

Environmental Regulation: A Novel “Booster” of Competition Policy?

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Motivation

- Cartels often operate in polluting industries.
- The same firms then face two agencies:
 - A competition authority (CA), deterring collusion.
 - An environmental agency (EPA), regulating emissions.
- Antitrust research studies the CA alone; environmental research studies the EPA alone.

Example: EU truck cartel

- MAN, Volvo/Renault, Daimler, Iveco, and DAF coordinated prices of medium and heavy trucks, 1997-2011.
- Fined €2.93 billion by the European Commission in 2016.
- Record EU cartel fine at the time.
- MAN received full immunity for revealing the cartel (leniency).

Example: EU truck cartel

- The cartel also coordinated:
 - the timing of introducing emission technologies (Euro VI standards);
 - passing on the costs of these technologies to customers.
- Trucks are regulated by EU standards on CO₂ and NO_x emissions.
- Collusion and environmental regulation in the *same* market.

Other examples

- **Steel abrasives (EU):**

- Fined €30.7 million in 2014; Ervin received immunity.
- Subject to the EU Industrial Emissions Directive.

- **LCD panels (US):**

- LG Display, Sharp, and Chunghwa fined \$585 million by the DOJ in 2008.
- Subject to RCRA for hazardous substances (arsenic, lead, cadmium).

Research question

- Do emission fees make competition policy more effective at deterring collusion?
 - Acting as a “booster.”
- Or do they hinder its effectiveness?
- Three competition-policy programs:
 - Audits, leniency, and whistleblower programs.

Main findings

- **No competition policy:** emission fees hinder collusion if profit losses from deviation are more affected by the fee than profit gains.
- **With competition policy:** emission fees amplify the effectiveness of audits, leniency, and whistleblower programs.
- We call this effect a “booster.”

Main findings

- **Endogenous fees:** the EPA sets a laxer fee if firms collude, inducing the same aggregate output with and without collusion.
- No trade-off between deterring collusion and curbing pollution.
- **Single fee:** if the EPA cannot condition the fee on the market structure, its fee is second best.

Policy implications

- **Audits:**

- The CA can reduce monitoring and fines in industries facing emission fees.
- Shifting efforts toward unregulated industries (technology, banking, media).

- **Leniency and whistleblower programs:**

- Rewards can be reduced in regulated industries without weakening deterrence.
- Making these programs more politically acceptable.

Leniency and whistleblower programs

	<i>Leniency</i>	<i>Whistleblower</i>
United States	1993	2020
European Union	1996	2019
South Korea	1997	2011
Japan	2006	2009
Brazil	2000	2016
Australia	2005	2019
Canada	2000	2019
China	2008	2015
India	2009	2021
United Kingdom	2003	2017
South Africa	2003	2017

- Often politically unpopular: they reward firms that colluded.

Related literature

- **Leniency programs:** Motta and Polo (2003), Aubert et al. (2006), Chen and Harrington (2007), Harrington (2008), Chen and Rey (2013).
- Firms face a single authority, the CA.
- **Our departure:** competition and environmental policy overlap in the same industry.

Related literature

- **Taxes and collusion:** Azacis and Collie (2018), Turner (2022).
- Taxes are exogenous cost shifters, with no CA.
- **Pollution and collusion:** Damania (1996), with no CA.
- **Our departure:** endogenous emission fees interacting with CA tools.

Outline of the presentation

- Model.
- Profit sensitivity to emission fees.
- Collusion without competition policy (benchmark).
- Audits, leniency, and whistleblower programs.
- Optimal emission fee, and a single second-best fee.
- Extensions and discussion.

Model

Model

- Two identical firms play an infinitely repeated game.
- Inverse demand $p(Q)$, with $p'(Q) < 0$ and $p''(Q) \geq 0$.
- Cost function $C(q_i)$, with $C'(q_i) > 0$ and $C''(q_i) \geq 0$.
- Per-unit emission fee $t \geq 0$.

Model

- **Competition:** output $q_i^C(t)$, profit $\pi_i^C(t)$.
- **Collusion:** output $q_i^M(t)$, profit $\pi_i^M(t)$.
- **Deviation:** $\pi_i^D(t)$ for one period, then $\pi_i^C(t)$ forever (grim trigger).
- Profits satisfy $\pi_i^D(t) \geq \pi_i^M(t) \geq \pi_i^C(t)$.

Model

- Collusion requires communication, which generates hard evidence.
- The CA finds evidence with probability $\rho \in [0, 1]$, imposing a fine $F > 0$.
- Firms can also bring evidence to the CA (depending on the program).
- Discount factor $\delta \in [0, 1]$.

Model - Time structure

- Following Aubert et al. (2006):
- **Stage 1.** Every firm chooses whether to communicate.
- **Stage 2.** If both communicate, evidence exists and firms play the repeated output game, choosing output and whether to report. Otherwise, Cournot in every period.
- **Stage 3.** If no firm reports, the CA finds evidence with probability ρ .
- *Later:* the EPA sets fee t before Stage 1.

Our goal

- Minimal discount factor sustaining collusion, $\bar{\delta}_k(t)$, for each program $k = \{A, L, W\}$.
- Effect of the emission fee: sign of $\frac{\partial \bar{\delta}_k(t)}{\partial t}$.
- **Booster:** does the fee make competition policy more effective?

$$\frac{\partial^2 \bar{\delta}_k(t)}{\partial \rho \partial t} > 0 \quad \text{and} \quad \frac{\partial^2 \bar{\delta}_k(t)}{\partial F \partial t} > 0$$

Profit sensitivity to emission fees

Effects of t on profits

- **Lemma 1.** *An increase in fee t satisfies*
 $0 \geq \pi_{i,t}^C(t) > \pi_{i,t}^M(t)$ *if and only if*

$$p'(Q) \frac{\partial q_j^C(t)}{\partial t} > \frac{q_i^C(t) - q_i^M(t)}{q_i^C(t)}. \quad (\text{C1})$$

Effects of t on profits

- **Left side:** price effect under Cournot.
- A higher fee forces the rival to produce less, raising prices (positive externality).
- **Right side:** percentage output reduction from colluding.
- When C1 holds, competing firms are less hurt by the fee than colluding firms.

Effects of t on profits

- **Lemma 2.** *A higher fee t yields*

$0 \geq \pi_{i,t}^C(t) > \pi_{i,t}^M(t) > \pi_{i,t}^D(t)$ if and only if

$$p'(Q) \frac{\partial q_j^M(t)}{\partial t} < \frac{q_i^D(t) - q_i^M(t)}{q_i^D(t)}. \quad (\text{C2})$$

- The price effect is smaller than the percentage output increase from deviating.
- A higher fee hurts profits the most when firm i deviates.

Example 1

- Linear demand $p(Q) = 1 - Q$, marginal cost $c \geq 0$, and fee t , with $1 > c + t$.

- Output levels:

$$q_i^C = \frac{1 - c - t}{3}, \quad q_i^M = \frac{1 - c - t}{4}, \quad \text{and} \quad q_i^D = \frac{3(1 - c - t)}{8}$$

- Profits $\pi_i^C = (q_i^C)^2$, $\pi_i^M = 2 (q_i^M)^2$, and $\pi_i^D = (q_i^D)^2$.

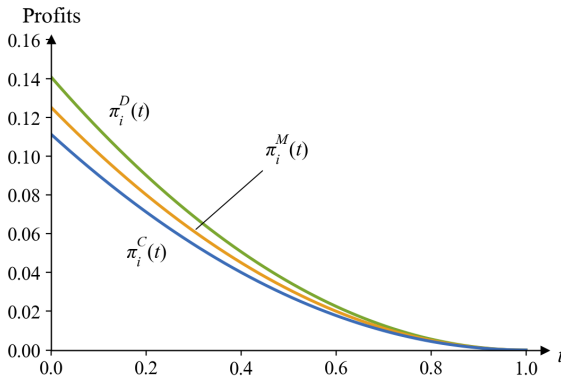
Example 1

- A marginal increase in t yields

$$\pi_{i,t}^C = -\frac{2(1-c-t)}{9}, \quad \pi_{i,t}^M = -\frac{1-c-t}{4}, \quad \text{and} \quad \pi_{i,t}^D = -\frac{9(1-c-t)}{32}$$

- Hence, $0 \geq \pi_{i,t}^C > \pi_{i,t}^M > \pi_{i,t}^D$: C1 and C2 hold.
- Same ranking under convex costs, differentiated products, $m \geq 2$ firms, and price competition.

Example 1 - Profits



- A higher fee lowers all three profits; deviation profits fall the most.

Asymmetric profit sensitivity

- Emission fees do not just shrink profit margins.
- They change profits *asymmetrically* across competition, collusion, and deviation.
- **Open question:** is the profit gain from deviating, $\pi_i^D - \pi_i^M$, more or less affected by t than the profit loss, $\pi_i^D - \pi_i^C$?
- We answer it program by program.

Benchmark: No competition policy

Benchmark - No CA

- With $\rho = 0$, collusion is sustained if

$$\frac{1}{1-\delta} \pi_i^M(t) \geq \pi_i^D(t) + \frac{\delta}{1-\delta} \pi_i^C(t)$$

- Rearranging,

$$\underbrace{\pi_i^D(t) - \pi_i^M(t)}_{PG(t)} \leq \frac{\delta}{1-\delta} \left[\pi_i^M(t) - \pi_i^C(t) \right] \quad (1)$$

Benchmark - No CA

- **Profit gain** from deviating: $PG(t) \equiv \pi_i^D(t) - \pi_i^M(t)$.
- **Profit loss** from abandoning collusion:
 $PL(t) \equiv \pi_i^D(t) - \pi_i^C(t)$.
- From $0 \geq \pi_{i,t}^C > \pi_{i,t}^M > \pi_{i,t}^D$:
$$0 > PG_t(t) > PL_t(t)$$
- A higher fee lowers both, but the profit loss falls more.

Benchmark - No CA

- Elasticities of the profit gain and loss with respect to t :

$$\varepsilon_{PG,t} \equiv \frac{PG_t(t)}{PG(t)}t \quad \text{and} \quad \varepsilon_{PL,t} \equiv \frac{PL_t(t)}{PL(t)}t$$

- Both are negative.
- $0 > \varepsilon_{PG,t} \geq \varepsilon_{PL,t}$: the profit loss is more sensitive to fees than the profit gain.

Benchmark - No CA

- **Lemma 3.** *Without competition policy, collusion can be supported if*

$$\delta \geq \bar{\delta}(t) \equiv \frac{PG(t)}{PL(t)}$$

- *where $\bar{\delta}(t) \in (0, 1)$, which increases in t if and only if $0 > \varepsilon_{PG,t} \geq \varepsilon_{PL,t}$.*

Benchmark - No CA

- Intuitively, a higher t reduces the future profit loss more than the current profit gain.
- Punishments become less threatening, making deviations more attractive.
- Collusion is then hindered by environmental regulation.
- Similar to Azacis and Collie (2018) and Turner (2022) with ad-valorem and per-unit taxes.

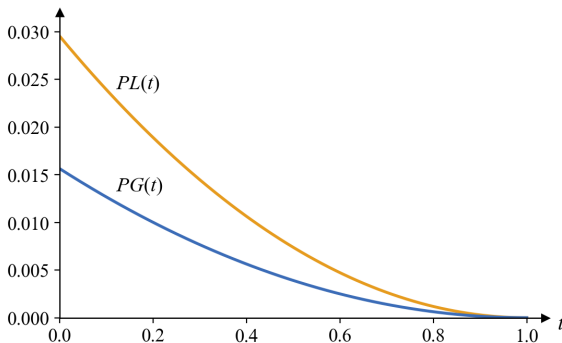
Example 2

- In the linear setting of Example 1:

$$PG(t) = \frac{(1 - c - t)^2}{64} \quad \text{and} \quad PL(t) = \frac{17(1 - c - t)^2}{576}$$

- Elasticities coincide, $\varepsilon_{PG,t} = \varepsilon_{PL,t} = -\frac{2t}{1-c-t}$.
- Hence, $\bar{\delta} = \frac{9}{17}$: collusion is unaffected by the fee.
- Same result in all four extensions.

Example 2 - Profit gain and loss



- Both fall in t at the same rate, so $\bar{\delta} = PG(t)/PL(t) = \frac{9}{17}$ for every fee.

Competition policy: Audits

Audits

- The CA finds evidence with probability ρ , imposing fine F ; expected fine ρF .
- Per-period profits:
 - Collusion: $\pi_i^M(t) - \rho F$.
 - Deviation: $\pi_i^D(t) - \rho F$ (evidence exists).
 - Competition: $\pi_i^C(t)$ (no evidence).
- The expected fine does not deter collusion by itself:
 $\rho F < PL(t) - PG(t)$.

Audits

- Collusion is sustained if

$$\underbrace{\left(\pi_i^D(t) - \rho F\right) - \left(\pi_i^M(t) - \rho F\right)}_{\pi_i^D(t) - \pi_i^M(t)} \leq \frac{\delta}{1 - \delta} \left[\left(\pi_i^M(t) - \rho F\right) - \pi_i^C(t) \right] \quad (2)$$

- Gain from cheating (left side) is unaffected.
- Value of continuing collusion (right side) decreases.

Audits

- **Proposition 1.** *Under audits, collusion can be sustained if*

$$\delta \geq \bar{\delta}_A(t) \equiv \frac{PG(t)}{PL(t) - \rho F}$$

- *where $\bar{\delta}_A(t) \in (0, 1)$, $\bar{\delta}_A(t) \geq \bar{\delta}(t)$, and $\bar{\delta}_A(t)$ unambiguously increases in ρ and F .*

Audits

- The effect of t depends on the adjusted profit-loss elasticity

$$\varepsilon_{PL,t}^A \equiv \varepsilon_{PL,t} \left(1 + \frac{\rho F}{PL(t) - \rho F} \right)$$

- **Case (i):** $\varepsilon_{PG,t} > \varepsilon_{PL,t}^A$. Then $\frac{\partial \bar{\delta}_A}{\partial t} > 0$, $\frac{\partial^2 \bar{\delta}_A}{\partial \rho \partial t} > 0$, and $\frac{\partial^2 \bar{\delta}_A}{\partial F \partial t} > 0$.

Audits

- **Case (ii):** $\varepsilon_{PL,t}^A > \varepsilon_{PG,t} \geq 2\varepsilon_{PL,t}^A$.
 - $\frac{\partial \bar{\delta}_A}{\partial t} < 0$, but $\frac{\partial^2 \bar{\delta}_A}{\partial \rho \partial t} > 0$ and $\frac{\partial^2 \bar{\delta}_A}{\partial F \partial t} > 0$.
- **Case (iii):** $\varepsilon_{PG,t} \leq 2\varepsilon_{PL,t}^A$.
 - $\frac{\partial \bar{\delta}_A}{\partial t} < 0$, $\frac{\partial^2 \bar{\delta}_A}{\partial \rho \partial t} < 0$, and $\frac{\partial^2 \bar{\delta}_A}{\partial F \partial t} < 0$.

Audits - The booster

- Effectiveness of audits: $\frac{\partial \bar{\delta}_A}{\partial \rho}$ and $\frac{\partial \bar{\delta}_A}{\partial F}$.
- Booster: these derivatives increase in the fee t .
- **Case (i):** fees hinder collusion and boost audits.
- **Case (ii):** fees alone facilitate collusion, but stricter policies by *both* agencies hinder it.

Audits - The booster

- **Case (iii):** the profit gain is very sensitive to the fee.
- Fees erode the gain from deviation enough to discipline collusion.
- More likely audits still deter collusion, but less effectively than without fees.
- Relative to Lemma 3, a stricter fee is more likely to hinder collusion with audits than without.

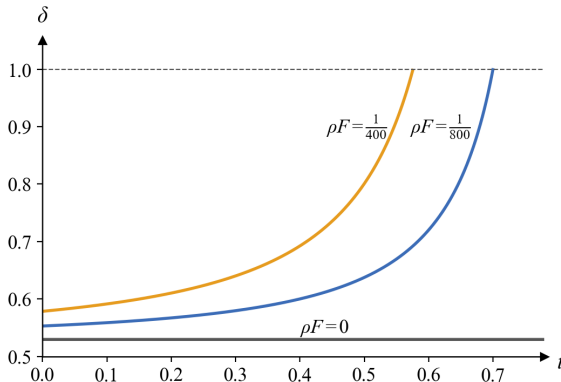
Example 3

- In the linear setting, collusion is sustained if

$$\delta \geq \bar{\delta}_A(t) = \frac{9(1 - c - t)^2}{17(1 - c - t)^2 - 576\rho F}$$

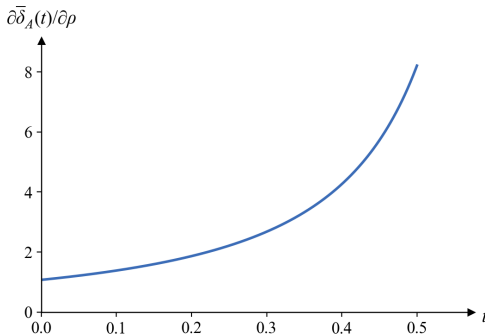
- $\bar{\delta}_A(t) \geq \frac{9}{17}$, increasing in ρ , F , and t .
- $\frac{\partial \bar{\delta}_A}{\partial \rho}$ and $\frac{\partial \bar{\delta}_A}{\partial F}$ increase in t : a booster under all parameter values.

Example 3 - Audit cutoff



- A higher expected fine raises $\bar{\delta}_A(t)$, and more so when t is high.

Example 3 - The booster under audits



- The effect of more likely audits, $\frac{\partial \bar{\delta}_A}{\partial \rho}$, increases in t : the booster.
- Parameters: $c = 0$, $\rho = F = \frac{1}{20}$.

Competition policy: Leniency programs

Leniency programs

- The firm reporting collusion receives a reduced fine R , where

$$0 \geq R > -\rho F$$

- Reporting is less costly than being caught by an audit.
- Examples: MAN (trucks) and Ervin (steel abrasives) received immunity.

Leniency programs

- Collusion is sustained if

$$\left(\pi_i^D(t) + \underbrace{R}_{\text{New}} \right) - \left(\pi_i^M(t) - \rho F \right) \leq \frac{\delta}{1 - \delta} \left[\left(\pi_i^M(t) - \rho F \right) - \pi_i^C(t) \right] \quad (3)$$

- Right side: unaffected relative to audits.
- Left side: deviating (and reporting) becomes more attractive.

Leniency programs

- **Proposition 2.** *Under leniency programs, collusion can be sustained if*

$$\delta \geq \bar{\delta}_L(t) \equiv \frac{PG(t) + R + \rho F}{PL(t) + R}$$

- $\bar{\delta}_L(t) \in (0, 1)$ and $\bar{\delta}_L(t) \geq \bar{\delta}_A(t) \geq \bar{\delta}(t)$.
- Unambiguously increasing in ρ , F , and R .

Leniency programs

- $\bar{\delta}_L(t)$ increases in t if and only if

$$\varepsilon_{PG,t} > \varepsilon_{PL,t} + \frac{PL_t(t)}{PL(t) + R} \left(\frac{R + \rho F}{PG(t)} - \frac{R}{PL(t)} \right) t$$

- This condition is less demanding than under audits.
- Derivatives $\frac{\partial \bar{\delta}_L}{\partial \rho}$ and $\frac{\partial \bar{\delta}_L}{\partial F}$ increase in t under all conditions.

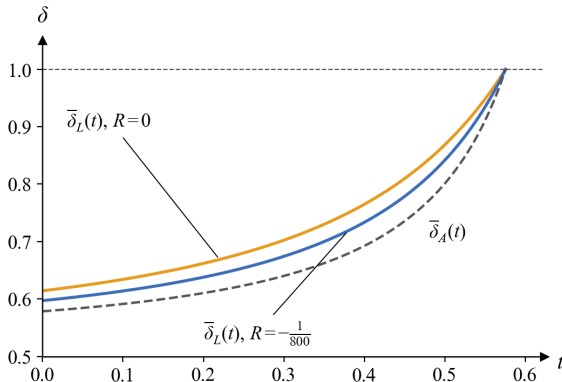
Example 4

- In the linear setting,

$$\bar{\delta}_L(t) = \frac{9 \left[(1 - c - t)^2 + 64(R + \rho F) \right]}{17(1 - c - t)^2 + 576R}$$

- Unambiguously increasing in ρ , F , R , and t .
- Booster under all parameter values.
- Figures: $c = R = 0$ and $\rho = F = \frac{1}{20}$.

Example 4 - Generosity of leniency



- Full immunity ($R = 0$) yields the highest cutoff; a smaller reduction ($R < 0$) moves $\bar{\delta}_L(t)$ toward $\bar{\delta}_A(t)$.

Leniency vs. audits

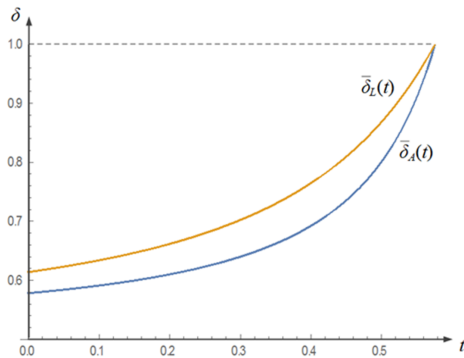


Fig. 1a. Cutoffs under leniency and audits.

- Both cutoffs increase in t : emission fees hinder collusion.

Leniency premium

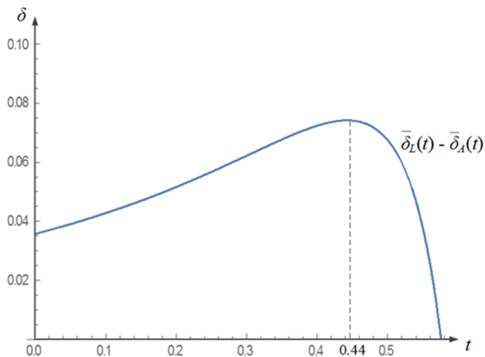


Fig. 1b. Leniency premium.

- Premium $\bar{\delta}_L(t) - \bar{\delta}_A(t)$ increases in t if and only if $t < 0.44$.

Leniency premium

- The premium is positive without fees, $t = 0$.
- Moderate fees expand the premium.
- Stringent fees shrink it: audits and leniency become similarly effective.
- The leniency premium diminishes in highly polluting industries.

Competition policy: Whistleblower programs

Whistleblower programs

- The CA rewards employees reporting evidence of collusion.
- The firm must pay a “bribe” B to each of the n informed employees, as in Aubert et al. (2006).
- Total bribes nB per period, when colluding or deviating.
- Competition profits are unaffected.

Whistleblower programs

- Collusion is sustained if

$$\pi_i^D(t) - \pi_i^M(t) \leq \frac{\delta}{1 - \delta} \left[\left(\pi_i^M(t) - \rho F - \underbrace{nB}_{\text{New}} \right) - \pi_i^C(t) \right] \quad (4)$$

- Left side: unaffected relative to audits.
- Right side: lower, so collusion is less attractive.

Whistleblower programs

- **Proposition 3.** *With whistleblower programs, collusion can be sustained if*

$$\delta \geq \bar{\delta}_W(t) \equiv \frac{PG(t)}{PL(t) - (\rho F + nB)}$$

- $\bar{\delta}_W(t) \in (0, 1)$, *unambiguously increasing in ρ , F , n , and B .*
- $\bar{\delta}_W(t) \geq \bar{\delta}_A(t) \geq \bar{\delta}$ *for all parameter values.*

Whistleblower programs

- Whistleblower vs. leniency: $\bar{\delta}_W(t) \geq \bar{\delta}_L(t)$ if and only if

$$nB > \frac{[PL(t) - PG(t) - \rho F](\rho F + R)}{PG(t) + \rho F + R}$$

- Whistleblower programs perform better when bribes are high.
- Effect of t : same three cases as audits, replacing ρF with $\rho F + nB$.

Whistleblower programs

- Adjusted elasticity: $\varepsilon_{PL,t}^W \equiv \varepsilon_{PL,t} \left(1 + \frac{\rho F + nB}{PL(t) - (\rho F + nB)} \right)$.
- Since $\varepsilon_{PL,t}^A > \varepsilon_{PL,t}^W$, a stricter fee is more likely to raise $\bar{\delta}_W(t)$ than $\bar{\delta}_A(t)$.
- Environmental regulation hinders collusion more easily under whistleblower programs than under audits.
- The booster is also more likely.

Example 5

- In the linear setting,

$$\bar{\delta}_W(t) = \frac{9(1 - c - t)^2}{17(1 - c - t)^2 - 576(\rho F + nB)}$$

- Increasing in ρ , F , n , B , and t ; booster holds.
- $\bar{\delta}_W(t) > \bar{\delta}_L(t)$ if and only if $t \geq t_{W,L}$.
- Figures: $n = 1$, with $B = \frac{1}{1,000}$ (low) or $B = \frac{1}{200}$ (high).

Whistleblower programs - Low bribes

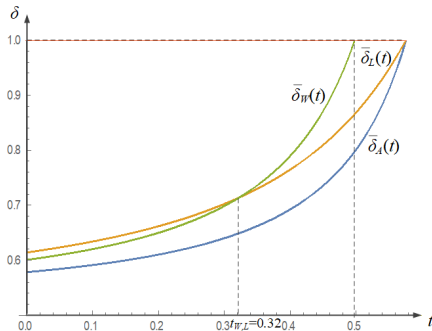


Fig. 2a. Cutoffs with low bribes.

- Leniency is more effective than whistleblowing for $t < t_{W,L} = 0.32$; the ranking reverses for stringent fees.

Whistleblower programs - High bribes

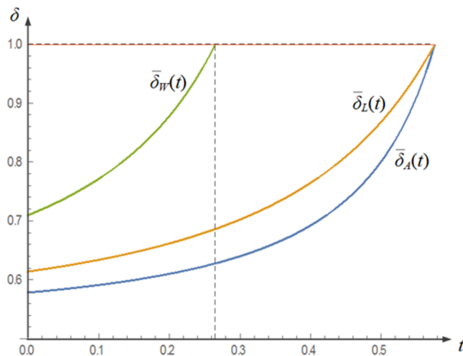
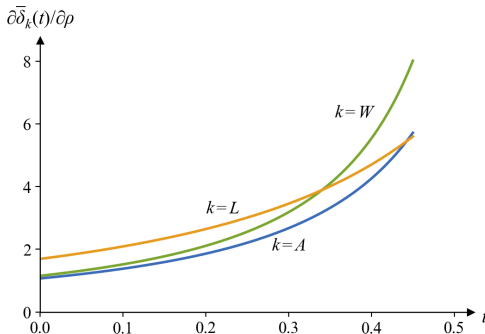


Fig. 2b. Cutoffs with high bribes.

- With high bribes, $\bar{\delta}_W(t) > \bar{\delta}_L(t)$ for every fee t .

Example 5 - Boosters across programs



- All boosters increase in t ; the whistleblower booster grows fastest.
- Parameters: $c = R = 0$, $\rho = F = \frac{1}{20}$, $n = 1$, $B = \frac{1}{1,000}$.

Optimal emission fee

The EPA's problem

- The EPA sets t anticipating whether firms compete or collude.
- Linear setting; under competition, $Q^C(t) = \frac{2(1-c-t)}{3}$.
- The EPA solves

$$\max_{t \geq 0} W = CS + PS + T - Env \quad (5)$$

- Environmental damage $Env = d (Q^C(t))^2$, with $d \geq 1/2$.

Optimal emission fee

- **Lemma 4.** *The regulator sets the emission fee*

$$t^c = \frac{(1 - c)(4d - 1)}{2(1 + 2d)}$$

- *which is unambiguously positive, increasing in pollution severity, d , and decreasing in marginal cost, c .*
- Higher c : less output and emissions, so a laxer fee.

Cutoffs at the optimal fee

- **Proposition 4.** *Cutoff $\bar{\delta}_k(t^C)$ is unambiguously increasing in c , d , ρ , and F , with*

$$\frac{\partial^2 \bar{\delta}_k(t^C)}{\partial \rho \partial c} > \frac{\partial^2 \bar{\delta}_k(t^C)}{\partial \rho \partial d} > 0$$

- *for every program $k = \{A, L, W\}$. Same ranking for the cross-partial in F .*
- *In addition, $\bar{\delta}_L(t^C) \geq \bar{\delta}_W(t^C) \geq \bar{\delta}_A(t^C)$ for all $d \leq \bar{d}_{W,L}$, but $\bar{\delta}_W(t^C) > \bar{\delta}_L(t^C) \geq \bar{\delta}_A(t^C)$ otherwise.*

Direct and indirect effects

	Direct effect	Indirect effect	Overall on $\bar{\delta}_A(t^C)$
Higher c	+	—	+
Higher ρ	+	N/A	+
Higher F	+	N/A	+
Higher d	N/A	+	+

- Higher c : direct effect hinders collusion, but the laxer fee facilitates it.
- Higher d : only an indirect effect, through a stricter fee.

Costs vs. pollution severity

- Under exogenous fees, higher c and higher t have the same effect on $\frac{\partial \bar{\delta}_k}{\partial \rho}$.
- Under endogenous fees, higher c boosts competition policy more than higher d .
- Intuitively, c affects profits directly and through the fee.
- d affects profits only through the fee, which rises less than proportionally.

Comparing programs

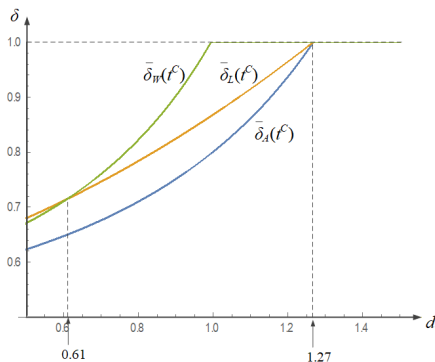


Fig. 3a. Cutoffs at the optimal fee.

- Leniency is more effective than whistleblowing only if $d < 0.61$.

The booster at the optimal fee

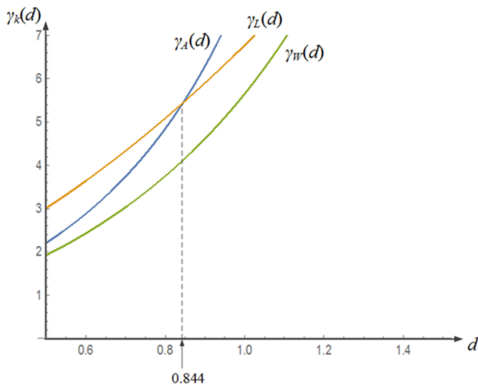


Fig. 3b. Booster, $\gamma_k(d) \equiv \frac{\partial \bar{\delta}_k(t^C)}{\partial \rho}$.

- Boosters increase in d : stricter fees make competition policy more effective.

The booster at the optimal fee

- With severe pollution, the booster is largest under audits.
- Audits start from the lowest cutoff: a “catching-up” effect.
- In heavily polluting industries, the CA could rely on audits, which are easier to implement.

Emission fees inducing collusion?

- If the EPA anticipates collusion, $Q^M(t) = \frac{1-c-t}{2}$, and it sets

$$t^M = \frac{(1-c)(2d-1)}{1+2d}$$

- Since $t^C > t^M$ and $\bar{\delta}_A(t)$ increases in t , $\bar{\delta}_A(t^C) > \bar{\delta}_A(t^M)$.

Emission fees inducing collusion?

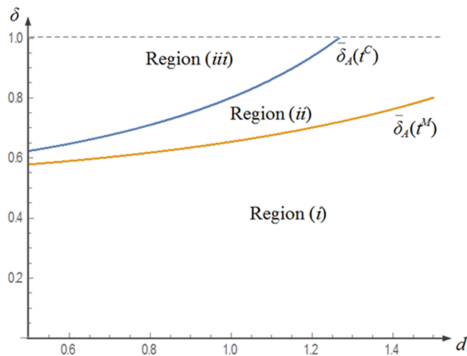


Fig. 4. Cutoffs under fees t^M and t^C .

- Region (ii): fee t^C deters collusion, but fee t^M allows it.

Emission fees inducing collusion?

- Regions (i) and (iii): fees do not change the market structure.
- Region (ii): collusion arises only under t^M , yielding

$$Q^M(t^M) = Q^C(t^C) = \frac{1 - c}{1 + 2d}$$

- Same output and welfare: the EPA sets t^C in regions (i)-(ii) and t^M in region (iii).

Welfare comparisons

- **Region (i)**, too lax fee: $\Delta W^C \equiv W^C(t^C) - W^C(t^M)$.
- **Region (iii)**, too stringent fee:
 $\Delta W^M \equiv W^M(t^M) - W^M(t^C)$.
- **Region (ii)**: $\Delta W^{C,M} \equiv W^C(t^C) - W^M(t^M)$.

Welfare comparisons

- **Corollary 1.** *Inefficiencies are*

$$\Delta W^C = \frac{(1-c)^2}{18(1+2d)} \quad \text{and} \quad \Delta W^M = \frac{(1-c)^2}{32(1+2d)}$$

- *both positive and decreasing in d ; and $\Delta W^{C,M} = 0$ for all parameter values.*
- No trade-off: the EPA does not use the fee to change the market structure.

A single, second-best fee

- So far, the EPA tailors the fee to the type of market (t^C or t^M).
- Now the EPA commits to a *single* fee.
- $\lambda \in [0, 1]$: the EPA's belief that firms compete.
- It maximizes $\lambda W(Q^C(t)) + (1 - \lambda) W(Q^M(t))$, where $W(Q) = (1 - c)Q - (\frac{1}{2} + d) Q^2$.

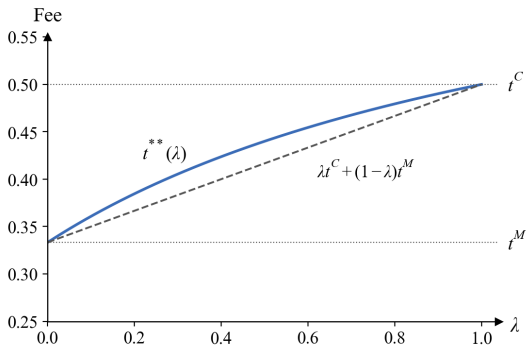
A single, second-best fee

- **Lemma 5.** *The agency sets the single emission fee*

$$t^{**}(\lambda) = \frac{16\lambda t^C + 9(1 - \lambda)t^M}{9 + 7\lambda}$$

- *which increases in λ , with $t^{**}(0) = t^M$ and $t^{**}(1) = t^C$.*
- Tilted toward t^C : Cournot output reacts more to the fee.

A single, second-best fee

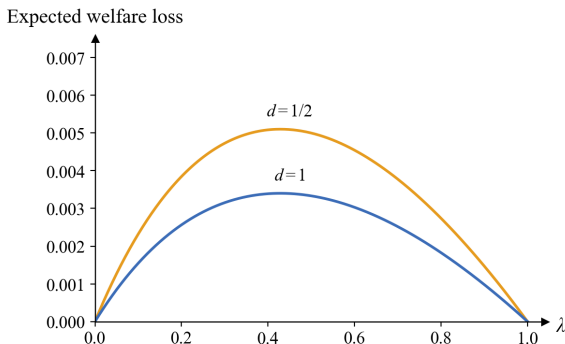


- $t^{**}(\lambda)$ lies above the belief-weighted fee: tilted toward t^C . Here $c = 0$ and $d = 1$.

A single, second-best fee

- **Proposition 5.** *For every $\lambda \in (0, 1)$: (i) $Q^C(t^{**}) > Q^* > Q^M(t^{**})$; (ii) the expected welfare loss is
$$\frac{\lambda(1-\lambda)(1-c)^2}{2(1+2d)(9+7\lambda)}$$*
- *decreasing in d ; and (iii) $\bar{\delta}_k(t^{**})$ increases in λ for every program k .*

A single, second-best fee



- The loss vanishes at $\lambda = 0$ and $\lambda = 1$, and is smaller when pollution is more severe.

A single, second-best fee

- The EPA cannot anticipate the market structure, so its fee is intermediate.
- If firms collude, the fee is too stringent: output below Q^* .
- If firms compete, the fee is too lax: output above Q^* .
- A stronger belief in competition (higher λ) raises the fee, hindering collusion.

Extensions

Extensions - Roadmap

- **Convex costs:** diseconomies (and economies) of scale.
- **Product differentiation:** goods are imperfect substitutes.
- **More firms:** $m \geq 2$ firms in the industry.
- **Price competition:** firms compete à la Bertrand.
- In each extension: collusion cutoffs, the optimal fee, and the booster.

Convex costs

- Costs $C(q_i) = cq_i + \frac{\beta}{2}q_i^2$, with $\beta \geq 0$ (diseconomies of scale).
- Without a CA, collusion holds if

$$\delta \geq \bar{\delta}(\beta) \equiv \frac{(3 + \beta)^2}{17 + 2\beta(6 + \beta)}$$

- $\bar{\delta}(0) = \frac{9}{17}$, decreasing in β : collusion ameliorates diseconomies of scale.
- Still unaffected by the fee t .

Convex costs

- Optimal fee:

$$t^c(\beta) = \frac{(1-c)(4d-1)}{2(1+2d) + \beta}$$

- Coincides with Lemma 4 at $\beta = 0$; decreasing in β .
- The fee curbs output more under convex costs, so a laxer fee suffices.

Convex costs

- Total effect of β on the audit cutoff:

$$\frac{d\bar{\delta}_A(\beta, t^C(\beta))}{d\beta} = \underbrace{\frac{\partial \bar{\delta}_A}{\partial \beta}}_{+ \text{ Direct}} + \underbrace{\frac{\partial \bar{\delta}_A}{\partial t^C}}_{+} \underbrace{\frac{\partial t^C(\beta)}{\partial \beta}}_{-} \quad (9)$$

– Indirect

- Convex costs reduce the value of continuing collusion (direct).
- But they lower the fee (indirect).

Convex costs

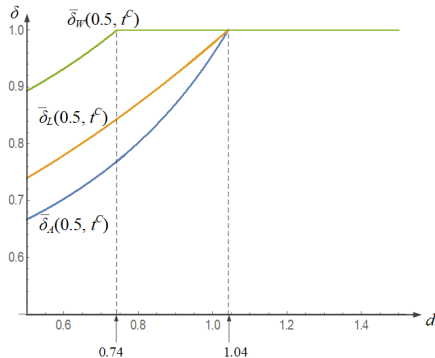


Fig. 5a. Cutoffs at the optimal fee, $\beta = 1/2$.

- Cutoffs shift up relative to Fig. 3a: the direct effect dominates.

Convex costs

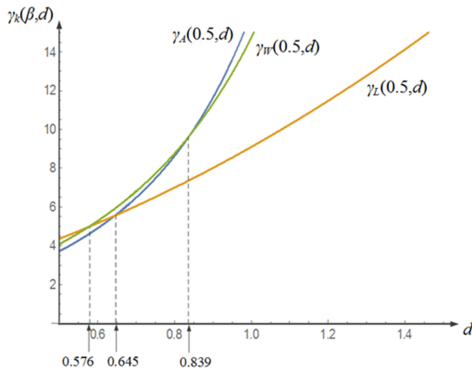


Fig. 5b. Booster, $\beta = 1/2$.

- The booster shifts up: cost convexity emphasizes it.

Economies of scale

- Concave costs, $\beta \in (-3, 0)$.
- Collusion is less attractive without a CA.
- But the booster becomes smaller.
- Collusion in industries with strong economies of scale may be harder to prosecute when the EPA regulates them.

Product differentiation

- Inverse demand $p(q_i, q_j) = 1 - q_i - \gamma q_j$, with $\gamma \in [0, 1]$.
- Without a CA, collusion holds if

$$\delta \geq \bar{\delta}(\gamma) \equiv \frac{(2 + \gamma)^2}{8 + \gamma(8 + \gamma)}$$

- Increasing in γ : more differentiated goods facilitate collusion.
- Optimal fee $t^C(\gamma) = \frac{(1-c)(4d-1)}{4d+1+\gamma}$, decreasing in γ .

Product differentiation

- **Lemma 6** (summary): $\bar{\delta}_k(\gamma, t)$ increases in γ when expected penalties are low.
- Coincides with Propositions 1-3 at $\gamma = 1$.
- Increases in t , c , ρ , and F .
- Booster: $\frac{\partial \bar{\delta}_k}{\partial \rho}$ and $\frac{\partial \bar{\delta}_k}{\partial F}$ still increase in t .

Product differentiation

- Low expected penalties: differentiation facilitates collusion in every program.
- Intermediate penalties: it hinders collusion only under whistleblower programs.
- High penalties: it hinders collusion under audits and whistleblowing, but not under leniency.
- Rewards lose part of their collusion-destruction effect with differentiated goods.

More firms

- With $m \geq 2$ firms and no CA, collusion holds if

$$\delta \geq \bar{\delta}(m) \equiv \frac{(m+1)^2}{m(m+6)+1}$$

- $\bar{\delta}(2) = \frac{9}{17}$, increasing in m , approaching 1.
- Optimal fee $t^C(m) = \frac{(1-c)(2dm-1)}{m(1+2d)}$, increasing in m .

More firms

- Total effect of m on the audit cutoff:

$$\frac{d\bar{\delta}_A(m, t^C(m))}{dm} = \underbrace{\frac{\partial \bar{\delta}_A}{\partial m}}_{+ \text{ or } - \text{ Direct}} + \underbrace{\frac{\partial \bar{\delta}_A}{\partial t^C} \frac{\partial t^C(m)}{\partial m}}_{+ \text{ Indirect}} \quad (16)$$

- Low expected fines: both effects positive, so more firms hinder collusion.
- High expected fines: a negative direct effect may dominate.

Price competition

- Without a CA, $\bar{\delta}^B(t) = \frac{1}{2}$: unaffected by the fee.
- With audits:

$$\bar{\delta}_A^B(t) \equiv \frac{(1 - c - t)^2}{2(1 - c - t)^2 - 8\rho F}$$

- Increasing in t , c , ρ , and F ; booster holds.
- Optimal fee $t^B = \frac{2d(1-c)}{1+2d} > t^C$: more output under Bertrand.

Price competition

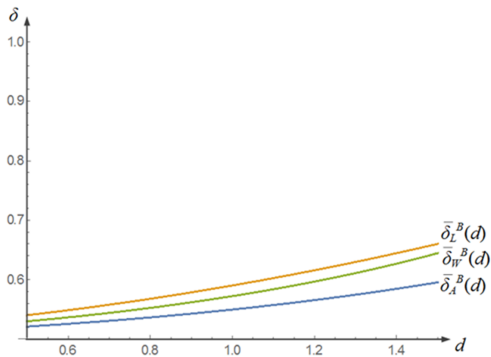


Fig. 6a. Cutoffs under price competition.

- $\bar{\delta}_k^B(t^B) < \bar{\delta}_k(t^C)$: collusion is easier under price competition.

Price competition

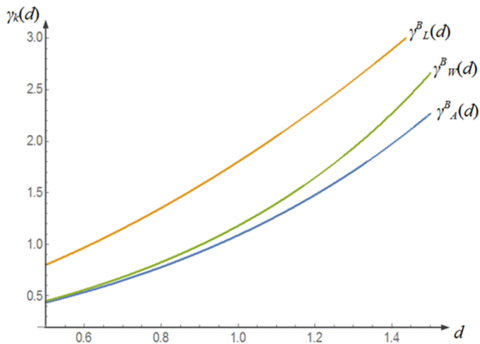


Fig. 6b. Booster under price competition.

- Boosters increase in d , but are smaller than under quantity competition.

Discussion

Production costs vs. emission fees

- A cost increase is not equivalent to a stricter fee.
- Higher d : only an indirect effect (stricter fee hinders collusion).
- Higher c : positive direct effect, negative indirect effect (laxer fee).
- Consistent across all four extensions.

Emission fees enhancing competition policy

- The mechanism is the environmental policy, not pollution itself.
- Stricter fees weaken cartel stability, boosting competition policy.
- A novel, unintended role for the EPA.
- Stronger booster with convex costs; weaker with economies of scale.

Policy reading

- **Leniency and whistleblowing:** lower rewards in regulated industries, easing public opposition.
- **Prioritizing antitrust efforts:** shift monitoring toward unregulated industries.
- A given antitrust effort deters more collusion where emission fees apply.

Concluding remarks

- Environmental regulation and competition policy reinforce each other.
- Emission fees make audits, leniency, and whistleblower programs more effective.
- Robust to convex costs, differentiated products, more firms, and price competition.
- CAs can reallocate monitoring and rewards toward unregulated sectors.

Further research

- **Cost asymmetries:** corner solutions under linear costs; several active firms under convex costs.
- **Sequential competition:** a leader and a follower.
- **Uninformed EPA:** fees based on expected costs.

Thank you!