Regulating non-point pollution in rivers and streams

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National Market Based Instruments (MBI)

Regulation and enforcement of an MBI scheme

- One of the key objectives of the National Action Plan is to improve the governance framework with regard to property rights and regulatory reforms for water and land use.

- It is recognised that necessary conditions for the implementations of MBIs are the enforcement of targets and monitoring the actions of major stakeholders.

More compliance is possible with trade than without : Compliance target

	Player #1	Player #2	Player #3	Player #4	Player #5	Player #6	Player #7	Player #8	Player #9	Player #10
Cost #1	39	23	9	35	12	44	12	44	44	11
Cost #2	64	82	26	53	58	69	108	168	68	14
Cost #3	70	213	127	111	76	206	195	177	173	46
Cost #4	78	232	196	120	98	283	300	225	233	60
Cost #5	141	262	226	139	121	331	318	261	248	95
Cost #6	162	263	237	159	124	363	349	293	265	97
Cost #7	180	272	388	166	193	411	480	296	304	99
Cost #8	208	310	395	250	198	480	487	301	530	112
Cost #9	212	376	490	321	210	628	519	400	581	114
Cost #10	287	465	504	442	584	1000	570	437	611	136

- Target 5 units each
- Fine $294 with audit probability 0.7; correct reporting fine $206.

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More compliance is possible with trade than without : Compliance with trade

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Characteristics of Nonpoint Pollution

- Many polluting firms or agents
- Driven by stochastic processes
- Interdependency
- Pollutants are not uniformly mixed
- Time lags
- Unable to observe inputs or practices (types)
- Imperfect knowledge about pollutant generation, transport and fate

How do we regulate non-point pollution?

- Segerson Model
  - A tax-subsidy scheme based on monitoring pollution at a group level
  - Polluters are taxed if the aggregate level of pollution exceeds a given level and a subsidy of it is below.
- Kritikos model
  - A tax scheme based on aggregate pollution and random individual auditing

The Segerson Model

- Segerson (1988) proposed a tax/subsidy scheme in which players face a collective penalty when ambient targets are exceeded.

- To avoid potential free rider problems associated with ambient pollution measures, the full social marginal damage cost is imposed on every firm.

- While recognizing that in such a scheme total collection exceeds marginal damages, Segerson (1988) argued that it is necessary for each firm to pay in order to maintain the correct marginal incentive to reduce pollutants and overcomes moral hazard problems traditionally associates with ambient tax systems.

- Other cited benefits include the fact that the authority only needs to measure ambient levels of pollution and could be based on environmental quality rather than simply emissions.

- The Segerson scheme consists of two components: a tax/subsidy scheme dependent on whether the differential between the level of ambient pollution (x) and the threshold, and a group fine *k* imposed when the threshold is exceeded.

Segerson model

$$T(x)=\begin{cases} t(x-\overline{x})+k & if\ \ x>\overline{x} \\ t(x-\overline{x}) & if\ \ x\le\overline{x} \end{cases}$$

x is the level of pollution

k is a fine for exceeding the target

$\overline{x}$ is the target

Kritikos Model

- Kritikos (2004) finds fault with the Segerson (1988) ambient tax and Xepapadeas's random fining contract models in that they are not incentive compatible with socially optimal outcomes and argues such models may lead to multiple Nash equilibrium.

- As a result, he proposes a combined individual and collective penalty system

Kritikos Model

$$\phi_j = \alpha\phi_j^I + \beta\phi_j^K$$

$$\alpha = \begin{cases} 1 \text{ if inspected and } \varepsilon_{\mathrm{j}} > \varepsilon_j^z \\ 0 \text{ otherwise} \end{cases}$$

$$\beta = \begin{cases} 0 \text{ for E} \leq \text{E}^z \\ 0 \text{ for E} > \text{E}^z \text{ if inpected and } \varepsilon_j \leq \varepsilon_j^z \\ 1 \text{ otherwise} \end{cases}$$

φ_j^I is the individual fine

φ_j^K is the group fine

α is the individual fine coefficient;

β is the group fine coefficient

ε_j is the individual pollution level

ε_j^K is the individual pollution target

E is the group pollution level

E^Z is the group target

Adapted from Kritikos (2004, 394)

Fines under the Kritikos model

Individual		Group	
		Compliant	Not compliant
Audited	Compliant	No fine	No fine
	Not Compliant	Individual fine	Individual and group fine
Not Audited	Compliant	No fine	Group fine
	Not Compliant	No fine	Group fine

Experimental Design

Trade	Individual random fining	Group ambient fine	Individual and group ambient fine
No Trade	4 sessions 20 rounds	4 sessions 20 rounds	4 sessions 20 rounds
Trade	4 sessions 20 rounds	4 sessions 20 rounds	4 sessions 20 rounds

Key Findings/Implications

What are the consequences of having group responsibility for an aggregate emissions target on compliance levels?

- Aggregate Compliance
  - Individual random auditing produces a lower level of aggregate compliance compared to a group ambient fine.
  - A two-fine system produces higher aggregate compliance compared to individual random auditing without trade. With trade, they produce the same level of aggregate compliance.
  - Two-fine systems and group ambient fining do not produce significantly different levels of aggregate compliance.

- Individual Compliance
  - Two-fine auditing maximized individual compliance in terms of the proportion of players meeting their individual targets with and without trade.
  - Group ambient fining did not produce a significant difference in individual compliance compared to individual random auditing.

Key Findings/Implications

- Net Cost Analysis
  - The expected fine of each auditing system was equal
  - Individual random auditing resulted in lower fines being imposed compared to the group ambient fine or two fine systems.
  - The group ambient fine or two fine systems were not significantly different in terms of total fines paid.

- Market Activity
  - Trading under the threat of a group fine produced lower average market prices for emission credits ,compared to trade under an individual random audit system.
  - Trading under the threat of a group fine produced higher average traded quantities of emission credits compared to trade under an individual random audit system.

Key Messages for Policy Makers

1. Auditing and regulation if MBIs is important. No or low probability of audit will result in ineffective schemes and no incentive to trade.

2. Compliance becomes financially viable for some emitters with trade than would have been possible without trade.

3. Increased enforcement may be mediated via market prices rather than increased compliance.

4. A two-fine system is superior to a simple individual random audit system with or without trade when MBIs are dealing with common pool resource issues.

5. Community awareness of non-compliance may inhibit trade.

6. If the probability of audit is low then do not make it public -- If high make it common knowledge. In the long run the probability of audit will be realized.

Development of comprehensive enforcement strategy for point non-point NMR markets

- Consider the use of:
  - Self reporting
  - Both ambient and individual fines in combination
  - Peer monitoring rather than authority monitoring
  - Communication of monitoring probabilities
  - Coordination of rewards/penalties for individual and group actions