Environmental Regulation and Mandatory Disclosure

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Information Disclosure

"[P]ublicity is justly commended as a remedy for social and industrial diseases. Sunlight is said to be the best of disinfectants."

Louis D. Brandeis (1856–1941)
Known as the People's Attorney

Introduction

Information Regulation

- Today, public provision of information becomes part of a regulatory strategy, even if information disclosure has always been around.
- Disclosure policy involves a public authority requiring the collection and dissemination of standardized information from identified businesses or other organizations at regular intervals for the purpose of improving the behavior of the information disclosers as well as information users, with particular issues receiving special attention.
- Owing to the many important studies on this subject, we know better now what to expect in some specific markets when public information is disclosed.
- Disclosure is a valuable public good, provides greater transparency in the market, and is generally efficiency enhancing.

Information Disclosure

- In the food sector: food processors are required to provide nutritional information; restaurants are required to post cleanliness scores.
- In the health sector: hospitals are required to disclose information regarding medical mistakes.
- In the manufacturing sector: firms are required to disclose to workers information on potentially harmful chemicals at the workplace and risks exposure to pollutants.
- In the political arena: as a bulwark against the corrosive effect of money on democratic institutions, candidates are required to provide information to the public on who contributed to their campaigns.
- In the public sector: Police Departments are required to disclose to communities the presence of individuals who served time in prison for violent or sexual crimes.
- And thanks to other disclosure requirements, one may learn about school performance, local water quality, vehicle safety, tires fuel efficiency, safety, and durability, farming activities and so on.

Theoretical Research on Public Disclosure

- Most studies discuss the problem of whether public information should be released or disseminate and analyze its welfare impact:
  - Morris and Shin (AER, 2002) model the Keynesian beauty contest and asked if it is desirable to have frequent and timely publications of economic statistics by government agencies and the central bank.
  - Angeletos and Pavan (AER, 2004) consider the payoffs with investment externalities and games.
  - Hellwing (2005, UCLA) applied such game to monopolistic competition.
  - Allen, Morris, and Shin (2006, Review of Financial Studies) applied the same game to financial markets.
  - Angeletos and Pavan (Econometrica, 2007) investigate a more general market environment.
  - Dewan and Myatt (2011, Journal of Theoretical Politics) applied a variant of the beauty-contest specification to political leadership...
- Rare papers considered the theoretical aspects of disclosure and environmental regulation (Elnaboulsi *et al.*, 2018).

Environmental Taxation and Disclosure

Environmental Taxation

- Environmental protection is a priority and a challenge for public authorities. The improvement of environmental quality is placed high on public representatives' agendas.
- Environmental policy is a major device in tackling environmental challenges and shaping industries' use of environmental resources.
- Emissions taxes are the most widely used and experienced market-based instruments in addressing environmental policies.
- The design of environmental taxation aims to accomplish deep and structural changes in the economic and ecological behavior of economic agents by adjusting price signals in an environmentally positive manner.

Environmental Taxation

- The proposed approaches to elicit agents' private information have not fully solved the issue in practice since the regulatory systems remain over burdened by the sheer number of asymmetries to be controlled and by the tasks of designing, implementing, monitoring and enforcing an effective control system.
- Without downplaying the importance and relevance of the literature on such instruments, we explore another path to deal with environmental externalities.
- Under asymmetric information, the related literature rarely considers the design and implementation of environmental taxes in the presence of disclosed information.
- Thus, we devise a way for the design and implementation of emission taxes to be improved via disclosure, which broaden the regulator' repertoire of the antidote for the most of the environment's ills.

Disclosure

- Some accurate information could come from empirical studies of how observables like production and pollution control technologies, input and output levels determine players' abatement costs.
- Some valuable information could come from mandatory reporting programs:
  - US Toxic Release Inventory (TRI)
  - European Pollutant Release and Transfer Register (E-PRTR)
  - EU Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).
- However, players retain a certain control over some information of interest, and hence there is an array of privately-held information that is woefully asymmetric and yet is not disseminated.

The Value of Disclosed Information

- The value of disclosed information has been rarely addressed in the context of emission taxes games with incomplete information.
- To fill this gap, we consider environmental regulation under disclosure with verifiable reports about players strategic decisions:
  - Players in the marketplace are required to make reports on their activities in which any claim is supported by the necessary accompanying evidence.
  - Examples include the physical design of production technology and its implementation, information on inputs (Real world examples are TRI, E-PRTR, REACH, or Indonesia's PROPER Program).
- However, we provide a richer information structure in which polluters have different private signals about the marginal production costs.

Research Questions

- In this paper, we seek to answer the following questions:
  1. Under what conditions public disclosed information enhances the environmental tax setting process?
  2. Does it induce changes in the behavior of players and lead to a reduction in emissions?
  3. Is there any incentive for a firm to share information and coordinate its actions with others' actions?
  4. How information precision impacts the regulatory process through taxation? In other words, a more precise signal induces a greater/lesser tax distortions?
  5. What are the social welfare effects of information precision?
- To this end, we consider a Stackelberg-Cournot setting in line with Elnaboulsi et al. (2018):
  - the regulator designs environmental taxes based on the presence of public and private signals about costs uncertainties,
  - the regulatory decision, once made, remains in force for an extended period of time while rivals respond in the marketplace.

Applications

- Our model may characterize a variety of oligopolistic markets where policy changes require long administrative and legal procedures (complex international negotiations).
- This setting is also relevant in industries where players generate a negative externality and where the regulator as well as competitors accumulate some accurate information about costs of complying with the environmental regulation (due to recurrent interaction).
- Examples are energy companies using fossil fuels and the chemicals industry.
  - Dealing with greenhouse gases in the U.S. energy sector, where electricity is produced by firms engaged in a Cournot competition (SO_2 /CO_2 emissions market).
  - Dealing with chemicals in the fracturing industry.
- One application is the European wholesale energy market where the European Commission is requesting market participants to make part of the private information on their activities publicly available, such as reporting sulfur dioxide emissions to predict acid rain.

The Model

Basic Elements

- We consider a single polluting industry, with $I = \{1, 2\}$ non-identical firms producing a homogeneous final good. We assume that players are facing the following inverse demand:

$$p = \alpha - \beta Q, \alpha, \beta > 0$$

where p denotes the unit price of the good and $Q = \sum_{i=1}^{2} q_i$ is the total output of the industry.

- On the supply side, the technology used by each firm is stochastic but it exhibits constant returns to scale.
- Emissions depend on the technology of production used by each firm:

$$e_i = \phi q_i, \text{ with } 0 < \phi < 1 \text{ for any } i \in I = \{1, 2\}.$$

which yields the environmental damage, D, generated by the activity:

$$D = \frac{1}{2} \delta \mathcal{E}^2; \ \delta > 0$$

where $\mathcal{E} = \sum_{i=1}^{2} e_i (q_i)$ represents the aggregate level of emissions.

Information Structure

- For a given state of the nature the marginal production and abatement cost is constant and equals to:

$$\widetilde{x}_i = u_i + \widetilde{c}_i$$

where u_i, is the disclosed information observed by all players.

  - $\widetilde{c}_i$, is a private cost component, which is different for each firm and is a private information known only to each firm:

$$\widetilde{c}_i = \widetilde{s} + \widetilde{\varepsilon}_i$$

  - $\widetilde{s}$ is a positive random variable and is distributed according to some prior density:

$$\widetilde{s} \sim \left(\mu_s, \sigma_s^2\right)$$

  - $\widetilde{\varepsilon}_i$ is a firm-specific noise term:

$$\widetilde{\varepsilon}_i \sim \left(\mu_{\varepsilon_i}, \sigma_{\varepsilon_i}^2\right)$$

Assumptions

Lemma

A firm can make inferences about the marginal cost of its rivals based upon its private information. $\forall i, j = 1, 2, i \neq j$; $\mathbb{E}[\tilde{c}_i|\tilde{c}_j]$ *is linear in* $\tilde{c}_j$.

$$\mathbb{E}[\tilde{c}_i|\tilde{c}_j] = \gamma_j \ \tilde{c}_j + \lambda_j, \ \text{where } \gamma_j = \frac{\sigma_s^2}{\sigma_{\varepsilon_j}^2}, \ \text{and } \lambda_j = \mu_{\varepsilon_i} - \frac{\sigma_s^2}{\sigma_{\varepsilon_j}^2}\mu_{\varepsilon_j}$$

Proof.

Following Ericson (1969) it is easy to compute $\mathbb{E}[\tilde{c}_i|\tilde{c}_j]$. □

- Under our assumptions:
  - the model satisfies the linear conditional expectation property;
  - the regulator's problem is concave in the control variables;
  - in equilibrium, any farmer in the marketplace pays a non-negative emission tax, i.e. produces positive quantities.

Assumptions

- In order to focus our analysis on the precision of players' private signals, we simplify our notations by assuming $\sigma_s^2 = 1$. Hence,

$$\gamma_j = \frac{1}{\sigma_{\varepsilon_j}^2}, \text{ and } \lambda_j = \mu_{\varepsilon_i} - \gamma_j \mu_{\varepsilon_j}$$

- Thus, $\forall i, j = 1, 2, i \neq j, \gamma_i$ represents the precision of signal i:
  - if $\sigma_{\varepsilon_i}^2 \longrightarrow \infty$ then $\gamma_i \longrightarrow 0$: the signal is uninformative;
  - if $\sigma_{\varepsilon_i}^2 \longrightarrow 0$ then $\gamma_i \longrightarrow \infty$: the signal is informative.
- In words, lower values (respectively higher) of $\sigma_{\varepsilon_i}^2$ means that all players are more (less) informed about the magnitude of the value of marginal production costs.

Timing

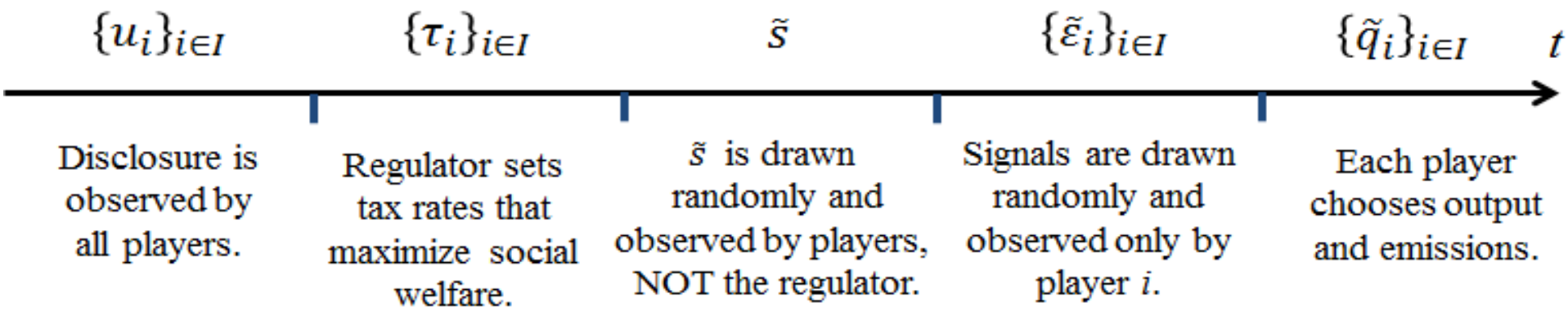

Figure 1: Timeline of the Game.

Firms' Problem

- At the last stage of the game, given the tax rates, players maximize their own profits:

$$\max_{<\tilde{q}_i>} \mathbb{E}_{\tilde{c}_j}\left[\left(\widetilde{p}-u_i-\tilde{c}_i-\phi\tau_i\right)\tilde{q}_i\middle|\,\tilde{c}_i\right];\ \forall i,j=1,2,i\neq j$$

Lemma

The second period game has a unique Bayesian Nash equilibrium. Further, in the unique equilibrium, both firms adopt linear production strategies:

$$\begin{aligned}\tilde{q}_i &= \theta_{i1}+\theta_{i2}\tilde{c}_i+\theta_{i3}u_i+\theta_{i4}u_j;\forall i,j\in I,i\neq j\\ \theta_{i1} &= \rho_{i0}+\rho_{i1}\ \tau_i+\rho_{i2}\ \tau_j.\end{aligned}$$

Proof.

Under the information structure adopted in this paper (unbiasedness, conditional independence, affine posterior expectation), maximizing the expected profits yields the above lemma. □

Regulator's Problem

- The regulator only observes the public component, and has prior beliefs on the other cost components.
- Given this common knowledge and the prior beliefs, the regulator sets an environmental tax in order to maximize the following social welfare function:

$$\mathbb{E}W = \mathbb{E}\left(CS - D\right) + \sum_{i=1}^{2} \mathbb{E}\pi_i + \ell\mathbb{E}R;\ \ell > 1$$

where ℓ represents the indirect social benefit of environmental taxation, CS stands for consumer surplus, D is environmental damage, π_i are farmer i's profits, and R is revenue.

Optimal Environmental Policy

Equilibrium under Asymmetric Information

Proposition

Under private and commons values, a risk neutral regulator sets differentiated tax rules. In a private information regime, and under linear conditional expectation properties, the regulator can NOT distinguish players in the market place and sets a common tax rule.

Proposition

Optimal taxes depend on the regulator's environmental valuation in terms of its vulnerability to environmental externalities, $\omega \equiv \left[\max\left(\frac{1-\ell'}{2}, \frac{1}{3}\right), 1\right]$. *A regulator who is highly concerned with the market failure arising from negative externalities tailors higher emissions taxes in order to prevent more welfare loss.*

Equilibrium under Asymmetric Information

- We identify two effects of public signals on the tax rates:
  1. A positive public signal increases production costs and signals the regulator that this firm may not be very efficient. Therefore, the less productively efficient a firm is (based on the public signals), the lower the profit margin and hence the lower the tax rate.
  2. The higher public signal, the less efficient (competitive) a firm is according to the regulator. Therefore, the higher its tax rate compared to the other firm.
- This first effect dominates the second in the total output, so the total output (market price) decreases (increases) with the public signals.

Information Sharing

The sharing information case

- What happens if firms engage in tacit collusion to cooperatively choose a strategy to face an environmental policy?
- Suppose that some mechanism exists for firms to truthfully share information on their private costs, while the regulator still remains uninformed about the private costs.
- Under what conditions do firms have the incentive to share this information?

The sharing information case

Proposition

When the regulator sets up emissions taxes to deal with pollution under asymmetric information about costs, if firms share information about their costs, then the optimal tax rules do not change.

Proposition

Under emissions taxes, sharing information may occur, yields higher output (and so emission) levels. It is mutually beneficial to firms when private marginal costs are high and the cost differential between the two firms is small.

Sharing Information

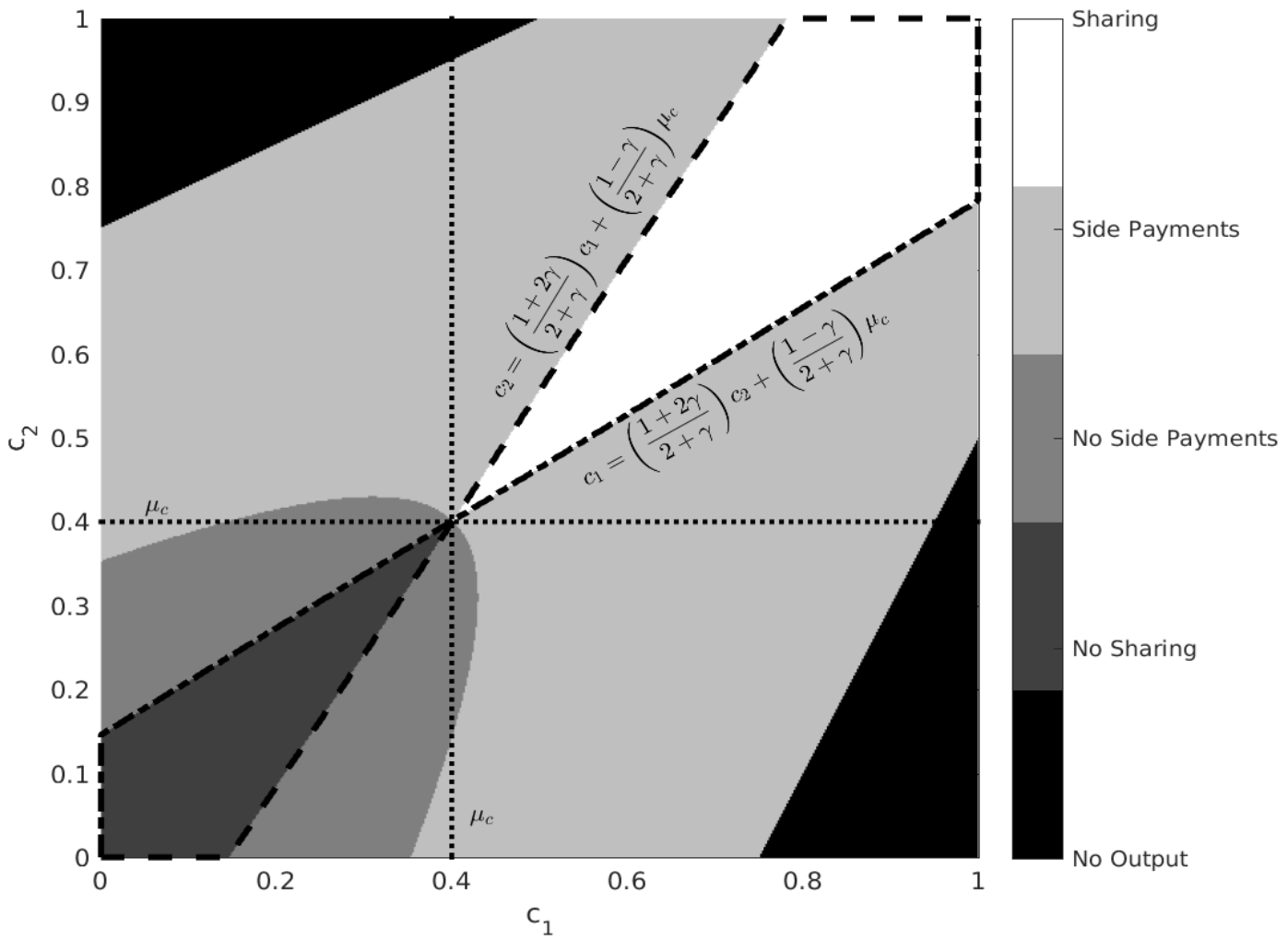

Figure 2: Sharing Information Case.

Information Precision and Welfare

Information Precision and Welfare

Proposition

Information precision affects competition in the marketplace, and hence the industry output. The regulator needs to offset the impact of higher production (which yields higher externalities) by setting environmental taxes accordingly.

Proposition

The welfare effects of information precision depends on the value of ω which represents the regulator's environmental valuation or the severity of emissions.

Information Precision and Welfare

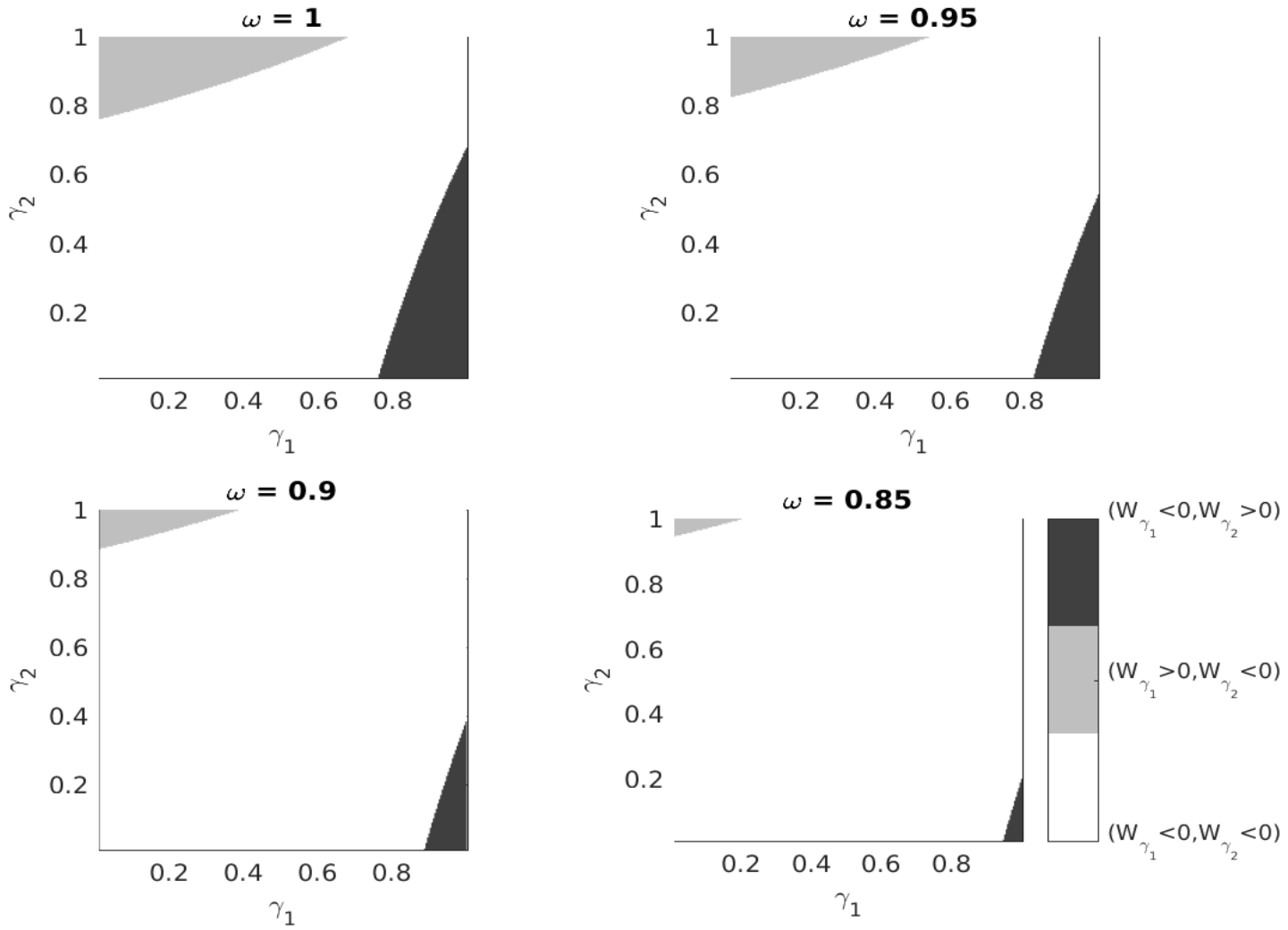

Figure 3: Precision and Welfare.

Conclusion

Conclusion

- We analyzed the impact of public and private information about production and abatement costs on the efficiency of emission taxes design.
- Facing private costs only, the regulator cannot distinguish the players in the marketplace. The regulator sets a common tax rule.
- Facing private and publicly-disclosed information about marginal production and abatement costs, the regulator sets firms specific environmental taxes.
- Sharing information may be mutually beneficial to firms if both firms have high marginal costs and the cost differential between firms is small.
- Further, the optimal tax rule and social welfare depends heavily on information precision and the regulator's environmental valuation.