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Carbon Intensity and Corporate Performance: A Micro-Level Study of EU ETS Industrial Firms

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Carbon intensity and corporate performance: A micro-level study of EU ETS industrial firms

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Abstract

To reach its 2050 objective of carbon neutrality, the European Union (EU) must continue to step up its climate efforts, while ensuring the competitiveness of its industries is not harmed. The EU Emission Trading Scheme (ETS) is at the core of the bloc's industrial decarbonization efforts. This paper explores this topic by digging into whether there is a causal relationship between industrial firms' emission intensity and their economic and financial performance. We construct a dataset covering around 1,200 industrial firms covered by the EU ETS' third phase and estimate a novel indicator of volume-based emission intensities for these firms. Applying an IV approach to a within-firm panel model, we find that firms' emission intensity is negatively related to their corporate performance, and that this does not depend on the competitive environment they operate in.

Keywords: EU ETS, heavy industry, emission intensity, corporate performance.

JEL Codes: D22, H23, L51, Q58

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1 Introduction

To reach carbon neutrality by 2050, the European Union (EU) must undertake a systemic transformation across its economy. One of the key sectors in this transformation is industry, which generates nearly 750 megatonnes of yearly greenhouse gas (GHG) emissions, or 22% of the bloc's total emissions (European Environmental Agency, 2022). Current policies aimed at industrial decarbonization are progressing rapidly, but are still projected to miss the mark on the EU's 2030 and 2050 climate targets (Climate Action Tracker, 2024; European Commission, 2023; European Environmental Agency., 2023). One significant blocking factor in intensifying efforts is concerns about the risk of carbon leakage (Intergovernmental Panel on Climate Change, 2023), a mechanism through which domestic producers lose out to unregulated foreign competition and decide to relocate - and therefore pollute - elsewhere (Markusen et al., 1993).

The EU's Emission Trading System (ETS) is the bloc's central tool for industrial decarbonization. Launched in 2005 (European Parliament and Council, 2003), this system creates a financial incentive for firms to decarbonize, both through short-term abatements and long-term innovation and investments. Policymakers have reformed the EU ETS throughout its different phases, gradually expanding its scope and increasing its stringency.[1] Today, it covers around 2,000 industrial firms and 4,000 energy firms and has one of the world's highest carbon prices, fluctuating between 60 and 100 euros per tCO_2e in the past years (International Carbon Action Partnership, 2023).

As the EU ETS' stringency has increased, the question of its impact on the competitiveness of EU producers has been raised.[2] To mitigate the risk of carbon leakage, "anti-leakage" measures were adopted hand-in-hand with the EU ETS' implementation, including the free allocation of allowances (European Parliament and Council, 2013), indirect cost compensations (European Commission, 2012), and more recently, a Carbon Border Adjustment Mechanism (European Parliament and Council, 2023). The joint development of these policies requires finding a difficult balance between creating a real incentive for firms to decarbonize while avoiding carbon leakage.

Existing literature has found that the EU ETS induced emission reductions in the firms it covers, (Colmer et al., 2023; Dechezleprêtre et al., 2023) and had either an insignificant or a positive effect on their economic performance (Colmer et al., 2023; Dechezleprêtre et al., 2022, 2023; Joltreau & Sommerfeld, 2019; Trinks & Hille, 2023; Verde, 2020). The system also appears not to have impacted firms' ability to pass through their costs (Cludius et al., 2020). Some evidence points to the fact that it induced some green innovation, highlighting a potential long-term effect on production processes (Borghesi et al., 2015; Calel, 2020; European Investment Bank, 2024; Teixidó et al., 2019). Most of this evidence focuses on the first two phases of the EU ETS, which were less stringent than later phases. Additionally, these papers do not explicitly study the relationship between firms' decarbonization dynamics and their competitiveness, but instead look at the overall

[1] This is discussed in section 2.1

[2] See the European Commission's web page on carbon leakage: "European Commission - Carbon Leakage"

effects of the EU ETS.

Thus, our research question is to determine whether firm-level decarbonization led to economic and financial improvements in industrial firms operating in an increasingly stringent EU ETS. This research question is related to a more general literature on the impacts of environmental choices on firms' economic and financial performance, as reviewed by Busch and Lewandowski (2018) and Dechezleprêtre and Kruse (2018). This strand of literature tends to find a negative relationship between firms' environmental and economic or financial performance, with some heterogeneity depending on firm and sector characteristics. This result is closely related to the strong Porter hypothesis (Porter, 1991; Porter & van der Linde, 1995), which states that well-designed climate policies induce firms to reduce their GHG emissions, but also to improve their economic performance through broad improvements in productivity and a reduction of energy and material costs.

The main contribution of this paper is to provide an ex-post study of the short-term relationship between climate and corporate performance in the context of the EU ETS' third phase. We do not directly isolate the policy effect of the EU ETS - given that the majority of large industrial installations are regulated after the first two phases, a differences-in-differences design is not possible. Instead, we apply a fixed-effects panel model using a within-firm estimator. Our explained variables are a range of indicators on economic and financial performance, including return on assets, profit margins, EBITDA[3] margins, the ratio of turnover over costs, and labor productivity. To avoid issues of endogeneity, we employ an Instrumental Variable (IV) strategy following the approach proposed by Fontagné et al. (2023), namely using a Bartik sectoral shift-share instrument.

A second contribution concerns the data that is used. We have extended and improved the matching of two firm-level databases, namely the EU Transaction Log (EUTL) and Bureau van Dijk's ORBIS database using Natural Language Processing methods, as explained in Cameron and Ho (forthcoming). This dataset provides climate and financial data for industrial firms, which tend to be large entities rather than small and medium-sized enterprises, for the entirety of the EU ETS' third phase, spanning all EU countries.

As a third contribution, this work introduces a new, volume-based measure of emission intensity, measured as the ratio between a firm's emissions and the volume of its industrial production. This moves away from the traditionally used value-based measure of emission intensity, which can take into account activities other than industrial production, such as services or marketing. To retrieve information of production volume, we exploit data from the EUTL on the volume of free allowances that installations receive and information on benchmarks and other relevant parameters reported in EU legislation. We address potential measurement errors due to lack of data availability at the sub-installation level by using a Monte Carlo process based on benchmark distribution parameters to generate corrected production values.

Finally, this paper also contributes to the literature by explicitly studying the role of the interna-

[3] Earnings Before Interest, Taxes, Depreciation, and Amortization

tional competition setting that EU ETS firms operate in. Indeed, a significant factor that affects how firms respond to carbon pricing is the exposure of their final goods to international trade and competition (Fischer & Fox, 2018). Hence, we formulate an empirical specification that explicitly controls for this crucial aspect. To do this, we compute two metrics at the product level to gage firms' exposure to international competition: the first assesses import competition intensity, while the second measures intra-branch trade, as defined by Gruebel and Lloyd (1975), and provides insights into the level of differentiation within the production of a good.

Overall, our findings align with existing literature, indicating that changes in firms' emission intensity are either not affecting their economic and financial performance, or they are slightly affecting it, meaning that reductions in emission intensity drive increases in corporate performance. This effect is stronger when controlling for the competitive environment that firms operate in. This result implies, first and foremost, that firms within the EU ETS have not been adversely affected by this decision; if anything, they have even slightly improved their corporate performance. This is an encouraging signal, and it will be interesting to observe if this trend continues amid the EU's latest regulatory, changes which are not covered in this study, including the last phase of the EU ETS and the implementation of a Carbon Border Adjustment Mechanism in its initial transitory phase.

While integrating costs and carbon reduction into the production process could potentially boost energy or intermediate input efficiency, heavy industry sectors require substantial investments to develop entirely new production processes for full or significant decarbonization. Therefore, these gains depend on how well these regulated sectors can adapt and innovate, particularly as the EU's climate policies become more stringent. Further research should be conducted to understand the underlying mechanisms of this relationship, particularly regarding the role of innovation in green or general technology.

The remainder of this paper is structured as follows. Section 2 discusses the policy context of the EU ETS and the empirical literature related to its impact on EU industries' climate and economic outcomes. Section 3 details our empirical specifications and expectations about the relationship between firms' economic outcomes and their emission performance. Section 4 describes our data, its construction, strengths and limitations, and the construction of our variables. Section 5 presents and discusses our results. Section 6 presents the limitations of our study and avenues for future research, and section 7 concludes and draws policy implications.

2 Context and related literature

2.1 Policy context: the EU Emissions Trading Scheme

The EU ETS was introduced in 2005 as a central pillar of the EU's climate strategy to comply with its commitment to the Kyoto Protocol. The system sets a yearly absolute cap on GHG emissions, which determines the number of allowances on the market. Allowances are then freely allocated or auctioned to participants, who can trade them throughout the regulatory period depending on their abatement decisions. At the end of this period, participants must surrender enough allowances to cover their emissions. They can decide to keep their permits for the future, allowing for inter-temporal arbitrage.

Since its implementation, the EU ETS has gone through four phases, each progressively tightening its regulation to align the system with the EU's climate targets. Phase 1 (2005-2007) was a 3-year pilot phase during which allowances were freely allocated based on a grandfathering approach and the overall cap was set based on the sum of national estimates provided by Member States.

Phase 2 (2008-2012) saw a 6.5% cap reduction compared to 2005, with around 10% of allowances auctioned - the rest remained freely allocated based on grandfathering. As shown in figure 1, most sectors received more free allowances than their ex-post verified emissions, and an oversupply was observed on the market by the end of Phase 2.[4] This is in part due to the 2008 financial crisis which cut down production, and in part due to the use of offsets from the UNFCCC's Clean Development Mechanism (Trotignon, 2011). These elements put a downward pressure on the price of carbon during the first two phases of the EU ETS (figure 2).

In phase 3 (2013-2020), the EU ETS was overhauled and strengthened. The cap was set for the EU as a whole, rather than as sum of nationally determined caps, and an annual linear factor of 1.74% was applied. Free allowances were allocated based on an emission intensity benchmark rather than grandfathering and the scheme was extended to additional sectors. To address allowance over-supply, regulators "back-loaded" 900 million allowances, meaning they postponed their auctioning from the beginning to the end of the phase. As a more long-term response, the Market Stability Reserve (MSR) was established in January 2019 (European Parliament and Council, 2015). The MSR absorbed the 900 million allowances that were initially back-loaded and absorbed or released allowances on the market based on pre-defined rules.[5] Another strong signal was sent to EU ETS participants through the European Green Deal (European Commission, 2019), an economic growth strategy set out in December 2019 whose primary objective is for the EU to reach carbon neutrality by 2050.

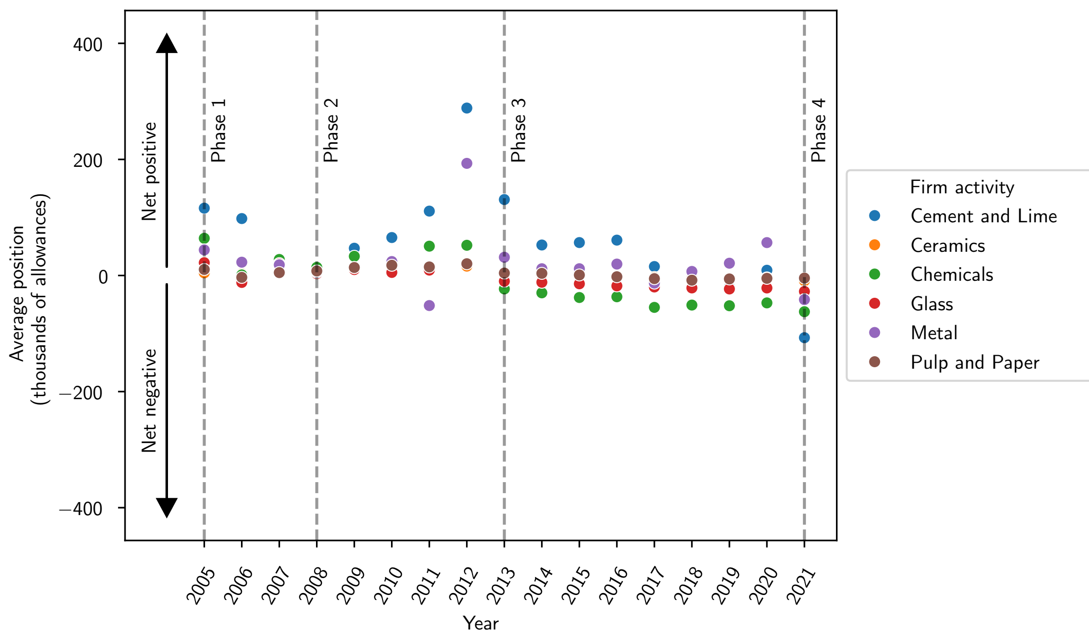
All of these policy developments make phase 3 of the EU ETS particularly interesting to study, as it represents the first truly constraining phase of the market for regulated firms. This is especially true starting in 2018 when a hike in prices can be observed.

In Phase 4 (2021-2030), the EU ETS saw further reforms with a faster emission cap reduction (4.3% until 2027, then 4.4%). Free allowances for sectors at risk of carbon leakage remain, but will be gradually phased out starting in 2026 when the EU's Carbon Border Adjustment Mechanism

[4]Ex-post estimates point to a surplus of 2 billion allowances at the start of phase 3 (Market Stability Reserve| europa.eu).

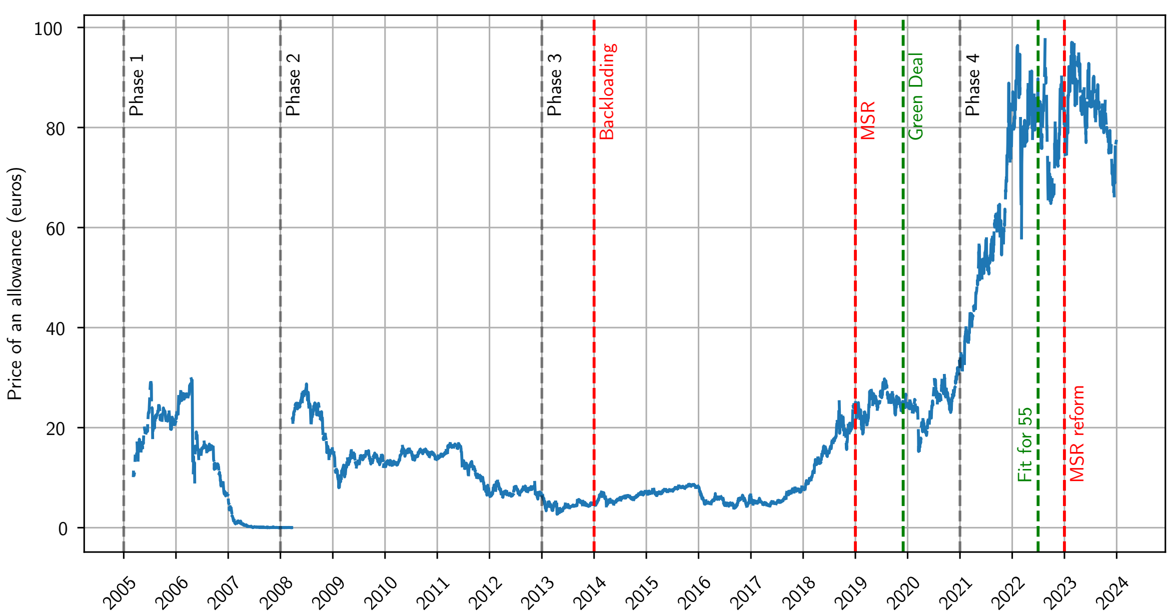
[5]Every year, the MSR required that 12 percent of the total number of allowances in circulation be added to its stock instead of being auctioned, unless this percentage represented 100 million allowances or less, in which case they would have been auctioned.

Figure 1: Average net position by sector in the EU ETS



Source: Authors based on the EUTL

Figure 2: Evolution of the price of carbon in the EU ETS



Source: Authors based on International Carbon Action Partnership

becomes fully operational. Amendments to the MSR invalidated excess allowances from previous years and increased the amount of allowances stored in the reserve.[6] In recent years, and especially since the beginning of the fourth phase in 2021, the carbon price has increased exponentially (figure 2). Our paper does not cover this phase partly due to data limitations, as well as changes in the allocation parameters resulting from recent changes in legislation. The latter prevents us from having comparable emission-based indicators across both phases 3 and 4.

2.2 Related literature: climate versus competitiveness?

As the EU ETS' different phases have unfolded, significant concerns have arisen regarding the potential impacts it may have on the competitiveness of EU industry, both on domestic and international markets (Sato et al., 2022). Two opposite hypotheses drive the debate on the impact of this system on firms' economic performance.

The first line of argument is that climate policies impose significant direct costs on regulated firms and therefore hinder their capacity to compete on international markets (Jaffe et al., 1995). Costs may also be indirect, resulting from input-output relationships between industries, such as when industrial sectors pays higher energy costs due to the power sector's full pass-through of EU ETS costs (Dagoumas & Polemis, 2020; Sijm et al., 2006).[7]

The opposing line of argument relates to the strong version of the Porter hypothesis (Porter, 1991; Porter & van der Linde, 1995), which states that environmental policies drive firms to reduce their environmental impacts, which also increases their overall productivity through process changes like increases in energy efficiency and material input use for instance. In line with this, one of the objectives of the EU ETS is to provide economic incentives for companies to innovate and use "more energy-efficient technologies" (European Parliament and Council, 2003). The strong Porter hypothesis implies that environmental policies, especially those that are market based, increase firms' profitability.

Current evidence converges towards the EU ETS having had either no effect or a small but positive effect on firms' economic performance. Verde (2020) and Joltreau and Sommerfeld (2019) review early literature on this topic and find that no significant effect is associated to firms being regulated by the EU ETS. They point to the over-allocation of allowances and the ability for firms to pass through their costs and generate windfall profits (Cludius et al., 2020) as explanations for these results. More recent evidence indicates that the EU ETS led to statistically significant increases in firm revenue and fixed assets (Dechezleprêtre et al., 2023). Additional evidence shows that carbon pricing tends to have an effect on investment decisions for manufacturing industries in Europe, although this effect is small and heterogeneous across countries (Borghesi et al., 2020;

[6] The percentage of allowances to be stored in the reserve was doubled to 24%, and the threshold for the auctioning of these allowances was also doubled to 200 million allowances.

[7] The extent to which these costs can be passed down to the consumers depends on a number of factors such as the price responsiveness of demand, competition dynamics – or lack thereof – and market geography (Clò, 2010; De Bruyn et al., 2010; Veith et al., 2009).

Koch & Mama, 2019), firms and sectors (D'Arcangelo & Galeotti, 2022; D'Arcangelo et al., 2023). Existing research supports the weak version of the Porter hypothesis, namely that the EU ETS has incentivized regulated firms to invest in green innovation (Borghesi et al., 2015; Calel, 2020; Teixidó et al., 2019).

Some literature has highlighted heterogeneity in the EU ETS' effects on firms' economic performance, particularly concerning firms' initial carbon intensity, productivity levels (Colmer et al., 2023), distance to a technology frontier (Koch & Themann, 2022), firm characteristics (D'Arcangelo et al., 2022). and investment behavior (European Investment Bank, 2024).

A vast majority of this literature focuses on the first two phases of the EU ETS. This is in part explained by a difficult access to up-to-date and reliable data, and in part due to the research design chosen in recent studies. Indeed, many papers like Dechezleprêtre et al. (2023) and Colmer et al. (2023) use a matched differences-in-differences design. This is a very robust methodology to estimate treatment effects, but it implies the presence of a close enough untreated control group in the sample. The sectoral scope of the EU ETS was extended in its third phases,[8] making this type of a design near impossible due to the absence of a suitable control group. Even when studying its first two phases, researchers employing differences-in-differences designs had to focus on specific countries and exclude the largest industrial firms from their sample.

Additionally, the papers discussed above do not explore the relationship between firms' decarbonization dynamics and their economic performance. They tend to report overall effects for all firms regulated under the EU ETS but do not focus on differential effects depending on whether firms reduce their emission intensity or not (Dechezleprêtre & Kruse, 2018). There is a broader literature which looks into this relationship, but which does not focus on the case of the EU ETS. Busch and Lewandowski (2018) review this literature through a meta-analysis, and find that carbon emissions tend to be negatively related to firms' financial performance. Another review by Dechezleprêtre and Kruse (2018) underlines that most studies on this topic find a positive relationship between environmental and economic performance at the firm level, but that this is not unanimous. Indeed, they note that these effects may be slightly heterogeneous depending on the environmental outcome that is chosen, the sector that is studied, and whether effects are short or long term.

More recently, Trinks et al. (2020) provide a wide-spanning study of the effect of carbon efficiency on financial performance on an international sample of firms. They find that carbon efficiency has a significantly positive relationship with firms' profitability. Some gray literature has also found evidence that firms can reduce up to 40% of their emissions in ways that are cost-cutting overall (McKinsey & Company, 2023). The European Investment Bank's annual report highlighted that most firms consider that the green transition will either be an opportunity for them or that it will not affect their business. Only a minority of firms in their sample consider it to be a risk to their

[8] In the third phase of the EU ETS, the following sectors were added to the scope of the regulation: production of primary and secondary aluminum, production of non-ferrous metals, production of mineral wool insulation material, drying or calcination of gypsum, production of chemicals, production of hydrogen, capture, transport and storage of GHG emissions.

business (European Investment Bank, 2024).

Based on this review of the literature, the Porter hypothesis seems to better explain the relationship between carbon pricing or firms' carbon performance and their economic performance, although this effect is heterogeneous depending on firms' sector and characteristics, as well as depending on the specific indicator which is studied. This paper complements existing literature by exploring the link between climate performance and corporate performance during the EU ETS' third phase.

3 Methodology

3.1 Empirical specification

To assess the short-term impact of carbon intensity on corporate performance, we adopt a within-firm identification strategy. Partly following Trinks et al. (2020), we employ the following empirical specification as our baseline model:

$$\log \text{CorpPerf}_{f,t} = \beta_0 + \beta_1 \log \text{EmissPerf}_{f,t-1} + \boldsymbol{z\mu_f} + \Lambda + \varepsilon_{f,t} \tag{1}$$

The outcome variable, CorpPerf, is the economic or financial performance of a firm f at time t. We use several different variables in turn to capture different aspects of firm profitability and viability. The variables which measure financial performance are return on assets, profit margins and EBITDA margins; those that measure economic performance are labor productivity and turnover over costs.[9] Our explanatory variable of interest, EmissPerf, is a firm's emission performance, measured as emission intensity in value or in volumes. Section 3.4 describes how we compute our novel indicator of emission intensity in volumes, and what advantages it has compared to the more standard value-based measure of emission intensity. To address the issue of multiple hypothesis testing - since we use several different outcome variables which may be related to each other - we report in all of our estimations the Holm-Bonferroni-corrected p-value of the coefficient for EmissPerf (Holm, 1979).

We control for the following vector of firm-specific variables $\boldsymbol{\mu}$:

- The number of new installations that a firm opened in a year to capture composition effects that may drive changes in emission intensity at the firm level;[10]
- A measure of firm-level stringency of the EU ETS, measured as the ratio between a firm's verified emissions and the amount of free allocations it receives for a given year as proposed by Borghesi et al. (2015).

[9] Table 2 in section 4.1 describes how each of these is defined.

[10] The number of installations that were closed is not included in the model because no firm in our sample closed an installation in the period that is studied.

- A firm's size, measured as turnover.
- A firm's current ratio, measured as its assets over its liabilities. This is to control for a firm's level of debt compared to its assets, as a proxy for its long-term financial health.
- The net value of transactions a firm makes on the EU ETS, measured as the difference between the total value of its purchased allowances and of its sold allowances in a year. This is to remove from our results any effects that would be driven purely by firms making profits from buying and selling allowances on the market. This indicator is formally computed as:

$$\begin{aligned}\text{Net transaction value}_t = &\sum_{i=1}^{52} \text{Mean weekly price} \times \text{Total allowances purchased in a week} \\ &- \sum_{i=1}^{52} \text{Mean weekly price} \times \text{Total allowances sold in a week}\end{aligned} \tag{2}$$

We check for multicollinearity issues that may arise from including these control variables together in appendix A. Correlations between these variables are below $|0.1|$ for most pairs of variables, with the exception of turnover and emission intensity, transaction values and emission intensity, and transaction values and turnover. For these three pairs, the correlation is still below $|0.5|$. Additionally, we run a simple IV regression without fixed effects and compute the variance inflation factor for each variable and find values close to 1 for all variables. This indicates multicollinearity is not an issue for these variables.

Finally, we also include a set of fixed effects Λ. In our OLS estimations, we include firm and sector-year fixed effects, while in our IV2SLS estimations we include firm and year fixed effects.

All of our variables are log-transformed to facilitate interpretation of our coefficients, to linearize the relationship between our outcome and explanatory variables, and to smooth the impact of outliers. We introduce a lag for our explanatory variables to address potential reverse causality bias, in line with the literature (Fontagné et al., 2023; Trinks et al., 2020). We also employ an instrumental variable strategy to address issues of endogeneity, as described in section 3.3.

In a second model, we explicitly control for the competition setting that firms operate in. This is done by including an interaction term between EmissPerf and the variable Comp, which captures this competition setting. Two alternative measures of Comp are used (import intensity and product specialization), as described in section 3.5. These are measured at the level of a product p and a country c. The following specification is employed:

$$\begin{aligned}\log \text{CorpPerf}_{f,t} =& \beta_0 + \beta_1 \log \text{EmissPerf}_{f,t-1} + \beta_2 \log \text{Comp}_{pc,t-1} \\ &+ \beta_3 \log \text{EmissPerf}_{f,t-1} \times \log \text{Comp}_{pc,t-1} \\ &+ \boldsymbol{z\mu_f} + \Lambda + \varepsilon_{f,t}\end{aligned} \tag{3}$$

3.2 Expectation of results

When investigating the relationship between firm-level emission intensity and economic or financial performance using a within-firm empirical specification, we are asking whether changes in the emission intensity of EU ETS-covered firms affects their economic and financial performance. Based on existing literature, two opposite effects can be expected.

The first effect derives from the fact that firms must incur abatement costs in order to reduce the emission intensity of their production. These abatement costs are defined in textbook environmental economics as the loss in profit induced by a reduction of emissions compared to baseline emissions (Tietenberg & Lewis, 2024). Incurring these abatement costs can reduce a firm's financial profitability, as well as its economic performance in the short run (Jaffe et al., 1995). We could therefore expect a positive relationship between emission intensity and economic and financial performance. In other words, if a firm abates its emissions and reduces its emission intensity, it must also suffer a drop in its financial results and economic viability.

The second effect points in the opposite direction, and stems from two different mechanisms (Busch & Lewandowski, 2018). The first of these effects is that reductions in emission intensity can lead to overall increases in productivity and profitability. This idea underpins the Porter hypothesis (Porter, 1991; Porter & van der Linde, 1995). One compelling example of this would be a firm which decides to invest in new production processes to improve its energy efficiency. These investments would reduce not just the emission intensity of its production, but also its total energy bill. If these "co-benefits" of decarbonization are strong enough, we would therefore expect a negative relationship between emission intensity and our outcome variables (Trinks & Hille, 2023). The second mechanism which explains this effect is that a firm covered by the EU ETS which reduces its carbon intensity or is over-allocated allowances can buy less or even sell allowances it no longer needs for compliance. This entails increases in profit and would further strengthen the negative relationship between emission intensity and financial or economic performance (Laing et al., 2014). We explicitly control for the second effect through the firm-level measure of the net value of transactions on the EU ETS. However, we do not have data on firm-level innovation patterns, and therefore cannot explicitly test for the first mechanism, though it would be a plausible explanation based on existing literature (Borghesi et al., 2015; Calel, 2020; Teixidó et al., 2019).

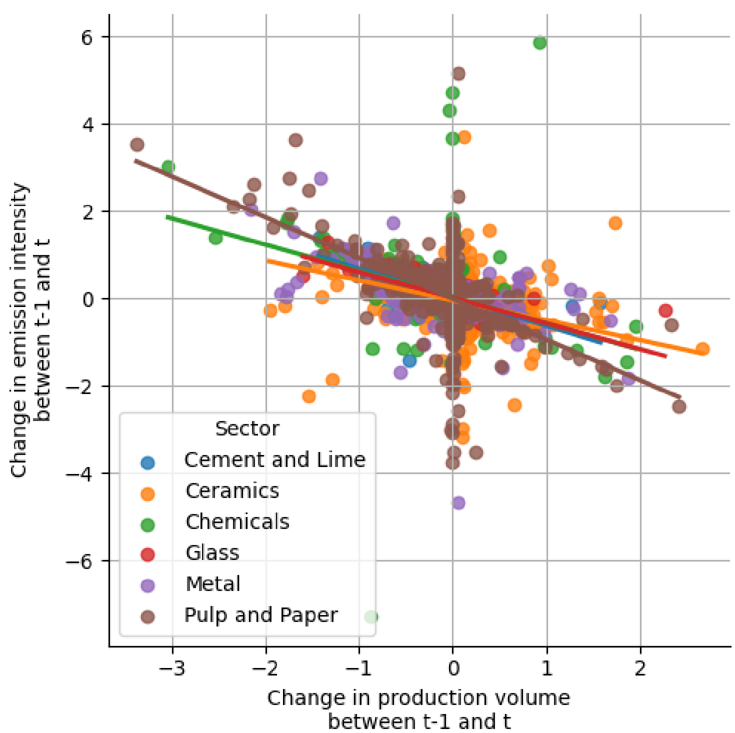
For our variables measuring financial performance, the empirical literature seems to point to the second effect being stronger than the first (Busch & Lewandowski, 2018). For our variables measuring economic performance, an additional consideration should be highlighted. The relationship between emission intensity and our economic variables could partly depend on whether there are economies or diseconomies of scale in emissions[11] and economies or diseconomies of scale in production. To illustrate this, let us posit a case in which firms have diseconomies of scale in emissions, meaning

[11]Economies of scale in emissions are taken to mean that the marginal emission intensity of an additional unit of production is decreasing in the volume of production. The existence of these economies or diseconomies of scale in emissions has not yet been fully established in the literature (Agnolucci & Arvanitopoulos, 2019).

that as they increase their production volumes, the marginal emission intensity of an additional unit increases proportionally more. In this case, these firms would have an incentive to reduce their production volumes instead of investing in the decarbonization of their production processes. Assuming there are economies of scale associated with their production, these reductions in volumes would result in a negative relationship between emission intensity (which increases) and firm productivity (which decreases).

We would also expect that these firms have large fixed costs due to their size and the nature of the production, and that they therefore have economies of scale in production. A reduction in volumes would negatively impact these firm's productivity. Figure 3 shows that in our data, it appears that changes in production volume are negatively correlated with changes in emission intensity. This might be a marker of economies of scale, which can mitigate the risk that our effects are purely driven by these scale effects. These aspects will be further analyzed by including an interaction term between firms that increase their volumes and those that decrease their volumes.

Figure 3: Change in emission intensity compared to change in production volumes



Source: Authors based on the EUTL and ORBIS
Note: The year-on-year change is computed as the ratio of the value in year t and the value in year t-1

Our model controlling for the competition setting that firms operate in (defined in equation 3) analyzes the way in which this setting impacts the relationship between emission intensity and economic or financial performance. The variables we use to measure this are import intensity and intra-branch trade to measure product specialization. Some existing literature indicates that firms exposed to less competitive environments tend to have more power to pass through their costs to downstream sectors and consumers (Cludius et al., 2020). As a result, we would expect the coefficient associated with import intensity to be negative and the coefficient associated with intra-branch trade to be positive - since the latter represents the degree to which products are differentiated within a sector, which is inversely related to the capacity that firms have to pass on their costs. However, there could also be a pro-competitive effect, as highlighted by some trade literature (Peltonen et al., 2008).

The interaction term which includes import intensity is expected to be negative. Indeed, we can hypothesize that companies faced with higher levels of competition have more pressure to decarbonize in ways that are also cost-cutting (or at least not cost-increasing) than firms faced with lower levels of competition that have slightly more capacity to absorb higher costs from decarbonization. On the other hand, the interaction term with intra-branch trade is expected to be positive for the opposite reasons.

Concerning our control variables, table 1 summarizes our expectations for the sign of the associated coefficients.

Table 1: Expectations for control variables

Variable name	**Expected sign of coefficient**	**Rationale**
# opened inst	Positive	New installations are likely less emission intensive than older installations given their use of newer technology.
Stringency idx	Positive (H1) or negative (H2)	H1: Porter hypothesis; H2: Carbon pricing is an additional cost which diminishes corporate performance.
log Turnover	Neutral	Existing literature does not find a link between the size of a firm and its emission intensity (Agnolucci & Arvanitopoulos, 2019).
log Current ratio	Positive	Less leveraged firms are expected to exhibit better corporate performance (Trinks et al., 2020)
Net transactions (val)	Negative	Firms that buy more allowances than they sell would have a positive value for net transactions and would likely be negatively affected on measures of economic and financial performance.

3.3 Addressing endogeneity : Instrumental Variable (IV) approach

When measuring the effect of firms' emission performance on their economic performance, reverse causality and simultaneity bias can be of concern. Firms that perform well in terms of economic results are likely to also perform relatively well from an environmental point of view due to factors like good management, efficient use of inputs, for instance. At the same time, other confounding factors may simultaneously affect firms' emission and economic performances, such as the price for fossil fuel energy (Trinks & Hille, 2023).

In recent energy pricing literature, there has been a growing emphasis on addressing endogeneity sources through the adoption of a Bartik (shift-share) instrument. We apply the same Bartik instrument as outlined in Fontagné et al. (2023) on our emission intensity variable, constructed as:

$$\text{EmissInt}^{IV}_{f,s,t} = \left[\frac{\text{EmissInt}_{f,s,t_0}}{\overline{\text{EmissInt}}_{s,t_0}} \right] \times \overline{\text{EmissInt}}_{s,t} \tag{4}$$

Where t_0 is the first time a firm is observed in our sample, and $\text{EmissInt}_{s,t}$ is the sectoral level of emission intensity at time t, excluding the observed firm f's emission intensity to mitigate endogeneity through a leave-one-out approach:

$$\overline{\text{EmissInt}}_{s,t} = \frac{1}{N-1} \sum_{i \neq f}^{N} \overline{\text{EmissInt}}_{i,s,t} \tag{5}$$

We always report the first-stage coefficient and its significance to test the relevance of our IV, the Kleibergen-Paap Wald F-statistic to test for its weakness, and the p-value of the Anderson-Rubin Wald test to check for the possibility of making inference even if there is a weak IV bias.

3.4 Measuring emission intensity

So far, most papers have measured emission intensity as total emissions over turnover (Dechezleprêtre et al., 2023), since this is easiest measure to compute with available data. However, turnover can come from activities other than industrial production, like marketing or service provision. This can bias results to incorrectly measure the emission intensity of industrial production.

We propose a measure of emission intensity as emissions over production volumes to better capture only industrial production. Since data on firm production volumes is scarce, especially across different countries and sectors, we rely on estimates based on the methodology detailed in appendix B. To summarize this methodology, we compute production volumes in year $t-1$ based on the volume of free allowances that installations receive in the EU ETS in year t:

$$V_{inst,t-1} = \frac{FA_{inst,t}}{B_{act} \times CSCF_t \times TCF_{sec,t}} \tag{6}$$

Where $FA_{inst,t}$ is the amount of free allowances an installation receives in year t, B_{act} is the activity emission intensity benchmark, $CSCF_t$ is the cross-sectoral correction factor and TCF_t is the transitional correction factor.[12]To mitigate uncertainty around the application of the activity benchmark, we use a Monte Carlo simulation to estimate production volumes. The uncertainty linked to this benchmark derives from the fact that benchmarks are defined at the product level, but the EUTL defines installation-level activities. We therefore use the mean and standard deviation of the benchmarks associated with all the products that can be associated with one type of activity in our Monte Carlo simulation.

3.5 Constructing measures of exposure to international competition

One of the important elements that could impact how firms react to carbon pricing is their exposure to international competition. Indeed, the competition setting in which they operate determines whether they are able to pass through their costs or not. As such, we compute two indicators of exposure to competition to assess how this factor impacts our measure of firms' economic performance. The first is a measure of import intensity. The second is a measure of intra-branch trade intensity developed in Gruebel and Lloyd (1975). Both of these indicators are computed at the product level, both in volumes and values.

The first indicator measures the level of import intensity within a market, and is computed as:

$$\text{Import Intensity}_{pct} = \frac{\text{Imports}_{pct}}{\text{Domestic production}_{pct} + \text{Imports}_{pct}} \tag{7}$$

Where the numerator Imports_{pct} is the volume or value of imports of products p to country c in year t. The denominator represents the size of country c's domestic market, i.e., the sum of its imports and domestic production.

The second indicator measures intra-branch trade intensity, which is a proxy for differentiation within the production of a good. Indeed, if there is substantial intra-branch trading for one product, this means that the product is substantially differentiated depending on who produces it. Producers have more market power in a market where products are specialized depending on their origin/production than in a market where all manufacturers produce a homogeneous good, and where buyers are indifferent between buying from one producer or the other. The indicator varies between 0 and 1, where 0 means that all trade within an industry is inter-branch, and that there is little differentiation, and 1 means all trade within an industry is intra-branch and there is a lot of differentiation. This measure was developed by Gruebel and Lloyd (1975) and is computed as:

$$\text{Intra-branch Trade}_{pct} = \frac{(\text{Exports}_{pct} + \text{Imports}_{pct}) - |\text{Exports}_{pct} - \text{Imports}_{pct}|}{\text{Exports}_{pct} + \text{Imports}_{pct}} \tag{8}$$

[12]Parameter $FA_{inst,t}$ is taken from the EU Transaction Log and parameters B_{act}, $CSCF_t$, and TCF_t are taken from EU legislation. Specific source documents for all of this information can be found in appendix B.

4 Data and descriptive statistics

4.1 Data overview

Two main databases were merged to provide data on firm-level climate and economic variables: Bureau van Dijk's ORBIS database,[13] and the European Union Transaction Log (EUTL).[14]

ORBIS is a commercial dataset encompassing approximately 40 million global companies. It standardizes financial data into a global format, facilitating cross-country comparisons. From this dataset we extract data on economic performance, which we complement with some computed variables. The following variables have been extracted or constructed: return on assets, profit margins, EBITDA margins, labor productivity and turnover over costs. Table 2 below provides details on how each of these variables is defined and computed.

Table 2: Definition of outcome variables

	Indicator	**Definition**
Financial indicators	Return on assets	$\frac{Turnover}{Assets}$
	Profit margin	$\frac{Profit\ before\ tax}{Operating\ revenue}$
	EBITDA margin	$Operating\ profit + depreciation$
Economic indicators	Labor productivity	$\frac{Turnover}{N^{\circ}\ employees}$
	Material input productivity	$\frac{Turnover}{Material\ costs}$

The EUTL is the central reporting and monitoring tool run by the European Commission that lists all transactions taking place within the EU ETS. It contains public information on the GHG emission compliance of the entities covered by the scheme.

The merged EUTL-ORBIS database provides firm-level data on verified CO_2 emissions and a range of financial indicators. While the EUTL does cover a few countries outside the EU, we have chosen to restrain our analysis to firms in the EU's 27 Member States. All data provided hereafter is for these 27 countries only. These two databases were merged through a matching procedure described in Cameron and Ho (forthcoming) which utilizes Natural Language Processes and expands on the previous work done by Letout (2021). Appendix C describes in detail how this data was cleaned and formatted.

[13] Orbis | Compare Private Company Data | Bureau van Dijk (bvdinfo.com)

[14] EU Emissions Trading System (ETS) data viewer — European Environment Agency (europa.eu).

4.2 Data coverage

The EU ETS regulates between 8,000 and 10,000 individual installations in the EU. Each of these installations is associated to an account run by its parent company - one company may report emissions for several installations. Companies submit an annual report to the national Union Registry where they are registered. Data from all EU national Union Registries is then aggregated in the EUTL. This means that multinational companies must have one account for each country in which they have a regulated installation, with no fully satisfactory way to link several accounts owned by a single parent company.

With this in mind, between 5,000 and 6,000 'national' firms report verified emissions in the EUTL every year. Of these, only about 2,000 firms are classified in an industrial sector (blue line in figure 4), the rest operating within the energy sector, which we do not include in this paper. We find a match in ORBIS for 65-80% of these industrial firms between 2013 and 2021 (orange line in figure 4). Our final sample is made up of firms that have a match in ORBIS and for which financial data is available and of sufficient quality in ORBIS (green line in figure 4) - totaling around 1,200 firms during phase 3 of the EU ETS. We drop the year 2020 to avoid data issues linked to COVID, as well as the year 2021 because the rules changed for the free allocation of allowances and our estimates of emission intensity would not be valid. Our sample is too restricted in the first phases of the EU ETS, so we do not include these years in our analysis.[15]

The firms covered in our sample represent the largest and most emission-intensive industrial firms in the EU, but are not representative of the much vaster industrial sector in the EU. The EU ETS covers only about 2-3% of all industrial firms in the EU. However, these firms are responsible for 30-40% of the bloc's industrial emissions.[16]On average, the EU ETS covers only the largest industrial firms in activity. As a result, this is also what our sample covers.

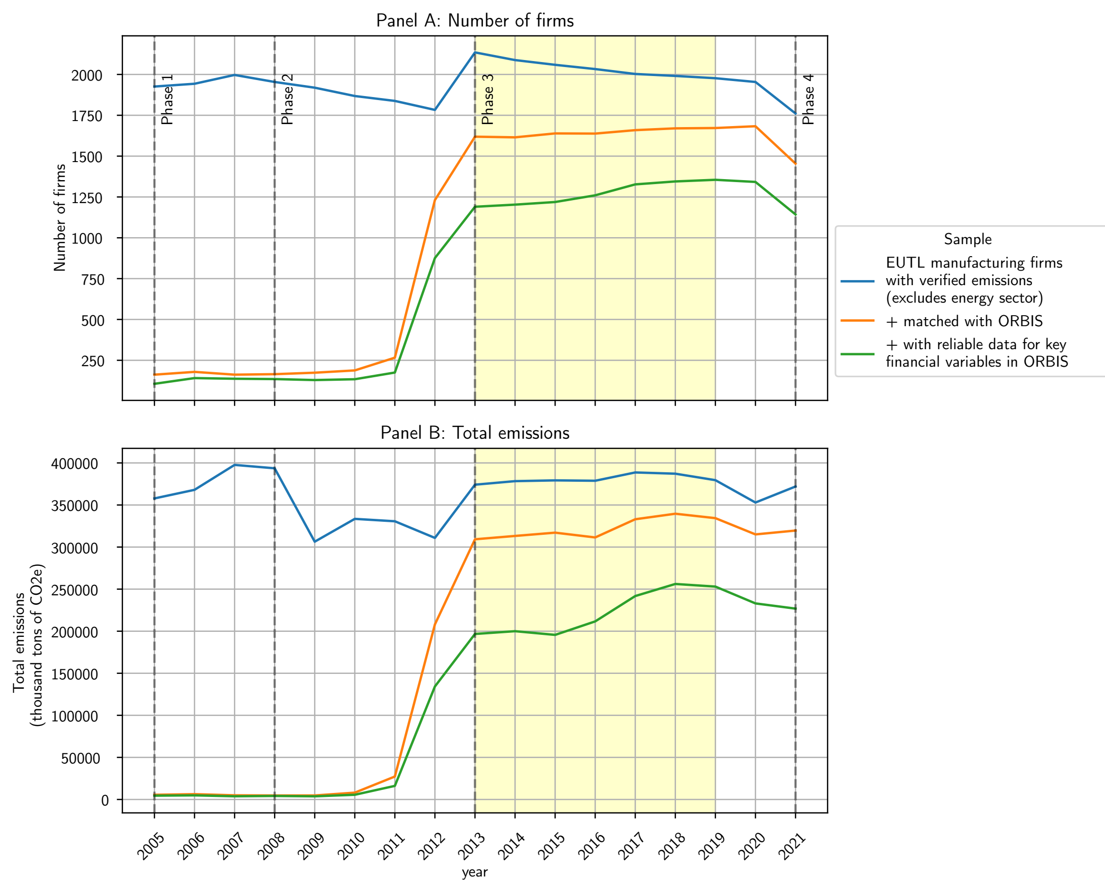
One important element to note is that we have chosen to only keep firms in our sample whose main activity is regulated in the EU ETS. This means for example that we keep steelmakers, but exclude pasta producers that are regulated under the EU ETS because they own energy-generating installations. The reason for this is that the financial data declared in ORBIS is related to a firm's total activities, while the EUTL only covers a firm's activities that are regulated under the EU ETS. By only keeping firms whose main activity is regulated - as defined by the NACE code they declare in ORBIS - we ensure better consistency between the financial and climate data from both of our sources. Appendix E provides details on this procedure.

[15]This may seem counter-intuitive since other studies have been able to study these phases, however certain elements differ from ours: first, these studies generally look at the entirety of firms regulated by the EU ETS, rather than just industry, which expands their sample; second, other data sources, like the E-PRTR, are used which can provide better matches for earlier years, but restricts the sample to only certain countries; third, the overall sample size of these studies is much smaller than ours, and therefore not comparable (see for example Dechezleprêtre et al. (2023) who have 240 pairs of firms in their sample, or Colmer et al. (2023) who have around 300 pairs).

[16]This is computed using values from Eurostat's 'env_ac_ainah_r2' series for emissions and 'sbs_na_ind_r2' series for the number and size of firms. Further details and descriptive statistics disaggregated by sector are provided in Appendix D.

To compute our two competition indices (described in section 3.5), further data on production and trade by sector and country are needed. To this end, we also merge our EUTL-ORBIS data with Eurostat's PRODCOM database,[17]using the NACE codes provided in PRODCOM. While PRODCOM provides a nomenclature that is more disaggregated, we compute an aggregate value at the NACE 2 or NACE 4 level to remain consistent with the EUTL-ORBIS database.

Figure 4: Data coverage over the EU ETS phases



Source: Authors based on EUTL and ORBIS.

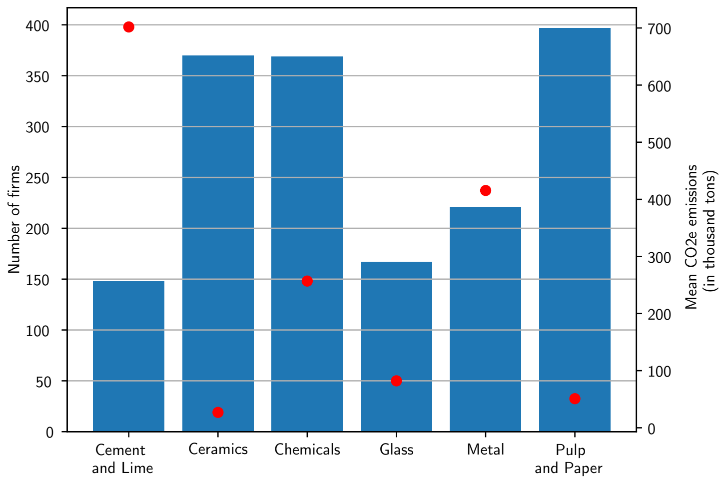
Note: All samples include only EU 27 countries. The yellow-highlighted area is the time period covered by this study.

4.3 Trends of key variables and sectoral heterogeneity

The number of firms and mean emissions for each of these validated sectors is given in figure 5. While certain sectors only make up a small share of total firms in our dataset, their high level of emissions makes them have a large overall impact on total emissions (cement and lime for instance). On the other hand, installations in sectors like pulp and paper, or ceramics, are quite numerous but have low average emissions.

[17]The data series code is 'ds-056120'.

Figure 5: Number of firms (lhs, bars) and average emissions (rhs, dots) by sector (2019)



Source: Authors based on EUTL and ORBIS.

Note: Sample only includes EU-27 countries.

Table 3: Average values by sector for key variables

	Cement and Lime	Ceramics	Chemicals	Glass	Metal	Pulp and Paper
Return on assets (€ turnover per € assets)	0.59 [0.44]	0.59 [0.42]	1.1 [0.74]	0.81 [0.47]	1.24 [1.58]	1.15 [0.66]
Turnover over costs (€ turnover per € costs)	2.39 [1.89]	3.17 [5.96]	4.08 [15.22]	2.26 [1.12]	1.86 [6.94]	2.23 [5.43]
EBITDA margin (%)	14.88 [12.55]	7.84 [16.73]	10.54 [11.35]	12.84 [10.22]	4.57 [12.82]	9.92 [10.37]
Profit margin (%)	6.03 [14.63]	-0.03 [18.15]	5.49 [12.2]	5.36 [11.96]	-0.03 [13.43]	4.94 [10.94]
Labor productivity (th. euros per person)	271.83 [259.25]	167.2 [215.16]	1098.34 [5037.61]	215.71 [159.6]	1186.81 [13433.53]	766.27 [6124.11]
Emission intensity (tCO2 per ton product)	1.02 [0.38]	0.08 [0.06]	1.0 [2.13]	0.48 [0.12]	1.03 [0.87]	0.32 [0.57]
Emission intensity (tCO2 per th. euros)	7.4 [2.86]	1.5 [2.04]	0.74 [1.07]	0.76 [0.53]	0.4 [0.5]	0.43 [0.51]
Import intensity (volumes)	0.12 [0.13]	0.24 [0.21]	0.45 [0.17]	0.39 [0.29]	0.37 [0.15]	0.32 [0.15]
Import intensity (value)	0.14 [0.13]	0.31 [0.2]	0.47 [0.15]	0.35 [0.23]	0.37 [0.15]	0.34 [0.15]
Intra-branch trade intensity (volumes)	0.38 [0.19]	0.33 [0.2]	0.43 [0.18]	0.49 [0.25]	0.41 [0.15]	0.46 [0.18]
Intra-branch trade intensity (value)	0.42 [0.18]	0.47 [0.27]	0.48 [0.19]	0.58 [0.24]	0.43 [0.16]	0.48 [0.17]

Note: Standard deviation is reported in square brackets.

The evolution of the emission variables by sector (figure 6) reveals that there is no significant overall change in either emission volumes or intensity for any industrial sector over the course of phase 3. On the contrary, the most recent year of data seems to indicate there has been an increase in emission intensity, potentially caused by the sudden stop and restarting of production due to the COVID crisis. Another interesting element when digging deeper into this data is that the mean emission intensity by sector hides some level of heterogeneity among firms in a single sector. The bottom panel of figure 6 illustrates this by showing the interval of the 25^{th} and 75^{th} percentiles around the average value of carbon intensity by sector (depicted as the shaded area). There is a wide dispersion of values in the chemicals sector, while the ceramics sector has more homogeneous values. This dispersion illustrates the different technologies and production processes that can be used within one sector, and their associated carbon intensities. Appendix F provides further information on the distribution of emission intensities within each sector.

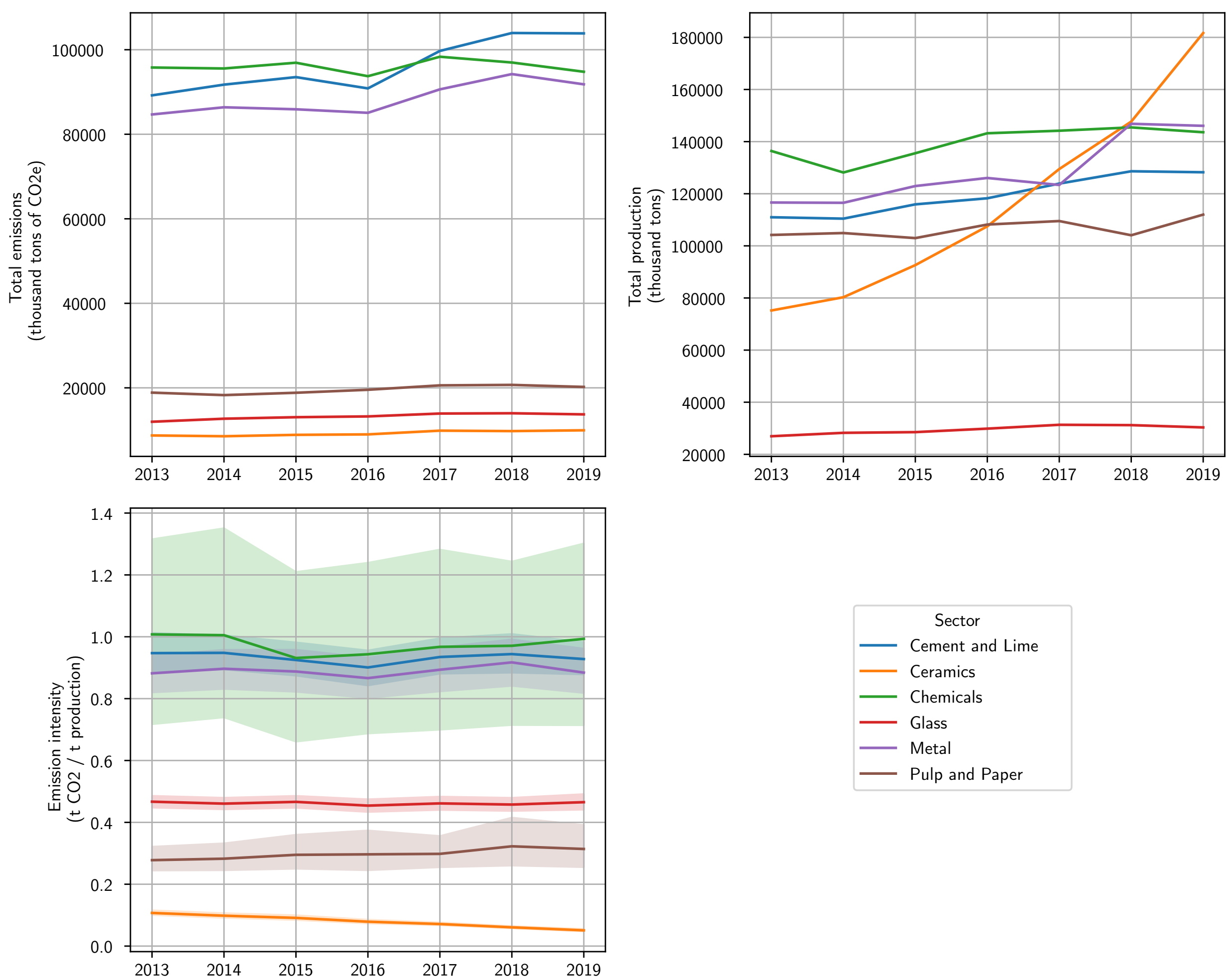
Turning now to the economic variables used in our analysis, table 3 presents descriptive statistics, highlighting substantial variations in the characteristics of the sectors we study. For example, the cement and lime sector exhibits notably higher levels of profit and emission intensity (in volumes) than sectors like ceramics or metal.[18] However, there is a high variability between firms, as shown by the standard deviation. Moreover, the mean evolution of these variables by sector highlights the existence of sector-level dynamics. No sector is consistently performing better or worse than others across all measures (figure 7).

As for our competition indicators, the dispersion in our measures of competition illustrates that these sectors operate in different market conditions, which may affect their ability to absorb input price increases through a reduction of their profit margins. For example, we could expect that some sectors tend to operate in more restricted or regionalized markets because their products are not easily transportable. This is the case for cement and lime for instance, which has a very low average import intensity. Less globalized markets can mean that less competitors can access the same markets, making firms more able to pass their costs though to downstream consumers. On the other hand, the cement and lime sector also has a relatively low intra-branch trade intensity, meaning that consumers likely do not differentiate much between products coming from one producer rather than another. This implies that firms compete more on price than quality or specialization.

Looking at the evolution over time, an apparent trend is visible in most sectors, but depends on the measure that is used (figure 8). The level of intra-branch trade intensity has increased for sectors such as cement and lime and metal, although with a slight decrease in recent years; it has remained stable for chemicals and pulp and paper, and decreased slightly for glass and substantially for ceramics (compared to 2014). Trends are not as clear for our second indicator, import intensity, except for ceramics and glass which exhibit an increase. It is clear that these different sectors do not face the same level of import intensity, and that this should be taken into account in our analysis.

[18] Note that ORBIS uses the accounting definition of the margin rate – i.e., the ratio of profit before tax over operating revenue – rather than the margin rate as defined in microeconomics.

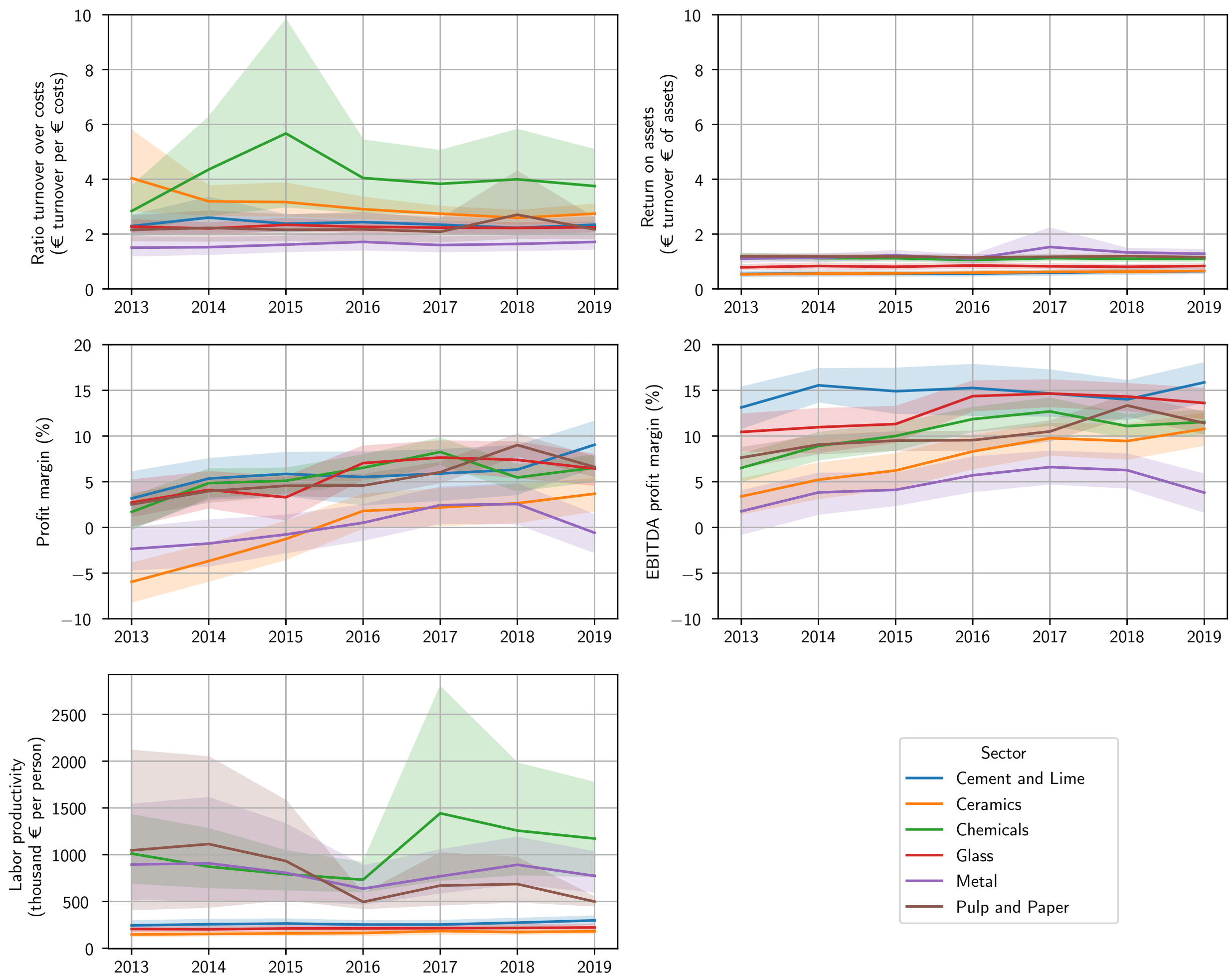
Figure 6: Volume of emissions, production and mean emission intensity by sector



Source: Authors' own calculations based on EUTL and ORBIS.

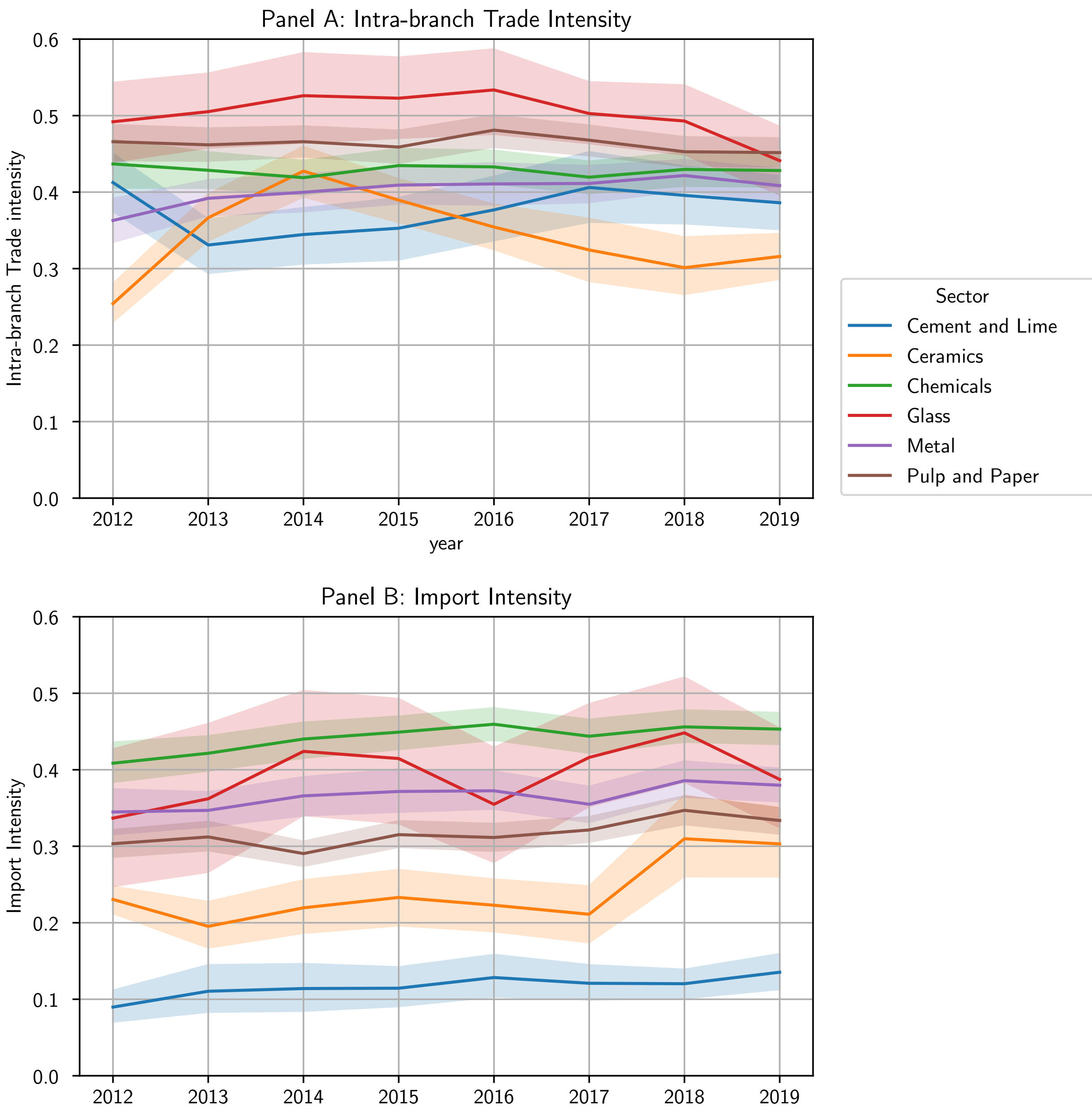
Note: The shaded area represents the interval between the 25th and 75th percentile of the sample.

Figure 7: Evolution of variables of interest by sector



Source: Authors' own calculations based on EUTL and ORBIS.

Figure 8: Evolution of competition indicators by sector



Source: Authors' own calculations based on EUTL and ORBIS.

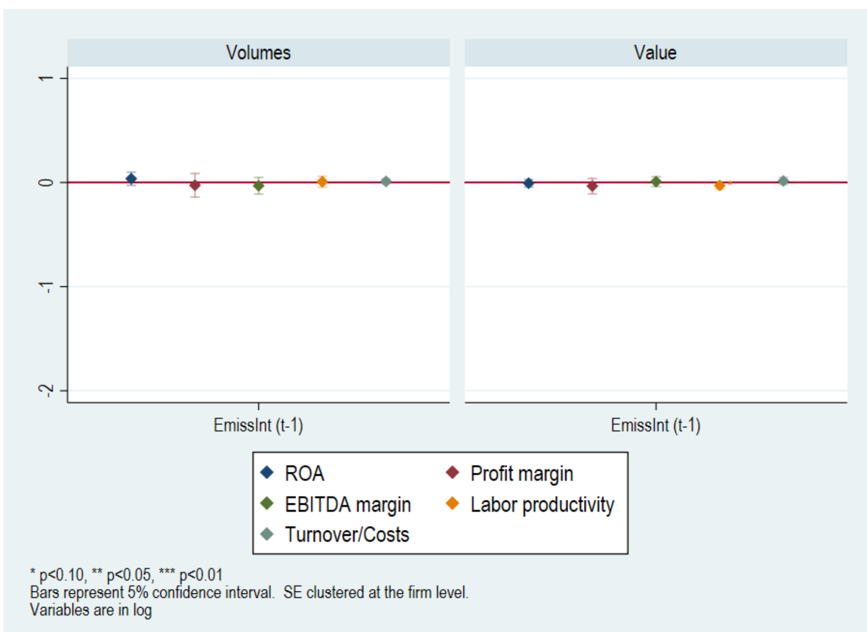
5 Empirical results

This section presents the results of our econometric specification to capture the impact of changes in a firm's emission intensity on its economic or financial performance. As outlined in section 3, we apply a log-transformation to our variables of interest hence our estimated coefficient can be interpreted as percentage changes. Overall, we find either no effect or a small but significant negative impact of emission intensity on our economic and financial outcome variables. This means that firms that reduced their emissions intensity either were not impacted by this reduction or slightly improved their corporate performance as a result of it. When we explicitly control for sector-specific competitive settings this result remains robust, and becomes slightly stronger in magnitude.

5.1 Impact of emission intensity on economic performance

We begin by reporting our results for equation 1. Figure 9 summarizes the results of the estimation of our model without using an IV. This illustrates that neither our volume-base nor our value-based measure of emission intensity significantly affect our variables of economic outcome.

Figure 9: Regression results - Non-IV Emission Intensity



Note: Full regression results can be found in tables 14 and 15 of appendix G. Standard errors are clustered at the firm level. Firm-level control variables included. Firm and sector-time fixed effects included.

We now turn to the results using our IV strategy. These results are reported in tables 4 and 5 for volume-based and value-based measures of emission intensity, respectively. To check for the relevance of our IV, we report the first-stage coefficient for emission intensity, the first-stage Kleibergen-Paap (K-P) Wald F-statistic, and the p-value of the Anderson-Rubin (A-R) test on weak-instrument-robust-inference. Our first-stage coefficients are positive and significant at the 1%

level for all of our regressions, and the K-P Wald F-statistic is high enough to confirm the absence of a weak-IV bias for our volume-based estimations. This is not the case for our value-based estimates. For the regressions where our variable of interest has a significant result, the A-R p-value confirms that we can make inference based on this result.

Our IV results indicate that emission intensity had a small but significant negative impact on return on assets when emission intensity is measured in volumes and on labor productivity when emission intensity is measured in value. However, neither of these coefficients remain significant when we apply the more conservative Holm-Bonferroni correction to our p-values. In terms of values, our regressions indicate that a 1% change in emission intensity in a given year induces a 0.12% change in the opposite direction in return on assets in the following year. For our other variables, there is no significant effect of emission intensity.

Looking to our control variables, a few elements are worth highlighting. First, our stringency index has a significantly positive but minimal effect on profit margins, EBITDA margin and turnover over costs. This could be a hint to the Porter hypothesis, meaning that firms that are faced with a higher stringency make their production processes slightly more efficient, and therefore also improve their margins. However, it has the opposite sign for labor productivity - and is also significant. This can mean that less carbon-intensive production processes are more labor-intensive than those which are more carbon-intensive. This hypothesis is plausible given existing evidence on this topic (Fragkos & Paroussos, 2018).

Another issue we look into is whether the effect is stronger towards the end of the EU ETS' phase 3, when regulatory constraints got stronger and the price began to rise substantially. We therefore include a dummy for years from 2018 onward to capture this effect and report results in table 6. The coefficient for emission intensity remains the same as in our previous regression, but the interaction term is negative and significant in our regressions for profit margin and EBITDA margins, and the post-2018 term is negative and significant in our regressions for profit margin and labor productivity. This indicates that on average after 2018, firms had worse profit and EBITDA margins and that changes in emission intensity had a stronger opposite effect on these margins. In other words, after 2018, reductions in emission intensity led to higher profit and EBTIDA margins than they did before 2018.

As discussed in section 3.2, economies or diseconomies of scale and/or of emissions may be driving our results. To test for this, we build a dummy variable which takes the value of 1 if a firm decreased its production volumes between year $t-1$ and year t. Table 7 presents results for our regressions including this dummy. Once again, the first-stage coefficients are positive and highly significant across all the regressions presented in this table, and the K-P F-statistic is far above the threshold indicating a weak-IV bias. Our results do not indicate that our results are driven by these dynamics. None of the coefficients for the production decrease dummy and the interaction term are significant.

Table 4: Regression of economic performance indicators on emission intensity IV (volumes)

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IV2SLS	IV2SLS	IV2SLS	IV2SLS
log EmissInt$_{t-1}$ (vol)	-0.123^{**}	-0.221	-0.132	-0.0683	-0.00662
	(0.0540)	(0.211)	(0.121)	(0.0456)	(0.0530)
# opened inst$_{t-1}$	0.00451	0.0262^{*}	0.0189	0.00150	0.00473
	(0.00459)	(0.0154)	(0.0153)	(0.00404)	(0.00493)
Stringency idx$_{t-1}$	-0.00000115	0.00000718^{***}	0.00000455^{***}	-0.00000211^{***}	0.00000154^{*}
	(0.00000107)	(0.00000107)	(0.000000924)	(0.000000558)	(0.000000926)
log Turnover$_{t-1}$	0.227^{***}	0.196	0.103	0.195^{***}	-0.125^{**}
	(0.0603)	(0.127)	(0.0643)	(0.0541)	(0.0579)
log Current ratio$_{t-1}$	-0.0457^{**}	0.0425	-0.00257	-0.0357^{**}	0.0222^{*}
	(0.0183)	(0.0431)	(0.0245)	(0.0146)	(0.0122)
logNet transactions (val)$_{t-1}$	-0.000406	-0.0000158	0.000471	-0.000436	0.000685^{*}
	(0.000429)	(0.00156)	(0.00106)	(0.000383)	(0.000371)
Observations	6048	4554	5385	6048	6048
Firm Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Sector-Time FE	No	No	No	No	No
First-stage coefficient	0.376^{***}	0.324^{***}	0.346^{***}	0.376^{***}	0.376^{***}
K-P rk Wald F-stat	127.036	74.876	100.772	127.036	127.036
A-R Wald test (p-val)	0.023	0.295	0.278	0.138	0.901
HB-corrected p-value	0.114	0.590	0.823	0.538	0.901

Notes: Standard errors are in parenthesis, clustered at the firm level. We report first-stage estimates of the coefficient for emission intensity, as well as its significance level, the Kleibergen-Paap F-statistic and the p-value of the Anderson-Rubin Wald test on the weak-instrument-robust inference. Additionally, second-stage Holm-Bonferroni-corrected p-values are reported for the Emission Intensity IV coefficient.

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Table 5: Regression of economic performance indicators on emission intensity IV (values)

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IV2SLS	IV2SLS	IV2SLS	IV2SLS
log EmissInt$_{t-1}$ (val)	−0.259	−1.331	0.265	−0.293*	0.0441
	(0.168)	(1.017)	(0.273)	(0.163)	(0.0920)
# opened inst$_{t-1}$	−0.00330	0.0527*	0.0158	−0.00234	−0.00309
	(0.00560)	(0.0310)	(0.0145)	(0.00606)	(0.00459)
Stringency idx$_{t-1}$	−0.00000151*	0.00000216	0.00000144	0.000000705	0.000000737*
	(0.000000899)	(0.00000274)	(0.00000169)	(0.000000662)	(0.000000407)
log Turnover$_{t-1}$	0.125*	−0.682	0.164	0.0385	−0.0928**
	(0.0684)	(0.594)	(0.164)	(0.0687)	(0.0430)
log Current ratio$_{t-1}$	−0.0285	0.0990*	−0.00514	−0.00972	0.0209
	(0.0174)	(0.0546)	(0.0220)	(0.0156)	(0.0130)
logNet transactions (val)$_{t-1}$	−0.00104**	0.000747	−0.000459	−0.000935**	0.0000718
	(0.000448)	(0.00211)	(0.000960)	(0.000439)	(0.000335)
Observations	8548	6107	7345	8548	8548
Firm Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Sector-Time FE	*No*	*No*	*No*	*No*	*No*
First-stage coefficient	0.120***	0.098*	0.128***	0.120***	0.120***
K-P rk Wald F-stat	10.643	3.694	8.641	10.643	10.643
A-R Wald test (p-val)	0.066	0.020	0.322	0.028	0.628
HB-corrected p-value	0.492	0.573	0.662	0.363	0.632

Notes: Standard errors are in parenthesis, clustered at the firm level. We report first-stage estimates of the coefficient for emission intensity, as well as its significance level, the Kleibergen-Paap F-statistic and the p-value of the Anderson-Rubin Wald test on the weak-instrument-robust inference. Additionally, second-stage Holm-Bonferroni-corrected p-values are reported for the Emission Intensity IV coefficient.

* p<0.10, ** p<0.05, *** p<0.01

Table 6: Regression of economic performance indicators on emission intensity IV (volumes) x post-2018 dummy

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IV2SLS	IV2SLS	IV2SLS	IV2SLS
log EmissInt$_{t-1}$ (vol)	-0.124^{**}	-0.134	-0.0394	-0.0526	0.0128
	(0.0552)	(0.217)	(0.129)	(0.0439)	(0.0557)
log EmissInt$_{t-1}$(vol) $\times$ Post-2018	0.000667	-0.0469^{*}	-0.0435^{***}	-0.00687	-0.00851
	(0.00605)	(0.0246)	(0.0148)	(0.00779)	(0.00528)
Post-2018	-0.155^{**}	-0.477^{***}	-0.142	-0.406^{***}	0.0154
	(0.0605)	(0.148)	(0.102)	(0.0465)	(0.0403)
# opened inst$_{t-1}$	0.00452	0.0254^{*}	0.0180	0.00141	0.00461
	(0.00459)	(0.0154)	(0.0149)	(0.00404)	(0.00490)
Stringency idx$_{t-1}$	-0.00000115	0.00000709^{***}	0.00000454^{***}	-0.00000210^{***}	0.00000155^{*}
	(0.00000107)	(0.00000115)	(0.000000990)	(0.000000554)	(0.000000926)
log Turnover$_{t-1}$	0.227^{***}	0.181	0.0893	0.193^{***}	-0.128^{**}
	(0.0604)	(0.127)	(0.0639)	(0.0540)	(0.0582)
log Current ratio$_{t-1}$	-0.0457^{**}	0.0422	-0.00191	-0.0357^{**}	0.0223^{*}
	(0.0183)	(0.0427)	(0.0243)	(0.0146)	(0.0122)
logNet transactions (val)$_{t-1}$	-0.000406	-0.000129	0.000426	-0.000433	0.000689^{*}
	(0.000429)	(0.00157)	(0.00106)	(0.000382)	(0.000370)
Observations	6048	4554	5385	6048	6048
Firm Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Sector-Time FE	*No*	*No*	*No*	*No*	*No*
First-stage coefficient	0.462^{***}	0.417^{***}	0.440^{***}	0.462^{***}	0.462^{***}
K-P rk Wald F-stat	52.230	32.771	42.864	52.230	52.230
A-R Wald test (p-val)	0.072	0.081	0.005	0.292	0.265
HB-corrected p-value	0.121	1.000	1.000	0.923	0.818

Notes: Standard errors are in parenthesis, clustered at the firm level. We report first-stage estimates of the coefficient for emission intensity, as well as its significance level, the Kleibergen-Paap F-statistic and the p-value of the Anderson-Rubin Wald test on the weak-instrument-robust inference. Additionally, second-stage Holm-Bonferroni-corrected p-values are reported for the Emission Intensity IV coefficient.

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Table 7: Regression of economic performance indicators on emission intensity IV (volumes) x production decrease dummy

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IV2SLS	IV2SLS	IV2SLS	IV2SLS
log EmissInt$_{t-1}$ (vol)	-0.121^{**}	-0.227	-0.134	-0.0674	-0.00667
	(0.0536)	(0.213)	(0.121)	(0.0450)	(0.0527)
log EmissInt$_{t-1}$(vol) $\times$ Prod Decrease	0.0109	0.00639	0.00688	0.00302	-0.00114
	(0.00744)	(0.0251)	(0.0146)	(0.00802)	(0.00592)
Prod Decrease	-0.00556	0.0289	0.0140	-0.00354	-0.000297
	(0.0108)	(0.0371)	(0.0226)	(0.0127)	(0.00868)
# opened inst$_{t-1}$	0.00423	0.0262^{*}	0.0188	0.00142	0.00476
	(0.00457)	(0.0153)	(0.0153)	(0.00405)	(0.00491)
Stringency idx$_{t-1}$	-0.00000118	0.00000726^{***}	0.00000459^{***}	-0.00000212^{***}	0.00000154^{*}
	(0.00000109)	(0.00000107)	(0.000000915)	(0.000000555)	(0.000000925)
log Turnover$_{t-1}$	0.226^{***}	0.196	0.102	0.195^{***}	-0.125^{**}
	(0.0600)	(0.127)	(0.0642)	(0.0541)	(0.0580)
log Current ratio$_{t-1}$	-0.0450^{**}	0.0421	-0.00278	-0.0355^{**}	0.0222^{*}
	(0.0182)	(0.0431)	(0.0245)	(0.0145)	(0.0122)
logNet transactions (val)$_{t-1}$	-0.000405	-0.0000270	0.000465	-0.000435	0.000685^{*}
	(0.000428)	(0.00156)	(0.00106)	(0.000384)	(0.000370)
Observations	6048	4554	5385	6048	6048
Firm Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Sector-Time FE	*No*	*No*	*No*	*No*	*No*
First-stage coefficient	0.472^{***}	0.419^{***}	0.433^{***}	0.472^{***}	0.472^{***}
K-P rk Wald F-stat	64.374	37.799	50.909	64.374	64.374
A-R Wald test (p-val)	0.047	0.566	0.535	0.276	0.956
HB-corrected p-value	0.120	0.573	0.801	0.538	0.899

Notes: Standard errors are in parenthesis, clustered at the firm level. We report first-stage estimates of the coefficient for emission intensity, as well as its significance level, the Kleibergen-Paap F-statistic and the p-value of the Anderson-Rubin Wald test on the weak-instrument-robust inference. Additionally, second-stage Holm-Bonferroni-corrected p-values are reported for the Emission Intensity IV coefficient.

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

5.2 Effect of competition setting

As discussed in section 3.5, we include a specification in which we interact our variable of interest, emission intensity, with indicators of the competition setting that firms operate in. This is to capture the difference in effects which may be driven by firms' capacity to pass through their costs to downstream sectors and consumers.

Tables 8 and 9 report our results for our volume-based estimations including an interaction term for import intensity and intra-branch trade, respectively. For both of these specifications, the first-stage coefficient for our variable of interest is always significant and the K-P F-statistic is always above the threshold of 10, indicating the absence of a weak-IV bias.

Once the competition interaction term is included in our regressions, the effect of emission intensity on return on assets is doubled. In our regressions using both measures of competition setting, it remains highly significant (1% level), even when the H-B correction is applied to our p-values (drops to 5% level of significance). Additionally, the effect on labor productivity becomes significant and negative, even when taking the H-B correction into account (drops to 10% level of significance). The coefficients for profit margins are significant at the 5% level in both regressions, but only remain significant with the H-B correction for import intensity. These stronger effects of emission intensity on our corporate performance variables seem to indicate that the competition setting matters in our specification, and that once cleaned of this effect, there is a stronger link between emission and corporate performance.

While including this competition parameter changes the significance and values of some of our coefficients of interest as discussed above, the interaction term and the competition term themselves are not always significant across specifications. Looking first at the effect of import intensity on our corporate performance variables, our coefficient is insignificant in all our regressions except when our outcome variable is EBITDA margin. In this case, the coefficient is positive and significant at the 5% level, which could indicate a pro-competitive effect (Peltonen et al., 2008). The fact that only the EBITDA margin exhibits this effect, but not the profit margin, suggests that once interest, taxes, depreciation and amortization are account for, the positive effect on profits is no longer found. Turning to our coefficient measuring the effect of intra-branch trade intensity on corporate performance, we find that it is positive and significant in our regressions for return on assets and profit margins. This seems to indicate that for these two measures of financial performance, firms that operate in sectors where products become more differentiated are able to translate this into a better overall performance, although the H-B corrected p-values remove the significance of the coefficient for profit margins.

The interaction term for import intensity is positive and significant for EBITDA margins. This result could be explained by the fact that investments in decarbonization are not profitable when amortization is not taken into account. In our regression which uses intra-branch trade, the coefficient is positive and significant for profit margins and EBITDA margins. The fact that the coefficient is positive for both of these measures is interesting. It could indicate that sectors where more product differentiation exists, investments in decarbonization can be profitable, even without accounting for amortization. An explanation for this could be that in sectors where product differentiation already exists, firms are more able to sell "greener" products at a premium by differentiation their offer based on this characteristic.

For the other outcome variables we have not discussed above, the competition setting does not appear to significantly affect the relationship between firms' emission intensity and their corporate outcomes.

For our value-based estimations, results are reported in tables 16 and 17 in appendix G. These results present a weak-IV bias (K-P F-statistics are lower than 10) and the coefficients of interest are barely significant - and not significant when the H-B correction is applied.

Table 8: Regression of economic performance indicators on emission intensity IV x import intensity (volume)

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IV2SLS	IV2SLS	IV2SLS	IV2SLS
log EmissInt_{t-1} (vol)	-0.286^{***}	-0.435	-0.0839	-0.198^{**}	0.0121
	(0.0977)	(0.355)	(0.212)	(0.0828)	(0.103)
log $\text{EmissInt}_{t-1}\times$ log ImpInt_{t-1} (vol)	-0.0140	0.0396	0.0567^{***}	-0.0102	-0.00352
	(0.00989)	(0.0251)	(0.0173)	(0.00928)	(0.0107)
log ImpInt_{t-1} (vol)	-0.0142	0.0567	0.0748^{**}	-0.0341	-0.0155
	(0.0256)	(0.0425)	(0.0378)	(0.0208)	(0.0293)
# opened inst_{t-1}	-0.000473	0.0319^{**}	0.0120	0.000314	0.00350
	(0.00584)	(0.0142)	(0.0121)	(0.00426)	(0.00506)
Stringency idx_{t-1}	-0.00000110	0.00000666^{***}	0.00000431^{***}	-0.00000195^{***}	0.00000145^{*}
	(0.000000987)	(0.00000128)	(0.00000105)	(0.000000602)	(0.000000839)
log Turnover_{t-1}	0.269^{***}	0.0984	0.0343	0.273^{***}	-0.182^{**}
	(0.0890)	(0.149)	(0.0775)	(0.0687)	(0.0798)
log Current ratio_{t-1}	-0.0441^{**}	0.00963	0.0167	-0.0412^{**}	0.0307^{**}
	(0.0208)	(0.0446)	(0.0280)	(0.0168)	(0.0151)
logNet transactions $(\text{val})_{t-1}$	-0.000121	-0.00262	0.000394	-0.000151	0.000932^{**}
	(0.000521)	(0.00182)	(0.00124)	(0.000471)	(0.000449)
Observations	4459	3337	3956	4459	4459
Firm Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Sector-Time FE	*No*	*No*	*No*	*No*	*No*
First-stage coefficient	0.528^{***}	0.505^{***}	0.506^{***}	0.528^{***}	0.528^{***}
K-P rk Wald F-stat	27.283	12.135	20.709	27.283	27.283
A-R Wald test (p-val)	0.008	0.015	0.000	0.034	0.871
HB-corrected p-value	0.017	0.663	1.000	0.067	0.907

Notes: Standard errors are in parenthesis, clustered at the firm level. We report first-stage estimates of the coefficient for emission intensity, as well as its significance level, the Kleibergen-Paap F-statistic and the p-value of the Anderson-Rubin Wald test on the weak-instrument-robust inference. Additionally, second-stage Holm-Bonferroni-corrected p-values are reported for the Emission Intensity IV coefficient.

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

Table 9: Regression of economic performance indicators on emission intensity IV x intra-branch trade intensity (volumes)

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IV2SLS	IV2SLS	IV2SLS	IV2SLS
log EmissInt$_{t-1}$ (vol)	-0.246^{***}	-0.674^{**}	-0.278	-0.227^{***}	-0.0592
	(0.0846)	(0.339)	(0.196)	(0.0759)	(0.0837)
log EmissInt$_{t-1}\times$ log IbInt$_{t-1}$ (vol)	0.0106	0.0718^{**}	0.0432^{**}	-0.00845	0.00330
	(0.00899)	(0.0317)	(0.0187)	(0.0128)	(0.00766)
log IbInt$_{t-1}$ (vol)	0.0502^{**}	0.200^{**}	0.0881	-0.00661	0.0163
	(0.0218)	(0.0879)	(0.0566)	(0.0322)	(0.0188)
# opened inst$_{t-1}$	0.000149	0.0362^{**}	0.0140	0.000438	0.00426
	(0.00573)	(0.0155)	(0.0140)	(0.00432)	(0.00533)
Stringency idx$_{t-1}$	-0.00000120	0.00000673^{***}	0.00000443^{***}	-0.00000206^{***}	0.00000143
	(0.00000100)	(0.00000144)	(0.00000112)	(0.000000647)	(0.000000958)
log Turnover$_{t-1}$	0.250^{***}	0.160	0.0528	0.247^{***}	-0.147^{**}
	(0.0770)	(0.138)	(0.0749)	(0.0619)	(0.0693)
log Current ratio$_{t-1}$	-0.0445^{**}	0.0529	0.00775	-0.0367^{**}	0.0245^{*}
	(0.0200)	(0.0495)	(0.0267)	(0.0157)	(0.0138)
logNet transactions (val)$_{t-1}$	-0.000322	-0.00139	0.00117	-0.000204	0.000845^{**}
	(0.000501)	(0.00176)	(0.00123)	(0.000446)	(0.000421)
Observations	4960	3726	4404	4960	4960
Firm Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Sector-Time FE	*No*	*No*	*No*	*No*	*No*
First-stage coefficient	0.413^{***}	0.384^{***}	0.389^{***}	0.413^{***}	0.413^{***}
K-P rk Wald F-stat	37.345	17.009	28.351	37.345	37.345
A-R Wald test (p-val)	0.000	0.004	0.010	0.002	0.498
HB-corrected p-value	0.015	0.140	0.313	0.014	0.479

Notes: Standard errors are in parenthesis, clustered at the firm level. We report first-stage estimates of the coefficient for emission intensity, as well as its significance level, the Kleibergen-Paap F-statistic and the p-value of the Anderson-Rubin Wald test on the weak-instrument-robust inference. Additionally, second-stage Holm-Bonferroni-corrected p-values are reported for the Emission Intensity IV coefficient.

* $p<0.10$, ** $p<0.05$, *** $p<0.01$

5.3 Discussion of results

The first element to be highlighted from our results is that the coefficient associated with emission intensity is significantly negative across all of our specifications where the outcome variable is return on assets. This is in line with Trinks et al. (2020) who find that carbon efficiency is associated to higher returns on assets in their sample as well.

When looking at regulatory changes during the EU ETS' third phase, results suggest that there is a pre-2018 period and a post-2018 period. The latter coincides with higher carbon prices, as well as the implementation of the MSR and the establishment of the European Green Deal. Our results indicate that changes in emission intensity led to opposite changes in profit margins and EBITDA margins, but only starting in 2018. This could signal the importance of the increased regulatory stringency, which creates long-term expectations for firms and consumers.

We also find there is no evidence that the effects of decarbonization on corporate results are stronger for firms that decrease their production volumes. This is encouraging, as it seems to indicate that firms do not gain from reducing their production volumes in the EU ETS.

Accounting for the competitive setting that firms operate in seems to reinforce the relationship between emission behavior and economic viability of firms. Indeed, the capacity for product differentiation tends to improve the relationship between emission intensity and firms' profit margins and EBITDA margins. In markets where products are already more differentiated, it may be easier to further differentiate products based on their carbon footprint, and to potentially increase sale prices and consequently, profit margins. Import intensity appears to have only a small pro-competitive impact on EBITDA margins.

6 Limitations and ways forward

While this work develops a solid methodology to account for a number of endogeneity concerns, it still presents several limitations. First, as mentioned before, due to the lack of emission data for countries or industries not covered by the EU ETS, isolating the pure effect of this treatment is not possible. It would be interesting to collect this type of data to investigate the effectiveness and full impact of this carbon market.

Moreover, we only study short-term effects (1 year) of firms' decarbonization dynamics on their performance. However, the impacts of decarbonization can span much longer periods. It would therefore be essential to continue monitoring these elements taking longer time-periods and lagged effects into account. A long term perspective would also need to test the Porter hypothesis. In this paper, we have discussed it as a potential explanation for the positive effect that is found between emission intensity and corporate performance. However, the data that is available to us does not allow for an explicit check of this channel. It would be particularly interesting to merge the dataset we have developed with other datasets on patents, like PATSTAT, or on firm-level research and development efforts. This would allow for a further exploration of the channels which underlie the effects we have highlighted in this study.

In our economic analysis, we have incorporated information regarding sectors' international exposure and product specialization to account for the fact that certain sectors may face more significant challenges in transitioning to low-carbon production processes than others. In this context, complementary measures could be explored to refine the assessment on the importance of specific product attributes. For instance, further research could delve into factors like the responsiveness of demand by estimating trade elasticities at the product level, as studied by Fontagné et al. (2019). Similarly, insights into product transportability, homogeneity, and complexity could also be valuable considerations in refining our understanding of sector-specific challenges and opportunities in the context of decarbonization efforts.

While we have focused on the context of carbon pricing in this paper, many other types of policies and contextual elements can also impact the profitability of firms in their transition. Some topics which would be particularly interesting to study include the effect of targeted support aimed at industrial decarbonization, and of energy price shocks.

Finally, there is an inherent limitation to our estimation of a volume-based emission intensity which is discussed in appendix B detailing our methodology. Our estimation of production volumes is based on the EUTL, which reports the volume of free allocations provided to installations covered under the EU ETS. However, these free allocations are actually determined at the sub-installation level. This means that there may be some inaccuracies in our estimation because we are not correctly associating benchmarks to installation-level reported activities. While we have attempted to mitigate this risk by including a Monte-Carlo simulation in our estimation, it remains a limitation. It could be a particularly important limitation in the case where an installation reduces its emissions by switching from making its own inputs to importing them, but this is not declared because it happens at a sub-installation level. In our estimation, this would inaccurately be interpreted as a reduction of emission intensity, when it would actually be a case of carbon leakage. This worry is somewhat mitigated by the fact that production volumes do not significantly decrease at the aggregate level in our sample, so this likely does not represent a significant share of installations in our sample.

7 Conclusions and policy implications

This paper analyses the relationship between firms' emission intensity and their corporate performance based on a constructed dataset providing detailed micro-level information of industrial firms covered by the EU ETS,which tend to be large entities rather than small and medium-sized enterprises. Unlike prior studies, our work covers the entire EU, all industrial sectors whose main activity is regulated under the EU ETS and provides results for the entirety of the EU ETS' third phase, except for 2020 which is excluded due to the COVID crisis. Additionally, we depart from the conventionally employed value-based metric for emission intensity and introduce a novel estimated volume-based measure of emission intensity.

Overall, we find a small but significant negative impact of changes in firms' emission intensity on their economic performance. This effect is stronger when we control for the competitive environment that firms operate in. It is also stronger in the years 2018-2019 when regulatory stringency was higher.

Our results have several implications from a policymaking perspective. While these results are an encouraging sign of the corporate benefits of decarbonisation, it would be interesting to see if this relationship persists under the EU's latest regulatory changes, including the final phase of the EU ETS and the initial transitory phase of the Carbon Border Adjustment Mechanism, which are not covered in our study.

One of the reasons that our results are small in magnitude could be that the ways in which firms are decarbonizing are only small, marginal changes for now - and therefore only have a minor impact on their overall functioning and profitability. However, heavy industry sectors require large investments to develop entirely new production processes to fully, or substantially, decarbonize. These types of changes have not yet materialized because they represent large investments. The realization of these benefits depends the ability of regulated sectors to effectively adapt and innovate while safeguarding their external competitiveness. This imperative is particularly pronounced in the face of climate targets requiring additional efforts for their fulfillment, combined with an increasingly complex environment shocked by an energy crisis, whose effects are still present, and an intensified competition in clean technology from foreign counterparts. In parallel to carbon pricing policies, policymakers should provide the right incentives to invest in the green transition, including fostering the re-industrialization of clean technology sectors and facilitating the decarbonization of EU industry. Recent EU initiatives outlined in the Green Deal Industrial Plan go in this direction, such as the Net-Zero Industry Act.

Moving forward, there are diverse opportunities for improving and extending this research. Firstly, further sector-level analyses of these effects could be beneficial, given the highly different nature and environments of the industrial sectors we study. Secondly, we could refine the emission intensity indicator further to address potential measurement errors arising from the lack of information at sub-installation level. Lastly, the question of the channels of effect is particularly relevant - incorporating data that proxies innovation and investments to better estimate and identify the potential long-term effects of climate regulations could be highly interesting. In this respect, further research is needed to investigate the underlying mechanisms of this relationship, with particular attention to the role of innovation in fostering the adoption of green or advanced technologies.

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A Multicollinearity checks

Table 10: Correlation matrix of key variables

	log EmissIntVol	Opened inst.	Stringency	log Turnover	log Current ratio	log Transaction value
log EmissIntVol	1	.0132713	-.0733783	.3372823	-.0468249	.2157891
Opened inst.	.0132713	1	.0103339	.0552011	-.0090577	.0622351
Stringency	-.0733783	.0103339	1	.0556543	-.0217132	.0668992
log Turnover	.3372823	.0552011	.0556543	1	-.0785095	.4627716
log Current ratio	-.0468249	-.0090577	-.0217132	-.0785095	1	-.0014217
log Transaction value	.2157891	.0622351	.0668992	.4627716	-.0014217	1

Table 11: Simple IV regression for VIF computation

	log ROA	log Profit Margin	log EBITDA Margin	log Turnover over costs	log Labor productivity
	(1)	(2)	(3)	(4)	(5)
	2SLS	2SLS	2SLS	2SLS	2SLS
log EmissInt$_{t-1}$ (vol)	0.0521***	0.0132	0.0194*	0.0355***	0.0883***
	(0.00982)	(0.0157)	(0.0101)	(0.00723)	(0.0109)
# opened inst$_{t-1}$	−0.200***	−0.0281	−0.0324	−0.125***	−0.204***
	(0.0205)	(0.0311)	(0.0211)	(0.0151)	(0.0227)
Stringency idx$_{t-1}$	−0.00000288***	0.00000130	0.00000200**	−0.00000218***	−0.000000347
	(0.000000898)	(0.00000126)	(0.000000875)	(0.000000661)	(0.000000992)
log Turnover$_{t-1}$	0.0137*	0.0958***	−0.0253***	−0.219***	0.200***
	(0.00706)	(0.0118)	(0.00757)	(0.00520)	(0.00780)
log Current ratio$_{t-1}$	−0.0915***	0.259***	0.119***	0.0632***	−0.000497
	(0.0155)	(0.0261)	(0.0166)	(0.0114)	(0.0171)
logNet transactions (val)$_{t-1}$	−0.00311**	0.00154	0.00283**	−0.00116	−0.00378***
	(0.00124)	(0.00199)	(0.00128)	(0.000915)	(0.00137)
Observations	5728	4353	5113	5728	5728
Firm Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm FE	*No*	*No*	*No*	*No*	*No*
Time FE	*No*	*No*	*No*	*No*	*No*
Sector-Time FE	*No*	*No*	*No*	*No*	*No*

Table 12: VIF values

	log ROA	log Profit margin	log EBITDA margin	log Turnover over costs	log Labor productivity
log Turnover $_{t-1}$	1.186353	1.129058	1.14659	1.186353	1.186353
log EmissIntVol $_{t-1}$	1.169397	1.113135	1.132136	1.169397	1.169397
Stringency $_{t-1}$	1.019482	1.024196	1.021268	1.019482	1.019482
log Transac. value $_{t-1}$	1.011524	1.010283	1.01235	1.011524	1.011524
Opened inst. $_{t-1}$	1.010654	1.00954	1.01016	1.010654	1.010654
log Current ratio $_{t-1}$	1.010102	1.008763	1.009523	1.010102	1.010102

B Estimation of production volumes

B.1 Methodology

In the EU ETS, the amount of free allowances given to each regulated installation is determined on a yearly basis depending on their past production volumes. Since the number of free allowances per installation is available in our dataset, it is possible to reverse the calculation and fall back on an estimate of production volumes for each installation. With some level of simplification,[19]free allocations are calculated as follows:

$$FA_{sub,t} = V_{sub,t-1} \times B_{prod} \times CSCF_t \times TCF_{sec,t}$$

Where:

- $FA_{sub,t}$ are free allocations for sub-installation *sub* in year t (free allocations are initially determined at the sub-installation level, although they are aggregated and reported at the installation level in the EUTL);
- $V_{sub,t-1}$ is the volume of production in tonnes for sub-installation *sub* in year $t-1$;
- B_{prod} is the production benchmark, given in free allowances per tonne of production and calculated based on the emission intensity of the 10% most efficient producers of this product;
- $CSCF_t$ is the yearly cross-sector correction factor, a correction factor applied to all installations in order to ensure the total amount of free allocations given out in a year is below the total yearly cap of allowances in the EU ETS;
- $TCF_{sec,t}$ is what we call the transitional correction factor, applied to gradually decrease the share of free allowances that installations receive in sectors not on the carbon leakage list (i.e., ensure a transition away from the free allocation). It therefore depends on the installation's sector of activity *sec*.

As such, it is possible to derive volumes from the following equation:

$$V_{sub,t-1} = \frac{FA_{sub,t}}{B_{prod} \times CSCF_t \times TCF_{sec,t}}$$

B.2 Data sources

Data is taken from the following sources for each of the variables in the equation above:

- FA: EUTL;
- B_{prod}: Annex I of the Commission Decision of 27 April 2011 determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council (notified under document C(2011) 2772) (2011/278/EU);

[19] In reality, allocation of free allowances is determined on the basis of product benchmarks, heat benchmarks, fuel benchmarks and process emission benchmarks. However, the most important benchmark for the sectors we study (which do not include electricity, refineries and steam and air conditioning) is the product benchmark. Additionally, no data is available regarding the other benchmarks, so these are excluded from our computation.

- $CSCF_t$: Cross-sectoral correction factors between 2013 and 2016 are taken from Annex II of the Commission Decision of 5 September 2013 concerning national implementation measures for the transitional free allocation of GHG emission allowances in accordance with Article 11(3) of Directive 2003/87/EC of the European Parliament and of the Council (notified under document C(2013) 5666) (2013/448/EU). Between 2017 and 2020, they are taken from Annex II Commission Decision (EU) 2017/126 of 24 January 2017 amending Decision 2013/448/EU as regards the establishment of a uniform cross-sectoral correction factor in accordance with Article 10a of Directive 2003/87/EC of the European Parliament and of the Council. The initial decision from 2013 establishing these factors was invalidated in 2016 by the Court of Justice of the European Union and subsequently amended in 2017. See Cross-Sectoral Correction Factor (CSCF) - Emissions-EUETS.com for details on this topic;

- $TCF_{sec,t}$: The transitional correction factor for the years 2013 to 2020 is taken from Annex VI of the Commission Decision of 27 April 2011 determining transitional Union-wide rules for harmonized free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council (notified under document C(2011) 2772) (2011/278/EU). Note that the TCF for sectors on the carbon leakage list for phase 3 is always equal to 1.

B.3 Implementation

Given data availability, the equation used to calculate production volumes must be slightly modified. Indeed, free allowance volumes are available in the EUTL at the installation level, not the sub-installation level. Therefore, the equation is modified as follows:

$$V_{inst,t-1} = \frac{FA_{inst,t}}{B_{act} \times CSCF_t \times TCF_{sec,t}}$$

Since product benchmarks cannot be matched directly to sub-installation activity, we need to match them to installation activities. While some products can be matched one-to-one to installation activities, there are many cases where products can be matched to several activities, or vice-versa, where several products can be matched to a single activity. This means there may be several product benchmarks for a single installation. To take this into account, we generate production volumes using a Monte Carlo process with 1000 iterations that computes the above formula based on the mean and standard deviation of the benchmarks that are applied to each installation. We take the mean value of all the production values that are generated from this process as production volume for each installation.

B.4 Limitations

While this methodology can give an estimate of production volumes at the installation level, it is limited by the level of aggregation of the EUTL. Indeed, the installation activity reported in this dataset is the main activity of each installation. However, this could mask some heterogeneity in the activities of sub-installations and consequently, of free allocation benchmarks. While we try to highlight this heterogeneity by adding confidence intervals based on the standard deviation of our aggregated benchmarks, this remains a limitation. Until benchmarks are perfectly matched based on the product of a sub-installation, the volume estimated will remain an approximation of reality. In the meantime, this estimation is likely not too far off given that for most installations, the main activity is the one for which there is a majority of production.

C Cleaning procedure

Our firm-level dataset on verified CO_2 emissions and a range of financial indicators was constructed and cleaned following four steps.

Step 1: Cleaning of data from the European Union Transaction Log

The European Union Transaction Log (EUTL) records data on compliance and transactions for all entities participating in the EU ETS. Compliance data comes with a two-year lag and encompasses various variables including verified CO_2 emissions by installation, number of allowances freely allocated, bought, and surrendered, and usage of CER credits, among others. Transaction data comes with a three-year lag and records the volume of allowances transferred between any two accounts in the system. Both transaction and compliance data are published on a yearly basis. The EUTL has been active since the implementation of the EU ETS, i.e., since 2005.

Only regulated firms (e.g., a power plant that is required by regulation to buy and surrender CO_2 allowances) are required to provide data for the compliance part of the EUTL, but unregulated firms that participate in the EU ETS (e.g., a bank that acts as a financial intermediary between a power plant and the ETS compliance office) are recorded in the EUTL. In our sample we include only regulated firms.

We used data files provided by Abrell (2023).[20] To perform our analysis, we cleaned and merged these files, through the following steps. First, we removed all empty observations after 2021 or those missing company registration numbers. Second, we excluded all observations reported in the Swiss ETS (CH ETS). Third, we dropped observations failing to report Operator Holding Accounts, as well as observations whose installation activity was 'Aircraft operator activities'. Lastly, we excluded account holders that could not be matched with any account.

[20] The author scraped the data from the EUTL and compiled it into a relational database made up of various CSV files. These files, along with documentation on Abrell's work and output, are available for download on Abrell's website: https://www.euets.info/download/

After this cleaning procedure, all observations were uniquely identifiable in the dataset by company registration number *(reg_ id)*, installation identifier *(inst_ id)*, and year *(year)*.

Step 2: Cleaning of data from ORBIS

Firms regulated by the EU ETS were extracted from the flat file of the ORBIS database. This sample was cleaned in order to be consistent with the EUTL, so both datasets could be merged together. The following cleaning was applied to the extracted ORBIS data, following Gal (2013), Gopinath et al. (2017), and Kalemli-Ozcan et al. (2015):

- Construction of a year value: observations do not have a year value but instead a closing date value, which refers to the date at which a company filed its yearly account information. For observations with only the year in the closing date, this year was kept. For observations with a year, month and/or day, the current year was kept if the date was after 1 June, and the prior year was instead used if the date was before 1 June;
- Dropped all observations with no value for the closing date (these had empty financial records anyways);
- Dropped all observations for which the number of months taken into account in the reporting was different from 12;
- Duplicates for a single company and year were cleaned according to the following rules (in order of priority):
  1. For companies reporting more than once in the same year, the latest date was kept;
  2. For companies with both an annual filing and a local registry filing, the annual filing was kept (this is the most consistent and comparable across firms and countries);
  3. Only unconsolidated accounts were kept;
- Dropped all firms whose NACE code was not an activity regulated under the EU ETS (as described in appendix E).
- Dropped all observations with insufficient quality of data, based on the following criteria:
  - Missing any of the following variables: total assets, turnover, sales or cost of employees
  - If any of the following variables were negative: total assets, number of employees, sales, tangible fixed assets
  - If any of the following variables were missing, negative, or equal to zero: material costs, total assets, tangible fixed assets, number of employees and operating revenue

After this cleaning, all observations were uniquely identifiable in this dataset by ORBIS company identifier *(orbis_ bvd_ id)* and year *(year)*.

Step 3: Finding matches between EUTL and ORBIS identifiers

To correctly match EUTL and ORBIS firm identifiers, we start from the matching provided by Letout (2021), which we extend and improve as described in Cameron and Ho (forthcoming).

Letout (2021) developed a script to match unique company identifiers from ORBIS to those in the EUTL.[21] While this matching procedure is an incredible asset to match the EUTL and ORBIS, some care must be taken to clean the matches in order to have the best correspondence between both datasets. The following cleaning was thus applied to the JRC's file:

- Dropped all observations that were not Operator Holding Accounts;
- Dropped all exact duplicates;
- Dropped duplicates of EUTL company identifier - ORBIS company identifier pairs where the only difference was a slightly different spelling of names / addresses;
- Dropped duplicates of EUTL identifier according to the following rules (in order of priority):
  1. If only one of the duplicated observations had a validated (by name and address) JRC match, the validated match was kept, and all others dropped;
  2. If some of the duplicated observations were a subsidiary of another, the mother company was kept, and all subsidiaries dropped.

After this cleaning, all observations were uniquely identifiable by ORBIS com+pany identifier *(orbis_bvd_id)* and EUTL identifier *(reg_id)*.

We further extend this matching by applying a natural language processing methodology, as described in Cameron and Ho (forthcoming). This provides an additional 1000 matches between EUTL and ORBIS identifiers.

Step 4: Merging of the EUTL and ORBIS

In the final step, we merge the EUTL and ORBIS, via the matching file provided by the JRC as well as our own additional matches. It is important to note that some ORBIS identifiers are associated with more than one EUTL identifier. This is caused by a single firm (identified by the ORBIS identifier) opening several accounts within the EU ETS (each of which is identified by a single EUTL identifier). Sometimes the accounts are used for different plants, other times one account is opened for a certain period, and another opened for another period.

The matching process proceeded as follows:

[21] The work is based on a project funded by DG GROW. The output of this work was a file containing the correspondence table between these identifiers, along with information on how the match was found and how accurate it is thought to be. Matches were found on the basis of two main sources of information: the name of a company and its address. Companies with a fully validated match are those where the name and address are almost perfectly matched between both datasets. However, this is a scale rather than a binary value, given that names and addresses are provided by the companies themselves and are often riddled with typos, slight differences in spelling, etc. For more details on the methodology applied in the script see Letout (2021)

1. Observations from the EUTL are matched many-to-one to the file contain all EUTL-ORBIS matches based on the EUTL company registration identifier *(reg_ id)*. After this, observations are uniquely identified by EUTL company registration identifier *(reg_ id)*, installation identifier *(inst_ id)*, ORBIS identifier *(orbis_ bvd_ id)*, and year *(year)*.

2. Observations from ORBIS are matched many-to-many to the file contain all EUTL-ORBIS matches based on ORBIS company identifier *(orbis_ bvd_ id)*. After this, observations are uniquely identified by ORBIS company identifier *(orbis_ bvd_ id)*, EUTL company registration identifier *(reg_ id)*, and year *(year)*.

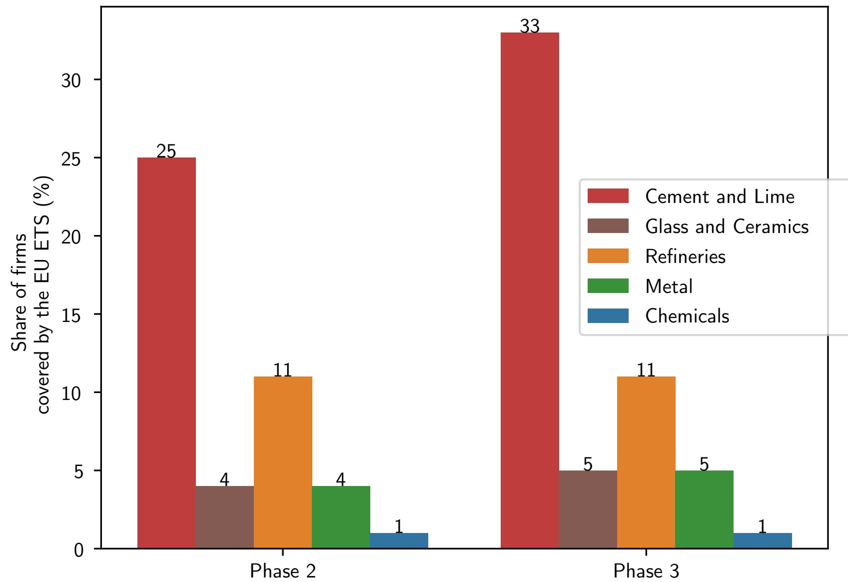
3. Observations from the EUTL are matched many-to-one to ORBIS based on EUTL company registration identifier *(reg_ id)*, ORBIS company identifier *(orbis_ bvd_ id)*, and year *(year)*.

All observations that do not have a match at any of these three steps were dropped. After this merging process, all observations were uniquely identifiable by EUTL company registration identifier *(reg_ id)*, installation id *(inst_ id)*, ORBIS company identifier *(orbis_ bvd_ id)*, and year *(year)*.

D Data representativeness

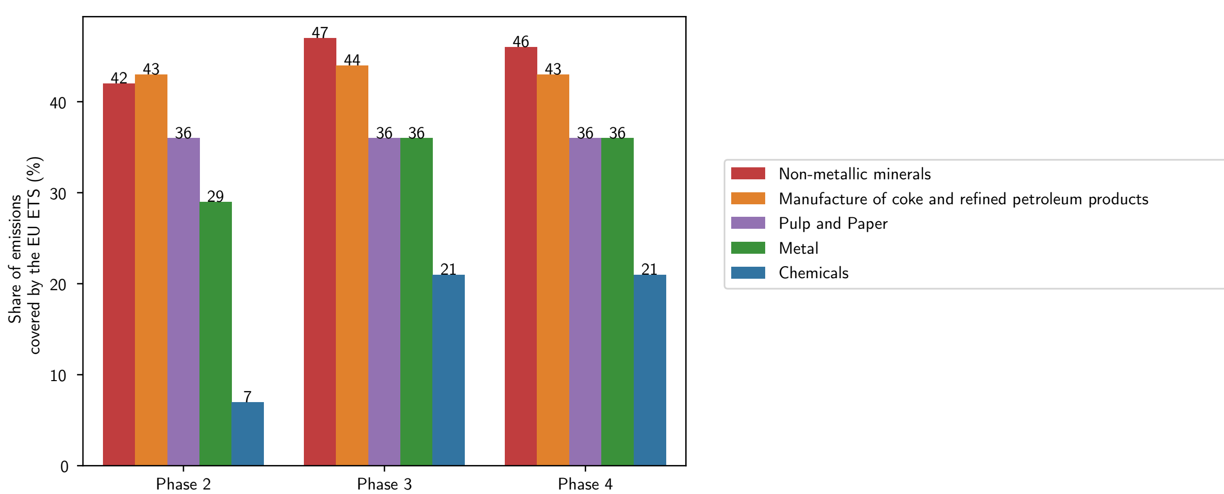
The dataset presented in this paper does not represent the entire universe of firms in the EU in the sectors that are studied. Indeed, only a small share of this universe is regulated by the EU ETS, as illustrated in figure 10. As a result, this database should not be taken as being representative of EU industry in a broad sense, but instead of the part of EU industry that is regulated by the EU ETS. However, since the criteria that is used to determine whether firms are regulated are based on firms' size and emission levels, this dataset does tend to capture the largest and most emission-intensive firms in the concerned sectors. This is illustrated by figure 11: while the EU ETS only regulates a small share of firms, a much larger share of total emissions in industrial sectors are covered. For example, the EU ETS only covers 5% of firms in the metal sector, but these firms generate more than a third of the sectors' GHG emissions. Additionally, figure 12 illustrates how our sample is biased towards larger firms, which are not the majority of firms in the sectors that we study. However, they are the firms that climate policies focus on as they are responsible for the most emissions.

Figure 10: Share of firms covered by the EU ETS by sector



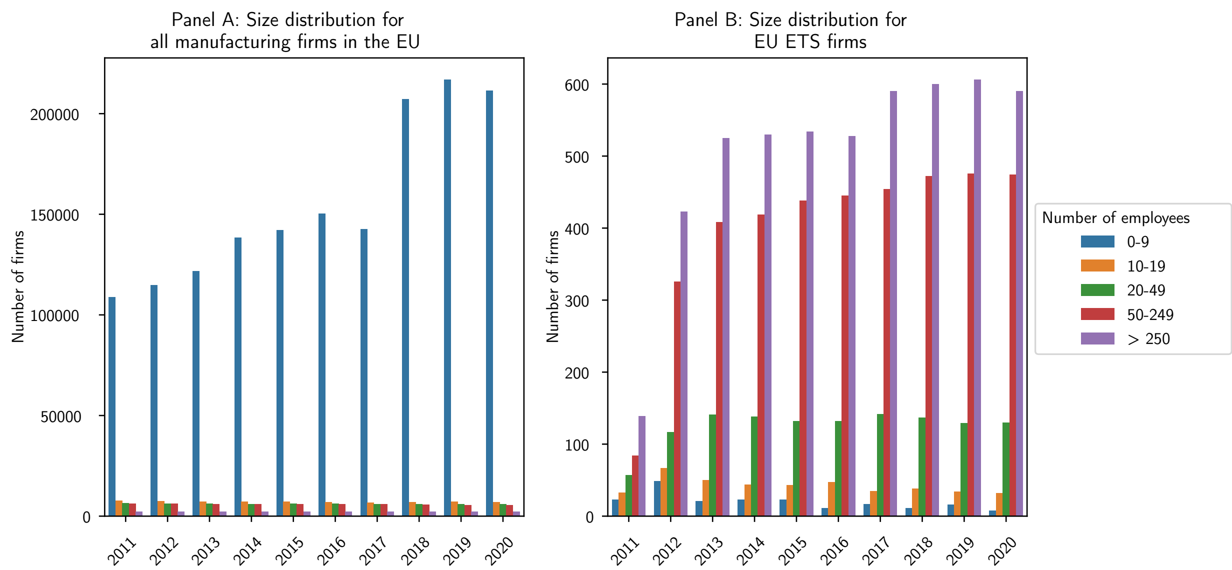
Source: EU Transaction Log and Eurostat (sbs_na_ind_r2).

Figure 11: Share of emissions covered by the EU ETS by sector



Source: EU Transaction Log and Eurostat (env_ac_ainah_r2).

Figure 12: Distribution by firm size (number of employees)

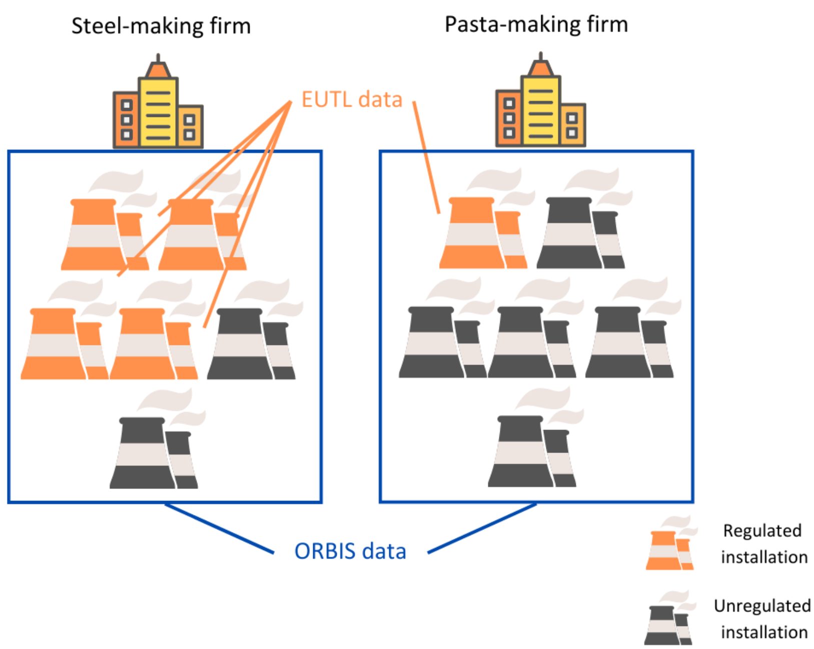


Source: EU Transaction Log, ORBIS and Eurostat (SBS_SC_IND_R2).

E NACE filtering procedure

When regulated firms report to their Union Registry for EU ETS compliance, they must provide information on their regulated installations' activity and annual emissions. When matching the EUTL's emissions data with financial data from ORBIS, the installation activity can no longer be used since an installation's activity does not always correspond to the overall activity or sector of its parent firm. ORBIS provides company-level NACE codes which can complement the EUTL's data on installation activity. Almost all sectors of the economy are represented in our matched database. However, not all available sectors should be kept for a rigorous analysis using both financial and emissions data. Indeed, for firms in many of the sectors available, the regulated installations represent only a small fraction of their parent company's overall activity. Since ORBIS' financial data covers the entirety of a company's activities it cannot be compared to the EUTL emissions data that only covers regulated installations for these firms (see figure 13 for an illustration).

Figure 13: Compatibility between ORBIS and the EUTL



Source: Authors' own illustration

To give a concrete example of this issue, Barilla reports in its 2021 Sustainability Report that its Scope 1 emissions amounted to 263,282t CO_2 in 2021. Some of the company's co-generation plants are regulated under the EU ETS. Looking in the EU Transaction Log, only 96,321t CO_2 emissions were reported by Barilla for these plants in 2021, making up slightly more than a third of their total Scope 1 emissions. It is clear that for this company, most emissions come from unregulated parts of its production process (i.e., pasta making), which are not regulated under the EUTL. As a result, financial data from ORBIS cannot be compared to emissions data from the EUTL for this firm. On the other hand, emissions reported in the EUTL by ArcelorMittal make up more than

60% of the Scope 1 emissions they report for Europe . This means that most Scope 1 emissions for ArcelorMittal are covered by the EUTL, and that we can more reliably compare this data to financial data from ORBIS. The preferred sample to use ORBIS and EUTL data jointly is therefore the one which is restricted to firms whose main activity is regulated under the EU ETS. The sectors selected based on this criterion are detailed table 13, along with their associated NACE codes and number of observations available. This note only considers sectors that were validated using this logic.

Table 13: Sectors selected for NACE-filtered sample

Sector category	NACE description	Associated NACE codes
Pulp and paper	Manufacture of paper and paper products	1700 (+ all subcategories)
Chemicals	Manufacture of chemicals and chemical products	2000 (+ all subcategories)
Glass	Manufacture of glass and glass products	2310 (+ all subcategories)
Ceramics	Manufacture of ceramic tiles and flags	2331
	Manufacture of other porcelain and ceramic products	2340 (+ all subcategories)
Cement and lime	Manufacture of cement, lime and plaster	2350 (+ all subcategories)
Metal	Manufacture of basic iron and steel and of ferro-alloys	2410
	Manufacture of tubes, pipes, hollow profiles and related fittings, of steel	2420
	Manufacture of other products of first processing of steel	2430 (+ all subcategories)
	Aluminum production	2442
	Lead, zinc and tin production	2443
	Copper production	2444
	Other non-ferrous metal production	2445

Source: Authors

F Distribution of emission intensity by sector

Figure 14: Distribution of emission intensity (volumes)

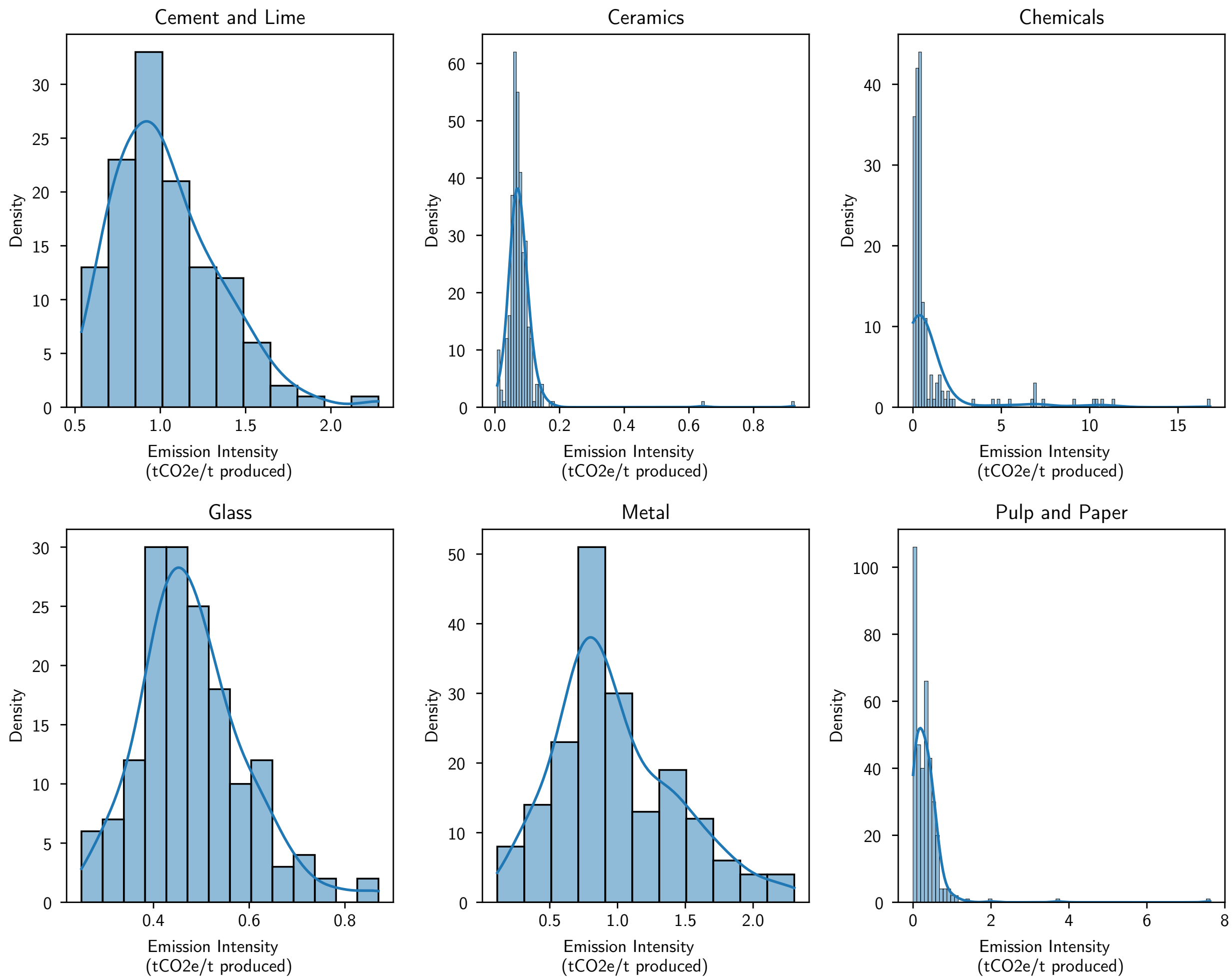
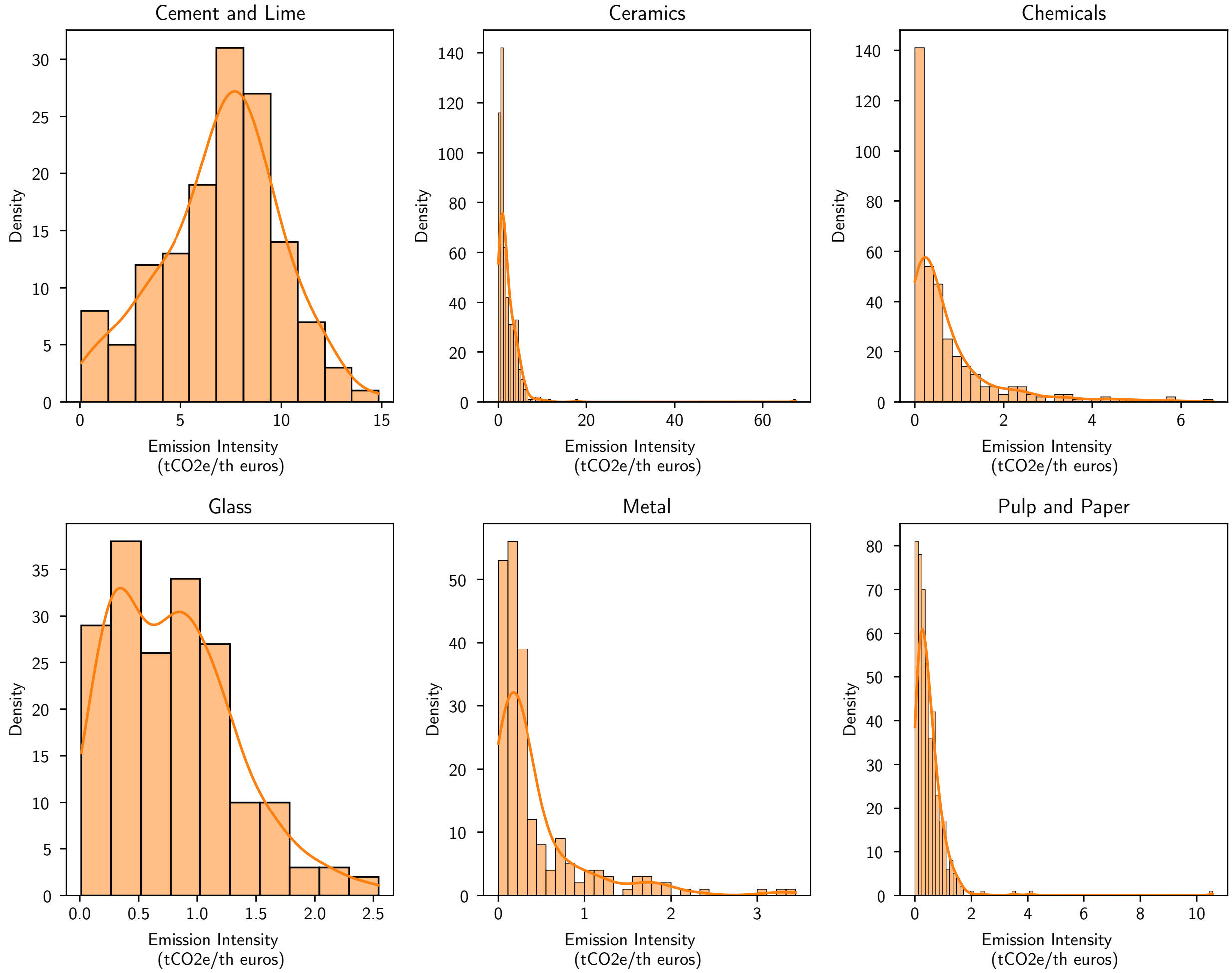


Figure 15: Distribution of emission intensity (values)



G Supplementary regression results

See next page.

Table 14: Regression of economic performance indicators on emission intensity (volumes)

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	OLS
log EmissInt_{t-1} (vol)	0.0363	−0.0265	−0.0308	0.00768	0.0103
	(0.0323)	(0.0581)	(0.0410)	(0.0261)	(0.0130)
# opened inst_{t-1}	0.00582	0.0374**	0.0288	−0.000319	0.00606
	(0.00429)	(0.0161)	(0.0201)	(0.00379)	(0.00471)
Stringency idx_{t-1}	−0.00000133	0.00000521***	0.00000417***	−0.00000267***	0.00000127
	(0.00000117)	(0.000000862)	(0.000000673)	(0.000000692)	(0.000000891)
log Turnover_{t-1}	0.205***	0.163	0.0877	0.182***	−0.128**
	(0.0606)	(0.130)	(0.0655)	(0.0567)	(0.0596)
log Current ratio_{t-1}	−0.0380**	0.0377	−0.00257	−0.0304**	0.0213*
	(0.0186)	(0.0428)	(0.0246)	(0.0147)	(0.0125)
logNet transactions $(\text{val})_{t-1}$	−0.000544	−0.000975	0.0000852	−0.000448	0.000659*
	(0.000432)	(0.00159)	(0.00109)	(0.000381)	(0.000395)
Observations	6128	4666	5481	6128	6128
Firm Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time FE	*No*	*No*	*No*	*No*	*No*
Sector-Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
HB-corrected p-value	1	1	1	0.769	1

Notes: Standard errors are in parenthesis, clustered at the firm level. Holm-Bonferroni-corrected p-values are reported for the Emission Intensity coefficient.

* p<0.10, ** p<0.05, *** p<0.01

Table 15: Regression of economic performance indicators on emission intensity (values)

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	OLS
log EmissInt_{t-1} (val)	-0.00692	-0.0343	0.00849	-0.0288^{*}	0.0149
	(0.0185)	(0.0377)	(0.0242)	(0.0174)	(0.0178)
# opened inst_{t-1}	-0.000159	0.0439^{**}	0.0315	-0.00284	-0.000654
	(0.00507)	(0.0177)	(0.0194)	(0.00561)	(0.00450)
Stringency idx_{t-1}	-0.00000158^{**}	0.000000137	0.00000186	0.000000500	0.000000693^{**}
	(0.000000697)	(0.00000146)	(0.00000146)	(0.000000634)	(0.000000326)
log Turnover_{t-1}	0.194^{***}	0.0634	0.0278	0.131^{***}	-0.108^{***}
	(0.0402)	(0.107)	(0.0571)	(0.0374)	(0.0372)
log Current ratio_{t-1}	-0.0271^{*}	0.0687^{*}	-0.00564	-0.0111	0.0207
	(0.0155)	(0.0401)	(0.0215)	(0.0132)	(0.0129)
logNet transactions $(\text{val})_{t-1}$	-0.00114^{***}	-0.00204	-0.000919	-0.00104^{***}	0.0000346
	(0.000406)	(0.00146)	(0.000941)	(0.000392)	(0.000353)
Observations	8696	6284	7501	8696	8696
Firm Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time FE	*No*	*No*	*No*	*No*	*No*
Sector-Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
HB-corrected p-value	1	1	0.726	0.485	1

Notes: Standard errors are in parenthesis, clustered at the firm level. Holm-Bonferroni-corrected p-values are reported for the Emission Intensity coefficient.

* p<0.10, ** p<0.05, *** p<0.01

Table 16: Regression of economic performance indicators on emission intensity IV x import intensity (values)

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IV2SLS	IV2SLS	IV2SLS	IV2SLS
log EmissInt_{t-1} (val)	-0.308^{*}	-0.708	0.357	-0.130	0.118
	(0.163)	(0.572)	(0.265)	(0.122)	(0.104)
log $\text{EmissInt}_{t-1} \times$ log ImpInt_{t-1} (val)	-0.0158	-0.0461	0.0193	0.000250	0.00291
	(0.00987)	(0.0366)	(0.0190)	(0.00949)	(0.00877)
log ImpInt_{t-1} (val)	-0.134^{*}	-0.341	0.0937	-0.0314	0.00650
	(0.0702)	(0.238)	(0.126)	(0.0631)	(0.0744)
# opened inst_{t-1}	0.00178	0.0397^{**}	0.00405	0.00191	-0.0000163
	(0.00504)	(0.0188)	(0.00982)	(0.00525)	(0.00366)
Stringency idx_{t-1}	-0.000000951	0.000000105	0.00000154	0.000000306	0.000000230
	(0.00000109)	(0.00000231)	(0.00000171)	(0.000000651)	(0.000000514)
log Turnover_{t-1}	0.0543	-0.499	0.180	0.0963	-0.0907^{*}
	(0.0742)	(0.372)	(0.181)	(0.0676)	(0.0524)
log Current ratio_{t-1}	-0.0208	0.0654	0.00836	-0.0181	0.0207
	(0.0210)	(0.0449)	(0.0257)	(0.0171)	(0.0156)
logNet transactions $(\text{val})_{t-1}$	-0.000791	-0.00265	-0.000227	-0.000850^{*}	0.000267
	(0.000527)	(0.00181)	(0.00113)	(0.000445)	(0.000402)
Observations	5946	4392	5218	5946	5946
Firm Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Sector-Time FE	No	No	No	No	No
First-stage coefficient	0.481^{***}	0.472^{***}	0.502^{***}	0.481^{***}	0.481^{***}
K-P rk Wald F-stat	5.366	3.987	4.127	5.366	5.366
A-R Wald test (p-val)	0.056	0.358	0.272	0.328	0.395
HB-corrected p-value	0.294	0.648	0.712	0.285	0.517

Notes: Standard errors are in parenthesis, clustered at the firm level. We report first-stage estimates of the coefficient for emission intensity, as well as its significance level, the Kleibergen-Paap F-statistic and the p-value of the Anderson-Rubin Wald test on the weak-instrument-robust inference. Additionally, second-stage Holm-Bonferroni-corrected p-values are reported for the Emission Intensity IV coefficient.

* p<0.10, ** p<0.05, *** p<0.01

Table 17: Regression of economic performance indicators on emission intensity IV and intra-branch trade intensity (value)

	log ROA	log Profit Margin	log EBITDA Margin	log Labor productivity	log Turnover over Costs
	(1)	(2)	(3)	(4)	(5)
	IV2SLS	IV2SLS	IV2SLS	IV2SLS	IV2SLS
log EmissInt$_{t-1}$ (val)	-0.297^{**}	-0.456	0.257	-0.216^{*}	0.0378
	(0.131)	(0.459)	(0.181)	(0.111)	(0.0708)
log EmissInt$_{t-1}\times$ log IbInt$_{t-1}$ (val)	-0.0116	0.0907	0.0595^{*}	0.00743	0.0139^{*}
	(0.0162)	(0.0558)	(0.0325)	(0.0132)	(0.00767)
log IbInt$_{t-1}$ (val)	-0.0349	0.681	0.474^{*}	0.0686	0.0957^{*}
	(0.103)	(0.431)	(0.259)	(0.0863)	(0.0544)
# opened inst$_{t-1}$	0.00281	0.0398^{**}	0.00861	0.00206	0.00178
	(0.00488)	(0.0183)	(0.0105)	(0.00549)	(0.00357)
Stringency idx$_{t-1}$	-0.00000131	0.000000924	0.00000158	0.000000683	0.000000614^{*}
	(0.000000843)	(0.00000197)	(0.00000164)	(0.000000635)	(0.000000348)
log Turnover$_{t-1}$	0.0510	-0.330	0.118	0.0504	-0.111^{**}
	(0.0670)	(0.318)	(0.131)	(0.0628)	(0.0458)
log Current ratio$_{t-1}$	-0.0235	0.109^{**}	0.00622	-0.0126	0.0185
	(0.0193)	(0.0477)	(0.0235)	(0.0161)	(0.0133)
logNet transactions (val)$_{t-1}$	-0.000928^{*}	-0.00171	0.000147	-0.000915^{**}	0.000301
	(0.000509)	(0.00172)	(0.00106)	(0.000455)	(0.000373)
Observations	6561	4858	5761	6561	6561
Firm Controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Firm FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Sector-Time FE	*No*	*No*	*No*	*No*	*No*
First-stage coefficient	0.429^{***}	0.437^{***}	0.428^{***}	0.429^{***}	0.429^{***}
K-P rk Wald F-stat	8.004	6.487	6.987	8.004	8.004
A-R Wald test (p-val)	0.015	0.103	0.142	0.002	0.187
HB-corrected p-value	0.117	0.641	0.468	0.208	0.593

Notes: Standard errors are in parenthesis, clustered at the firm level. We report first-stage estimates of the coefficient for emission intensity, as well as its significance level, the Kleibergen-Paap F-statistic and the p-value of the Anderson-Rubin Wald test on the weak-instrument-robust inference. Additionally, second-stage Holm-Bonferroni-corrected p-values are reported for the Emission Intensity IV coefficient.

* p<0.10, ** p<0.05, *** p<0.01

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