Environmental Economics – Lecture 6

Environmental R&D

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Requate (2005), Hoel (2010)

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Review last lecture

Regulation under imperfect information

1. Regulator does not know the firm's "type"
   - Prices vs. Quantities
   - Revealing private control cost information

2. Regulator does not know the firm's action
   - Midnight dumping and deposit-refunds
   - Audits and Enforcement
   - Dynamics and Commitment

Key concepts last lecture

- Prices vs quantities: The preference for one or the other instrument depends on the relative steepness of the marg damage and benefit functions
- Private control cost can be elicited by a hybrid instrument
- Midnight dumping may be prevented by an adequate system of deposit taxes and refund subsidies
- Firms may find it in their best interest to violate existing regulations, approving potential punishment
- The expectation of a "ratchet effect" may prevent firms from undertaking cost-saving investments

Preview this lecture

1. Abatement cost that depend on (endogenous) technology
2. Socially efficient amount of R&D
3. Can a market regulated by taxes or quotas achieve the first-best?
4. A distinct “environmental innovation” policy?

Modeling endogenous technology

- Innovations, learning-by-doing, and inventions: Here focus on costly R&D. Assume that technology y increases from the status-quo of $y = 0$ proportional to the amount of expenditures x such that $y = gx$
- Without concern for environment, we have: $\hat{m}(y)$ defined by $f'_m(m, y) = 0$
- Business as Usual (BaU) is zero abatement under original technology: $a = \hat{m}(0) - m = 0, \quad a \in [\hat{m}(0) - m(y), \hat{m}(0)]$.
- Denote abatement cost by $C(a, y)$.

Modeling endogenous technology

Different types of technological improvements

- Increased technological efficiency
- Reduced cost of clean substitutes
- Reduced cost of clean-up

Socially efficient amount of R&D

- Let the value of abatement be $V(a) = V^* - D(\hat{m}(0) - a)$.
- Social objective is to maximize $V(a) - C(a, gx) - x$ by choosing a and x
- First order conditions are

$$C_a(a, y) = V'(a) \tag{1}$$

$$-C_y(a, y) = \frac{1}{g} \equiv f \tag{2}$$

Many small innovations

Increments in y are so small that the emission price τ is practically independent of the innovator's choice.

Crucial assumption: Spill-over effects from R&D: Only a fraction k of total benefits from innovation are private:

$$-C_y g \Delta x = k(-C_y g \Delta x) + (1-k)(-C_y g \Delta x)$$

Many small innovations

1. Regulator cannot commit to refrain from setting τ optimally once y is decided
   - Too little R&D and too little abatement $k < 1$.
   - Regardless whether τ results from price or quantity regulation
2. Regulator can commit to τ before innovators choose x
   - R&D is larger under tax than under quota regulation when regulator commits to a level of τ which is optimal under $y = 0$
   - When the regulator anticipates the reaction of the innovators, there will sub-optimally low R&D ($y^{NC} < y^{PO}$), but abatement will exceed the level that would be efficient at y^{NC}

“Breakthrough” innovations

- Commitment problem plays a central role also here:
- With a tax, innovators have no incentive to innovate as they anticipate that all rents will be taxed away
- Quotas are preferable (though still not giving the first-best) as they do allow some incentives to innovate

Key concepts this lecture

1. The non-excludability of innovations leads to market failures related to environmental R&D
2. For "small innovations" there is no difference to conventional R&D with respect to pro-innovation policies
3. For "breakthrough" there is a difference in that the demand for R&D is caused by the regulation. Hence there is a rationale to consider abatement and environmental R&D together.
4. The comparison between taxes and quotas depends on whether the regulator can commit and the type of innovation.

Preview next lecture

Stock pollution problems Perman et al (2011), ch.16

1. Different types of stock-pollutant problems
2. Optimal control theory applied to a local stock-pollutant problem
3. Optimal dynamic tax paths for different types of damage functions