Trading of Emission Allowances and Financial Frictions

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ABSTRACT

This paper examines the role of financial frictions on the trading of emission allowances. Based on a wide international sample of firms and data from the European Union Emission Trading System (the most liquid and developed in the world) we document that firms with liquidity needs are significantly more likely to sell allowances. We also observe more frequent selling of allowances when the transaction is likely to boost earnings and avoid accounting losses. This selling behavior is particularly pronounced in the final month of the fiscal year and at times of higher carbon prices. Our results have implications for the efficacy of carbon markets. The evidence supports the concern that substantial trading of emission allowances by firms with compliance obligations is driven by reasons other than meeting emission requirements.

Keywords: Financial frictions; Emission Trading; Emission Allowance; Pollution Pricing.

JEL Classifications: M10, M41, Q50.

1. Introduction

International carbon markets -and particularly, Emission Trading Systems (ETS)- are an increasingly popular tool to regulate carbon emissions as an alternative to prescriptive "command-and-control" regulation and taxation (The Economist, 2022).[1] However, the functioning of these markets faces several challenges, and -as a result- their institutional design keeps evolving (ECB, 2022). One important concern is that a non-negligible part of the trading of emission rights (commonly known as "allowances") could be misaligned with the social purpose of the carbon market. To the extent that trading affects allowance allocation and pricing, such misalignment could weaken firms' incentives to reduce emissions and thus undermine the efficacy of the carbon market as an instrument to achieve environmental goals. Consistent with this concern, European regulators have hinted at the possibility that the recent increase in EU emissions allowance prices could be partly driven by reasons other than meeting emission requirements (ECB, 2022).

This paper takes a first step to explore the validity of this concern by studying whether the trading of carbon allowances is affected by financial frictions. Focusing on the firms subject to mandatory emission compliance, we analyze whether a meaningful amount of selling of carbon allowances is driven by liquidity and financial reporting considerations -rather than by environmental considerations. We address our research question in the context of the rights and obligations created by the European Union Emission Trading System (henceforth "EU ETS"). This cap-and-trade system covers more than 11,000 power stations and industrial plants in 30 countries

[1] Typically, an ETS sets a cap on the total amount of emissions that companies in the system can produce. This cap is set to achieve targeted reductions over time in the system wide emissions. The right to emit one ton of carbon dioxide per period is usually called "allowance". Theoretically, the "cap-and-trade" principle is grounded in Ronald Coase's theorem stating that environmental protection should be left to the forces of the free market through an economically efficient allocation of property rights (Coase, 1960). That is, by putting a price on carbon, carbon markets reshape firms' incentives to reduce emissions. At the end of 2021 more than 21% of the world's emissions were covered by some form of carbon pricing. Major economies implementing an ETS include the European Union, Canada, Japan, New Zealand, South Korea, the UK, the US and, recently, China (the Chinese carbon market started operating in July 2021).

that collectively are responsible for around 40% of the GHG (greenhouse gas) emissions in the European Union. In 2021 the EU ETS comprised approximately 90% of the entire global carbon credits turnover, making it the most liquid and developed ETS system in the world. The EU ETS is often seen as a template for other countries to follow in developing a coordinated approach to emissions pricing (PWC IETA 2021).

Selling carbon allowances can help firms manage their financial position in two ways. The first one is a liquidity advantage; the sale proceeds add to the firm's cash inflows. The second one is a reporting advantage; selling emission allowances can generate an accounting gain and improve commonly used financial ratios (i.e., quick ratio or interest coverage ratio). The resulting boost in reported performance could provide a low risk means to increase management compensation (Burns and Kedia 2006), reduce the potential of shareholders exercising the abandonment option (Berger et al. 1996), and avoid contractual penalties or help obtain more favorable financing conditions (Dichev and Skinner 2002, DuCharme et al. 2004).

Our sample includes all the firms participating in the EU ETS from 2013 to 2017 that meet our data requirements (3,109 firms). These companies include aircraft operators, refineries, and a variety of industrial and manufacturing businesses. Using public data on trading of carbon allowances, we first document that the selling of allowances is associated with irregularities in the management of EU ETS obligations. When a firm is a net seller of allowances, it is more likely to borrow from future allocations of allowances to cover current obligations. Net sellers also exhibit more pronounced patterns of abnormal surrender of emission allowances (which suggest a deviation from the specified compliance cycle for the EU ETS). In addition, we observe that these firms are more likely to fail to surrender sufficient allowances to cover emissions for the year.

Taken together, these patterns raise concerns about the selling of carbon allowances and call for a deeper analysis of the motivations behind this trading activity.

Our subsequent empirical analyses focus on whether the selling of allowances is more prevalent among firms with liquidity needs and/or among firms with an incentive to increase reported earnings. Regarding liquidity incentives, we find that net selling of allowances is significantly more common among firms that begin a financial year with less cash and receivables than the liabilities it expects to pay during the year (i.e., a quick ratio below 1). This association is robust to using a variety of alternative measures of liquidity. Critically, we also find that the previous patterns are more pronounced for firms with tighter financial constraints (presumably, these firms' selling of allowances responds to difficulties tapping into funding sources)

Regarding reporting incentives, we adjust earnings for allowance sale transactions to identify firms with low accounting performance "ex-ante" (i.e., before the transaction). We find robust evidence that firms with "ex-ante" losses (i.e., pre-selling earnings below zero) are significantly more likely to sell allowances. The propensity to sell allowances does not appear to be related to the magnitude of earnings in itself, but rather to whether earnings exceed a particular threshold as a result of the accounting gain from the sale. Our tests account for the economic value of the sale, for contemporaneous purchases of allowances, and for "normal allowance management" (i.e., trading of allowances to fulfil ETS obligations). Tellingly, the positive association between selling allowances and low earnings performance only occurs when selling is expected to have a positive impact on reported earnings (i.e., when the firm holds ex-ante a substantial amount of excess carbon allowances).

To further sharpen identification, we analyze trading patterns around specific performance thresholds and time periods. We find that selling allowances is more common when reported

earnings just meet or beat the "zero" threshold. Moreover, we observe a significant increase in selling activity among ex-ante loss firms in the last month (December) and in the last quarter (Q4) of the fiscal year.[2] We do not observe a similar increase in selling activity for firms without ex-ante losses nor do we observe any association between purchases in the last month and quarter of the fiscal year for firms with ex-ante losses. When we examine firms that have a non-December fiscal year end, we do not find evidence of increased selling activity in December.

Also consistent with the notion that the association between allowance trading and accounting losses is driven by reporting incentives, we find that there is more selling activity when the market price for emissions allowances is higher. As in previous tests, this pattern is only significant for firms with ex-ante losses and for firms with the possibility of generating an accounting gain by selling allowances. Further, the results are more pronounced for firms with an increase in leverage, which are more likely to face pressure from lenders. In contrast, the association is weaker among firms with higher growth options, namely firms for which reporting a loss is relatively less costly (Joos and Plesko, 2005).

The magnitude of the documented patterns is not negligible. Our sample firms sell allowances for at least 500 million tons of emissions each year, which is more than 80% of their aggregated annual emissions on average. The average net seller of allowances sells 146,000 thousand tons of emission allowances per year. For firms with a quick ratio of less than 1 (i.e., firms without enough cash and receivables to cover their short-term liabilities) the probability of being a net seller of allowances increases by a factor of close to 0.3x or 3.5 percentage points (the unconditional probability is 13%). For firms with "ex-ante" losses (i.e., firms with pre-sale

[2] Our primary sample is limited to firms with a fiscal year end of December 31 so that the period over which emissions are monitored for a given compliance cycle (calendar year) is equal to the period over which financial performance is measured (fiscal year).

earnings below zero) the probability of being classified as a seller increases by a factor of close to 0.5x or 6.1 percentage points. In terms of volume, firms with ex-ante losses typically sell 165,000 net tons of emission allowances per year, which is 37% more units than other firms. On average, the sales proceeds amount to $1 million EUR per firm which translates into an increase in ROA of 0.6 percentage points.

Our paper advances the burgeoning literature studying the efficacy of carbon markets as an environmental tool. Notably, this research provides evidence that the trading of carbon allowances affects firm's innovation efforts (e.g., Calel and Dechezleprêtre, 2016). More recent papers study the phenomenon of "carbon leakage", i.e., whether firms "export" (part of) their pollution abroad (Ben-David et al., 2021, Dechezleprêtre et al., 2022; Naegele and Zaklan, 2019; Borghesi et al., 2020). However, this literature is generally silent on the role of financial frictions in the carbon markets. A remarkable exception is Antoniou et al. (2020), who documents that the costs of compliance and the specific features of the permits markets affect the cost of capital of the firms participating in cap-and-trade programs. We contribute to this literature from a different angle; we study whether financial frictions affect the trading of carbon allowances.[3]

The results of this paper have important regulatory implications. While it is commonly accepted that pollutant pricing mechanisms, including ETS, are key to achieve net-zero emissions by 2050, this type of carbon market has been fraught with major problems since its inception. The controversies include overallocation of allowances, legal uncertainty (the cap determination

[3] Our paper is also related to a growing literature examining managerial short-termism in the context of ESG reporting. For instance, using plant-level data, Thomas et al. (2021) show that US firms that meet or just beat consensus EPS forecasts release significantly more toxic emissions. Similarly, Liu et al. (2021) using a sample of firms in China find that firms with earnings pressure, measured through managers' incentives to meet or beat earnings expectations, have higher intensity sulfur dioxide emissions. Our results complement this literature showing that corporate performance needs significantly affect ESG decisions, through the selling of emissions allowances. In addition, by examining reporting incentives and emissions in private companies our paper sheds light on an understudied segment of the marketplace (Burgstahler et al. 2006, Coppens and Peek 2005).

process was considered cumbersome, unharmonized, and opaque), windfall profits and subsidization of polluting industries, unfairness in the allocation of emissions (inefficient installations being rewarded with larger amounts of free emissions), and fraud.[4] These inefficiencies have often resulted in reduced (sometimes close to zero) carbon prices, thereby weakening firms' incentives to curb emissions. By pointing at trading of allowances as an additional source of inefficiency, our results support recent calls for closer regulatory oversight of this aspect (ECB, 2022).

Our study also has implications for disclosure regulation and standard setting. Investors and other interested parties have raised questions about the intersection of sustainability matters with financial accounting standards. While integrating ESG (Environmental, Social, and Governance) aspects into financial statements poses considerable challenges, major regulators and standard setters have stated publicly that they expect firms to do it.[5] The accounting for emission allowances (i.e., the rights to produce emissions without incurring penalties) is a particularly controversial issue in this regard. Despite having been subject to substantial discussion by both the IFRS and the FASB, the regulatory process is stalled and there is currently no standardized approach to account for emission allowances.[6] This regulatory void has resulted in a variety of accounting

[4] The most significant instances of fraud that triggered structural changes in the EU ETS between the first two phases and the third phase include the use of the system to steal VAT payments collected from allowance sale transactions, the re-selling of certified emission reduction units that had already been used, and the theft of allowances via phishing or other credential theft schemes.

[5] For example, in October 2021 ESMA (the European Securities and Markets Authority) issued the following public statement: "ESMA highlights that issuers and auditors must consider climate risks when preparing and auditing IFRS financial statements to the extent that the effects of those risks are material to those financial statements, even if IFRS Standards do not explicitly refer to climate-related matters (ESMA32-63-1186, October 29, 2021)." FASB (i.e., the US Financial Accounting Standards Board) and the IFRS Foundation (in charge of international accounting standards) have published educational papers on this matter.

[6] This lack of agreement is understandable, as the accounting for carbon allowances poses several non-trivial questions. For example, what type of asset is an emissions allowance? Is it a financial asset, an intangible asset, or inventory? What is the nature of any liability created for a participant in a cap-and-trade ETS and when/how should it be recognized? The obligation arises only as emissions are made. Some allowances are government grants; should the firm realize a day 1 gain or treat it as deferred income? Which measurement and re-measurement approach best reflects

approaches, which potentially undermines the comparability and reliability of financial statements (PWC IETA, 2021; Black, 2013; Ertimur et al., 2020). Our results highlight the importance of rekindling this debate; if emission allowances were recorded on the Balance Sheet at fair value and marked to market at each reporting period, the ability to boost earnings by timing the recognition of gains would disappear.

Finally, our evidence calls for reconsidering the current policy of making trading data from the EU ETS transaction log public in May three years after the close of the compliance period. A timelier disclosure of trading activity would facilitate monitoring by market participants, regulators, and the general public, potentially curbing firms' incentives to trade carbon allowances for reasons that are not aligned with the ultimate purpose of emission trading systems.

2. Background and Hypothesis

2.1 EU ETS

The European Union Emissions Trading System (EU ETS) has been the world's largest Greenhouse Gas (GHG) trading mechanism until the recent start of the Chinese carbon market in July 2021. The EU ETS was approved in 2003 and formally launched in 2005. It is a central pillar of the goal of the European Union to attain climate neutrality by 2050.[7] The system covers primarily emission intensive industries such as power and heat generation, energy intensive industries and civil aviation. These industries represent around 40% of EU GHG emissions (ICAP, 2021).[8] Following the success of the EU ETS, many countries are developing or have already

the economic effects of emission allowances, fair value or cost? For a more in depth discussion of these issues see PWC IETA 2021.

[7] "*The EU ETS is a cornerstone of the Union's climate policy and constitutes its key tool for reducing greenhouse gas emissions in a cost-effective way*". REGULATION (EU) 2021/1119 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 June 2021, also referred to as the European Climate Law.

[8] https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=43

launched their own emissions trading systems including Canada, China, Japan, New Zealand, South Korea, the UK, and the US. In 2020, Switzerland established a link between its own emissions trading system with the EU ETS.[9]

The EU ETS is organized following a cap-and-trade principle. The EU sets a cap on the total amount of emissions that companies in the system can produce. This cap is set to achieve targeted reductions over time in the system wide emissions. Within the system, one *emission allowance* (commonly referred to as "EUA" or just "allowance") represents the right to emit one ton of carbon dioxide per period. Each year, a certain number of allowances is given to installations for free or introduced into the system via an auctioning process. Installations can trade these allowances with other participants or keep them for future periods. Accordingly, firms primarily acquire emission allowances through a purchase at market value ("purchased allowances") or through a government grant for zero cost ("granted allowances"). By creating an active market for allowances, a price for emissions is revealed. Trading in turn helps ensure all firms face a common emission price and facilitates reduction in emissions where it is the least expensive to do so.

The EU ETS has been implemented through 4 phases. This study uses data from Phase 3, which ran from 2013 to 2020 and included significant reforms as compared to the first two phases. A single cap on emissions was defined at the whole EU level, instead of national level caps. Auctioning became the default allocation method instead of allocating units for free, although installations in most industries continued to receive free allowances to cover at least a portion of their expected annual emissions. Short- and long-term measures were designed to address surplus allowances issues. As a consequence, the price of EUAs started to rise gradually during Phase 3 as shown in Figure 1.

[9] https://ec.europa.eu/clima/policies/ets/markets_en

The business operations cycle of the EU ETS runs from January 1st to December 31st of year *t*. By March 31st of *t+1* (*t* being the current year), installations should present their emissions reports from that operations cycle to be checked by accredited verifiers. By April 30th of *t+1*, installations should surrender allowances against their verified GHG emissions. If an installation surrendered lower allowances than their reported emissions, they would have to pay the corresponding fines.[10] The period from January 1st of year *t* to April 30th of year *t+1* is known in the EU ETS terminology as the "compliance period" since firms (or installations) have until April 30th to trade for EUAs and meet their emissions obligations.

The 16-month compliance period means that there is a 4-month overlap between consecutive compliance periods. Given that firms receive granted allowances in the first two months of the compliance period, the granted allowances for compliance period *t+1* will be received by a firm prior to the end of compliance period *t*. Firms are able to use the granted allowance intended for compliance period *t+1* to settle the emissions obligations from period *t*. Accordingly, firms that end fiscal year *t* with a shortage of emission allowances do not necessarily need to purchase allowances before the end of the compliance period to have a sufficient balance of allowances to cover their emissions liability.

2.2 Accounting for Emission Allowances

An ETS system creates certain rights and obligations that need to be accounted for in corporate financial statements. There is currently no internationally recognized accounting guidance on this topic. A detailed discussion of this topic is included in Appendix B. Most firms record purchased allowances at the purchase price and granted allowances at cost or nil value

[10] The actual amount of the fines has been changing over the years. During phase 3, which covers our sample period, installations had to pay 100€ per excess ton of CO2.

(PWC IETA 2021, Black 2013, and PWC IETA 2007). At subsequent remeasurement periods, firms predominantly continue to use the initial measurement value and only adjust carrying values for impairments. Most firms do not record emission liabilities until the emissions for the year exceed the allowances held by the firm. When there is a shortfall of allowances, a provision is generally accrued for at the current fair value of the emission allowances that would need to be acquired to offset the uncovered emissions. This liability credit has an offsetting debit to an emissions expense account that reduces firm operating income.

In the case of granted allowances, this means the recorded value for emission allowances stays at zero unless an allowance is sold. This can create a pool of value that is not recognized in the firm's financial statements. When allowances are sold, the majority of firms report gains or losses in the income statement as part of operating income (either revenue, cost of goods sold, or other operating income per PWC IETA 2021). For allowances previously recorded at nil value, such gains can have a substantial impact on earnings. However, if emissions for the fiscal year are expected to exceed the emission allowances held by the firm, the impact to earnings from such gains will generally be offset by the emission liability provision and associated emissions expense entries recorded to cover the additional shortfall created by the sale. Sales of granted allowances also commonly generate cash or cash equivalents, which have a positive effect on a firm's reported current assets.

2.3 Motivations for Selling Emission Allowances

We envision that there are three primary motivations for selling emissions allowances.

(i) Normal Allowance Management. The trading of allowances in an ETS is meant to discover a price for carbon and thus facilitate a cost-efficient reduction in system wide emissions. For emitting companies required to participate in the ETS, trading is meant to facilitate compliance

with environmental requirements (we refer to this purpose as "normal allowance management"). This motivation should result in lower selling when the firm's emission needs are increasing or expected to increase and higher selling when the firm has excess emission allowances.

(ii) Liquidity Needs. Firms with higher short term cash flow obligations and/or lower short term cash flow resources could be tempted to sell emission allowances to meet liquidity needs without incurring additional financing costs. To the extent that trading allowances for liquidity purposes diverts from normal allowance management, this trading behavior could reduce the efficacy of an ETS. The notion that firms sell emission allowances to meet short term liquidity needs is supported by anecdotal evidence (PWC IETA, 2021).

(iii) Boosting Earnings. Prior literature extensively documents that firms take actions to avoid reporting accounting losses and to minimize the magnitude of the reported loss. An accounting loss is a common heuristic that can trigger broader concerns across the stakeholder base regarding the future viability of the business and increase the potential of shareholders exercising the abandonment option (Berger et al. 1996, Burgstahler and Dichev 1997a). Reporting a loss and a loss of a larger magnitude can also impact executive bonus payments and/or trigger increased risk of negative career outcomes (Healy 1985). Firms reporting accounting losses may have greater difficulty accessing debt markets for new financing. Further, reporting a loss is a common debt covenant violation or, more generally, can be seen as a signal of increased risk of creditor interference and loss of control for a firm. Firms facing a potential covenant violation have been shown to make income increasing accounting choices (Sweeney 1994, Dichev and Skinner 2002). This effect may be even stronger for private companies, particularly in Europe, where extensive creditor rights elevate the threat of creditor intervention (Burgstahler et al. 2006).

Prior research has established that firms make short-term focused operational decisions to improve their reported performance, a behavior commonly known as "real earnings management" (Roychowdhury, 2006). In the case of emission allowances, firms with pools of off-balance sheet emissions allowances can time the selling of these allowances to recognize gains and improve reported earnings. The incentives to do so are stronger among firms with poor financial performance and greater pressure to meet certain earnings targets. In addition to misleading users of financial information, selling emission allowances to boost earnings diverts from normal allowance management and thus potentially reduces the efficacy of an ETS.

It is likely that external parties (e.g., market participants, regulators, environmental activists) do not see through firms' strategic selling of allowances, at least in the short run. Critically, trading data from the EU ETS transaction log is made public in May three years after the close of the compliance period. This lagged disclosure of trading activity makes it hard for external parties to monitor firms' trading of carbon allowances.[11]

3. Data and Research Design

3.1 Sample and Data

To construct our sample, we start with the universe of installations and account holders participating in the EU ETS, available through the EU ETS transaction log.[12] From this dataset, we retrieve the necessary information to compute for each installation (i.e. individual plant or factory) the activity related to compliance obligations as described in Section 2 (e.g., granted allowances received for free, verified emissions, allowances surrendered) and the activity related

[11] Inferring allowance trading from financial statements is difficult due to the aggregated nature of accounting information. Collecting information from allowance trading in the footnotes of financial statements in a systematic way is also unfeasible, as there is no disclosure requirement.
[12] https://ec.europa.eu/clima/ets/

to the firms' trading behavior (e.g., allowances bought and sold). We aggregate installation activity up to the account holder level, which is the legal entity of record for the installation or group of installations in the registry.[13] As part of this aggregation, we net out any intracompany transactions. We pull spot market price history for EU ETS emission allowances from Refinitiv Datastream.

Our sample covers the year 2013 through 2017. Ending the sample period in 2017 responds to data limitations. Trading data from the EU ETS transaction log is made public in May three years after the close of the compliance period. It follows that the trading activity for the year 2017 was not released until May of 2021. We exclude observations prior to 2013 to focus our analysis on Phase 3 of the EU ETS and avoid potential abnormal trading activity during the closing of Phase 2. Finally, we hand match the account holders to firms from Orbis Bureau van Dijk to retrieve financial statement information. We drop all firms that do not have a December fiscal year end (so that the business cycle over which emissions are measured for the EU ETS matches the fiscal year for all firms in our sample). This data set provides financial information for a broad set of public and private European firms, enabling us to examine the effect of financial performance on firms' allowances trading decisions. Our final sample contains 11,982 firm-years observations, which represent 3,109 unique firms and 5,926 unique installations.

3.2 Descriptive Statistics

Table 1, Panels A and B provide a breakdown of our sample by year and industry. Table 1, Panel C shows that the firms in our sample come from almost all the countries covered by the EU ETS.[14] The countries with the largest representation in our sample are France, Germany, Italy, and

[13] To match installations to account holders we rely on information from the EU ETS registry and leverage prior research by Abrell 2021, which is publicly available at EUETS.INFO.

[14] We do not have firms from Malta and Liechtenstein because of data limitations. While the United Kingdom is no longer covered in the EU ETS after 2020, this country participated in the system over our sample period and thus is included in the analysis.

Spain. Across Panels A, B and C we observe that emission allowance selling activity is significant in all countries, industries, and years in the sample. Table 1 Panel D presents descriptive statistics for the variables used in our tests (see Appendix A for variable definitions).[15]

We also observe a remarkable number of firms with excess allowances across all industries, countries, and time periods. Table 1, Panel A, shows a declining trend in excess units, which is consistent with efforts during Phase 3 of the EU ETS to reduce excess allowances in the system. However, the balance of firms with excess allowances remained significant at the end of 2017. Figure 2 shows the volume of allowances sold in relation to the volume of emissions over the sample period. The sample firms sold allowances for more than 500 million tons of CO2 per year. Aggregated over the sample period, this amounts to more than 80% of total emissions.

4. Irregularities in the Management of ETS Obligations

As a first step in our empirical analysis, we explore whether net selling of allowances is associated with irregularities in the management of ETS obligations. Finding such an association would raise concerns about the implications of this selling activity for the well-functioning of the ETS, thereby calling for a deeper examination of the motivations behind this trading activity (which we conduct in later sections).

Specifically, we estimate the following OLS regression:

$$ETS\_Irregularity_{it} = \alpha\ Netseller_{it} + \Phi\ Controls_{it} + \beta_s + \chi_c + \delta_t + \varepsilon_{it} \quad (1)$$

where *ETS_Irregularity* is one of the following measures of the presence of irregularities in the management of ETS obligations, *Borrow_Future*, *Abnormal_Surrender*, and *Non_Compliant*. β_s, χ_c, and δ_t represent industry sector, country, and year fixed effects, respectively.

[15] Continuous variables are winsorized at the top and bottom 1%.

Borrow_Future is an indicator for firms that use granted allowances intended for the next year to offset current year emissions. As discussed in Section 2, compliance periods last for 16 months creating a 4 month overlap between consecutive compliance periods. Firms receive granted allowances for year *t+1* (*t* being the current year) in January or February of year *t+1* (months 1&2 of compliance period *t+1*) but do not have to surrender allowances to cover year *t* emissions until April of year *t + 1* (month 16 of compliance period *t*). This overlap exists to balance the need of firms to have clarity on granted allowances early in compliance period *t+1*, while also needing adequate time after the end of year *t* to prepare emission reports, to submit them for independent verification and approval by the EU ETS, and ultimately to arrange surrender of allowances sufficient to cover verified emissions. However, an unintended consequence of this is that firms can borrow from granted allowances intended for year *t+1* to cover year *t* emissions, a behavior we refer to as "borrowing from the future" (hence the label *Borrow_Future*).

Abnormal_Surrender is an indicator variable for firm-years where a firm made an initial large surrender and then a subsequent smaller or series of smaller surrenders. In a normal compliance period firms have until March 31st of year *t+1* (month 15 of compliance period *t*) to present their emissions reports to accredited verifiers and until April 30th (month 16) to surrender verified emissions. However, to the extent that there are issues with the verification of the company's reported emissions or concerns regarding the accuracy of the verified emission report itself, portions of the actual surrender may be delayed past April 30th. *Abnormal_Surrender* is consistent with a large initial surrender being made to cover accrued emissions liabilities according to the firms' computations and then subsequent additional surrenders being made after resolving issues with delays or feedback on the emissions reports received during the verification and

monitoring process. We consider this "abnormal" pattern as an indication of irregularities in the management of the EU ETS obligations.

Non_Compliant is an indicator variable for whether in that year at least one of the installations of the firm is not compliant with the obligations of the EU ETS. An installation is considered not compliant when it fails to surrender sufficient allowances to cover its emissions from that compliance period.

On the right-hand side of equation (1), *Netseller* is an indicator variable that equals one if the firm sells more allowances than it purchases in that year, and zero otherwise. [16] We do not include free allocations and surrenders as trading activity. We also require that EUR value of net sales is at least 0.01% of beginning of year total assets to prevent including activity that essentially nets to zero. It is difficult to identify related party transactions between installations in the EU ETS transaction log. By using *Netseller* we can eliminate this data issue via the aggregation process of trading activity from the installations level to the ETS legal entity. During the aggregation step, intra-firm transfers would be recorded by one related installation as a sell and by the other related installation as a buy and the two would cancel each other out in our *Netseller* calculation. To ensure that our measurement choices do not affect our inferences, we repeat our tests using alternative measures of selling activity, including the natural log of estimated proceeds from net sales (*NetSales_Proceeds*), the natural log of the net number of allowances sold (*Net_Units_Sold*), and gross measures of each of these variables (*Seller*, *Sales_Proceeds*, *Units_Sold*) that do not net out

[16] For fiscal year 2013 we identify significant transactions related to the transition from Phase 2 to Phase 3 scattered throughout the transaction log through the first 8 months of the fiscal year. To avoid mistakenly classifying such transactions as normal buying and selling of allowances we exclude the first 8 months of transaction log data of 2013 for purposes of calculating allowances sales. Our results are robust to excluding from the analysis observations corresponding to year 2013.

purchases of allowances (see online appendix OA.0 for detailed variable definitions). Inferences are unaffected.

Controls include two different vectors of control variables. *Normal Allowance Management* and *Firm Characteristics*. The vector *Normal Allowance Management* contains variables that are expected to be associated with trading activity related to EU ETS compliance and includes the variables described in the remainder of this paragraph. *Pre_Selling_Excess* is an indicator that equals one if the firm's stock of allowances before the selling activity is greater than the expected emissions at the end of the year, and zero otherwise. Consistent with prior research (Ertimur et al., 2020), we assume expected emissions for the year are equal to the actual reported emissions. *Pre_Selling_Excess* is included to control for variation in firms allowance holdings relative to current year emission obligations before any sales of allowances. *Δ_Sales* is the increase (decrease) in sales in the current year scaled by prior year sales and is included to control for changes in volume that could indicate higher (lower) future need for emission allowances. Because firms with greater pollution have a greater need for allowances, we also include *Emissions*, defined as the logarithm of total emissions in the previous year (in tons of CO2). *Increase_Emissions* is an indicator for years where a firm's emissions increase. This variable is included to control for trading of allowances related to situations where a firm's expected needs for emissions allowances are increasing/decreasing.

Firm Characteristics includes firm-level characteristics shown in prior literature to be associated with firms' financing and reporting choices. *Pre_Selling_ROA* is defined as earnings (net income) minus gains from sales of allowances, all scaled by lagged total assets (e.g., Cohen

and Zarowin, 2010).[17] *Total_Assets* is defined as the natural log of beginning of year total assets. *Revenues* is defined as the natural log of revenues for the current year. We include these two measures of firm size because larger firms tend to have greater monitoring and lower earnings management (Kim et al. 2017). *Cashflow* is constructed following Givoly and Hayn (2000), namely as net income adjusted for depreciation and changes in working capital accounts and long-term debt. We include this variable to control for the documented relation between cashflows and the ability to conduct earnings management (Zang 2012). *Leverage* is calculated as long-term debt (including the current portion) divided by lagged total assets.

Finally, we include industry and country fixed effects to control for a wide range of potential time invariant differences across industries and/or countries that could impact irregularities in the EU ETS system.[18] We include year fixed effects to control for global trends in emissions patterns due to variation in economic conditions, institutional changes in the EU ETS system, or other EU-wide factors.

Table 2 shows a significant relation between selling allowances and all three measures of irregularities in the management of carbon allowances in the EU ETS. When a firm is a net seller, it is 17.0% more likely to borrow from the future to meet its current emission obligations. Further, it is 1.0% more likely to exhibit an abnormal surrender pattern and 2.0% more likely to be out of compliance with its emissions obligations. The unconditional average probabilities of

[17] We do not adjust the ROA of firms without excess allowances because, as explained in Section 6 and other parts of the paper, in this case selling of allowances does not generate an accounting gain under the dominant accounting treatment observed in practice (Ertimur et al., 2020). Because the EU ETS Transaction log does not contain transaction prices, we compute the proceeds from sales of allowances using the average price of allowances during the year. In the online appendix we show that using alternative pricing assumptions does not alter inferences.

[18] At the industry level, there is variation in the amount of freely allocated allowances. This variation is justified based on competitive pressures outside of the EU and/or on the ability to reduce emissions. At the country level, EU members maintain authority over the administration of aspects of the EU ETS ,including inspection of installations, enforcement of non-compliance and acceptance of verified emissions reports.

Borrow_Future, *Abnormal_Surrender* and *Non_Compliant* are 37.4%, 1.1%, and 4.8%, respectively.

5. Liquidity Needs

We next examine whether the selling of emission allowances is more common among firms facing liquidity pressure. We estimate the following OLS regression:

$$Netseller_{it} = \alpha\, Liquidity\_Need_{it} + \Phi\, Controls_{it} + \beta_c + \chi_n + \delta_t + \varepsilon \qquad (2)$$

where *Netseller* is as previously defined.[19] To capture liquidity-related motivations to sell allowances we include *Liquidity_Need,* which is an indicator for firms with quick ratio less than one. The quick ratio is calculated as the sum of cash, cash equivalents, and receivables divided by current liabilities (all measured at the start of the year). This commonly used financial ratio provides a measure of the firm's liquid assets in relation to the liabilities it expects to need to pay within the next year. Firms with a ratio less than one are those firms that do not have sufficient cash and receivables at the beginning of year *t* to pay the existing liabilities that are due during year *t*. *Controls* includes the two vectors of control variables equation (1) (i.e., *Normal Allowance Management* and *Firm Characteristics*). β, χ, and δ denote industry, country, and year fixed effects, respectively (subscripts omitted).

The results in Table 3, Panel A, are consistent with allowances being sold for liquidity management purposes; net selling is more frequent among firms with lower liquid assets in relation to short-term debts. The association also holds when we include the vectors *Normal Allowance Management* and *Firm Characteristics* (Columns 2 and 3, respectively). Regarding the variables in *Normal Allowance Management*, Table 3, Panel A, reveals that a firm is more likely to be a net

[19] Our inferences are not sensitive to using alternative measures of selling activity (see Table OA.1 in the Online Appendix).

seller when the level of excess allowances is higher and less likely to be a net seller when the emissions needs are larger and when sales increase. Other firm characteristics such as size, revenues, leverage, and cash flow from operations do not appear to significantly affect the probability of net selling. In terms of magnitude, firms with *Liquidity_Need* = 1 are 3.5% more likely to be a net seller than other firms. The unconditional probability of being a net seller is 13.1%, which suggests that the result is economically significant.

In Table 3, Panel B, we repeat the analysis using alternative measures of liquidity. *Lower_Quick_Ratio* (column 1) is an indicator for observations in the lowest quartile of quick ratio by industry and year. *Quick Ratio* (column 2) is the raw value of the quick ratio (rather than an indicator variable for low values of this metric). *Cash_Ratio* (column 3) is computed as cash and cash equivalents divided by current liabilities (all measured at the start of the year). The cash ratio -which is widely used in practice and in academia- is a more restrictive measure of a firms' ability to pay its short-term obligations than the quick ratio. As shown in Table 3, Panel B, these alternative measures of liquidity are also significantly related to selling of allowances. Consistent with Panel A, the negative coefficients on *Quick_Ratio* and *Cash_Ratio* indicate that higher ratios (which means more liquidity) are associated with a lower probability of being a net seller.

To corroborate that the results in Table 3 are driven by liquidity incentives, we examine whether the association documented in that table is stronger under tighter financial constraints. To the extent that raising additional debt or equity capital is more expensive for financially constrained firms, we expect that such firms are more likely to generate liquidity by selling allowances. Accordingly, we estimate the following OLS regression:

$$Netseller_{it} = \alpha_1 Liquidity\_Need_{it} * FinConstraint_{it} + \alpha_2 FinConstraint_{it} + \alpha_3 Liquidity\_Need_{it} + \Phi Controls_{it} + \beta_c + \chi_n + \delta_t + \varepsilon \quad (3)$$

where *Netseller* and *Liquidity_Need* are as previously defined. *FinConstraint* is Whited and Wu (2006)'s measure of the degree of financial constraints.[20] Higher values of this metric indicate tighter financial constraints. For robustness, we repeat the analysis using *Tighter_FinConstraint,* which is an indicator for observations in the highest quartile of *FinConstraint* by industry and year. *Controls* include the same control variables as in equation (1) (i.e., *Normal Allowance Management* and *Firm Characteristics*). β_s, χ_c, and δ_t denote industry sector, country, and year fixed effects, respectively.

Table 4 presents the results. The coefficient on the interaction between *Liquidity_Need* and *FinConstraint* is positive and statistically significant, which is consistent with the notion that firms with liquidity needs and tighter financial constraints are more likely to sell allowances for liquidity purposes than other firms (column 1). The same pattern holds when we replace *FinConstraint* with *Tighter_FinConstraints* (column 2). The results in Table 4 indicate that, compared to other firms with a *Quick_Ratio* less than 1, firms in the highest quartile of *FinConstraint* are 3.7% more likely to be a net seller.

6. Boosting Earnings

6.1. "Ex-ante" Losses

We next examine whether the selling of emission allowances is more common among firms with incentives to boost earnings. We estimate the following OLS regression:

$$Netseller_{it} = \alpha\, Pre\_Selling\_Loss_{it} + \Phi\, Controls_{it} + \beta_c + \chi_n + \delta_t + \varepsilon \qquad (4)$$

where *Netseller* is as previously defined. *Pre_Selling_Loss* is an indicator for firms with *Pre_Selling_ROA* less than zero (recall that this variable measures ROA adjusted for the proceeds

[20] Bureau van Dijk Orbis does not provide dividend payment information for our sample firms. Thus, we calculate the Whited-Wu Index with the simplifying assumption that all firms have the same dividend policy.

from sales of allowances). We include *Pre_Selling_Loss* to explore whether sales of allowances are stronger in the region of performance where a firm is likely to face increased pressure on its reported earnings (Burgstahler et al. 2006, Degeorge et al., 1999). *Controls* includes the two vectors of control variables used in prior tests (i.e., *Normal Allowance Management* and *Firm Characteristics*) and *Quick_Ratio*. We note that *Firm Characteristics* includes *Pre_Selling_ROA*, which ensures that the coefficient on *Pre_Selling_Loss* does not reflect a general association between performance and sales of allowances. Equation (4) includes *Quick_Ratio* to control for liquidity incentives (see section 5). β, χ, and δ denote industry, country, and year fixed effects, respectively.

Table 5 provides evidence that firms with "ex-ante" losses are more likely to sell allowances (the coefficient on *Pre_Selling_Loss* is positive and statistically significant). The coefficient on *Pre_Selling_ROA* is not statistically significant, which suggests that *Pre_Selling_Loss* does not merely capture an association between allowance selling and financial performance.[21] The results suggest that the probability of being a net seller is 6.1% higher (t-stat=5.20) for firms with ex-ante losses than for other firms. The unconditional probability of being a net seller is 13.1%, which suggests that the result is economically significant.

6.2. Ex-ante Level of Allowances

As a first step to sharpen identification, we exploit variation in firms' "ex-ante" (i.e., pre-selling) levels of excess allowances. From a cash perspective, selling allowances generates an inflow regardless of whether the firm has excess allowances or not. However, from an accounting perspective, the sale of allowances has a positive impact on earnings only if the firm has excess

[21] In untabulated tests we also control for the interaction between *Pre_Selling_ROA* and *Pre_Selling_Loss*, which allows for different slopes for firms with positive vs. negative earnings. The coefficient on the interaction is not statistically significant and the coefficient on *Pre_Selling_Loss* remains positive and statistically significant.

allowances. If there is a shortfall of allowances, a liability is accrued for at the current fair value of the emission allowances, and the corresponding increase in current liabilities has an offsetting debit in an emissions expense account that reduces firm operating income. We thus expect that, if driven by an attempt to boost earnings, the association between selling of allowances and pre-selling losses documented in Table 5 will exist only among firms with excess allowances.

According to the previous reasoning, we modify Equation 4 to include the interaction between *Pre_Selling_Loss* and *Pre_Selling_Excess*. As shown Table 6, this interaction is positive and statistically significant. The results in Table 6 also reveal that the relation between *Pre_Selling_Loss* and *Netseller* is only significant when the firm holds ex-ante excess allowances (i.e., *Pre_Selling_Excess* = 1), that is, when the sale is expected to positively impact reported earnings. Thus, this evidence is consistent with the notion that firms with ex-ante accounting losses are more likely to sell allowances for reporting purposes.

There are two aspects of the EU ETS system that are important to interpret the evidence in Table 6. First, having an excess of allowances in the current year does not imply that a firm should sell those excess allowances. Firms may carry over excess allowances into future years in anticipation that the ETS will gradually reduce emission caps and granted allowances (which will likely result in higher market prices). Second, a firm without excess allowances can sell allowances and still meet its emission obligations. As discussed in Section 2, firms receive granted allowances for year *t+1* (*t* being the current year) in January or February of year *t+1* and those granted allowances can be used to cover year *t* emissions because the compliance period of *t* does not end until April of year *t+1*.

6.3. Meeting or Beating Earnings Thresholds

As a further step to sharpen identification, we examine reporting thresholds (e.g., Burgstahler and Dichev 1997b, Roychowdhury 2006). We first focus on the "zero earnings" threshold (that is, the threshold defining accounting losses). Following Burgstahler et al. (2006), we define *I[ROA(t) in X]* as an indicator variable for firms with reported *ROA* between 0% and X, when X is 0.25% (Column 1), 0.5% (Column2), or 1% (Column3). ROA is measured based on reported earnings (we do not adjust for sales of allowances to allow for the possibility that selling allowances occurs in combination with other real or accrual-based earnings management behavior).

In each of Columns 1-3 of Table 7 Panel A we find that net selling is significantly more likely for firms whose reported *ROA* falls just above 0. We also note that the magnitude of the coefficient on *I[ROA(t) in X]* decreases monotonically as we increase the size of the "just meet or beat" window. As a placebo, we repeat this test looking at the threshold of *ROA* between 1% and 2% and do not find a significant positive relation (column 4 of Table 7). In parallel to prior tests, we repeat the tests partitioning on *Pre_Selling_Excess*. Consistent with our previous results, Panels B and C reveal that the association between *Netseller* and *I[ROA(t) in X]* is significant only for the subsample of firms with excess allowances.

In online appendix OA.3 we repeat the analysis using two alternative earnings thresholds: (i) prior year performance and (ii) industry performance. Using these benchmarks to evaluate a firm's current performance is also a common heuristic for budgeting, performance evaluation, and incentive compensation. As shown in Table OA.3, we find that when *Pre_Selling_ROA* is either lower than the prior year *ROA* or lower than the industry average *ROA* the probability of firms being a *Netseller* of allowances increases significantly. Also consistent with prior tests, the association is also stronger when the firm holds an excess of carbon allowances.

6.4. Timing of Allowance Sales

We next study the timing of the sales of allowances. We first examine variation in the volume of sales over the year (see Figure 3). Figure 3, Panel A, shows monthly volume amounts for firms with fiscal year end in December. The figure reveals significant increases of sales in two points in time. First, there is increased selling activity around March and April. These are the two months where firms are most likely to surrender allowances to meet their compliance obligation for prior year emissions and accordingly heightened trading for normal allowance management is expected. Second, we see a large spike in selling in the last month of the fiscal year prior to the closing of the accounting cycle. One explanation of the spike in activity in December is that firms sell allowances to boost earnings. This is consistent with prior research showing that opportunistic behavior is more likely to occur towards the end of the fiscal year (Zang 2012).

To confirm this interpretation for the spike in allowance sales in December, we next conduct a parallel analysis for firms with fiscal year end in a month other than December (as previously explained, these observations are excluded from the sample used in our tests). For these firms, the fiscal year ends predominantly in March, June, or September. As shown in Figure 3, Panel B, we do not observe any spike in December for these firms. Rather, there is a large spike in September, which is one of the most frequent fiscal year end months for this subsample, which corroborates our interpretation that a substantial amount of selling activity is driven by reporting purposes.

More formally, we next test whether our sample of firms with ex-ante accounting losses and ex-ante excess allowances are more likely to sell allowances towards the end of the fiscal year. We repeat our main analysis replacing *Netseller* with *%Sold_LastQ*, which is computed as the fraction of sales volume in the last three months of the fiscal year. Similarly, we compute

%Sold_Dec as the fraction of sales volume in December (the last month of the fiscal year for all our firms). The rest of the specification is as in prior analyses. As a placebo test, we repeat the analysis for purchases of carbon allowances (purchasing allowances does not result in any accounting gain).

As shown in Table 8, firms with ex-ante accounting losses and ex-ante excess allowances conduct a larger percentage of sales of allowances towards the end of the fiscal year. In contrast, we do not observe a similar pattern for purchases of allowances. These results corroborate our interpretation of prior tests that reporting incentives affect firms' decision to sell emission allowances.

6.5. Variation in Allowance Sales with the Price of Carbon

Our next test analysis exploits variation in the market price for emission allowances. Importantly, the relative impact of selling excess emission allowances on earnings is a function of this price. If allowances are being sold to increase earnings, we expect a higher probability of observing sales when prices are relatively higher.[22]

To test whether this is the case, we conduct a more granular analysis at the month level. Accordingly, we redefine our dependent variable, *Netseller_Month*, as an indicator equal to 1 for months in which a firm sells more allowances than it purchases. *Price_Month* is the spot market price for an emission allowance at the beginning of the month. We then estimate the following model:

$$Netseller\_Month_{im} = \alpha_1 Price\_Month_{im} + \alpha_2 Pre\_Selling\_Loss_{it} +$$

$$\alpha_3 Price\_Month_{im} * Pre\_Selling\_Loss_{it} + \Phi\, Controls_{it} + \beta_c + \chi_n + \delta_t + \mu_m + \varepsilon \qquad (5)$$

[22] This conjecture is consistent with prior accounting research showing that as the benefit of using a particular method for increasing earnings grows or declines, managers respond by shifting which method they use towards the most beneficial one (e.g., Cohen et al., 2008; Chan et al., 2015).

where *m* and *t* denote month and year subscripts, *Controls* include the same control variables as in Equation 4. β, χ, δ, and μ represent industry, country, year and month fixed effects respectively. Our sample size increases by a factor of 12 for these tests consistent with the use of monthly price and sales activity variables. Because financial statements for the majority of our sample firms are only available on an annual basis, all variables denoted with a *t* subscript are defined at year level. We add month fixed effects to control for the seasonality identified in Figure 3 and discussed in section 6.4.

As shown in Table 9, Column 3, we find that when prices are higher, selling of allowances is higher for firms with "ex-ante" losses and excess allowances (i.e., firms with both a reporting incentive to increase earnings and the ability to positively impact earnings through allowance sales). In contrast, we do not observe a similar positive association for firms with "ex-ante" losses but without excess allowances (Column 4).

6.6. Reporting Incentives Related to External Financing

As a final step to corroborate our interpretation of prior results, we next exploit cross-sectional variation in firms' potential benefits from reporting higher earnings. First, we focus on external financing which, as shown by prior literature, is an important source of pressure for firms that often results in attempts to boost earnings. Financial statements are an important input to investment decisions by external capital providers and firms raising external capital have been shown to conduct income increasing earnings management (Teoh et. al 1998, Cohen and Zarowin 2010, Liu et. al 2010). Examining periods where significant new debt obligations are issued by a firm is particularly relevant in our setting, as most of our sample firms are not publicly listed and heavily rely on bank financing. Consistent with our interpretation of the patterns documented in the previous sections, Table 10 shows that the observed relation between *Pre_Selling_Loss* and

Netseller is significantly stronger among firms experiencing an increase in long term debt during the year (see columns 1 and 2).

Second, we explore cross-sectional variation in sales growth. An accounting loss does not provide the same signal for distressed firms, where it reflects poor or deteriorating performance, as it does for firms where the current period losses represent an investment in future positive earnings (Joos and Plesko 2005). In fact, prior literature documents that higher growth firms face lower financing-related pressures as a result of perceived higher growth options (Biddle et al. 2009). For these firms there is also a lower concern that investors will exercise the abandonment option upon seeing poor financial performance (Burgstahler and Dichev 1997a). As such, firms with accounting losses but relatively high sales growth likely do not face the same level of external scrutiny on financial performance as other firms reporting losses. Consistently, Table 10 (columns 3 and 4) show that the relation between *Pre_Selling_Loss* and *Netseller* is stronger for firms with below median levels of sales growth.

6.7. Sensitivity and Robustness

We next conduct a battery of sensitivity and robustness tests to alleviate concerns that our results are driven by research design or sample selection choices. These tests are presented in the Online Appendix and include tests examining alternative measures of selling activity, alternative fixed effect structures, alternative earnings thresholds (i.e., previous year performance and industry peer performance), the inclusion of additional controls related to normal allowance management, alternative price assumptions for allowance sales, exclusion of large countries and industries in the sample, exclusion of firms with changes in the number of installations, and exclusion of firm-years with extreme changes in production. Our results survive all these additional robustness tests (please see the online appendix for additional details).

7. Conclusions

Using emission and allowance data from the European Union Emission Trading System (EU ETS), this paper studies the role of financial frictions in the selling of carbon emission allowances. We first observe that selling of carbon allowances is associated with irregularities in the management of EU ETS obligations, which raises concerns and calls for a deeper analysis of the motivation behind this trading activity.

We next examine whether selling of allowances is associated with liquidity needs and incentives to boost earnings. Regarding liquidity motivations, we document that firms with liquidity needs are significantly more likely to sell allowances, particularly when they are financially constrained. Regarding reporting motivations, we find that selling activity is more pronounced when pre-selling earnings performance is below zero. The latter pattern is only significant for the subset of firms with excess emission allowances, namely when selling allowances is expected to create a positive impact on earnings. Corroborating the role of reporting incentives in the trading of emission allowances, we also observe that selling allowances is more common among firms that report earnings that just meet or beat the "zero" threshold, and that selling by ex/ante loss firms occurs more frequently towards the end of the fiscal year. These patterns are more pronounced when the price of allowances, and hence the earnings impact from selling allowances, increases. In cross-sectional tests, we find that the association between emission trading and accounting earnings is stronger for firms with greater external financing pressures.

The results of this paper have important regulatory implications. While it is commonly accepted that emission trading systems are key to achieve net-zero emissions by 2050, this type of carbon market has been fraught with major problems since its inception. By pointing at trading of

allowances as an additional source of inefficiency, our results support recent calls for closer regulatory oversight of this aspect. Our results also have implications for disclosure regulation and standard setting. Despite having been subject to substantial discussion by both the IFRS and the FASB, there is no accounting standard for emission allowances. Our results highlight the importance of rekindling this debate; if emission allowances were recorded on the balance at fair value and marked to market at each reporting period, the ability to boost earnings by timing the recognition of gains would disappear. Finally, our evidence calls for a timelier disclosure of allowance trading activity (which is currently made public three years after the close of the compliance period) to facilitate monitoring by external parties (e.g., market participants, regulators, environmental activists).

References

ABRELL, J, “Database for the European Union Transaction Log” (2021) available via Google Scholar with data publicly available at euets.info.

ANTONIOU, F., M. DELIS, S. ONGENA, and C. TSOUMAS. "Pollution permits and financing costs." (December 18, 2020). Swiss Finance Institute Research Paper No. 20-117, available at SSRN: https://ssrn.com/abstract=3752426 or http://dx.doi.org/10.2139/ssrn.3752426

BEN-DAVID, I., Y. JANG, S. KLEIMEIER, and M. VIEHS, "Exporting pollution: Where do multinational firms emit CO2?" Economic Policy 36, (2021): 377-437.

BERGER, P. G., E. OFEK, and I. SWARY, "Investor valuation of the abandonment option." Journal of Financial Economics 42, no 2 (1996): 257-287.

BIDDLE, G.C., G. HILARY, and R. Verdi, "How does financial reporting quality relate to investment efficiency?" Journal of Accounting and Economics, 48 no. 2-3, (2009): 112-131.

BLACK, C. "Accounting for carbon emission allowances in the European Union: In search of consistency." Accounting in Europe 10, no. 2 (2013): 223-239.

BORGHESI, S., C. FRANCO, and G. MARIN. "Outward foreign direct investment patterns of Italian firms in the European union’s emission trading scheme." The Scandinavian Journal of Economics, 122-1 (2020): 219–256.

BURGSTAHLER, D., and I. DICHEV. "Earnings, adaptation and equity value." The Accounting Review 72, no. 2 (1997a): 187-215.

BURGSTAHLER, D., and I. DICHEV. "Earnings management to avoid earnings decreases and losses." Journal of Accounting and Economics 24, no. 1 (1997b): 99-126.

BURGSTAHLER, D., L. HAIL, and C. LEUZ. "The importance of reporting incentives: Earnings management in European private and public firms." The Accounting Review 81, no. 5 (2006): 983-1016.

BURNS, N., and S. KEDIA. "The impact of performance-based compensation on misreporting." Journal of Financial Economics 79, no. 1 (2006): 35-67.

CALEL, R., and A. DECHEZLEPRÊTRE. "A. Environmental policy and directed technological change: evidence from the European carbon market." Review of Economics and Statistics, 98-1 (2016): 173–191.

CHAN, L., K. CHEN, T. CHEN, and Y. YU, “Substitution between real and accruals-based earnings management after voluntary adoption of compensation clawback provisions.” The Accounting Review 90, no.1 (2015): 147-174.

COASE, R., “The Problem of Social Cost.” The Journal of Law & Economics, no 3 (1960): 1-44.

COHEN, D., A. DEV, and T. LYS, “Real and accrual-based earnings management in the pre-and post-Sarbanes-Oxley periods.” The Accounting Review 83, no 3 (2008): 757-787.

COHEN, D., and P. ZAROWIN. "Accrual-based and real earnings management activities around seasoned equity offerings." Journal of Accounting and Economics 50, no. 1 (2010): 2-19.

COPPENS, L., and E. PEEK. "An analysis of earnings management by European private firms." Journal of International Accounting, Auditing and Taxation 14, no. 1 (2005): 1-17.

DEGEORGE, F., J. PATEL, and R. ZECKHAUSER. "Earnings management to exceed thresholds." Journal of Business 72, no. 1 (1999): 1-33.

DECHEZLEPRÊTRE, A., C. GENNAIOLI, R. MARTIN, M. MUÛLS, and T. STOERK, "Searching for carbon leaks in multinational companies." Journal of Environmental Economics and Management , no. 112 (2022): 1-20.

DICHEV, I., and D. SKINNER. "Large–sample evidence on the debt covenant hypothesis." Journal of accounting research, 40(4) (2002): 1091-1123.

DUCHARME, L., P. MALATESTA and S. SEFCIK. "Earnings management, stock issues, and shareholder lawsuits." Journal of Financial Economics 71, no. 1 (2004): 27-49.

EUROPEAN CENTRAL BANK (ECB) Economic Bulletin Issue 3, 2022. "The role of speculation during the recent increase in EU emissions allowance prices", by Ampudia, M., G. Bua, D. Kapp, and D. Salakhova.

ERTIMUR, Y., J. FRANCIS, A. GONZALES, and K. SCHIPPER. "Financial reporting for pollution reduction programs." Management Science 66, no. 12 (2020): 6015-6041.

GIVOLY, D., and C. HAYN. "The changing time-series properties of earnings, cash flows and accruals: Has financial reporting become more conservative?" Journal of Accounting and Economics, 29, no. 3 (2000): 287-320.

GIVOLY, D., C. HAYN, and S. KATZ. "Does public ownership of equity improve earnings quality?" The Accounting Review 85, no. 1 (2010): 195-225.

GRAHAM, J. R., C. R. HARVEY, and S. RAJGOPAL. "The economic implications of corporate financial reporting." Journal of Accounting and Economics, 40 no1-3 (2005): 3-73.

HEALY, P. M. "The effect of bonus schemes on accounting decisions." Journal of Accounting and Economics 7, no. 1-3 (1985): 85-107.

HRIBAR P, and D. COLLINS “Errors in estimating accruals: Implications for empirical research.” Journal of Accounting research, no. 1 (2002):105-34.

INTERNATIONAL ACCOUNTING STANDARDS BOARD "Pollutant pricing mechanisms: Comparison of possible approaches – a simplified example." Staff Paper (2015).

JOOS, P., and PLESKO, G. A. "Valuing loss firms." The Accounting Review, 80, no. 3 (2005): 847-870.

KIM, J., Y. KIM, and J. ZHOU. "Languages and earnings management " Journal of Accounting and Economics, 63, (2017): 288-306.

LIU, Y., Y. NING, and W. DAVIDSON. (2010). "Earnings management surrounding new debt issues." Financial Review, 45, no.3 (2010): 659-681.

LIU, Z., H. SHEN, M. WELKER, N. ZHANG, and Y. ZHAO. "Gone with the wind: An externality of earnings pressure." Journal of Accounting and Economics (2021): 101403.

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

PRICE WATERHOUSE COOPERS (PWC) and THE INTERNATIONAL EMISSIONS TRADING ASSOCIATION (IETA). Trouble-entry Accounting. Report, PWC and IETA (2007).

PRICE WATERHOUSE COOPERS (PWC) and THE INTERNATIONAL EMISSIONS TRADING ASSOCIATION (IETA). Emissions trading systems: The opportunities ahead. Report, PWC (2021)

ROYCHOWDHURY, S. "Earnings management through real activities manipulation." Journal of Accounting and Economics 42, no. 3 (2006): 335-370.

SWEENEY, A. P. "Debt-covenant violations and managers accounting responses." Journal of Accounting and Economics 17, no. 3 (1994): 281-308.

TEOH, S., I. WELCH, and T. WONG. "Earnings management and the long-run market performance of initial public offerings. " The Journal of Finance, 53, no. 6 (1998): 1935-1974.

THOMAS, J., W. YAO, F. ZHANG, and W. ZHU. "Meet, beat, and pollute." RAST Conference Version (2021).

WHITED, T., and G. WU, "Financial constraints risk." The Review of Financial Studies, 19 no 2 (2006): 531-559.

ZANG, A. Y., "Evidence on the trade-off between real activities manipulation and accrual-based earnings management." The Accounting Review, 87, no. 2 (2012): 675-703.

Appendix A: Variable definitions

Variable	Description	Source
Dependent Variables		
Borrow_Future	Indicator variable for whether in that compliance year the firm uses granted allowances from compliance period *t+1* to cover its allowance surrenders required for emissions generated during compliance period *t*.	ETS website
Abnormal_Surrender	Indicator variable for whether in that compliance year the firm makes an initial large surrender and then a subsequent smaller or series of smaller surrenders. Logic is that initial surrender was made to cover accrued emissions liability and then subsequent additional surrenders were made after feedback/monitoring provided by review of the emissions report during the verification process	ETS website
Non_Compliant	Indicator variable for whether in that compliance year at least one of the installations of the firm is not compliant with the obligations of the EU ETS.	ETS website
Netseller	Indicator variable for whether in that year the firm sells more allowances than it purchases. Does not include free allocations or surrenders as trading activity. To be coded as 1, the EUR value of net sales must be at least 0.01% of beginning of year total assets (this prevents including activity that essentially nets to zero).	ETS website, Bureau van Dijk Orbis
%Sold_LastQ	The sum of allowances sold in October, November, and December divided by total allowance sales for the year.	ETS website
%Sold_Dec	Allowances sold in December divided by total allowance sales for the year.	ETS website
%Buy_LastQ	The sum of allowances purchased in October, November, and December divided by total allowances purchased for the year.	ETS website
%Buy_Dec	Allowances purchased in December divided by total allowances purchased for the year.	ETS website
Netseller_Month	Indicator variable for firm-months where the firm sells more allowances than it purchases. Does not include free allocations or surrenders as trading activity. To be coded as 1, the EUR value of net sales must be at least 0.01% of beginning of year total assets (this prevents including activity that essentially nets to zero).	ETS website
Independent Variables		
Quick_Ratio	Cash and cash equivalents plus receivables divided by current liabilities at the start of the year.	Bureau van Dijk Orbis
Liquidity_Need	Indicator variable for firm-years with *Quick_Ratio* < 1 at the start of year	Bureau van Dijk Orbis
Pre_Selling_Loss	Indicator variable for firm-years where *Pre_Selling_ROA* is negative	Bureau van Dijk Orbis
Pre_Selling_Excess	Indicator variable for firm-years where the estimated year end holdings of EAUs before any selling activity during the year exceeded the firm's emissions for that year, 0 otherwise.	ETS website

ROA	Net income divided by total assets at the start of the year	Bureau van Dijk Orbis
NetProceeds	[(Total number of Allowances sold - Total number of Allowances bought) * Average spot market price of allowances during the year] / Total Assets (t-1)	ETS website Refinitiv Datastream
Pre_Selling_ROA	ROA if *Pre_Selling_Excess* = 0 ROA – *NetProceeds* if *Pre_Selling_Excess* = 1	ETS website, Bureau van Dijk Orbis Refinitiv Datastream
Δ_Sales	[Revenue (t) - Revenue (t-1)] / Revenue (t-1)	Bureau van Dijk Orbis
Total_Emissions	Disclosed emissions for the calendar year from the EU ETS system	ETS website
Emissions	Logarithm of (1 + *Total_Emissions*) from the prior year	ETS website
Increase_Emissions	Indicator variable for firm-years with an increase in total emissions with respect to the prior year	ETS website
Total Assets	Logarithm of total assets at the start of year	Bureau van Dijk Orbis
Revenues	Logarithm of Sales	Bureau van Dijk Orbis
Cashflow	Net income + depreciation - Δ current assets - Δ current liabilities + Δ long term debt + Δ cash	Bureau van Dijk Orbis
Leverage	Total long term debt divided by total assets at the start of the year	Bureau van Dijk Orbis
Cash_Ratio	Cash and cash equivalents divided by current liabilities at the start of the year	Bureau van Dijk Orbis
FinConstraint	- 0.091 * (*Cashflow*/total assets) + 0.021 * (long term debt/ total assets) - 0.044 * *Total Assets* + 0.102 * Industry Sales Growth + 0.035 * *Δ_Sales*	Bureau van Dijk Orbis
Tighter_FinConstraint	Indicator that takes the value 1 if *FinConstraint* is in the top quartile by industry and year.	Bureau van Dijk Orbis
I[ROA(t) in X]	Indicator variable that equals 1 if ROA is within interval X, where X={[0%;0.25%], [0%;0.5%], [0%;1.0%], [1.0%;2.0%]}, and 0 otherwise	Bureau van Dijk Orbis
Price_Month	Spot market price of allowances at the beginning of the month	Refinitiv Datastream

Appendix B: Accounting for emission allowances

There is currently no internationally recognized guidance on accounting for emission allowances. In 2004, shortly before the launch of the EU ETS, the International Accounting Standards Board (IASB) issued IFRIC 3 on emissions rights. However, IFRIC 3 was withdrawn shortly thereafter in June of 2005 after intense criticism by firms. Multiple attempts by the IASB and the FASB to clarify the accounting since then have stalled, been rescinded or have been downgraded to research pipelines for future consideration. In the absence of authoritative guidance, significant and persistent diversity in how firms account for ETS has emerged (e.g., PWC IETA 2007, Black 2013, IASB 2016, PWC IETA 2021).

An ETS system creates certain rights and obligations that need to be accounted for. Emission allowances can be viewed as an asset related to the right they create to produce emissions without incurring penalties. The obligation to deliver allowances to cover emissions can be viewed as creating an emissions liability for a firm. For a full discussion of the variation in how these rights and obligations are accounted for we encourage readers to reference Ertimur et al. (2020) or the IASB Staff Paper *Pollutant Pricing Mechanism: Comparison of Possible Approaches* (2015). Firms are not required to disclose what methodology they use and as a result we are not able to identify how specific firms account for emission assets and liabilities. Given our research question, we focus on the predominant method used in practice consistent with Ertimur et al. (2020) and highlight how that method leaves room for boosting accounting earnings and generating cash by selling carbon allowances.

Emissions allowances are recorded in a variety of asset accounts, but the two most common are intangible assets and inventory. The value recorded for purchased allowances is relatively straightforward with most firms recording an asset at the purchase price with a corresponding credit to cash or payables. The value recorded for granted allowances is more complicated. The majority of firms record granted allowances at cost or nil value (PWC IETA 2021, Black 2013, and PWC IETA 2007). However, a smaller portion of firms record such assets at fair value based on market prices for emissions allowances at the time of grant with a corresponding entry to either profit and loss or deferred income (27% of firms per PWC IETA 2021, 31% per Black 2013, and 24% per PWC IETA 2007).

There is also diversity in the subsequent re-measurement of allowance assets (both purchased and granted allowances). Some firms adjust carrying value to fair value for each reporting period. Other firms use the initial measurement value and only adjust for impairments, which in the case of granted allowances recorded at nil value means the value stays at zero unless an allowance is sold. There is a relation between the initial accounting for allowance assets and the method chosen for subsequent re-measurement. Firms that initially record granted allowances at cost typically do not re-measure at fair value in subsequent reporting periods but instead continue to report granted allowances at cost or nil value. Firms that initially record granted allowances at fair value are split between adjusting the carrying value at subsequent re-measurement dates or not. The methodology used for re-measurement of purchased allowances generally is the same as the re-measurement methodology used for granted allowances.

The accounting for emissions allowances described above can create a pool of value that is not recognized in the firm's financial statements. For a given firm, the magnitude of this potential pool of off balance sheet allowance assets would vary with the accounting methodology used. It would be largest when a firm records granted allowances at nil value and does not mark allowances to market at subsequent re-measurement periods (the predominant method observed in practice). It would essentially be non-existent for a firm that initially records and subsequently re-measures granted allowances at fair value (i.e., the method proposed by Ertimur et al., 2020).

There is also variation in how firms record an emissions liability for emissions generated during the year. Broadly speaking, firms tend to follow what Black (2013) dubbed a "gross liability" approach or a "net liability" approach. Under a gross liability approach, the liability provision reflects the value of the total allowances required to offset the current year emissions. Under a net liability approach, a provision is only created when the emissions exceed the granted allowances held by the firm. As could be expected, the method firms choose for recording allowance assets impacts the most likely method used for recording emissions liabilities. Black (2013) found that 82% of firms initially recording a nil value for granted allowances followed a net liability approach. Similarly, 90% of firms that initially recorded granted allowances at fair value followed a gross liability approach.

This means that under the predominant accounting methodology, the majority of firms do not record emission liabilities until emissions exceed allowances held. When there is a shortfall of allowances, a provision is generally accrued for at the current fair value of the emission allowances that would need to be acquired to offset the additional emissions. This liability credit would have an offsetting debit to an emissions expense account that reduces the firms operating income.

When allowances are sold, the majority of firms report gains or losses in the income statement as part of operating income (either revenue, cost of goods sold, or other operating income per PWC IETA 2021). For allowances recorded/re-measured at fair value, gains or losses upon sale are expected to be relatively small. However, for allowances previously recorded at nil value (again the predominant method), such gains can have a substantial impact on earnings. If emissions for the fiscal year are expected to exceed the emission allowances held, the impact to earnings from such gains will be fully offset by the emission liability provision discussed above.

Figure 1. Price of emission allowances traded in the EU ETS

This figure shows the evolution of the spot price for EU ETS emission allowances (EUAs) in Euro per ton of emissions for our sample period (2013-2017).

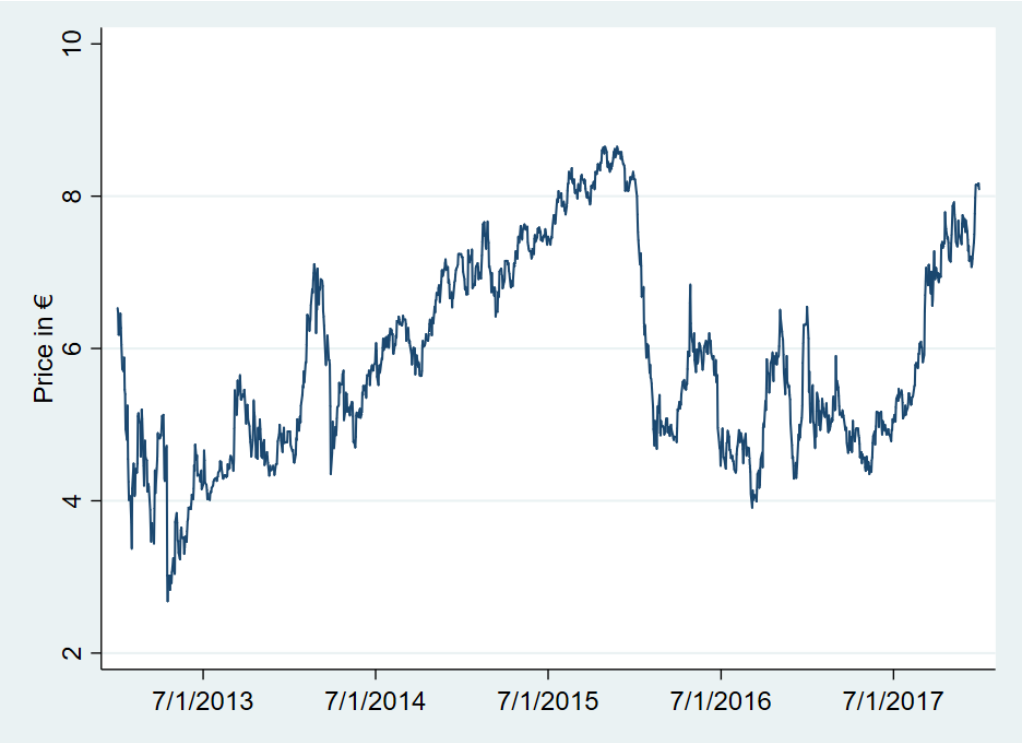


Figure 2. Aggregate sales of emission allowances traded in the EU ETS

This figure shows the significant emission allowance sales activity in our sample both in levels and relative to firm's total annual emissions. The darker grey bars represent the total annual emissions for firms in our sample in millions of tons of CO2 (left axis). The lighter grey bars represent the total amount of emission allowances sold by firms in our sample in millions of tons of CO2 (left axis). The dotted line represents the ratio of total emission allowances sold during the year to total emissions for each year in our sample (right axis).

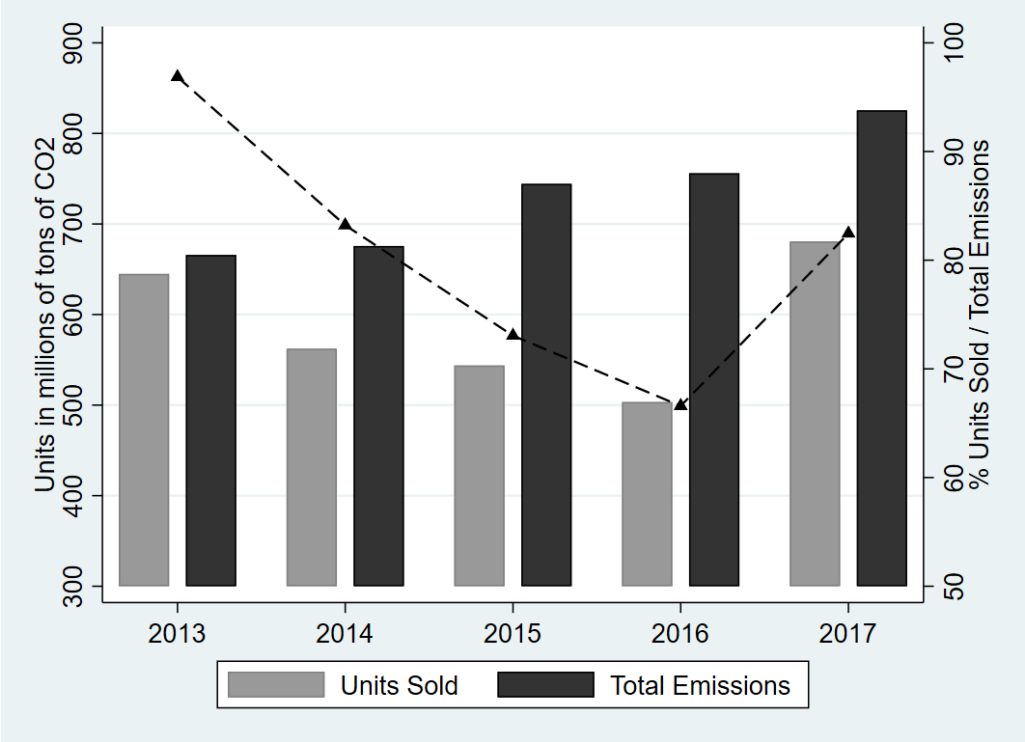
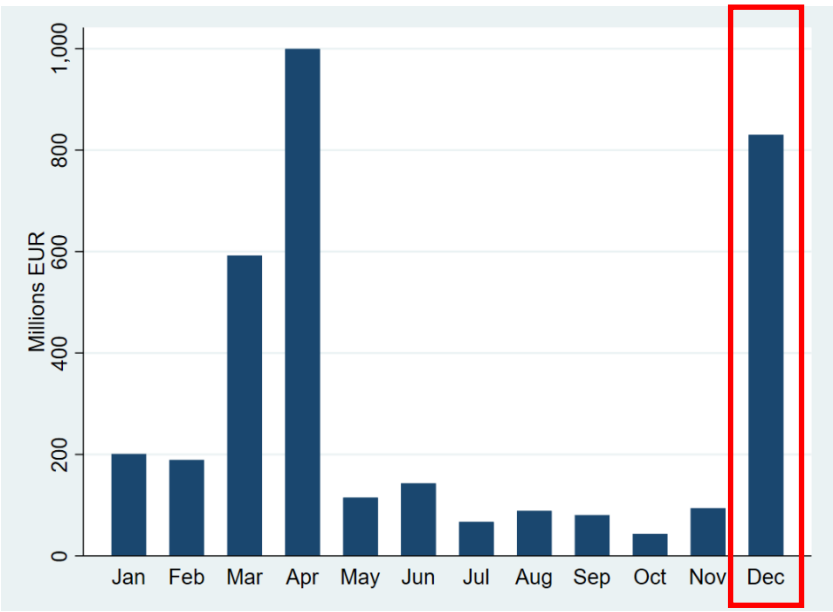


Figure 3. Distribution of sales volume over the year

This figure shows the distribution of allowance sales across calendar months of the year over the period 2013 to 2017. Panel A includes firms with a fiscal year end in December Panel B shows the allowance sales for firms with fiscal year end in months other than December. The bars represent the total allowance sales per calendar month in millions of Euros (left axis).

Panel A. Firms with fiscal year end in December



Panel B. Firms with fiscal year end in months other than December

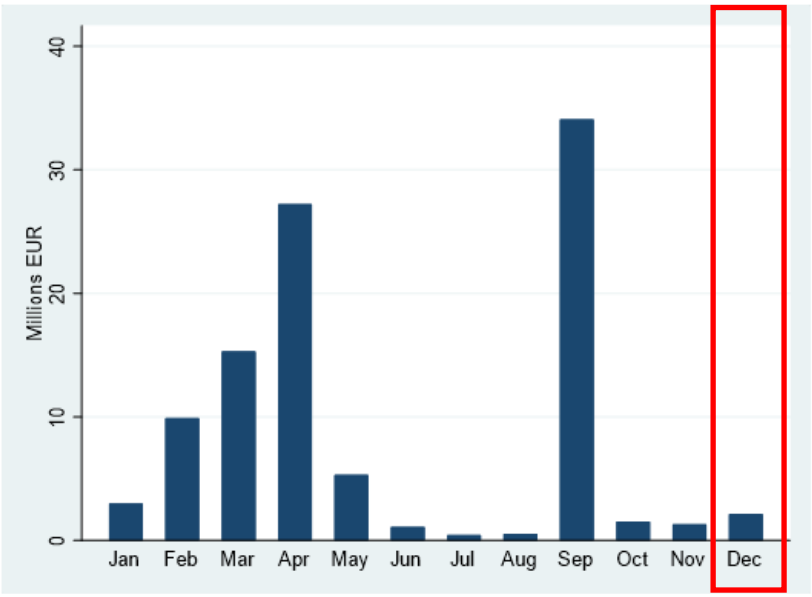


Table 1. Sample composition and descriptive statistics

This table presents descriptive statistics for our sample. The sample spans from 2013 to 2017 and includes 11,982 firm-year observations for 3,109 distinct firms. Panel A presents the composition of our sample by year. Panel B presents the composition of our sample by industry. Panel C presents the composition of our sample by country. Panel D presents descriptive statistics. All variables are defined in detail in Appendix A.

Panel A. Composition by Year

Year	# of obs.	% of obs.	# of unique firms	Mean value of *Netseller*	Mean value of *Pre_Selling_Excess*
2013	1,998	16.68	535	0.12	0.76
2014	2,346	19.58	567	0.16	0.67
2015	2,523	21.06	602	0.16	0.63
2016	2,544	21.23	665	0.10	0.60
2017	2,571	21.46	740	0.12	0.55
Total	11,982	100	3,109		

Panel B. Composition by Industry

Industry	# of obs.	% of obs.	# of unique firms	Mean value of *Netseller*	Mean value of *Pre_Selling_Excess*
Aviation	703	5.87	193	0.05	0.27
Cement and lime	595	4.97	140	0.34	0.84
Chemicals	413	3.45	109	0.32	0.71
Combustion	6,215	51.87	1,657	0.09	0.61
Iron and steel, coke, metal ore	646	5.39	160	0.19	0.73
Other metals including aluminum	202	1.69	55	0.10	0.58
Other non-metallic minerals	1,570	13.10	397	0.11	0.70
Pulp and paper	1,309	10.92	319	0.19	0.70
Refineries	184	1.54	47	0.15	0.57
Other	145	1.21	32	0.14	0.81
Total	11,982	100	3,109		

Table 1. Sample composition and descriptive statistics (cont'ed)

Panel C. Composition by Country

Country	# of obs.	% of obs.	# of unique firms	Mean value of *Netseller*	Mean value of *Pre_Selling_Excess*
Austria	150	1.25	52	0.16	0.75
Belgium	669	5.58	156	0.14	0.67
Bulgaria	260	2.17	58	0.16	0.44
Croatia	64	0.53	18	0.14	0.42
Cyprus	4	0.03	1	0.50	0.00
Czech Republic	580	4.84	132	0.10	0.65
Denmark	115	0.96	61	0.11	0.60
Estonia	51	0.43	11	0.18	0.57
Finland	380	3.17	94	0.19	0.86
France	1,138	9.50	292	0.13	0.69
Germany	1,078	9.00	349	0.08	0.68
Greece	64	0.53	16	0.11	0.55
Hungary	308	2.57	68	0.15	0.46
Iceland	27	0.23	8	0.07	0.44
Ireland	89	0.74	28	0.03	0.39
Italy	1,978	16.51	477	0.13	0.56
Latvia	9	0.08	2	0.11	0.11
Lithuania	18	0.15	4	0.22	0.78
Luxembourg	42	0.35	13	0.10	0.64
Netherlands	42	0.35	19	0.31	0.50
Norway	214	1.79	51	0.13	0.55
Poland	632	5.27	189	0.07	0.74
Portugal	358	2.99	87	0.20	0.73
Romania	392	3.27	91	0.21	0.69
Slovakia	230	1.92	56	0.14	0.73
Slovenia	106	0.88	28	0.09	0.66
Spain	1,561	13.03	373	0.12	0.59
Sweden	507	4.23	129	0.28	0.83
United Kingdom	916	7.64	246	0.10	0.53
Total	11,982	100	3,109		

Table 1. Sample composition and descriptive statistics (cont'ed)

Panel D. Descriptive Statistics

Variable	N	mean	sd	p25	p50	p75
Borrow_Future	11,982	0.374	0.484	0	0	1
Abnormal_Surrender	11,982	0.011	0.105	0	0	0
Non_Compliant	11,982	0.048	0.214	0	0	0
Netseller	11,982	0.131	0.338	0	0	0
Pre_Selling_Excess	11,982	0.634	0.482	0	1	1
Δ_Sales	11,982	0.043	0.265	−0.059	0.011	0.091
Emissions	11,982	10.17	2.538	9.081	10.26	11.63
Increase_Emissions	11,982	0.531	0.499	0	1	1
Pre_Selling_ROA	11,982	0.032	0.090	0.001	0.027	0.067
Total_Assets	11,982	4.954	1.826	3.641	4.687	5.923
Revenues	11,982	4.728	1.821	3.404	4.520	5.744
Cashflow	11,982	0.081	0.142	0.020	0.076	0.141
Leverage	11,982	0.206	0.228	0.003	0.140	0.333
Quick_Ratio	11,982	0.891	1.214	0.315	0.589	1.011
Cash_Ratio	11,982	0.321	0.697	0.010	0.070	0.315
FinConstraint	11,972	−0.220	0.081	−0.265	−0.210	−0.163
Pre_Selling_Loss	11,982	0.234	0.423	0	0	0

Table 2. Selling allowances and ETS irregularities

This table examines the association between selling allowances and irregularities in the management of ETS obligations. The dependent variables, *Borrow_Future*, *Abnormal_Surrender*, and *Non_Compliant* capture irregularities in the management of EU ETS obligations (see Appendix A for detailed definitions). *Netseller* is an indicator variable for whether in that year the firm sells more allowances than it purchases. Variable definitions are presented in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Dep. var.:	*Borrow_Future*	*Abnormal_Surrender*	*Non_Compliant*
	(1)	(2)	(3)
Netseller	0.170***	0.010***	0.020**
	(14.10)	(2.81)	(2.12)
Pre_Selling_Excess	−0.766***	−0.002	0.023***
	(−90.22)	(−0.59)	(3.58)
Δ_Sales	0.020*	0.004	0.020**
	(1.69)	(0.77)	(2.12)
Emissions	0.044***	0.002***	0.003**
	(19.97)	(3.34)	(2.04)
Increase_Emissions	0.030***	0.000	−0.005
	(5.27)	(0.13)	(−1.42)
Pre_Selling_ROA	−0.032	−0.001	−0.063**
	(−0.74)	(−0.09)	(−2.02)
Total_Assets	−0.021***	0.004**	0.025***
	(−3.56)	(2.10)	(4.88)
Revenues	−0.019***	−0.002	−0.009*
	(−3.28)	(−1.06)	(−1.84)
Cashflow	−0.009	0.006	−0.016
	(−0.39)	(0.73)	(−1.16)
Leverage	0.017	−0.005	−0.034**
	(0.86)	(−0.93)	(−2.30)
Year Fixed Effects	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
adj R-squared	0.609	0.019	0.040
Observations	11,982	11,982	11,982

Table 3. Selling allowances and liquidity needs

This table examines the association between liquidity needs and selling of emission allowances. The dependent variable, *Netseller* is an indicator variable for whether in that year the firm sells more allowances than it purchases. In Panel A, *Liquidity_Need* is an indicator variable for firm-years with a quick ratio less than one (the quick ratio is cash and cash equivalents plus receivables divided by current liabilities). In Panel B, *Lower_Quick_Ratio*, *Quick_Ratio*, and *Cash_Ratio* are alternative measures of liquidity needs. See Appendix A for detailed variable definitions. t-statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Panel A. Allowance selling for firms with liquidity needs

Dep. var.: *Netseller*	(1)	(2)	(3)
Liquidity_Need	0.039***	0.042***	0.035***
	(4.66)	(5.22)	(4.23)
Pre_Selling_Excess		0.123***	0.126***
		(16.64)	(16.65)
Δ_Sales		−0.020*	−0.015
		(−1.76)	(−1.30)
Emissions		−0.007***	−0.009***
		(−3.73)	(−4.66)
Increase_Emissions		−0.004	−0.003
		(−0.61)	(−0.44)
Pre_Selling_ROA			−0.196***
			(−4.34)
Total_Assets			0.005
			(0.95)
Revenues			0.004
			(0.82)
Cashflow			0.016
			(0.71)
Leverage			0.008
			(0.43)
Year Fixed Effects	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
adj R-squared	0.067	0.097	0.100
Observations	11,982	11,982	11,982

Panel B : Alternative Measures of Liquidity

Dep. var.: *Netseller*	(1)	(2)	(3)
Lower_Quick_Ratio	0.041***		
	(4.35)		
Quick_Ratio		−0.016***	
		(−5.27)	
Cash_Ratio			−0.024***
			(−5.12)
Controls	Yes	Yes	Yes
Year, Country & Industry FEs	Yes	Yes	Yes
adj R-squared	0.101	0.101	0.101
Observations	11,982	11,982	11,982

Table 4. Financial Constraints and Low Liquidity

This table examines the association between liquidity needs and selling of emissions allowances as a function of financial constraints. The dependent variable, *Netseller* is an indicator variable for whether in that year the firm sells more allowances than it purchases. *Liquidity_Need* is an indicator variable for firm-years with a quick ratio less than one. *FinConstraint* is Whited and Wu (2006)'s measure of the degree of financial constraints. *Tighter_FinConstraints* is an indicator that takes the value 1 if *FinConstraint* is in the bottom quartile by industry and year All variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Dep. var.: *Netseller*	(1)	(2)
*Liquidity_Need * FinConstraints*	0.223**	
	(2.52)	
*Liquidity_Need * Tighter_FinConstraints*		0.037**
		(2.23)
FinConstraints	0.416	
	(1.24)	
Tighter_FinConstraints		−0.057***
		(−3.71)
Liquidity_Need	0.083***	0.026***
	(3.87)	(2.69)
Pre_Selling_Excess	0.126***	0.125***
	(16.66)	(16.62)
Δ_Sales	0.010	−0.020*
	(0.53)	(−1.75)
Emissions	−0.009***	−0.009***
	(−4.54)	(−4.76)
Increase_Emissions	−0.003	−0.003
	(−0.47)	(−0.47)
Pre_Selling_ROA	−0.183***	−0.197***
	(−4.05)	(−4.38)
Total_Assets	0.030**	0.001
	(1.97)	(0.12)
Revenues	0.005	0.004
	(0.93)	(0.73)
Cashflow	0.071*	0.003
	(1.96)	(0.14)
Leverage	−0.001	0.006
	(−0.04)	(0.32)
Year Fixed Effects	Yes	Yes
Country Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
adj R-squared	0.101	0.102
Observations	11,982	11,982

Table 5. Selling allowances and Reporting Incentives

This table examines the association between reporting pre-selling losses and selling of emissions allowances. The dependent variable, *Netseller* is an indicator variable for whether in that year the firm sells more allowances than it purchases. *Pre_Selling_Loss* is an indicator variable for firm-years where *Pre_Selling_ROA* (ROA adjusted for the proceeds from selling allowances) is negative. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Dep. var.: *Netseller*	(1)	(2)	(3)
Pre_Selling_Loss	0.070***	0.065***	0.061***
	(7.24)	(6.93)	(5.20)
Pre_Selling_Excess		0.121***	0.124***
		(16.43)	(16.55)
Δ_Sales		−0.015	−0.015
		(−1.35)	(−1.33)
Emissions		−0.007***	−0.009***
		(−3.51)	(−4.73)
Increase_Emissions		−0.001	−0.002
		(−0.10)	(−0.30)
Quick_Ratio			−0.015***
			(−5.01)
Pre_Selling_ROA			−0.024
			(−0.44)
Total_Assets			0.005
			(1.10)
Revenues			0.004
			(0.75)
Cashflow			0.015
			(0.66)
Leverage			0.005
			(0.27)
Year Fixed Effects	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
adj R-squared	0.072	0.101	0.104
Observations	11,982	11,982	11,982

Table 6. Ex-ante excess of emission allowances

This table examines the association between reporting pre-selling losses and selling of emissions allowances as a function of the firm having excess of allowances. The dependent variable, *Netseller* is an indicator variable for whether in that year the firm sells more allowances than it purchases. *Pre_Selling_Loss* is an indicator variable for firm-years where *Pre_Selling_ROA* (ROA adjusted for the proceeds from selling allowances) is negative. *Pre_Selling_Excess* is an indicator variable for firm-years where the estimated year end holdings of allowances before any selling activity during the year exceeded the firm's emissions. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Dep. var.: *Netseller*	(1)	(2)	(3)
Pre_Selling_Loss Pre_Selling_Excess*	0.082***	0.081***	0.076***
	(5.09)	(5.01)	(4.75)
Pre_Selling_Loss	0.012	0.013	0.011
	(1.26)	(1.28)	(0.95)
Pre_Selling_Excess	0.104***	0.103***	0.108***
	(13.41)	(13.38)	(13.63)
Δ_Sales		−0.013	−0.014
		(−1.20)	(−1.18)
Emissions		−0.007***	−0.009***
		(−3.49)	(−4.68)
Increase_Emissions		−0.001	−0.002
		(−0.09)	(−0.28)
Quick_Ratio			−0.015***
			(−4.88)
Pre_Selling_ROA			−0.026
			(−0.47)
Total_Assets			0.006
			(1.11)
Revenues			0.004
			(0.68)
Cashflow			0.015
			(0.67)
Leverage			0.005
			(0.24)
Year Fixed Effects	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
adj R-squared	0.101	0.103	0.106
Observations	11,982	11,982	11,982

Table 7. Selling activity around earnings thresholds

This table examines the likelihood of selling allowances around reporting thresholds. The dependent variable, *Netseller* is an indicator variable for whether in that year the firm sells more allowances than it purchases. *I[ROA in X]* is an indicator variable for firm-years where the reported ROA is within range X, where X equals 0% to 0.25%, 0% to 0.5%, 0% to 1% or 1% to 2%. Panel A includes all sample observations. Panel B and C include observations with/without excess allowances (*Pre_Selling_Excess* = 1 and *Pre_Selling_Excess* = 0, respectively). All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Panel A : Full sample

	Treatment			*Placebo*
Dep. var.: *Netseller*	*X = [0; 0.25]*	*X = [0; 0.5]*	*X = [0; 1]*	*X = [1; 2]*
	(1)	(2)	(3)	(4)
I[ROA in X]	0.045**	0.041***	0.030***	0.016
	(2.45)	(2.95)	(2.63)	(1.41)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
adj R-squared	0.105	0.105	0.105	0.104
Observations	11,982	11,982	11,982	11,982

Panel B: *Pre_Selling_Excess* = 1

	Treatment			*Placebo*
Dep. var.: *Netseller*	*X = [0; 0.25]*	*X = [0; 0.5]*	*X = [0; 1]*	*X = [1; 2]*
	(1)	(2)	(3)	(4)
I[ROA in X]	0.062**	0.051**	0.038**	0.025
	(2.32)	(2.55)	(2.37)	(1.52)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
adj R-squared	0.093	0.093	0.093	0.093
Observations	7,600	7,600	7,600	7,600

Panel C: *Pre_Selling_Excess* = 0

	Treatment			*Placebo*
Dep. var.: *Netseller*	*X = [0; 0.025]*	*X = [0; 0.5]*	*X = [1; 2]*	*X = [1; 2]*
	(1)	(2)	(3)	(4)
I[ROA in X]	0.007	0.014	0.007	0.001
	(0.46)	(1.04)	(0.59)	(0.12)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
adj R-squared	0.034	0.035	0.035	0.034
Observations	4,381	4,381	4,381	4,381

Table 8. Timing of the selling of emissions allowances

This table examines the proportion of allowances sold/purchased right before fiscal year end. In column 1 (3), *%Sold_LastQ (%Buy_LastQ*) is the sum of allowances sold (purchased) in October, November, and December divided by total allowance sales for the year. In column 2 (4), *%Sold_Dec* (*%Buy_Dec*) is allowances sold (purchased) in December divided by total allowance sales for the year. *Pre_Selling_Loss* is an indicator variable for firm-years where *Pre_Selling_ROA* (ROA adjusted for the proceeds from selling allowances) is negative. *Pre_Selling_Excess* is an indicator variable for firm-years where the estimated year end holdings of EAUs before any selling activity during the year exceeded the firm's emissions. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

	Sales of carbon allowances		Purchases of carbon allowances (placebo)	
Dep. var.:	*%Sold_LastQ*	*%Sold_Dec*	*%Buy_LastQ*	*%Buy_Dec*
	(1)	(2)	(3)	(4)
*Pre_Selling_Loss * Pre_Selling_Excess*	0.031***	0.021***	0.005	0.015
	(3.25)	(3.06)	(0.38)	(1.38)
Pre_Selling_Loss	−0.010	−0.010**	−0.008	−0.011
	(−1.53)	(−2.24)	(−0.71)	(−1.15)
Pre_Selling_Excess	0.043***	0.026***	0.021***	0.010
	(8.52)	(7.29)	(3.07)	(1.62)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
adj R-squared	0.041	0.034	0.082	0.088
Observations	11,982	11,982	11,982	11,982

Table 9. Variation in Sales with the Price of Carbon

This table examines variation in selling of allowances with price changes during the year. The analysis is conducted at the month level. The dependent variable, *Netseller_Month*, is an indicator variable for firm-months where the firm sells more allowances than it purchases. *Pre_Selling_Loss* is an indicator variable for firm-years where *Pre_Selling_ROA* (ROA adjusted for the proceeds from selling allowances) is negative. *Price_Month* is the spot market price of allowances at the beginning of the month. *Pre_Selling_Excess* is an indicator variable for firm-years where the estimated year end holdings of EAUs before any selling activity during the year exceeded the firm's emissions. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

	Full Sample		*Pre_Selling_ Excess =0*	*Pre_Selling_ Excess =1*
Dep. var.: *Netseller_Month*	(1)	(2)	(3)	(4)
*Pre_Selling_Loss * Price_Month*		0.001	−0.001*	0.003**
		(1.43)	(−1.66)	(2.33)
Price_Month	0.002***	0.002***	0.000	0.002***
	(4.01)	(3.29)	(0.41)	(3.07)
Pre_Selling_Loss	0.009***	0.001	0.011*	−0.005
	(3.93)	(0.21)	(1.69)	(−0.68)
Controls	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
adj R-squared	0.030	0.030	0.017	0.030
Observations	143,784	143,784	52,572	91,212

Table 10. Reporting Incentives Related to External Financing

This table examines cross-sectional variation in the association between reporting pre-selling losses and selling of emissions allowances. The dependent variable, *Netseller* is an indicator variable for whether in that year the firm sells more allowances than it purchases. *Pre_Selling_Loss* is an indicator variable for firm-years where *Pre_Selling_ROA* (ROA adjusted for the proceeds from selling allowances) is negative. In columns 1 and 2, Δ*Debt* is the change in debt with respect to prior year. In columns 3 and 4, High/Low refers to observations with above/below median values of *Sales Growth*, defined as the fractional change in sales with respect to the prior year. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

		Change in debt with respect to prior year (Δ*Debt*)		*Sales Growth*	
		Δ*Debt* ≤ 0	Δ*Debt* > 0	High	Low
Dep. var.: *Netseller*		(1)	(2)	(3)	(4)
Pre_Selling_Loss	β	0.048***	0.091***	0.036**	0.076***
		(3.80)	(4.14)	(2.36)	(4.96)
p-value of **β (i) – β (i+1)** where i = 1,3		*0.0716**		*0.0379***	
Controls		Yes	Yes	Yes	Yes
Year Fixed Effects		Yes	Yes	Yes	Yes
Country Fixed Effects		Yes	Yes	Yes	Yes
Industry Fixed Effects		Yes	Yes	Yes	Yes
adj R-squared		0.109	0.097	0.098	0.113
Observations		8,731	3,251	5,991	5,991

Trading of Emission Allowances and Reporting Incentives

Online Appendices

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OA.0 Additional Variable Definitions

Variable	Description	Source
Dependent Variables		
Seller	An indicator variable equal to 1 for firm-years where a firm sold EUAs, 0 otherwise. Requires that EUR value of Sales is at least 0.01% of beginning of year total assets to prevent including insignificant sales activity.	ETS website
Sales_Proceeds	Log (1 + Proceeds) with: Proceeds = (Total number of EUA sold * Average Price of EUA during the year) / Total Assets (t-1)	ETS website, Bureau van Dijk Orbis, Refinitiv Datastream
NetSales_Proceeds	Log (1 + NetProceeds) with: NetProceeds = [(Total number of EUA sold - Total number of EUA bought) * Average Price of EUA during the year] / Total Assets (t-1)	ETS website, Bureau van Dijk Orbis, Refinitiv Datastream
Units_Sold	Log (1 + (Total number of EUA sold))	ETS website
Net_Units_Sold	Log (1 + (Total number of EUA sold - Total number of EUA bought)); 0 if units sold are lower than units bought	ETS website
Independent Variables		
I[Pre_Selling_ROA(t) < ROA(t-1)]	An indicator variable equal to 1 for firm-years where *Pre_Selling_ROA* is lower than the firm's ROA in the prior year	Bureau van Dijk Orbis
I[Pre_Selling_ROA(t) < ROA_Industry(t)]	An indicator variable equal to 1 for firm-years where *Pre_Selling_ROA* is below the industry average ROA for the year	Bureau van Dijk Orbis
CAPEX	[Fixed Assets (t) – Fixed Assets (t-1)]/Total Assets (t-1)	Bureau van Dijk Orbis

OA.1 Alternative measures of allowance selling activity

We check the robustness of our inferences to using alternative measures of allowance selling activity. We replace *Netseller* with five alternative constructs. *Seller* equals one if the firm sells allowances during the year, and zero otherwise. *NetSales_Proceeds* is the logarithm of the net value of allowances sold. *Sales_Proceeds* is the logarithm of the total value of allowances sold. *Net_Units_Sold* is the logarithm of the net units sold. *Units_Sold* is the logarithm of the total number of units sold. Table OA.1, Panels A-C replicates the analysis in Table 2. Table OA.1, Panel D, replicates the analysis in Table 3. Table OA.1, Panel E, replicates the analysis in Table 5. As shown in Table OA.1, all our inferences hold.

OA.2 Alternative fixed effects structures

We also analyze the sensitivity of our inferences to alternative fixed effect structures. Our initial analysis is based on differences across firms controlling for industry, country, and time fixed effects. We repeat the analysis including industry-year, country-year, and firm fixed effects to further alleviate the potentially confounding effect of industry, country, and firm heterogeneity. As shown in Table OA.2, our inferences largely hold using these alternative specifications. Consistent with Table 3, we find a positive and significant association between *Liquidity_Need* and *Netseller*, that exists for both firms with and without an excess when we use industry-year and country-year fixed effects. Consistent with Tables 5 and 6, we also find a positive and significant association between *Pre_Selling_Loss* and *Netseller*, and find the association is more pronounced for firms with a *Pre_Selling_Excess* across all specifications. The association between liquidity and net selling is not statistically significant when we include firm fixed effects. This could reflect that we have little within-firm variation, which lowers the power of our tests (our time series includes only 5 years of data).

OA.3 Alternative Earnings Thresholds

Tables 5 and 6 show that firms are more likely to sell allowances below the "zero" earnings threshold. We next explore whether our inferences hold using two alternative earnings thresholds: (i) prior year performance and (ii) industry performance. Using these benchmarks to evaluate a firm's current performance is a common heuristic for budgeting, performance evaluation, and incentive compensation. Consistent with these alternative benchmarks being relatively popular, prior literature finds evidence that a decrease in performance with respect to the prior year or a performance lower than that of industry peers is associated with job losses, less career advancement, and lower variable compensation (e.g., Healy 1985, Graham et al. 2005).

We thus repeat the analysis in Tables 5 and 6 replacing *Pre_Selling_Loss* with two alternative variables. I[*Pre_Selling_ROA(t) < ROA(t-1)*] is an indicator variable for firm-years where *Pre_Selling_ROA* is lower than the firms *ROA* in the prior year. I[*Pre_Selling_ROA(t) < ROA_Industry(t)*] is an indicator variable for firm-years where *Pre_Selling_ROA* is below the expected industry average ROA.[23] As shown in Table OA.3, we find that, consistent with Tables

[23] We use the ex-post realized industry average ROA as a proxy for a Firm's expectation of the current year industry ROA. However, results are robust to using the industry average ROA from the prior year as an alternative proxy for current year expectations as well.

5 and 6, when *Pre_Selling_ROA* is either lower than the prior year *ROA* or lower than the industry average *ROA* the probability of firms being a *Netseller* of allowances increases significantly. The association is also stronger when the firm holds an excess of carbon allowances.

OA.4 Additional Controls for Normal Allowance Management

One potential concern about our results is that selling of allowances could be driven by managers' expectations about future emissions. Such selling activity would be consistent with normal allowance management rather than being motivated by liquidity needs and/or reporting incentives. To further address this concern, we repeat our primary tests including a battery of additional control variables that are meant to capture managerial expectations about future emissions. Following a long tradition in the accounting and finance literature, we proxy for managerial expectations using ex-post realizations of future outcomes directly or indirectly related to the volume of carbon emissions. Specifically, we add controls for future emissions (*Emissions (t+1)*), future change in sales (*Δ_Sales (t+1)*), future capital expenditures (*CAPEX (t+1)*), and future return on assets (*ROA (t+1)*). In parallel to our tests, we also include an interaction between our experimental variables and each of these additional control variables.

The results of Table OA.4 are consistent with the notion that firms sell allowances in anticipation of lower future emissions (a behavior that is in line with the intended market mechanism of the EU ETS). The additional control variables exhibit a significant association with *Netseller*. A firm is more likely to be a net seller when it has lower future emissions, revenue, capital expenditures and ROA. However, the positive association between *Liquidity_Need* and *Netseller* and the positive association between *Netseller* and *Pre-Selling_Loss* are robust to including these additional controls. Further, in contrast with our results using our experimental variables, we do not see a significant relation between *Netseller* and the interaction of *Liquidity_Need* and *Pre_Selling_Loss* with any of the additional control variables. Overall, the evidence in Table OA.4 suggests that normal allowance management does not explain our primary results.

OA.5 Robustness to excluding firms with a substantial decrease in sales

To complement the previous analysis on normal allowance management, we analyze the sensitivity of our results to excluding firms with significant drop in production. We repeat our primary tests excluding firms with decreases in sales larger than X (X ={10%, 20%, or 30%}). The results in Table OA.5 show that our inferences are unaffected.

OA.6 Robustness to alternative measures of carbon price levels

In our main analyses, we estimate the impact of allowances sales on earnings using the average price of allowances over the year. To alleviate concerns about this measurement choice, we repeat our primary tests using the price either at the beginning of the year or at the end of the year. As shown in Table OA.6, our inferences are unaffected.

OA.7 Robustness to changes in the number of installations

Following Givoly and Hayn (2000) and Givoly, et al. (2010), we use a combination of income statement and balance sheet data to estimate cash flow from operations. We use this approach because Orbis Bureau van Dijk does not include cash flow statement information for our sample firms. Prior research has shown that this methodology can introduce measurement error and even bias if the partitioning variable of interest in the study is correlated with the occurrence of mergers and acquisitions or discontinued operations (Hribar and Collins 2002).

To ensure this is not an issue in our study, we assess the sensitivity of our results to excluding firms with changes in their number of installations (which should be correlated with mergers, acquisitions, or divestitures/discontinuation of production units). First, we exclude observations with an increase in the number of installations (which is common in acquisitions). Second, we exclude observations with a decrease in the number of installations (which is common in discontinued operations). Third, we exclude observations with changes (either positive or negative) in the number of installations. As shown in Table OA.7, our inferences are unaffected.

OA.8 Robustness to excluding the overrepresented countries

In Table OA.8 we assess the sensitivity of our results to excluding countries that represent a large portion of our sample observations. We repeat our primary tests excluding one country at a time. We focus on the four countries with more than 1,000 observations in our sample (France, Germany, Italy, and Spain). Our inferences are unaffected.

OA.9 Robustness to the overrepresented industries

In Table OA.9 we assess the sensitivity of our results to excluding industries that represent a large portion of our sample observations. We repeat our primary tests excluding one industry at a time. We focus on the four industries with the highest number of observations in our sample (Combustion, Other non-metallic minerals, Pulp and paper, Aviation). Our inferences are unaffected.

Table OA.1. Alternative measures of allowance selling activity

This table repeats the analyses in Tables 2, 3 and 5 using alternative definitions of allowance sales. In Panels A-C, we repeat the ETS Irregularities analysis from Table 2 In Panel D, we repeat the liquidity need analysis from Table 3, Column (3) and in Panel E we repeat the reporting incentives analysis from Table 5, Column (3). All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Panel A. ETS Irregularities – *Abnormal_Surrender* (Table 2)

Dep. var.: *Abnormal_Surrender*	(1)	(2)	(3)	(4)	(5)
Seller	0.005*				
	(1.72)				
NetSales_Proceeds		0.007**			
		(2.47)			
Sales_Proceeds			0.005*		
			(1.90)		
Net_Units_Sold				0.001**	
				(2.54)	
Units_Sold					0.001**
					(2.21)
Controls	Yes	Yes	Yes	Yes	Yes
Year, Country & Industry FE	Yes	Yes	Yes	Yes	Yes
adj R-squared	0.019	0.019	0.019	0.019	0.019
Observations	11,982	11,982	11,982	11,982	11,982

Panel B. ETS Irregularities – *Borrow_Future* (Table 2)

Dep. var.: *Borrow_Future*	(1)	(2)	(3)	(4)	(5)
Seller	0.161***				
	(19.88)				
NetSales_Proceeds		0.102***			
		(12.52)			
Sales_Proceeds			0.092***		
			(15.58)		
Net_Units_Sold				0.015***	

				(13.41)	
Units_Sold					0.015***
					(18.72)
Controls	Yes	Yes	Yes	Yes	Yes
Year, Country & Industry FE	Yes	Yes	Yes	Yes	Yes
adj R-squared	0.616	0.608	0.615	0.609	0.616
Observations	11,982	11,982	11,982	11,982	11,982

Panel C. ETS Irregularities- *Non_Compliant* (Table 2)

Dep. var.: *Non_Compliant*	(1)	(2)	(3)	(4)	(5)
Seller	0.039***				
	(5.30)				
NetSales_Proceeds		0.011**			
		(2.11)			
Sales_Proceeds			0.022***		
			(4.79)		
Net_Units_Sold				0.002**	
				(2.29)	
Units_Sold					0.005***
					(6.60)
Controls	Yes	Yes	Yes	Yes	Yes
Year, Country & Industry FE	Yes	Yes	Yes	Yes	Yes
adj R-squared	0.155	0.111	0.162	0.119	0.234
Observations	11,982	11,982	11,982	11,982	11,982

Panel D. Liquidity needs (Table 3)

Dep. var.:	*Seller*	*NetSales_Proceeds*	*Sales_Proceeds*	*Net_Units_Sold*	*Units_Sold*
	(1)	(2)	(3)	(4)	(5)
Liquidity_Need	0.047***	0.058***	0.065***	0.373***	0.539***
	(4.16)	(4.83)	(4.83)	(4.83)	(4.87)
Controls	Yes	Yes	Yes	Yes	Yes
Year, Country & Industry FE	Yes	Yes	Yes	Yes	Yes

adj R-squared	0.152	0.107	0.159	0.115	0.232
Observations	11,982	11,982	11,982	11,982	11,982

Panel E. Reporting incentives (Table 5)

Dep. var.:	*Seller*	*NetSales_Proceeds*	*Sales_Proceeds*	*Net_Units_Sold*	*Units_Sold*
	(1)	(2)	(3)	(4)	(5)
Pre_Selling_Loss	0.072***	0.103***	0.128***	0.709***	0.665***
	(5.25)	(5.56)	(5.17)	(5.49)	(4.43)
Controls	Yes	Yes	Yes	Yes	Yes
Year, Country & Industry FE	Yes	Yes	Yes	Yes	Yes
adj R-squared	0.155	0.111	0.162	0.119	0.234
Observations	11,982	11,982	11,982	11,982	11,982

Table OA.2. Alternative fixed effect structures

This table examines the sensitivity of the results in Tables 3, 5 and 6 to alternative fixed effect structures. All the variables are defined in detail in Appendix A. t-statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Dep. var.: *Netseller*	(1)	(2)	(3)	(4)	(5)	(6)
Liquidity_Need	0.032***	0.031***	0.031***	0.030***	0.001	0.001
	(3.88)	(3.81)	(3.74)	(3.68)	(0.11)	(0.13)
Pre_Selling_Loss	0.062***	0.010	0.062***	0.011	0.028**	−0.014
	(5.22)	(0.87)	(5.32)	(0.95)	(2.29)	(−1.01)
*Pre_Selling_Loss * Pre_Selling_Excess*		0.078***		0.078***		0.065***
		(4.88)		(4.83)		(3.56)
Pre_Selling_Excess	0.122***	0.105***	0.117***	0.100***	0.103***	0.089***
	(16.18)	(13.21)	(15.65)	(12.74)	(8.83)	(7.69)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects					Yes	Yes
Country Fixed Effects			Yes	Yes		
Industry Fixed Effects	Yes	Yes				
Country-Year Fixed Effects	Yes	Yes				
Industry-year Fixed Effects			Yes	Yes		
Firm Fixed Effects					Yes	Yes
adj R-squared	0.105	0.108	0.122	0.124	0.369	0.370
Observations	11,971	11,971	11,972	11,972	11,661	11,661

Table OA.3. Alternative earnings thresholds

This table presents an alternative version of the test of selling allowances to beat earnings thresholds in Table 7. Rather than the zero-earnings threshold considered in Table 7, this analysis considers two alternative thresholds: prior profitability and industry profitability. *I[Pre_Selling_ROA(t) < ROA(t-1)]* is an indicator for whether pre-selling ROA is lower than the ROA reported in the previous year. *I[Pre_Selling_ROA(t) < ROA_Industry(t)]* is an indicator for whether pre-selling ROA is lower than the average ROA reported by industry peers in that year All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Dep. var.: *Netseller*	(1)	(2)	(3)	(4)
I[Pre_Selling_ROA(t) < ROA(t-1)]	0.016**	−0.015**		
	(2.40)	(−2.23)		
*Pre_Selling_Excess * I[Pre_Selling_ROA(t) < ROA(t-1)]*		0.049***		
		(4.52)		
I[Pre_Selling_ROA(t) < ROA_Industry(t)]			0.004	−0.022**
			(0.41)	(−2.30)
*Pre_Selling_Excess * I[Pre_Selling_ROA(t) < ROA_Industry(t)]*				0.041***
				(3.30)
Pre_Selling_Excess	0.125***	0.103***	0.124***	0.102***
	(16.56)	(11.85)	(16.54)	(10.72)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
adj R-squared	0.105	0.106	0.104	0.105
Observations	11,982	11,982	11,982	11,982

Table OA.4. Additional Controls for Normal Allowance Management

This table examines the robustness of the results in Tables 3, 5 and 6 to including additional control variables for normal allowance management (i.e., selling allowances in anticipation of future low performance and emissions). Managerial expectations are measured using ex-post realizations of emissions, sales, CAPEX, and ROA. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

Dep. var.: *Netseller*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity_Need	0.032***	0.037	0.032***	0.033***	0.031***	0.030***	0.032***	0.036***
	(3.87)	(1.03)	(3.85)	(3.99)	(3.80)	(3.60)	(3.84)	(3.70)
Pre_Selling_Loss	0.061***	0.057	0.060***	0.060***	0.059***	0.059***	0.060***	0.059***
	(5.18)	(1.62)	(5.05)	(5.07)	(5.01)	(5.03)	(5.02)	(4.97)
Emissions (t+1)	−0.006*	−0.006						
	(−1.83)	(−1.33)						
*Emissions (t+1) * Liquidity_Need*		−0.000						
		(−0.14)						
*Emissions (t+1) * Pre_Selling_Loss*		0.000						
		(0.14)						
Δ_Sales (t+1)			−0.030*	0.029				
			(−1.95)	(0.86)				
*Δ_Sales (t+1) * Liquidity_Need*				−0.063				
				(−1.62)				
*Δ_Sales (t+1) * Pre_Selling_Need*				−0.031				
				(−0.89)				
CAPEX (t+1)					−0.059*	−0.139***		
					(−1.85)	(−2.58)		
*CAPEX (t+1) * Liquidity_Need*						0.075		
						(1.18)		
*CAPEX (t+1) * Pre_Selling_Loss*						0.084		
						(1.12)		
ROA (t+1)							−0.091*	−0.070
							(−1.88)	(−0.87)
*ROA (t+1) * Liquidity_Need*								−0.077
								(−0.83)
*ROA (t+1) * Pre_Selling_Loss*								0.103

								(0.98)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
adj R-squared	0.105	0.104	0.104	0.104	0.105	0.105	0.105	0.105
Observations	11,839	11,839	11,763	11,763	11,775	11,775	11,723	11,723

Table OA.5. Robustness to significant decrease in sales

This table examines the robustness of the results in Tables 3, 5 and 6 to excluding firms with an extreme decrease in sales. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

	Exclude observations with a decrease in sales larger than 10%		Exclude observations with a decrease in sales larger than 20%		Exclude observations with a decrease in sales larger than 30%	
Dep. var.: *Netseller*	(1)	(2)	(3)	(4)	(5)	(6)
Liquidity_Need	0.033***	0.033***	0.031***	0.030***	0.031***	0.031***
	(3.84)	(3.79)	(3.68)	(3.61)	(3.82)	(3.75)
Pre_Selling_Loss	0.061***	0.008	0.059***	0.009	0.059***	0.011
	(4.58)	(0.61)	(4.79)	(0.69)	(4.87)	(0.87)
*Pre_Selling_Loss * Pre_Selling_Excess*		0.080***		0.077***		0.073***
		(4.30)		(4.49)		(4.44)
Pre_Selling_Excess	0.122***	0.107***	0.124***	0.109***	0.124***	0.108***
	(15.34)	(12.90)	(16.18)	(13.55)	(16.34)	(13.68)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
adj R-squared	0.103	0.105	0.103	0.105	0.102	0.104
Observations	10,000	10,000	11,203	11,203	11,622	11,622

Table OA.6. Robustness to alternative measures of carbon price levels

This table examines the robustness of the results of Tables 3, 5 and 6 to using the carbon price either at the beginning of the year or at the end of the year. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

	Beginning of year price		End of year price	
Dep. var.: *Netseller*	(1)	(2)	(3)	(4)
Liquidity_Need	0.034***	0.033***	0.033***	0.032***
	(4.14)	(4.07)	(3.98)	(3.91)
Pre_Selling_Loss	0.065***	0.015	0.067***	0.015
	(5.49)	(1.23)	(5.63)	(1.23)
*Pre_Selling_Loss * Pre_Selling_Excess*		0.077***		0.079***
		(4.73)		(4.85)
Pre_Selling_Excess	0.125***	0.108***	0.125***	0.107***
	(16.53)	(13.65)	(16.47)	(13.44)
Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
adj R-squared	0.103	0.105	0.104	0.106
Observations	11,982	11,982	11,982	11,982

Table OA.7. Robustness to changes in the number of installations

This table examines the robustness of the results in Tables 3, 5 and 6 to excluding firms with increases, decreases, and changes in the number of installations. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

	Excluding firms with an increase in the number of installations		Excluding firms with a decrease in the number of installations		Excluding firms with a change in the number of installations	
Dep. var.: *Netseller*	(1)	(2)	(3)	(4)	(5)	(6)
Liquidity_Need	0.034***	0.034***	0.034***	0.033***	0.036***	0.035***
	(4.18)	(4.11)	(4.14)	(4.06)	(4.44)	(4.36)
Pre_Selling_Loss	0.061***	0.012	0.062***	0.010	0.062***	0.011
	(5.22)	(0.98)	(5.27)	(0.83)	(5.30)	(0.93)
*Pre_Selling_Loss * Pre_Selling_Excess*		0.075***		0.080***		0.078***
		(4.68)		(4.97)		(4.84)
Pre_Selling_Excess	0.124***	0.107***	0.125***	0.107***	0.125***	0.107***
	(16.39)	(13.55)	(16.60)	(13.60)	(16.46)	(13.55)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
adj R-squared	0.104	0.105	0.105	0.107	0.105	0.107
Observations	11,795	11,795	11,785	11,785	11,598	11,598

Table OA.8. Robustness to excluding overrepresented countries

This table repeats examines the robustness of the results in Tables 3, 5 and 6 to excluding the countries with the highest number of sample observations. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

	Excluding France		Excluding Germany		Excluding Italy		Excluding Spain	
Dep. var.: *Netseller*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity_Need	0.032***	0.031***	0.033***	0.033***	0.030***	0.029***	0.026***	0.026***
	(3.75)	(3.70)	(3.77)	(3.73)	(3.38)	(3.32)	(2.96)	(2.91)
Pre_Selling_Loss	0.059***	0.014	0.064***	0.014	0.046***	0.007	0.064***	0.007
	(4.82)	(1.14)	(5.08)	(1.08)	(3.51)	(0.48)	(5.00)	(0.53)
*Pre_Selling_Loss * Pre_Selling_Excess*		0.070***		0.077***		0.060***		0.086***
		(4.03)		(4.51)		(3.33)		(5.07)
Pre_Selling_Excess	0.125***	0.110***	0.126***	0.109***	0.119***	0.106***	0.130***	0.111***
	(15.69)	(13.20)	(15.66)	(12.84)	(14.53)	(12.23)	(16.00)	(13.06)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
adj R-squared	0.105	0.107	0.104	0.106	0.104	0.105	0.107	0.110
Observations	10,844	10,844	10,904	10,904	10,004	10,004	10,421	10,421

Table OA.9. Robustness to excluding overrepresented industries

This table repeats examines the robustness of the results in Tables 3, 5 and 6 to excluding the industries with the highest number of samples observations. All the variables are defined in detail in Appendix A. t- statistics are in parentheses, standard errors are clustered at the firm level. *, **, and *** denote significance at the 10%, 5%, and 1% level (two-tail) respectively. Intercepts are omitted.

	Excluding "Combustion"		Excluding "Other non metallic minerals"		Excluding "Pulp and paper"		Excluding "Aviation"	
Dep. var.: *Netseller*	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Liquidity_Need	0.044***	0.043***	0.027***	0.027***	0.028***	0.028***	0.034***	0.034***
	(3.37)	(3.28)	(3.07)	(3.03)	(3.34)	(3.25)	(3.97)	(3.92)
Pre_Selling_Loss	0.086***	0.035*	0.063***	0.013	0.052***	0.005	0.061***	0.011
	(4.87)	(1.70)	(4.93)	(1.04)	(4.26)	(0.40)	(4.97)	(0.82)
*Pre_Selling_Loss * Pre_Selling_Excess*		0.074***		0.078***		0.073***		0.075***
		(3.02)		(4.51)		(4.40)		(4.34)
Pre_Selling_Excess	0.155***	0.138***	0.131***	0.113***	0.116***	0.100***	0.119***	0.103***
	(12.45)	(10.71)	(15.90)	(12.99)	(15.05)	(12.27)	(15.44)	(12.73)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
adj R-squared	0.122	0.123	0.113	0.115	0.0991	0.101	0.104	0.105
Observations	5,767	5,767	10,412	10,412	10,673	10,673	11,279	11,279