

Firm Trading Behaviour and Transaction Costs in the EU's Emission Trading System

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Motivation

- In theory the EU ETS as with any other emissions-trading programme, should be **cost-effective** (Montgomery, 1972).
- Cost-effectiveness is obtained by allowing full transferability of emissions permits.
- Whether or not this cost-effective outcome is achieved in practice depends on **how efficiently markets operate**.
- One source of friction in these markets might be **trading transaction costs.**

Taxonomy

- **Trading transaction costs** are the costs, other than price, incurred in the process of exchanging goods and services.
- These include the costs of researching the market, finding buyers or sellers, negotiating and enforcing contracts for permit transfers etc.
- Trading transaction costs can
 - diminish the incentive to trade,
 - and, once the decision to trade has been made, they can diminish the actual amount traded.

Theory

- Stavins (1995) established a theory on **trading transaction costs** in pollution trading programmes.
- He shows that, in the presence of these costs, the efficient equilibrium of the trading systems might be undermined due to a decrease in the volume of emissions traded.

Empirical evidence (cont')

- The **lead permit trading programme** experienced high trading levels. However, Kerr and Mare (1998) found that transaction costs dissipated 10-20% of potential trading surpluses.
- A study of the RECLAIM found that without transaction costs the probability of trading would have been 32 and 12% higher in 1995 and 1996, respectively (Gangadharan 2000). Transaction costs were more significant in the early stages of the programme, and then decreased as the market matured, and participants learnt how to trade (Cason and Gangadharan 2003).
- The well-known Acid Rain Program for trading SO₂ emission can be regarded as efficient. Brokerage fees – a proxy for trading transaction costs – were estimated to be minimum (Joskow et al. 1998).

TC and the EU ETS: Case Studies

Sweden: Sandoff and Schaad (2009) find that ETS firms were very inactive in trading EUAs. They conclude that *"formulating trading strategies is not a top priority among the participating companies. This seems to be especially true for small companies."*

Ireland: Jaraite et al. (2010) observe the non-trading behaviour in Ireland. However, they conclude that *"it cannot be explained by trading transaction costs but rather by an inclination among smaller firms in particular to use allowances for compliance only..."*

Germany: Heindl (2012) surveys German ETS firms and finds that *"administrative costs for permit trading account for 19.57% of overall TC".*

The main goal

- To analyse the trading behaviour and trading transaction costs for all ETS firms in the first phase (2005-2007) of the EU ETS.
- In particular, we seek to address the following questions:
 - First, what ETS firms decided to trade allowances, and how do they differ from non-traders?
 - Second, what factors explain the extent of trading?
 - Third, why some ETS firms choose to exchange allowances indirectly (i.e. via third parties) rather than directly?
- More specifically, our interest lies in whether transaction costs affected the trading behaviour of ETS firms.



European Union Emission Trading Scheme (EU ETS)



How is the EU ETS organised?

- Trading phases:
 - the 1st phase (2005-2007);
 - the 2nd phase (2008-2012); and
 - the 3rd phase (2013-2020).

There is an implicit message from policy makers that this programme will continue working until 2050.

Coverage of the 1st phase

- All EU member states
- $-CO_2$ emissions only
- Combustion installations with a rated thermal input in excess of 20 MW (mainly powergen)
- Oil refineries, the production of ferrous metals, cement, lime, ceramics and pulp and paper etc.
- ~ 50% of CO $_{\rm 2}$ emissions and 40% of total GHG emissions
- About 11,500 installations were covered

Cap-setting (1st phase)

- Permit allocation was free
- 1 EU allowance (EUA) allowed to emit 1 tonne of CO₂
- Historical emissions used as a basis for allocation
- Full banking and borrowing was permitted within the 1st phase.
- Each installation has to comply on annual basis.
 EUAs = Emissions



Figure 4 – Net allowance position by country over 2005-2007, in volume (Mt) and as a percentage of national allocation (coloured areas)

Notes: Since emissions data from Romania and Bulgaria were not available at the date of publication, no results have been calculated for these newest members of the EU ETS. Malta 2007 emissions were not yet reported at the time of writing and have been approximated by the average 05-06.

Source: copied from Trotignon and Delbosc (2008).

Figure 2 – The 2005 compliance data release; impact on the spot price of the European allowance



Source: BlueNext, PointCarbon.

Source: copied from Trotignon and Delbosc (2008).

Data on transactions (1)

- This study exploits a dataset which allows investigating the trading behaviour of **all** ETS firms as well as significance of trading transaction costs.
- The data are obtained from the Community Independent Transaction Log (now EUTL).
- The CITL contains information about
 - the amount of permits allocated
 - permits surrendered
 - verified emissions for each ETS installation
 - information about a holder of each installation;
 - information about from which account to which account the EUAs were transferred;
- CITL data are publicly available, BUT the data on permit transactions are published with a time lag of 5 years.

Data on transactions (2 cont')

- The focus is only on transactions performed by ETS installations.
- The installations level data on compliance and transfers were aggregated to the firm level.
- We look at
 - ETS firms that **sold** some allowances to other ETS firms or third parties, and
 - ETS firms that **bought** some allowances from other ETS firms or third parties.
 - We analyse sellers and buyers separately.

Data on transactions (3 cont')



From the transaction cost perspective, **indirect trading** is perceived as entailing trading transaction costs. Because of this, brokerage fees are treated as a best proxy of trading transaction costs as one only engages in indirect trading if his or her transaction costs of direct trading are higher than brokerage fee.

Empirical strategy

- ETS firms make two decisions with respect to trading in an effort to maximise their profitability:
 - Whether to participate in allowance trading

 (a participation decision)

 How many allowances to trade given their part
 - 2) How many allowances to trade given their participation (a quantity decision)
- This means that the zero values in transaction data represent firms' optimal decisions rather than some sort of missing values.
- Because of this, we use the corner solution models (lognormal hurdle models a la Cragg (1971) and Duan et al. (1984)).

Factors affecting trade

- A number of variables are included in the models as the determinants of trading decisions.
 - Firm-level revenue (main activity) to proxy firm size (source: AMADEUS)
 - Fixed capital is used to proxy technology (*source*: AMADEUS)
 - The sectoral dummies (*source*: AMADEUS)
 - Firm net allocation positions (allocation emissions) to capture the potential extent of trading (*source*: CITL)
 - The regional dummies to understand geographical variation in the decision to sell allowances (*source*: CITL)
 - Firm size in terms of allocated permits: large (with an allocation share larger than 2% of the particular country's total allocation, medium (0.1% 2%) and small (up to 0.1%) (*source*: CITL)

TC Variables

- We construct two TC variables (based on Gangadharan, 2000)
- Search costs
 - Might be high for firms inexperienced in trading & for small firms.
 - Might be lower for ETS firms with multiple installations.
 - The number of ETS installations within each ETS firm will be used to capture search costs.
- Information costs
 - The number of transaction that are performed by a firm can capture information costs to some degree.
 - We expect that as the number of transaction increases, information costs go down.
 - We construct a dummy variable, which is equal to one if a firm traded more than twice in the years 2005 and 2006. We include this variable in the models only for the years 2006 and 2007.

The presentation of the dataset

Year	Total no. of firms	No. of sellers	No. of indirect sellers	No. of "long" sellers	No. of buyers	No. of indirect buyers	No. of "long" buyers
2005	5 871	1 481	1 209	1 318	735	374	381
2006	5 889	1 950	1 600	1 719	1 283	820	592
2007	5 735	862	689	775	706	477	311
Total	17 495	4 293	3 498	3 812	2 724	1 671	1 284

- The year 2007 was the least active in terms of selling activity, and the year 2005 in terms of buying activity.
- Most firms who sold some EUAs had the "long" net allocation position.
- About 2000 "long" firms did not sell EUAs at all!
- Germany, France, Poland, Spain and the UK were the top sellers.
- Germany, Italy, the United Kingdom, France and Spain were the top buyers.
- More than half of trading firms traded indirectly.

Why do firms decide to trade EUAs?

1nd Question

The results: participation decision (Hurdle 1)

Dependent variable: firms'										
choice	If firms sold some EUAs				If firms bought some EUAs					
to trade or not to	2005	2006	2007	2005-2007	2005	2006	2007	2005-2007		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		
Net allocation	0.0001**	0.0002***	0.0003***	0.0000	-0.0003***	-0.0003***	0.0000	-0.0002		
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0001)		
No. of installation within a firm	0.0853***	0.0983***	0.0410***	0.0279***	0.1327***	0.0850***	0.0248***	0.0101		
	(0.0097)	(0.0116)	(0.0088)	(0.0080)	(0.0101)	(0.0112)	(0.0078)	(0.0067)		
Sold ≥ 2 (lag)		0.8236***	0.5445***	-0.9695***						
		(0.0543)	(0.0535)	(0.0648)						
Bought >=2 (lag)						1.1290***	0.6927***	-1.0898***		
						(0.0840)	(0.0685)	(0.0938)		
Medium firms	0.5487***	0.4397***	0.5941***	0.3715***	0.4368***	0.2652***	0.2489***	0.2025***		
	(0.0512)	(0.0503)	(0.0563)	(0.0467)	(0.0605)	(0.0536)	(0.0604)	(0.0457)		
Largest firms	0.6736***	0.5103***	0.9255***	0.5593***	0.7892***	0.3602***	0.4791***	0.1984**		
	(0.1097)	(0.1120)	(0.1087)	(0.0959)	(0.1218)	(0.1183)	(0.1147)	(0.0931)		
Net allocation (Mundlak term)				0.0002				0.0002*		
				(0.0001)				(0.0001)		
Sold >=2 (lag, Mundlak term)				2.9699***						
				(0.1017)						
Bought ≥ 2 (lag, Mundlak term)								3.1612***		
								(0.1300)		
Sectoral dummies	yes	yes	yes	yes	yes	yes	yes	yes		
Regional dummies	yes	yes	yes	yes	yes	yes	yes	yes		
Year dummies	-	-	-	yes	-	-	-	yes		
Constant	-0.6623***	-0.6068***	-1.3547***	-1.7328***	-1.2689***	-0.8257***	-1.3204***	-1.4298***		
	(0.0615)	(0.0619)	(0.0732)	(0.0699)	(0.0734)	(0.0645)	(0.0736)	(0.0633)		
Log likelihood	-2798.9	-3133.7	-2025.9	-4581.5	-1759.6	-2671.7	-1965.5	-4339.1		
Wald test (Chi2)	1034.2	1093.1	771.1	1365.0	909.3	750.8	331.6	1021.0		
Wald test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
Observations (total)	5 871	5 754	5 702	11 456	5 871	5 754	5 702	11 456		

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1,

The results (1)

- It is evident that the transaction costs variables search costs and information costs – were significant in explaining the trading decisions in the first phase of the EU ETS.
- ETS firms with larger number of ETS installations (with lower search costs) were more likely to participate in trading.
- Information costs were significant in the years 2006 and 2007.
 - If the number of trades recorded in 2005 and 2006 was =>2, then the probability that an average ETS firm trades in 2006 and 2007 is higher.

The results (2)

- ETS firms with larger net allocation positions were more likely to sell allowances and less likely to buy them (not in 2005)
- **Firm size** matters in making trading decisions: medium and large ETS firms in terms of allocation were more likely to trade allowances.
- ETS firms in the power **generating sector** were more likely to participate in allowance trading than other ETS firms.

What factors explain the extent of trading?

2nd Question

The results: quantity decision (Hurdle 2)

Dependent variable:	If firms sold some EUAs				If firms bought some EUAs			
EUAs bought/sold	2005	2006	2007	2005-2007	2005	2006	2007	2005-2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Net allocation	0.0001	0.0001*	0.0003***	-0.0002	-0.0005***	-0.0004***	-0.0003***	-0.0004**
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)
No. of installation within a firm	0.0264***	0.0321***	0.0273***	0.0196***	0.0186	0.0160	-0.0006	-0.0019
	(0.0100)	(0.0087)	(0.0089)	(0.0073)	(0.0148)	(0.0106)	(0.0122)	(0.0086)
Sold ≥ 2 (lag)		0.2886***	0.2985***	-0.6481***				
		(0.0843)	(0.1052)	(0.0814)				
Bought ≥ 2 (lag)						0.7254***	0.2659	-0.7313***
						(0.1382)	(0.1638)	(0.1514)
Medium firms	1.8249***	1.8148***	1.4594***	1.5845***	1.8652***	1.9455***	1.8075***	1.7352***
	(0.1063)	(0.0853)	(0.1178)	(0.0732)	(0.2052)	(0.1263)	(0.1676)	(0.1019)
Largest firms	4.2319***	3.9071***	2.8494***	3.3865***	4.0464***	3.8316***	2.6325***	3.1664***
	(0.1891)	(0.1557)	(0.1779)	(0.1279)	(0.3259)	(0.2238)	(0.2763)	(0.1787)
Net allocation (Mundlak term)				0.0003*				0.0000
				(0.0002)				(0.0002)
Sold >=2 (lag, Mundlak term)				1.5713***				
				(0.1162)				
Bought ≥ 2 (lag, Mundlak term)								2.0029***
								(0.1846)
Sectoral dummies	yes	yes	yes	yes	yes	yes	yes	yes
Regional dummies	yes	yes	yes	yes	yes	yes	yes	yes
Year dummies	-	-	-	yes	-	-	-	yes
Observations	1,481	1,944	856	2,800	735	1,278	704	1,982
R-squared (within for panel models)	0.422	0.438	0.438	0.071	0.349	0.455	0.356	0.003

Standard errors in parentheses, *** p<0.01, ** p<0.05, *

p<0.1

The summary of the results

• Both transaction costs variables have a significant effect on the amount of permits traded:

Firms with multiple installations sold more permits. Trading experience had a significant effect in explaining the extent of trading.

Medium and large ETS firms traded more permits than small ETS firms.

Why do firms trade indirectly?

3rd Question

The results: indirect trading decision

Dependent variable:	If firms sold some EUAs only indirectly				If firms bought some EUAs only indirectly			
Firm's choice to trade indirectly or directly	2005	2006	2007	2005-2007	2005	2006	2007	2005-2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Net allocation	-0.0000	0.0001*	0.0000	-0.0001	0.0002**	0.0000	0.0001	-0.0003
	(0.0001)	(0.0001)	(0.0001)	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0003)
No. of installation within a firm	-0.0865***	-0.1136***	-0.0285***	-0.0990***	-0.0714***	-0.0831***	-0.0423***	-0.1148***
	(0.0128)	(0.0128)	(0.0102)	(0.0147)	(0.0159)	(0.0137)	(0.0132)	(0.0236)
If sold twice and more (lag)		-0.1546**	0.1104	0.1178				
		(0.0726)	(0.0995)	(0.1183)				
If bought twice and more (lag)				0.1570		-0.3130***	0.1570	0.4131**
				(0.1294)		(0.1083)	(0.1294)	(0.2106)
Medium firms	-0.2948***	-0.0633	-0.0991	-0.1101	0.0517	-0.1320	-0.4938***	-0.3742**
	(0.0842)	(0.0749)	(0.1114)	(0.1050)	(0.1240)	(0.0966)	(0.1322)	(0.1622)
Largest firms	-0.7196***	-0.4136***	-0.4380***	-0.6962***	-0.2055	-0.1508	-0.4229*	-0.4090
	(0.1567)	(0.1399)	(0.1688)	(0.1890)	(0.2065)	(0.1780)	(0.2202)	(0.2893)
Net allocation (Mundlak term)				0.0002				0.0004
				(0.0003)				(0.0004)
Sold twice and more (lag, Mundlak term)				-0.4585***				
				(0.1687)				
Bought twice and more (lag, Mundlak								
term)								-1.0001***
								(0.2843)
Sectoral dummies	yes	yes	yes	yes	yes	yes	yes	yes
Regional dummies	yes	yes	yes	yes	yes	yes	yes	yes
Year dummies	-	-	-	yes	-	-	-	yes
Log likelihood	-884.31201	-1143.1277	-551.44189	-1686.449	-406.32593	-794.13796	-440.81644	-1215.4689
Wald test (Chi2)	230.07	303.58	72.26	127.4	88.07	182.5	78.37	62.36
Wald test (p-value)	0	0	0	0	0	0	0	0
Observations (total)	1,481	1,944	855	2,800	733	1,278	703	1,982

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

The results

- ETS firms with multiple installations and ETS firms experienced in trading were less likely to trade indirectly.
- ETS firms in the power generating sector were more likely to trade indirectly than firms in the other sectors.
- This result does not signify that power generator had higher transaction costs, but available in-house capacity to trade indirectly.
- ETS firms operating in the member states that accessed the EU in 2004 were more likely to sell their allowances indirectly.

Conclusions

- To the best of our knowledge, our study is the first to empirically analyse permit trading transaction costs for ALL ETS firms during the first phase of the EU's ETS.
- Our analysis shows that transaction costs played an important role in the initial years of the EU ETS.
- These costs were significant in explaining why some ETS firms did not participate in the European emissions trading market and chose to trade allowances indirectly via third parties.
- Also, transaction costs are important in explaining the extent of trading.

Thank you for your attention!

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Extra material

The theoretical model



The theoretical model (cont)



If trading transaction costs are present, the result of trading is to equilibrate the *sum* of marginal abatement costs and marginal transaction costs across polluters.

Also, the total cost incurred by all regulated firms is no longer the simple sum of abatement costs, but rather this amount plus total transaction costs.

Empirical strategy (1 cont')

- We use a double-hurdle (DH) model, originally proposed by Cragg (1971) and Duan et al. (1984).
- It assumes that firms make two decisions concerning allowance trading.
- Each decision might be determined by different factors and the effects of each factor can be different for each decision.
- The DH models allow testing whether transaction costs affect the participation and quantity decisions in different ways.

Empirical strategy (2 cont')

1 HURDLE (PARTICIPATION DECISION)

•Analyse factors affecting the participation in trading and indirect trading

•The cross-sectional and panel probit models are estimated

•The panel probit model controls for unobserved heterogeneity by including Mundlak terms (means of the time varying explanatory variables).

2 HURDLE (QUANTITY DECISION)

•Investigate to what extent the TC variables affect the extent of trading

•Cross-sectional and panel models are estimated

•The panel model controls for unobserved heterogeneity by including Mundlak terms (means of the time varying explanatory variables).

This paper maintains Cragg's (1971) original assumptions that Hurdel 1 and Hurdle 2 models are independent.

DESCRIPTIVE STATISTICS

		All firms		Firms that sold EUAs		Firms that bought EUAs	
Variable	Measurement units	Obs.	Mean	Obs.	Mean	Obs.	Mean
Firms that sold some allowances	A dummy variable	17495	0.245	4293	1.000	2724	0.492
Firms that bought some allowances	A dummy variable	17495	0.156	4293	0.312	2724	1.000
No. of permits sold	Thousands EUAs	17495	52.5	4293.0	213.8	2724.0	226.4
No. of permits bought	Thousands EUAs	17495	35.4	4293.0	121.5	2724.0	227.0
If sold only indirectly	A dummy variable	17495	0.146	4293	0.596	2724	0.155
If bought only indirectly	A dummy variable	17495	0.072	4293	0.086	2724	0.460
Difference btw. allocation and emissions	Thousands EUAs	17495	11.0	4293.0	44.2	2724.0	-44.0
Number of installation within a firm	No. of installations	17495	1.736	4293	2.697	2724	3.188
If sold more than twice in 2005-2006	A dummy variable	11456	0.077	2800	0.146	1982	0.224
If bought more than twice in 2005-2006	A dummy variable	11456	0.170	2800	0.361	1982	0.263
Small firms in terms of allocation	A dummy variable	17495	0.766	4293	0.566	2724	0.616
Medium firms in terms of allocation	A dummy variable	17495	0.200	4293	0.354	2724	0.298
Largest firms in terms of allocation	A dummy variable	17495	0.035	4293	0.081	2724	0.086
France and Belgium	A dummy variable	17495	0.128	4293	0.176	2724	0.114
Germany	A dummy variable	17495	0.167	4293	0.154	2724	0.206
Hungary and Austria	A dummy variable	17495	0.044	4293	0.034	2724	0.027
Italy Greece Portugal and Spain	A dummy variable	17495	0.257	4293	0.147	2724	0.220
Estonia Latvia Lithuania	A dummy variable	17495	0.025	4293	0.038	2724	0.019
Netherlands	A dummy variable	17495	0.022	4293	0.041	2724	0.025
CZ Poland Slovakia Slovenia	A dummy variable	17495	0.173	4293	0.172	2724	0.098
Denmark Finland and Sweden	A dummy variable	17495	0.105	4293	0.161	2724	0.177
UK and Ireland	A dummy variable	17495	0.079	4293	0.076	2724	0.115
Power generation	A dummy variable	17495	0.187	4293	0.281	2724	0.230
Food beverages and tobacco	A dummy variable	17495	0.068	4293	0.057	2724	0.065
Textiles and leather	A dummy variable	17495	0.017	4293	0.010	2724	0.004
Wood and paper	A dummy variable	17495	0.145	4293	0.141	2724	0.134
Coke cement and refined products	A dummy variable	17495	0.063	4293	0.082	2724	0.081
Chemicals and pharmaceutical products	A dummy variable	17495	0.049	4293	0.056	2724	0.048
Glass ceramics and plastic	A dummy variable	17495	0.195	4293	0.126	2724	0.137
Metals	A dummy variable	17495	0.016	4293	0.014	2724	0.012
Computers and machinery	A dummy variable	17495	0.031	4293	0.019	2724	0.023
Other sectors	A dummy variable	17495	0.229	4293	0.214	2724	0.265
Revenue	Millions euro	11758	654.0	3037.0	1092.3	1874.0	1366.7
Fixed assets	Millions euro	12018	440.6	3107.0	772.5	1895.0	1093.3

What's more?

- Exclusion of firms that traded within-firm boundaries:
 - The results indicate that the exclusion of firms that traded within-firm boundaries did not affect significantly the results presented above. The main difference is that the number of installations within firms became insignificant in explaining the buying decisions in the years 2006 and 2007. The full set of results is available from the authors upon request.
- Inclusion of revenue and fixed assets:
 - The results indicate that firms with higher revenue are more likely to trade allowances and less likely to trade indirectly. Revenue has no affect on the amount of permits traded. ETS firms with higher fixed assets are more likely to trade indirectly. This result might be linked to the finding discussed above that firms operating in the power generating sector (power generators have significantly higher fixed assets) are more likely to trade indirectly via third parties due to available in-house capacity.