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Firm Trading Behaviour and Transaction Costs in the European Union's Emission Trading System: An Empirical Assessment[1]

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Abstract

To the best of our knowledge, this study is one of the first to empirically analyse the trading behaviour in the first phase of the European Union's Emissions Trading System. We use a unique dataset that allows investigating the importance of permit trading transaction costs, such as information costs and search costs. This paper shows that transaction costs played an important role in the initial years of the programme. 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 rather than directly. This study also supports the concerns that transaction costs might be excessive for smaller participants.

Keywords: CITL, emissions trading, Europe, firm-level data, transaction costs

[1] This working paper replaces the earlier version of this study. The main difference from the earlier study is that the current paper uses the bigger dataset and employs the different empirical strategy. The main results remain the same throughout both papers.

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1. Introduction

Emission trading gains momentum in the European Union (EU). The EU's Emission Trading System (EU ETS) has been working since 2005 and will do so at least until 2020. In principle, the EU ETS, as with any other emissions-trading programme, is cost-effective. 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 is trading transaction costs.

In this paper, we investigate for the presence of trading transaction costs in the first phase (2005-2007) of the EU ETS. In particular, we seek to address the following questions in an empirical framework: What firms decide to trade, and how do they differ from non-traders? Further, how do transaction costs affect decisions of ETS firms? Are transaction costs significant and do they decrease over time due to learning-by-doing processes? There has not been much attempt to analyse these issues in the biggest and the most complex European emission trading system from an empirical perspective.

The most important theoretical result is of Stavins (1995) who studies the potential impacts of trading transaction costs on pollution trading. Within his theoretical framework, 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.

Although the empirical literature on transaction costs is rather rich, Krutilla and Krause (2010) in their recent survey still believe that "empirical assessments of transaction costs in the environmental literature are relatively patchy and incomplete" (p. 336). The existing empirical research has mainly focused on measuring trading transaction costs of the pioneering US permit trading programmes. For example, the lead permit trading programme, aimed at reducing the amount of lead added to gasoline, 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). This suggests that transaction costs are more significant in the early stages of the programme, and then decrease as the market matures, and participants learn how to trade (Cason and Gangadharan 2003). The well-known Acid Rain Program for trading SO_2 emission can be regarded as efficient. Brokerage fees – a proxy for trading transaction costs – were estimated to be minimum (Joskow et al. 1998).

The research on trading transaction costs in the EU ETS is rather limited. The first trading phase (2005-2007) revealed that a number of tradable permits expired worthless at the end of the first trading period (Ellerman and Trotingnon 2009). It has been discussed that it is very likely that a large part of these permits never entered the market, i.e. some ETS participants used permits only for compliance, but not for revenue purposes. To some extent this is confirmed by Jaraitė et al. (2010) who analyse for the presence of trading transactions costs, among other types of transaction costs, in Ireland. They find that some Irish firms did not sell

surplus permits in the market and conclude that this non-trading behaviour cannot be explained by trading transaction costs but rather by an inclination among smaller firms in particular to use permits for compliance only, caution at the beginning of the period and the low permit prices at the end of the trading period seem to be the primary reasons for non-participation in trading.

This study contributes to the empirical research on transaction costs in the most complex and ambitious emissions tradable programme ever developed. We use a unique dataset to investigate the trading behaviour of *all* ETS firms throughout the first phase of the EU ETS. Additionally, this dataset allows identifying several firm-level transaction costs variables and to check for their significance in firms' decisions to trade. We find that transaction costs can explain why a number of ETS firms did not participate in the European emission trading market and chose to trade allowances indirectly rather than directly. This study also supports the concerns that transaction costs might be excessive for smaller participants.

The rest of the paper is organised as follows. The next section gives a brief description of the EU ETS and the introduction to the dataset that provides the basis for this analysis. Section 3 provides an empirical framework to analyse the trading behaviour and significance of transaction costs in the EU ETS market. The results and their implications are discussed in Section 4. Section 5 highlights the contributions of this paper and concludes.

2. Background on the EU ETS and CITL data

2.1 The brief description of the EU ETS

The EU ETS operates over pre-defined time periods, with the first period (2005-2007) being the subject of this study. The second phase coincides with the commitment period of the Kyoto Protocol (2008-2012), and this will be pursued by a third period (2013-2020).

The inclusion criteria for the first phase of the EU ETS are set in Annex I of the Emissions Trading Directive (European Parliament and Council 2003). This period covered CO_2 emissions from so called combustion installations with a rated thermal input in excess of 20 megawatts (mainly electricity and heat generators), oil refineries, the production and processing of ferrous metals, the manufacture of cement, the manufacture of lime, ceramics, glass, and pulp and paper. This coverage accounted for about a half of CO_2 emissions and 40% of total greenhouse gas emissions. About 11 500 installations in all EU27 member states were covered.

In the EU ETS, each installation should comply with the Emissions Trading Directive on annual basis. Compliance consists of surrendering tradable rights to emit, called European Union Allowances (EUAs). Each EUA is equal to one tonne of CO_2 emitted. Each installation is required to hold a number of EUAs corresponding to its actual verified emissions. If it is assumed that installations surrender the allowances allocated to them first before making any exchanges in the market, the differences between each installation's actual emissions and its allocation indicate the extent of trading. Each *net long* installation (allocation is greater than

actual emissions) is a potential seller; and each *net short* installation (allocation is lower than actual emissions) is a potential buyer.[2]

However, annual differences between allowances and actual emissions do not necessarily imply a transfer involving another installation or third party. ETS installations can bank EUAs not used in one year for use in a later year and they can borrow from the allocation for the next year to cover deficits in any given year. Banking and borrowing is allowed within but not between the trading phases.

2.2 The presentation of the CITL data

Each EU member state hosts a national registry consisting of accounts for all ETS installations. The registries keep information on the initial allocation of allowances, the annual verified actual emissions, the surrendered allowances, and all transfers in and out of the accounts. A copy of the national registry records is maintained in the Community Independent Transaction Log (CITL). The CITL is the central registry for the EU ETS. The CITL data on compliance and transfers are publicly available, but the data on transfers are published with a time lag of five years. This means that all transfers of EUAs that were made, for example, in 2007 became displayed from 15 January onwards of year 2012.

In this paper, the focus is only on transactions performed by ETS installations, i.e. the trading behaviour of third parties is not considered. More explicitly, we will analyse the trading behaviour of installations that *sold* some allowances to other installations or third parties, and on installations that *bought* some allowances from other installations or third parties. Technically, a transfer at no price is also possible, but prices at which allowances were transferred are not publicly available. In the CITL data, installations are named as Operator holding accounts and third parties – as Person holding accounts. An exchange of allowances between two Operator holding accounts can be named as a *direct* trade, whereas a transfer between an Operator holding account and a Person holding account can be titled as an *indirect* trade.[3]

For the purpose of this analysis, the installation level data on compliance and transfers were aggregated to the firm level. At the time this study was performed, the transfers were available for the period 2005-2007. The last transfer was made in the end of December 2007. As the compliance period for the year 2007 finished in April 2008, it means that our dataset does not cover all transfers performed in the phase of the EU ETS. However, knowing that EUA price approached zero in the end of 2007, we expect that most transactions were performed before 2008.

[2] According Ellerman and Trotingnon (2009), there were only 27 instances over the three-year period with emissions exactly equal to the annual allocation.

[3] 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 (direct) trading if his or her transaction costs of direct trading are higher (lower) than brokerage fee.

3. The empirical strategy

The empirical strategy is built upon the main objectives of this study. We seek to answer the following questions: First, why ETS firms decide to trade allowances? Second, why ETS firms choose to exchange allowances indirectly rather than directly? Third, what factors explain the extent of trading? More specifically, our interest lies in whether transaction costs affect the trading behaviour of ETS firms.

3.1 Model choice

In our framework, ETS firms make two decisions with respect to trading in an effort to maximise their profitability: (1) whether to participate in allowance trading (a participation decision), and (2) how many allowances to trade given their participation (a quantity decision). Thus, the zero values in our data represent firms' optimal decisions rather than some sort of missing values. Because of this, corner solution models are more appropriate than selection models for our analysis.[4]

The Tobit model (Tobin 1958) might be used to deal with the above corner solution problem. However, the this model can be very restrictive for both economic and statistical reasons since it assumes that the same set of variables determines both the probability of participation in trade and the level of trade, and that the factors affect both decisions in a similar way. A double-hurdle (DH) model, originally proposed by Cragg (1971), is a more flexible modelling framework in addressing corner solution problems. 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 model fits well the research questions of this study since it allows testing whether transaction costs affect the participation and quantity decisions in different ways.

This study follows the modified Cragg's (1971) model. The first stage (Hurdle 1) of the analysis constructs a model of the probability of trading focusing on the role of transaction costs. Then we estimate a model of the probability of trading indirectly. For both cases the underlying trading decisions are modelled as:

$$Y_{it}^{*} = \boldsymbol{z_i\beta} + \boldsymbol{x_{it}\gamma} + \eta_i + \varepsilon_{it}, \tag{1}$$

where Y_{it}^{*} is a latent variable that underlines an observed indicator variable that captures whether or not a firm trades according to the following rule:

$$Y_{it} = \begin{cases} 1 & Y_{it}^{*} > 0 \\ 0 & otherwise, \end{cases} \tag{2}$$

and

[4] The Heckman selection approach is designed for cases when there are some sort of missing values, which might be reported as zeros in a dataset (Wooldridge 2010).

$$\boldsymbol{Pr(Y_{it} = 1|z_i, x_{it}, \eta_i) = \Phi(z_i\beta + x_{it}\gamma + \eta_i + \varepsilon_{it})}, \quad (3)$$

where $\boldsymbol{z_i}$ are firm-specific time invariant variables; $\boldsymbol{x_{it}}$ are firm-specific time variant variables; η_i are firm-specific time invariant unobservables such as firm culture, firm social responsibility, management background etc. The first stage uses the probit regressions to analyse factors affecting the participation in trading and indirect trading.

As said above, one of the challenges when analysing the trading behaviour is that many firms choose not to trade, so the data take on the properties of non-linear corner solution variables. The covariates of the non-linear panel model must be independent of unobserved heterogeneity η_i. In the linear model, unobserved heterogeneity can be controlled for by including fixed firm-specific effects. In non-linear models, however, any attempt to estimate fixed unobserved heterogeneity effects will lead to the incidental parameters problem, resulting in biased and inconsistent estimates. However, using random effects requires the assumption that the random effects are not correlated with the explanatory variables in the model. This is a restrictive assumption, particularly in the context of the model we are attempting to estimate, where firm specific variables, such as choice of capital inputs and firm characteristics, are likely to be correlated with unobserved heterogeneity.

The assumption of independence between covariates and unobserved heterogeneity can be relaxed using a corrected random effects (CRE) framework which follows Mundlak (1978) and Chamberlain (1984). To control for potential correlations between the random effects and the other exogenous variables, the CRE option is to model the unobserved heterogeneity (η_i) as a function of the means of the time varying explanatory variables:

$$\eta_i = \boldsymbol{\bar{x}_i\psi} + a_i, \quad (4)$$

where $\boldsymbol{\bar{x}_i}$ is an average of $\boldsymbol{x_{it}}$ over time for each firm. We assume that time invariant a_i is distributed as $N(0, \sigma_a^2)$ and is uncorrelated with $\boldsymbol{x_{it}}$ and other time invariant exogenous variables.

The model can now be written as:

$$Pr(EXIT_{it} = 1|\boldsymbol{z_i, x_{it}, \bar{x}_i}, a_i) = \Phi(\boldsymbol{z_i\beta + x_{it}\gamma + \bar{x}_i\psi} + a_i + \varepsilon_{it}). \quad (5)$$

In the second stage (Hurdle 2), we investigate to what extent the transaction costs variables affect the extent of trading. For this purpose, we use a model that accounts for time invariant unobserved heterogeneity:

$$Trade_{it} = \boldsymbol{z_i\beta + x_{it}\gamma} + \eta_i + \nu_{it}, \quad (6)$$

where a $Trade_{it}$ variable is the amount of traded allowances (in logs) by individual firms; v_{it} is an error term.

This paper maintains Cragg's (1971) original assumptions that conditional on the explanatory variables, the errors between Hurdle 1 and Hurdle 2 are independent and normally distributed and that the covariance between the two errors equals zero.

Before exploiting the panel nature of the dataset, we also estimate the cross-sectional hurdle models for each available year to explore the learning-by-doing effects of allowance trading.

3.2 The choice of factors affecting trade

The above models include a number of variables as the determinants of the trading decisions. These variables are: firm revenue, firm fixed assets, firm net allocation position, firm size in terms of allocation, the sectoral and regional dummies, and some transaction costs variables.

Firm output is an indicator of firm size in terms of its main activity. We use firm-level revenue to proxy firm output.[5] Additionally, this variable might indicate whether a firm is a part of growing or declining industry. Notice, that revenue takes into account only income received from the main activity, i.e. income associated with trading allowances is not reflected in this variable and therefore this does not cause an endogeneity problem.

The technology of a firm is an important factor influencing the level of pollution. Also, technology depicts pollution abatement potential and hence a possibility to free up allowances. Fixed capital[6] is used in this paper to proxy technology. Fixed capital, conditional on firm size (capital intensity), might indicate technological differences across firms. Additionally, we use several sectoral dummies, which will give an idea of products being manufactured by each ETS firm. However, these dummies are very aggregate and probably will not give much firm specific information.

Firm net allocation positions are used to capture the potential extent of trading. As said above, we expect that firms with the positive net allocation positions are the potential sellers of allowances, whereas firms with the negative net allocation position are the potential buyers of allowances.

Following Jaraitė et al. (2010), we group ETS firms according to the level of firms' allocated permits into three categories: 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%). We expect small ETS firms to be less experienced in trading when compared to large ETS firms who trade on daily basis in different markets (e.g. electricity generators).

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[5] Firm-level revenue as well as fixed capital are obtained from the Amadeus (Bureau van Dijk). This database includes firm-level accounting and other data in standardised financial format. The general source for the Amadeus is national official public bodies in European countries. The Amadeus database is a very useful information source for cross-country comparisons as it provides harmonised accounts for large fraction of European firms. A lot of effort has been used to identify ETS firms in this dataset. Detailed information of how this identification was performed can be received from the authors upon request.

[6] See Footnote 5.

We also include few regional dummies to understand whether there is any geographical variation in the decision to trade allowances. We were unable to use country-level dummies due to the issue of multicollinearity.

As discussed above, a number of firms did not sell their surplus allowances during the first phase of the EU ETS. One of the reasons for this could be high transaction costs that might prevent firms entering the market. When transaction costs are non-zero, some firms might opt out of the market meaning that we should take into account transaction costs variables when modelling the trading decisions. Based on the available data, we construct two variables – search costs and information costs – that identify transaction costs in the EU ETS market.

According to Gangadharan (2000), search costs can potentially be rather high for heterogeneous firms as they do not often interact in the same input or output markets. Also, some ETS firms consist of more than one ETS installation meaning that these firms have a possibility to trade/transfer allowances within a firm. This reduces their search costs. Also, we might expect these firms to trade directly without the help of a broker. Using information from the CITL and national allocation plans we are able to count the number of ETS installations within each ETS firm.

The number of transactions that is performed by a firm can capture information costs to some degree. This gives the number of times a firm enters the market. Every time a firm trades directly or indirectly it gains more experience in the market, obtains more information. 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 twice or more in the years 2005 and 2006.

4. The results

4.1 The descriptive statistics

Table 1 summarises the dataset according to the year, the type of trade, and the allocation position. The dataset consists of 18 086 observations for the period 2005-2007.[7] About a quarter of ETS firms sold some allowances, and about one sixth of ETS firms bought some allowances. More than half of these trading firms sold/bought allowances indirectly to/from the third parties. The year 2005 was the least active in terms of trading activity. This might be explained by the fact that many member states were late to set up their national registries. The year 2006 was the most active in terms of selling activity, whereas the year 2007 – in terms of buying activity. As expected, most firms who sold some allowances had the positive net allocation. About a half of firms who bought some allowances were "long" too. We might expect that these firms primarily bought allowances not for compliance, but for financial speculation purposes. The data reveals that more than thousand ETS firms bought and sold some allowances within the same year.

[7] Some adjustments were made to the CITL data. As a result of that, several unrepresentative observations dropped out. The details can be obtained from the authors upon request.

Table 1 The presentation of the dataset

Year	Total	Sold some EUAs	Sold, "long" firms	Sold only indirectly	Bought some EUAs	Bought, "long" firms	Bought only indirectly
2005	5 951	767	703	617	234	129	112
2006	6 072	2 177	1 955	1 558	1 078	558	498
2007	6 063	1 607	1 393	978	1 384	672	743
Total	18 086	4 551	4 051	3 153	2 696	1 359	1 353

Sources: CITL and authors' calculations.

From Table 2 it is evident that Germany, France, Poland, Spain and the United Kingdom were the top sellers. However, in Estonia, Finland and the Netherlands more than half ETS firms sold their allowances in the market. In terms of buying activity, the most active were Germany, Italy, the United Kingdom, France and Spain. To some extent the geographical distribution of trading activities reflect the net allocation positions for each country. For example, Germany, France and Poland had the positive net allocation positions and were among the top sellers of allowances; while Italy, the UK and Spain had the negative net allocation positions and were among the top buyers of allowances.

Table 2 The geographical distribution of trading activity

	No. of firms who sold some EUAs	Mean of no. EUAs sold (in thousands)	No. of firms who bought some EUAs	Mean of no. EUAs bought (in thousands)	Total number of firms
Austria	28	58.2	22	28.2	343
Belgium	141	287.4	66	297.8	590
Czech Republic	280	176.8	83	114.1	765
Denmark	257	132.5	143	180.6	731
Estonia	45	410.5	14	330.0	86
Finland	214	110.8	138	59.8	421
France	672	125.8	233	87.3	1717
Germany	695	189.5	567	147.1	3030
Greece	13	213.6	8	129.8	291
Hungary	120	103.8	50	87.3	444
Ireland	29	20.1	36	58.5	213
Italy	189	381.2	309	277.8	1658
Latvia	59	67.8	19	58.8	171
Lithuania	67	241.3	18	165.5	201
Netherlands	192	437.2	78	478.0	387
Poland	379	195.4	110	62.9	1672
Portugal	118	129.3	52	126.3	603
Slovakia	133	121.3	48	80.1	393
Slovenia	12	21.3	32	20.1	276
Spain	323	158.2	217	353.3	2115
Sweden	275	58.9	180	57.0	767
United Kingdom	310	557.6	273	763.8	1212
Total	4551	202.6	2696	230.1	18086

Sources: CITL and authors' calculations.

The average size of firm-level selling/buying transactions and its geographical distribution is presented in Table 2. It is important to remind that these transfers might also include transfers at no price. On average, an ETS firm sold 202.6 thousand EUAs and bought 230.1 thousand

EUAs. ETS firms in the UK, the Netherlands and Estonia sold on average the largest amount of permits, whereas ETS firms in the UK, the Netherlands and Spain bought on average the largest amount of permits.

Table 3 presents the descriptive statistics of all variables used in this study. Separately, the summary statistics are reported for firms that sold and bought some allowances. It is evident that firms that traded some allowances were bigger in terms of capital and revenues than an average ETS firm. Firms that bought some allowances had larger capital and revenue compared to firms that sold some EUAs. The average net allocation position, i.e. the difference between the allocated allowances and verified emissions, was positive for sellers and negative for buyers. Also, firms who traded some EUAs consisted of more installations than the average firm. It is also evident that buyers had, on average, more installations than sellers. The summary statistics for sectoral dummies reveal that firms in the power generating sector were the most active in allowance trading.

[Insert Table 3 about here]

4.2 The discussion of the main estimation results[8]

The results of the cross-sectional and panel first stage hurdle models are presented in Table 4.[9] Columns 1-4 summarise the determinants of the decision to sell allowances; Columns 5-8 summarise the determinants of the choice to buy allowances. 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 were more likely to participate in trading. This might indicate that for a firm with multiple installations it was easier to find a trading partner, i.e. it could sell/buy its allowances within a firm meaning that its search costs were lower than for a ETS firm with a single installation. Also, ETS firms with multiple installations might have a separate unit to deal with EU ETS issues and a coordinated compliance strategy. Another important result related to transaction costs is that information costs were significant in the years 2006 and 2007. If the number of trades recorded in 2005 and 2006 was equal or greater than two, then the probability that an average ETS firm trades in 2006 and 2007 is higher. This suggests that firms that entered the market several times have more information on the procedures to be followed and hence incur lower information costs. In the panel probit models (see columns 4 and 8), this result is captured by the coefficients for the Mundlak terms of the information costs variables.[10]

[Insert Table 4 about here]

[8] Due to a large number of missing observations for firm revenue and fixed capital, these variables were excluded from the models reported in this paper. The results of the models that include these variables are available from the authors upon request. These variables are insignificant in most models and do not alter the main findings of this paper.

[9] The marginal effects for all non-linear models were estimated too. They are in line with the estimates of the baseline specifications and, hence, are not reported here, but available from the authors upon request.

[10] The Mundlak terms can be thought of as representing the permanent (long-run) changes in the relevant variables, i.e. the level effects while the time-varying variables capture the transient changes or shock effects (short-run).

As expected, ETS firms with larger net allocation positions were more likely to sell allowances and less likely to buy them. This result is significant in the cross-sectional models for the years 2006 and 2007 and in the panel probit model for sellers. We also find that firm size matters in making trading decisions: medium and large ETS firms in terms of allocation were more likely to trade allowances. In other words, small ETS firms were less prone to participate in allowance trading. This result supports the concerns raised by the European Commission (e.g. see CEC (2008)) that trading transaction costs might be excessive for smaller participants. The coefficients of the sectoral dummy variables indicate that ETS firms in the power generating sector were more likely to participate in allowance trading than other ETS firms. This might be explained by the size of energy generating firms as well as their trading experience in other input and output markets. The coefficients for the regional dummies reveal that most countries were less likely to buy allowances and more prone to sell them when compared to Germany. The exceptions are Austria, Hungary, Italy, Greece, Portugal and Spain, where ETS firms were less probable to sell allowances. These results to some extent reflect the country-level net allocation positions.

The second aim of this study is to understand why ETS firms choose to trade allowances indirectly rather than directly.[11] As mentioned above, from the transaction costs perspective, indirect trading is perceived as entailing trading transaction costs. This suggests that firms with high transaction costs are more likely to trade allowances indirectly. The results of the cross-sectional and panel first stage hurdle models for the indirect trading choice are presented in Table 5. Columns 1-4 summarise the determinants of the decision to sell allowances indirectly; Columns 5-8 summarise the determinants of the choice to buy allowances indirectly.

[Insert Table 5 about here]

Transactions costs appear to be significant in explaining the choice to trade allowances indirectly. As expected, ETS firms with multiple installations were less likely to trade indirectly. This confirms our arguments presented above that search costs for ETS firms with multiple installations are lower. These firms have a possibility to trade within firm boundaries; also, they are bigger and have a sufficient in-house capacity to trade directly with other ETS firms. Another finding is that firms who sold their allowances in the previous periods are more likely to sell EUAs indirectly. To some extent this might indicate that selling allowances through third parties was not expensive, i.e. fixed transaction fees were low enough not to discourage experienced firms to sell their allowances indirectly. That brokerage fees for trading allowances were low and declining during the first trading phase is confirmed by Convery and Redmond (2007). However, the effect of information costs is opposite for buyers. In 2006, experienced buyers were less likely to trade indirectly. This effect is also confirmed by the Mundlak term of the information costs variable. This finding is along our expectations that firms experienced in trading would be less prone to trade indirectly. The difference between sellers and buyers might indicate that brokers were more active on the supply side of the market. Anecdotal evidence collected at the interviews of Irish ETS firms

[11] See Subsection 2.2 for the definitions of direct and indirect trading.

shows that brokers were very active in convincing over-allocated ETS firms to sell surplus allowances.[12]

The remaining estimates show that the net allocation position had no effect on the decision to trade allowances indirectly. Medium and large ETS firms in terms of allocation were less prone to trade indirectly. This result is applicable only for sellers. The coefficients of the sectoral dummy variables indicate that ETS firms in the power generating sector were more likely to trade indirectly than firms in the other sectors. We suggest that this result does not signify that power generator had higher transaction costs, but available in-house capacity to trade indirectly. The coefficients for the regional dummies are significant only for some regions. The noticeable result is that ETS firms operating in the member states that accessed the EU in 2004 were more likely to sell their allowances indirectly. To some extent this might signify that these firms did not have a sufficient capacity and experience to trade directly.

The last aim of this study is to investigate whether trading transaction costs are important in explaining the extent of trading. According to Stavins (1995), fixed trading transaction costs can affect whether or not a particular transaction takes place but not its magnitude. Variable trading transaction costs or so-called positive marginal transaction costs reduce the amount exchanged in each trade and may diminish the number of trades. In return, this may affect the overall cost-effectiveness of the permit trading programme.

Table 6 presents the results of the cross-sectional and panel (random effects) second stage hurdle models. Columns 1-4 summarise the results for sellers, and Columns 5-8 – for buyers. Both transaction costs variables have a significant effect on the amount of permits traded. This might indicate that transaction costs in the EU ETS are not only fixed in nature, but also are affected by the amount of allowances traded. The number of installations within a firm had a positive effect on the amount of allowances sold. As discussed above, this might signify that firms with multiple installations are more active in selling allowances due to larger in-house trading capacity. This is also confirmed by the coefficients for size dummies. Medium and large ETS firms traded more permits than small ETS firms. Another important result related to transaction costs is that past trading experience had a significant effect in explaining the extent of trading. The remaining estimates are similar to the ones in the first stage hurdle models and, hence, are not discussed here.

[Insert Table 6 about here]

As a final step of this study, we run the above models with two additional economic variables – revenue from the main activity and fixed capital – to control for firm size and technology. Revenue might be also an indicator of whether a firm is a part of an expanding or declining industry. These variables turned out to be insignificant and are therefore not reported. The full set of results is available from the authors upon request.

[12] These interviews were performed during the write-up of Jaraitė et al.'s (2010) study.

5. The conclusions

Several authors (Coase 1960; Tietenberg 2006) have commented on the importance of a comprehensive approach to assessing transaction costs. The assessment of trading transaction costs is especially important in the early stages of any pollution trading programme. To the best of our knowledge, our study is the first to empirically analyse permit trading transaction costs for *all* firms covered under the first phase the EU's Emissions Trading System.

This study exploits the unique dataset that allows investigating the trading behaviour of ETS firms as well as significance of trading transaction costs, such as information costs and search costs. In particular, we aimed to address the following questions in an empirical framework: What firms decide to trade, and how do they differ from non-traders? Further, how do transaction costs affect decisions of ETS firms? Are transaction costs significant and do they decrease over time due to learning-by-doing processes? 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. This study also supports the concerns raised by the European Commission (e.g. see CEC, 2008) that transaction costs might be excessive for smaller participants.

The further research on the trading behaviour in the EU ETS might focus on EUA price effects as well as on the trading behaviour of third parties and their interactions with ETS installations.

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Table 3 The descriptive statistics

		All firms			Firms that sold EUAs			Firms that bought EUAs		
Variable	Measurement units	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.
Firms that sold some allowances	A dummy variable	18086	0.252	0.434	4551	1.000	0.000	2696	0.510	0.500
Firms that bought some allowances	A dummy variable	18086	0.149	0.356	4551	0.302	0.459	2696	1.000	0.000
No. of permits sold	Thousands EUAs	18086	51.0	507.9	4551	202.6	997.4	2696	207.9	1090.1
No. of permits bought	Thousands EUAs	18086	34.3	517.4	4551	111.9	949.9	2696	230.1	1323.3
Difference btw. allocation and emissions	Thousands EUAs	18086	11.0	383.5	4551	35.1	588.5	2696	-50.1	824.8
Number of installation within a firm	No. of installations	18086	1.714	2.709	4551	2.623	4.638	2696	3.171	5.644
If traded more than twice in 2006-2007	A dummy variable	11993	0.051	0.221	3778	0.098	0.298	2458	0.174	0.379
Small firms in terms of allocation	A dummy variable	18086	0.771	0.420	4551	0.574	0.495	2696	0.618	0.486
Medium firms in terms of allocation	A dummy variable	18086	0.195	0.396	4551	0.349	0.477	2696	0.295	0.456
Largest firms in terms of allocation	A dummy variable	18086	0.034	0.181	4551	0.077	0.267	2696	0.087	0.282
France and Belgium	A dummy variable	18086	0.128	0.334	4551	0.179	0.383	2696	0.111	0.314
Germany	A dummy variable	18086	0.168	0.373	4551	0.153	0.360	2696	0.210	0.408
Hungary and Austria	A dummy variable	18086	0.044	0.204	4551	0.033	0.177	2696	0.027	0.161
Italy, Greece, Portugal and Spain	A dummy variable	18086	0.258	0.438	4551	0.141	0.348	2696	0.217	0.413
Estonia, Latvia, Lithuania	A dummy variable	18086	0.025	0.157	4551	0.038	0.190	2696	0.019	0.136
Netherlands	A dummy variable	18086	0.021	0.145	4551	0.042	0.201	2696	0.029	0.168
CZ, Poland, Slovakia, Slovenia	A dummy variable	18086	0.172	0.377	4551	0.177	0.381	2696	0.101	0.302
Denmark, Finland and Sweden	A dummy variable	18086	0.106	0.308	4551	0.164	0.370	2696	0.171	0.377
UK and Ireland	A dummy variable	18086	0.079	0.269	4551	0.074	0.263	2696	0.115	0.319
Power generation	A dummy variable	18086	0.183	0.387	4551	0.283	0.451	2696	0.226	0.418
Food, beverages and tobacco	A dummy variable	18086	0.067	0.251	4551	0.054	0.227	2696	0.062	0.240
Textiles and leather	A dummy variable	18086	0.017	0.130	4551	0.010	0.101	2696	0.004	0.064
Wood and paper	A dummy variable	18086	0.145	0.352	4551	0.143	0.350	2696	0.141	0.348
Coke, cement and refined products	A dummy variable	18086	0.062	0.240	4551	0.078	0.268	2696	0.083	0.276
Chemicals and pharmaceutical products	A dummy variable	18086	0.048	0.213	4551	0.053	0.225	2696	0.046	0.210
Glass, ceramics and plastic	A dummy variable	18086	0.198	0.398	4551	0.122	0.327	2696	0.134	0.341
Metals	A dummy variable	18086	0.016	0.125	4551	0.013	0.114	2696	0.013	0.113
Computers and machinery	A dummy variable	18086	0.031	0.173	4551	0.020	0.139	2696	0.023	0.151
Other sectors	A dummy variable	18086	0.234	0.423	4551	0.223	0.417	2696	0.267	0.443
Revenue	Millions euro	12019	643.9	3843.8	3227	1058.4	4658.3	1887	1423.9	5622.1
Fixed assets	Millions euro	12313	433.1	3393.7	3308	748.7	4880.0	1908	1114.0	6466.0

Sources: AMADEUS, CITL and authors' calculations.

Table 4 The determinants of the participation in the EU ETS market (Hurdle 1)

Variables	If firms sold some EUAs				If firms bought some EUAs			
	2005	2006	2007	2005-2007	2005	2006	2007	2005-2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Net allocation	0.0001	0.0003***	0.0002***	-0.0001	-0.0001	-0.0001**	-0.0002***	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0002)
No. of installation within a firm	0.0382***	0.0949***	0.1031***	0.0855***	0.0632***	0.1181***	0.0802***	0.0831***
	(0.0089)	(0.0111)	(0.0112)	(0.0102)	(0.0094)	(0.0103)	(0.0104)	(0.0107)
If sold twice and more (lag)		1.3097***	0.7290***	-1.5513***				
		(0.0956)	(0.0461)	(0.0836)				
If bought twice and more (lag)						0.9369***	1.0754***	-1.6874***
						(0.1378)	(0.0677)	(0.1224)
Medium firms	0.7846***	0.4585***	0.4791***	0.3678***	0.5682***	0.3381***	0.2106***	0.2544***
	(0.0599)	(0.0496)	(0.0510)	(0.0489)	(0.0846)	(0.0547)	(0.0528)	(0.0554)
Largest firms	0.9457***	0.4026***	0.9220***	0.6099***	0.9018***	0.4991***	0.4647***	0.4000***
	(0.1183)	(0.1131)	(0.1135)	(0.1111)	(0.1432)	(0.1125)	(0.1129)	(0.1209)
France and Belgium	0.2891***	0.3493***	0.4717***	0.4780***	-0.4501***	-0.3263***	-0.2057***	-0.2982***
	(0.0749)	(0.0668)	(0.0700)	(0.0659)	(0.1155)	(0.0757)	(0.0710)	(0.0746)
Hungary and Austria	-1.8865***	0.0186	-0.2292**	-0.0058	-1.2820***	-0.5538***	-0.4691***	-0.5123***
	(0.2832)	(0.0951)	(0.1071)	(0.0949)	(0.2893)	(0.1195)	(0.1093)	(0.1134)
Italy, Greece, Portugal and Spain	-1.0830***	-0.0787	-0.1172*	-0.0298	-1.1367***	-0.1249*	-0.1322**	-0.1117*
	(0.0980)	(0.0587)	(0.0635)	(0.0574)	(0.1528)	(0.0640)	(0.0583)	(0.0613)
Estonia, Latvia, Lithuania	-0.5415***	0.4364***	-0.1396	0.2612**	-0.7295***	-0.4817***	-0.5938***	-0.7006***
	(0.1456)	(0.1219)	(0.1274)	(0.1154)	(0.2305)	(0.1422)	(0.1453)	(0.1515)
Netherlands	0.5596***	0.6993***	0.3475***	0.4491***	-0.1304	0.0170	-0.4151***	-0.4252***
	(0.1332)	(0.1343)	(0.1315)	(0.1275)	(0.1811)	(0.1357)	(0.1454)	(0.1477)
CZ, Poland, Slovakia, Slovenia	-0.7934***	0.2097***	0.2198***	0.2815***	-0.9205***	-0.6440***	-0.2934***	-0.4614***
	(0.0892)	(0.0614)	(0.0655)	(0.0603)	(0.1399)	(0.0762)	(0.0667)	(0.0710)
Denmark, Finland and Sweden	0.3137***	0.3570***	0.1273*	0.2735***	-0.1549	0.0965	-0.0563	0.0240
	(0.0776)	(0.0710)	(0.0753)	(0.0693)	(0.1050)	(0.0733)	(0.0734)	(0.0756)
UK and Ireland	-0.0886	0.2250***	-0.1275	0.0433	0.0200	0.0653	-0.0405	-0.0070
	(0.0961)	(0.0802)	(0.0883)	(0.0792)	(0.1160)	(0.0829)	(0.0829)	(0.0855)
Food, beverages and tobacco	-0.5955***	-0.4360***	-0.3914***	-0.4144***	-0.0170	-0.0736	0.0105	-0.0274
	(0.1144)	(0.0816)	(0.0877)	(0.0801)	(0.1622)	(0.0916)	(0.0867)	(0.0898)
Textiles and leather	-0.6447**	-0.2761**	-0.6438***	-0.3655***	-5.0252	-0.6254***	-0.5461***	-0.6525***
	(0.2549)	(0.1389)	(0.1807)	(0.1415)	(12,669.3702)	(0.2224)	(0.2043)	(0.2030)
Wood and paper	-0.1239	-0.2766***	-0.3468***	-0.3393***	0.1954*	-0.1742**	0.1156*	-0.0268
	(0.0785)	(0.0631)	(0.0680)	(0.0627)	(0.1177)	(0.0717)	(0.0684)	(0.0714)

Table 4 (cont')

Variables	If firms sold some EUAs				If firms bought some EUAs			
	2005	2006	2007	2005-2007	2005	2006	2007	2005-2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Coke, cement and refined products	-0.5583***	-0.4072***	-0.1400	-0.2403***	0.1145	-0.2468***	0.2021**	0.0275
	(0.1081)	(0.0842)	(0.0862)	(0.0820)	(0.1394)	(0.0934)	(0.0871)	(0.0918)
Chemicals and pharmaceutics	-0.5092***	-0.2699***	-0.1344	-0.1535*	-0.0010	-0.0804	0.0237	-0.0183
	(0.1195)	(0.0923)	(0.0945)	(0.0886)	(0.1737)	(0.1034)	(0.0985)	(0.1031)
Glass, ceramics and plastic	-0.6907***	-0.4366***	-0.2306***	-0.2791***	-0.4582***	-0.5220***	0.1416**	-0.0947
	(0.0932)	(0.0600)	(0.0637)	(0.0585)	(0.1638)	(0.0747)	(0.0645)	(0.0680)
Metals	-0.9483***	-0.5260***	-0.2193	-0.3173**	0.3452	-0.0995	-0.0480	-0.0534
	(0.2583)	(0.1479)	(0.1575)	(0.1425)	(0.2459)	(0.1707)	(0.1650)	(0.1659)
Computers and machinery	-0.5885***	-0.5430***	-0.3872***	-0.4255***	-0.1499	0.0317	-0.2977**	-0.1817
	(0.1647)	(0.1116)	(0.1213)	(0.1093)	(0.2543)	(0.1230)	(0.1314)	(0.1276)
Other sectors	-0.3925***	-0.5760***	-0.1596***	-0.3018***	0.0786	-0.0328	-0.0078	-0.0113
	(0.0702)	(0.0587)	(0.0606)	(0.0568)	(0.1021)	(0.0638)	(0.0630)	(0.0647)
Year 2006 dummy				0.2092***				-0.3969***
				(0.0319)				(0.0349)
Net allocation (Mundlak term)				0.0004**				-0.0001
				(0.0002)				(0.0002)
Sold twice and more (lag, Mundlak term)				4.3220***				
				(0.1407)				
Bought twice and more (lag, Mundlak term)								5.4963***
								(0.2252)
Constant	-0.9087***	-0.4851***	-1.0208***	-1.2212***	-1.7477***	-0.9269***	-0.9442***	-1.1008***
	(0.0690)	(0.0606)	(0.0647)	(0.0655)	(0.0986)	(0.0652)	(0.0639)	(0.0713)
Log likelihood	-3167.0	-7301.0	-5900.8	-5373.6	-1312.3	-4645.5	-5575.4	-4743.3
Wald test (Chi2)	532.4	1736.3	1301.2	1407.7	67.3	727.6	1051.1	939.4
Wald test (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations (total)	5951	5947	6046	11993	5951	5947	6046	11993

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

Table 5 The determinants of the choice to trade allowances indirectly

Variables	If firms sold some EUAs indirectly				If firms bought some EUAs indirectly			
	2005	2006	2007	2005-2007	2005	2006	2007	2005-2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Net allocation	0.0001	0.0000	-0.0001	-0.0001	0.0001	-0.0000	-0.0000	0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0003)
No. of installation within a firm	-0.0270***	-0.0928***	-0.1014***	-0.1909***	-0.0115	-0.0633***	-0.1042***	-0.2495***
	(0.0093)	(0.0109)	(0.0124)	(0.0211)	(0.0120)	(0.0127)	(0.0139)	(0.0387)
If sold twice and more (lag)		0.2146**	0.1835**	0.4615***				
		(0.0885)	(0.0731)	(0.1316)				
If bought twice and more (lag)						-0.5588***	0.0024	0.6021***
						(0.1693)	(0.0930)	(0.2154)
Medium firms	-0.3599***	-0.1626**	0.0148	-0.1976*	-0.1860	-0.0011	-0.1838*	-0.1661
	(0.1323)	(0.0740)	(0.0833)	(0.1194)	(0.2143)	(0.1020)	(0.0943)	(0.2115)
Largest firms	-0.7284***	-0.3364**	-0.1447	-0.4871**	-0.6342**	0.2541	-0.0440	0.4855
	(0.2033)	(0.1371)	(0.1367)	(0.2175)	(0.3094)	(0.1818)	(0.1627)	(0.3853)
France and Belgium	0.3377**	0.2757**	0.5935***	0.7880***	-0.0231	-0.2637*	-0.0363	-0.3720
	(0.1690)	(0.1100)	(0.1209)	(0.1806)	(0.3130)	(0.1510)	(0.1320)	(0.3118)
Hungary and Austria	(a)	0.4550**	0.3275*	0.7130**	0.2544	-0.3508	-0.2415	-0.8434*
		(0.1809)	(0.1988)	(0.2800)	(0.9481)	(0.2572)	(0.2177)	(0.5020)
Italy, Greece, Portugal and Spain	0.4298	-0.0797	0.1336	0.0575	0.5226	-0.2784**	0.2663**	0.2474
	(0.3749)	(0.1083)	(0.1232)	(0.1714)	(0.4867)	(0.1262)	(0.1087)	(0.2532)
Estonia, Latvia, Lithuania	0.5160	0.2724	0.3346	0.5836**	0.0084	-0.5639*	-0.4164	-1.0960*
	(0.3615)	(0.1739)	(0.2155)	(0.2882)	(0.6127)	(0.2943)	(0.2901)	(0.6386)
Netherlands	0.3982*	0.1280	0.2024	0.4468	0.0622	-0.3991*	-0.3498	-0.8199
	(0.2407)	(0.1739)	(0.1938)	(0.2903)	(0.4219)	(0.2381)	(0.2653)	(0.5664)
CZ, Poland, Slovakia, Slovenia	0.2954	0.6424***	0.6790***	1.2132***	-0.1361	0.2656	0.0745	0.1627
	(0.2442)	(0.1135)	(0.1189)	(0.1851)	(0.4167)	(0.1706)	(0.1302)	(0.3079)
Denmark, Finland and Sweden	0.4246**	-0.2866***	-0.2934**	-0.4739***	0.3034	-0.7803***	-0.5752***	-1.6779***
	(0.1684)	(0.1079)	(0.1283)	(0.1790)	(0.2441)	(0.1329)	(0.1285)	(0.3159)
UK and Ireland	0.2588	0.1899	0.0098	0.3024	0.5870**	0.1322	0.0645	0.3191
	(0.2242)	(0.1343)	(0.1627)	(0.2198)	(0.2768)	(0.1487)	(0.1464)	(0.3285)
Food, beverages and tobacco	-0.3612	-0.3374**	-0.3420**	-0.6981***	-0.9141*	-0.1667	-0.2130	-0.6059
	(0.2830)	(0.1341)	(0.1613)	(0.2197)	(0.4849)	(0.1815)	(0.1679)	(0.3734)
Textiles and leather	(a)	0.1470	-0.2036	0.1476	(b)	0.1618	-0.6241	-1.0922
		(0.2821)	(0.4246)	(0.4944)		(0.5665)	(0.5339)	(1.0909)
Wood and paper	-0.5374***	-0.0634	-0.3119***	-0.2747*	-0.3861	-0.0920	-0.3668***	-0.7947***
	(0.1741)	(0.0998)	(0.1187)	(0.1633)	(0.3000)	(0.1424)	(0.1301)	(0.3060)

Table 5 (cont')

Variables	If firms sold some EUAs indirectly				If firms bought some EUAs indirectly			
	2005	2006	2007	2005-2007	2005	2006	2007	2005-2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Coke, cement and refined products	-0.9202***	-0.1701	-0.4540***	-0.5212***	-0.1726	-0.2452	-0.3672**	-0.9351***
	(0.2236)	(0.1257)	(0.1318)	(0.1938)	(0.3381)	(0.1744)	(0.1489)	(0.3526)
Chemicals and pharmaceutics	-0.2772	0.0107	-0.0764	-0.0117	0.0987	0.1011	-0.4102**	-0.5349
	(0.2877)	(0.1494)	(0.1624)	(0.2382)	(0.4544)	(0.2002)	(0.1841)	(0.4272)
Glass, ceramics and plastic	0.0349	0.2011*	-0.1278	0.0742	0.3296	0.0318	-0.1264	-0.1366
	(0.3357)	(0.1122)	(0.1193)	(0.1704)	(0.5701)	(0.1626)	(0.1259)	(0.2953)
Metals	-1.1287*	0.3463	-0.1863	0.2017	-1.0896	0.4688	0.2071	0.5382
	(0.6012)	(0.3171)	(0.2875)	(0.4229)	(0.6891)	(0.3768)	(0.3555)	(0.7395)
Computers and machinery	(a)	-0.4921**	0.2007	-0.5763*	0.4708	0.0780	0.0636	0.0525
		(0.2055)	(0.2649)	(0.3352)	(0.6952)	(0.2423)	(0.2824)	(0.5467)
Other sectors	-0.6247***	-0.2843***	-0.2186**	-0.5326***	-0.1758	-0.1394	-0.2719**	-0.6541**
	(0.1562)	(0.0923)	(0.1033)	(0.1506)	(0.2456)	(0.1180)	(0.1150)	(0.2590)
Year 2006 dummy				0.5945***				0.1097
				(0.0890)				(0.1380)
Net allocation (Mundlak term)				0.0000				-0.0002
				(0.0003)				(0.0003)
Sold twice and more (lag, Mundlak term)				-0.1505				
				(0.1973)				
Bought twice and more (lag, Mundlak term)								-2.0458***
								(0.4336)
Constant	1.2932***	0.7967***	0.4007***	0.9497***	0.1631	0.3958***	0.6386***	1.6647***
	(0.1590)	(0.0973)	(0.1101)	(0.1762)	(0.2458)	(0.1237)	(0.1173)	(0.3058)
Log likelihood	-339.7	-1152.3	-946.1	-1985.9	-150.6	-677.1	-856.5	-1415.3
Wald test (Chi2)	70.8	291.5	253.4	190.1	22.8	133.9	192.8	88.1
Wald test (p-value)	0.000	0.000	0.000	0.000	0.297	0.000	0.000	0.000
Observations (total)	749	2,175	1,603	3,778	234	1,078	1,380	2,458

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
(a) Dropped as predicts success perfectly.
(b) Omitted because of collinearity.

Table 6 The determinants of the extent of trading (Hurdle 2)

Variables	If firms sold some EUAs				If firms bought some EUAs			
	2005	2006	2007	2005-2007	2005	2006	2007	2005-2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Net allocation	0.0001	0.0001	0.0001	-0.0000	-0.0004***	-0.0005***	-0.0003***	-0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
No. of installation within a firm	0.0238**	0.0216**	0.0370***	0.0192***	0.0078	0.0142	0.0186*	0.0052
	(0.0102)	(0.0085)	(0.0093)	(0.0073)	(0.0200)	(0.0119)	(0.0105)	(0.0091)
If sold twice and more (lag)		0.7890***	0.3098***	-0.4947***				
		(0.0949)	(0.0866)	(0.0731)				
If bought twice and more (lag)						0.9912***	0.4762***	-0.6704***
						(0.2292)	(0.1211)	(0.1237)
Medium firms	1.6913***	1.6800***	1.8377***	1.6086***	2.1063***	1.7664***	1.8840***	1.6657***
	(0.1344)	(0.0785)	(0.0983)	(0.0671)	(0.3947)	(0.1450)	(0.1232)	(0.1003)
Largest firms	3.6781***	4.0021***	3.6058***	3.6019***	2.8316***	3.8874***	3.7584***	3.5579***
	(0.2218)	(0.1498)	(0.1632)	(0.1242)	(0.5577)	(0.2503)	(0.2092)	(0.1765)
France and Belgium	0.0362	0.0905	0.3266**	0.2156**	-0.2892	0.2277	-0.3205*	-0.1069
	(0.1728)	(0.1183)	(0.1441)	(0.0998)	(0.5728)	(0.2216)	(0.1745)	(0.1467)
Hungary and Austria	-1.8908*	-0.4965***	-0.8426***	-0.5311***	-1.7688	-0.6932*	-1.0684***	-0.8297***
	(1.1075)	(0.1854)	(0.2416)	(0.1566)	(1.7434)	(0.3815)	(0.2923)	(0.2403)
Italy, Greece, Portugal and Spain	-0.5326	-0.0825	0.0450	0.0334	-0.9343	-0.1905	-0.2253	-0.1429
	(0.3414)	(0.1200)	(0.1519)	(0.1003)	(0.9026)	(0.1872)	(0.1427)	(0.1201)
Estonia, Latvia, Lithuania	-1.4706***	-0.6769***	-0.4469*	-0.5089***	0.0240	-0.7781*	-1.0699***	-0.9575***
	(0.3443)	(0.1854)	(0.2585)	(0.1614)	(1.1562)	(0.4329)	(0.3884)	(0.3072)
Netherlands	-0.8776***	-0.3024	0.0422	-0.1741	-1.4618*	-0.1577	0.0304	-0.1291
	(0.2618)	(0.1926)	(0.2419)	(0.1673)	(0.7813)	(0.3459)	(0.3564)	(0.2642)
CZ, Poland, Slovakia, Slovenia	-0.4316*	0.3756***	0.2726*	0.3490***	-0.1677	-0.5576**	-0.5317***	-0.3845***
	(0.2475)	(0.1145)	(0.1402)	(0.0955)	(0.7819)	(0.2452)	(0.1723)	(0.1474)
Denmark, Finland and Sweden	-0.7157***	-1.2715***	-1.6279***	-1.2961***	-0.6224	-1.0209***	-1.6537***	-1.3385***
	(0.1772)	(0.1220)	(0.1568)	(0.1049)	(0.4541)	(0.1877)	(0.1665)	(0.1334)
UK and Ireland	0.3806	0.2514*	0.0593	0.2274*	-0.3309	0.1736	-0.0584	-0.0369
	(0.2345)	(0.1463)	(0.2018)	(0.1268)	(0.5020)	(0.2176)	(0.1938)	(0.1548)
Food, beverages and tobacco	-0.5565*	-0.1342	-0.1686	-0.1240	0.9859	-0.3252	-0.2345	-0.1767
	(0.2852)	(0.1493)	(0.1933)	(0.1255)	(0.8416)	(0.2664)	(0.2199)	(0.1760)
Textiles and leather	-1.0333	-0.4194	-1.2068**	-0.5313**		-0.8028	-0.1769	-0.3365
	(0.7842)	(0.2735)	(0.4913)	(0.2546)		(0.8635)	(0.7158)	(0.5402)
Wood and paper	-0.3003*	0.1796*	-0.0588	0.0622	0.7892	-0.1569	-0.2566	-0.1635
	(0.1724)	(0.1066)	(0.1436)	(0.0925)	(0.5579)	(0.2081)	(0.1714)	(0.1406)

Table 6 (cont')

Variables	If firms sold some EUAs				If firms bought some EUAs			
	2005	2006	2007	2005-2007	2005	2006	2007	2005-2007
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Coke, cement and refined products	-0.0336	0.0905	0.0474	0.1275	0.5037	-0.0627	0.0409	0.1005
	(0.2501)	(0.1380)	(0.1596)	(0.1125)	(0.6323)	(0.2547)	(0.1972)	(0.1647)
Chemicals and pharmaceutics	0.3326	0.2743*	-0.0604	0.2235*	0.7972	0.0778	-0.2691	-0.0737
	(0.2853)	(0.1559)	(0.1904)	(0.1314)	(0.8565)	(0.2964)	(0.2474)	(0.2024)
Glass, ceramics and plastic	-0.9044***	-0.2198*	-0.5026***	-0.2561***	0.6853	-0.3781	-0.6095***	-0.4334***
	(0.2795)	(0.1129)	(0.1414)	(0.0938)	(1.0221)	(0.2381)	(0.1636)	(0.1397)
Metals	0.4963	0.2564	0.3159	0.3112	-0.8942	-0.1127	-0.2165	-0.1333
	(0.7029)	(0.2816)	(0.3331)	(0.2228)	(1.1778)	(0.5241)	(0.4465)	(0.3509)
Computers and machinery	-0.5186	-0.1888	-0.2039	-0.1912	-0.1647	-0.4635	-0.1629	-0.2970
	(0.4619)	(0.2305)	(0.2988)	(0.1934)	(1.2594)	(0.3508)	(0.3635)	(0.2598)
Other sectors	-0.3680**	-0.1580	-0.3159***	-0.1657**	0.2274	-0.3418**	-0.5422***	-0.3669***
	(0.1545)	(0.0993)	(0.1207)	(0.0829)	(0.4556)	(0.1685)	(0.1488)	(0.1187)
Year 2006 dummy				-0.2002***				-0.4974***
				(0.0485)				(0.0756)
Net allocation (Mundlak term)				0.0001				-0.0003*
				(0.0001)				(0.0002)
Sold twice and more (lag, Mundlak term)				1.6679***				
				(0.1102)				
Bought twice and more (lag, Mundlak term)								2.2489***
								(0.1983)
Constant	2.7398***	2.1888***	2.2496***	2.0373***	1.1867***	1.6296***	2.0427***	1.8499***
	(0.1580)	(0.1041)	(0.1320)	(0.0942)	(0.4565)	(0.1765)	(0.1503)	(0.1267)
F-test (Wald test (Chi2) for panel models)	24.630	78.090	58.300	2583	3.060	32.370	46.980	1501
F-test (p-value) (Wald test (p-value) for panel models)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Observations	767	2 175	1 603	3,778	234	1 078	1 380	2,458
R-squared (within for panel models)	0.410	0.444	0.448	0.031	0.223	0.403	0.423	0.0301

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