Emissions markets as financial markets

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Based on joint research with Aurélie Slechten, Lancaster University

Foundations for emissions markets

Foundations for emissions market rely on the idea that equilibrium prices reflect **market fundamentals**:

- Elements of the economic environment that impact the abatement costs and emissions of compliance traders
- Rules that determine the supply of allowances at any point in time
- Formal market rules that constrain or enable compliance traders to optimize their abatement efforts

Such prices produce **constrained static and dynamic allocative efficiency** (corollary of First Welfare Theorem)

- Constrained because of uncertainty (Schennach, 2000) or limits on borrowing (Rubin, 1996)

A finance perspective on emissions markets

In practice, there are frictions that prevent prices to reflect market fundamentals:

- Some already identified in the literature: transaction costs (e.g. Jaraité-Kažukauské and Kažukauskas, 2015, Baudry et al., 2021), market power (Malueg and Yates, 2009), behavioral limitations (Quemin and Trotignon, 2021)
- **Focus of this talk**: frictions identified in the finance literature including asymmetric information, market fragmentation, risk management constraints, and cross-market spillovers

Why do we care ?

- Positive perspective: these frictions impact prices (price forecasting) and limit the ability of emissions markets to meet their stated goals
- Normative perspective: some of them can be remedied

A benchmark model of price formation (based on Cantillon and Slechten, 2018)

A benchmark model of price formation

Time is discrete and bounded, $t = 1, \ldots, T$ (no discounting)

N compliance traders (N large), each characterized by

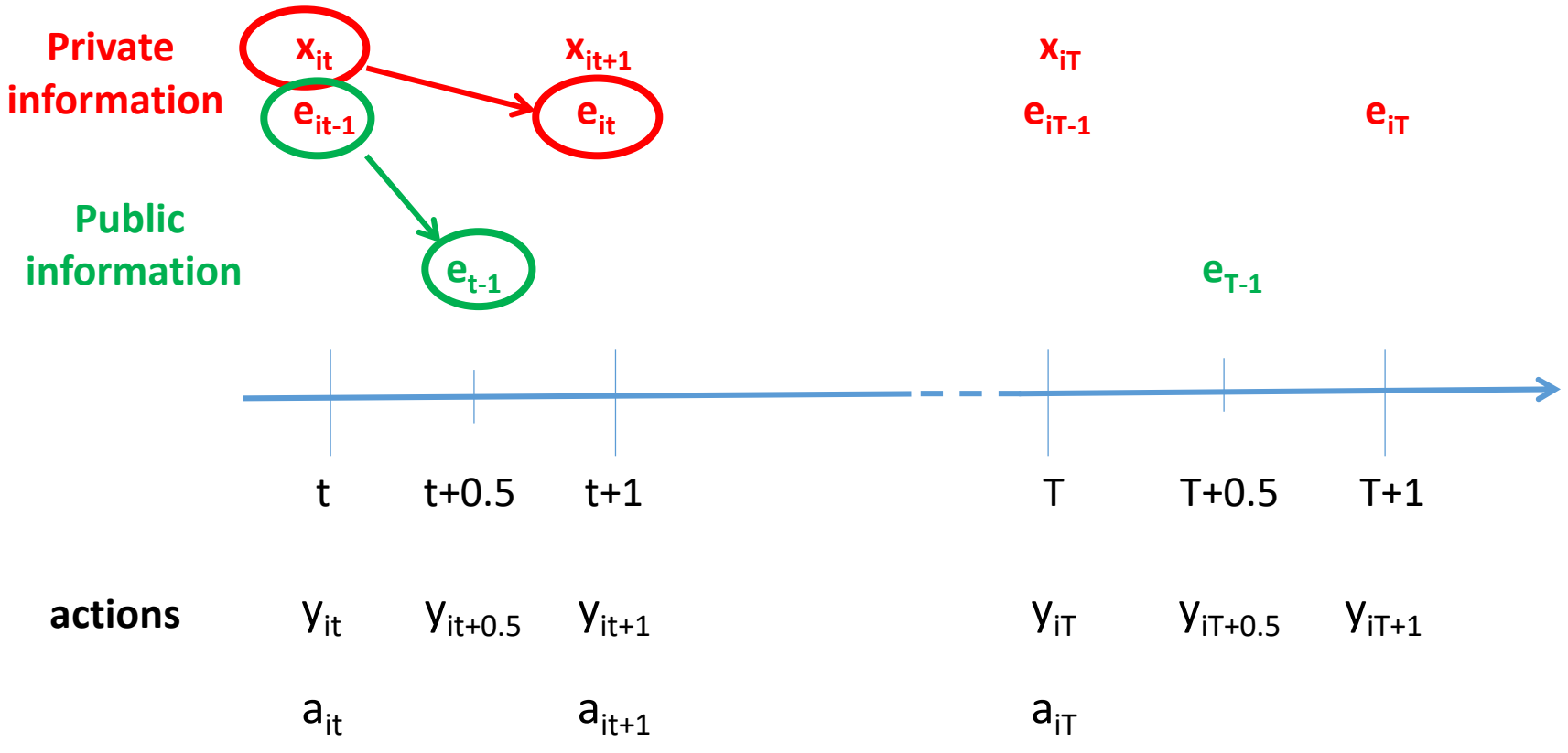
- an (instantaneous) abatement technology θ_i, at cost $c(a_{it}, \theta_i)$
- its BAU emissions $e_{it} \sim N(\mu_t, \sigma^2)$

Compliance traders must surrender allowances to cover their emissions (penalty K), minimize their total cost of compliance

Each period is divided into 2 subperiods

- In subperiod 1: learns about period t-1 **own** emissions (e_{it-1}) and gets a **noisy signal** about period t **own** emissions $x_{it} = e_{it} + \varepsilon_{it}$, decides how much to abate
- In subperiod 2: **public signal** about aggregate past emissions $\sum_i e_{it-1}$
- Trading happens in all subperiods (price equates supply and demand)

Timing of information and actions



BAU emissions:

$$e_{it} \sim N(\mu_t, \sigma^2)$$

Abatement costs:

$$\frac{1}{2}\theta_i a_i^2$$

Noisy signal at time t

$$x_{it} = e_{it} + \varepsilon_{it}$$

No borrowing constraint

Omniscient social planner equilibrium

- Define $Z_t = \sum_{k=0}^{t} e_k - \sum_{k=0}^{t} a_k$, excess emissions at time t
- With normal shocks to emissions, if the number of compliance traders is large enough, then $Z_T|I_t$ is approximately normally distributed where I_t represents all info available at time t

$$Z_T|I_t \sim N(E[Z_T|I_t], V[Z_T|I_t])$$

$$p_t = K \text{ proba}(Z_T > 0)$$

$$p_t = K\left[1 - \Phi\left(\frac{-E[Z_T|I_t]}{V(Z_T|I_t]}\right)\right]$$

Price which reflects market fundamentals

Can the omniscient social planner be implemented as a decentralized eqm ?

Can participants infer a sufficient statistic from prices ?

Yes, under some conditions:

1. Own emissions is the only source of private information
2. Full participation
3. Market is fully integrated (single price)
4. Participants only care about minimizing costs of compliance

This is a special case of the strong form of the **Efficient Market Hypothesis.**

Property of equilibrium prices in the benchmark model

- Prices are martingales: the best predictor of tomorrow's price is today's price
- Price movements follow the arrival of new information, namely:
  - The extent to which past realized emissions differ from the expectation the market had, $E[e_{t-1}|x_{t-1}]$
  - The extent to which prediction about current period emissions (based on the noisy signal) differ from $N\mu_t$
  - Importantly, prices do not react to the publication of past aggregate emissions
- Extent of reaction depends on the number of periods remaining, reliability of information, curvature of abatement costs
- The possibility of abatement dampens emissions shocks
- Prices eventualy converge to K or 0

Failure of information aggregation

Information aggregation and thus the ability of prices to reflect market fundamentals break down when:

- abatement technology is also private information
- not all compliance traders participate
- allowances are traded in several venues and the law of one price fails
- Market participants trade-off compliance cost minimization with other goals or are impacted by what is happening in other markets

In these cases, public sources of information can help and market will react to public information (ample evidence for this)

Agenda for the rest of the talk: provide suggestive evidence for these frictions

1. Partial participation and price formation

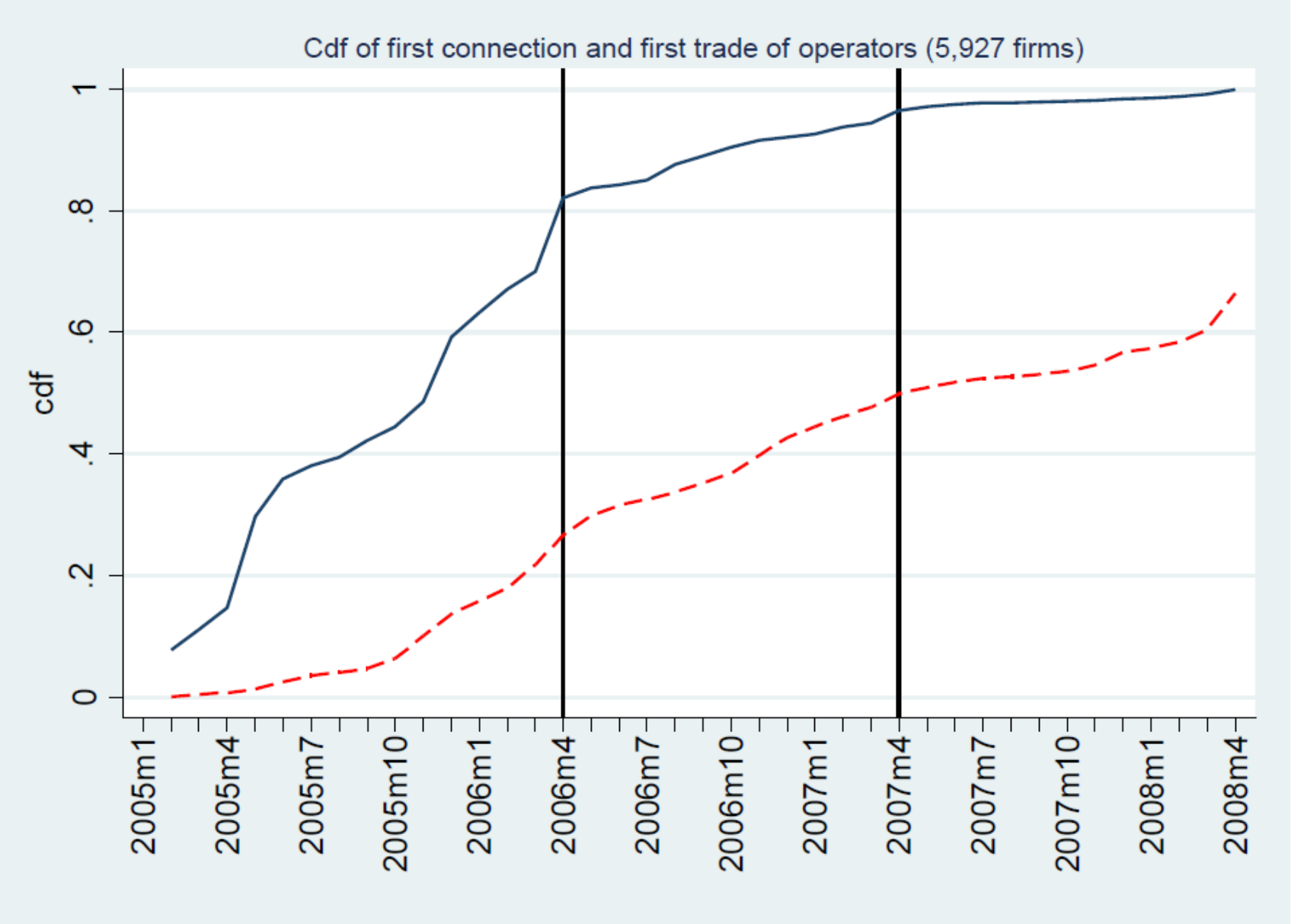
Partial participation in the EU ETS

- Partial participation in the EU ETS has been extensively documented

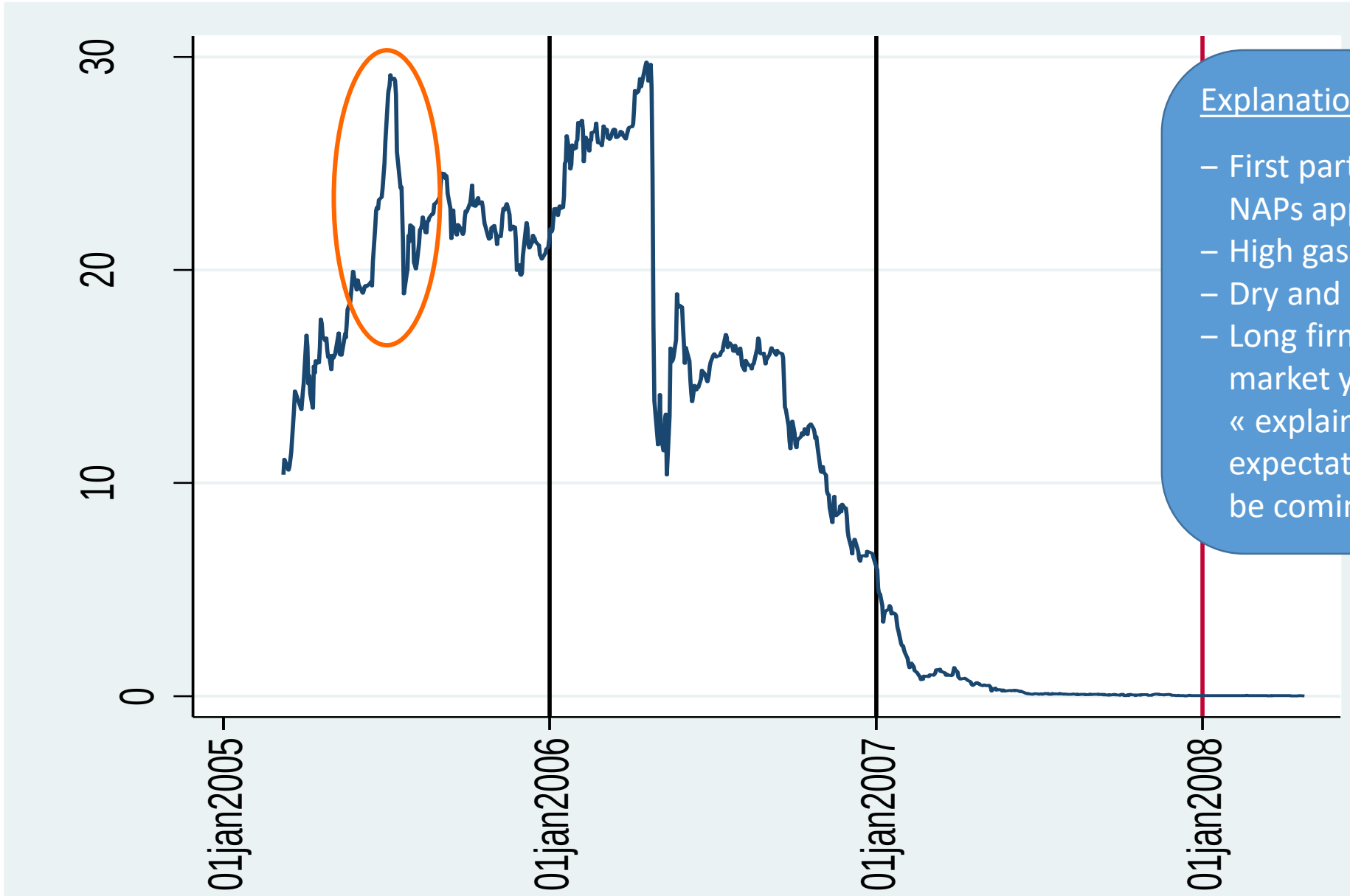
- Reasons for partial partial participation:
  - [in phase I] delays in setting up registries
  - [mainly in phase I] generous allocation of allowances
  - Overlapping compliance periods
  - Transaction costs

- Partial participation and information aggregation ? Clearly, market can’t integrate information of non participants

Partial participation in phase I



Partial participation and price formation

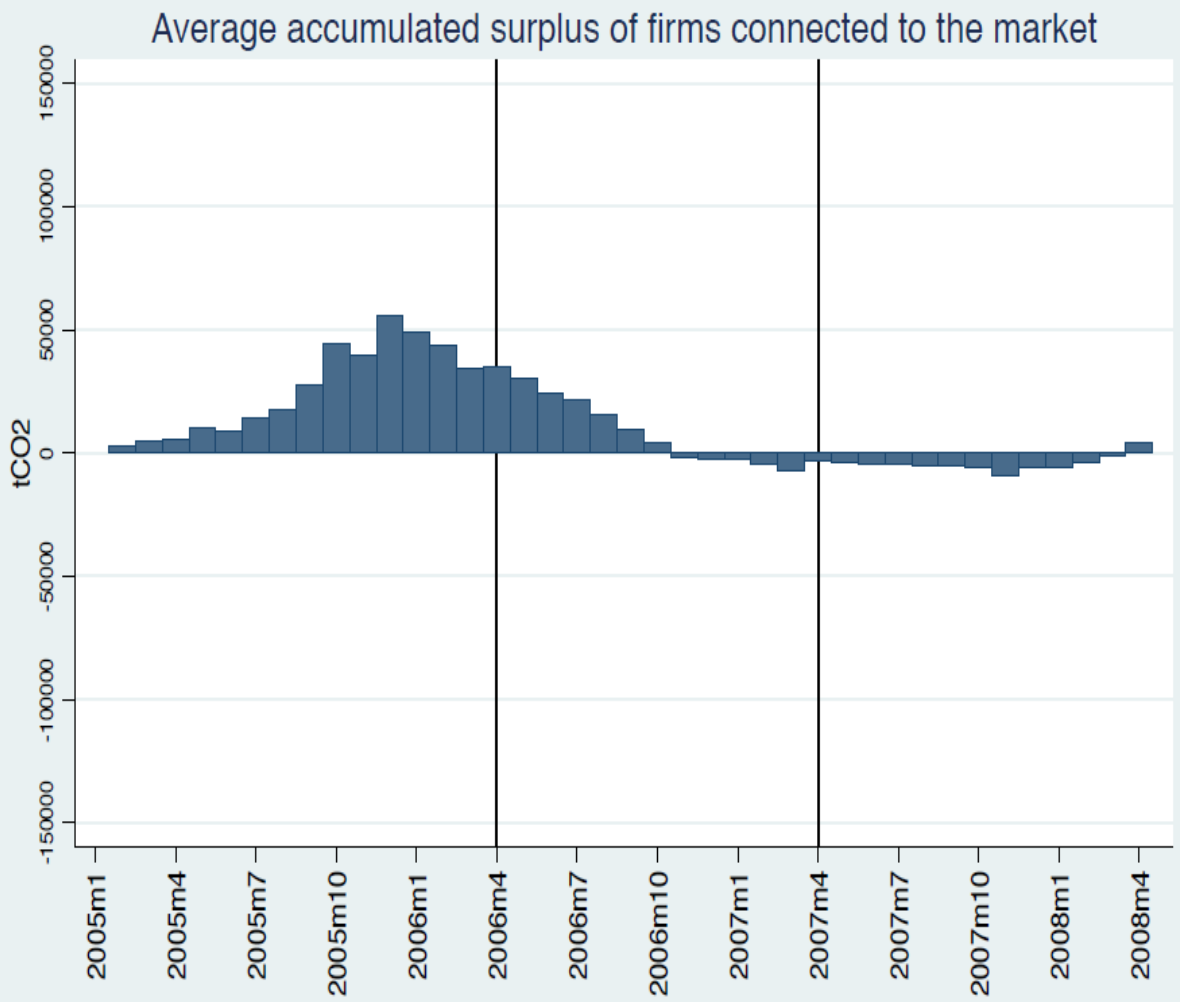


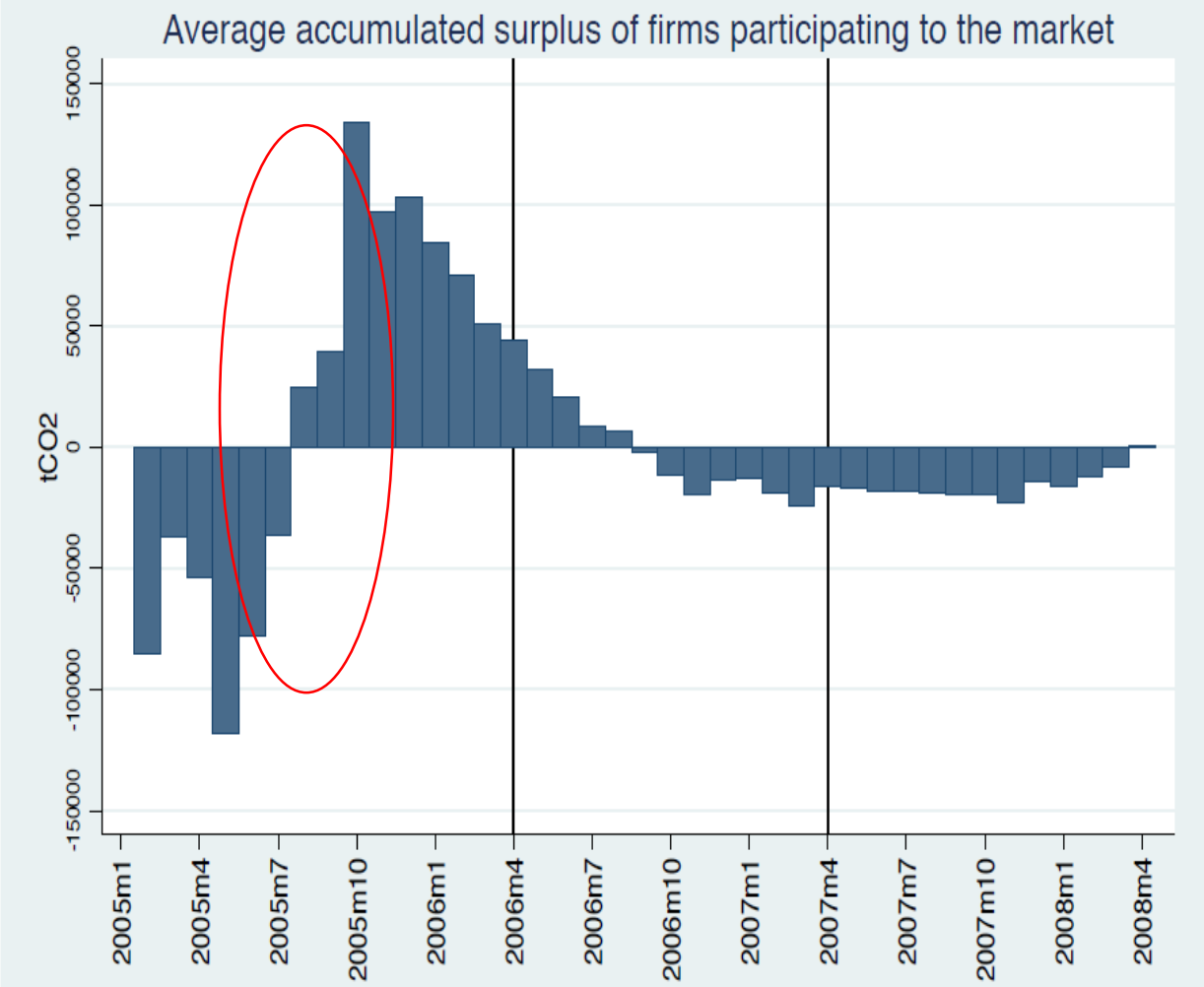
Source: EEX until June 2005 and Bluenext afterwards

Explanations for « bubble »:

- First part of 05: several NAPs approved with cuts
- High gas prices
- Dry and hot summer
- Long firms not in the market yet (drop « explained » by expectations that they'll be coming soon)

Partial participation (evidence from phase I)





Accumulated surplus of firm i at time t = $\sum_0^t allocation_{ik} - \sum_0^t surrender_{ik} + \sum_{k=0}^t y_{ik}$

2. Market fragmentation and price formation

Price formation in fragmented markets

Benchmark model had a centralized market. Information aggregation is more challenging in fragmented markets.

Work in finance by D. Duffie, P. Kondor, M Rostek and coauthors

- **OTC markets**: modelled as search models (no structure on interactions) or networks (structure about who meets whom)
- **Competing exchange venues**, where some traders may be in a position to arbitrage among them

Common failure of the law of one price unless markets « sufficiently connected »: role of information dissemination and market infrastructure

Challenges for information aggregation in the EU ETS

The EU ETS is a highly fragmented market (up to 12 exchanges at some point + OTC)

This adds to other structural factors making information aggregation challenging in phase I

- High level of uncertainty about BAU emissions and scope for abatement due to scope of scheme (sectors, countries) and lack of historical data
- Short planning timeline and delays in implementation
- In phase II, willingness to leverage flexible mechanisms of the Kyoto protocol (a design decision)

Market fragmentation in phase I – evidence from the EU transaction log

	Venue	*Total*	*Percent*
Exchange (spot)	Bluenext	10,268	26.44
	ECX	337	0.87
	EEX	550	1.42
	EXAA	188	0.48
	GME	59	0.15
	Nordpool	991	2.55
OTC	OTC	26,302	67.72
	OTCBluenext	52	0.13
	OTCNordpool	95	0.24
	Total	**38,842**	**100**

31.87%

Role of financial intermediaries

Fraction of transactions (phase I, accounts aggregated at the ownership level)

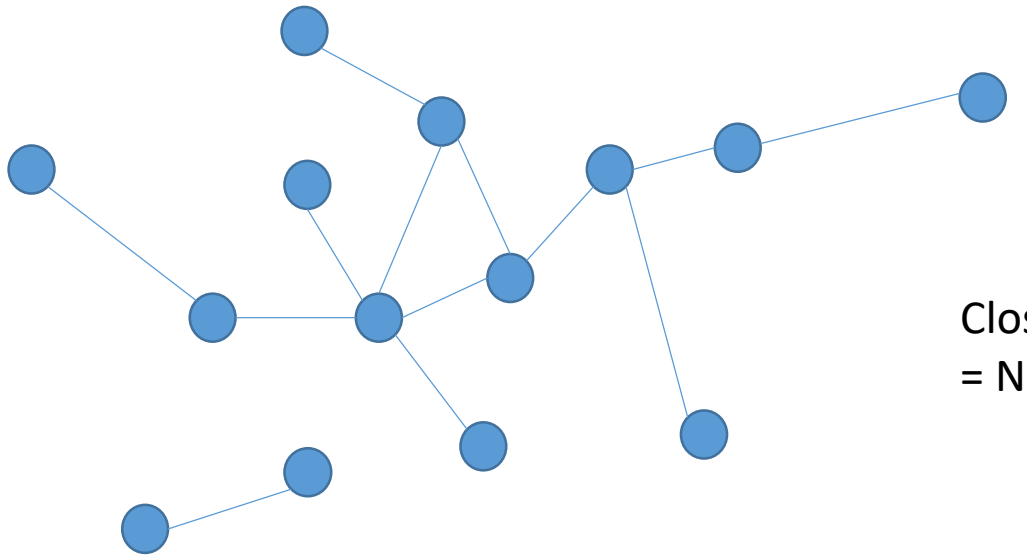
Buyer is \ Seller is	Exchange	Financial intermediary	Operator	Other
Exchange	0.0%	9.0%	4.4%	2.2%
Financial intermediary	6.3%	6.4%	20.7%	2.6%
Operator	6.3%	8.3%	17.6%	3.8%
Other	3.0%	2.6%	6.0%	1.0%

Financial intermediaries brought sellers to market

(see related evidence by Martino and Trotignon, 2013, Borghesi and Flori, 2018Cludius and Betz, 2020)

Market integration or market fragmentation ?

- A decentralized market may still be integrated if traders have access to prices on different venues and channels
- Use transactions and network theory to measure market integration: Every firm is a node and two nodes are connected if they traded at any point in time during phase I.



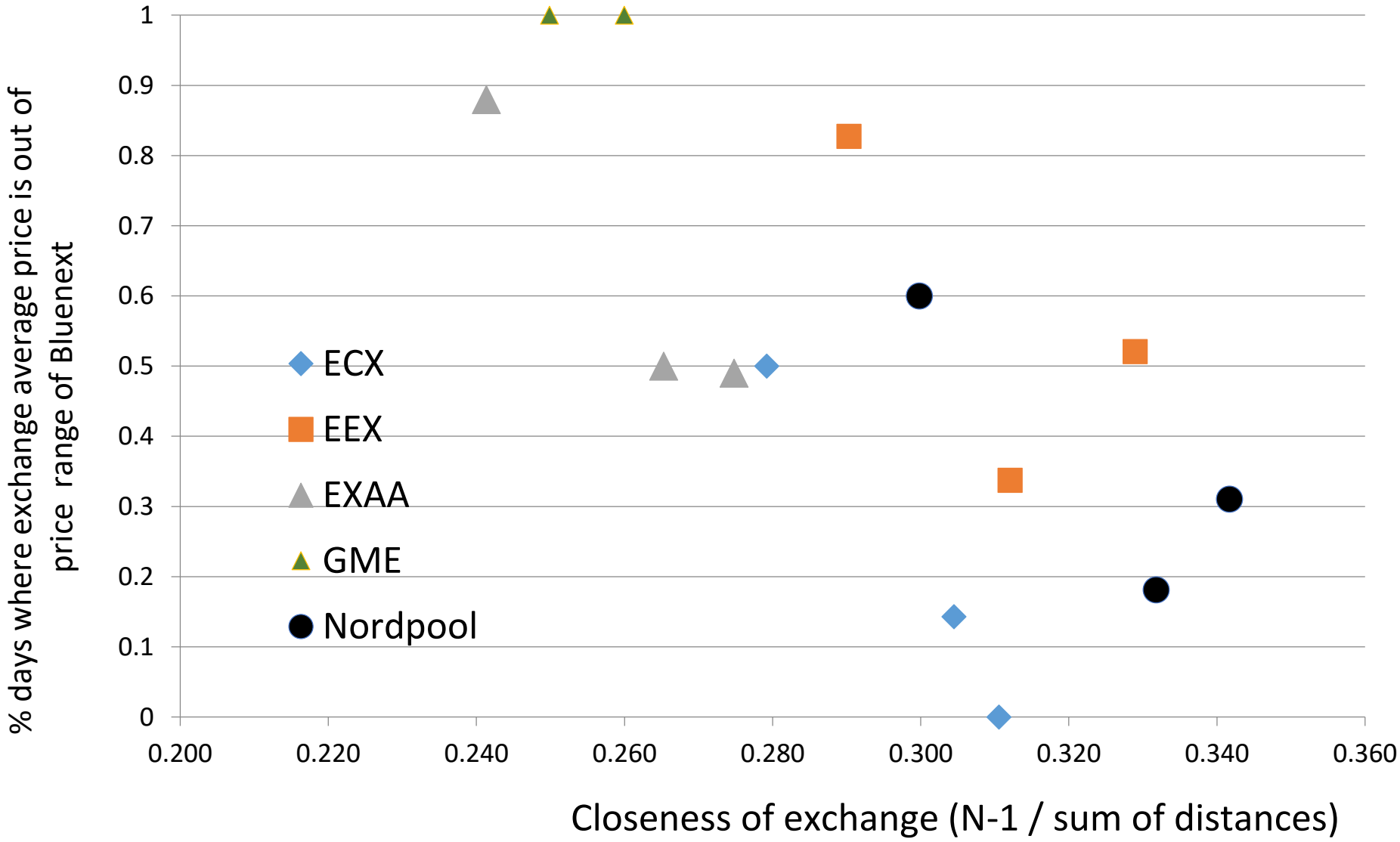
Closeness of a node
= N-1 / (sum of distances to the other N-1 nodes)

Market integration or market fragmentation: Results

- **Large connected network** of size 4,116, 16 networks ranging from size 3 to size 7 and 89 connected pairs (the remaining firms did not trade at all during phase I). Smaller networks are either geographically specialized or sector-specific
- All exchanges and most financial intermediaries belong to the large network, even if we take a shorter time window.
- Most exchanges are located at a short distance of one another and all of them are at distance 2 from Bluenext, meaning that, for each exchange, there is at least one firm that sent orders both to that exchange and to Bluenext. Firms that trade on multiple exchanges can arbitrage and therefore contribute to price discovery.

→ Exchanges and financial intermediaries likely to play a central role for price discovery

Market fragmentation and the failure of the law of one price in the EU ETS



A direct consequence of the failure of the law of one price is that prices will deviate from fundamentals

Note: Each observation corresponds to a year

3. Risk management constraints and price over-reaction

Understanding price over-reaction in the EU ETS

- According to the benchmark model, when prices reflect market fundamentals:
  - Shifting allocations within a phase should not have an impact on prices unless the market-level borrowing constraint binds (but this has never been the case)
  - The impact of short-term shocks should be spread out over remaining compliance periods

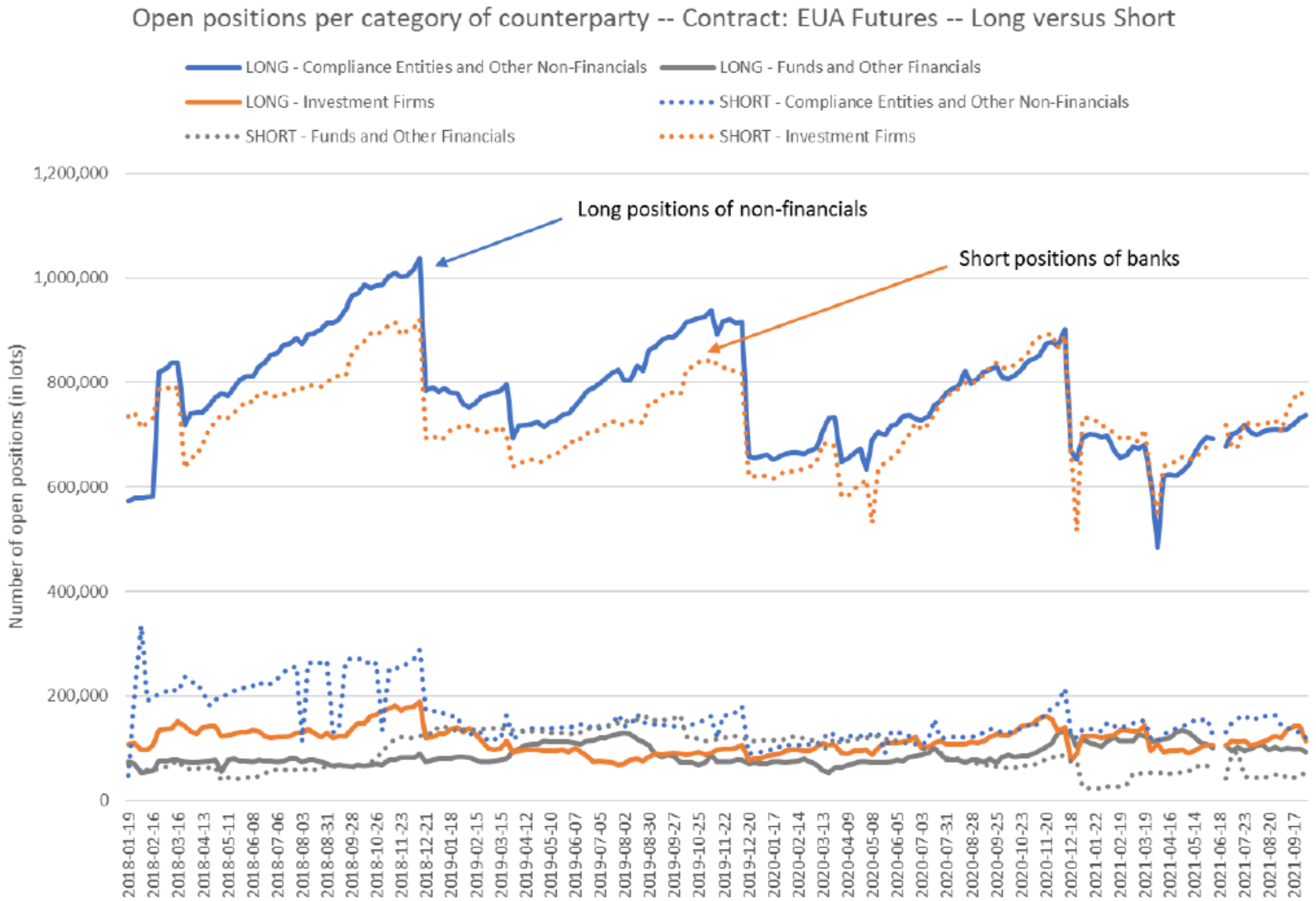
- This is not what we see

Risk management constraints

- Even though firms were allowed to borrow from their own future allowances to cover current emissions, interviews and hedging data suggest many sought to cover their emissions as they accrued
  - Buy (spot) allowances
  - Buy futures

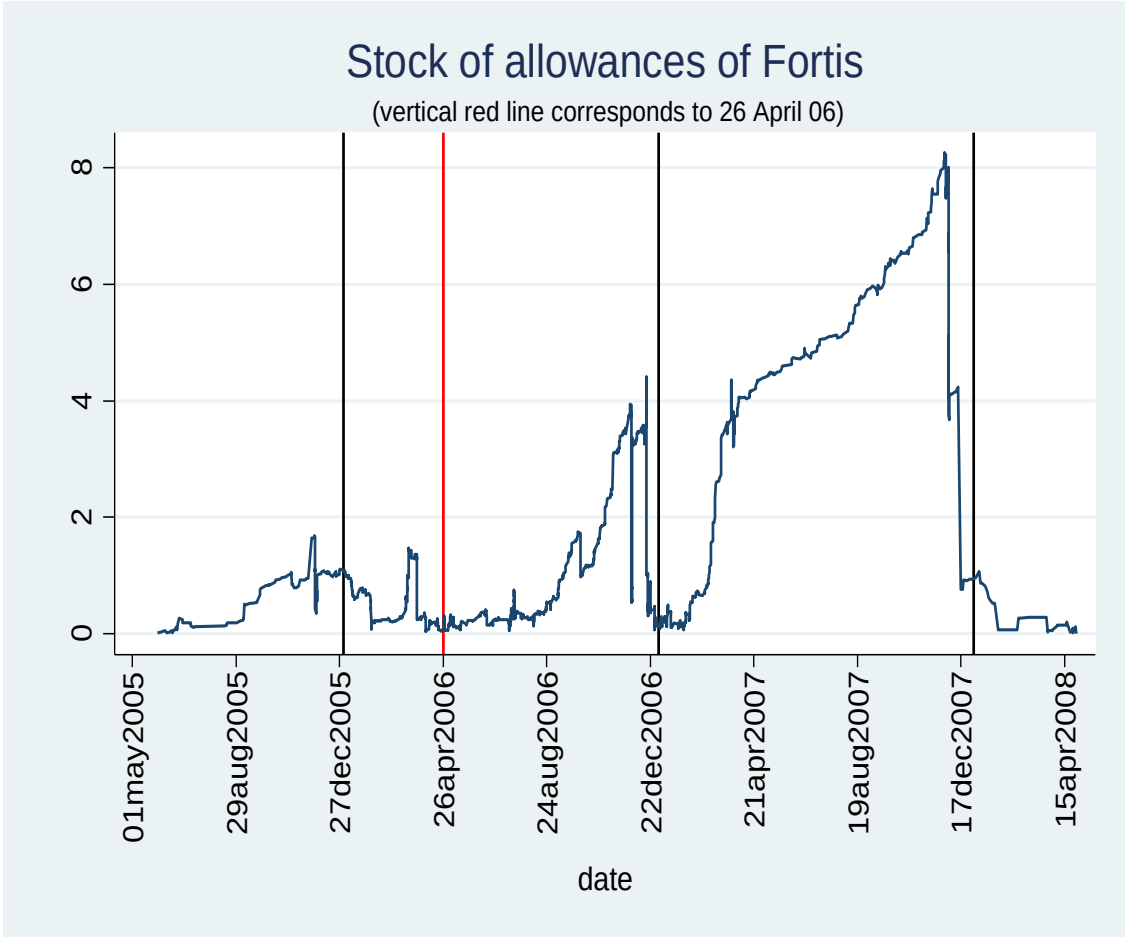
- **Financial intermediaries** typically stood on the sell side of these futures (Cludius and Betz, 2020) and were themselves subject to risk management constraints to cover their positions

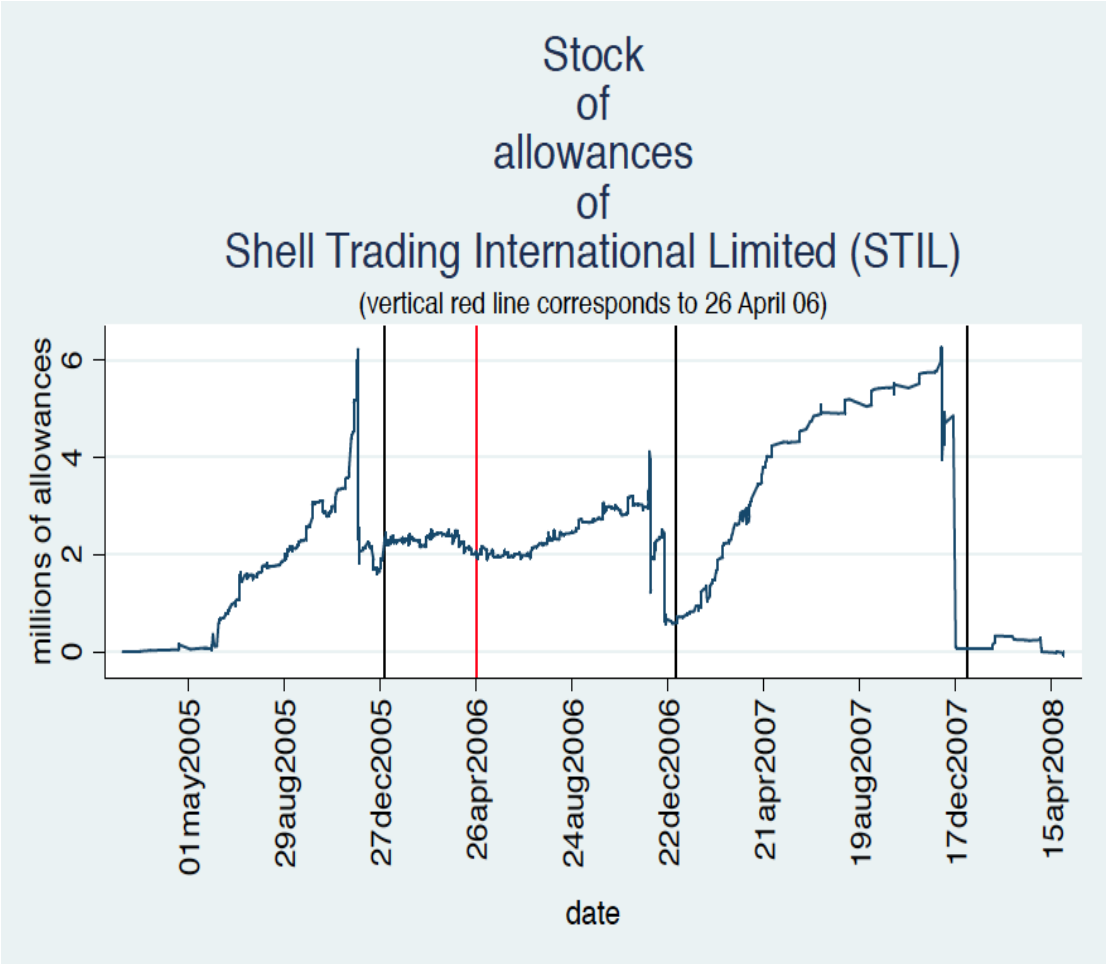
Role of financial intermediaries as a counterparty



Source ESMA (2021), p. 37 (based on ICE and EEX weekly possition reports)

Evidence for risk management constraints faced by financial intermediaries (spot market)





Risk management constraints and price over-reaction

- Risk management constraints introduce an endogenous borrowing constraint on the market
  - Financial intermediaries provide a buffer but do not fully eliminate these risk management constraints
- This leads prices to deviate from market fundamentals and over-react to availability of EUAs

4. Cross-market spillovers

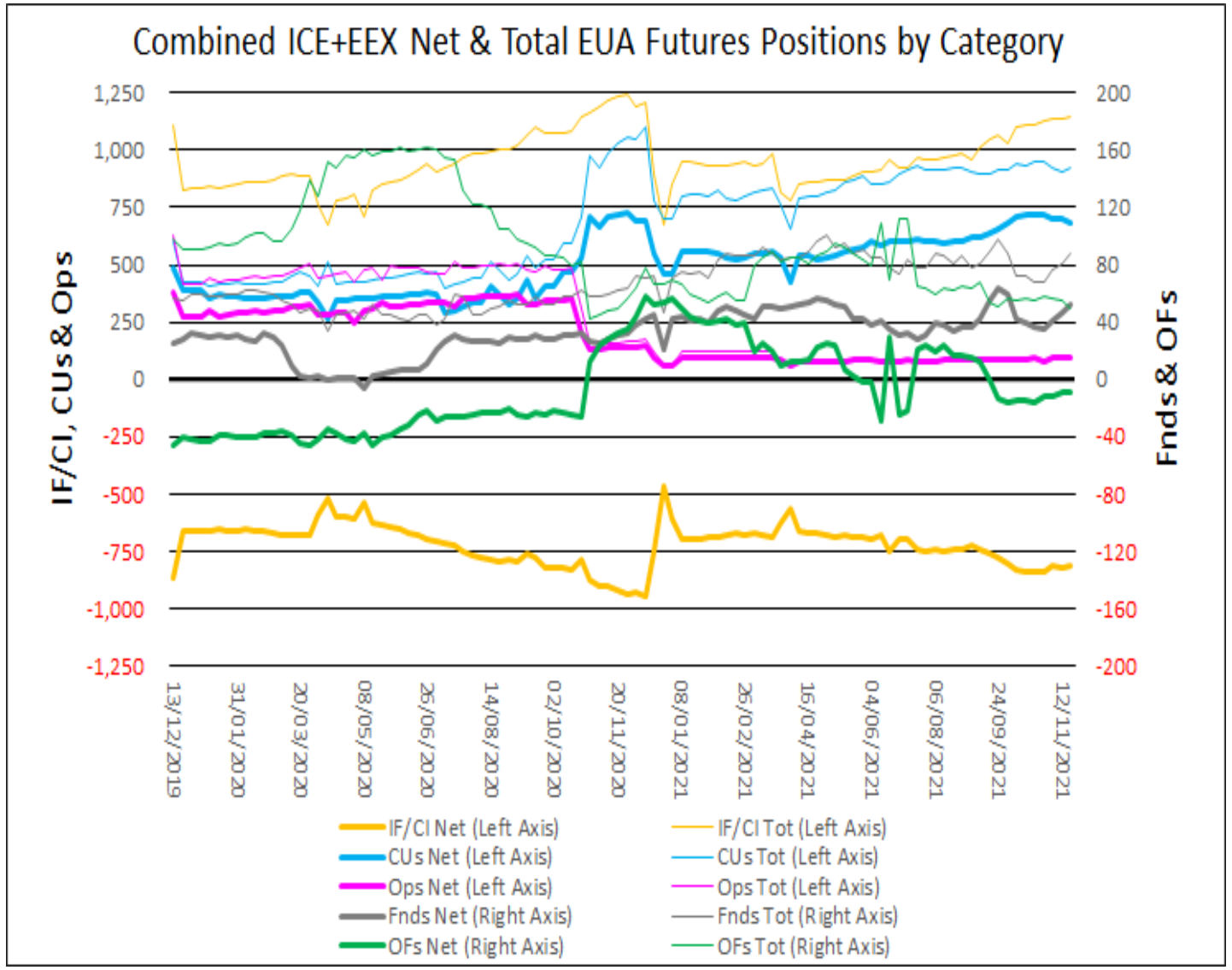
Cross-market spillovers

- Emissions markets attract other participants than compliance traders
  - financial intermediaries
  - Speculators, hedgers, pension funds

- Participation (nb of market participants) in carbon market has almost doubled since 2018 (ESMA, 2021)

- Participation by non-compliance traders brings liquidity but
  - Induces **excess volatility** relative to market fundamentals because of spillover effects from shocks in other markets (Ing-Haw and Xiong, 2014, Sockin and Xiong, 2015)
  - makes information aggregation more challenging (can be seen as noise traders)

Market participants in EUA futures – positions



Source: https://carbon-pulse.com/144981/

Commitment of Traders (ICE+EEX), in Mt CO2

- Investment funds (Fnds): Entities holding investments directly in the commodity derivatives market as a form of collective investment scheme
- **Investment firms or credit institutions (IF/CI)**
- Other financials (OFs): Firms not falling within any of the other categories.
- **Commercial undertakings (CUs): Non-financial entities** using the market to hedge their positions
- **Compliance traders** (Ops)

Table & chart abbreviations:
TotL – Total Longs | TotS – Total Shorts | TotP – Total Positions
WCh – Weekly Change (in absolute terms) | %Ch – Weekly % Change | NetP – Net Positions | L/S – Long/Short Ratio
%OIL – % of Total Long Open Interest | %OIS – % of Total Short OI | %OIT – % of Total OI #F – # of Reporting Firms | %TotF – % of Total Reporting Firms

Summary and implications

Summary

- Finance lens on emissions market brings up new questions, mostly centered around informational frictions
- We have identified a number of factors that prevent prices of emissions allowances to fully reflect market fundamentals
  - Private information about abatement opportunities
  - Partial participation
  - Market fragmentation
  - Risk management constraints
  - Cross-market spillovers
- These factors are likely to distort prices away from market fundamentals and make them more volatile, reducing allocative efficiency

Final comments and implications

- Quantifying the exact impact of these frictions on allocative efficiency requires information on transaction prices, or in their absence, simulations of calibrated models with and without frictions
  - Work in progress
- Quantifying these costs is important to have a full picture of the practical costs and benefits of economic instruments and explore remedies:
  - Market transparency measures
  - Measures to increase participation
  - Staggered or higher frequency compliance

Extra slides

Description of phase I dataset

Trader dataset

- All active accounts in phase I (11,594 accounts)
- Aggregation at the firm-level (7,387 unique firms)
  - 6,407 operators
  - 11 exchanges (6 real exchanges + network of brokers)
  - 39 financial intermediaries
  - 930 others

Transaction dataset

- All spot transactions on phase I allowances
  - Drop initial allocations and remittances (58%) and intra-firm transactions (9%)
- Transactions matched to a price using exchange tick data (30%) and/or OTC price index
- Final dataset 38,842 transactions

Current (2021) market organisation for EUA allowances

	Primary market	Secondary markets
EEX	*Spot auctions of:* EUA EUAA	Daily futures on EUA and EUAA Monthly, quarterly and yearly futures on EUA Yearly futures on EUAA Options on EUA Futures
ICE Endex	NA	Daily futures on EUA Monthly and quarterly futures on EUA Monthly and quarterly futures on EUAA Options on EUA Futures
Nasdaq Oslo	N/A	Daily futures on EUA Quarterly and yearly futures on EUA

Table 1: Carbon markets offering at EU trading venues

Source: ESMA (2021)