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AN EXPERIMENTAL STUDY OF INVESTMENT DECISIONS IN CARBON EMISSION TRADING SCHEMES: WHAT DETERMINES EFFICIENCY?

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Overview

- Motivation
- Related literature
- Our paper
- Experimental design
- Treatments
- Results and hypothesis
- Discussion and outlook

Motivation

- Emissions trading schemes (ETS) claim higher efficiency compared to other instruments like command and control. Policy makers take efficiency of ETS for granted.
- Uncertainty and irreversibility of investments is often neglected in economic models and firms are assumed to be risk neutral.
- Australia is introducing a Carbon Pollution Reduction Scheme which is different to the EU scheme e.g. annual permit vintages instead of commitment periods allow for future vintage trading
- Very little is know on how firms make investment decisions in emissions trading schemes.
- In this paper, we assess how companies make investment decision in and Emissions Trading Scheme facing price uncertainty and irreversibility of investment.

Related literature

- **Efficiency of ETS**: Montgomery (1972) formally demonstrate that under ideal conditions (e.g. no uncertainty and thus no risk-averse firms) efficiency of emissions trading schemes is independent of method of initial allocation
- Experiments show that **initial allocation** can have an impact on the efficiency of an emissions trading scheme: Efficiency is relatively lower in systems in which initial allocation is unbalanced and a high trading volume is necessary because firms with low reduction measures have a high number of permits allocated and vice versa. (Ehrhart et al., 2005).

Related literature

- **Closest to our paper: Risk aversion** of firms concomitant with **uncertainty** in a trading scheme may reduce efficiency when **permits are allocated for free** in a way which creates **net buyers and net sellers**:
  - This is shown in a theoretical model by Baldurson & von der Fehr (2004) which holds under certain conditions.
  - Ben-David et al. (2000) can not support the hypothesis experimentally, most likely the uncertainty manipulations in their experiment are too weak.
  - Forward markets can counteract but not eliminate the inefficiencies based on Baldurson & von der Fehr (2004).
- In theory a firm is risk neutral as it is owned by well-diversified stock holders. However, **risk aversion** of firms was empirically shown by Mehra & Prescott (1985) and small companies which are part of emissions trading schemes may as well be more risk averse since they have less access to capital markets.

Our hypothesis are….

In an emissions trading scheme in which permits are allocated for free, firms may be risk-averse and investment decisions are irreversible can lead to **inefficiencies** because of (hypothesis 1):

- Less emissions reductions by net sellers
- Increased emissions reductions by buyers
- A lower trading volume than in the competitive equilibrium
- Higher total emissions reduction costs in the system

Efficiency can be improved by a well functioning **vintage market** for permits for future years which reduces price uncertainty compared to a situation where no future vintage market exists (hypothesis 2).

Assessment of subject's risk attitude

- Based on Holt and Laury (2002) and adopted by Gangadharan and Nemes (2005) we assess risk attitude of subjects in a pre-experimental quiz
- Lottery game which set binary choices between games with different pay-off probabilities
- Lottery winnings are determined at the end of the experiment
- All our subjects were risk averse to a certain degree

Basic Design of the Trading Experiment (Ehrhart et al. 2005):

- Simulation of 8 periods (years)
- Participation of 8 subjects (in each group)
- Each subject represents a company which is characterized by:
  - Projected returns (without abatements and emissions trading),
  - Projected emissions (without abatements),
  - 3 different abatement measures (in terms of costs).
- At the beginning of each period, subjects have to decide on the activation of their abatement measures.
- The emissions target is tightened over time.
- Free allowances are allocated at the beginning of each period ("grandfathering").
- In every period there are two trading dates (One-shot uniform price double auctions).

Basic Design: Companies

- The projected emissions (without abatement) are the same for each company: 200 tonnes of CO_2 per period.
- Each company: 3 abatement measures
  Each measure: 30 tonnes emissions reduction per period
- An activated measure operates from its activation period until the last period.
- Companies differ with respect to two variables:
  - Number of allocated allowances
    - LA: low allocation (below average)
    - HA: high allocation (above average)
  - Costs of their abatement measures
    - LC: low-cost abatement measures
    - HC: high-cost abatement measures
- Experiments consists of:
  – Four companies with high allocation and low abatement cost (HA / LC)
  – Four companies with low allocation and high abatement cost (LA / HC)

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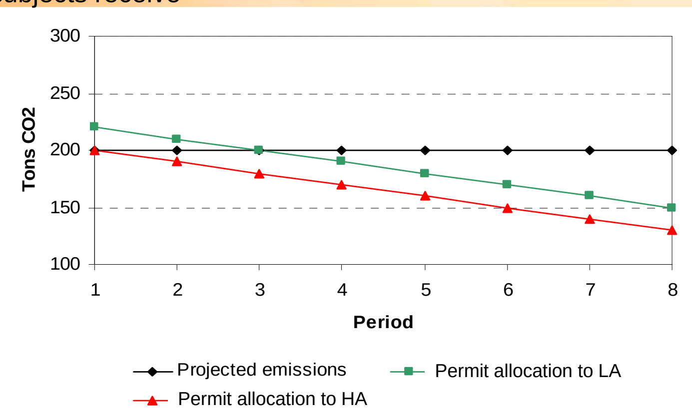
Basic Design: Allocation of Allowances

HA-subjects receive less allowances than LA-subjects and HA-subjects receive



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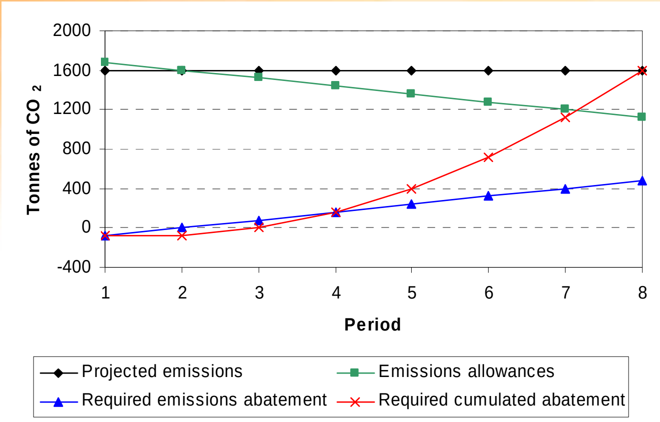
Basic Design: Global emissions and abatement



Projected emissions development, sum of allocated allowances and required abatement volume the same in all treatments

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Treatments

Spot market only	Spot market and future vintage trading
Treatment I 4 groups 8 companies	**Treatment II** 4 groups 8 companies

Futures market is simulated as spot trading in future vintages

Reference Solutions

- Optimum = cost minimal solution, i.e. the cap is reached by the cheapest measures.
  - Induces optimal prices and minimal trading volumes
  - Net buyers implement no reduction measures
  - Net sellers implement
- Command and control Benchmark (CCB) = situation without emissions trading and without banking

Result 1

- ***Under price uncertainty risk-averse sellers implement reduction measures never, or significantly later, than prescribed in the optimum. In contrast risk-averse buyers, who, in the optimum do not implement any measures do in fact implement reduction measures rather than rely upon the permit market.***

Hypothesis 1 is supported

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Table: Optimal implementation stage of a measure, and mean actual implementation stage (difference scores).

	Reduction measure	Difference mean implementation – optimum (in trading periods)[1]	P (1-sample t-test, 1-sided)
Net sellers	M1	2.13 (late)	<0.000
	M2	2.72	<0.00
	M3	-0.84[2]	<0.01
Net buyers	M1	-5 (early)	<0.0000
	M2	-0.81	<0.006
	M3	-0.38	>0.05

[1] Positive difference scores indicate a late implementation on average, negative scores premature implementation.
[2] This score is negative because M3 should NEVER be implemented according to the model

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Results 2 and 3

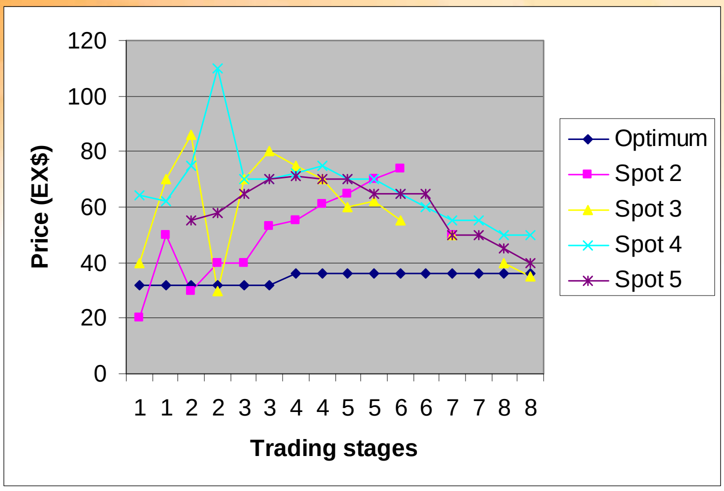
Price uncertainty leads to reduced efficiency of the market due to:

- ***lower trading volume***
- ***higher total reduction costs.***

Hypothesis 1 is supported

Treatment	Trading Volume [t CO2] Ø	Opt.	CCB	Total Reduction Costs [Ex$ per ton CO2] Ø	Opt.	CCB	Efficiency Indicator
Spot	**680**	**1,120**	**0**	**9,310**	**3,540**	**13,410**	**0.42**
s1	871	1,120	0	8,205	3,540	13,410	0.53
s2	736	1,120	0	8,175	3,540	13,410	0.53
s3	582	1,120	0	9,311	3,540	13,410	0.42
s4	529	1,120	0	11,550	3,540	13,410	0.19
Spot & Future vintages	**763**	**1,120**	**0**	**9,360**	**3,540**	**13,410**	**0.41**
f1	933	1,120	0	10,485	3,540	13,410	0.30
f2	392	1,120	0	8,850	3,540	13,410	0.46
f4	795	1,120	0	8,940	3,540	13,410	0.45
f5	932	1,120	0	9,165	3,540	13,410	0.43
Ehrhart et al.	**688**	**1,120**	**0**	**8,083**	**3,540**	**13,410**	**0.54**

Spot price development



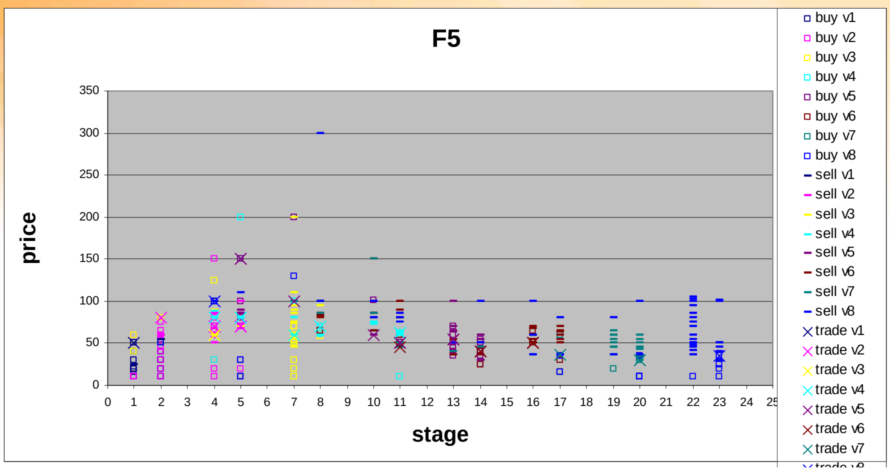
Result 4

- ***Future vintage trading does not improve the efficiency of the scheme.***
- Hypothesis 2 not supported!

Explanations:

- Future vintage trading did not function well
  - In early stages we observe more buying orders and in later stages more selling orders. Thus, net buyers were trying to buy in the early stages when there were not enough sellers. The net buyers experienced a lack of supply, lost confidence in the forward market and felt compelled to implement expensive measures in order to be compliant with the emissions targets.
  - Because there was no matching there were no future price signals which could have reduced price uncertainty

Vintage trading



Conclusions

Initial allocation which creates net buyers and net sellers may impact on market efficiency since:

- net buyers tend to over implement reduction measures (they need to buy and at the beginning prices were high)
- net sellers tend to implement measures too late and offer permits at high prices at the beginning

Future vintage trading may not function as well to be able to reduce these inefficiencies.

Assessment of a logit model to determine which factors influence investment decisions

Outlook: Will auctioning (everybody will be net buyer) improve efficiency?