

Optimal Monitoring and Countries' Compliance with International Environmental Taxes

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Introduction

Enforcement of environmental protection policies is key

Noncompliance with environmental taxes exists due to information asymmetries between the regulator and the regulated entity

- national regulations:
emissions are not monitorable \Rightarrow Firms under-report actual emissions and evade the emission tax (e.g. Harford (1978, 1987), Kaplow and Shavell (1994), Innes (1999), Pérez-Castrillo and Macho-Stadler (2006))

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- international regulations:
effective tax rates are not monitorable \Rightarrow Countries distort the emission tax by fiscal policy adjustments (e.g. Wiener (1999), Victor (2001), Nordhaus (2007))

Introduction

The effective emission tax rate can be distorted by

- reducing taxes which indirectly tax emissions
- subsidizing emission intense production processes
- taxing substitutes/subsidizing complements to the regulated good

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We extend Pérez-Castrillo and Macho-Stadler (2006) by fiscal cushioning and analyze

1. a single country's optimal compliance decision, and
2. the regulator's optimal monitoring policy.

Model - Full Compliance

International regulatory authority announces the exogenous tax rate t on emissions \rightarrow countries implement the tax in their domestic fiscal system

- Given the tax rate t , the domestic economy (fully compliant) chooses the emission level e to maximize profits Φ

$$\Phi(e) = g(e) - te,$$

where $g(e)$ denotes benefits from emissions.

\Rightarrow Emissions under full compliance e^* are characterized by

$$g'(e^*) = t.$$

Model - Noncompliance

Fiscal cushioning reduces the effective tax $t^* \leq t$

- tax distortion $\rightarrow g'(e) = t^* \Rightarrow e > e^*$
- emissions and the associated emissions increase

Under-reporting actual emissions $z < e$:

- fraction β of the tax rate is transferred to the treaty regime
 \Rightarrow under-reporting reduces tax transfers

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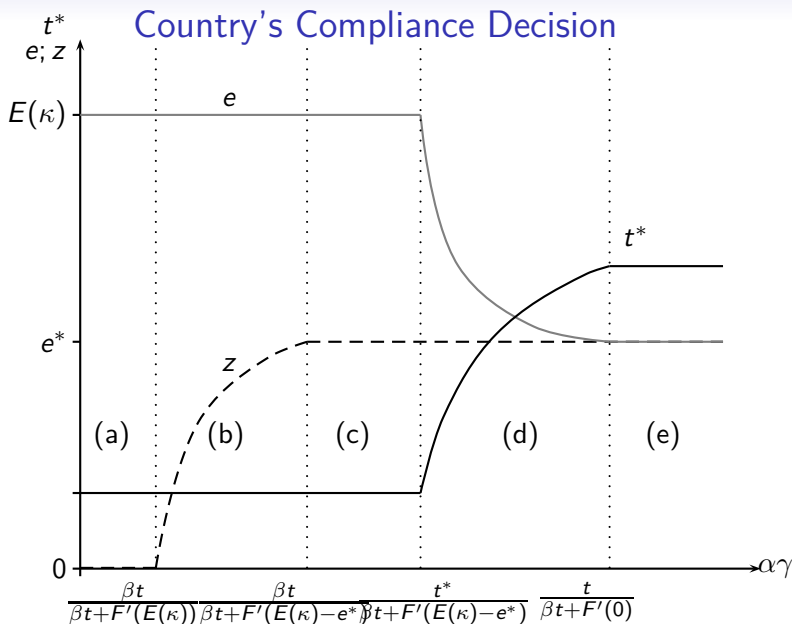
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Sanction when noncompliance is detected $\alpha\gamma F(e - z)$

- α monitoring probability
 - γ probability of detection
 - $F(\cdot)$ increasing and convex: $F'(\cdot) > 0$, $F''(\cdot) > 0$
- } $\alpha\gamma$ perceived audit pressure



Insights

- (Partial) compliance with respect to fiscal cushioning requires an perceived audit pressure within region (d) or (e).
→ feasible only if the probability of detection is high enough!
- Monitoring has a stronger deterrence effect on the report than on fiscal cushioning
→ particular *bad* news for a regulator that seeks to minimize fiscal cushioning or emissions.

Rationale:

perceived costs for higher reports are scaled down by β , while countries benefit to the full extend from higher emissions.

Regulator's perspective

Consider a continuum of countries:

- heterogeneous in the probability of detection $\gamma \in [0, 1]$.
- homogeneous in the potential for fiscal cushioning $\kappa = \check{\kappa}$

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Given a (limited) monitoring budget B , the regulator chooses a monitoring policy $\alpha(\gamma, \check{\kappa})$ to minimize the aggregate emission level e . The monitoring policy is optimal if a reallocation of budget does not reduce aggregate emissions.

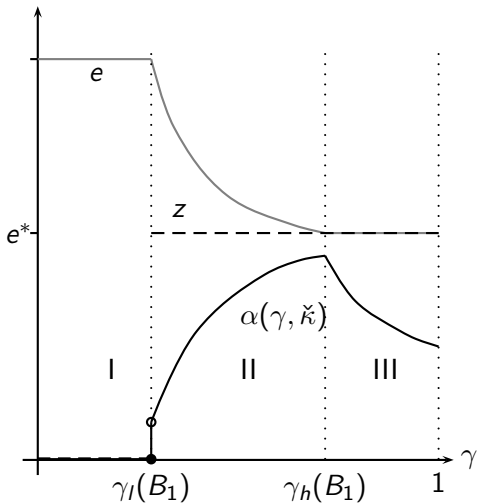
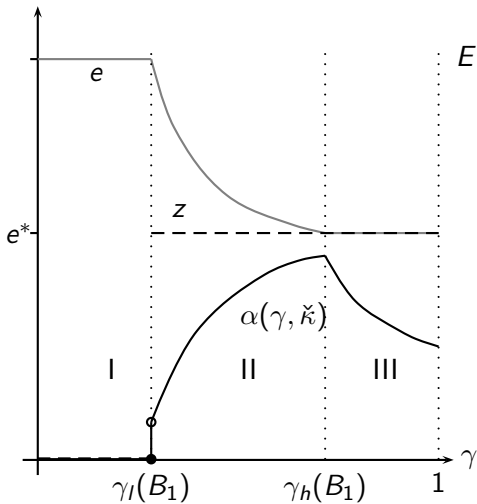
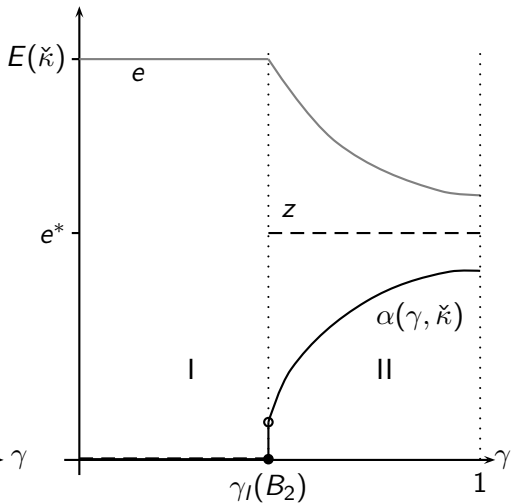
$\alpha; e; z$ 

Fig. 2a: $B_1 \in (\underline{B}^{\kappa}, \bar{B}^{\kappa})$

$\alpha; e; z$ Fig. 2a: $B_1 \in (\underline{B}^{\check{\kappa}}, \overline{B}^{\check{\kappa}})$ $\alpha; e; z$ Fig. 2b: $B_2 \in (B_{crit}^{\check{\kappa}}, \underline{B}^{\check{\kappa}}]$

Limited Budget

The thresholds $\underline{\gamma}(B)$ and $\bar{\gamma}(B)$ depend on the monitoring budget B

- $B < B_{crit} \Rightarrow \underline{\gamma}(B) = \bar{\gamma}(B) = 1 \Rightarrow$ only region I exists
- $B \in [B_{crit}; \underline{B}] \Rightarrow \tilde{\gamma} < \underline{\gamma}(B) < \bar{\gamma}(B) = 1 \Rightarrow$ regions I and II exist
- $B \in (\underline{B}, \bar{B}) \Rightarrow \tilde{\gamma} < \underline{\gamma}(B) < \bar{\gamma}(B) < 1 \Rightarrow$ regions I, II, and III exist

Concluding Remarks

- Fiscal cushioning can significantly reduce the effectiveness of international environmental tax regulations
- Countries' compliance decisions are particular *bad* news for a regulator that seeks to minimize actual fiscal cushioning
- Some countries can never be incentivized to (partially) comply even when the regulator has unlimited access to monitoring resources.
- With limited budget, the regulator targets those countries first, which are easy to detect.

Thank you very much for your attention.

Fiscal Cushioning

Effort put into fiscal cushioning $x \in [0; t]$:

- $x = 0$ no effort in fiscal cushioning
- $x = t$ maximum effort in fiscal cushioning

Potential for fiscal cushioning $\kappa \in [0, \bar{\kappa}]$ with $\underline{\kappa} \geq 0$ and $\bar{\kappa} < 1$

- $\kappa \rightarrow 0$ limited potential for fiscal cushioning
- $\kappa \rightarrow 1$ great potential for fiscal cushioning

\Rightarrow effective tax rate on emissions $t^* \leq t$, which is

- t for $x = 0$, and
- $t(1 - \kappa) > 0$ for $x = t$.

Model - Noncompliance

Effort in fiscal cushioning $x \geq 0$:

- distortion of the abatement decision
→ $g'(e) = t^* \leq t \Rightarrow e \geq e^*$
- emissions and associated benefits increase

Under-reporting actual emissions $z \leq e^*$:

- fraction β (small enough) of reported tax money is transferred to the treaty regime
⇒ under-reporting emissions reduces tax transfers

Sanction when noncompliance is detected $\alpha\gamma F(e - z)$

- α monitoring probability
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 - $F(\cdot)$ increasing and convex: $F'(\cdot) > 0$, $F''(\cdot) > 0$
- } $\alpha\gamma$ perceived audit pressure

Country's Perspective

A country chooses the optimal amount of fiscal cushioning x and reported emissions z to maximize

$$\Pi(e(x, \kappa), z; \gamma, \alpha) = g(e) - [1 - \alpha\gamma]\beta tz - \alpha\gamma\beta te - \alpha\gamma F(e - z),$$

- $g(e)$: benefits from actual emissions e ,
- α : monitoring probability,
- γ : probability of detection,
- F : sanction for noncompliance,
- z : reported emissions,
- t : (intended) tax rate.

Country's Perspective

The optimal compliance decision $(x^0; z^0)$ is characterized by the FOCs:

$$\frac{\partial \Pi}{\partial z} = -[1 - \alpha\gamma]\beta t + \alpha\gamma F'(e - z) = 0$$

and

$$\frac{\partial \Pi}{\partial x} = t^* - \alpha\gamma\beta t - \alpha\gamma F'(e - z) = 0$$

Note: Depending the level of the perceived audit pressure $\alpha\gamma$, one of the FOCs is always binding \Rightarrow corner solutions for z and/or x

Proposition

Given a global tax rate t , the sanction $F(\cdot)$, a monitoring probability α , a probability of detection γ , the potential for fiscal cushioning κ , and considering assumption 1, a country's optimal compliance decision (x^0, z^0) on the amount of fiscal cushioning and reported emissions is

- (a) $z^0 = 0$ and $x^0 = t$ for $\alpha\gamma < \frac{\beta t}{\beta t + F'(E(\kappa))}$. The amount of emissions is E_κ
- (b) $z^0 \in (0, e^*)$ and $x^0 = t$ for $\alpha\gamma \in \left[\frac{\beta t}{\beta t + F'(E(\kappa))}; \frac{\beta t}{\beta t + F'(E(\kappa) - e^*)} \right)$. The amount of emissions is $E(\kappa)$.
- (c) $z^0 = e^*$ and $x^0 = t$ for $\alpha\gamma \in \left[\frac{\beta t}{\beta t + F'(E(\kappa) - e^*)}; \frac{t(1-\kappa)}{\beta t + F'(E(\kappa) - e^*)} \right)$. The amount of emissions is $E(\kappa)$.
- (d) $z^0 = e^*$ and $x^0 \in (t, 0)$ for $\alpha\gamma \in \left[\frac{t(1-\kappa)}{\beta t + F'(E(\kappa) - e^*)}; \frac{t}{\beta t + F'(0)} \right)$. The amount of emissions is implicitly defined by $g'(e) = t - \kappa x$.
- (e) $z^0 = e^*$ and $x^0 = t$ for $\alpha\gamma \geq \frac{t}{\beta t + F'(0)}$. The amount of emissions is e^* .

Objective function

The regulator's objective is to minimize actual fiscal cushioning $\check{\kappa}x$

$$\min \int_0^1 e(x(\gamma), \check{\kappa})v(\gamma)d\gamma$$

s. t.

$$\int_0^1 \alpha(\gamma, \check{\kappa})v(\gamma)d\gamma \leq B$$

and

$$z(\gamma), x(\gamma, \check{\kappa}) \in \operatorname{argmax} \Pi(\gamma, \kappa, \alpha(\gamma; \check{\kappa}); x, z)$$

Unlimited Budget

Proposition

When $B \geq \bar{B}$, the optimal monitoring policy is such that

- $\alpha = 0$ for all $(\gamma, \check{\kappa})$ -type countries with $\gamma \in [0; \tilde{\gamma}(\check{\kappa})]$,
- $\alpha = 1$ for all $(\gamma, \check{\kappa})$ -type countries with $\gamma \in [\tilde{\gamma}(\check{\kappa}); \hat{\gamma}]$,
- $\alpha(\gamma) = \text{Min}\{1; \hat{\alpha}(\gamma)\}$ for all $(\gamma, \check{\kappa})$ -type countries with $\gamma \in [\hat{\gamma}; 1]$.

Minimum emission level that can be achieved

$$e_{min}^{\check{\kappa}} = E(\check{\kappa})V(\tilde{\gamma}(\check{\kappa})) + \int_{\tilde{\gamma}(\check{\kappa})}^{\hat{\gamma}} e^{**}(\gamma)v(\gamma)d\gamma + \int_{\hat{\gamma}}^1 e^*v(\gamma)d\gamma$$

$$\check{\kappa}x_{min} = \check{\kappa}tV(\tilde{\gamma}(\check{\kappa})) + \int_{\tilde{\gamma}(\check{\kappa})}^{\hat{\gamma}} \check{\kappa}x^*v(\gamma)d\gamma$$

Unlimited Budget - Insights

- the regulator's monitoring budget should never exceed \bar{B}
→ stricter monitoring does not improve compliance rates
- all countries subject to audits (truthfully) report e^* emissions
- Only countries with $\gamma \geq \tilde{\gamma}(\tilde{\kappa})$ are subject to audits
⇒ low γ -values can be expected for a majority of countries
⇒ ineffective environmental policy

Minimum level of fiscal cushioning

Required budget to achieve e_{min} is

$$\bar{B}^{\check{k}} = V(\hat{\gamma}) - V(\tilde{\gamma}(\check{k})) + \int_{\hat{\gamma}}^1 \hat{\alpha}(\gamma)v(\gamma)d\gamma.$$

Optimal Monitoring with Limited Budget

Proposition

When the regulator's monitoring budget is limited, i.e. $B < \overline{B}^{\gamma, \check{\kappa}}$, two threshold values $0 < \tilde{\gamma}(\check{\kappa}) < \underline{\gamma}(B) < \overline{\gamma}(B) \leq 1$ exist. The optimal audit policy is such that

- I. $\alpha = 0$, for all $(\gamma; \check{\kappa})$ -type countries with $\gamma \leq \underline{\gamma}(B)$,
- II. $\alpha(\gamma) \in [\tilde{\alpha}(\gamma, \check{\kappa}); \text{Min}\{\hat{\alpha}(\gamma); 1\})$, for all $(\gamma; \check{\kappa})$ -type countries with $\underline{\gamma}(B) < \gamma < \overline{\gamma}(B)$, and
- III. $\alpha(\gamma) = \text{Min}\{1; \hat{\alpha}(\gamma)\}$, for all $(\gamma; \check{\kappa})$ -type countries with $\overline{\gamma}(B) \leq \gamma \leq 1$.

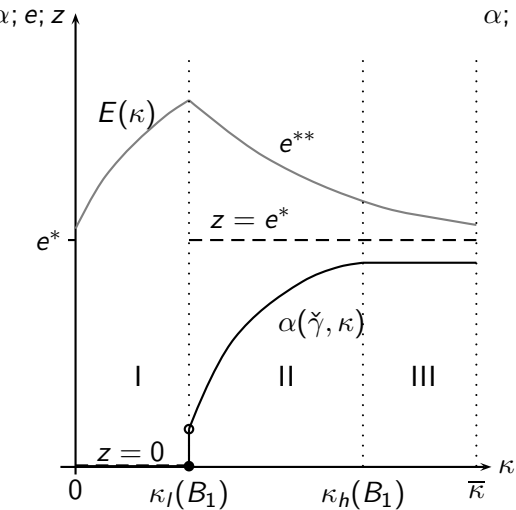


Fig. 3a: $B_1 \in (\underline{B}^{\check{\gamma}}, \overline{B}^{\check{\gamma}})$

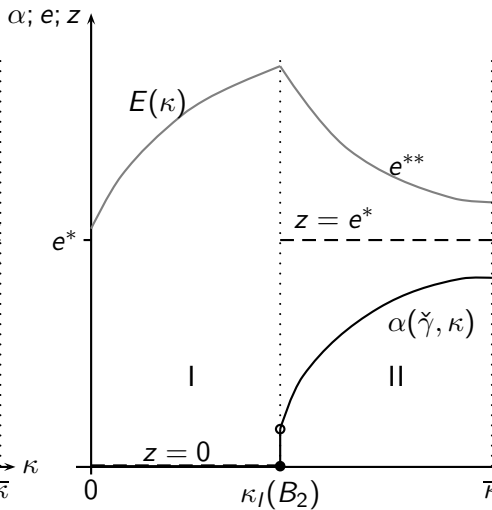


Fig. 3b: $B_2 \in (B_{crit}^{\check{\gamma}}, \underline{B}^{\check{\gamma}}]$