Coase and Cap-and-Trade: Evidence on the Independence Property from the European Carbon Market

Aleksandar ZAKLAN
DIW Berlin

EUI FSR Climate Annual Conference 2021

November 29, 2021

Introduction

Motivation

- Cap-and-trade is an increasingly popular approach to mitigating pollution externalities
- EU ETS as a multinational cap-and-trade scheme blueprint for market-based climate policy worldwide
- Coase (1960); Montgomery (1972): Under certain conditions pollution outcomes are invariant to the allocation of property rights
- Independence property attractive for policy makers, as changes in allocation "only" have distributional implications
- Dependence between allocations and emissions indicates friction in the carbon market

Introduction

Research question and contribution

- Paper tests whether emissions are independent from allowance allocations for power producers regulated under the EU ETS
- Additional analysis on the response of trading and banking to changes in allocation
- Despite its importance, available evidence on the independence property is extremely scarce

Introduction

Empirical strategy

- Ideally, randomize allocations
- Matched difference-in-differences (DID) strategy using a panel of power producers from coal and gas during 2009-2017
- Exogenous variation in allocation levels due to a policy change (loss in free allocation + 10c rule)
- Main analysis focuses on a pooled sample, but I also explore heterogeneity by emitter size

Introduction

Literature

- Fowlie and Perloff (2013) exploit exogenous variation from allocation rule via IV strategy
- Reguant and Ellerman (2008) use short-term power production model exploiting variation in allocation formula
- Contributes to growing literature on ex-post evaluation of climate policy, e.g.
  - Bayer and Aklin (2020); Colmer et al. (2020) on internal effectiveness of EU ETS
  - Dechezleprêtre et al. (2021); Naegele and Zaklan (2019) on international effectiveness of EU ETS, i.e. carbon leakage
  - Abrell et al. (2019) on effectiveness of UK Carbon Price Support
  - Calel and Dechezleprêtre (2016); Calel (2020) analyze the EU ETS's impact on innovation

Introduction

Preview of main results

- Change in allocation policy does not affect emissions for power sector as a whole or for larger emitters ($\geq$ 25% in terms of firms' 2009 emission distribution)
  - Firms acquire additional permits, no change in banking patterns
- Independence property fails for small emitters ($<$ 25% of firms' emission distribution), they decrease emissions due to allocation policy change
  - No significant changes in acquisitions or banking
  - But: small emitters represent $<$ 1% of sector's aggregate emissions

Challenges to the Independence property

- Trading costs (e.g. Stavins, 1995; Baudry et al., 2021):
  - Baudry et al. (2021): Trading costs may be $\approx 0.50 - 1.50$ euro per allowance
  - Small emitters especially affected (Jaraitė et al., 2010; Heindl, 2017; Abrell et al., 2021)
- Behavioral bias
  - Venmans (2016): Belgian industrials under EU ETS invest more in abatement when allocation is below emissions than when it is above
  - Hortaçsu et al. (2019): In Texas power market small emitters are less sophisticated bidders

Allocation of allowances to power producers

- Power producers lost free allocation in 2013 (treatment group)
- 10c rule: some producers eligible for free allocation (control group)
  - If national electricity network poorly connected to the European grid or
  - if $>$ 30% of country's electricity from one fossil fuel and GDP p.c. $\leq$ 50% of EU level in 2006
  - Eligible: Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland and Romania
  - Of eligibles Latvia and Malta opted out of 10c
- Stated goal: producers shall undertake modernization measures in exchange for free allocation
- $\Rightarrow$ Valid control group despite strings attached to free allocation

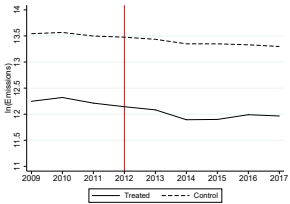
Data sources

- Data on emissions, trading and banking from EU Transaction Log (EUTL)
  - Sample period: 2009-2017
  - Balanced panel
  - Firm definition according to EUTL
- Data on the main fuel type of installations from Open Power System Data (OPSD)
  - Additional data from Global Energy Observatory and manual web search
- Country-level electricity market covariates and GDP from Eurostat
- Data on allowance and fuel prices from Bloomberg

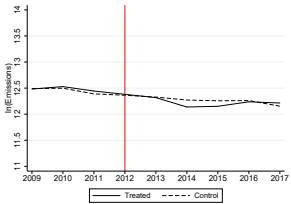
Descriptive overview

	Treatment group			Control group		
	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median
All firms						
Emissions (tons of CO2)	1,742,528	6,848,563	191,182	2,890,725	7,183,806	682,723
Net ext. acquisitions (no. allowances)	1,020,562	5,495,316	12,642	1,000,017	3,788,904	35,093
Bank (no. allowances)	590,500	2,363,338	53,781	1,377,606	4,663,946	216,823
No. firms (no. obs)	304 (2,736)			81 (729)		
Small emitters						
Emissions (tons of CO2)	13,795	11,453	10,293	105,150	67,940	91,114
Net ext. acquisitions (no. allowances)	1,364	13,430	0	15,079	54,629	0
Bank (no. allowances)	28,014	38,111	18,695	72,305	82,223	46,259
No. firms (no. obs)	76 (684)			20 (180)		
Non-small emitters						
Emissions (tons of CO2)	2,318,772	7,824,052	403,134	3,804,029	8,072,944	1,282,283
Net ext. acquisitions (no. allowances)	1,360,295	6,309,327	80,877	1,322,947	4,318,229	133,471
Bank (no. allowances)	777,995	2,703,126	121,967	1,805,573	5,305,845	403,389
No. firms (no. obs)	228 (2,052)			61 (549)		

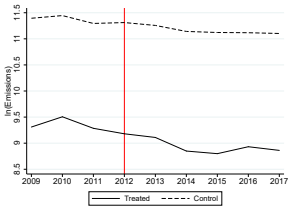
Parallel trends



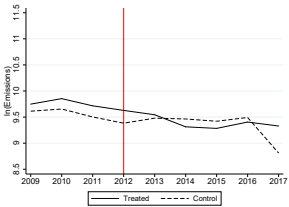
(a) All firms, unmatched



(b) All firms, matched



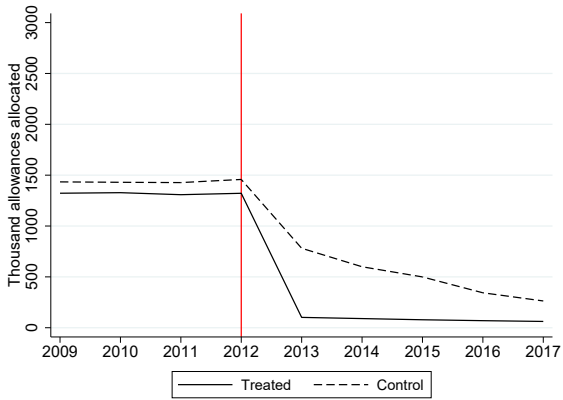
(c) Small emitters, unmatched



(d) Small emitters, matched

Firm level emissions, by emitter size and treatment status

Identification



Firm-level allowance allocations, by treatment status

Empirical model

- Two-way fixed effects DiD model:

$$y_{it} = \alpha_i + \lambda_t + \boldsymbol{\rho} D_{it} + X'_{ct}\beta + \epsilon_{it}$$

  - y_{it}: emissions (log), net external acquisitions (levels), bank inflow (levels)
  - ρ: average treatment effect on the treated (ATT)
  - X_{ct}: country-level covariates electricity consumption, RE produced, net power exports, GDP
  - α_i: producer fixed effects
  - λ_t: year fixed effects
  - Standard errors clustered at firm level
- Event study specification:

$$y_{it} = \alpha_i + \lambda_t + \sum_{j=-m}^{q} \rho_j D_{it,t=0+j} + X'_{ct}\beta + \epsilon_{it}$$

  - m (=4) pre-treatment periods, and q (=5) post-treatment periods

Effect of change in allocation on firm-level emissions

Baseline firm-level results

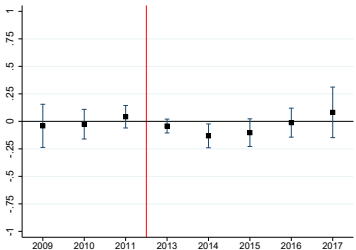
	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample			Matched sample		
1(Auctioning of allowances)	-0.095	-0.144	-0.140	-0.066	-0.056	-0.080
	(0.040)	(0.045)	(0.045)	(0.059)	(0.066)	(0.057)
Country-level controls	N	Y	Y	N	Y	Y
Global controls	N	N	Y	N	N	Y
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	N	Y	Y	N
F-test leads (p-value)	0.03	0.10	0.02	0.40	0.22	0.77
Obs	3,465	3,465	3,465	5,112	5,112	5,112
No. firms	385	385	385	352	352	352
R^2	0.984	0.985	0.984	0.984	0.984	0.984

Heterogeneous effects by emitter size

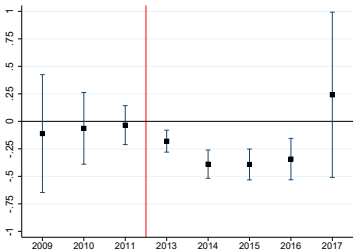
Small and non-small emitters, matched sample

	(1)	(2)	(3)	(4)	(5)	(6)
	Small emitters			Non-small emitters		
1(Auctioning of allowances)	-0.156	-0.192	-0.206	-0.052	-0.042	-0.059
	(0.104)	(0.097)	(0.072)	(0.042)	(0.043)	(0.042)
Country-level controls	N	Y	Y	N	Y	Y
Global controls	N	N	Y	N	N	Y
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	N	Y	Y	N
F-test leads (p-value)	0.46	0.98	0.01	0.69	0.84	0.88
Obs	1,044	1,044	1,044	2,772	2,772	2,772
No. firms	62	62	62	203	203	203
R^2	0.829	0.833	0.821	0.966	0.967	0.966

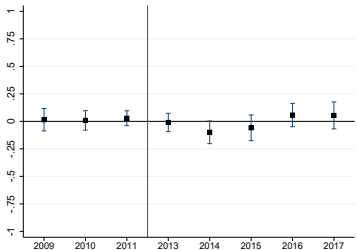
Dynamics



(a) All firms



(b) Small emitters



(c) Non-small emitters

Treatment effect dynamics by emitter size, matched samples

Trading

Net external acquisitions, matched sample

	(1)	(2)	(3)	(4)	(5)	(6)
	All firms		Small emitters		Non-small emitters	
1(Auctioning of allowances)	264.246	381.013	-3.963	-0.815	528.280	812.788
	(178.397)	(167.366)	(5.990)	(4.962)	(294.315)	(278.104)
Country-level controls	N	Y	N	Y	N	Y
Global controls	N	N	N	N	N	N
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
F-test leads (p-value)	0.51	0.87	0.03	0.13	0.62	0.60
Obs	5,112	5,112	1,044	1,044	2,772	2,772
No. firms	352	352	62	62	203	203
R^2	0.652	0.655	0.340	0.363	0.640	0.645

Banking

Annual banking flows, matched sample

	(1)	(2)	(3)	(4)	(5)	(6)
	All firms		Small emitters		Non-small emitters	
1(Auctioning of allowances)	63.935	23.885	-2.203	-0.914	114.004	103.207
	(39.514)	(50.601)	(1.894)	(2.143)	(71.774)	(92.987)
Country-level controls	N	Y	N	Y	N	Y
Global controls	N	N	N	N	N	N
Firm FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
F-test leads (p-value)	0.14	0.20	0.08	0.11	0.18	0.18
Obs	5,112	5,112	1,044	1,044	2,772	2,772
No. firms	352	352	62	62	203	203
R^2	0.171	0.173	0.224	0.230	0.221	0.223

Conclusions

- I fail to reject independence between allocations and emissions for the power sector overall and for the 75% of firms representing more than 99% of emissions
- Suggestive evidence that the independence property fails for small emitters
- Larger emitters compensate for the loss in allocation mainly through external allowance acquisitions, smaller ones rely more on internal abatement
- Small emitters may be unable to fully absorb trading costs or exhibit behavioral patterns leading to an increased focus on abatement

Thank you for your attention!

Aleksandar Zaklan
azaklan@diw.de

References I

Abrell J., Cludius J., Lehmann S., Schleich J., and Betz R. (2021) Corporate Emissions-Trading Behaviour During the First Decade of the EU ETS. *Environmental and Resource Economics*: 1–37.

Abrell J., Kosch M., and Rausch S. (2019) How Effective Was the UK Carbon Tax?-A Machine Learning Approach to Policy Evaluation. *CER-ETH–Center of Economic Research at ETH Zurich Working Paper*, 19: 317.

Baudry M., Faure A., and Quemin S. (2021) Emissions Trading with Transaction Costs. *Journal of Environmental Economics and Management*, 108: 102468.

Bayer P. and Aklin M. (2020) The European Union Emissions Trading System Reduced CO2 Emissions Despite Low Prices. *Proceedings of the National Academy of Sciences*, 117(16): 8804–8812.

Calel R. (2020) Adopt or Innovate: Understanding Technological Responses to Cap-and-Trade. *American Economic Journal: Economic Policy*, 12(3): 170–201.

Calel R. and Dechezleprêtre A. (2016) Environmental Policy and Directed Technological Change: Evidence from the European Carbon Market. *Review of Economics and Statistics*, 98(1): 173–191.

Coase R. H. (1960) The Problem of Social Cost. *The Journal of Law and Economics*, 3: 1–44.

References II

Colmer J., Martin R., Muûls M., Wagner U. J. et al. (2020) Does Pricing Carbon Mitigate Climate Change? Firm-Level Evidence from the European Union Emissions Trading Scheme. *Firm-Level Evidence from the European Union Emissions Trading Scheme (November 5, 2020)*.

Dechezleprêtre A., Gennaioli C., Martin R., Muûls M., and Stoerk T. (2021) Searching for Carbon Leaks in Multinational Companies. *LSE Grantham Research Institute on Climate Change and the Environment Working Paper No. 165*.

Fowlie M. and Perloff J. M. (2013) Distributing Pollution Rights in Cap-and-Trade Programs: Are Outcomes Independent of Allocation? *Review of Economics and Statistics*, 95(5): 1640–1652.

Heindl P. (2017) The Impact of Administrative Transaction Costs in the EU Emissions Trading System. *Climate Policy*, 17(3): 314–329.

Hortaçsu A., Luco F., Puller S. L., and Zhu D. (2019) Does Strategic Ability Affect Efficiency? Evidence from Electricity Markets. *American Economic Review*, 109(12): 4302–42.

IEA (2019) World Energy Investment 2019. *International Energy Agency (IEA), Paris, https://www.iea.org/reports/world-energy-investment-2019*.

References III

Jaraitė J., Convery F., and Di Maria C. (2010) Transaction Costs for Firms in the EU ETS: Lessons from Ireland. *Climate Policy*, 10(2): 190–215.

Montgomery W. D. (1972) Markets in Licenses and Efficient Pollution Control Programs. *Journal of Economic Theory*, 5(3): 395–418.

Naegele H. and Zaklan A. (2019) Does the EU ETS cause carbon leakage in European manufacturing? *Journal of Environmental Economics and Management*, 93: 125–147.

Reguant M. and Ellerman A. D. (2008) Grandfathering and the Endowment Effect: An Assessment in the Context of the Spanish National Allocation Plan. *Center for Energy and Environmental Policy Research, Cambridge, Massachusetts*.

Stavins R. N. (1995) Transaction Costs and Tradeable Permits. *Journal of Environmental Economics and Management*, 29(2): 133–148.

Venmans F. M. J. (2016) The Effect of Allocation Above Emissions and Price Uncertainty on Abatement Investments under the EU ETS. *Journal of Cleaner Production*, 126: 595–606.