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Implications of Different Sanction Regimes on the Efficiency of Emission Trading

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Agenda

- **Motivation**
- **Contribution**
- **Methodology**
- **Theoretical model & results**
- **Experimental method**
- **Outlook**

Motivation

- **Sanction is an important element in emissions trading scheme to ensure economic efficiency & environmental effectiveness**
- **Existing emissions trading programs use different sanction forms, but very little information is known about their effects on market efficiency**
- **In the presence of imperfect information (e.g. uncertainty about future emissions, perceptions about the risk of illiquidity in permit market) high penalties might lead to overinvestment in reduction measures because the cost of potentially being non-compliant will be high compared to the cost of reducing emissions.**
- **It is important to learn how different enforcement mechanisms can affect the compliance rate and the actual efficiency gains of a trading scheme for a particular market design of the scheme.**
- **Australia is going to implement Carbon Pollution Reduction Scheme in 2010 will use price cap as a sanction form. The price cap is set at $40 and annually increased by 5% in real terms**
  - **There are some questions on the effects of price cap in compromising the emissions target as well as market efficiency**

Contribution

- **Research questions:**
  1. **How does sanction design affect compliance strategy?**
     - **Compliance strategies: Investment in abatement measures & permit trading**
     - **Sanction types:**
       - **Fixed Penalty Rate (FPR), which can be set as a price cap**
       - **Make-Good Provision (MGP),**
       - **Mix of both**
  2. **How does sanction design influence market performance?**

     Measures of market performance: Market price, Trading volume, Market efficiency : the actual over the theoretical cost saving, Convergence path of permit prices to equilibrium
- **Main contribution of this research**
  - **focus on the effects of different forms and levels of sanction mechanism on market performance, assuming that there is 'perfect' monitoring & enforcement**
  - **Look at how different initial allocation rules might effect market performance, as this has been a main concern in the actual ETS**
  - **Implication on policy design of efficient & effective sanction in ETS**

Methodology

- **Theoretical approach**
  - **Simple, two-period, perfect competition model**
  - **Result from theoretical work will be the hypothesis for the experiments**
- **Laboratory experiment**
  - **Reasonings:**
    - **Actual efficiency is difficult to measure with real world data**
    - **An ETS will only have one sanction design and it is difficult to make comparison across different schemes**
    - **With experimental method, we can have more control over laboratory environment & variables and try to isolate the effects of a change in one variable**

Theoretical Model

- **Basic model:**

Profit = Total Revenue – Total Production Costs – Total Abatement Costs

– Total permit holding costs – Total penalty costs

$$\underset{K_{it}, a_i, l_{it}}{Max} \; \Pi_i = \sum \bar{\pi}\, q_{it}(K_{it}) - \sum \bar{r}\, K_{it} - \sum c_i(a_i) - \sum \bar{p}_t d_{it} - sanction * v_{it}$$

s.t. $v_{it} = e_{it} - a_i - l_{it} \geq 0$

$\bar{\pi}$ = price of good

$\bar{r}$ = capital rent

$\bar{p}$ = permit price

K_{it} = capital of firm i at time t

q_{it} = output of firm i at time t

$d_{it} = l_{it} - \bar{s}_{it}$ = net traded permit of firm i at time t

$\bar{s}_{it}$ = grand fathered permit of firm i at time t

v_{it} = violation of firm i at time t

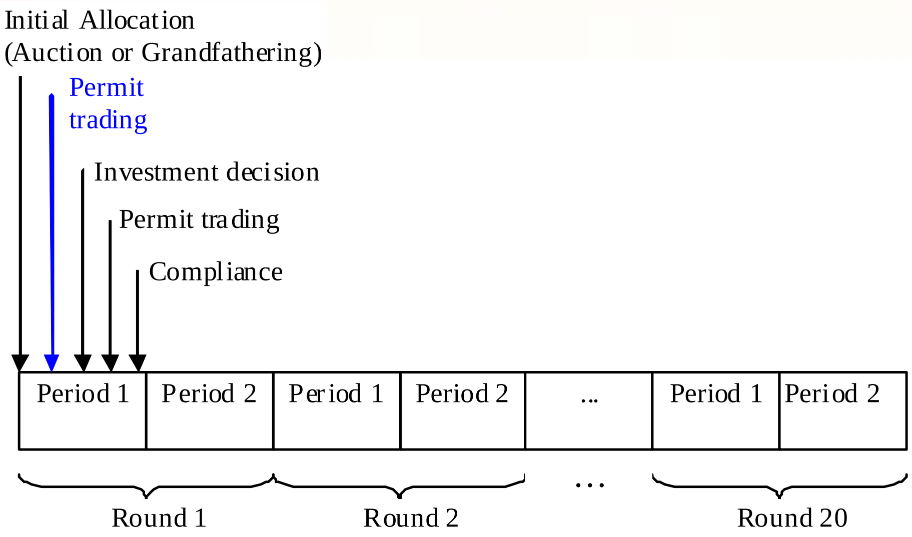
- **Key assumptions:**
  - **Firms are price takers in permit markets**
  - **Firms differ in their marginal abatement costs, $c_i(a_i)$.**
  - **Investment in abatement measures is irreversible and should be made in the first period**
  - **Firms need to surrender permit for each unit of emissions $e_{it}(q_i)$ that they produce.**
  - **No banking and borrowing**

Results

- **Initial allocation mechanism should not affect compliance decision**
- **As long as sanction level is kept above the permit price, *f* > *p*, thus firm will find it optimal to comply by holding a number of permit or making investment in abatement measure**
  - **These results are consistent for 3 forms of sanctions**
- **When firm complies**
  - **it will equalise its marginal abatement cost to permit prices in two periods**
  - **in each period, firm will equalise its marginal benefit net of compliance costs to capital rent ⇒MC = MB**
- **With increasing penalty rate**
  - **Violation rate is decreasing until penalty rate equals permit price, *f* = *p***
  - **Investment in abatement measure is also increasing**
  - **Production level is decreasing until *f* = *p***
  - **Firm will hold an optimal number of permit holding after *f* = *p***
- **With increasing restoration rate**
  - **Investment in abatement measure is increasing until restoration rate, rho = 1**
  - **First period violation is decreasing then drops to zero when rho = 1**
  - **Production level is decreasing until rho = 1**
  - **Firm will hold an optimal number of permit holding after rho = 1**
- **In the Mix of FPR & MGP**
  - **Increasing penalty rate has more effects on permit holding, production level, and violation rate in the second period, as well as investment in abatement measures**
  - **The restoration rate has more effects on permit holding, production level, and violation rate in the first period**

Experimental Design

- **12 treatment cells related to 3 treatment variables: sanction forms, sanction levels, and initial allocation mechanism (grandfathering or auction)**
- **Key market design:**
  - **20 repeated rounds of market game, each with 2 periods.**
  - **10 players in each treatment cell: 5 net buyers and 5 net sellers, which are differed by their MACs and endowments**
  - **Trading institution: double auction**
  - **Information structure: individual player's characteristics are private information, but global parameters are public information**
  - **Banking and borrowing are not allowed**



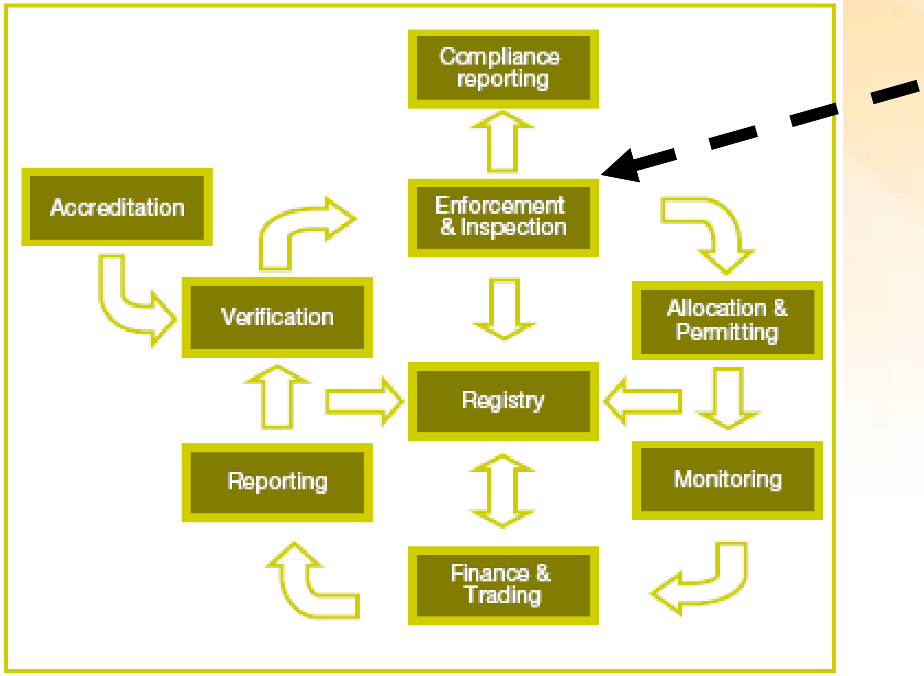
Treatment Variables

Sanction Design	Trading Institution		
	Grandfathered allocation	Auctioned allocation	Penalty linked to auction
Fixed penalty rate -Low level (slightly above equilibrium price) - High level (1:5)	Treatment I Treatment II	Treatment V Treatment VI	Treatment IX
Make-good provision restoration rate (1:1.5)	Treatment III	Treatment VII	-
Mix of fixed penalty and make-good provision - High level penalty rate and low level make-good provision	Treatment IV	Treatment VIII	Treatment X

Outlook

- A theoretical paper on the effects of different sanction design is forthcoming
- Programming of the experiment with Z-Tree and the preparation of the running of the experiment is underway and the experiment will be run in the first half of the year

Emissions Compliance Processes



Emissions Compliance Processes Reference Model (PriceWaterhouseCoopers 2007)

Sanction form and level

Sanction:

a threatened penalty for disobeying a law or rule

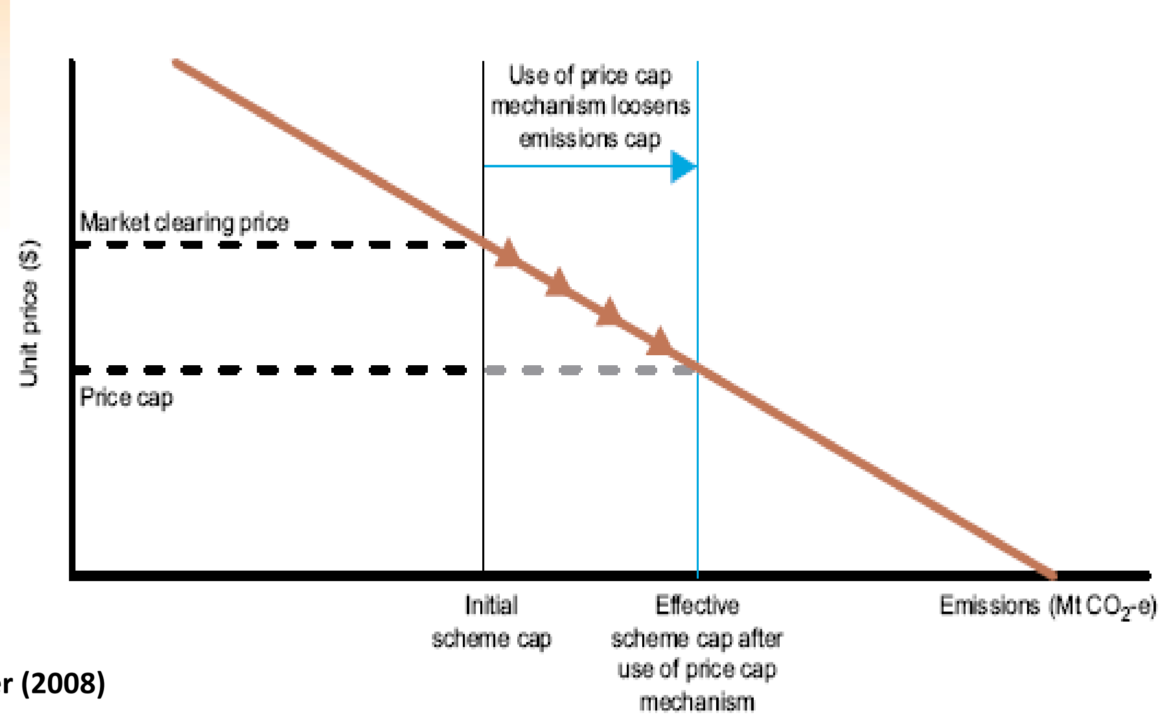
Penalty:

a punishment for a crime (violation) … which must be clearly stated before it can be enforced

Oxford Reference Online (2007)

Price cap

- **Price cap is a mechanism for setting the maximum cost of compliance under the scheme**
- **If the permit price rises above the price cap, then price cap becomes with 2 implications:**
  - **Firms can still comply by buying permit from government at the triggered price (increasing effective supply of permits)**
  - **Firms are temporarily released from surrendering the required number of permits, hence firms are still under compliance.**



Green Paper (2008)

Existing and Future ETS related to Climate Change

Sanction Type	Schemes	Pollutants	Sector coverage	Details on sanctions	Compliance
Fine only (Fixed Penalty Rate)	NSW GGAS	6 GHGs	Electricity generators	A$16 incl. taxes	1% carried-fwd shortfalls
	Denmark 2000-2003	CO_2	Electricity producers	€5.3/ton	Very low in a particular year
	Chile	PM	680 sources emitting >1000m3/h	Penalty fee	Low, then high
	LA RECLAIM	NO_x,SO_2	311 facilities emitting >4 ton NO_x	$500/violation/day, determined by court	84% - 97 % (1994-2003)
Make-Good Provision	US OTC	NO_x	2579 units of power plants and large combustion sources in eastern US	Quota reduction at 3:1	Over 99% (2006)
Mix	US Acid Rain	SO_2	3456 electric generating units	Penalty $2963/ton (2004) + MGP 1:1	100% (2005)
	EU ETS	CO_2	Major installations	€40 (rising to €100 in 3 yrs) + MGP 1:1.3	Very high
	Australian CPRS 2010	6 major GHGs	Stationary energy, transport, fugitive emissions, industrial processes, waste and forestry sectors at the start	Price cap $40 increased by 5% annually	-
	RGGI (seven Northeastern states) 2009	CO_2	Fossil fuel electricity generators above a size threshold of 25MW in	Safety valve / price cap, linked to CDM	-
	WCI (7 Western US States and 4 Canadian Prov.s) 2012	6 major GHGs	electricity generation, commercial and industrial combustion, and industrial process emissions	MGP 1:3 + state penalty	-
	UK Carbon Reduction Scheme	CO_2	Large non-energy intensive business and public sector entities that are not covered by the EU ETS	Safety valve / price cap, linked to EU ETS	-
	New Zealand ETS	6 major GHGs	Forestry 2008, all sectors by 2013	Penalty NZ$60 + MGP 1:2	-

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