The Informational Role of Emission Markets: Prices vs Quantities with Dispersed Information About Externalities

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Two Types of Asymmetric Information

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1. Marginal Abatement Cost: Firms know their own cost of reducing emissions
   - → Relative slopes of marginal benefit and marginal costs determine whether prices or quantities better (Weitzman, 1974, and much subsequent literature)

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   - → Traders bet on future policy by buying/selling bankable emission permits
   - → They may use private info about damages to predict future policy
   - → Result: Quantity policy can dominate a price policy for any slope of marginal abatement costs—and always does so for sufficiently flat marginal abatement costs.

Related Work

Lemoine (2022): Designing policies that base emission incentives on dispersed private information about damages

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- → And introduces costs by making permit prices volatile

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Relative to Pizer and Prest (2020), the partially revealing nature of equilibrium:

→ Limits informational benefit of a quantity policy

→ And introduces costs by making permit prices volatile

Here possible for regulation by prices to dominate regulation by quantities

Model

Two periods

Emissions (rep. firm): $e_t = Z - A_t$, with A_t abatement

Abatement costs (rep. firm): $C(A_t) = \chi A_t + \frac{1}{2}\kappa[A_t]^2$, with $\chi \geq 0$ and $\kappa > 0$

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→ Corner case in which regulation by prices always dominates regulation by quantities in Weitzman (1974)

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Initially common prior over *d*, with mean $\mu > 0$ and variance $\sigma^2 > 0$

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3) Agents choose period 1 abatement and permit purchases, markets clear

4) d is revealed to the regulator

5) Regulator chooses period 2 tax τ_2 or cap Q_2 and agents choose period 2 actions

Period 1 Permit Market

Net permit demand X_i from type i traders: maximize expected utility of wealth at start of period 2

Informed traders' aggregate demand: $X = \sum_i X_i$.

Noise traders' demand: θ, with variance $\Theta^2 > 0$

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Linear Bayesian Nash equilibrium in demand functions:

→ Demand functions based on posterior for d implied by conjecture about how prices aggregate signals

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Linear Bayesian Nash equilibrium in demand functions:

- → Demand functions based on posterior for d implied by conjecture about how prices aggregate signals
- → In equilibrium, that conjecture valid for market-clearing price derived from demand functions

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Firms minimize the sum of abatement costs and compliance costs

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Regulator minimizes the expectation of abatement costs plus damages

→ So $\tau_t^* = E_t[d]$

→ Which implies $\tau_1^* = \mu$ and $\tau_2^* = d$

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Regulator minimizes the expectation of abatement costs plus damages

→ So period 2 cap sets $p_2^* = d$

→ And period 1 cap sets $E[p_1^*] = \mu$

Equilibrium Permit Price

Lemma

There exist $b, \beta, V > 0$ such that $b + \beta \in (0, 1)$; $V \in \left(\sigma^2 \frac{\nu^2}{N\sigma^2+\nu^2}, N\sigma^2 \frac{\nu^2}{N\sigma^2+\nu^2}\right)$; b, β, and V are independent of κ; and

$$p_1^* = \mu + \frac{N\kappa}{N\kappa + (1+r)\alpha V}(b+\beta)\left[d - \mu + \frac{1}{N}\sum_i \epsilon_i\right] + \frac{(1+r)\alpha V}{N\kappa + (1+r)\alpha V}\frac{b+\beta}{b}\kappa\theta.$$

Works to make emission cap equivalent to emission tax

The other terms create a wedge between emission taxes and caps

Equilibrium Permit Price

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Favors a cap by incorporating dispersed information about d: on average, moves p_1^* towards d when $\mu \neq d$

But noise (ϵ_i) in signals can happen to move p_1^* away from d

Equilibrium Permit Price

Lemma

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Noise traders (θ) can move p_1^* away from d

Comparing Prices and Quantities

Regulator's expected period 1 total costs TC_1:

$$E[TC_1] = \mu(Z - E[A_1^*]) + \underbrace{E[C(A_1^*)]}_{\text{pro-tax}} \underbrace{-Cov[A_1^*, d]}_{\text{pro-cap}}.$$

Same under a tax or a cap

Any wedge due to uncertainty about abatement under a cap

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Favors a tax:

Cap makes abatement A_1 randomly volatile (through the ϵ_i and θ)

Raises expected costs $E[C(A_1)]$ via Jensen's inequality

Comparing Prices and Quantities

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Favors a cap:

Permit price p_1 covaries positively with true social cost d, due to signals s_i covarying with d.

So abatement covaries with d under a cap, reducing expected social costs

Advantage of p over q: $\Delta = \sum_{t=1}^{2} E\left[TC_t^Q - TC_t^P\right]$

Proposition (Advantage of prices over quantities)

$$\Delta = -\frac{b+\beta}{N\kappa + (1+r)\alpha V} N\sigma^2 + \frac{1}{2}\kappa\left(\frac{b+\beta}{N\kappa + (1+r)\alpha V}\right)^2\left[\frac{[(1+r)\alpha V]^2}{b^2}\Theta^2 + N^2\sigma^2 + N\nu^2\right]$$

Informational benefit of a cap (< 0):

Private information, as partially revealed by equilibrium price, reduces expected cost

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Volatility cost of a cap (> 0):

Ex ante, abatement is volatile under a cap because of (i) noise traders (the Θ^2) and also because (ii) traders' private signals are uncertain

In (ii), uncertainty about d (σ^2) is on net good but noise in signals (ν^2) is bad

Policy Ranking

Proposition (Ranking)

- 1) $\Delta < 0$ for κ sufficiently small.

Quantity policy always dominates if marginal abatement cost sufficiently flat (i.e., κ is small)

Intuition: Jensen's inequality loses bite as abatement cost becomes linear, so volatility cost of cap vanishes

Policy Ranking

Proposition (Ranking)

- 2) $\Delta < 0$ for all κ if either σ^2 is sufficiently large or ν^2 is sufficiently small.

Quantity policy dominates for any slope of marginal abatement cost when marginal damage is especially uncertain or when private information is especially precise

Policy Ranking

Proposition (Ranking)

- 2) $\Delta < 0$ for all κ if either σ^2 is sufficiently large or ν^2 is sufficiently small.

Quantity policy dominates for any slope of marginal abatement cost when marginal damage is especially uncertain or when private information is especially precise

With linear damages, a price policy always dominates in Weitzman (1974), but here we see the opposite!

Policy Ranking

Proposition (Ranking)

- 3) If $\Delta > 0$ for any κ, then there exists $\hat{\kappa} > 0$ such that $\Delta > 0$ if and only if $\kappa > \hat{\kappa}$.

If it dominates anywhere, a price policy dominates a quantity policy at steep marginal abatement cost curves (large κ)

Policy Ranking

Proposition (Ranking)

- 4) $\Delta \to 0$ as κ becomes large or σ^2 becomes small.

Policies become equivalent as marginal abatement cost curve becomes vertical (so emissions unresponsive) and when marginal damage is especially certain (private signals irrelevant)

Policy Ranking

Proposition (Ranking)

- 5) Δ is bounded above but unbounded below, approaching negative infinity as κ and ν^2/σ^2 jointly become small.

Advantage of a price policy is bounded (dominates only when κ large, but that is case when emissions unresponsive)

Policy Ranking

Proposition (Ranking)

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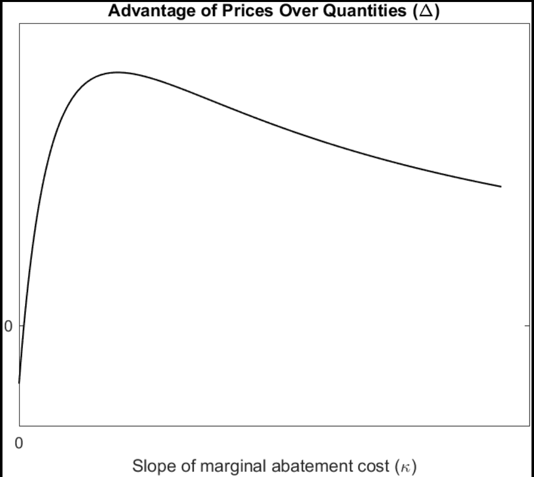
Advantage of a price policy is bounded (dominates only when κ large, but that is case when emissions unresponsive)

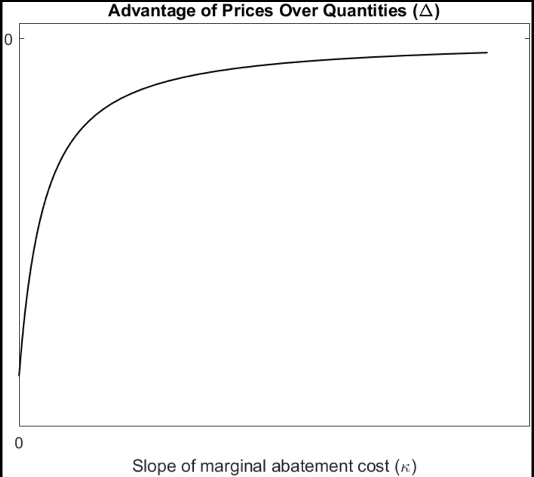
Advantage of a quantity policy is unbounded (dominates when κ small)

Become arbitrarily large when damage uncertain and private signals precise

Numerical Examples



(a) Prices dominate for $\kappa > \hat{\kappa}$



(b) Quantities dominate for all κ

Conclusions

Any degree of dispersed information about damages can make a quantity policy dominate a price policy, even for flat marginal damage

→ Equilibrium permit prices aggregate private information about marginal damages as traders attempt to smooth permit prices over time

→ Emission tax does not use private information to update early-period emissions

Future work should empirically study degree of dispersed information about climate damages