

The Role of Information and Market Concentration in Regulation

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- Environmental instrument choice is usually analyzed with price-taking firms and a regulator facing uncertainty.
- In many applications, emissions are concentrated among a small number of strategic players.
- Firms have (dispersed) private information about abatement costs; a market fundamental can correlate costs across firms and with damages.
- Question: How do *market concentration* and *information structure* jointly reshape
 - ① welfare under taxes and quotas, and
 - ② the tax–quota ranking criterion, and
 - ③ the design of a “first best” (information-revealing) regulation?

- n strategic agents choose emissions e_i (or submit permit demand schedules).
- Benefits from own emissions; damages from aggregate emissions $E = \sum_j e_j$.
- Private cost signal: $\theta_i = \alpha + \eta_i$ (market fundamental α + idiosyncratic η_i).
- Damage shock: $\gamma = \phi\alpha + \varepsilon \Rightarrow$ private cost information correlates with damages.
- Two policies:
 - 1 **Quota / cap-and-trade:** fixed Q , endogenous permit price via demand-function competition.
 - 2 **Tax:** fixed unit price p , but strategic agents internalize some of the pollution externality.

Key Parameters (Comparative Statics Objects)

- **Market concentration:** n (higher n = more competitive; not a larger economy).
- **Relative information precision:** $\tau \equiv \sigma_{\eta}^2 / \sigma_{\alpha}^2$
 - holding σ_{α}^2 fixed, higher τ means *less precise private signals* and more cross-sectional dispersion.
- **Cost–damage correlation (via fundamental):** λ (regression coefficient of damage shock on the *average* cost signal).
- **Weitzman slope ratio:** $W \equiv D/B$ (marginal damages slope relative to marginal abatement cost slope).

Interpretation: n governs strategic wedges; (τ, λ) govern how information and fundamentals transmit into volatility/dispersion; W governs the welfare cost of volatility.

Primitive Payoff (Equation 1)

Each agent conditions on its private signal θ_i and forms expectations over others' actions (and, under a quota, over the price):

$$\mathbb{E} \left[\underbrace{(b_0 + \theta_i - p)e_i - \frac{b}{2}e_i^2}_{\text{private benefit minus payments}} - \underbrace{\left((d_0 + \phi\alpha + \varepsilon) \sum_j e_j + \frac{d}{2} \left(\sum_j e_j \right)^2 \right)}_{\text{damages from aggregate emissions}} \right]. \quad (1)$$

- Under a **quota**, p is endogenous; $E = \sum_j e_j$ is fixed at Q .
- Under a **tax**, p is exogenous; E is endogenous and agents internalize part of the damage response.

Quota (Cap-and-Trade): Demand-Function Competition

- Regulator sets cap Q . Agents submit (linear) demand schedules for permits.
- Market clears: permit price adjusts so $\sum_i e_i = Q$.
- Strategic channel: each agent shades its demand to reduce the equilibrium price (a pecuniary externality).
- With heterogeneous (and imperfectly observed) costs, shading generates **allocative inefficiency**:
 - dispersion of realized marginal abatement costs across firms.

Takeaway: Under a binding quota, aggregate emissions are fixed, but market power + private information distort *who abates*.

Tax: Strategic Emissions Choice

- Regulator sets a unit tax p .
- Strategic channel: each agent understands that higher own emissions raise aggregate emissions, hence raise *its own* damages.
- This yields partial internalization of the pollution externality (stronger when n is small).
- But heterogeneity + imperfect information can still generate **dispersion** in equilibrium marginal abatement costs.

Takeaway: Under a tax, the key distortion is not price shading but an endogenous wedge in how strongly agents internalize damages.

FE \rightarrow RAE Mapping and Welfare Decomposition (Big Idea)

- Start with the fragmented economy (FE): n heterogeneous strategic agents.
- Map to a representative-agent analog (RAE) that preserves:
 - expected aggregate emissions, and
 - the welfare consequences of second moments (volatility and dispersion).
- Decomposition: welfare under either instrument can be written as

(certainty-equivalent component depending on $\mathbb{E}[E]$) + β (second moments).

- For **certainty-equivalent** tax/quota pairs (same $\mathbb{E}[E]$), ranking reduces to comparing the β terms.

This is what makes comparative statics in (n, τ, λ, W) transparent.

Comparative Statics Under a Quota: Competition Helps

- Mechanism: market power \Rightarrow stronger demand shading \Rightarrow larger allocative inefficiency.
- Result (qualitative): equilibrium welfare under a quota
 - increases with n (more competition), and
 - the gain from competition is larger when signals are less precise / dispersion is larger (higher τ).
- Intuition: imprecise private information amplifies the cross-firm wedge created by strategic shading.

In cap-and-trade, the main welfare loss with market power is misallocation (unequal MACs), not the level of aggregate emissions.

Comparative Statics Under a Tax: Internalization vs Volatility

- As n rises, each agent internalizes less of the pollution externality \Rightarrow expected emissions tend to rise.
- Volatility of emissions responds to:
 - W : steeper marginal damages make volatility more costly, which strategic agents partially internalize.
 - λ : stronger cost–damage correlation makes responding to cost information more valuable, tending to raise volatility.
 - τ : changes the relative weight of dispersion vs aggregate volatility in welfare via the β -term.
- Net effect: under taxes, the same change in information precision can shift welfare through distinct second-moment channels.

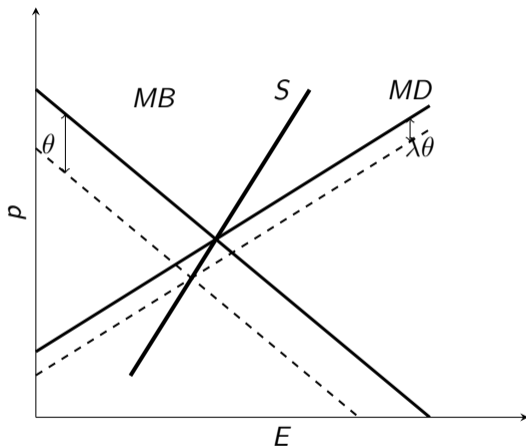
Instrument Ranking: The Organizing Criterion

- Compare **certainty-equivalent** tax and quota policies (same $\mathbb{E}[E]$).
- In the competitive limit ($n \rightarrow \infty$), the ranking collapses to an augmented Weitzman–Stavins criterion:

$$\text{Taxes dominate quotas} \iff 1 - 2\lambda > W.$$

- Positive cost–damage correlation ($\lambda > 0$) tilts the ranking toward **quantity** regulation.
- For finite n , concentration and information precision matter directly: the ranking depends on (n, τ, λ, W) through the second-moment term.
- For example: A less precise private signal (larger τ) favors taxes iff $W < 1$.

A “first best” policy: the Smart Tax with $n = \infty$



Solid: expected MB/MD. Dashed: conditional shifts from a cost shock θ and induced MD shift $\lambda\theta$.
The locus of conditional optima traces $S(E)$. *This policy is not implementable with $n = \infty$.*

Smart Tax: Implementing the Team Outcome (Finite n)

- Benchmark: a “team problem” where agents maximize aggregate welfare but do not share signals.
- The team equilibrium coincides with the outcome of a planner who observes the *average* signal.
- A **smart tax**—a schedule $S(E)$ mapping aggregate emissions into the tax—can support the team outcome as a Nash equilibrium when n is finite.
- Practical point: with a moderate/small number of strategic agents, informational demands of the smart tax are identical to those already assumed in standard tax/cap games.

Implications for Stock Pollutants

- In dynamic (stock pollutant) settings, positive serial correlation in abatement costs induces perfect positive correlation between marginal abatement costs and the social cost of carbon.
- When we use a static model to think about climate policy, positively correlated costs and damages should be considered the leading case.
- This correlation can push the ranking toward quantity regulation even when the *level* slope of SCC is small.
- “Policy stringency” matters dynamically: laxer expected future policies can steepen the effective marginal damage object relevant for ranking.
- Bottom line: the static logic is informative, but dynamic feedback/open-loop distinctions can materially change welfare comparisons.

- Market concentration and dispersed/correlated information change the nature of distortions under both instruments.
- The FE→RAE decomposition separates expected-emissions effects from second-moment effects, enabling clean comparative statics in (n, τ, λ, W) .
- Ranking:
 - competitive limit returns the augmented Weitzman–Stavins criterion $1 - 2\lambda > W$;
 - finite n introduces meaningful dependence on concentration and information precision.
- Design:
 - with finite strategic agents, a smart tax can implement the team outcome without requiring more information than standard equilibrium reasoning already uses.

Citations from the Literature Review (by category)

1) Dispersed information, aggregation, higher-order beliefs

- Vives (2008)
- Morris & Shin (2002)
- Angeletos & Pavan (2007)
- Lemoine (2022)
- Cantillon & Slechten (2018)
- Marcoul (2020)
- Englander et al. (forthcoming)

2) Imperfect competition in permit markets

- Malueg & Yates (2009)
- Montero (2009)
- Wirl (2009)

3) Taxes vs. quotas under uncertainty

- Weitzman (1974)
- Stavins (1996)
- Newell & Pizer (2003)
- Karp & Zhang (2005)
- Karp & Traeger (2024)
- Karp (2025)

4) More efficient instruments / information-revealing designs / hybrids

- Montero (2008)
- Lemoine (2022)
- Karp & Traeger (2025)
- Roberts & Spence (1976)
- Weitzman (1978)