Regulation with Competing Objectives, Self-Reporting, and Imperfect Monitoring

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Introduction

- Environmental information disclosure programs may yield both direct and indirect benefits
  - Indirect benefit results from increasing firms' private costs of emitting, and thereby reducing emissions
  - Direct benefit occurs if disclosure itself reduces the social costs associated with a given level of emissions

Introduction

- Firms may incur costs in many ways when disclosing (potentially) harmful emissions:
  - Most directly if reported emissions are taxed
  - Due to increased exposure to liability
  - Market reaction impacting the firm's value
  - Consumer demand response

Introduction

- Timely disclosure of emissions may reduce social costs in several ways
  - Private parties and public agents can respond to mitigate or avoid damages
  - Contaminated resources can be avoided
  - Clean-up can be more efficiently managed
  - Cumulative harm of repeated emissions can be foreseen and mitigated

Introduction

- Focus of both theoretical and empirical literature has been on emissions reductions arising from disclosure programs (the indirect benefit): Malik [1992], Swierzbinski [1994], Hamilton [1995], Khanna et al. [1998], Livernois and McKenna [1999], Konar and Cohen [2001]
- Less attention has been given to the fact that information disclosure may directly improve social welfare
  - "The environmental information embodied in [disclosure programs] has economic value…even in the absence of any changes in emissions by firms." [EPA, 2001]

Introduction

- We present a model of optimal regulatory policy when a disclosure program yields both direct and indirect benefits, but enforcement of disclosure requirements is costly and imperfect
- We first must model the behavior of a firm which chooses both how much to emit and how much of its emissions to disclose as a function of the regulatory environment

Introduction

- Model of firm behavior assumes:
  - Firm pays a tax on disclosed emissions
  - Firm pays a penalty on revealed undisclosed emissions
  - An imperfect audit by the regulator may reveal some (not necessarily all) undisclosed emissions
- Given this understanding of firm behavior, the regulator chooses tax rate and audit probability (i.e. enforcement intensity) to minimize social welfare costs

Introduction

- In our framework a regulator has competing objectives
  - Internalizing socials costs, e.g. through emissions taxes, will deter emissions
  - Increasing the cost firms incur for disclosed emissions generates a disincentive to disclose information
- Regulator must also account for enforcement costs of achieving compliance

Related literature

- Malik [1992] and Swierzbinski [1994] have shown that environmental disclosure programs can improve social welfare, but through a very different mechanism
  - Do not incorporate direct benefit of disclosure
  - Benefit of self-disclosure occurs by enabling regulator to achieve a given level of emissions reductions with lower enforcement costs
  - Utilize framework in which firm's fully reveal their emissions under optimal regulatory policy ("truthful revelation")
  - Audits (if undertaken) perfectly reveal firm behavior

Model of the Representative Firm

- A representative firm is subject to a mandatory disclosure program which requires the firm to report an emissions level
- The firm is audited with probability p
- At time zero
  - The firm emits an amount of pollution, denoted e
  - The firm chooses reported emissions to submit to regulator, with z denoting the share of actual emissions reported
  - The firm is subject to a per unit tax on reported emissions, denoted α

Model of the Representative Firm

- At time one
  - If the firm is audited the audit reveals a quantity of emissions, denoted x, which depends on the firm's actual emissions and a random variable u: $x=eu$
    - Assume u is distributed with pdf $f(u)$ and cdf $F(u)$ on $[0,b]$
    - We allow possibility that audit "reveals" more than is actually emitted, but assume the single mode of the distribution lies at 1
  - If the revealed level of emissions is greater than the reported level, the firm incurs a constant per unit penalty of β on revealed but unreported emissions

Model of the Representative Firm

- Firm chooses report, z, to minimize expected costs,

$$\underset{z}{Min}\ e\left[\alpha z + p\int_{z}^{1}\beta(u-z)\,f(u)du\right]$$

- Condition for optimum:

$$\alpha = p\beta\left[1-F(z^*)\right]$$

  - An interior solution on z* requires $\alpha < p\beta$

- This yields a constant marginal cost of emitting

$$\mu^*(\alpha, p) \equiv \alpha z^* + p\beta\int_{z^*}^{1}(u-z^*)f(u)du$$

Model of the Representative Firm

- Optimal level of disclosure, z*, decreases with the tax rate and increases with the audit probability and the penalty rate
- Unit cost of emitting (given optimal disclosure), μ^*, increases with the tax rate, penalty rate, and audit probability

Model of the Representative Firm

- Given optimal disclosure and consequent unit-cost of emitting, the firm chooses emissions e to maximize the net benefit of emitting
  - Let $B(e)$ represent the value of emissions to the firm, with $B'(e)>0$, $B''(e)<0$
  - The firm chooses e^* to maximize $B(e)-C(e,z^*)=B(e)-e\cdot\mu^*$
  - Optimal emissions are defined by $\mu^*=B'(e^*)$
- The firm's emissions decrease with the tax, penalty, and audit probability

Model of the Regulator

- We formalize the direct benefit of disclosure of emissions as follows
  - Let m denote the per unit social cost of undisclosed emissions and s denote the reduction in the social costs that results from disclosure, with $s < m$
  - Given disclosure z^*, the per unit social cost of emissions is then given by $m - sz^*$

Model of the Regulator

- Regulator chooses tax, α, and audit probability, p
  - Penalty, β, is exogenous
  - Regulator knows how policy choices will impact firm behavior

Model of the Regulator

- The regulator's objective is to minimize social costs:

$$V = e(\mu^*)[m - sz^* - \mu^*] + pw - \int_{\mu^*}^{\mu_c^*} e(\rho)d\rho$$

  - The first term is social cost of emissions net of expected payments by the firm
  - Expected auditing costs are pw
  - The final term captures the net benefit to the firm of emitting

Model of the Regulator

- The first order conditions for an interior solution yield

$$e'(\mu^*)\frac{\partial \mu^*}{\partial \alpha}(m - sz^* - \mu^*) = e(\mu^*)s\frac{\partial z^*}{\partial \alpha}$$

$$e(\mu^*)s\frac{\partial z^*}{\partial p} - e'(\mu^*)\frac{\partial \mu^*}{\partial p}(m - sz^* - \mu) = w$$

Model of the Regulator

- The optimal tax is increasing in m, the per unit social cost of undisclosed emissions and decreasing in s, the difference between the per unit social costs of undisclosed and disclosed emissions
  - The effect of the cost of auditing on the optimal tax is ambiguous
- The optimal audit probability is decreasing in the cost of auditing, w.
  - The effect of a change in m or s in the optimal audit probability is ambiguous

Policy Implications

- Consider a disclosure program aimed at emissions for which the social cost becomes negligible if disclosed, (as s approaches m in our model)
  - Optimal policy is then zero tax, which enables full reporting compliance to be achieved with negligible enforcement costs
  - It may even be optimal to insulate firms from other sources of disclosure costs, such as liability, in order to ensure full disclosure

Policy Implications

- Conversely, consider a disclosure program aimed at emissions for which disclosure does not significantly reduce social costs, (as s approaches 0 in our model)
  - Optimal policy is then to internalize the social cost while minimizing enforcement costs
  - This implies setting the tax rate $\alpha > p\beta$, which results in no disclosure but maximizes the firm's expected cost of emitting for any audit probability

Policy Implications

- Most cases where disclosure programs are employed almost certainly lie in middle, where achieving both the direct and indirect benefits is desired
  - Our model illustrates the inherent tension between these objectives
  - The model shows how the optimal policy balance depends on the relative costs of undisclosed vs. disclosed emissions, and the cost of enforcement