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The link between Environmental Performance and Firm Value: The Case of the EU Emission Trading Scheme

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ABSTRACT

Prior studies have failed to unequivocally find a positive effect of environmental performance on firm value for firms operating under the European Union Emission Trading Scheme (EU ETS). As this is often attributed to the overallocation of emission allowances in the first two phases of the Scheme, we examine its third phase. In this phase, the stringency of the system increased as the allocation rules regarding the distribution of free carbon allowances were tightened. Using a difference-in-difference estimation, we find that a lack of emission allowances is translated into lower firm value in phase III, even at low carbon prices. This negative impact on firm value is especially pronounced for firms that are financially constrained and highly exposed to the renewed regulation. In contrast, foreign direct investments (FDI) towards environmentally lax countries outside the Scheme mitigate this impact. Our results are consistent with increased carbon risk in phase III of the EU ETS for underallocated firms. Furthermore, while previous research, focusing on the first two phases of the Scheme, does not find evidence of carbon leakage, our findings provide suggestive evidence that this could be occurring in the third phase of the Scheme as investing in pollution havens salvages firm value for underallocated multinationals.

JEL classification: G14, Q48

Keywords: EU ETS, FDI, carbon risk, firm value

1. Introduction

The increasingly ubiquitous consequences of climate change have triggered an interest in the academic literature over the last decades in terms of "greening the business" (Kolk, 2016). This interest was spurred by a series of studies that showed that various measures of environmental performance, such as pollution control (Spicer, 1978), carbon efficiency (Brouwers, Schoubben, & Van Hulle, 2018), compliance with environmental regulation (Dasgupta, Hong, Laplante, & Mamingi, 2006) and even certain environmental awards (Jacobs, Singhal, & Subramanian, 2010), are all positively related to firm value. As such, three main channels are mentioned in the academic literature through which better environmental performance can be translated into higher firm value. First, Busch & Hoffmann (2011) indicate that, given the materiality of the climate change issue, environmental performance positively affects firm value as it can strengthen the legitimacy of the firm in the eyes of the stakeholders. Aside from these reputational benefits, significant cost savings can also be attributed to cleaner production (Aggarwal & Dow, 2012). Finally, less pollution also decreases carbon risk and the related financial vulnerability of firms from the global transition towards a low-carbon economy (Nguyen & Phan, 2020). As the EU ETS is a cap-and-trade scheme that tries to decarbonize Europe by explicitly putting a price on carbon —and given the uncertainty of the future price of carbon allowances in particular— this carbon risk is especially relevant for EU ETS-covered firms (Oestreich & Tsiakas, 2015; Stefan & Wellenreuther, 2020).

Environmental performance in general (Griffin, Neururer, & Sun, 2020) and its impact on firm value in particular (Sam & Zhang, 2020) are thus gaining importance in the corporate finance literature. This is also partly due to the introduction of ever more stringent environmental regulation by governments worldwide. Regulatory tools like cap-and-trade systems are becoming the method of choice to combat climate change both in a developed context (e.g., the EU) as well as in a developing context (e.g., China). However, the literature on the impact of environmental performance on firm value with regard to these environmental regulatory frameworks is rather scant. In order to fill this research gap, we explore the value relevance of the world's most developed cap-and-trade emission trading scheme, the European Union Emission Trading Scheme (EU ETS).

The idea of cap-and-trade relies on the creation of economic incentives to abate pollution. Under this regulatory framework, firms receive a specified amount of tradable emission allowances for free that are compared to their verified emissions each year. When firms face an underallocation of emission allowances, they need to buy additional allowances or pay substantial fines. As such, the EU ETS was the first official regulatory framework to put a price on carbon in Europe.

We use the introduction of the third phase of the EU ETS to examine the impact of an increase in the stringency of this environmental policy on firm value. While phase I (2005-2007) was characterized by an overallocation of emission allowances (Grubb, Azar, & Persson, 2005) and the economic crisis affected the demand for emission allowances in the second phase (2008-2012), leaving an excess of unused allowances (Joltreau & Sommerfeld, 2019), the allocation rules regarding the distribution of free carbon allowances were tightened in the third phase (2013-2020).[1] First, auctioning instead of free allocation of allowances became the default in phase III, with an estimated 57% of allowances being auctioned off (aus dem Moore, Großkurth, & Themann, 2019). Furthermore, the National Allocation Plans, used in the previous phases to allocate allowances, were abolished and replaced by centralized allocation of emission allowances at the level of the European Commission. This lead to more homogeneity within the Scheme and reduced the propensity to overallocate emission allowances to industries in more environmentally lenient countries (Bailey, 2010). Aside from these changes that reduced the free allocation of allowances, the Union-wide cap also decreased with an annual linear reduction factor of 1.74% throughout phase III (Perino & Willner, 2017). However, in spite of all these measures, carbon prices remained low until 2017. This was mainly due to the excess allowances floating around in the system that were transferred from the second phase.[2] Given that the system's stringency —and the resulting carbon risk for "dirty" firms— increased in phase III, on the one hand, but carbon prices remained low —limiting the actual cost exposure—, on the other hand, we are interested in whether these renewed allocation rules could affect firm value at the relatively low prevailing carbon prices.

[1] 2020 will not be included in our analyses due to a possibly distortive effect of COVID-19.

[2] Phase II ended with an excess of approximately 2 billion emission allowances in the system. From 2017 onwards, carbon prices rose significantly due to the reform of the Market Stability Reserve and the introduction of a cancellation mechanism that would severely diminish the amount of allowances in circulation in Phase IV of the Scheme. As such, the EUA futures price from ICE ECX platform equaled €5,15 per tonne of CO_2-equivalent emissions on 01/01/2017, €11,06 on 01/01/2018 and already €22,23 on 01/01/2019.

When examining the emission-to-cap (ETC) ratio[3] in Figure 1 of 358 EU ETS-covered firms[4] that account for approximately 50% of the emissions regulated by the EU ETS at the end of phase II, we indeed observe that, prior to the third phase, the median firm received more free emission allowances annually than its verified emissions. However, this changed in phase III with a strong reduction in the amount of freely allocated allowances as main driver for this phenomenon.

[INSERT FIGURE 1 AROUND HERE]

If investors would take into account the augmented carbon risk from the increase in stringency of the Scheme, we would assume markets to discount the value of firms that faced an allowance deficit[5] at the end of second phase in the new and more stringent third phase, given that these underallocated firms started the latter phase with a higher environmental inefficiency.

Using environmental data examining the freely allocated carbon allowances and verified emissions within the EU ETS of firms that are covered by the policy as well as investment data on their foreign direct investment (FDI) projects, we investigate how the renewed allocation rules impact these listed firms' financial performance after the inception of the third phase of the Scheme. Our results show that underallocated firms lost value after the introduction of phase III, regardless of the low carbon price. This effect was especially pronounced when these underallocated firms faced financial constraints and were highly exposed to the renewed regulation. Finally, we know from the tax haven literature that international investments can be used to flee from stringent regulation (e.g., Su & Tan, 2018). As the EU ETS only has a limited jurisdiction, we examine investment projects towards pollution havens outside the Scheme and show that this strategy indeed does mitigate the negative impact from an underallocation position on firm value.

Our findings contribute to the research on the financial impact of environmental performance and climate regulation and the moderating role investment behavior can play in this context. First, to our

[3] The ETC is defined as the freely allocated emission allowances to the listed firms minus their verified emissions, scaled by these freely allocated allowances. A larger ETC thus means more excess emission allowances. While emission allowances and verified emissions are distributed at the installation level, the algorithm on how this information is mapped to our listed firms is explained in the data section.

[4] EU ETS-covered means that our set of multinationals have to comply, directly or indirectly through subsidiaries under their control, to the EU ETS as they control an installation covered under the Scheme.

[5] As emission allowances need to be handed over annually, a cumulative underallocation position at the end of phase II boils down to firms being unable to build cumulative excesses in the second phase of the EU ETS.

knowledge, our research is the first to examine the effect on firm value of the renewed allocation rules of phase III. Prior studies have failed to unequivocally find a positive effect of environmental performance on firm value for firms operating under the EU ETS. As this is often attributed to the overallocation of emission allowances in the first two phases of the Scheme, with Naegele & Zaklan (2019) even arguing that this overallocation of free carbon allowances led to a net subsidy for the majority of the sectors covered by the EU ETS, we examine phase III in which free allocation of allowances was drastically reduced. We show that worse environmental performance is translated into decreased firm value, even though carbon prices were rather low. This shows that, while a sufficiently large carbon price is often deemed a requirement for environmental policy to impact firm competitiveness (Joltreau & Sommerfeld, 2019), the third phase of the EU Emission Trading Scheme did appear to punish bad environmental performance, even at low carbon prices.

Furthermore, our results show an interesting interplay between evasive investment behavior outside of the EU ETS scope and firm value. Even though carbon leakage in the first two phases of the EU ETS has already been examined in the academic literature through surveys (Dechezleprêtre, Gennaioli, Martin, Muuls, & Stoerk, 2019; Martin, Muûls, De Preux, & Wagner, 2014), firm level FDI (Koch & Basse Mama, 2019) or asset erosion data (aus dem Moore et al., 2019), and evidence has been lacking so far, our results show that firm-specific environmental characteristics need to be taken into account when examining the value implications of investment behavior outside the EU ETS. While these results contrast prior literature, they are not unexpected as they are in line with “Jurisdiction shopping”. This concept from the international business literature comprises that firms locate in countries that provide the best policy framework for their needs (Georgallis, Pimentel, & Kondratenko, 2020). As the literature on carbon leakage currently focuses mainly on the first two phases of the Scheme and given the well-known issues in terms of stringency of the system in these phases, the incentives to resort to investment leakage became much more pronounced in the third phase of the EU ETS as carbon risk increased, especially for environmentally inefficient firms.

Finally, our results have important policy implications regarding the effectiveness of the allocation rules within the EU ETS in impacting firm competitiveness. Given that we find evidence of investment projects towards pollution havens outside the Scheme salvaging firm value for environmentally inefficient firms, the

European Commission needs to reconsider its leniency for installations operating in leakage sectors in terms of the freely allocated emission allowances they receive.

2. Literature review and hypotheses development

In this section, we examine the literature on the implications of environmental (in)efficiency on financial performance. Additionally, we investigate how environmental motives could affect FDI behavior and how environmentally motivated FDI strategies in turn could result in improved firm value.

2.1 Environmental performance and firm value

As noted in the introduction, environmental performance is a multidimensional construct. It encompasses, among others, carbon efficiency (Brouwers et al., 2018), compliance with environmental regulation (e.g., avoiding spills and court actions as noted in Dasgupta et al., 2006) as well as environmental awards (Jacobs et al., 2010). These various dimensions also entail different channels through which they can affect a firm's financial position. The three main channels through which better environmental performance is theorized to improve firm value entail: reputation enhancement, cost savings and decreased carbon risk. Environmental awards, for instance, may convince consumers or investors to opt for green companies as they are becoming more environmentally aware (Busch & Hoffmann, 2011). As such, stakeholders regard environmental performance as a virtue, reflected in a higher market value of well-performing firms. In contrast, failure to comply with environmental laws has been shown to lead to a reduction in stock prices with court actions being able to lead to substantial fines (Dasgupta et al., 2006).[6] The EU ETS, on the other hand, explicitly valorizes carbon efficiency through the creation of emission allowances. A larger stock of these allowances constitutes a resource under the resource based view (Barney, 1991) and decreases carbon risk. Moreover, in case of a high carbon price, these allowance stocks can additionally lead to significant monetary benefits.

While the idea of relating environmental performance to firm value is not novel (e.g., Spicer (1978) already shows a positive correlation between environmental performance and financial performance in the

[6] From the perspective of the natural-resource based view (Hart, 1995), environmental capabilities, as they might be difficult to imitate, can lead to sustained competitive advantages (Porter & van der Linde, 1995). These competitive advantages, however, originate mainly from either reputational benefits or significant cost savings with respect to the industry-peers.

paper and pulp industry between 1968 and 1973), this link has received increased attention in recent years with results being inconclusive. This attention was spurred by the dawn of international climate treaties (e.g., the Paris climate agreement) and growing media coverage of the impact of climate change (Boiral, Henri, & Talbot, 2012). The majority of the literature studying the relation between environmental and financial performance tends to show, however, that there is value in good environmental performance. These results prevail in Asia (Fujii, Iwata, Kaneko, & Managi, 2013; Nakao, Amano, Matsumura, Genba, & Nakano, 2007), the US (Konar & Cohen, 2001) as well as Europe (Clarkson, Li, Pinnuck, & Richardson, 2015). Also when specifically focusing on emission allowances, Johnston, Sefcik, & Soderstrom (2008) show a positive effect of sulfur dioxide (SO_2) emission allowances held by US electric utilities on their market value.

Nevertheless, Alvarez (2012) does not find a significant link between environmental performance and firm value with Wang, Li, & Gao (2014) even showing a negative association between these two concepts. This negative relation between environmental performance and firm value is based on the win-lose perspective (Boiral et al., 2012), which stipulates that the efforts required to increase environmental performance are accompanied by costs that diminish the overall competitiveness of the firm.

2.2 The introduction of the third phase of the EU ETS

The EU ETS was introduced in 2005 as the main European environmental regulatory tool to tackle climate change. It was introduced in different phases, with phase I (the pilot phase) ranging from 2005 to 2007, phase II (coinciding with the Kyoto Protocol commitment period) extending from 2008 to 2012 and phase III spanning from 2013-2020 (aus dem Moore et al., 2019). Currently, the EU ETS is in its fourth phase, which is characterized by the highest carbon price levels since the Scheme's inception.[7] The first two phases of the Emission Trading Scheme, however, came under scrutiny in the academic literature given the disappointing results in terms of pollution reduction measures taken by firms (Bel & Joseph, 2015).

Nevertheless, the introduction of the EU ETS has led to the first official carbon price coming into effect in Europe. Installations covered by the Scheme need to hand over emission allowances equal to their verified emissions annually. If they fail to hand over sufficient allowances, fines for non-compliance are imposed on

[7] Even though the allowance price dropped due to the economic crisis in phase II, the impact of the COVID-19 crisis on the carbon price is limited. As such, the EUA futures price from ICE ECX platform reached €37,07 on 01/03/2021.

them, rising from €40 per tonne in phase I to €100 per tonne in phase II[8] (Clarkson et al., 2015). As emissions can be seen as reflecting future regulatory costs (Sam & Zhang, 2020), heavily polluting companies are likely to suffer more from environmentally stringent policies. Consistent with this costs perspective, the negative effect of carbon intensity on firm value is well-known in the academic literature (e.g., Matsumura, Prakash, & Vera-Muñoz, 2014).

Regarding the impact of the EU ETS on firm value, most research has analyzed its value implications during the first two phases of the Scheme. As such, Chan, Li, & Zhang (2013) do not find a negative effect of the EU ETS on firm performance of three heavily polluting industries (cement, iron and steel) between 2005-2009. Nevertheless, Brouwers, Schoubben, & Van Hulle (2018) show that a firms' emission intensity, using its verified emissions under the EU ETS, negatively impacts firm value when these companies are unable to pass through their costs of compliance, even in the more lenient first two phases of the Scheme. Given the prevailing ambiguity with respect to the impact of the EU ETS on firm value during its first two phases, this paper examines whether the introduction of phase III —and the resulting change in allocation rules regarding the distribution of free allowances in particular— can provide a more conclusive answer in this respect.

Before developing our hypotheses, we address the historic development of the renewed allocation rules and the resulting appropriateness for our difference-in-differences specification. As the main revisions for the allocation rules in the third phase, where auctioning became the default and the National Allocation Plans were abolished, were already agreed upon in 2008[9], firms may have shown anticipatory behavior to this increase in stringency in phase III. Nevertheless, the carbon price in Figure 2 tends to show a decreasing trend over time in phase II, which may have limited the incentives to proactively start saving emission allowances.

[INSERT FIGURE 2 AROUND HERE]

A possible explanation can be found when examining Fan, Jia, Wang, & Xu, (2017). The main regulatory changes throughout phase II are listed in this paper. While a general notion of the increase in stringency for phase III may have been present, given the amount of events and the prevailing excess of

[8] Note that these fines are much higher than the prevailing carbon prices, which remained well below €10 in the third phase of the EU ETS until 2018. The EUA futures from ICE ECX platform peaked during our sample period of 2005-2019 at €29.8 at the end of the third phase.
[9] https://ec.europa.eu/clima/sites/clima/files/ets/reform/docs/com_2012_652_en.pdf

allowances in the system, clear incentives to preventively start saving allowances may have been limited. Moreover, even if the firms exerted anticipatory behavior by saving emission allowances throughout phase II, the size of the negative effect of an allowance shortage at the end of phase II is likely be to a lower bound of the actual effect on firm value in phase III, given the 5 year restructuring period.[10]

As Joltreau & Sommerfeld (2019) indicate that an overallocation of emission allowances led to a lack of impact on firm profitability of the EU ETS during the first two phases, we hypothesize that if valuation effects would be present in the third phase, these would predominantly occur for firms that were already underallocated when the Scheme was too lenient in its prior phases. In line with this reasoning, the negative effect of allowance shortfalls on firm value has been shown for the first two phases of the EU ETS (Clarkson et al., 2015). As carbon risk —and its impact on the discounting of future cashflows— materializes from the third phase onwards, this leads us to the following hypothesis.

H1: Strengthening of the EU ETS through the introduction of phase III reduced firm value for environmentally inefficient firms

2.3 Regulatory exposure

While firm value tends to decrease with worse environmental performance, not all firms are exposed to the increased stringency of the EU ETS in phase III to the same extent. To examine this exposure, we first introduce the concept of carbon leakage. Carbon leakage is referred to as the phenomenon where firms shift their activities to countries outside of the jurisdiction covered by the unilateral environmental regulation (Venmans, 2012). This behavior hurts the economies of the countries participating in the EU ETS as they lose investments. Moreover, it also undermines the efficiency of climate regulation as emissions shift alongside the investments, instead of abatement taking place. To mitigate the incentives for multinationals to flee the EU ETS, the European Commission decided to continue to grandfather emission allowances in phase III for installations in carbon leakage sectors (Clò, 2010). Product benchmarks, defined as the average emissions of the 10% best performing installations in the EU that produce a particular product, were used to determine the amount of free allocations. While, for instance, firms operating in power generation did not receive any

[10] Note that a strictly exogenous shock is not a requirement for a difference-in-difference model (e.g., Francis, Hasan, Park, & Wu, 2015).

allowances for free throughout phase III, firms operating in sectors exposed to carbon leakage kept receiving a higher share of emission allowances for free. As such, 100% of benchmark allocations were granted to installations in carbon leakage sectors throughout this phase (Koch & Basse Mama, 2019).[11] Firms in the remaining sectors received 80% of the product benchmark in 2013, which was reduced to 30% by 2020.

Given this lenient treatment in terms of the renewed allocation rules for firms operating in leakage sectors, we would expect the impact of these renewed rules on firm value in phase III to be limited for this subsample. In contrast, the impact should be particularly pronounced for firms that were more affected by the renewed regulation in terms of the allowances they lost. This leads to the following hypothesis.

H2: The effect of a carbon allowance shortage on firm value increases with higher exposure to the renewed regulation.

2.4 Financial constraints

The importance of financial flexibility is well-known with Gamba & Triantis (2008) stipulating that it allows firms to avoid financial distress when confronted with adverse shocks, while also permitting them to finance profitable investment opportunities as they arise. In line with this notion, Opler & Titman (1994) already found that more financially constrained firms lost more market share in industry downturns.

Sam & Zhang (2020) indicate that emissions can be seen as reflecting future regulatory costs. The underlying reasoning that these emissions provide a notion of the operating and capital costs required to mitigate them is particularly applicable to the EU ETS, as this scheme explicitly prices carbon. Even though carbon prices were low, the increased carbon risk in phase III encompasses a notion of the future regulatory costs that will originate from bad environmental performance. Therefore, one can assume that firms with financial buffers could better absorb these costs, while financially constrained firms would be likely to suffer more from these environmental costs. Consistent with this, Nguyen & Phan (2020) state that financially constrained emitters face increased difficulties in covering the increased carbon costs due to the ratification of the Kyoto Protocol in Australia. We argue that, while the inception of the renewed rules in the third phase of

[11] The list of carbon leakage sectors, published in the Official Journal of the European Union, can be found on the following link: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2019:120:FULL&from=EN.

the EU ETS could diminish the value of underallocated firms, this effect should be exacerbated if the firm is financially constrained.

H3: The effect of a carbon allowance shortage on firm value increases when the firm is financially constrained.

2.5 Internationalization, carbon leakage and firm value

Whether global diversification has a positive impact on firm value has long been debated within the academic literature (Doukas & Kan, 2006; Doukas & Lang, 2003; Gande, Schenzler, & Senbet, 2009). As such, various incentives for the cross-border expansion of a firm's activities have already been examined, with tax evasion (e.g., Su & Tan, 2018) as well as access to cheap labor (e.g., Duanmu, 2014) all proving important determinants. When relating these determinants to firm value, however, we observe that fleeing stringent regulation does not always have a positive impact. For instance, Akhtar, Akhtar, John, & Wong (2019) show that news on tax evasion negatively affects firm value in the short-term due to reputational damage, but that this effect is not persistent. Similarly, Alimov (2015) argues that stringent employment regulations attract foreign acquirers and these transactions are associated with higher operating income. This paper examines yet another driver for international investment behavior by investigating how FDI would be a moderating factor in the relation between environmental performance and firm value.

Given the increased relevance of environmental performance in recent years, firms tend to take into account their environmental capabilities when determining their FDI strategies (Bu & Wagner, 2016). It is well-established in the international business literature that FDI in general (Doukas & Lang, 2003) and international investment strategies in particular (e.g., tax evasion as noted in Akhtar, et al., 2019) have the potential to affect firm value. When examining these international investment strategies from an environmental perspective, empirical evidence suggests that multinationals take into account environmental stringency in their location decision (Dean, Lovely, & Wang, 2009; List & Co, 2000; Mulatu, 2017; Poelhekke & Van der Ploeg, 2015). Multinationals are faced with cross-country variation in environmental stringency that allows less carbon-efficient firms to shift their emissions towards more environmentally lenient regions to save on abatement efforts (Ben Kheder & Zugravu, 2012; List & Co, 2000). This strategy is referred to as the pollution haven effect (Cole, Elliott, & Zhang, 2017).

Given the unilateral nature of the EU ETS, operating under the Scheme provides polluting firms with the incentive to expand or set up new installations in countries not covered by its jurisdiction (Clò, 2010). When relating this to the pollution haven effect, more carbon-inefficient firms have a higher incentive to engage in evasive FDI and direct their international investment projects towards more environmentally lenient countries. This, in turn, can decrease their carbon risk under the EU ETS, resulting in our final hypothesis.

H4: The impact of a carbon allowance shortage on firm value decreases when firms pursue FDI in environmentally lax countries outside the EU ETS.

3. Data

We examine the value of listed firms covered by the world's most developed emission trading system, the EU Emissions Trading Scheme, between 2005-2019. The European Union Transaction Log (EUTL), known as the Community Independent Transaction Log (CITL) prior to phase III, is used as our main source of environmental data (Calel & Dechezleprêtre, 2016; Venmans, 2012). The EUTL covers the freely allocated allowances as well as yearly verified emissions of all EU ETS installations and is used to aggregate this information over all affiliates at the parent firm level. The advantage of using the EUTL is that it entails mandatory reporting of objective measures of environmental performance as opposed to multidimensional constructs such as ESG scores (Busch & Hoffmann, 2011). We start from the matching algorithm of Brouwers et al. (2018) and map 358 listed firms to EU ETS installations in the first two phases of the Scheme. This allows us to determine the existence of a cumulative deficit of allowances at the end of phase II for each firm. These analyzed installations comprise approximately 50% of the verified emissions covered under the EU ETS at the wake of phase III.[12]

Given that we additionally investigate investment behavior, these listed parent firms are matched to FDI data, extracted from the fDi markets database, which contains detailed information on our sample firms' international investment projects during phase III of the EU ETS. Finally, we use Worldscope to gather firm-specific accounting information.

[12] We also extend this algorithm to phase III by verifying whether the mapped installations remained owned by either the listed firms or one of their subsidiaries or whether the installations were divested or discontinued. Moreover, we examined installations that were previously not mapped by the algorithm but who changed ownership for the third phase. Finally, we also examine new installations set up during the third phase of the EU ETS.

4. Methodology

4.1 Baseline specification

Antoniou, Delis, Ongena, & Tsoumas, (2020) are followed in using the introduction of phase III of the EU ETS as shock for a difference-in-difference (DiD) analysis. The DiD method alleviates endogeneity concerns as both underallocation and firm value may be correlated with unobservable firm characteristics. Consistent with Clarkson et al. (2015), we compare the total amount of verified emissions by a firm to the freely allocated carbon allowances they receive under the EU ETS. As the banking of emission allowances from the first phase to the second phase was not allowed (aus dem Moore et al., 2019), the treatment group comprises listed firms facing a cumulative deficit of emission allowances with respect to their verified emissions at the end of phase II. We compare the value of these underallocated firms with that of firms facing a cumulative excess of allowances at the end of phase II (our control group).

As such, the following difference-in-differences model is estimated:

$$Q_{i,t} = \gamma * Short_i * Post_t + \beta_1 * growth_{i,t-1} + \beta_2 * capint_{i,t-1} + \beta_3 * size_{i,t-1} + \beta_4 * lev_{i,t-1} + \propto_i + \delta_t + \varepsilon_{i,t} \quad (1)$$

Where $Q_{i,t}$ represents the value of Tobin's Q for firm i in year t, measured as the sum of the firm's market value of equity and book value of debt scaled by its book value of equity and debt. $Short_i$ equals one if the MNE had a cumulative shortage of emission allowances at the end of the second phase and equals zero otherwise. $Post_t$ is an indicator variable reflecting the post-treatment period and therefore equals one from 2013 onwards and zero otherwise. $Size_{i,t-1}$ is the natural logarithm of total assets. $Capint_{i,t-1}$ are capital expenditures divided by total assets. $Leverage_{i,t-1}$ reflects the debt position of the company. $Growth_{i,t-1}$ is the annual percentage change in sales. As can be derived from the subscripts, all control variables are lagged with one period to control for simultaneity issues. $\propto_i$ and δ_t reflect the firm-specific and year-specific fixed effects respectively. Standard errors are robust to heteroskedasticity and clustered at the firm-level across all estimated models (Nguyen & Phan, 2020).

We do not aim to explain why the firms in our treatment group were underallocated at the wake of phase III (e.g., whether it was through insufficient restructuring or even a lack of trying to improve themselves combined with a willingness to buy allowances at the low prevailing carbon prices). We are, however, interested in whether this underallocation position, combined with the increased stringency of phase III of the EU ETS, was able to trigger a negative effect on their market value. As such, we are particularly interested in the γ variable of our model. Furthermore, we ensure that DiD is an appropriate methodology by verifying both graphically as well as through empirical analysis (see section 6.2) that the firms in our treatment and control group follow parallel trends prior to the initiation of phase III.

4.2 Regulatory exposure

Regarding the exposure to the renewed regulation, we use the sector classification of the European Commission at the 4-digit NACE level to determine which of our firms are subject to carbon leakage. To this end, we split the sample into two subsamples with one comprising firms operating in carbon leakage sectors, while the other subsample contains firms not exposed to carbon leakage. Similar to our reasoning, De Jonghe, Mulier, & Schepens (2020) show that only firms operating in non-leakage sectors decreased their carbon emission intensity after the significant rise in carbon prices from 2017 onwards. We analyze these two subsamples using the baseline regression specification.

Moreover, in line with the argument that some firms were treated more leniently after the introduction of the third phase, we define an additional sample split. To this end, we split the sample using an ex-post output-based measure by distinguishing between those firms whose freely allocated allowances were reduced from 2012 to 2013 on the one hand, and those companies whose allowances were not reduced on the other hand. This split is analyzed using the baseline specification as well.

4.3 Financial constraints

In terms of financial constraints, we follow Nguyen & Phan (2020) by using the size-age index[13], developed by Hadlock & Pierce (2010), to examine whether a firm was financially constrained or not. Consistent with Nguyen & Phan (2020), a firm is classified as being financially constrained if its size-age index is above the sample median. These sample splits are analyzed using the baseline regression specification.

Furthermore, we change the regression specification in the following manner to examine an alternative measure of financial constraints.

[13] The size-age index is calculated using the following formula: saindex=(0.737*size) + (0.043*size^2) - (0.040*age)

$$Q_{i,t} = \lambda * Short_i * Post_t * Lowcf_{i,t-1} + \gamma * Short_i * Post_t + \tau * Lowcf_{i,t-1} * Post_t + \beta_1 * growth_{i,t-1} + \beta_2 * capint_{i,t-1} + \beta_3 * size_{i,t-1} + \beta_4 * lev_{i,t-1} + \propto_i + \delta_t + \varepsilon_{i,t} \quad (2)$$

A dummy variable, based on the median of the net operating cash flow[14] (Nguyen & Phan, 2020), is used to determine whether a firm is financially constrained. The dummy ($Lowcf_{i,t-1}$) is equal to one if the firms has a net operating cash flow below this median.

4.4 Internationalization, carbon leakage and firm value

Finally, we investigate the FDI projects established outside the legislation's jurisdiction by the EU ETS-covered MNEs in our sample. As the EU ETS is a unilateral policy, investments outside its jurisdiction are not covered by the Scheme. Therefore, FDI projects (targeting environmentally lenient countries) would provide the possibility of shifting polluting activities towards these locations. We examine both FDI targeted at countries outside the EU ETS in general as well as FDI targeting countries that are environmentally lax. To this end, we define the variable $FDI_{i,t-1}$, which is a dummy equal to 1 if the firm has set up at least 1 FDI project outside the EU ETS in a particular year. Furthermore, we use a reasoning consistent with Chung (2014) to define environmentally lax destination countries as follows. Using the average WEF environmental stringency index[15] of the destinations between 2013 and 2019, a destination is classified as being environmentally lax if its average stringency score is lower than the most lenient country covered by the EU ETS (being Bulgaria) in this period. The list of countries being perceived as environmentally lax that have received FDI is listed in Table A.2 in the Appendix. $LAXFDI_{i,t-1}$ is therefore defined as a dummy equal to 1 if the firm has set up at least 1 FDI project outside the EU ETS in a particular year in a country that is more environmentally lenient than Bulgaria. The regression specification for the FDI analysis is defined as follows.[16]

$$Q_{i,t} = \pi * Short_i * Post_t * FDI_{i,t-1} + \gamma * Short_i * Post_t + \varphi * FDI_{i,t-1} * Post_t + \beta_1 * growth_{i,t-1} + \beta_2 * capint_{i,t-1} + \beta_3 * size_{i,t-1} + \beta_4 * lev_{i,t-1} + \propto_i + \delta_t + \varepsilon_{i,t} \quad (3)$$

[14] These results are robust to using the industry-corrected (at the 2-digit SIC level) median net operation cash flow.
[15] The WEF environmental stringency index is using responses of business executives on the following question: "How stringent is your country's environmental regulation? (1 = lax compared to most countries, 7 = among the world's most stringent)"
[16] The FDI variable is replaced by the LAXFDI variable for the respective analysis.

5. Univariate results

First, we examine the variables used in our analysis. The mean firm size equals 14,682, which can be translated in an average firm size of approximately 2.4 billion euros. Moreover, the average Tobin's Q is larger than 1, reflecting that the average market value is higher than the respective book value in our sample. Furthermore, we compare the mean values of the variables used in our analysis for the treatment and control group in the year prior to the introduction of phase III in Table 2. We note that the mean value for all variables, with the exception of firm size, does not differ significantly between the two subsets of firms.

[INSERT TABLES 1 & 2 AROUND HERE]

As we are interested in the EU ETS' impact on firm value, we analyze Tobin's Q prior to and after the inception of the third phase in Table 3. First, we observe that mean firm value is not significantly different in phase II for firms facing a cumulative deficit of allowances at the end of this phase as opposed to firms with a cumulative excess in this period. However, the t-test does show that from phase III onwards, the value of firms in the treatment group is significantly higher (t.stat=2.211) than that of firms in the control group. Moreover, we also observe a significantly positive effect on mean firm value when examining the transition from the second to the third phase of the EU ETS for the excess subsample (t.stat=6.435), while this effect is insignificant for firms in the shortage subsample. These findings in our univariate analysis thus tend to support the notion that worse environmental performance in phase II of the EU ETS is translated into relatively lower firm value in the third phase.

[INSERT TABLE 3 AROUND HERE]

6. Multivariate results

6.1 Baseline specification

To examine the first hypothesis on the effect of an allowance deficit on firm value after the introduction of phase III of the EU ETS, we investigate Table 4. We observe that, across all four specifications, the effect of a cumulative deficit of emission allowances at the end of the second phase is significantly negative on firm value in the third phase, supporting our first hypothesis. These results are economically meaningful. When examining column 4, we note that having a cumulative shortage of emission allowances at the end of the second phase results in a loss in Tobin’s Q equal to .1145 in phase III — consistent with 21.12% of the standard deviation of Tobin’s Q for the firms in the shortage subsample—, on average, all else equal.

[INSERT TABLE 4 AROUND HERE]

6.2 Parallel trends assumption

Figure 3 shows the evolution of Tobin’s Q over time of both firms facing a cumulative shortage of emission allowances at the end of phase II as well as firms having an excess of emission allowances. When examining three years prior to the introduction of phase III, the year of the introduction itself, and up until three years after its inception, there appears to be a shock in firm value as of 2013, with the excess subsample increasing their Tobin’s Q relative to the shortage subsample.

[INSERT FIGURE 3 AROUND HERE]

As we do not merely want to rely on the interpretation of this graph to apply the difference-in-difference model, we additionally estimate a dynamic model to ensure the validity of the parallel trend assumption prior to the treatment (Nguyen & Phan, 2020). Thirdphase^{-3}, Thirdphase^{-2}, Thirdphase^{-1}, Thirdphase^{0} and Thirdphase^{+1} are indicator variables that reflect up to three years before the inception of the third phase, the year of the inception of phase III itself and one year after its inception, respectively. We observe from Table 5 that prior to the inception of phase III, the interaction variables are insignificant. This supports the notion that firms with a cumulative excess and a cumulative deficit of allowances followed similar trends in terms of their firm value (Tobin’s Q) prior to the third phase. However, once the third phase was introduced, the interaction term becomes significant.

[INSERT TABLE 5 AROUND HERE]

6.3 Regulatory exposure

When examining the first two columns of Table 6, we observe that the effect of a cumulative deficit of emission allowances at the end of the second phase on firm value in phase III is insignificant for the subsample of firms operating in carbon leakage sectors. However, for firms not operating in these carbon leakage sectors, the effect is significant at the 1% level. This is consistent with firms in leakage sectors receiving a more lenient treatment in the third phase in terms of the renewed allocation rules (De Jonghe et al., 2020), in line with our second hypothesis.

Moreover, the regulatory exposure to the renewed regulation is alternatively examined by subsamples based on whether firms lost allowances between 2012 and 2013 (columns 3 and 4). We observe that only for the firms whose freely allocated allowances were reduced between 2012 and 2013, the negative treatment effect remains.

[INSERT TABLE 6 AROUND HERE]

6.4 Financial constraints

Financial constraints are assumed to strengthen the impact of the renewed regulation according to our third hypothesis. The results in Table 7 indeed show that, while a shortage of emission allowances tends to negatively affect firm value in the third phase of the EU ETS, the effect of this deficit on firm value is exacerbated if a firm is financially constrained. As such, the first two columns in Table 7 examine financially constrained firms based on the size-age index from Hadlock & Pierce (2010). The treatment effect is negatively significant in this subsample at the 5% level. In contrast, the impact of the treatment effect on financially unconstrained firms, based on the size-age index, is insignificant (columns 3 and 4). Moreover, a low net operating cashflow is used as alternative measure reflecting financial constraints (Nguyen & Phan, 2020). The three-way-interactions (SHORT*POST*L.LOWCF)[17] in columns 5 and 6 are negatively significant at the 5% and 1% level, respectively, consistent with the previous analysis. Both analyses therefore corroborate that the effect of a carbon allowance shortage on firm value increases when the firm is financially constrained, as stated in the third hypothesis.

[INSERT TABLE 7 AROUND HERE]

6.5 Internationalization, carbon leakage and firm value

Finally, the moderating impact of investment behavior in the relation between environmental performance and firm value is examined in Table 8. First of all, we examine FDI targeting countries outside the EU ETS jurisdiction in phase III in columns 1 and 2, without taking into account the environmental

[17] To control for simultaneity issues, the cashflow variable is lagged with one time period.

stringency of the respective destination. This investment behavior does not lead to an improvement in firm value for the firms in our treatment group. Additionally, the effect of evasive FDI targeting environmentally lax countries outside the EU ETS jurisdiction is examined in columns 3 and 4. While the three-way-interaction for FDI in general (SHORT*POST*L.FDI)[18] is insignificant, we note that FDI targeting environmentally lax countries (SHORT*POST*L.LAXFDI) has a positive effect on firm value for firms facing a cumulative deficit of emission allowances at the end of phase II. This effect is significant at the 5% level, substantiating our final hypothesis.

[INSERT TABLE 8 AROUND HERE]

6.6 Robustness checks

6.6.1 Alternative measure of environmental performance

While we analyze the environmental performance of our sample firms by examining their allocation position, alternative environmental characteristics that determine the exposure to the renewed regulation exist as well. Brouwers et al. (2018) show that environmental performance, measured by the industry-corrected verified emissions of the firm, has a positive effect on firm value. Consistent with these findings, we would assume firms with worse environmental performance relative to their peers at the end of the second phase to be more exposed to the change in allocation rules in phase III. Moreover, it is to be noted that it is difficult for firms to exert anticipatory behavior on this measure as it is cumbersome to estimate how the EP of competitors evolves throughout the years.

To this end, the treatment specification is changed, with all firms in the upper quartile of this industry-corrected[19] emission intensity variable being classified as treated. The dummy variable $\mathrm{Upperindcor}_i$ is introduced, which captures the firms in this upper quartile in 2012. The following specification is defined.

$$Q_{i,t} = \theta * Upperindcor_i * Post_t + \beta_1 * growth_{i,t-1} + \beta_2 * capint_{i,t-1} + \beta_3 * size_{i,t-1} + \beta_4 * lev_{i,t-1} + \propto_i + \delta_t + \varepsilon_{i,t} \quad (4)$$

[18] To control for simultaneity issues, the FDI measures are lagged with one time period.
[19] Industry-correction is achieved by subtracting the median emission intensity at the 2-digit SIC level.

However, environmental performance can also be a source of reputation on the one hand (Busch & Hoffmann, 2011) as well as cost savings on the other hand (Aggarwal & Dow, 2012). That is why we define an alternative treatment specification, with all firms in the lower quartile of this industry-corrected emission intensity variable being classified as treated. The dummy variable $\mathrm{Lowerindcor}_i$ is introduced, which captures the firms in this lower quartile in 2012. The following specification is defined.

$$Q_{i,t} = \omega * Lowerindcor_i * Post_t + \beta_1 * growth_{i,t-1} + \beta_2 * capint_{i,t-1} + \beta_3 * size_{i,t-1} + \beta_4 * lev_{i,t-1} + \propto_i + \delta_t + \varepsilon_{i,t} \quad (5)$$

When examining the first column of Table 9, we observe that, as expected, the more stringent allocation rules have a significantly negative effect on firms that are inefficient with respect to their industry peers. Moreover, the negative impact on inefficient firms is insignificant for the leakage subsample (column 3), while it is reinforced for the non-leakage subsample (column 5). This supports our main results that higher exposure to the renewed regulation is translated into lower firm value for firms with bad environmental performance. Nevertheless, firms that outperform their industry peers do not seem to benefit in terms of firm value (column 2), even in the sectors most exposed to the renewed regulation (column 6). Therefore, the Porter hypothesis that environmental capabilities can lead to a sustained competitive advantage (Porter & van der Linde, 1995) through either reputation (Busch & Hoffmann, 2011) or cost savings (Aggarwal & Dow, 2012) does not seem to be supported by our findings. These findings tend to show that, while firms have incentives to ensure that they are not outperformed by their industry peers, they have limited incentives to go above and beyond in terms of their environmental performance. The EU ETS thus appears unlikely to trigger a virtuous cycle of environmental investments where firms covered by the Scheme would continuously challenge each other to improve themselves.

[INSERT TABLE 9 AROUND HERE]

6.6.2 Sample between 2008-2017

In our main analysis, we focus on the impact of the renewed allocation rules after the introduction of the third phase of the EU ETS with respect to the first two phases of the Scheme. To ensure that the effect of the increased stringency of the EU ETS from phase III onwards on firm value is captured, we make the following adjustments to our sample. First, as the banking of allowances was not permitted from phase I to phase II, a possible cumulative deficit only starts building from 2008. Therefore, we eliminate the first phase from our analysis. This means that our sample will start from 2008 onwards and includes a time period of 5 years prior to the introduction of the third phase. Corresponding to this, we include 5 time periods after the introduction of phase III in our sample. To this end, the sample ends in 2017. While this balances the time period pre- and post-treatment, another advantage of using this as final year of our sample, is that carbon prices rose significantly after this period. Removing years after 2017 from our sample ensures that our effects are not solely driven by a possible increase in attention for environmental regulation due to this carbon price increase.

[INSERT TABLE 10 AROUND HERE]

Table 10 shows that firms facing a cumulative deficit of allowances at the end of phase II suffered value losses in the early years of the third phase. Moreover, this effect was more pronounced for firms more exposed to the renewed regulation, as is shown in columns 2 and 3. In contrast, FDI targeting environmentally lax countries outside the Scheme mitigates this negative impact (column 4).

6.6.3 Previous financial performance

This paper is interested in the effect of a cumulative deficit of allowances at the end of phase II on firm value in the subsequent phase of the EU ETS. However, as previously noted, the renewed rules regarding the allocation of allowances in phase III were already generally agreed upon in 2008. Therefore, concerns may be raised that firms facing a cumulative deficit of emission allowances at the end of phase II encompass a subsample of firms that are overall inefficient (and not just with respect to their environmental performance). As such, these firms may have failed to restructure themselves from 2008 onwards. Due to this general inefficiency, this subsample may also lose more firm value in the third phase. Therefore, we explicitly include lagged levels of financial performance as an additional control in our analyses in Table 11. We observe that, for the same levels of financial performance, firms facing a shortage of emission allowances at the end of phase II lost firm value in phase III. Moreover, the negative effect of the increased exposure as well as the positive effect of evasive investment behavior outside the Scheme remain significant.

[INSERT TABLE 11 AROUND HERE]

6.6.4 Propensity score matching

Even though both our treatment and control group consist of EU ETS-covered firms and Table 2 only indicates a significant difference in size among the two groups, we implement propensity score matching to determine whether the negative effect of an emission allowance deficit on firm value after the inception of the third phase of the EU ETS remains. We follow the method of Buchanan, Cao, & Chen (2018). As such, we apply the propensity matching approach to 2012 and select the closest match with replacement of our treated firms by using five dimensions. We use the four control variables from our baseline specification as well as the 4-digit NACE code of the firms to ensure they are in similar industries. Furthermore, we impose a common support by dropping treatment observations whose p-score is higher than the maximum or less than the minimum p-score of the controls.

[INSERT TABLE 12 AROUND HERE]

When examining column 1 of Table 12 with respect to column 4 of Table 4, our results show that the magnitude of the treatment effect increases in size and is once more significant. Moreover, also in terms of the exposure to the new regulation, the negative effect on firm value for the non-leakage subsample increases in size with respect to column 2 in Table 7. Finally, also the effect of evasive FDI behavior increases with respect to column 4 in Table 8 and even becomes significant at the 1% level.

6.6.5 Cumulative shortage both in 2012 as well as in 2019

As the EU ETS became more stringent in its third phase, we hypothesize that firms that were already struggling with their allowance position at the end of phase II would feel a negative impact on firm value in this new phase. Even though there is consistency regarding the allocation position (88,89% of the firms facing a cumulative deficit in 2012 still faced a cumulative shortage of allowances in 2019), we now change our treatment specification by, instead of categorizing firms with a cumulative deficit of allowances in 2012 as treated, only classifying firms as treated if they faced a cumulative shortage of emission allowances in 2012 and still did so in 2019. Our results in Table 13 show that the negative effect on firm value of the allowance deficit after the inception of phase III prevails. Interestingly, column 4 shows that the positive effect of FDI targeting environmentally lax countries outside the EU ETS jurisdiction disappears. This reflects that investing in pollution havens does not salvage firm value if the strategy is unable to remedy the underallocation position of the EU ETS-covered firm.

[INSERT TABLE 13 AROUND HERE]

6.6.6 Carbon risk

As noted in the literature review, the link between environmental performance and financial performance can come from three main channels: reputation enhancement, decreased carbon risk and cost savings. As carbon prices were low, the cost channel is unlikely to have played a major part in this loss of firm value in phase III. Moreover, when examining the firms that are outperforming their peers in terms of environmental performance in Table 9, we do not observe a positive effect on firm value for this subsample, questioning the reputation channel. Therefore, it appears that investors discount firm value due to carbon risk. As such, we investigate two risk measures commonly used in the academic literature. On the one hand, we examine the earnings volatility of the firm (σ_{ROA}), using a five-year rolling window to calculate the annual standard deviation of the EBIT scaled by total assets (Nguyen & Phan, 2020). On the other hand, we examine the firm's idiosyncratic risk ($\sigma_{IDIOSYNC}$). As such, we regress the daily individual stock returns on the market returns to obtain the annualized standard deviation of the residuals (Dhaliwal, Judd, Serfling, & Shaikh, 2016). If investors would take into account the carbon risk from allowance shortages —and as a result discount firm value after the inception of phase III—, we would predominantly expect an impact on the idiosyncratic risk of the environmentally inefficient firms and a limited impact on their earnings volatility, given the low prevailing carbon prices.

[INSERT TABLE 14 AROUND HERE]

Table 14 examines both earnings volatility as well as the market-based idiosyncratic volatility. Consistent with our expectations, due to the limited magnitude of the carbon prices, a shortage of emission allowances does not have a significant effect on earnings volatility in phase III of the Scheme. However, when examining columns 3 and 4, we note that there is a significantly positive treatment effect on the firm's idiosyncratic volatility. This is consistent with an increase in firm-specific risk after the inception of phase III of the EU ETS for firms lacking sufficient carbon allowances. These results are not surprising as recent literature indicates that even within the US, where such an elaborate environmental framework is not available, a carbon risk premium exists (Bolton & Kacperczyk, 2020)

7. Conclusion and discussion

This paper examines the impact of inadequate environmental performance on firm value after the inception of the third phase of the EU ETS. Our results show that firms faced with a deficit of emission allowances at the end of phase II were negatively influenced in terms of their market value after the introduction of the renewed allocation rules in phase III. This is in line with other research emphasizing the importance of a firm's allowance position (Venmans, 2016). Moreover, in line with issue materiality (Busch & Hoffmann, 2011), this effect was exacerbated when firms had financial constraints and environmental characteristics increasing the exposure to the renewed regulation. Finally, prior research often examined FDI from carbon emitting multinationals using the perspective of the pollution haven effect. This phenomenon encompasses that the FDI of polluting MNEs is aimed at environmentally lax countries to avoid the abatement costs required in the more stringent countries where they are already operating. Our findings show that investing in environmentally lax countries outside the Scheme indeed does mitigate the negative treatment effect. When relating our results to the three main channels in which better EP can be translated into higher firm value, increased carbon risk appears to drive our results. Finally, similar to Antoniou, Delis, Ongena, & Tsoumas (2020), our results highlight the importance of reducing the excess emission allowances within the Scheme to ensure its impact. As such, the Market Stability Reserve introduced in 2019 and the related Cancellation Mechanism coming into effect in 2023 are promising avenues to attain further climate goals and possibly trigger a virtuous cycle of environmental investments.

While our research provides suggestive evidence in favor of carbon leakage in the third phase of the EU ETS, a possible extension of our work is to examine actual emission shifts outside the EU ETS jurisdiction. Following our results, we would expect the FDI investments in environmentally lax countries to be accompanied by a shift in emissions towards them. As these international investment projects are also accompanied by the creation of employment, the resulting loss of economic activity for the EU could, moreover, be analyzed. Furthermore, our findings tend to indicate that outperforming one's industry-peers does not lead to a competitive advantage, which, in turn, is translated into higher firm value. However, advocates of carbon taxes agree that a sufficiently and persistently large carbon price is a requirement to provide long-term investment incentives (Brink, Vollebergh, & van der Werf, 2016). Therefore, a final important extension of our work is to examine whether the recent surge in carbon prices in the EU ETS shifted the perception of environmental performance from being a constraint to be satisfied to being a manner in which a valuable competitive advantage can be achieved.

To conclude, our research shows that, even though carbon prices were rather low, the renewed allocation rules in the third phase of the EU ETS entailed a negative effect on firm value for firms struggling in terms of their emission allowance position due to carbon risk, especially when they were financially constrained or highly exposed to the renewed regulation. Moreover, multinationals that are more carbon inefficient in their installations operating under the EU ETS tend to benefit from expanding their activities towards environmentally lax destinations that are not covered under the Scheme, providing suggestive evidence of carbon leakage.

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Table 1. Descriptive statistics

This table provides the descriptive statistics for the control variables included in the empirical models. SIZE is the natural logarithm of total assets. CAPINT are capital expenditures divided by total assets. LEVERAGE reflects the debt position of the company. GROWTH is the annual percentage change in sales. Q is Tobin's Q at the firm level. Variables are defined in detail in the appendix, Table A.1.

	Mean	St. Dev	Min	Q1	Median	Q3	Max	Skewness	Kurtosis	obs
SIZE	14.682	2.264	3.178	13.067	14.872	16.318	19.979	-.281	2.687	5,391
CAPINT	0.052	0.037	0.001	0.027	0.045	0.068	0.200	1.497	5.831	5,282
LEVERAGE	0.388	0.210	0.000	0.249	0.385	0.525	0.875	.157	2.683	5,330
GROWTH	0.055	0.188	-0.518	-0.026	0.041	0.120	0.873	1.015	7.956	5,017
Q	1.158	0.631	0.008	0.829	1.111	1.451	3.356	.786	4.400	5,234

Table 2. Comparison treatment vs control group

This table provides the mean values in the year prior to the introduction of phase III for both the treatment as well as the control group. Additionally, the mean differences and t-statistics are reported. *,** and *** represent significance at the 10%, 5% and 1% level, respectively.

	Treated	Control	Mean diff	T-stat
SIZE	15.525	14.705	0.820	2.299**
CAPINT	0.051	0.048	0.003	0.560
LEVERAGE	0.416	0.387	0.029	0.910
GROWTH	0.059	0.023	0.036	1.566
Q	1.021	1.066	-0.045	0.476

Table 3. Univariate analysis

The table presents the univariate analysis of firm value prior to and after the introduction of the third phase of the EU ETS. Excess encompasses the subsample of firms with a cumulative excess of emission allowances at the end of phase II. Shortage encompasses the subsample of firms without a cumulative excess of emission allowances at the end of phase II. The mean of Tobin's Q, the standard deviation and the respective t-statistics are reported in the table.

	Excess		Shortage		Excess-shortage	
	Mean	S.D.	Mean	S.D.	Mean diff	t-stat
Q						
Phase II	1.043	.017	1.071	.029	-.028	-0.701
Phase III	1.198	.017	1.113	.027	.085	2.211**
Mean diff (post-pre)	.155		.041		0.113	
t-stat	6.435***		1.045			

Table 4. Firm value

The table presents the estimates of the difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances at the end of phase II. Columns 1 and 2 examine the impact of a cumulative deficit of emission allowances at the end of phase II on firm value in phase III. Columns 3 and 4 examine the impact of a cumulative deficit of emission allowances at the end of phase II on firm value in phase III while also including various firm-specific control variables. Regression models in columns 2 and 4 also control for year- and firm fixed effects Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1) Q	(2) Q	(3) Q	(4) Q
SHORT*POST	-.1633	-.1299	-.1504	-.1145
	(.0471)***	(.0433)***	(.0487)***	(.0464)**
SHORT	.0776		.0178	
	(.0781)		(.0813)	
POST	-.1087		-.1123	
	(.0402)***		(.0430)**	
L.SIZE			.0530	-.2381
			(.0136)***	(.0358)***
L.CAPINT			-.1074	.5167
			(.6875)	(.3163)
L.LEVERAGE			.0030	.0006
			(.0013)**	(.0009)
L.GROWTH			.1689	.0871
			(.0628)***	(.0369)**
Firm-Fixed effects	NO	YES	NO	YES
Year-Fixed effects	NO	YES	NO	YES
Constant	1.3070	-.0939	.4066	3.7307
	(.0580)***	(.0328)***	(.2154)*	(.3591)***
R-squared	0.0027	0.8132	0.0550	0.8332
Observations	4,812	4,812	4,132	4,132

Table 5. Parallel trends assumption

The table presents the estimates of the dynamic difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances at the end of phase II. Columns 1 and 2 examine the pre-treatment parallel trend assumption. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1) Q	(2) Q
SHORT	-.0286	
	(.0781)	
SHORT*THIRDPHASE^{-3}	-.0183	-.0068
	(.0394)	(.0342)
SHORT*THIRDPHASE^{-2}	-.0218	-.0021
	(.0432)	(.0390)
SHORT*THIRDPHASE^{-1}	-.0714	-.0379
	(.0444)	(.0427)
SHORT*THIRDPHASE^{0}	-.1008	-.0690
	(.0410)**	(.0385)*
SHORT*THIRDPHASE^{+1}	-.0937	-.0578
	(.0433)**	(.0383)
THIRDPHASE^{-3}	-.0839	
	(.0241)***	
THIRDPHASE^{-2}	-.1891	
	(.0229)***	
THIRDPHASE^{-1}	-.1466	
	(.0184)***	
THIRDPHASE^{0}	-.0537	
	(.0180)***	
THIRDPHASE^{+1}	-.0243	
	(.0186)	
Firm controls	YES	YES
Firm-Fixed effects	NO	YES
Year-Fixed effects	NO	YES
Constant	.3232	3.6111
	(.2095)	(.3779)***
R-squared	0.0631	0.8322
Observations	4,132	4,132

Table 6. Regulatory exposure

The table presents the estimates of the difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances at the end of phase II. Columns 1 and 2 examine the exposure to the renewed regulation by splitting the sample based on the carbon leakage classification of the European Commission at the 4-digit NACE level. Columns 3 and 4 examine the exposure to the renewed regulation by splitting the sample based on whether the firms faced a reduction in emission allowances from 2013 to 2013 or not. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1)	(2)	(3)	(4)
			no allowance	allowance
	leakage	non-leakage	reduction	reduction
	Q	Q	Q	Q
SHORT*POST	-.0197	-.1447	-.0340	-.1297
	(.1160)	(.0533)***	(.1344)	(.0476)***
L.SIZE	-.3257	-.2156	-.2442	-.2365
	(.0840)***	(.0413)***	(.0949)**	(.0376)***
L.CAPINT	.6455	.6017	1.1713	.3955
	(.5497)	(.3952)	(.7754)	(.3388)
L.LEVERAGE	.0011	.0004	-.0002	.0008
	(.0016)	(.0011)	(.0026)	(.0009)
L.GROWTH	.2194	.0262	.2080	.0630
	(.0751)***	(.0450)	(.0726)***	(.0412)
Firm-Fixed effects	YES	YES	YES	YES
Year-Fixed effects	YES	YES	YES	YES
Constant	7.4463	3.4279	2.5437	3.5323
	(1.5816)***	(.4209)***	(1.0216)**	(.4711)***
R-squared	0.7865	0.8520	0.7519	0.8466
Observations	1,204	2,782	682	3,450

Table 7. Financial constraints

The table presents the estimates of the difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances at the end of phase II. Columns 1 and 2 examine a subsample of financially constrained firms based on the median size-age index. Columns 3 and 4 examine a subsample of financially unconstrained firms based on the median size-age index. Columns 5 and 6 examine financial constraints based on the median net operating cashflow. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1) FC Q	(2) FC Q	(3) UC Q	(4) UC Q	(5) Q	(6) Q
SHORT*POST	-.1182	-.1410	-.1050	-.1223	-.0830	-.0910
	(.0539)**	(.0574)**	(.0766)	(.0787)	(.0470)*	(.0472)*
SHORT*POST*L.LOWCF					-.0753	-.0381
					(.0155)***	(.0155)**
POST*L.LOWCF					-.0873	-.1028
					(.0250)***	(.0237)***
L.SIZE		-.2996		-.1219		-.2388
		(.0561)***		(.0502)**		(.0360)***
L.CAPINT		.1786		.9053		.3922
		(.3862)		(.4325)**		(.3113)
L.LEVERAGE		.0849		.0291		.1125
		(.1260)		(.1384)		(.0899)
L.GROWTH		.0750		.1069		.0869
		(.0484)		(.0588)*		(.0365)**
Firm-Fixed effects	YES	YES	YES	YES	YES	YES
Year-Fixed effects	YES	YES	YES	YES	YES	YES
Constant	1.2837	5.2164	1.4606	2.8725	-.0874	3.6145
	(.0621)***	(.7714)***	(.0000)	(.8110)***	(.0395)**	(.4503)***
R-squared	0.8053	0.8313	0.8265	0.8424	0.8241	0.8361
Observations	2,445	2,147	2,199	1,775	4,421	4,101

Table 8. FDI

The table presents the estimates of the difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances at the end of phase II. Columns 1 and 2 examine the impact of foreign direct investments to countries outside the EU ETS. Columns 3 and 4 examine the impact of foreign direct investments to environmentally lax countries outside the EU ETS. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1) Q	(2) Q	(3) Q	(4) Q
SHORT*POST	-.1305	-.1217	-.1373	-.1228
	(.0448)***	(.0468)**	(.0443)***	(.0465)***
SHORT*POST*L.FDI	.0049	.0162		
	(.0204)	(.0208)		
L.FDI*POST	.0234	.0509		
	(.0266)	(.0259)*		
SHORT*POST*L.LAXFDI			.0501	.0505
			(.0233)**	(.0230)**
L.LAXFDI*POST			-.0438	-.0185
			(.0332)	(.0300)
L.SIZE		-.2435		-.2358
		(.0362)***		(.0356)***
L.CAPINT		.4947		.5181
		(.3153)		(.3172)
L.LEVERAGE		.0007		.0006
		(.0009)		(.0009)
L.GROWTH		.0864		.0867
		(.0369)**		(.0367)**
Firm-Fixed effects	YES	YES	YES	YES
Year-Fixed effects	YES	YES	YES	YES
Constant	.3811	3.7963	.4023	3.7140
	(.0354)***	(.3628)***	(.0331)***	(.3573)***
R-squared	0.8188	0.8336	0.8193	0.8335
Observations	4,566	4,132	4,566	4,132

Table 9. Alternative stringency measure

The table presents the estimates of the difference-in-differences models. The treatment group in columns 1, 3 and 5 comprises firms that have an industry-corrected emission intensity in the upper-quartile in 2012. The treatment group in columns 2, 4 and 6 comprises firms that have an industry-corrected emission intensity in the lower-quartile in 2012. Columns 1 and 2 examine the baseline regression specification. Columns 3, 4, 5 and 6 examine the exposure to the renewed regulation by splitting the sample based on the carbon leakage classification of the European Commission at the 4-digit NACE level. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1)	(2)	(3)	(4)	(5)	(6)
			leakage	leakage	non-leakage	non-leakage
	Q	Q	Q	Q	Q	Q
UPPERINDCOR*POST	-.0921		.0449		-.1754	
	(.0421)**		(.0774)		(.0482)***	
LOWERINDCOR*POST		-.0558		-.0477		-.0627
		(.0424)		(.0757)		(.0527)
L.SIZE	-.2222	-.2105	-.2942	-.2960	-.1968	-.1828
	(.0357)***	(.0352)***	(.0813)***	(.0800)***	(.0409)***	(.0405)***
L.CAPINT	.4464	.4497	.4428	.4608	.5760	.5305
	(.2934)	(.2970)	(.5320)	(.5319)	(.3543)	(.3653)
L.LEVERAGE	.0003	.0237	.1259	.1193	-.0072	-.0101
	(.0009)	(.0882)	(.1612)	(.1638)	(.0977)	(.0993)
L.GROWTH	.1073	.1095	.2243	.2274	.0420	.0480
	(.0354)***	(.0350)***	(.0726)***	(.0735)***	(.0424)	(.0416)
Firm-Fixed effects	YES	YES	YES	YES	YES	YES
Year-Fixed effects	YES	YES	YES	YES	YES	YES
Constant	3.3456	3.1897	6.8848	6.9563	4.3888	4.2628
	(.4506)***	(.4424)***	(1.5879)***	(1.5583)***	(.3693)***	(.3655)***
R-squared	0.8354	0.8348	0.7923	0.7923	0.8526	0.8505
Observations	4,295	4,295	1,217	1,217	2,951	2,951

Table 10. Sample between 2008-2017

The table presents the estimates of the difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances at the end of phase II. Column 1 examines the baseline regression specification. Columns 2 and 3 examine the exposure to the renewed regulation by splitting the sample based on the carbon leakage classification of the European Commission at the 4-digit NACE level. Column 4 examines the effect of evasive investment behavior outside the Scheme. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1)	(2) leakage	(3) non-leakage	(4)
	Q	Q	Q	Q
SHORT*POST	-.0811	.0239	-.0983	-.0896
	(.0344)**	(.0827)	(.0405)**	(.0343)***
SHORT*POST*L.LAXFDI				.0519
				(.0297)*
L.LAXFDI*POST				-.0239
				(.0230)
L.SIZE	-.1897	-.3135	-.1254	-.1857
	(.0554)***	(.0857)***	(.0727)*	(.0549)***
L.CAPINT	.2235	.3729	.2766	.2304
	(.3082)	(.5113)	(.4174)	(.3075)
L.LEVERAGE	.0009	.1243	-.0545	-.0006
	(.1041)	(.1958)	(.1076)	(.1047)
L.GROWTH	.0891	.2252	.0218	.0897
	(.0435)**	(.0823)***	(.0547)	(.0435)**
Firm-Fixed effects	YES	YES	YES	YES
Year-Fixed effects	YES	YES	YES	YES
Constant	5.2389	6.9920	3.3188	5.2109
	(.5200)***	(1.6525)***	(1.0528)***	(.5167)***
R-squared	0.8809	0.8164	0.9035	0.8813
Observations	2,536	739	1,706	2,536

Table 11. Previous financial performance

The table presents the estimates of the difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances at the end of phase II. Column 1 examines the baseline regression specification. Columns 2 and 3 examine the exposure to the renewed regulation by splitting the sample based on the carbon leakage classification of the European Commission at the 4-digit NACE level. Column 4 examines the effect of evasive investment behavior outside the Scheme. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1) Q	(2) leakage Q	(3) non-leakage Q	(4) Q
SHORT*POST	-.1208	-.0325	-.1450	-.1294
	(.0414)***	(.1128)	(.0460)***	(.0415)***
SHORT*POST*L.LAXFDI				.0493
				(.0221)**
L.LAXFDI*POST				-.0223
				(.0295)
L.ROE	.2290	.1061	.2792	.2267
	(.0541)***	(.1327)	(.0561)***	(.0540)***
L.SIZE	-.2314	-.3363	-.1914	-.2292
	(.0362)***	(.0885)***	(.0399)***	(.0359)***
L.CAPINT	.4476	.3705	.7101	.4480
	(.2789)	(.4495)	(.3526)**	(.2795)
L.LEVERAGE	.0650	.0318	.0653	.0612
	(.0898)	(.1623)	(.0993)	(.0902)
L.GROWTH	.0523	.2130	-.0202	.0523
	(.0380)	(.0763)***	(.0440)	(.0378)
Firm-Fixed effects	YES	YES	YES	YES
Year-Fixed effects	YES	YES	YES	YES
Constant	3.7582	7.6640	3.3954	3.7460
	(.3867)***	(1.6531)***	(.4037)***	(.3846)***
R-squared	0.8447	0.8119	0.8596	0.8451
Observations	4,068	1,185	2,741	4,068

Table 12. Propensity score matching

The table presents the estimates of the difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances at the end of phase II. Column 1 examines the baseline regression specification. Columns 2 and 3 examine the exposure to the renewed regulation by splitting the sample based on the carbon leakage classification of the European Commission at the 4-digit NACE level. Column 4 examines the effect of evasive investment behavior outside the Scheme. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1)	(2) leakage	(3) non-leakage	(4)
	Q	Q	Q	Q
SHORT*POST	-.1253	.0050	-.1630	-.1459
	(.0603)**	(.1527)	(.0667)**	(.0615)**
SHORT*POST*L.LAXFDI				.0997
				(.0331)***
L.LAXFDI*POST				-.0298
				(.0360)
L.SIZE	-.1684	-.2248	-.1758	-.1703
	(.0587)***	(.1812)	(.0596)***	(.0585)***
L.CAPINT	-.5838	-.3912	-.8280	-.5422
	(.5662)	(.9133)	(.7576)	(.5712)
L.LEVERAGE	.0016	.4408	.0760	.1543
	(.0018)	(.3429)	(.2072)	(.1811)
L.GROWTH	.0813	.1085	.0402	.0842
	(.0607)	(.1402)	(.0740)	(.0609)
Firm-Fixed effects	YES	YES	YES	YES
Year-Fixed effects	YES	YES	YES	YES
Constant	3.7754	5.6622	3.8755	3.8074
	(.5408)***	(3.2440)*	(.5697)***	(.5388)***
R-squared	0.8164	0.7842	0.8258	0.8182
Observations	1,347	310	965	1,347

Table 13. Cumulative shortage in 2012 and 2019

The table presents the estimates of the difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances both in at the end of phase II as well as at the end of phase III. Column 1 examines the baseline regression specification. Columns 2 and 3 examine the exposure to the renewed regulation by splitting the sample based on the carbon leakage classification of the European Commission at the 4-digit NACE level. Column 4 examines the effect of evasive investment behavior outside the Scheme. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1) Q	(2) leakage Q	(3) non-leakage Q	(4) Q
SHORT2019*POST	-.1137	-.0197	-.1448	-.1168
	(.0499)**	(.1160)	(.0581)**	(.0513)**
SHORT2019*POST*L.LAXFDI				.0239
				(.0689)
L.LAXFDI*POST				-.0261
				(.0333)
L.SIZE	-.2371	-.3257	-.2133	-.2359
	(.0360)***	(.0840)***	(.0415)***	(.0358)***
L.CAPINT	.5217	.6455	.6126	.5200
	(.3161)	(.5497)	(.3958)	(.3166)
L.LEVERAGE	.0590	.1113	.0367	.0585
	(.0912)	(.1616)	(.1055)	(.0915)
L.GROWTH	.0865	.2194	.0248	.0867
	(.0368)**	(.0751)***	(.0449)	(.0368)**
Firm-Fixed effects	YES	YES	YES	YES
Year-Fixed effects	YES	YES	YES	YES
Constant	3.6087	7.4266	3.4056	3.5962
	(.3649)***	(1.5992)***	(.4230)***	(.3641)***
R-squared	0.8331	0.7865	0.8519	0.8331
Observations	4,132	1,204	2,782	4,132

Table 14. Carbon risk

The table presents the estimates of the difference-in-differences models with the treatment group comprising firms that face a cumulative deficit of emission allowances at the end of phase II. Columns 1 and 2 examine the impact of a cumulative deficit of emission allowances at the end of phase II on earnings volatility. Columns 3 and 4 examine the impact of a cumulative deficit of emission allowances at the end of phase II on idiosyncratic volatility. Standard errors are robust to heteroskedasticity and are clustered at the firm-level. These are reported between parentheses. *,** and *** represent significance at the 10%, 5% and 1% level, respectively. Variables are defined in the appendix, Table A.1.

	(1)	(2)	(3)	(4)
	σ_{ROA}	σ_{ROA}	$\sigma_{IDIOSYNC}$	$\sigma_{IDIOSYNC}$
SHORT*POST	.0071	.0051	.0030	.0026
	(.0068)	(.0074)	(.0012)**	(.0013)**
SHORT	-.0113		-.0034	
	(.0060)*		(.0009)***	
POST	-.0018		-.0022	
	(.0062)		(.0011)**	
Firm-Fixed effects	NO	YES	NO	YES
Year-Fixed effects	NO	YES	NO	YES
Constant	.0412	.0045	.0194	.0501
	(.0067)***	(.0037)	(.0013)***	(.0008)***
R-squared	0.0110	0.5819	0.0383	0.5060
Observations	3,320	3,320	4,654	4,654

Figure 1. Emission-to-cap ratio

The left panel of this figure reports the median emission-to-cap ratio of the EU ETS-covered multinationals in our sample. The ETC is defined as (freely allocated allowances-verified emissions)/ freely allocated allowances. The right panel reports the total amount of freely allocated emission allowances (red) and verified emissions (orange) across all EU ETS installations (source: https://www.eea.europa.eu/data-and-maps/dashboards/emissions-trading-viewer-1).

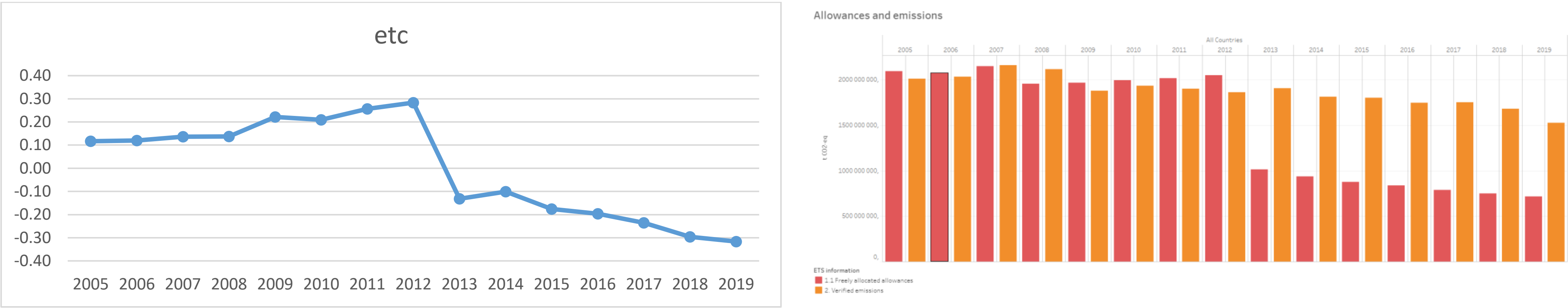
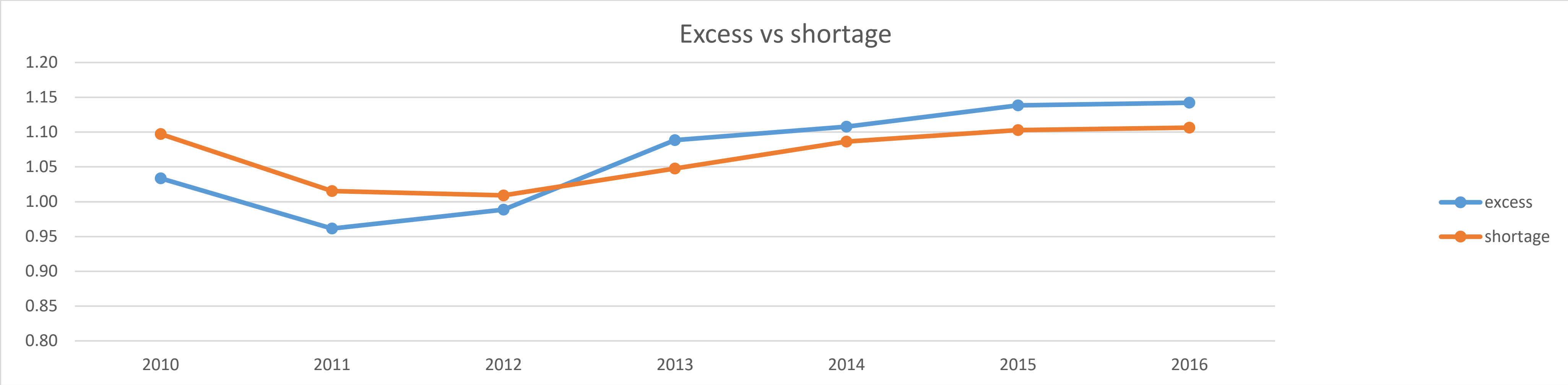


Figure 2. EUA futures price

This figure reports EUA futures price from the ICE ECX platform over time.

Figure 3. Tobin's Q

This figure reports the median value of Tobin's Q over time, distinguished between firms having a cumulative excess of emission allowances at the end of the second phase on the one hand and firms having a cumulative shortage of emission allowances at the end of the second phase on the other hand.



9. Appendix

Table A.1. Variable definitions

This table contains the definitions and data sources of the main variables used in this paper.

Variable	Definition	Source
Q	(market value of equity + book value of debt) / (book value of equity + book value of debt).	Worldscope
SHORT	Dummy equal to 1 if the firm has a cumulative shortage of emission allowances in the second phase of the EU ETS.	European Union Transaction Log
POST	Dummy equal to 1 after the introduction of the third phase of the EU ETS.	/
UPPERINDCOR	Dummy equal to 1 if the firm has an industry-corrected emission intensity in the upper-quartile in 2012.	European Union Transaction Log
LOWERINDCOR	Dummy equal to 1 if the firm has an industry-corrected emission intensity in the lower-quartile in 2012.	European Union Transaction Log
SHORT2019	Dummy equal to 1 if the firm has a cumulative deficit of emission allowances both in 2012 as well as in 2019.	European Union Transaction Log
LOWCF	Dummy equal to 1 if the firm has a net operating cashflow below the sample median.	Worldscope
FDI	Dummy equal to 1 if the firm has set up at least 1 FDI project outside the EU ETS in that particular year.	fDi markets
LAXFDI	Dummy equal to 1 if the firm has set up at least 1 FDI project outside the EU ETS in that particular year in a country that is more environmentally lenient than the most environmentally lax EU ETS country.	fDi markets
$THIRDPHASE^{-t}$	Indicator variable that indicates t years before the inception of the third phase.	/
SIZE	Logarithm of total assets.	Worldscope
CAPINT	Capital expenditures scaled by total assets.	Worldscope
LEVERAGE	(Long Term Debt + Short Term Debt & Current Portion of Long Term Debt) / (Total Capital + Short Term Debt & Current Portion of Long Term Debt) * 100.	Worldscope
GROWTH	Annual percentage change in sales.	Worldscope
LEAKAGE	Dummy equal to 1 if the firm is exposed to carbon leakage. The current classification of European Commission at the 4-digit NACE level is used.	Worldscope & European Commission
ALLOWANCE REDUCTION	Dummy equal to 1 if the firm experienced a decrease in emission allowances between 2012 and 2013	European Union Transaction Log
σ_{ROA}	Earnings volatility of the firm, using a five-year rolling window to calculate the annual standard deviation of the EBIT scaled by total assets	Worldscope
$\sigma_{IDIOSYNC}$	The annualized standard deviation of the residuals from the regression of the daily individual stock returns on market returns	Worldscope

Table A.2. Environmentally lax countries that received FDI

This table contains the list of environmentally lax countries that received FDI in our sample.

Algeria	Bolivia	Cote d'Ivoire	Iran	Mauritania	Nigeria	Uganda
Angola	Bosnia-Herzegovina	Egypt	Kuwait	Mongolia	Pakistan	Ukraine
Argentina	Burundi	El Salvador	Kyrgyzstan	Mozambique	Paraguay	Venezuela
Bangladesh	Cambodia	Georgia	Lebanon	Myanmar	Serbia	Vietnam
Benin	Cameroon	Guinea	Malawi	Nepal	Thailand	