
  - In this case, regulator knows firm is violating; firm is sanctioned; firm keeps violating: Prefers sanctions to abatement cost!

Regulator's response

- Sufficiently high penalties and/or monitoring probabilities can ensure full compliance
  - e.g.: q=1, $P'(m^{max}) > f'(m^{max})$, and $P'' \geq 0$
  - Credible threats of sufficiently harsh punishment can eradicate crime
- In practice: Expected penalty is limited
  - Costly monitoring (inspection costs etc): May limit q
  - Costly sanctioning (legal procedures etc): May limit P(*m*)
  - Imperfect monitoring: May limit P(*m*)
    (type I & II errors, fairness concerns)
  - Fairness, more generally: May limit P(*m*)
    (Reasonable/political acceptable)

Regulator's response – general remarks

- Enforcement costs are real economic costs
  - Some goals may not be worth it, given the enforcement costs
  - Example of transaction costs
  - Arise (partly) because of information asymmetries and strategic incentives (private information on e.g. costs, emissions)
- Enforcement costs are not independent of the goal
  - Easy measurement/verification -> lower enforcement cost
- Relevant for all policy instruments
  - e.g.: collection of emission taxes requires knowledge of emission levels
- Enforcement and regulation must be considered jointly
- The regulator may have to take into account: Regulation will not be perfectly obeyed
  - Full compliance usually too expensive
  - Some taxes will be evaded; some illegal emissions will take place.



M^{*E} = Pareto efficient emission level, taking real enforcement costs into account

Next

- Next week: No lecture
  - Work with voluntary term paper

- Michael Hoel's lectures
  - Feb. 28: Optimal environmental taxation in the presence of other taxes. Readings: **Bovenberg 1999, Hoel 2008**
- April 11: Voluntary approaches (Nyborg)
  - Readings: **Nyborg and Rege**; Lyon and Maxwell

Voluntary term paper

- Your assignment is the ECON4910 exam given in the spring of 2010.
- You can find it at the current course's web page or
  http://www.sv.uio.no/econ/studier/admin/eksamen/tidligere-eksamensoppgaver/eksamensoppgaver%20master/econ4910/Ordin%C3%A6r/4910.v10.pdf
- Next lecture (Feb 28; no lecture in week 8):
  - Bring your paper to class, exchange with partner
  - After class: Correct partner's paper (solution will be posted on the course's web page Feb 28)
- Lecture March 7:
  - Bring your partner's (corrected) paper and your notes/remarks
  - After class: Exchange & discuss

Points to consider when commenting

- For every question:
- Is the main argument understood?
  - Is it well explained? Do you have trouble understanding the explanation? Why/why not?
  - Is it precise? If not, what could be clarified?
- Does the answer indicate critical/independent thinking?
  - Could it have been passively copied without understanding its meaning?
- Are formal models applied in useful & meaningful ways?
  - If formal models are used, why are they useful here?
  - If formal models are not used, should they? Why/why not?
- Important points missing?
- Superfluous material included?
- Mistakes/errors? Notation well defined?