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Working Paper 12/165
August 2012

Economics Working Paper Series

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

# Verified emissions and stock prices: Is there a link? - An empirical analysis of the European Emission Trading Scheme

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August 28, 2012

**Abstract**

This study examines the relation of stock returns and the announcements on verified emissions in the European Emission Trading Scheme (EU ETS). In a first step we employ event study methods to detect possibly abnormal returns on the respective announcement dates using a sample of quoted stock market firms from Austria, Denmark, Germany and the UK. In a second step we link the estimated abnormal returns to firm characteristics based on the EU ETS (such as verified emissions or over-allocation) as well as to financial firm level data in a cross-sectional analysis. Even though the overall cost from the new regulation on the individual firms was minor, we find evidence for the asset value hypothesis, which states that higher verified emissions induce a higher future permit allocation. This suggests that investors did not perceive the EU ETS in its first set-up as an efficient and effective environmental policy instrument.

*Keywords: Event study, European emission trading scheme, Regulation, Verified Emissions, Emission trade*

*JEL classification: G14, Q48, Q52*

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# 1 Introduction

There is widespread consensus that the climate is changing because of anthropogenic greenhouse gas (GHG) emissions and that worldwide effort is needed to fight the subsequent negative consequences. Agreement on the instruments and their impacts on development or economic prosperity is far from being broad, however. Under the Kyoto Protocol, adopted in 1997, the European Community decided to cut its GHG emissions by overall 8% between 2008 and 2012 relatively to 1990 levels. Even before the ratification of the Kyoto Protocol the EU intended to launch an emissions trading scheme to gain experience, as a global trading system was expected to be introduced in 2008.[1] Implementing an emission trading scheme generally has the following direct impacts: i) it forms an additional cost to the producing firm and ii) when permits are allocated for free (grandfathered), firms maintain a valuable asset. These effects work in different directions and are supposed to occur in varying intensity for countries, sectors and points in time, depending very much on the characteristics of the trading scheme.

In 2003 the basic conditions of the European market for emission allowances (or permits) were agreed on, where one allowance gives the right to emit one ton of $CO_2$. In the first phase of the EU ETS emissions permits were predominantly grandfathered to the affected firms by allocation mechanisms formed by national politicians. During the three years of the first period firms could bank and borrow within the years, however, no exchange with later periods was allowed, so that the first period was a self-contained market unaffected by future caps. The general rules are given by the Commission, however, there is a wide delegation of tasks to the member states concerning allocation procedures, registration of firms, their certificates and emissions as well as the setting of an overall country-specific emissions cap.

In this paper we analyze how the implementation of the EU ETS affected the involved firms' stock returns. By conducting an event study, we can detect how investors value information about announcements concerning verified emissions. One would expect to find positive as well as negative abnormal returns as a reaction on the general information about the emissions trading market. The announcement of the effective emissions reveals information about the true amount of emissions needed for stock market participants. Investors can then correct their beliefs about the used technologies and applied abatement possibilities of the individual firm and hence stock prices react. In the cross sectional analysis we find evidence for the asset value hypothesis and only weak evidence for the abatement hypothesis, suggesting that investors were more concerned about the asset value of the permits issued to the firms than the induced abatement.

[1] See the Green Paper on greenhouse gas emissions trading within the European Union (European Comission 2000).

The remainder of the paper is organized as follows. In Section 2 we present an overview of the related literature. Section 3 discusses regulation and performance related issues. In Section 4 we state our hypotheses. Section 5 presents the employed financial and EU ETS data. In Section 6 we introduce the event study methodology employed in this paper. Section 7 presents the empirical results. Finally, Section 8 concludes.

## 2 Literature overview

Several studies evaluate the efficiency of the EU ETS. This brief overview of the existing literature concentrates on studies concerning individual firms and the development of the permit price in the first period.

Focusing on the competitive situation and its change, Demailly and Quirion (2008) do not find any evidence for a negative effect on the competitiveness from emissions trading for the iron and steel industry, a sector that is strongly exposed to competition from outside of the EU. In their cross-country analysis they find rather high evidence for a moderate cost pass-through and therefore conclude that concerns about the competitive situation are no reason not to tighten the cap in the second period. Sijm et al. (2006) test empirically if a change in the permit price is passed through on the end prices and find strong evidence for so called windfall profits for German and Dutch electricity producers. They conclude that firms with market power can profit from regulation if the permits are grandfathered. The free allocation of emission allowances then mainly gives the respective firm an additional income opportunity. In a simulation with UK data Smale et al. (2006) find mostly positive changes in earnings (EBITDA), depending on the energy-intensity and the exposure to international competition of the sector. These findings are supported by the study of Bovenberg and Goulder (2000), finding that mostly a small allocation of emission allowances is sufficient to fully compensate for changes in profits due to $CO_2$ costs.

Emission permits have become a new input factor in production for the firms covered by the EU ETS. Therefore several studies focus on the development of permit prices. Before the start of the EU ETS Christiansen et al. (2005) propose, by reviewing other emission markets, that the permit prices will be mainly driven by policy and regulatory issues, market fundamentals, temperature development, and technical indicators. Alberola et al. (2009) analyze the price development in the first phase of the EU ETS and at the start of the second phase. They find that the market for tradable permits is highly sensitive to the ratio between the overall cap and the needed certificates. Interestingly, they find evidence for a high degree of heterogeneity in the agents' anticipations, what might be explained by the lack of

experience of traders. Ellerman and Buchner (2008) take a first look at the allocation data and analyze sectoral and country specific allocation differences and derive some first conclusions about the impact on permit prices. Using event-study methodology, Mansanet-Bataller and Pardo (2007) analyze the effect of official announcements from the European Commission concerning the EU ETS on permit prices and find a general sensitivity of permit prices to such announcements.

Hintermann (2010), as well as Montagnoli and de Vries (2010), find evidence that the market for permits in the first part of phase I was not efficient. Hintermann (2010) divides phase I into two periods: before April 2006 and from April 2006 on, because of the significant price drop of permits in late April 2006. He sets up a model which seeks to explain the price evolution with economic fundamentals.[2] The results are that, in the pre-crash period, prices are rarely explained by economic fundamentals, whereas in the post-crash period they are. He concludes that this is due to a lack of market efficiency in the pre-crash period. Montagnoli and de Vries (2010) use several variance ratio tests to check the efficient market hypothesis on permit prices. Their results suggest that the efficient market hypothesis holds in the phase II period whereas it does not hold in phase I. Interestingly they find some support (albeit weaker than for phase II) that the efficient market hypothesis holds also in the post-crash period, supporting the findings of Hintermann (2010).

Oberndorfer (2009) and Veith et al. (2009) examine the relation between stock returns of corporations of the European power sector and returns of permits. They both find that stock returns of electricity producers and permit prices are generally positively related, and interpret this finding as evidence for the possibility of firms from the power sector to create windfall profits by overcompensating permit costs.

To our best knowledge the only event study relating corporate stock returns to EU ETS events so far is Bushnell et al. (2011). They conduct an event study to detect the impact of the permit price crash in late April 2006 on 548 firms covered by the EU ETS. The authors find evidence for a sector specific reaction on permit price changes and a positive relationship between the permit price drop and the stock returns and conclude that the market mainly sees permits as an asset.

In this paper we rather focus on the impact of verified emissions and the closely linked policy issues like the overall emissions cap and the grandfathered permits. Whereas the above mentioned studies relate the impact of the permit price to firm returns.

[2]Hintermann (2010) develops a model which is based on the idea that the optimal amount of abatement is a function of allowance prices and fundamental variables like temperature, precipitation, Nordic reservoir levels, stock market conditions and other influences. The empirical implementation of this model regresses permit price changes on changes of the aforementioned variables.

## 3 Regulation and performance

The first decision the member states had to take were on the following two issues: the overall emissions cap and the affected firms. A country's overall cap is mainly determined by the given reduction target and the already established reduction efforts[3] or the intention to make use of flexible mechanisms as for example clean development mechanism (CDM) and joint implementation (JI).[4]

Thereafter, certificates could be allocated according to the guidelines given in Art 2003/87/EC. An in-depth analysis of the role of the central register, the Community Independent Transactions Log (CITL), played in the first period of the EU ETS is given in Trotignon and Delbosc (2008). According to Zapfel (2007), the main characteristics of the allocation process are the ex-ante nature (no possibilities to change the national allocation plan after the Commissions verification), the periodic decision-making and the strong central control by the Commission.

In the first period, auctioning of permits was allowed for up to 5% of a member states total allocation, however, most countries chose to grandfather 100% in the first allocation round.[5] After the questions about the cap and the general allocation mechanisms were answered, the member states had to decide on potentially more political questions; as on the allocation between the sectors and the individual installations. Most countries chose to set sectoral caps considering different forms of compliance factors and, if applicable, some form of benchmarking to decide on the allocation on the installation level.[6]

For most of the member countries no data were available for the $CO_2$ emissions in appropriate disaggregated form, so collection of the data was an important and time sensitive task. Only the UK and Denmark did have an emissions trading scheme installed before 2005, hence, for most stakeholders the situation was new and the possible economic consequences for the firms of this new asset was at least insecure. Therefore the public consultation and securing of political acceptability was a big issue during the allocation process both between and within the countries (Convery 2009).

The countries considered in this study – Austria, Denmark, Germany and the UK – chose different allocation processes and started with very different preconditions, which qualifies them as interesting examples for the study at hand. The main difference is certainly the size of the countries and therefore

[3] For example in the transportation sector or for private households.

[4] In the first phase there was generally no limit for how much emissions reductions firms could realize through CDM or JI, looking at the 2005 to 2010 market data summarized in the World Bank's 2011 contribution (Linacre et al. 2011) we see that the share of CDM to the total of all allowances has been constantly between 16 and 28%.

[5] Only Hungary, Ireland and Lithuania chose to auction part of the allowances, Denmark sold 5% of the certificates with help of professionals. For a discussion on auction versus grandfathering see Cramton and Kerr (2002).

[6] Austria, Belgium, Denmark, Lithuania and the Netherlands explicitly used some sort of benchmarking mechanism in their allocation.

the size of the share of total emissions (Trotignon and Delbosc 2008). As well as the already mentioned fact that the UK and Denmark already had an emissions trading scheme before the EU ETS.

# 4 Hypotheses

In this section we postulate the hypotheses which are analyzed later on in the empirical part of the paper (Section 7). Subsection 4.1 deals with connections on the firm level which may be plausible explanations for systematic over- or under-performance on the event dates. Subsection 4.2 discusses the possible aggregated effects of verified emissions announcements on the overall sample.

The introduction of an environmental regulation aims at internalizing an external effect. For the affected firms producing by emitting $CO_2$ became costly after the first of January 2005. In the first phase, from 2005 until the end of 2007, the permits were mostly allocated to the respective firms for free, so that only a difference in the amount of needed permits versus the amount of freely allocated permits affected a firm's expected return relative to the unregulated situation. A divergence between the amount of allocated permits and the needed ones was very likely, however. The allocation of permits remained fix for a three years time period. But the need for permits depends on variable and uncertain parameters as the development of the demand and the change in abatement possibilities.[7] The biggest possible mismatch between the freely distributed and the needed amount of permits, however, changes in value with the overall need for permits.[8]

## 4.1 Impact on firm performance

For the respective firms there are two possibly simultaneous and inverse effects on their expected returns if their verified emissions deviate from the allocated permits:

- *Abatement effect*: production costs are lower (higher) with higher (lower) resulting over-allocation and increase (decrease) a firms' expected profit.
- *Asset value effect*: any higher (lower) realization of verified emissions, increases (decreases) the expected value of permits distributed in future periods and increases (lowers) therefore a firms' expected profit.

[7] Natural gas is seen as one of the main abatement possibilities (switch from electricity production with coal or oil to gas (Mansanet-Bataller et al. 2007, Hintermann 2010)), the mark-up in price denotes then the (variable) abatement cost.

[8] According to Mansanet-Bataller and Pardo (2007) and Conrad et al. (2012) the price for allowances depends mainly on macroeconomic factors, institutional changes and gas prices.

How strong these effects are for a certain firm depends on the intensity of $CO_2$ in the production process and how big the share of costs related to emissions permits is relative to other input factors. It is also expected that these two effects are strongly related to each other, and therefore are not completely separable.

Our goal is to identify the total effect that news about verified emissions have on stock prices. The above mentioned effects on a firms expected profit are supposed to be incorporated into the stock market as soon as investors update their expectations; and therefore so-called "abnormal returns" may occur, when the market learns about news regarding verified emissions.

In the remaining part of this subsection we discuss how the match of allocation works in detail, how preliminary information is supposed to be incorporated into firm returns and the relevance of the verified emissions announcements regarding firm returns in general.

**Match of allocation**: In the first quarter of 2006, 2007, 2008 and 2009 respectively the central register CITL published the verified emissions of the previous year. Looking at these four events we expect to see an adjustment in the stock prices for those firms with a distinct over- or under-allocation. Especially in May 2006 investors could verify for the first time if the permits were appropriately allocated or not. Under the abatement hypothesis firms with a distinct over-allocation are supposed to show a positive abnormal return (and a negative one for firms short in allocations), as their profit expectations could be upgraded by an additional component. These firms are supposed to be able to gain benefits from selling its spare permits. The firms with a distinct under-allocation need to buy additional permits and therefore we expect to find negative abnormal returns for them. Under the asset value hypothesis this relation turns out to be somewhat the other way around. The higher the verified emissions of firms are, the higher is the number of permits which they expect to receive in the next period. Therefore verified emissions itself are seen as an asset and the more unanticipated verified emissions are reported, the more abnormal returns will be generated. Additionally we expect to find positive abnormal returns for firms with a positive change in verified emissions.

**Preliminary information**: The two events reflecting preliminary information about the emissions are supposed to show no significant cumulated abnormal returns as no details on the firms are announced then. Industries that are supposed to be long in allowances possibly lose from the drastic devaluation of the permits in late April 2006.

**Relevance**: Finally note that the arguments outlined above apply only to the degree of relevance it has for the firms decision processes. We already noted that permits have been cheap enough – at least

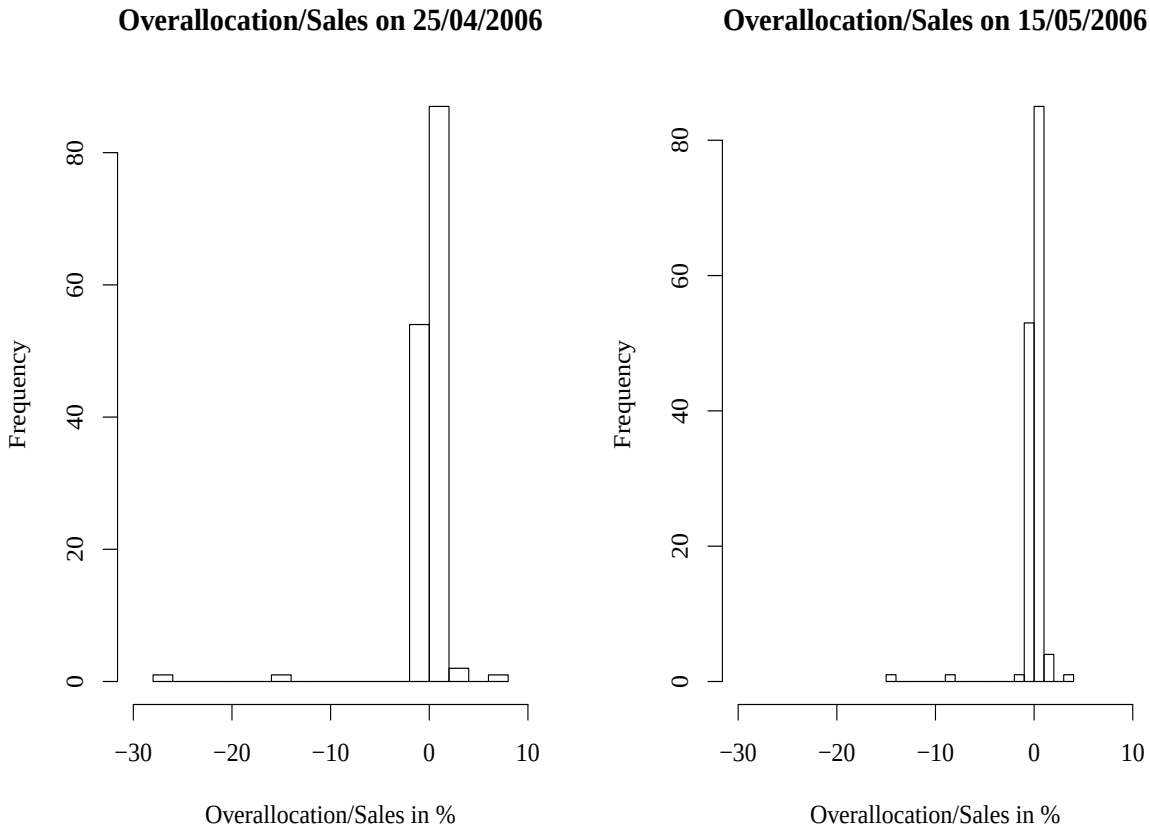


Figure 1: This figure shows over-allocation times permit price divided by sales for 25/04/2006 (left panel) and 02/05/2006 (right panel). *Source:* Own calculations based on data provided by the CITL and Thomson Reuters Datastream.

for some time periods – to be of rather minor relevance in the first compliance period of the EU ETS. Therefore, investors response is expected to be small as well and hence the reaction of stock market prices are marginal. We report under-allocation multiplied with the permit price divided by sales, hereafter called *relative abatement costs*, to get an idea of how "big" possible gains or losses are economically. Figure 1 shows the histogram of all firms in the sample for 25/04/2006 (left panel) and 15/05/2006 (right panel). The left panel shows the distribution before the sharp price drop of permits in late April 2006, the right panel a few days after it. Even before the price drop there are only two firms whose relative abatement cost exceeds five per cent (26.80 an 14.96 respectively). For all other firms the under-allocation is rather small, or they have an over-allocation of permits. Since permit prices have been lower for the other event dates in this study, the relative abatement costs are always below the 25/04/2006 values, being at most 15 % for all the other cases. Table 1 shows the descriptive statistics of the relative

abatement cost for the two dates discussed as well as for the remaining event dates.

Table 1: Descriptive statistics - Over-allocation times price divided by sales

| Date | Obs | Min | Max | Med | Mean | SD |
|---|---|---|---|---|---|---|
| 25/04/2006 | 146 | −26.80 | 6.09 | 0.00 | −0.13 | 2.65 |
| 15/05/2006 | 146 | −14.89 | 3.39 | 0.00 | −0.07 | 1.47 |
| 02/04/2007 | 148 | −0.83 | 0.20 | 0.00 | −0.01 | 0.09 |
| 08/05/2007 | 148 | −0.42 | 0.10 | 0.00 | −0.00 | 0.05 |
| 28/05/2008 | 148 | −14.19 | 4.26 | 0.01 | −0.00 | 1.68 |
| 31/03/2009 | 184 | −12.05 | 3.31 | 0.00 | −0.07 | 1.06 |

Note: The table shows descriptive statistics of the fraction of over-allocation times price divided by sales in percent. We report the date of the calculation (Date), the number of firm observations (Obs), minimum (Min), maximum (Max), median (Med), mean (Mean) and standard deviation (SD).

We expect individual reactions of stock market returns, especially for the events when the firms announce their verified emissions. Firms that invest in abatement technology and by that reduce their emissions, can profit from a resulting over-allocation, given the abatement hypothesis applies. However, for firms with a distinct under-allocation profit expectations are downgraded and we expect to see negative abnormal returns. For both situations the effect is strongest for the first time the market learns about a distinct over- respectively under-allocation. Given the observation on the relative abatement costs, one has to bear in mind, that it will be hard to find strong evidence for the stated hypotheses because the potential gains or losses are rather small for most of the firms. This applies especially for the two event dates in 2007, where the permit price was almost zero.

## 4.2 Impact on the overall sample

Traditional event studies cumulate the standardized abnormal returns of the firms that are affected by an event to make a statement about how much the specific event influences stock market returns.[9] In our analysis we expect to see the following cumulated effects:

**A Positive cumulated abnormal return** can occur when the permits market happens to be less tight than expected by investors. The majority of the firms have a lower additional marginal emissions cost and therefore the expected return rises (this would correspond with a general over-allocation). The same effect appears when the firms "over-abated" and the regulation leads to efficiency enhancing investments,

[9] See Section 6 for the respective literature and more detailed explanations.

that not only reduce the emissions intensity of production but also upgrade the general competitive situation.[10] Without a change of the production costs, an update of the expected returns is needed, when the firms realize windfall profits.[11] That means that the costs of the permits can be more than shifted on to the customers.

**A Negative cumulated abnormal return** occurs analogue to a positive cumulated abnormal return when the firms publish surprisingly high verified emissions. The costs of production are higher than expected and the investors downgrade their expectations and negative abnormal returns can be observed.

**No cumulated abnormal return** is seen when the majority of the stock returns do not react in the same direction because of the evaluated event. When there exist significant differences, either on a country-, sectoral- or even firm-specific level we expect no cumulated abnormal return as diverging effects can compensate for each other. A second possibility for no cumulated abnormal returns is when the investors do not react on the new information, so that no abnormal return occur at all.

# 5 Data

Our estimations are based on information of all installations covered by the EU ETS as stated in the central register.[12] First, we group the installations on the firm level and then match them with financial data from Thomson Reuters Datastream.[13]

We analyze the dates shown in Table 2. On two dates preliminary information from several countries leaked into the market, thereby no information about the individual firm's verified emissions were available. On the four other dates the verified emissions of the previous year were officially announced by the central register.

In total we are able to identify 206 quoted stock companies from Austria, Denmark, Germany and the UK that have installations obliged by the EU ETS. We are able to cover 24% of 2005 allocated permits or 26% of 2005s verified emissions respectively (see Figure 2). For the particular estimations, however, we had to use substantially smaller samples as we controlled for confounding effects in the period of three days around the event.[14] As the considered events were all in March, April or May, many firms

[10] For a discussion between over-allocation and abatement see Ellerman and Buchner (2008).

[11] See Veith et al. (2009) and Sijm et al. (2006).

[12] We use information on verified emissions and distributed permits we found on the Database extract of the CITL as of 05/06/2009. Currently you find most of the information on `http://ec.europa.eu/environment/ets/`.

[13] We assume that reallocation of permits within a firm is cost-free.

[14] We checked the main newspapers on LexisNexis of the respective country to ensure that no other unforeseeable event led to a jump in stock prices (see McWilliams and Siegel 1997). Such confounding events can be earnings announcements, restructuring announcements, changes in analyst reports or similar events. News related to the EU ETS are explicitly not considered as confounding events.

Table 2: Event dates

| Date | Description | Peculiarity |
|---|---|---|
| 25/04/2006 | Preliminary information of 2005 verified emissions | No individual information |
| 15/05/2006 | Verified emissions 2005 | |
| 02/04/2007 | Preliminary information of 2006 verified emissions | No individual information |
| 08/05/2007 | Verified emissions 2006 | |
| 28/05/2008 | Verified emissions 2007 | |
| 31/03/2009 | Verified emissions 2008 | Second compliance period |

Note: This table lists the event dates considered in this study. Source: The European Community Transaction Log.

had to be excluded because they reported their annual financial accounting at this time of the year. The possibility of new information not yet incorporated in the respective stock prices was then substantial. Further exclusions were made due to liquidity issues. To control for sufficient liquidity of each stock, we impose minimum requirements related to trading characteristics of the respective stocks in the estimation and event window. More specific: stocks that had not been traded (that means we do not observe a price change) on at least 60% of all days, excluding holidays and stocks without a price change on more than ten successive days were excluded.

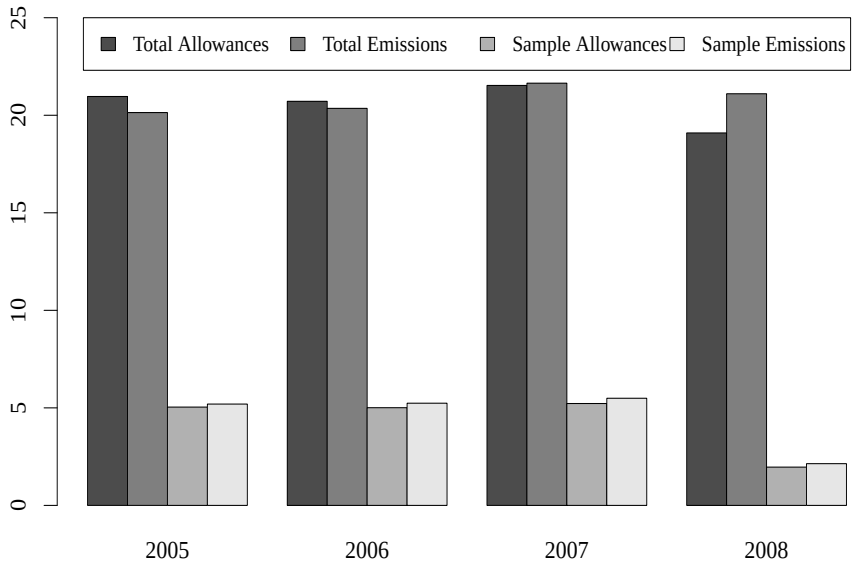


Figure 2: This figure shows total allowances distributed by the CITL (dark), total verified emissions (light) and the respective values for our sample. *Source:* Own calculations based on data provided by the CITL.

# 6 Methodology

This section describes the event study approach we employ in the empirical part of the paper (Section 7). It is based on Campbell et al. (1997, ch. 4) and we assume that information is incorporated into the market within a few days; namely within the period of three days before the event date until three days after the event date. Furthermore we rely on the efficiency of financial markets (see McWilliams and Siegel 1997, p.630), which seems to be sufficiently justified.[15]

We use the following factor model to describe daily stock returns:

$$R_{it} = \alpha_i + \boldsymbol{x}_t \boldsymbol{\beta}_i + \varepsilon_{it} \tag{1}$$

where $R_{it}$ denotes the return of stock $i$ in excess of the risk free rate and $\alpha_i$ is a firm-specific intercept that we include to account for a possible systematical over- or under-performance unrelated to the risk factors. The vector $\boldsymbol{x}_t$ includes the following factors:

- the return of the market portfolio,
- the Fama-French factors which account for systematic size and value respective growth influences,[16]
- the return of the emission certificate spot or future price,[17]
- the return of the oil, gas and electricity forward price and
- the return of the forward dollar exchange rate of the domestic currency,

all in excess of the risk free rate in time $t$ (with the Fama-French factors being the exception, because they are already constructed as long-short portfolios). The factor sensitivities of stock $i$ are denoted by $\boldsymbol{\beta}_i$. $\varepsilon_{it}$ is an error term with expectation zero, a constant variance and no serial correlation.

Most event studies employ the one factor model based on the CAPM which incorporates the excess return of the market portfolio only. We use an expanded model for two reasons: First, since we examine events which occur to all firms at the same time, cross sectional correlation might be a serious problem. Kolari and Pynnönen (2010) show that by adding the Fama-French factors (see Fama and French (1993)) to the one factor model, the cross sectional correlation of the error terms are reduced intelligibly. Second,

[15] See e.g. Fama (1991) in general and for our application Hintermann (2010) and Montagnoli and de Vries (2010).
[16] For a detailed description of the Fama-French factors employed here see the Appendix A.
[17] Prices are taken from the EEX, the European Energy Exchange AG.

the price evolution of emission certificates, oil, gas and electricity are likely to be linked to stock prices (e.g. Oberndorfer 2009, Veith et al. 2009). We therefore include the respective return series.

By estimating equation (1) and subtracting the fitted returns $\hat{R}_{it}$ from the actual returns $R_{it}$, we obtain the abnormal returns for firm $i$:

$$AR_{it} = R_{it} - \hat{R}_{it}, \tag{2}$$

thereby data of the last $-L-9$ to $-9$ days before the event date (which is $t = 0$) is used for the estimation, with $L$ the length of the estimation window as shown in Figure 3.[18]

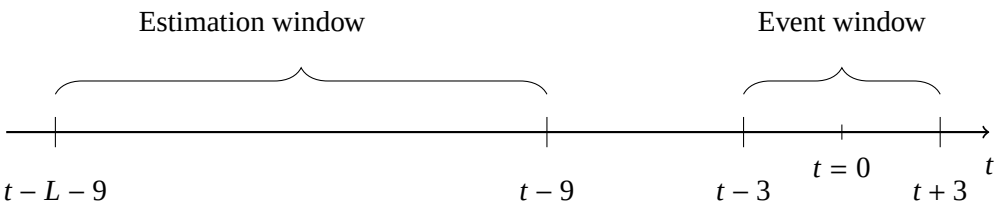


Figure 3: Sequence of estimation and event window

The abnormal returns are estimated according to equation (2) for all days of the so-called event window which ranges from day -3 to day 3. We also calculate *scaled cumulative abnormal returns* (*SCAR*) over various time intervals:

$$SCAR_i^{t_1,t_2} = \frac{\sum_{t=t_1}^{t_2} AR_{it}}{s_i}, \tag{3}$$

where $s_i$ is an estimate of the standard deviation of the cumulative abnormal returns and $(t_1, t_2) \in \{(-3,3), (-3,1), (-1,1), (-1,3), (0,0)\}$.[19] To asses the general impact of the event we calculate *average scaled cumulative abnormal returns* (*ASCAR*) over all firms affected by the event:

$$ASCAR^{t_1,t_2} = \sum_{i=1}^{N} SCAR_i^{t_1,t_2}, \tag{4}$$

where $N$ is the total number of firms.

To conduct inferences whether the event in question has an impact on stock returns, we calculate the statistic proposed by Kolari and Pynnönen (2010), which is an adjustment of the $t$ statistic proposed by Boehmer et al. (1991), taking cross-correlation into account:

[18] We chose the length of the estimation window to be $L = 200$, except for the 25/04/2006 ($L = 175$) and the 15/05/2006 ($L = 190$), depending on the availability of the emission certificate spot and future series.

[19] For details see Kolari and Pynnönen (2010) or Campbell et al. (1997).

$$t_{AB} = \frac{ASCAR^{t_1,t_2} \cdot \sqrt{N}}{s_A \sqrt{1 + (N-1)\bar{r}}} \tag{5}$$

where $s_A$ is the square root of a feasible estimator of the abnormal return variance and $\bar{r}$ is the average of the sample cross-correlations of the estimation-period residuals.[20]

We include the market and Fama-French factors on the country level, as local factors provide a better description of average returns than global factors (see Griffin 2002, Fama and French 2012). In the event study literature it is well-known that local factors provide accurate inferences (e.g. Campbell et al. 2010). All returns are denominated in euro values and we use so-called "lumped returns", which means that a zero return is obtained if there is no trade.[21]

# 7 Results

In this section we first discuss the results from the event study (Subsection 7.1). In a second step these results are analyzed with cross sectional methods to shed light on the mechanisms which influence the reaction of investors (Subsection 7.2). In a third step we conduct several robustness checks of the cross sectional analysis (Subsection 7.3).

## 7.1 Event study

Cumulated abnormal returns show how the general reaction of stock prices of the observed firms is due to new information. In Table 4 we observe significant results for the announcement of 2005, 2007 and 2008 verified emissions (see Panels B, E and F).

[Insert Table 4 about here]

Different from what might be expected, we see no significant cumulated abnormal returns for the first event (Panel A), when the market learned that there was a general over-allocation and the permit price dropped by around two-thirds. The total emissions were lower than expected and market members reacted by selling emission certificates.[22] Despite this fast and sharp reaction in the permit market, there was no significant reaction on the stock markets. If one considers that we control for permit price effects

[20] For details see Kolari and Pynnönen (2010).

[21] Campbell et al. (2010), Bartholdy et al. (2007) suggest that trade-to-trade returns are used, but also show that the difference between trade-to-trade and lumped returns is negligible in most cases.

[22] The prise drop can also be seen for permit futures with different expiring dates, indicating that this first information about verified emissions changed the beliefs about the EU ETS market.

in the factor model, one possible explanation is that there is a stock market reaction, but this is well explained by the permit return factor in the employed factor model.

Panel B shows the cumulated abnormal returns for the published verified emissions of 2005. For all estimation windows we find significant negative cumulated abnormal returns. This detailed announcement on verified emissions on a firm base gave investors new information about the individual firm's situation, so that the link from permit to stock price became more obvious. As the permit prices just started to stabilize after the dramatic drop in late April, the negative cumulated abnormal returns corresponds to the hypothesis that investors downgraded their expectations about the firms' profits as the permits were mainly seen as an asset, that now had lost much of its value.

In Panel E we find significant positive cumulated abnormal returns on the event day ([0]) and for the event window [-3,1]. Different from the second event in May 2006, the price for the first period permits was almost zero. Hence, rather then the direct value or cost from 2007's emissions and respective allocation the verified emissions might have been evaluated with respect to the second period's allocation. This means that a growth in verified emissions led to a positive update of future return expectations.

For the last event, shown in Panel F, we observe significant positive cumulated results for the two event windows [-1,1] and [-1,3]. Confirming the results of Panel E, that positive cumulated returns might suggest that higher verified emissions are seen as a positive signal by investors.

Note that the nonparametric sign test as described in MacKinlay (1997), yields similar results (see Table 5). Especially for the second event (Panel B) more than 70% of all firms showe a negative abnormal return, strongly indicating that not some few large abnormal returns drove the significant findings in Panel B of Table 4, but that the negative impact of the event affected most of the considered firms. The same statement holds true for Panel E and Panel F, with positive abnormal returns as described above.

[Insert Table 5 about here]

From a regulators perspective, aiming at a lower total amount of emissions, this result is disappointing. The event study supports the value asset hypothesis rather then the abatement hypothesis. We are able to confirm the findings of other studies (Bushnell et al. 2011, Oberndorfer 2009, Veith et al. 2009) in which permits are rather seen as an asset and not as an instrument that forces the firms to engage in abatement.

## 7.2 Cross sectional analysis

The event study results in Section 7.1 show significant positive, significant negative and insignificant abnormal returns for the examined events. Since the allocation and the need for permits is different for the individual firms, our next goal is to analyze which characteristics are the drivers of the observed abnormal returns. Thereby note that insignificant cumulated abnormal returns for the whole sample do not imply that there are no significant abnormal returns for individual firms. Therefore we include all six event dates in the analysis, and not only the events with significant cumulated returns for the overall sample. In this section we analyze the drivers of the abnormal returns for each event date by means of an OLS regression:

$$SCAR_i^{t_1,t_2} = a + \boldsymbol{z}_i' \boldsymbol{b} \cdot + e_i, \tag{6}$$

$SCAR_i^{t_1,t_2}$ is the standardized cumulated abnormal return estimated in the event study (see equation 3) of firm $i$. $e_i$ is the usual error term with zero expectation and constant variance. The vector $\boldsymbol{z}_i$ includes the following variables for each firm $i$:

- Sales of firm $i$ in the previous year ($\text{Sales}_i$),
- Market-to-Book-Value of firm $i$ based on the preceding December ($\text{MtBV}_i$),
- Over-allocation with respect to the published verified emissions ($\text{OA}_i$),
- Verified Emissions divided by Sales ($\text{VE}_i/\text{Sales}_i$),
- Country dummy, which is one for firms located in Denmark or UK and zero otherwise ($\text{CD}_i$),[23]
- Yearly change in over-allocation for firms with a zero or positive over-allocation in $\tau$ and zero otherwise ($\Delta\text{OA}_i^+$),
- Yearly change in over-allocation for firms with a negative over-allocation in $\tau$ and zero otherwise ($\Delta\text{OA}_i^-$),
- Yearly change in verified emissions divided by Sales ($\Delta\text{VE}_i/\text{Sales}_i$).

The yearly change variables ($\Delta\text{OA}_i^+$, $\Delta\text{OA}_i^-$, $\Delta\text{VE}_i/\text{Sales}_i$) are only included in the regressions for the 2007, 2008 and 2009 event dates, since there are no verified emissions and allowances data available for

[23] Denmark and the UK had a national emissions trading scheme before the EU ETS was introduced.

2005. $\tau$ indicates the year in which the respective event is observed. Furthermore we exclude the Sales variable in the regressions for the 2009 event date, due to possible problems with multicollinearity. $\text{Sales}_i$, $\text{MtBv}_i$ and $\text{VE}_i$ are in logarithms. We exclude all observations where verified emissions or allowances are zero or missing. We estimate equation (6) for $(t_1, t_2)$ pairs (-3,3), (-3,1), (-1,1), (-1,3) and (0,0). The variables of primary interest are the EU ETS related variables ($\text{VE}_i/\text{Sales}_i$, $\text{OA}_i$, $\Delta\text{OA}_i^+$, $\Delta\text{OA}_i^-$ and $\Delta\text{VE}_i/\text{Sales}_i$). The other variables are included to correct for other possible influences which may be correlated with the variables of interest.

In this section we estimate equation (6) with a standard OLS procedure. For 25/04/2006, when investors learned that the market was long in allowances and their price dropped by nearly two-thirds, we find a significant positive effect of the over-allocation variable (see Table 6) for the event windows [-3,1] and [-1,1]. Possibly some firms even informed the public about their over-allocation before the countries and the central register could do so. Note that the overall effect of the event study results in Section 7.1 (see Table 4) does not show a significant positive effect for all firms at an aggregate level.[24] However, we do observe significant positive individual abnormal returns for some firms; and the cross sectional analysis suggests that these positive abnormal returns occurs for firms with a distinct over-allocation. This result is in line with the abatement effect, since a higher over-allocation is associated with a higher abnormal return on average.[25]

[Insert Table 6 about here]

When the 2005 verified emissions were announced on 15/05/2006, we find negative effects from over-allocation on abnormal returns for event windows enclosing three days after the event (see Table 7). Although the event study results of Section 7.1 report significant negative cumulated abnormal returns, this result cannot be explained sufficiently with the specification of equation (6), since abnormal returns of some event windows are to a great deal unexplained (e.g. [-1,1] with an $R^2$ of 0.05) and the F-statistic of joint significance of all explanatory variables is insignificant for all event windows. Concerning the hypothesis stated in Section 4.1, we observe the opposite of the abatement effect. However, since the abatement effect and the asset value effect can hardly be disentangled, we interpret the above findings as evidence for the asset value effect.

[24] Since we do not expect to find "big" effects (see Section 4), we conduct hypothesis tests on the 10 % significance level. However, in the tables we additionally report stars to indicate common significance level, as well as p-values for most of the results, so that readers can evaluate the results themselves.

[25] Note also that over-allocation for all firms in the year before was exactly zero, since the EU ETS was not implemented then. So the over-allocation variable for the 2006 events can also be interpreted as the change in over-allocation variable from 2005 to 2006.

[Insert Table 7 about here]

From the third event (02/04/2007) on we include the two change in over-allocation variables and the change in verified emissions variable in the vector $\boldsymbol{z}_i$ to estimate equation (6), because now data of the previous year is available.[26] On 02/04/2007 the coefficient for the change in VE/Sales variable is positive and significant (see Table 8). This observation supports the asset value hypothesis. All other EU ETS related variables are insignificant for this event date.

[Insert Table 8 about here]

For the second event date in 2007 (08/05/2007), we observe a significant negative coefficient for the over-allocation variable for two of the event windows [-3,3] and [-3,1] (see Table 9). This finding is in so far remarkable that the coefficient for the over-allocation in levels is significant and not the one of the change in over-allocation. This finding can be interpreted that firms with a general over-allocation are punished by investors. These firms have been know to investors since 15/05/2006, one explanation might be that investor realized on this event that more emissions are value creating, thereby providing support for the asset value hypothesis.

[Insert Table 9 about here]

The results for the 28/05/2008 event shows no significant effects for any of the variables of interest as can be seen in Table 10.

[Insert Table 10 about here]

For the last event evaluated, the 31/03/2009, we observe significant negative coefficients for the change in over-allocation variable, for under-allocated firms, for three event windows ([-3,3],[-3,1] and [-1,1]; see Table 11). Firms which are short of permits on the 31/03/2009 on average lose market value, when they move their under-allocation closer to zero. For over-allocated firms this coefficient is also negative, but much smaller than for under-allocated firms and not significant. Moreover, the over-allocation in levels variable is positive and significant for two event windows ([-3,3] and [-3,1]). This means that more over-allocated (less under-allocated) firms in general have a higher abnormal return. Additionally the change in VE/Sales variable is positive and significant for one event window ([-1,1]). In summary

[26] Change in verified emissions is calculated as log VE 2005 - log VE 2006.

these observations point more into the direction of the asset value hypothesis (negative change in over-allocation and positive change in VE/Sales), but also suggest that this hypothesis is much more relevant for firms which are under-allocated.

[Insert Table 11 about here]

In summary, four of the six examined events support the asset value hypothesis, one supports the abatement hypothesis and one supports neither of them. Our results suggest that for the first event (25/04/2006) abatement was positively interpreted by investors, and therefore increased the stock price of firms. However, in the subsequent events stock market participants valued things differently. The next five events are more supportive to the view that more emissions create future value and therefore support the asset value hypothesis. Always keep in mind that we did not expect to find strong effects since the overall relevance of the cost related to permits is not that big (see Section 4).

## 7.3 Robustness

The estimations in Section 7.2 were performed by OLS. For our sample the two following critical issues might arise i) unreliable inferences due to a rather small sample size for the cross sectional regressions and ii) a possible sample-selection bias in the cross sectional regressions due to the exclusion of firms with confounding effects. Therefore we employ alternative estimation procedures, which correct for these issues and discuss the deviations from the OLS results.

### 7.3.1 Small sample

Since we are dealing with a rather small sample in the cross sectional regressions (between 35 and 55 observations), inferences based on asymptotic results may be misleading. To correct for this issue, we apply a wild bootstrap procedure to obtain reliable inferences. See Flachaire (2005) for details. Our estimations are based on 10,000 bootstrap replications and inferences are based on the $HC_3$ specification of the Heteroskedasticity Consistent Covariance Matrix Estimator. Note that we do not assume that the error distribution is symmetric. Therefore we do not report p-values and indicate only the usual significance levels. Results are provided in Tables 12 to 17.

[Insert Table 12 about here]

[Insert Table 13 about here]

[Insert Table 14 about here]

[Insert Table 15 about here]

[Insert Table 16 about here]

[Insert Table 17 about here]

In general the results of the bootstrap estimations support the findings of the OLS results. However two kinds of exceptions occur. First, coefficients which are only marginally insignificant (p-value around 0.13) in the OLS results are significant on the 10% level in the bootstrap results. Second, the coefficients for the change in over-allocation variable for 08/05/2007 are now positive and significant. These exceptions only have a minor impact on the interpretations of the results. For 15/05/2006 the VE/Sales coefficient is negative and significant for one event window. This is somehow in contrast to the asset value hypothesis, but the coefficient of the over-allocation variable is still significant for two event windows. For 02/04/2007 the VE/Sales variable becomes significant for two event dates. Moreover, for 08/05/2007 the coefficients for the change in over-allocation variable for under-allocated firms is now positive and significant for four out of five event windows. This changes the evidence in favor of the abatement hypothesis for 08/05/2007 for under-allocated firms. For the 28/05/2008 the change in over-allocation coefficient for under-allocated firms is negative significant for one event window. Which supports the asset value hypothesis.

To sum up, we mainly find support for the results obtained with OLS. However, one event (08/05/2007) no longer supports the asset value hypothesis; rather we see support for the abatement hypothesis for under-allocated firms. The event in 2008 (28/05/2008) supports the asset value hypothesis. In the results of the third event (08/05/2007) the evidence for the asset value hypothesis is now weaker. The OLS results for the 25/04/2006 and the 31/03/2009 remain virtually unchallenged.

#### 7.3.2 Sample selection

Due to the removal of firms with possible confounding events, the sample at hand might not be completely random. We therefore estimate a sample selection model based on the full-information maximum likelihood (FIML) estimator (see Nawata (1994) or Puhani (2000) for details). In a survey on Monte Carlo studies of sample selection estimators, Puhani (2000) concludes that "If there are no collinearity problems, ... the FIML estimator is recommended, as it is usually more efficient than the LIML estima-

tor".[27] Since the condition number of the regressors as proposed by Puhani (2000) is always well below 20 (usually about 4 or 5), we conclude that there is no multicollinearity problem in our sample and follow this recommendation. Furthermore we use the Heckman (1979) LIML estimates as starting values for the FIML estimator (as initially recommended by Heckman (1979)). We use the following explanatory variables in the selection equation: Sales, Market-to-Book value, Number of Employees, over-allocation and VE/Sales. For the past 2006 events we also include the two change in over-allocations variables (as described in Section 7.2) and the change in VE/Sales variable. To evaluate the goodness of fit of the model we report Wald, Likelihood Ratio and Lagrange Multiplier tests which all judge the joint significance of all explanatory variables of the outcome equation, excluding the constant.[28] The results are reported in Tables 18 to 23.

[Insert Table 18 about here]

[Insert Table 19 about here]

[Insert Table 20 about here]

[Insert Table 21 about here]

[Insert Table 22 about here]

[Insert Table 23 about here]

We now shortly discuss the deviations with regard to the OLS results of Section 7.2. For the 25/04/2006 all EU ETS related variables are insignificant, although very close to the OLS coefficient. For the 15/05/2006 event we still obtain a negative coefficient for the over-allocation variable, but in the FIML case only one of them is significant (as opposed to two significant coefficients in the OLS results). For the 02/04/2007 the results change considerably. The coefficient for change in VE/Sales at the event date is no longer significant. Instead the coefficient for change in over-allocation for under-allocated firms is now significant and positive. Furthermore, the VE/Sales variable is now significant (and is still positive) for two event windows. Concerning the posted hypothesis in Section 4, the positive change in over-allocation for under-allocated firms favors the abatement hypothesis (for under-allocated firms) and the positive coefficients for VE/Sales are more in favor of the asset value hypothesis. For the 08/05/2007

[27] LIML refers in this context to the estimator proposed by Heckman (1979).

[28] Asymptotically the three test statistics are equivalent, but the small sample properties are in general unknown (Greene 2003, ch. 17). Therefore we report all three test statistics.

the results are pretty much in line with the OLS results. For the 28/05/2008 we observe a significant negative coefficient for over-allocation for one event window and a positive and significant coefficient for the change in VE/Sales variable for another event window. These results support the asset value hypothesis. For the 31/03/2009 the results are weakened in comparison to the OLS results, but still support the asset value hypothesis.

In summary four of the six examined events support the asset value hypothesis, one supports both hypothesis (asset value hypothesis and abatement hypothesis) and one supports neither of them.

### 7.3.3 Weighted least squares

The estimation procedures so far rely on an equal weight for each observation. However, one might argue that firms with higher verified emissions are more important observations for our purposes than firms with lower verified emissions. Therefore we redo the estimations of Section 7.2 with a weighted least squares (WLS) approach. As weights we use verified emissions relative to the overall emissions of the respective event sample.[29] In contrast to the other estimations in this section we use the *cumulative abnormal returns (CAR)* as opposed to the scaled cumulative abnormal returns.[30] This is because the *SCAR* are already scaled by the standard deviations of the cumulated abnormal returns and a weighting of the *SCAR* would still be influenced by the size of the standard deviations. To ensure that the effect of the weighting scheme has the desired effect, we therefore use *CAR*.

We report the results in Tables 24 to 29.

[Insert Table 24 about here]

[Insert Table 25 about here]

[Insert Table 26 about here]

[Insert Table 27 about here]

[Insert Table 28 about here]

[Insert Table 29 about here]

[29] For details on WLS see Greene (2003, ch. 11).
[30] We calculate *CAR* as $CAR_i^{t_1,t_2} = \sum_{t=t_1}^{t_2} AR_{it}$.

For the 25/04/2006 the results equal very much the OLS results, the coefficient for over-allocation has the same sign and is also significant for two event windows.[31] For the 15/05/2006 the results still confirm the OLS findings. The coefficient for over-allocation has the same sign as in the OLS case and is furthermore significant for all event windows. For the 02/04/2007 the results are more ambiguous. The significant negative coefficients for the change in over-allocations variable for over-allocated firms and the significant negative over-allocation and positive coefficients for the VE/Sales variable are in favor of the asset value hypothesis, whereas the significant negative coefficients for the change in VE/Sales variable support the abatement hypothesis. Which of these effects prevail is not obvious. The 08/05/2007 results are also ambiguous. The significant negative coefficients of the change in over-allocation variable for over-allocated firms, the significant negative coefficients of the over-allocation variable and the significant positive coefficient for the change in VE/Sales variable support the asset value hypothesis. In contrast, for one event window the coefficient of the change in over-allocation variable for over-allocated firms is positive and significant (window [0]), therefore supporting the abatement hypothesis. Moreover, the significant positive coefficients for the change in over-allocation variable for under-allocated firms and the significant negative coefficients of the VE/Sales variable support also the abatement hypothesis. Overall it is unclear which effect is more important. However, one may argue due to the asymmetric effect of the changes in over-allocation variable, that for over-allocated firms the asset value hypothesis is more important (at least for the event windows [-3,3] and [-3,1]), whereas for the under-allocated firms the abatement hypothesis is more important (at least for event windows [-3,3], [-3,1] and [-1,3]). For the 28/05/2008 the results differ from the OLS results. A significant negative coefficient for the change in over-allocation variable for under-allocated firms points to the asset value hypothesis (note that a significant and negative coefficient for over-allocation partly offsets this effect, but is much smaller) for one event window ([0]). For two other event windows ([-1,3] and [-3,1]) a significant negative coefficient for the over-allocation coefficient and a significant positive coefficient for the VE/Sales variable again support the asset value hypothesis. The results for the event on 31/03/2009 support the OLS results. For the change in over-allocation variable for under-allocated firms coefficients signs and significance levels are similar to the OLS results and likewise for the coefficient of the over-allocation variable. In addition, the coefficient of the change in VE/Sales variable is now significant positive for two additional event windows ([-1,3] and [0]). Note also that the F-statistics are mostly significant, and the $R^2$ measures are quite high. In summary we observe for the WLS results one event which is supportive for the abatement

[31] Note that the WLS coefficients are not directly comparable to OLS coefficients, because a different weighting scheme is used.

hypothesis, three events which are supportive for the asset value hypothesis and two events that are rather unclear.

### 7.3.4 Panel data

As argued in Section 7.3.1 the sample size may be rather small to provide reliable statistical inferences. Another solution to this problem is the use of panel methods. Therefore we pool the observations of four of the six events, as this method requires variation in independent variables over time. We use the events, when the verified emissions for the firms were published and drop the two events when preliminary information leaked into the market. To employ panel data methods one has to assume that the impact of the explanatory variables on the dependent variable is somehow homogeneous over time. Note that this assumption is possibly not reasonable in our case. On the other hand if the assumption is true, we may benefit from the increased sample size. Furthermore, the problem of sample selection as described in Section 7.3.2 leads to a reduced sample with only very few firms. To increase the sample size and to account for the sample selection problem explicitly, we employ a panel data estimator designed for this situation. Therefore we employ the procedure proposed by Wooldridge (1995). However, this estimator requires some assumptions, e.g., that the conditional mean of the fixed effects of the main equation has a certain functional form.[32] For a further discussion of these issues see Dustmann and Rochina-Barrachina (2007).

To judge the goodness of fit and the explanatory power of the variables we report the $R^2$ measure and three $F$-statistics. The first $F$-statistic ($F_0$) tests the hypothesis that all dependent variables (excluding the constant) are jointly zero. The second $F$-statistic ($F_1$) tests the hypothesis that all EU ETS related variables are jointly zero (OA, VE/Sales and additionally either ΔVE/Sales or ΔVE/Sales and ΔOA but without OA for the second kind of estimations). The third $F$-statistic ($F_2$) tests the hypothesis that all EU ETS related variables are jointly zero and that the fixed effects are not related to these variables. We report two kinds of results. In the first one, we use all four years for the estimation, but include only the over-allocation and VE/Sales variables in levels, because of the lack of such information before 2006. In the second one, we use also the change in over-allocation and change in VE/Sales variables, and can therefore include only three event dates (from 2007-2009). *SCAR* is used as dependent variable.

Table 30 shows the results for the panel estimation including the 2006-2009 events. The coefficient of the over-allocation variable is highly significant and negative for the event windows [-3,-1] and [-1,1].

[32] Wooldridge (1995, p. 126) assumes that the fixed effects are a linear function of the past, future and contemporaneous explanatory variables.

The coefficient of the VE/Sales variable is negative and significant for one event window ([-3,1]). Since the coefficient of the over-allocation variable is negative and highly significant for two event dates, as opposed to the negative coefficient of the VE/Sales variable, which is only significant on the 10 % level for one event date, we interpret this as evidence in favor of the asset value hypothesis. Note also that the $F_1$ statistic is highly significant for the event windows [-3,1] and [-1,1], suggesting that EU ETS related information provides important direct information for abnormal returns on these dates. In addition, the $F_2$ statistic is significant for all event dates, which suggests that EU ETS related information might also have an impact via fixed time constant effects.

We estimate the panel also for the 2007-2009 events. Since there are numerical problems at hand when including all variables, we estimate two specifications: one with all variables of the first specification plus change in VE/Sales and one with additionally change in over-allocation, but without over-allocation itself.[33] The results are reported in Tables 31 and 32 respectively. For the first specification (see Table 31), we see that the coefficient for over-allocation is negative and significant for all event windows. Also, the VE/Sales coefficient is positive and significant for one event date ([0]). These results underpin the asset value hypothesis. For the second specification (see Table 32) the coefficients for the change in over-allocation variable are negative and significant for all event dates. Also, the VE/Sales coefficient is positive and significant for two event dates ([-3,3] and [0]). Additionally, the change in VE/Sales coefficient is negative and significant for one event date [0]. Since the negative change in VE/Sales coefficient is only significant for one event date, and in addition much smaller then the positive VE/Sales coefficient, we consider the results as supportive for the asset value hypothesis. Note also, that the $F$-statistics are all significant.

# 8 Conclusion

We investigate the impact of verified emissions announcement on stock returns and find a significant *cumulated* negative impact for the verified emissions of 2005 and a partly significantly positive one for verified emissions 2007 and 2008. Looking at the *individual* abnormal returns we find more support for the asset value hypothesis as for the abatement hypothesis. From all considered event dates we get the picture that for the first event (25/04/2006) the abatement hypothesis was at work, and for all subsequent the asset value hypothesis seems to be more plausible. These findings are quite robust across different

[33] We do not report the change in over-allocation variable separated for under- and over-allocated firms as in the other results, because for the panel case the assumption of an symmetric impact seems to be justified. In addition the results are practically the same as in the symmetric case and are therefore not reported, but are available on request.

estimation procedures. Table 3 provides an overview of the results regarding the two hypothesis with the different estimation procedures employed in the paper. By assuming that the market reaction is somewhat homogeneous across the different event dates, we estimate the cross sectional relation also with a panel approach, and find support for the asset value hypothesis, whether we use the 2006-2009 or the 2007-2009 events.

Table 3: Results – overview

| Date | Event study | OLS | Bootstrap | FIML | WLS |
|---|---|---|---|---|---|
| 25/04/2006 | NE | A | A | NE | A |
| 15/05/2006 | AV | AV | unclear | AV | AV |
| 02/04/2007 | NE | AV | AV | unclear | unclear |
| 08/05/2007 | NE | AV | A | AV | unclear |
| 28/05/2008 | AV | NE | AV | AV | AV |
| 31/03/2009 | AV | AV | AV | AV | AV |

Note: This table shows an overview of our results obtained with different methods and procedures. A: abatement hypothesis, AV: asset value hypothesis, NE: no effect, unclear: no clear effect of neither of the hypothesis.

We can conclude by saying that our results support the asset value hypothesis, which states that investors see emission allowances as an asset distributed by the regulator to the firms (in the first phase of the emission trading scheme allowances were mainly free). When the amount of these assets changes, investors update their expectations and we observe abnormal returns. The exception to this finding is the first event (25/04/2006) for which the abatement hypothesis is supported.

In general our findings point to the conclusion that investors do not believe that the European emission trading scheme set incentives for abatement, but they rather perceive verified emissions as an asset assigned to firms and updated their expectations according to the asset value assigned to the permits.

# Appendix

## A Fama-French factors

To construct proxies for the Fama-French factors SMB and HML, we use various index series for different size and value-growth styles. For Germany we construct the SMB factor as the difference between the SDAX and the DAX return. The German HML factor is constructed as the difference of the MSCI Large Value portfolio plus the MSCI Medium Value portfolio divided by two and the MSCI Large Growth portfolio plus the MSCI Medium Growth portfolio divided by two. The Austrian SMB factor is the difference between the Small FTSE portfolio and the Large ATX portfolio. The Austrian HML factor is the difference of the MSCI Large Value portfolio plus the MSCI Small Value portfolio divided by two and the MSCI Large Growth portfolio plus the MSCI Small Growth portfolio divided by two. The Danish SMB factor is calculated as the difference of the OMX Copenhagen Smallcap index and the OMX Copenhagen 20. The Danish HML factor is the difference of the MSCI Large Value portfolio plus the MSCI Small Value portfolio divided by two and the MSCI Large Growth portfolio plus the MSCI Small Growth portfolio divided by two. The UK SMB factor is calculated as the difference of the FTSE All Small index and the FTSE 100 Index. The UK HML factor is the difference of the MSCI Large Value portfolio plus the MSCI Medium Value portfolio plus the MSCI Small Value portfolio divided by three and the MSCI Large Growth portfolio plus the MSCI Medium Growth portfolio plus the MSCI Small Growth portfolio divided by three. The SMB factors of Austria and Denmark are based on price indices, whereas all other factors are based on total return indices (and therefore include dividends). The factor versions used in this study are selected among a set of possible candidates. We select the factor specification whose monthly version has the highest correlation with the monthly factors described in Schmidt et al. (2011).

### Acknowledgements

We thank Lucas Bretschger and Ian MacKenzie for helpful comments and Maria Fraga, Laura Ochoa Gomez and Daniel Truttmann for their research assistance.

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Table 4: Event study results

| Window | [-3,3] | [-3,1] | [-1,1] | [-1,3] | [0] |
|---|---|---|---|---|---|
| Panel A: 25/04/2006 (59 firms) | | | | | |
| *ASCAR* | −0.07 | −0.15 | −0.15 | −0.06 | −0.12 |
| $t_{AB}$ | −0.39 | −0.89 | −0.94 | −0.32 | −0.90 |
| p-value | 0.70 | 0.37 | 0.35 | 0.75 | 0.37 |
| Panel B: 15/05/2006 (53 firms) | | | | | |
| *ASCAR* | −0.43 | −0.40 | −0.49 | −0.49 | −0.32 |
| $t_{AB}$ | −2.50 | −2.53 | −2.87 | −2.78 | −1.99 |
| p-value | 0.01 | 0.01 | 0.00 | 0.01 | 0.05 |
| Panel C: 02/04/2007 (60 firms) | | | | | |
| *ASCAR* | 0.05 | 0.15 | 0.23 | 0.10 | 0.01 |
| $t_{AB}$ | 0.35 | 1.11 | 1.34 | 0.56 | 0.03 |
| p-value | 0.72 | 0.27 | 0.18 | 0.58 | 0.98 |
| Panel D: 08/05/2007 (45 firms) | | | | | |
| *ASCAR* | −0.15 | −0.12 | −0.11 | −0.15 | 0.02 |
| $t_{AB}$ | −0.91 | −0.80 | −0.67 | −0.83 | 0.10 |
| p-value | 0.36 | 0.42 | 0.50 | 0.41 | 0.92 |
| Panel E: 28/05/2008 (57 firms) | | | | | |
| *ASCAR* | 0.22 | 0.25 | 0.27 | 0.22 | 0.29 |
| $t_{AB}$ | 1.48 | 1.71 | 1.64 | 1.33 | 1.85 |
| p-value | 0.14 | 0.09 | 0.10 | 0.18 | 0.06 |
| Panel F: 31/03/2009 (54 firms) | | | | | |
| *ASCAR* | 0.20 | 0.14 | 0.35 | 0.37 | 0.16 |
| $t_{AB}$ | 1.24 | 0.91 | 2.26 | 2.19 | 0.92 |
| p-value | 0.21 | 0.36 | 0.02 | 0.03 | 0.36 |

Note: The table shows estimation results for average standardized cumulated abnormal returns (*ASCAR*, see equation 4), the adjusted BMP statistic ($t_{AB}$) proposed by Kolari and Pynnönen (2010) and its p-value.

Table 5: Sign test - percentage of positive abn. returns

| % pos. | [-3,3] | [-3,1] | [-1,1] | [-1,3] | [0] |
|---|---|---|---|---|---|
| Panel A | 0.44 | 0.53 | 0.42 | 0.42 | 0.42 |
| p-value | 0.43 | 0.79 | 0.30 | 0.30 | 0.30 |
| Panel B | 0.38 | 0.28 | 0.26 | 0.28 | 0.38 |
| p-value | 0.10 | 0.00 | 0.00 | 0.00 | 0.10 |
| Panel C | 0.53 | 0.57 | 0.62 | 0.55 | 0.55 |
| p-value | 0.70 | 0.37 | 0.09 | 0.52 | 0.52 |
| Panel D | 0.38 | 0.42 | 0.42 | 0.42 | 0.49 |
| p-value | 0.14 | 0.37 | 0.37 | 0.37 | 1.00 |
| Panel E | 0.58 | 0.61 | 0.63 | 0.58 | 0.65 |
| p-value | 0.29 | 0.11 | 0.06 | 0.29 | 0.03 |
| Panel F | 0.59 | 0.54 | 0.76 | 0.70 | 0.59 |
| p-value | 0.22 | 0.68 | 0.00 | 0.00 | 0.22 |

Note: The table shows the percentage of firms with positive abnormal returns for the respective event window and its p-value of a corresponding sign test, where the panels correspond with table 4.

Table 6: OLS results (25/04/2006)

| | Constant | Sales | MtBv | OA | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|
| [-3,3] | -0.250 | 0.169 | -0.022*** | 0.352 | 0.178 | -0.265 | 0.053 | 2.067* |
| p-val | 0.878 | 0.736 | 0.007 | 0.297 | 0.731 | 0.378 | | 0.086 |
| [-3,1] | -0.602 | 0.006 | -0.012 | 0.792** | -0.028 | -0.084 | 0.095 | 1.424 |
| p-val | 0.640 | 0.989 | 0.863 | 0.017 | 0.952 | 0.769 | | 0.232 |
| [-1,1] | -0.465 | 0.148 | -0.027 | 0.669* | 0.150 | -0.082 | 0.105 | 1.066 |
| p-val | 0.763 | 0.780 | 0.671 | 0.061 | 0.779 | 0.776 | | 0.391 |
| [-1,3] | -0.113 | 0.264 | -0.031** | 0.209 | 0.299 | -0.279 | 0.068 | 1.611 |
| p-val | 0.949 | 0.620 | 0.021 | 0.548 | 0.580 | 0.369 | | 0.175 |
| [0] | 0.473 | -0.205 | 0.006 | 0.417 | -0.193 | -0.097 | 0.064 | 0.996 |
| p-val | 0.707 | 0.679 | 0.916 | 0.390 | 0.706 | 0.678 | | 0.430 |

Note: The table shows OLS estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the $R^2$ measure ($R^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 55.

Table 7: OLS results (15/05/2006)

| | Constant | Sales | MtBv | OA | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|
| [-3,3] | 2.006* | -0.167** | -0.038 | -0.821* | -0.093 | -0.049 | 0.133 | 1.901 |
| p-val | 0.093 | 0.042 | 0.624 | 0.050 | 0.133 | 0.873 | | 0.114 |
| [-3,1] | 1.365 | -0.121 | -0.020 | -0.464 | -0.043 | 0.030 | 0.059 | 0.791 |
| p-val | 0.290 | 0.157 | 0.760 | 0.357 | 0.440 | 0.928 | | 0.562 |
| [-1,1] | 1.329 | -0.129 | -0.001 | -0.303 | -0.015 | 0.156 | 0.05 | 0.601 |
| p-val | 0.337 | 0.169 | 0.978 | 0.517 | 0.797 | 0.652 | | 0.699 |
| [-1,3] | 2.040* | -0.176** | -0.025 | -0.728* | -0.077 | 0.024 | 0.112 | 1.667 |
| p-val | 0.094 | 0.039 | 0.706 | 0.081 | 0.188 | 0.938 | | 0.163 |
| [0] | 1.859 | -0.147* | -0.026 | -0.225 | -0.037 | 0.016 | 0.078 | 0.795 |
| p-val | 0.145 | 0.089 | 0.765 | 0.702 | 0.579 | 0.964 | | 0.559 |

Note: The table shows OLS estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the $R^2$ measure ($R^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 49.

Table 8: OLS results (02/04/2007)

| | Constant | Sales | MtBv | $\Delta OA^+$ | $\Delta OA^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | -1.681 | 0.132$^*$ | -0.037 | 0.782 | -0.199 | -0.084 | 0.062 | 0.065 | 0.131 | 0.172 | 0.956 |
| p-val | 0.131 | 0.095 | 0.484 | 0.228 | 0.892 | 0.747 | 0.727 | 0.129 | 0.597 | | 0.482 |
| [-3,1] | -1.561 | 0.126 | -0.048 | 1.281 | -0.106 | -0.011 | 0.179 | 0.046 | 0.222 | 0.158 | 0.621 |
| p-val | 0.167 | 0.117 | 0.243 | 0.143 | 0.943 | 0.967 | 0.464 | 0.350 | 0.377 | | 0.781 |
| [-1,1] | -0.059 | 0.041 | -0.051 | 1.874 | 1.484 | -0.275 | 0.440 | 0.105 | 0.406 | 0.154 | 1.046 |
| p-val | 0.967 | 0.640 | 0.279 | 0.209 | 0.437 | 0.399 | 0.156 | 0.261 | 0.175 | | 0.418 |
| [-1,3] | -0.468 | 0.062 | -0.036 | 1.119 | 1.024 | -0.297 | 0.238 | 0.112 | 0.250 | 0.169 | 1.136 |
| p-val | 0.699 | 0.413 | 0.502 | 0.290 | 0.526 | 0.396 | 0.286 | 0.122 | 0.345 | | 0.359 |
| [0] | 1.661 | -0.084 | -0.012 | 1.369 | 2.970 | -0.029 | 0.376$^*$ | 0.102 | 0.038 | 0.142 | 2.044$^*$ |
| p-val | 0.270 | 0.324 | 0.751 | 0.354 | 0.135 | 0.933 | 0.095 | 0.226 | 0.906 | | 0.063 |

Note: The table shows OLS estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the $R^2$ measure ($R^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 53.

Table 9: OLS results (08/05/2007)

| | Constant | Sales | MtBv | $\Delta OA^+$ | $\Delta OA^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 2.002 | -0.116 | 0.010 | 1.836 | 1.327 | -0.826$^*$ | -0.017 | -0.012 | -0.681$^*$ | 0.399 | 2.137$^*$ |
| p-val | 0.237 | 0.310 | 0.753 | 0.382 | 0.589 | 0.073 | 0.959 | 0.874 | 0.070 | | 0.069 |
| [-3,1] | 2.228 | -0.137 | 0.041 | -0.505 | 1.609 | -0.931$^{**}$ | -0.213 | -0.067 | -0.791$^{**}$ | 0.527 | 3.398$^{***}$ |
| p-val | 0.115 | 0.164 | 0.570 | 0.755 | 0.320 | 0.011 | 0.319 | 0.223 | 0.014 | | 0.008 |
| [-1,1] | 2.339 | -0.155 | 0.031 | -0.421 | 1.691 | -0.795 | -0.075 | -0.014 | -0.296 | 0.332 | 0.720 |
| p-val | 0.118 | 0.137 | 0.537 | 0.765 | 0.484 | 0.225 | 0.876 | 0.866 | 0.530 | | 0.672 |
| [-1,3] | 1.958 | -0.120 | -0.004 | 2.335 | 1.277 | -0.667 | 0.132 | 0.042 | -0.255 | 0.286 | 0.785 |
| p-val | 0.277 | 0.316 | 0.909 | 0.432 | 0.678 | 0.247 | 0.832 | 0.638 | 0.595 | | 0.620 |
| [0] | 0.434 | -0.040 | -0.015 | 1.355 | 0.718 | -0.182 | 0.326 | 0.001 | 0.269 | 0.159 | 0.248 |
| p-val | 0.812 | 0.756 | 0.702 | 0.409 | 0.733 | 0.790 | 0.696 | 0.989 | 0.650 | | 0.977 |

Note: The table shows OLS estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the $R^2$ measure ($R^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 35.

Table 10: OLS results (28/05/2008)

| | Constant | Sales | MtBv | $\Delta$OA$^+$ | $\Delta$OA$^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 1.035 | -0.051 | -0.290 | -0.135 | 2.749 | -0.488 | 0.099 | -0.038 | 0.415 | 0.167 | 0.653 |
| p-val | 0.346 | 0.472 | 0.245 | 0.934 | 0.281 | 0.278 | 0.842 | 0.633 | 0.144 | | 0.729 |
| [-3,1] | -0.905 | 0.072 | -0.287 | -0.180 | 0.690 | -0.465 | 0.067 | -0.048 | 0.566$^{**}$ | 0.288 | 1.384 |
| p-val | 0.422 | 0.306 | 0.261 | 0.882 | 0.743 | 0.317 | 0.817 | 0.460 | 0.049 | | 0.233 |
| [-1,1] | -0.750 | 0.058 | -0.278 | 0.347 | 0.004 | -0.657 | 0.178 | -0.045 | 0.660$^{**}$ | 0.304 | 1.976$^{*}$ |
| p-val | 0.374 | 0.306 | 0.215 | 0.851 | 0.999 | 0.259 | 0.678 | 0.611 | 0.017 | | 0.075 |
| [-1,3] | 1.543$^{*}$ | -0.087 | -0.271 | 0.283 | 2.562 | -0.620 | 0.186 | -0.032 | 0.436 | 0.175 | 1.974 |
| p-val | 0.067 | 0.117 | 0.279 | 0.894 | 0.308 | 0.242 | 0.766 | 0.749 | 0.113 | | 0.075 |
| [0] | -0.381 | 0.031 | -0.100 | 0.307 | -3.990 | 0.094 | 0.201 | -0.006 | 0.308 | 0.195 | 1.104 |
| p-val | 0.763 | 0.717 | 0.730 | 0.859 | 0.131 | 0.869 | 0.638 | 0.941 | 0.326 | | 0.381 |

Note: The table shows OLS estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the $R^2$ measure ($R^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 49.

Table 11: OLS results (31/03/2009)

| | Constant | MtBv | $\Delta$OA$^+$ | $\Delta$OA$^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 0.167 | -0.023 | -0.071 | -1.093$^{**}$ | 0.931$^{*}$ | -0.015 | -0.008 | -0.410 | 0.123 | 1.175 |
| p-val | 0.901 | 0.892 | 0.884 | 0.021 | 0.090 | 0.823 | 0.951 | 0.360 | | 0.346 |
| [-3,1] | 1.071 | 0.070 | -0.134 | -1.375$^{***}$ | 0.949$^{**}$ | 0.014 | 0.049 | -0.775$^{**}$ | 0.347 | 4.613 |
| p-val | 0.216 | 0.440 | 0.761 | 0.000 | 0.045 | 0.797 | 0.487 | 0.013 | | 0.001 |
| [-1,1] | 0.708 | 0.158$^{*}$ | -0.272 | -0.752$^{*}$ | 0.096 | 0.122$^{*}$ | -0.053 | -0.379 | 0.268 | 2.047 |
| p-val | 0.476 | 0.091 | 0.570 | 0.070 | 0.824 | 0.068 | 0.464 | 0.304 | | 0.082 |
| [-1,3] | -0.330 | 0.024 | -0.160 | -0.504 | 0.230 | 0.063 | -0.101 | -0.003 | 0.094 | 0.466 |
| p-val | 0.805 | 0.883 | 0.746 | 0.388 | 0.706 | 0.354 | 0.408 | 0.994 | | 0.851 |
| [0] | 0.240 | 0.165 | 0.457 | -0.012 | -0.548 | 0.098 | -0.052 | -0.253 | 0.191 | 0.844 |
| p-val | 0.839 | 0.154 | 0.376 | 0.983 | 0.314 | 0.187 | 0.513 | 0.435 | | 0.560 |

Note: The table shows OLS estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the $R^2$ measure ($R^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 38.

Table 12: Bootstrap results (25/04/2006)

| Window | Constant | Sales | MtBv | OA | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|
| [-3,3] | -0.250 | 0.169 | -0.022 | 0.352 | 0.178 | -0.265 | 0.053 | 2.067 |
| [-3,1] | -0.602 | 0.006 | -0.012 | 0.792** | -0.028 | -0.084 | 0.095 | 1.424 |
| [-1,1] | -0.465 | 0.148 | -0.027 | 0.669* | 0.150 | -0.082 | 0.105 | 1.066 |
| [-1,3] | -0.113 | 0.264 | -0.031 | 0.209 | 0.299 | -0.279 | 0.068 | 1.611 |
| [0] | 0.473 | -0.205 | 0.006 | 0.417 | -0.193 | -0.097 | 0.064 | 0.996 |

Note: The table shows Bootstrap estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the adjusted $R^2$ measure ($\overline{R}^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). All inferences are based on a wild bootstrap procedure (see Flachaire (2005) for details). Number of observations: 55.

Table 13: Bootstrap results (15/05/2006)

| Window | Constant | Sales | MtBv | OA | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|
| [-3,3] | 2.006* | -0.167** | -0.038 | -0.821** | -0.093* | -0.049 | 0.133 | 1.901 |
| [-3,1] | 1.365 | -0.121 | -0.020 | -0.464 | -0.043 | 0.030 | 0.059 | 0.791 |
| [-1,1] | 1.329 | -0.129 | -0.001 | -0.303 | -0.015 | 0.156 | 0.050 | 0.601 |
| [-1,3] | 2.040* | -0.176** | -0.025 | -0.728* | -0.077 | 0.024 | 0.112 | 1.667 |
| [0] | 1.859* | -0.147* | -0.026 | -0.225 | -0.037 | 0.016 | 0.078 | 0.795 |

Note: The table shows Bootstrap estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the adjusted $R^2$ measure ($\overline{R}^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). All inferences are based on a wild bootstrap procedure (see Flachaire (2005) for details). Number of observations: 49.

Table 14: Bootstrap results (02/04/2007)

| | Constant | Sales | MtBv | $\Delta$OA$^+$ | $\Delta$OA$^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | -1.681* | 0.132** | -0.037 | 0.782 | -0.199 | -0.084 | 0.062 | 0.065* | 0.131 | 0.172 | 0.956 |
| [-3,1] | -1.561* | 0.126** | -0.048 | 1.281 | -0.106 | -0.011 | 0.179 | 0.046 | 0.222 | 0.158 | 0.781 |
| [-1,1] | -0.059 | 0.041 | -0.051 | 1.874 | 1.484 | -0.275 | 0.440 | 0.105 | 0.406 | 0.154 | 1.046 |
| [-1,3] | -0.468 | 0.062 | -0.036 | 1.119 | 1.024 | -0.297 | 0.238 | 0.112* | 0.250 | 0.169 | 1.136 |
| [0] | 1.661 | -0.084 | -0.012 | 1.369 | 2.970 | -0.029 | 0.376* | 0.102 | 0.038 | 0.142 | 2.044 |

Note: The table shows Bootstrap estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the adjusted $R^2$ measure ($\overline{R}^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). All inferences are based on a wild bootstrap procedure (see Flachaire (2005) for details). Number of observations: 53.

Table 15: Bootstrap results (08/05/2007)

| | Constant | Sales | MtBv | $\Delta$OA$^+$ | $\Delta$OA$^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 2.002 | -0.116 | 0.010 | 1.836 | 1.327$^{**}$ | -0.826 | -0.017 | -0.012 | -0.681$^{*}$ | 0.399 | 2.137 |
| [-3,1] | 2.228$^{*}$ | -0.137 | 0.041 | -0.505 | 1.609$^{**}$ | -0.931$^{**}$ | -0.213 | -0.067 | -0.791$^{***}$ | 0.527 | 3.398 |
| [-1,1] | 2.339$^{*}$ | -0.155$^{*}$ | 0.031 | -0.421 | 1.691$^{**}$ | -0.795$^{*}$ | -0.075 | -0.014 | -0.296 | 0.332 | 0.720 |
| [-1,3] | 1.958 | -0.120 | -0.004 | 2.335 | 1.277$^{*}$ | -0.667 | 0.132 | 0.042 | -0.255 | 0.286 | 0.785 |
| [0] | 0.434 | -0.040 | -0.015 | 1.355 | 0.718 | -0.182 | 0.326 | 0.001 | 0.269 | 0.159 | 0.248 |

Note: The table shows Bootstrap estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the adjusted $R^2$ measure ($\overline{R}^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). All inferences are based on a wild bootstrap procedure (see Flachaire (2005) for details). Number of observations: 35.

Table 16: Bootstrap results (28/05/2008)

| | Constant | Sales | MtBv | $\Delta$OA$^+$ | $\Delta$OA$^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 1.035 | -0.051 | -0.290 | -0.135 | 2.749 | -0.488 | 0.099 | -0.038 | 0.415 | 0.167 | 0.653 |
| [-3,1] | -0.905 | 0.072 | -0.287 | -0.180 | 0.690 | -0.465 | 0.067 | -0.048 | 0.566$^{**}$ | 0.288 | 1.384 |
| [-1,1] | -0.750 | 0.058 | -0.278 | 0.347 | 0.004 | -0.657 | 0.178 | -0.045 | 0.660$^{**}$ | 0.304 | 1.976 |
| [-1,3] | 1.543$^{*}$ | -0.087 | -0.271 | 0.283 | 2.562 | -0.620 | 0.186 | -0.032 | 0.436$^{*}$ | 0.175 | 1.974 |
| [0] | -0.381 | 0.031 | -0.100 | 0.307 | -3.990$^{*}$ | 0.094 | 0.201 | -0.006 | 0.308 | 0.195 | 1.104 |

Note: The table shows Bootstrap estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the adjusted $R^2$ measure ($\overline{R}^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). All inferences are based on a wild bootstrap procedure (see Flachaire (2005) for details). Number of observations: 49.

Table 17: Bootstrap results (31/03/2009)

| | Constant | MtBv | $\Delta$OA$^+$ | $\Delta$OA$^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 0.167 | -0.023 | -0.071 | -1.093$^{*}$ | 0.931$^{*}$ | -0.015 | -0.008 | -0.410 | 0.123 | 1.175 |
| [-3,1] | 1.071 | 0.070 | -0.134 | -1.375$^{***}$ | 0.949$^{**}$ | 0.014 | 0.049 | -0.775$^{**}$ | 0.347 | 4.613$^{**}$ |
| [-1,1] | 0.708 | 0.158$^{*}$ | -0.272 | -0.752$^{**}$ | 0.096 | 0.122$^{**}$ | -0.053 | -0.379 | 0.268 | 2.047 |
| [-1,3] | -0.330 | 0.024 | -0.160 | -0.504 | 0.230 | 0.063 | -0.101 | -0.003 | 0.094 | 0.466 |
| [0] | 0.240 | 0.165 | 0.457 | -0.012 | -0.548 | 0.098 | -0.052 | -0.253 | 0.191 | 0.844 |

Note: The table shows Bootstrap estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report OLS coefficients, the adjusted $R^2$ measure ($\overline{R}^2$) and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). All inferences are based on a wild bootstrap procedure (see Flachaire (2005) for details). Number of observations: 38.

Table 18: FIML results (25/04/2006)

| | Constant | Sales | MtBv | OA | VE/Sales | CD | Wald test | LR test | LM test |
|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | -0.249 | 0.167 | -0.021 | 0.350 | 0.176 | -0.265 | 2.405 | 2.974 | 5.958 |
| p-val | 0.898 | 0.822 | 0.666 | 0.546 | 0.820 | 0.399 | 0.791 | 0.704 | 0.310 |
| [-3,1] | -0.599 | 0.002 | -0.012 | 0.788 | -0.031 | -0.084 | 3.731 | 5.448 | 10.784* |
| p-val | 0.728 | 0.997 | 0.728 | 0.107 | 0.967 | 0.756 | 0.589 | 0.364 | 0.056 |
| [-1,1] | -0.466 | 0.149 | -0.027** | 0.671 | 0.152 | -0.082 | 7.863 | 6.094 | 8.612 |
| p-val | 0.746 | 0.814 | 0.021 | 0.223 | 0.820 | 0.757 | 0.164 | 0.297 | 0.126 |
| [-1,3] | -0.114 | 0.266 | -0.031*** | 0.210 | 0.300 | -0.279 | 21.456*** | 3.874 | 2.742 |
| p-val | 0.926 | 0.632 | 0.000 | 0.679 | 0.616 | 0.336 | 0.001 | 0.568 | 0.740 |
| [0] | 0.473 | -0.206 | 0.006 | 0.417 | -0.194 | -0.097 | 2.543 | 3.649 | 9.305* |
| p-val | 0.740 | 0.733 | 0.850 | 0.397 | 0.765 | 0.675 | 0.770 | 0.601 | 0.098 |

Note: The table shows FIML estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report FIML coefficients, and the Wald, Likelihood Ration (LR) and Lagrange Multiplier (LM) statistics which all test the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 55.

Table 19: FIML results (15/05/2006)

| | Constant | Sales | MtBv | OA | VE/Sales | CD | Wald test | LR test | LM test |
|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 1.971 | -0.167 | -0.038 | -0.814 | -0.093 | -0.046 | 4.315 | 6.984 | 14.160** |
| p-val | 0.156 | 0.116 | 0.795 | 0.149 | 0.225 | 0.899 | 0.505 | 0.222 | 0.015 |
| [-3,1] | 1.329 | -0.121 | -0.020 | -0.457 | -0.042 | 0.033 | 1.647 | 2.995 | 7.257 |
| p-val | 0.364 | 0.311 | 0.914 | 0.406 | 0.608 | 0.932 | 0.896 | 0.701 | 0.202 |
| [-1,1] | 1.297 | -0.129* | -0.002 | -0.297 | -0.015 | 0.159 | 3.886 | 2.505 | 1.696 |
| p-val | 0.226 | 0.079 | 0.970 | 0.505 | 0.825 | 0.622 | 0.566 | 0.776 | 0.889 |
| [-1,3] | 2.008* | -0.176** | -0.025 | -0.722* | -0.077 | 0.026 | 6.435 | 5.818 | 4.884 |
| p-val | 0.068 | 0.025 | 0.588 | 0.070 | 0.212 | 0.956 | 0.266 | 0.324 | 0.430 |
| [0] | 1.827 | -0.147 | -0.026 | -0.219 | -0.036 | 0.018 | 3.145 | 3.973 | 5.034 |
| p-val | 0.141 | 0.120 | 0.746 | 0.617 | 0.556 | 0.956 | 0.678 | 0.553 | 0.412 |

Note: The table shows FIML estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report FIML coefficients, and the Wald, Likelihood Ration (LR) and Lagrange Multiplier (LM) statistics which all test the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 49.

Table 20: FIML results (02/04/2007)

| | Constant | Sales | MtBv | $\Delta$OA$^+$ | $\Delta$OA$^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | Wald test | LR test | LM test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | -1.589 | 0.081 | -0.037 | 0.763 | -0.202 | -0.085 | 0.055 | 0.065 | 0.130 | 10.470 | 9.920 | 9.219 |
| p-val | 0.138 | 0.732 | 0.242 | 0.526 | 0.854 | 0.800 | 0.819 | 0.183 | 0.590 | 0.234 | 0.271 | 0.324 |
| [-3,1] | -1.277 | -0.032 | -0.048 | 1.254 | -0.111 | -0.012 | 0.170 | 0.046 | 0.220 | 8.517 | 9.059 | 11.828 |
| p-val | 0.186 | 0.881 | 0.189 | 0.316 | 0.927 | 0.976 | 0.440 | 0.353 | 0.298 | 0.385 | 0.337 | 0.159 |
| [-1,1] | 0.669 | -0.362 | -0.051 | 1.850 | 1.488 | -0.276 | 0.432 | 0.104* | 0.404 | 10.089 | 8.793 | 8.495 |
| p-val | 0.603 | 0.294 | 0.168 | 0.149 | 0.328 | 0.405 | 0.240 | 0.095 | 0.229 | 0.259 | 0.360 | 0.387 |
| [-1,3] | -0.075 | -0.155 | -0.036 | 1.104 | 1.026 | -0.299 | 0.234 | 0.112** | 0.248 | 13.725* | 9.788 | 8.674 |
| p-val | 0.916 | 0.525 | 0.387 | 0.392 | 0.518 | 0.338 | 0.400 | 0.026 | 0.374 | 0.089 | 0.280 | 0.371 |
| [0] | 2.286 | -0.430 | -0.012 | 1.347 | 2.977* | -0.034 | 0.372 | 0.101 | 0.037 | 7.411 | 8.007 | 9.537 |
| p-val | 0.139 | 0.307 | 0.808 | 0.502 | 0.074 | 0.951 | 0.405 | 0.240 | 0.930 | 0.493 | 0.433 | 0.299 |

Note: The table shows FIML estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report FIML coefficients, and the Wald, Likelihood Ration (LR) and Lagrange Multiplier (LM) statistics which all test the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 53.

Table 21: FIML results (08/05/2007)

| | Constant | Sales | MtBv | $\Delta OA^+$ | $\Delta OA^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | Wald test | LR test | LM test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 1.985 | -0.106 | 0.010 | 1.877 | 1.316 | -0.827$^{*}$ | -0.012 | -0.012 | -0.680$^{*}$ | 10.602 | 17.825$^{**}$ | 25.392$^{***}$ |
| p-val | 0.228 | 0.531 | 0.913 | 0.108 | 0.135 | 0.095 | 0.935 | 0.834 | 0.083 | 0.225 | 0.023 | 0.001 |
| [-3,1] | 1.883$^{**}$ | 0.058 | 0.041 | -0.479 | 1.601 | -0.930$^{***}$ | -0.210 | -0.068 | 0.791$^{***}$ | 24.229$^{***}$ | 26.087$^{***}$ | 15.306$^{*}$ |
| p-val | 0.050 | 0.730 | 0.393 | 0.698 | 0.143 | 0.005 | 0.251 | 0.271 | 0.003 | 0.002 | 0.001 | 0.053 |
| [-1,1] | 2.227$^{*}$ | -0.092 | 0.031 | -0.374 | 1.679 | -0.796 | -0.070 | -0.015 | -0.295 | 8.191 | 13.950$^{*}$ | 23.961$^{***}$ |
| p-val | 0.074 | 0.518 | 0.342 | 0.721 | 0.106 | 0.148 | 0.611 | 0.832 | 0.381 | 0.415 | 0.083 | 0.002 |
| [-1,3] | 2.190$^{*}$ | -0.251 | -0.004 | 2.396 | 1.262 | -0.669 | 0.138 | 0.041 | -0.253 | 12.042 | 11.856 | 27.214$^{***}$ |
| p-val | 0.083 | 0.236 | 0.890 | 0.194 | 0.625 | 0.117 | 0.537 | 0.566 | 0.476 | 0.149 | 0.158 | 0.001 |
| [0] | 0.994 | -0.356 | -0.016 | 1.452 | 0.700 | -0.187 | 0.337 | -0.000 | 0.273 | 9.419 | 6.184 | 6.347 |
| p-val | 0.799 | 0.314 | 0.923 | 0.569 | 0.594 | 0.748 | 0.227 | 0.998 | 0.688 | 0.308 | 0.627 | 0.608 |

Note: The table shows FIML estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report FIML coefficients, and the Wald, Likelihood Ration (LR) and Lagrange Multiplier (LM) statistics which all test the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 35.

Table 22: FIML results (28/05/2008)

| | Constant | Sales | MtBv | $\Delta OA^+$ | $\Delta OA^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | Wald test | LR test | LM test |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 1.201 | -0.143 | -0.290 | -0.143 | 2.742 | -0.487$^{*}$ | 0.098 | -0.038 | 0.415 | 13.827$^{*}$ | 8.948 | 10.384 |
| p-val | 0.512 | 0.538 | 0.178 | 0.950 | 0.648 | 0.098 | 0.570 | 0.483 | 0.165 | 0.086 | 0.347 | 0.239 |
| [-3,1] | -0.791 | 0.010 | -0.286 | -0.188 | 0.679 | -0.464 | 0.067 | -0.048 | 0.566$^{**}$ | 28.548$^{***}$ | 16.603$^{**}$ | 10.627 |
| p-val | 0.503 | 0.942 | 0.125 | 0.873 | 0.871 | 0.172 | 0.481 | 0.339 | 0.013 | 0.000 | 0.035 | 0.224 |
| [-1,1] | -0.440 | -0.110 | -0.274 | 0.348 | -0.028 | -0.655 | 0.179 | -0.046 | 0.658$^{**}$ | 20.647$^{***}$ | 17.773$^{**}$ | 21.579$^{***}$ |
| p-val | 0.735 | 0.666 | 0.144 | 0.792 | 0.891 | 0.235 | 0.460 | 0.538 | 0.044 | 0.008 | 0.023 | 0.006 |
| [-1,3] | 1.864 | -0.262 | -0.269 | 0.282 | 2.541 | -0.618 | 0.187 | -0.032 | 0.435 | 4.662 | 9.427 | 21.870$^{***}$ |
| p-val | 0.263 | 0.386 | 0.320 | 0.822 | 0.256 | 0.388 | 0.502 | 0.705 | 0.264 | 0.793 | 0.308 | 0.005 |
| [0] | -0.033 | -0.158 | -0.098 | 0.307 | -4.013 | 0.096 | 0.202$^{**}$ | -0.006 | 0.307 | 24.717$^{***}$ | 10.541 | 7.584 |
| p-val | 0.976 | 0.225 | 0.702 | 0.780 | 0.207 | 0.850 | 0.033 | 0.937 | 0.359 | 0.002 | 0.229 | 0.475 |

Note: The table shows FIML estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report FIML coefficients, and the Wald, Likelihood Ration (LR) and Lagrange Multiplier (LM) statistics which all test the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 49.

Table 23: FIML results (31/03/2009)

| | Constant | MtBv | $\Delta OA^+$ | $\Delta OA^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | Wald test | LR test | LM test |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 0.179 | -0.022 | -0.072 | -1.098 | 0.930 | -0.015 | -0.021 | -0.412 | 5.270 | 4.987 | 6.441 |
| p-val | 0.925 | 0.892 | 0.920 | 0.140 | 0.235 | 0.892 | 0.916 | 0.417 | 0.627 | 0.662 | 0.489 |
| [-3,1] | 1.083 | 0.071 | -0.133 | -1.375$^{***}$ | 0.945$^{**}$ | 0.016 | 0.064 | -0.777$^{***}$ | 27.635$^{***}$ | 16.151$^{*}$ | 9.403 |
| p-val | 0.475 | 0.596 | 0.660 | 0.001 | 0.043 | 0.758 | 0.637 | 0.010 | 0.000 | 0.024 | 0.225 |
| [-1,1] | 0.716 | 0.161 | -0.265 | -0.735 | 0.086 | 0.131 | 0.068 | -0.382 | 5.192 | 11.776 | 29.263$^{***}$ |
| p-val | 0.343 | 0.226 | 0.252 | 0.293 | 0.839 | 0.135 | 0.400 | 0.230 | 0.637 | 0.108 | 0.000 |
| [-1,3] | -0.321 | 0.026 | -0.157 | -0.496 | 0.224 | 0.068 | -0.038 | -0.005 | 2.742 | 3.754 | 6.692 |
| p-val | 0.771 | 0.842 | 0.590 | 0.416 | 0.623 | 0.351 | 0.730 | 0.982 | 0.908 | 0.808 | 0.462 |
| [0] | 0.266 | 0.167 | 0.462 | -0.003 | -0.560 | 0.108 | 0.048 | -0.258 | 7.862 | 8.148 | 18.701$^{***}$ |
| p-val | 0.900 | 0.316 | 0.522 | 0.997 | 0.499 | 0.310 | 0.821 | 0.719 | 0.345 | 0.320 | 0.009 |

Note: The table shows FIML estimation results for equation (6). Dependent variable: *SCAR*. Observations where one of the dependent variables are missing or verified emissions or allowances are zero were dropped. We report FIML coefficients, and the Wald, Likelihood Ration (LR) and Lagrange Multiplier (LM) statistics which all test the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 38.

Table 24: WLS results (25/04/2006)

| | Constant | Sales | MtBv | OA | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|
| [-3,3] | -0.058 | -0.004 | -0.002$^{*}$ | 0.035 | -0.009 | -0.013 | 0.051 | 2.008$^{*}$ |
| p-val | 0.676 | 0.909 | 0.053 | 0.161 | 0.801 | 0.506 | | 0.094 |
| [-3,1] | -0.044 | -0.004 | -0.001 | 0.038$^{**}$ | -0.008 | -0.005 | 0.113 | 1.757 |
| p-val | 0.507 | 0.839 | 0.324 | 0.018 | 0.713 | 0.646 | | 0.139 |
| [-1,1] | -0.041 | 0.001 | -0.001$^{*}$ | 0.027$^{**}$ | -0.001 | -0.001 | 0.102 | 1.859 |
| p-val | 0.489 | 0.948 | 0.077 | 0.036 | 0.937 | 0.894 | | 0.119 |
| [-1,3] | -0.056 | 0.001 | -0.002$^{**}$ | 0.024 | -0.003 | -0.009 | 0.041 | 3.885$^{***}$ |
| p-val | 0.674 | 0.978 | 0.011 | 0.284 | 0.928 | 0.606 | | 0.005 |
| [0] | -0.003 | -0.005 | 0.000 | 0.008 | -0.006 | -0.001 | 0.063 | 1.446 |
| p-val | 0.879 | 0.492 | 0.791 | 0.192 | 0.423 | 0.836 | | 0.225 |

Note: The table shows WLS estimation results for equation (6). Dependent variable: *CAR*. Observations where the dependent variables is missing or verified emissions or allowances are zero, were dropped. We report WLS coefficients, the $R^2$ and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 55.

Table 25: WLS results (15/05/2006)

| | Constant | Sales | MtBv | OA | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|
| [-3,3] | 0.010 | -0.002 | -0.003 | -0.085$^{**}$ | -0.003 | -0.023 | 0.472 | 7.694$^{***}$ |
| p-val | 0.907 | 0.741 | 0.674 | 0.014 | 0.366 | 0.113 | | 0.000 |
| [-3,1] | 0.056 | -0.005$^{*}$ | -0.002 | -0.055$^{*}$ | -0.003 | 0.001 | 0.584 | 8.580$^{***}$ |
| p-val | 0.263 | 0.094 | 0.586 | 0.071 | 0.304 | 0.933 | | 0.000 |
| [-1,1] | -0.033 | 0.001 | 0.002 | -0.037$^{**}$ | 0.002 | 0.003 | 0.335 | 3.496$^{**}$ |
| p-val | 0.364 | 0.720 | 0.545 | 0.010 | 0.348 | 0.721 | | 0.010 |
| [-1,3] | -0.079 | 0.004 | 0.001 | -0.067$^{**}$ | 0.002 | -0.021 | 0.345 | 2.350$^{*}$ |
| p-val | 0.191 | 0.256 | 0.882 | 0.010 | 0.585 | 0.136 | | 0.057 |
| [0] | -0.007 | -0.001 | 0.002 | -0.031$^{**}$ | -0.002 | -0.003 | 0.714 | 5.412$^{***}$ |
| p-val | 0.805 | 0.692 | 0.466 | 0.027 | 0.175 | 0.618 | | 0.001 |

Note: The table shows WLS estimation results for equation (6). Dependent variable: *CAR*. Observations where the dependent variables is missing or verified emissions or allowances are zero, were dropped. We report WLS coefficients, the $R^2$ and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 49.

Table 26: WLS results (02/04/2007)

| | Constant | Sales | MtBv | $\Delta$OA$^{+}$ | $\Delta$OA$^{-}$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | -0.088$^{**}$ | 0.005$^{*}$ | 0.006$^{*}$ | -0.024 | -0.032 | -0.066$^{***}$ | -0.023$^{**}$ | 0.001 | -0.011 | 0.810 | 63.404$^{***}$ |
| p-val | 0.049 | 0.059 | 0.068 | 0.543 | 0.584 | 0.001 | 0.013 | 0.802 | 0.255 | | 0.000 |
| [-3,1] | -0.128$^{**}$ | 0.007$^{*}$ | 0.005$^{*}$ | -0.031 | -0.015 | -0.054$^{**}$ | -0.025$^{**}$ | 0.003 | 0.002 | 0.786 | 128.010$^{***}$ |
| p-val | 0.043 | 0.054 | 0.099 | 0.397 | 0.810 | 0.020 | 0.011 | 0.316 | 0.855 | | 0.000 |
| [-1,1] | -0.032 | 0.002 | 0.004 | -0.053 | 0.038 | -0.023 | -0.024$^{***}$ | 0.005$^{*}$ | 0.010 | 0.709 | 101.481$^{***}$ |
| p-val | 0.704 | 0.720 | 0.123 | 0.261 | 0.422 | 0.287 | 0.006 | 0.077 | 0.258 | | 0.000 |
| [-1,3] | 0.008 | -0.001 | 0.005$^{*}$ | -0.046$^{*}$ | 0.020 | -0.035$^{**}$ | -0.023$^{***}$ | 0.002 | -0.002 | 0.776 | 41.963$^{***}$ |
| p-val | 0.909 | 0.900 | 0.072 | 0.303 | 0.659 | 0.049 | 0.004 | 0.324 | 0.774 | | 0.000 |
| [0] | 0.036 | -0.002 | 0.0001 | -0.053$^{**}$ | 0.003 | 0.005 | 0.005 | 0.002 | 0.005 | 0.350 | 611.892$^{***}$ |
| p-val | 0.453 | 0.456 | 0.736 | 0.018 | 0.882 | 0.526 | 0.110 | 0.105 | 0.301 | | 0.000 |

Note: The table shows WLS estimation results for equation (6). Dependent variable: *CAR*. Observations where the dependent variables is missing or verified emissions or allowances are zero, were dropped. We report WLS coefficients, the $R^2$ and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 53.

Table 27: WLS results (08/05/2007)

| | Constant | Sales | MtBv | $\Delta OA^+$ | $\Delta OA^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 0.085$^{***}$ | -0.004$^{***}$ | 0.002$^{***}$ | -0.029$^{***}$ | 0.112$^{***}$ | -0.059$^{***}$ | 0.026$^{**}$ | -0.001 | -0.026$^{***}$ | 0.927 | 147.061$^{***}$ |
| p-val | 0.001 | 0.009 | 0.000 | 0.003 | 0.000 | 0.000 | 0.052 | 0.786 | 0.000 | | 0.000 |
| [-3,1] | 0.176$^{***}$ | -0.011$^{***}$ | 0.003$^{***}$ | -0.036$^{***}$ | 0.072$^{**}$ | -0.062$^{***}$ | 0.033$^{***}$ | -0.007$^{***}$ | -0.022$^{***}$ | 0.882 | 64.294$^{***}$ |
| p-val | 0.000 | 0.000 | 0.000 | 0.001 | 0.014 | 0.000 | 0.006 | 0.001 | 0.000 | | 0.000 |
| [-1,1] | 0.159$^{***}$ | -0.011$^{***}$ | 0.001$^{*}$ | 0.024 | 0.085 | -0.066$^{***}$ | 0.028$^{**}$ | -0.008$^{**}$ | 0.001 | 0.642 | 6.908$^{***}$ |
| p-val | 0.003 | 0.003 | 0.058 | 0.316 | 0.159 | 0.002 | 0.038 | 0.027 | 0.894 | | 0.000 |
| [-1,3] | 0.068$^{***}$ | -0.004$^{**}$ | 0.000 | 0.031 | 0.124$^{***}$ | -0.063$^{***}$ | 0.021 | -0.002 | -0.003 | 0.856 | 27.589$^{***}$ |
| p-val | 0.007 | 0.016 | 0.741 | 0.115 | 0.001 | 0.000 | 0.134 | 0.366 | 0.534 | | 0.000 |
| [0] | -0.008 | -0.001 | 0.000$^{**}$ | 0.042$^{***}$ | 0.014 | -0.018$^{**}$ | 0.006 | -0.003$^{*}$ | 0.002 | 0.743 | 6.628$^{***}$ |
| p-val | 0.542 | 0.347 | 0.010 | 0.000 | 0.466 | 0.026 | 0.268 | 0.054 | 0.453 | | 0.000 |

Note: The table shows WLS estimation results for equation (6). Dependent variable: *CAR*. Observations where the dependent variables is missing or verified emissions or allowances are zero, were dropped. We report WLS coefficients, the $R^2$ and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 35.

Table 28: WLS results (28/05/2008)

| | Constant | Sales | MtBv | $\Delta OA^+$ | $\Delta OA^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 0.146$^{***}$ | -0.008$^{**}$ | -0.022$^{***}$ | -0.038 | -0.020 | -0.027 | -0.001 | 0.001 | 0.027$^{***}$ | 0.590 | 3.857$^{***}$ |
| p-val | 0.006 | 0.013 | 0.009 | 0.222 | 0.889 | 0.309 | 0.890 | 0.701 | 0.002 | | 0.002 |
| [-3,1] | -0.026 | 0.003 | -0.016$^{*}$ | -0.019 | -0.208 | 0.019 | -0.008 | 0.004$^{**}$ | 0.020$^{**}$ | 0.551 | 7.974$^{***}$ |
| p-val | 0.489 | 0.187 | 0.059 | 0.381 | 0.108 | 0.411 | 0.307 | 0.030 | 0.010 | | 0.000 |
| [-1,1] | -0.006 | 0.001 | -0.015$^{***}$ | -0.015 | -0.148 | 0.009 | 0.000 | 0.004 | 0.033$^{***}$ | 0.665 | 44.710$^{***}$ |
| p-val | 0.861 | 0.569 | 0.002 | 0.623 | 0.318 | 0.691 | 0.955 | 0.209 | 0.000 | | 0.000 |
| [-1,3] | 0.166$^{***}$ | -0.009$^{***}$ | -0.021$^{***}$ | -0.034 | 0.040 | -0.037$^{*}$ | 0.008 | 0.001 | 0.040$^{***}$ | 0.737 | 20.263$^{***}$ |
| p-val | 0.000 | 0.000 | 0.000 | 0.217 | 0.778 | 0.058 | 0.253 | 0.793 | 0.000 | | 0.000 |
| [0] | -0.028 | 0.002 | -0.004 | -0.035 | -0.261$^{**}$ | 0.051$^{**}$ | 0.002 | 0.002 | -0.003 | 0.442 | 4.767$^{***}$ |
| p-val | 0.401 | 0.283 | 0.534 | 0.293 | 0.031 | 0.030 | 0.758 | 0.498 | 0.633 | | 0.000 |

Note: The table shows WLS estimation results for equation (6). Dependent variable: *CAR*. Observations where the dependent variables is missing or verified emissions or allowances are zero, were dropped. We report WLS coefficients, the $R^2$ and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 49.

Table 29: WLS results (31/03/2009)

| | Constant | MtBv | $\Delta OA^+$ | $\Delta OA^-$ | OA | $\Delta$VE/Sales | VE/Sales | CD | $R^2$ | $F$ |
|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 0.029 | -0.007 | -0.011 | -0.099$^{***}$ | 0.076$^{**}$ | 0.001 | -0.001 | -0.028 | 0.184 | 4.133$^{***}$ |
| p-val | 0.693 | 0.436 | 0.757 | 0.001 | 0.026 | 0.764 | 0.850 | 0.247 | | 0.003 |
| [-3,1] | 0.102$^{***}$ | 0.001 | -0.017 | -0.106$^{***}$ | 0.069$^{**}$ | 0.002 | 0.005 | -0.047$^{***}$ | 0.422 | 7.004$^{***}$ |
| p-val | 0.008 | 0.888 | 0.508 | 0.000 | 0.011 | 0.365 | 0.108 | 0.001 | | 0.000 |
| [-1,1] | 0.079$^{*}$ | 0.004 | -0.020 | -0.041$^{**}$ | 0.005 | 0.006$^{***}$ | 0.000 | -0.015 | 0.277 | 4.233$^{***}$ |
| p-val | 0.084 | 0.316 | 0.348 | 0.017 | 0.806 | 0.006 | 0.935 | 0.216 | | 0.002 |
| [-1,3] | 0.006 | -0.004 | -0.013 | -0.033 | 0.012 | 0.005$^{*}$ | -0.006 | 0.004 | 0.109 | 0.809 |
| p-val | 0.932 | 0.634 | 0.659 | 0.234 | 0.706 | 0.094 | 0.345 | 0.855 | | 0.586 |
| [0] | 0.041 | 0.004 | 0.015 | 0.001 | -0.021 | 0.004$^{*}$ | 0.000 | -0.011 | 0.170 | 0.881 |
| p-val | 0.301 | 0.181 | 0.272 | 0.946 | 0.165 | 0.054 | 0.957 | 0.272 | | 0.533 |

Note: The table shows WLS estimation results for equation (6). Dependent variable: *CAR*. Observations where the dependent variables is missing or verified emissions or allowances are zero, were dropped. We report WLS coefficients, the $R^2$ and the F-statistic which tests the null hypothesis that all dependent variables, excluding the constant, are jointly zero. We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$). Number of observations: 38.

Table 30: Panel results 2006-2009

| | Constant | Sales | MtBv | OA | VE/Sales | $R^2$ | $F_0$ | $F_1$ | $F_2$ |
|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 1.381$^{**}$ | -0.081 | -0.041$^{***}$ | -0.432 | 0.104 | 0.144 | 64.056$^{***}$ | 1.149 | 4.641$^{***}$ |
| p-val | 0.032 | 0.843 | 0.000 | 0.270 | 0.572 | | 0.000 | 0.320 | 0.000 |
| [-3,1] | -0.605 | 0.241 | -0.030$^{***}$ | -1.102$^{***}$ | -0.082$^{*}$ | 0.148 | 532.053$^{***}$ | 12.296$^{***}$ | 15.961$^{***}$ |
| p-val | 0.190 | 0.108 | 0.000 | 0.000 | 0.071 | | 0.000 | 0.000 | 0.000 |
| [-1,1] | -0.042 | 0.174 | -0.008$^{**}$ | -0.740$^{***}$ | -0.053 | 0.143 | 155.018$^{***}$ | 7.432$^{***}$ | 11.744$^{***}$ |
| p-val | 0.938 | 0.373 | 0.011 | 0.000 | 0.673 | | 0.000 | 0.001 | 0.000 |
| [-1,3] | 1.183$^{**}$ | 0.121 | -0.038$^{***}$ | -0.412 | 0.094 | 0.122 | 47.075$^{***}$ | 1.122 | 2.961$^{***}$ |
| p-val | 0.015 | 0.728 | 0.000 | 0.163 | 0.692 | | 0.000 | 0.328 | 0.002 |
| [0] | 0.075$^{***}$ | -0.028 | -0.003$^{***}$ | 0.004 | 0.001 | 0.186 | 23.743$^{***}$ | 0.023 | 7.876$^{***}$ |
| p-val | 0.001 | 0.198 | 0.000 | 0.831 | 0.912 | | 0.000 | 0.977 | 0.000 |

Note: The table shows Panel estimation results for equation (6). Dependent variable: *SCAR*. Observations where the dependent variables is missing or verified emissions or allowances are zero, were dropped. We report coefficients, $R^2$ and three F-statistics which tests the null hypotheses that all dependent variables, excluding the constant, are jointly zero ($F_0$), all EU ETS related variables excluding fixed effects are jointly zero ($F_1$) and all EU ETS related variables including fixed effects are jointly zero ($F_2$). We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$).

Table 31: Panel results 2007-2009 I

| | Constant | Sales | MtBv | OA | ΔVE/Sales | VE/Sales | $R^2$ | $F_0$ | $F_1$ | $F_2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 16.090 | -10.515$^{**}$ | -0.038$^{***}$ | -0.558$^{**}$ | 0.001 | 0.277 | 0.245 | 17.834$^{***}$ | 3.414$^{**}$ | 3.760$^{***}$ |
| p-val | 0.201 | 0.033 | 0.006 | 0.025 | 0.989 | 0.153 | | 0.000 | 0.020 | 0.000 |
| [-3,1] | -19.826$^{***}$ | 6.887$^{***}$ | -0.040$^{***}$ | -0.640$^{***}$ | 0.027 | 0.051 | 0.185 | 86.038$^{***}$ | 6.112$^{***}$ | 5.172$^{***}$ |
| p-val | 0.010 | 0.007 | 0.000 | 0.001 | 0.663 | 0.623 | | 0.000 | 0.001 | 0.000 |
| [-1,1] | -0.780$^{**}$ | 0.457$^{***}$ | -0.002$^{***}$ | -0.059$^{***}$ | -0.001 | 0.010 | 0.138 | 213.407$^{***}$ | 15.268$^{***}$ | 10.844$^{***}$ |
| p-val | 0.024 | 0.005 | 0.000 | 0.000 | 0.752 | 0.211 | | 0.000 | 0.000 | 0.000 |
| [-1,3] | 0.816$^{**}$ | -0.598$^{***}$ | -0.002$^{***}$ | -0.021$^{**}$ | -0.001 | 0.007 | 0.270 | 23.968$^{***}$ | 2.252$^{*}$ | 4.261$^{***}$ |
| p-val | 0.047 | 0.000 | 0.002 | 0.019 | 0.751 | 0.460 | | 0.000 | 0.086 | 0.000 |
| [0] | 10.625 | 1.001 | -0.046$^{***}$ | -0.660$^{***}$ | -0.024 | 0.286$^{**}$ | 0.186 | 18.582$^{***}$ | 6.792$^{***}$ | 6.163$^{***}$ |
| p-val | 0.417 | 0.818 | 0.008 | 0.001 | 0.719 | 0.041 | | 0.000 | 0.000 | 0.000 |

Note: The table shows Panel estimation results for equation (6). Dependent variable: *SCAR*. Observations where the dependent variables is missing or verified emissions or allowances are zero, were dropped. We report coefficients, $R^2$ and three F-statistics which tests the null hypotheses that all dependent variables, excluding the constant, are jointly zero ($F_0$), all EU ETS related variables excluding fixed effects are jointly zero ($F_1$) and all EU ETS related variables including fixed effects are jointly zero ($F_2$). We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$).

Table 32: Panel results 2007-2009 II

| | Constant | Sales | MtBv | ΔOA | ΔVE/Sales | VE/Sales | $R^2$ | $F_0$ | $F_1$ | $F_2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| [-3,3] | 33.810$^{**}$ | -9.200 | -0.038$^{*}$ | -0.714$^{***}$ | -0.079 | 0.441$^{**}$ | 0.245 | 18.907$^{***}$ | 4.966$^{***}$ | 7.931$^{***}$ |
| p-val | 0.024 | 0.103 | 0.070 | 0.004 | 0.408 | 0.013 | | 0.000 | 0.003 | 0.000 |
| [-3,1] | 28.122$^{***}$ | 6.981$^{**}$ | -0.042$^{***}$ | -0.317$^{**}$ | -0.013 | 0.071 | 0.185 | 21.683$^{***}$ | 2.613$^{*}$ | 5.178$^{***}$ |
| p-val | 0.002 | 0.024 | 0.000 | 0.013 | 0.905 | 0.558 | | 0.000 | 0.055 | 0.000 |
| [-1,1] | -1.147$^{***}$ | 0.556$^{***}$ | -0.002$^{***}$ | -0.044$^{***}$ | 0.006 | 0.015$^{*}$ | 0.306 | 39.684$^{***}$ | 23.223$^{***}$ | 8.116$^{***}$ |
| p-val | 0.005 | 0.007 | 0.000 | 0.000 | 0.187 | 0.076 | | 0.000 | 0.000 | 0.000 |
| [-1,3] | 1.535$^{***}$ | -0.533$^{***}$ | -0.001$^{*}$ | -0.030$^{***}$ | -0.005 | 0.015 | 0.280 | 35.723$^{***}$ | 6.101$^{***}$ | 12.666$^{***}$ |
| p-val | 0.002 | 0.002 | 0.058 | 0.000 | 0.204 | 0.128 | | 0.000 | 0.001 | 0.000 |
| [0] | 21.670 | 1.698 | -0.046$^{**}$ | -0.691$^{***}$ | -0.114$^{*}$ | 0.409$^{***}$ | 0.169 | 27.648$^{***}$ | 9.493$^{***}$ | 16.956$^{***}$ |
| p-val | 0.173 | 0.712 | 0.043 | 0.000 | 0.073 | 0.002 | | 0.000 | 0.000 | 0.000 |

Note: The table shows Panel estimation results for equation (6). Dependent variable: *SCAR*. Observations where the dependent variables is missing or verified emissions or allowances are zero, were dropped. We report coefficients, $R^2$ and three F-statistics which tests the null hypotheses that all dependent variables, excluding the constant, are jointly zero ($F_0$), all EU ETS related variables excluding fixed effects are jointly zero ($F_1$) and all EU ETS related variables including fixed effects are jointly zero ($F_2$). We report significance levels for 1% ($***$), 5% ($**$) and 10% ($*$).

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