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Emissions Abatement: the Role of EU ETS and Free Allowances

The Italian Case

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Emissions Abatement: the Role of EU ETS and Free Allowances
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Carla Guerriero* **and Antonia Pacelli†**

Abstract
This paper uses Italian data on industrial plant emissions over a 12 years period to assess the differential impact of negative shocks in the allocation of free allowances across various industrial sectors in the context of the EU Emission Trading Scheme (ETS). Specifically, it examines the consequences of reduced free allowances for certain sectors in contrast to those that maintain their existing allocation. By using a novel indicator of emission intensity based on quantity this study shows that the absence of free allowances does not directly impact the incentive to abate emissions but foster the entry of cleaner producers. The results offer evidence of regional heterogeneity by analysing the variations in policy effects between the South and the North of Italy.

JEL Classification: D22, H23, Q54, Q58.

Keywords: Carbon pricing, free allowances, carbon leakage, emission intensity.

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1 Introduction

The European Emission Trading Scheme (EU ETS) is a marked based regulatory instrument that aims to reduce greenhouses gases (GHGs) emissions, main drivers of climate change. The EU ETS is the first and largest emissions cap and trade system which works on global pollutants. Introduced in 2005, it covers 31 countries (27 EU countries plus United Kingdom, Iceland, Liechtenstein and Norway). It caps the total volume of GHGs from more than 10,000 power stations, industrial plants and airline companies between airports of participating countries, responsible together for around 50% of European GHGs emissions and 5% of global emissions (Ispra Report, 2019). Nowadays, the EU ETS is a milestone of the European climate policy and it represents a leading and virtuous example for many other countries in the world.

The cap and trade system in Europe covers the direct emissions of firms in carbon dioxide equivalent ($C0_2eq$).[1] The criteria under which sectors and production plants are covered by the policy are illustrated in the Annex I of the Directive 87/2003/CE. Every year EU ETS firms have to surround emission permits (EUAs) that correspond to the quantity of $C0_2eq$ produced. We are currently in the fourth phase of the EU ETS. The directive became effective in 2005, when the first and pilot phase started (Phase I), ending in 2007. In the Phase I and II (2008-2012), almost all the EUAs were allocated for free, based on historic emissions (grandfathering). The penalty imposed on the companies for non-compliance in the first phase was 40 euros per tonne of CO_2eq. As it is well known, too many EUAs had been freely allocated to plants, and it lead to an oversupply of EUAs and a consequent fall in their price, eventually to zero at the end of the period. Providing allowances for free to some firms which are in the ETS or about to enter in the system is the result of the analysis on carbon leakage, competitiveness and international trade considerations. Carbon leakage refers to the situation that may occur if businesses transfer their production (or, import carbon-intensive intermediate goods) to other countries with laxer emission constraints or where emissions are completely unregulated. This could lead to an increase in global emissions and therefore the scope of the policy might be completely undermined. The free allocation of allowances deals with the risk of carbon leakage by reducing the costs of compliance faced by the operators covered by the EU ETS. Moreover, policy makers justify the existence of the free allowances to safeguard the competitiveness of industries covered by the EU ETS. From 2008 to 2012 (Phase II), the EU imposed

[1] Each allowance gives to the holder the right to emit a ton of CO_2 or the equivalent amount of other powerful GHG, nitrous oxide (N_2O) and perfluorocarbons (PFCs).

a tighter emission cap by reducing the total volume of EUAs by 6.5% compared to the first phase. In 2008 Iceland, Norway and Liechtenstein joined the EU ETS. Within this phase, flights within the borders of the EU ETS countries were included. Up to 10% of the allowances could be auctioned. The penalty for non-compliance became of 100 euros per ton of CO_2eq. The price felt down again from 30 euros to less than 7 euros due to the great financial crisis. 2013 is the beginning of the Phase III, which is the focal point of this paper. The EU-Parliament (2009) revised the EU ETS from the third phase in many aspects.[2] The main points are that it includes an emission cap uniformly over the EU to achieve the GHG reduction target more effectively. The cap decreases by 1.74% per year. More importantly, the main allocation method was modified from grandfathering to auctioning. In 2013, allowances for more than 40% of all verified emissions were auctioned. The current phase is the Phase IV (2021-2030) which also faced novelty and amendments: among those, an increased reduction of the cap (from 1.74% to 2.2% per year) and the gradual phase out of free allocations. The current price of the EU ETS allowance is 80 euros per ton.

The beginning of the Phase III (2013) is a crucial point in the development of the EU ETS: in 2009, the European Commission revised the EU ETS for the third phase. The main reason that made this amendment necessary was the ineffectiveness of the EU ETS due principally to the very low price; moreover, it was subject to several frauds as mentioned in the work Nield (2011). In the Phase III,the main allocation method was modified: from grandfathering to auctioning.[3] Based on some benchmarks and carbon leakage considerations, some EU ETS sectors kept the same share of free allowances (as steel, ceramics and refinery) of the previous phase.

This paper evaluates an aspect of fundamental importance for the EU ETS: emissions abatement. The most hoped-for effect of introducing a market of permits to emit CO_{2eq} is to provide incentives to companies to produce the same quantity with a lower environmental impact. The objectives of this study are the following: first, the objective is to build a powerful emission intensity indicator based on emissions and quantity, exploit a unique dataset[4] covering emissions and quantity of Italian plants from 2005 to 2019, for 8 manu-

[2] Directive 2009/29/EC.

[3] Hepburn et al. (2011) study the different macro effects of auctioning vs free allowances allocation methods.

[4] The Italian dataset through the Convention ISPRA-DiSES. The dataset contains plant-level detailed data on emissions, quantity and plant location, which is relevant for building the emission intensity indicator and for the regional analysis: North vs South.

facturing sectors.[5] Secondly, by using the novel indicator the study investigates what is the impact of a shock in provision of free allowances on abatement behaviour of firms. This question is particularly attractive since we observe a severe cut in free allowances issuance in 2013, after the 2009 amendment. Third, analysing the potential regional heterogeneity within Italy (northern vs southern areas) sheds light on the differences in emission intensity patterns. This research contributes to the existing literature by providing insights into the effectiveness of policy changes and potential regional disparities within the EU ETS framework. Understanding these dynamics is crucial for policymakers and stakeholders involved in climate mitigation efforts. The increasing importance of the role of carbon markets for our institutions was clarified in the speech of the European Commission President, Ursula von der Leyen, during the COP28 (December, 2023):

> We all know: if we want to keep global warming below the tipping point of 1.5 degrees, we need to cut global emissions. There is a way to cut emissions while fostering innovation and growth. Put a price on carbon. The message is very clear: you are polluting, you must pay a price. You want to avoid the payment, then innovate and decarbonise.

The empirical exercise proposed in this research project focuses on Italian firms. Italy generates 11.4% of EU's total greenhouse gases emissions, and almost the 10% of the ETS plants are based in Italy. Since 2005, it has reduced emissions at a faster rate compared to the EU average, as reported in the European Parliament Briefing (2021). Moreover, the North and the South of Italy are characterized by heterogeneity in industrial sectors and economic structure, which is interesting to further investigate.

The branch of the literature on the impact of EU ETS has grown fast in recent years. Some papers have investigated how the EU ETS affects various economic and environmental aspects, including emissions, economic performance, and investments. These studies typically concentrate on individual European countries due to the existence of national registries for detailed firm private data. Wagner et al. (2014) is a paper focused on french manufacturing firms, and similar research has been carried out for Germany (Petrick and Wagner (2014), Löschel et al. (2019)), Norway (Klemetsen et al., 2020) and group of countries as shown in Dechezleprêtre et al. (2023), which includes the United Kingdom, France, Norway, and the Netherlands. These studies consistently identify a reduction in carbon emissions of approximately 8-10%, without observing significant effects on economic performance indicators such as employment, value added, carbon leakage,

[5] Agri-food, ceramics, glass, paper and wood, refinery, steel, textile and thermoelectric.

and/or investments. For example, Naegele and Zaklan (2019) reviews the studies on carbon leakage and the authors so far do not find any evidence of carbon leakage caused by the introduction of EU ETS. These results might be driven by the low price of carbon and the relatively short time span considered. Given the low cost of the emission permits, it becomes challenging to rationalize decisions such as relocating production facilities or shifting supply chains towards goods imported from unregulated regions. Related to the present paper, a feature discussed in the literature is how to define emission intensity. Generally, it is defined as the ratio between emissions and GDP (European Parliament Briefing, 2021), or emissions and value added or employment if the analysis is at firm level (Wagner et al., 2014). By using the rich dataset at plant level of the Italian Registry, the contribution of this work is to construct a pure indicator of emission intensity based on quantity.

Furthermore, it is important to note that many of these papers acknowledge the potential role of free allowances within the EU ETS, although they generally do not conduct extensive investigations into their impact on the outcomes under consideration. Related to the investment branch of the literature, some papers focus on the potential effect on innovation (D'Arcangelo and Galeotti, 2022) and productivity (D'Arcangelo et al., 2022). Calel and Dechezleprêtre (2016) find that the EU ETS has increased low-carbon innovation among regulated firms by around 10%. This paper adds an additional feature to this result: the implementation of low-carbon technologies mainly comes from the new entrant firms in the EU ETS, belonging to the sectors that faced a cut in the free allowances provision.

The main finding of this work is that the cut of free allowances has an impact on the emission intensity at sectoral level. In particular, the group of sectors facing a reduction in free allowances experiences a decline in emission intensity compared to the others that continue to receive full or same share of subsidies. However, this study shows that the result is mainly driven by new entrants, at least in the short-run. The reduction of free allowances on emission intensity does not provide direct incentives to abate emissions, but the reduction fosters the entry of more sustainable producers. It is consistent with the assumption made in the theoretical model of Ambec et al. (2023). Emission intensity is measured as an estimate of the direct CO_2eq embodied in each product, representing a novel approach in the literature. This lack in the previous studies is mostly due to the limited availability of plant-level production data.

Can European authorities learn from the Italian case? Focusing on the role of free allowances as policy tool, the contribtion of the paper to the existent literature is the analysis of the effect of reducing free allowances on the emission intensity. Since the aim of the policy is to effectively and efficiently reduce the emissions (at least cost for firms),[6] it is crucial to evaluate the optimal policy tools mix to achieve these objectives.

The paper proceeds as follows: Section 2 describes the context and the state of the art of the EU ETS. In the Section 3 are described the data and the methodology used in the analyses, followed by the Section 4 which illustrates the results.

2 Free Allowances and Emissions

The practical effectiveness of the EU ETS relies on plants paying the permit price for their emissions. The allocation of a significant share or the provision of total free allowances can potentially influence the entry and exit of environmentally unsustainable producers and affect emission reductions at the sectoral level. The theoretical model presented by Ambec et al. (2023) shows that the share of free allowances does not directly provide incentives to abate emissions, but it fosters the entry of carbon intensive producers. Does it describe the mechanisms in the real world?

An examination of Figure 1 reveals a substantial reduction in the issuance of free allowances in the first year of Phase III (2013-2020), due to the implementation of the EU-Parliament (2009) Directive 2009/29/EC. As shown in Figure 1, it presents also the annual $C0_2eq$ emissions tonnes in Italy from plants covered by the EU ETS policy. The emissions exhibit a declining trend, which intuitively aligns with the objectives of the policy to reduce greenhouse gas emissions. However, as previously mentioned, the underlying aim of this European directive is to achieve emission reductions without compromising the economic performances of the regulated firms. Therefore, while a decreasing emissions trend appears favorable, it is crucial to examine whether it is driven by a shift towards low-carbon production or due to underproduction. This aspect holds significant relevance in evaluating the intended and unintended effects of the policy.

[6] Article 1 of the EU-Parliament (2003) Directive 2003/87 clarifies that the aim is "the reduction of greenhouse gas emissions in a cost-effective and economically efficient manner". The presence of free allowances might influence and drive emission abatement decisions.

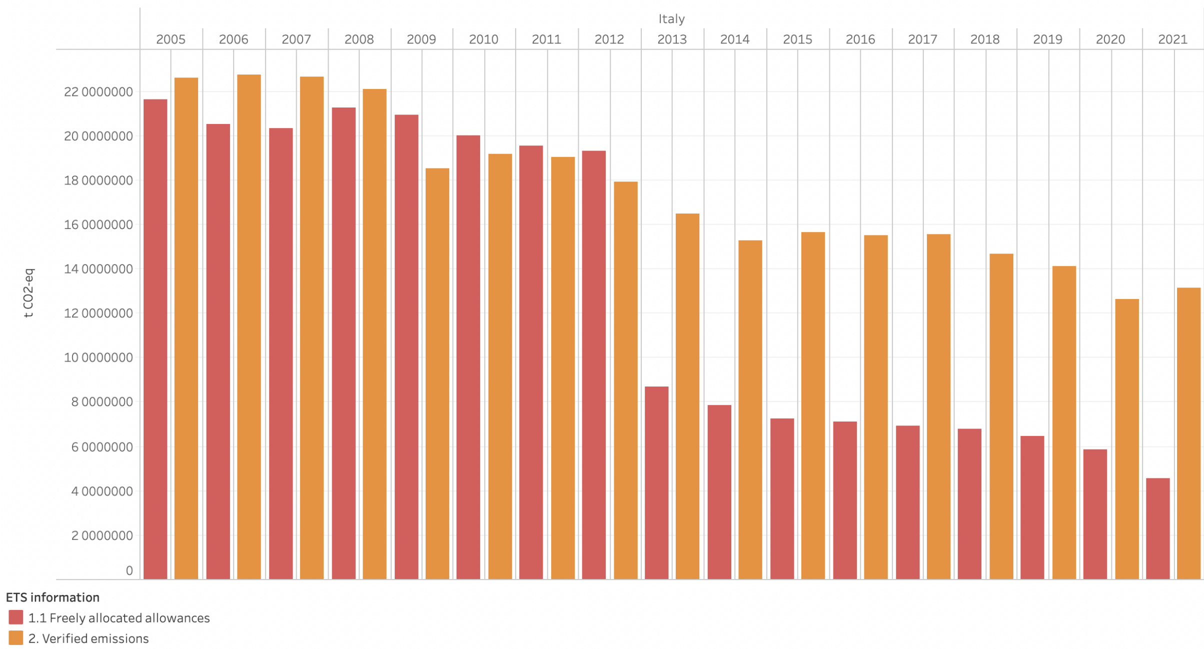

Figure 1: Free allowances and verified ETS emissions in Italy, all sectors.
Source: European Environmental Agency data viewer.

3 Data and Methodology

The objective of this section is to provide a description of the dataset used in the present paper with a particular focus on the components of principal metric driving the analysis: the emission intensity. It is essential to analyse its two components (quantity and emissions) to comprehend the economic implications of the policy and its instruments. Following the illustration of the data, the section proceeds to show the methodology employed in the data analysis.

3.1 Data

The database utilized for this study incorporates data from multiple sources, including the publicly available EUTL platform, the European Environmental Agency (EEA) data source, and the Italian Registry of the EU ETS.[7] The data goes from the EU ETS implementation (2005) to the year before the COVID-19 pandemic (2019). The analysis includes eight sectors, considering both 2-digit and 4-digit NACE classifications, as well as specific product-level analyses. The sectors and corresponding NACE codes are outlined in Table

[7] Access to this dataset was obtained through the ISPRA-DiSES Convention, ensuring compliance with privacy rules. The data provided are aggregated at the sectoral level, preserving confidentiality.

3.1.

Sector	NACE (Rev.2)
Agri-food	10;11
Ceramics	23 (excl. 23.1;23.5)
Glass	23.1
Paper and Wood	16;17;18
Refinery	19
Steel	24-25
Textile	13
Thermoelectric	35

Table 3.1: Sectors and NACE codes.

The inclusion of sector-specific considerations arises from the heterogeneity in the 2013 cut of free allowances across sectors. Notably, the reduction in free allowances predominantly affected sectors such as thermoelectric, agrifood, textile, glass, and paper. In contrast, the remaining sectors either retain full subsidies or continue to receive an equivalent proportion of free allowances, as in the case of the refinery sector.

Hence, the primary variables subject to investigation in the ensuing analyses encompass plant-level observations of emissions, quantity produced, geographical location, and allocated free allowances.

It is essential to underscore that the sample utilized for this analysis exhibits an unbalanced nature, attributed to the inherent dynamics of the EU ETS framework. This unbalanced nature arises from plants opting in and out the EU ETS (see Figure 2).

Notably, the transition from Phase II to Phase III of the EU ETS witnesses a substantial number of plants undertaking the opt-in and opt-out options. Of particular interest is the examination of the sectors where such opt-in and/or opt-out dynamics are observed, along with an exploration of the type of new entrants within each sector.

3.1.1 Quantity and emissions

The emission intensity metric has two components: emissions and quantity. The first stage involves comprehending the temporal trajectory of these components and elucidating their interrelationship. This endeavor aims to discern the distinct impact of an incremental unit of quantity produced on emissions. This analysis helps to disentangle fixed and variable environmental costs. Fixed environmental costs are independent from

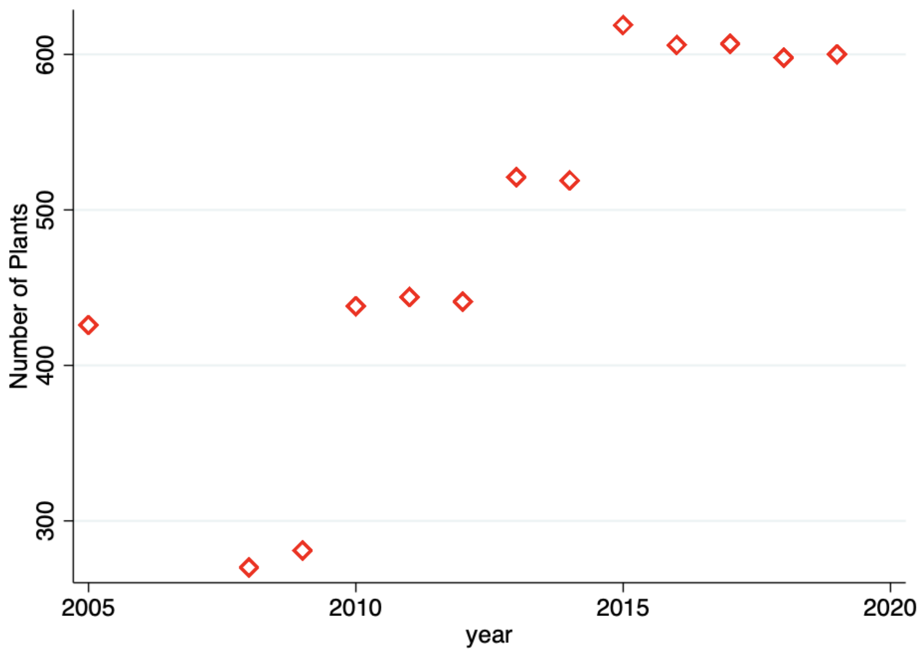

Figure 2: Number of plants in the sample.

the amount of quantity processed and produced - for instance, machinery that constantly operates. In contrast, variable environmental costs exhibit a direct correlation with quantity, and any fluctuations in the latter generates alterations in the former.

Overall, the quantity produced by EU ETS plants has increased over time in the sectors considered in this analysis, as Figure 3 shows. One reason of this increasing trend depends on the increased number of plants over time (from 400 to 600 plants in the Italian sample). However, also considering only the plants that have observations before and after 2013, the quantity has an increasing trend.

Figure 4 provides a flavour of the heterogeneity across sectors in the quantity trends. It is possible to generally observe an increasing trend, except for glass and thermoelectric sectors, where it is pretty stable or decreasing. In the glass sector in 2013 an 2014 some firms misreported the data: production data are not on tonnes but number of pieces or square meters, which makes hard the conversion in tonnes. So, the trend in the production of glass is stable and does not experience any drop in those years. Without considering new entrants and opting out plants, sectors as agri-food, textile and refinery have an increasing trend in production, whereas in the other we observe a stable or decreasing trend. Ceramics is a sector that experienced a relevant opted in in 2013, however the plants already covered before the beginning of Phase III overall reduced their production.

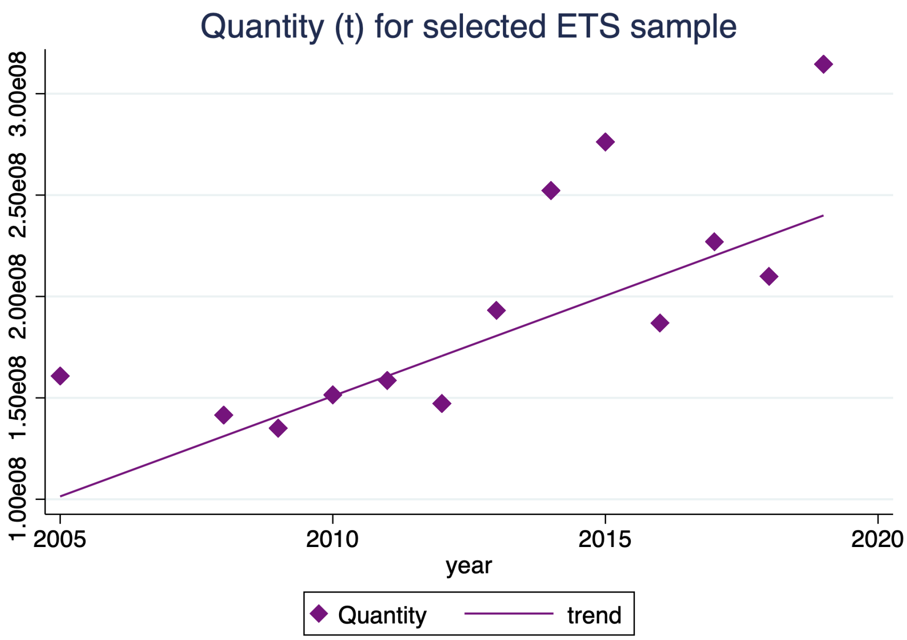

Figure 3: Quantities for selected Italian plants, excluding thermoelectric.

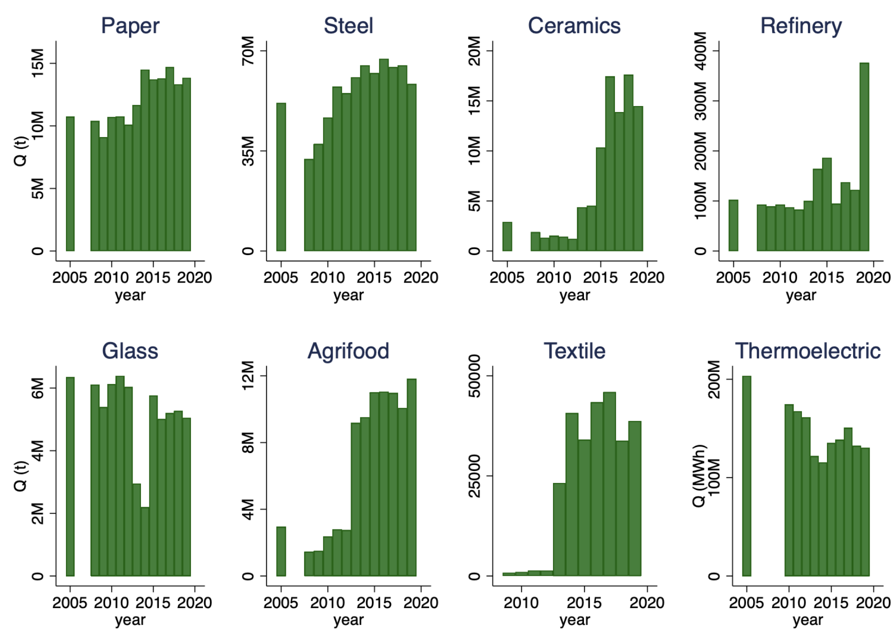

Figure 4: Quantities for selected Italian sectors.

The other component of interest is the level of emissions. Figure 5 exploits the path of emissions, considering exclusively the plants situated within Italian borders across the specified sectors (sourced from EEA data). The graph distinctly illustrates a decline in emissions commencing from 2009, coinciding with the period of the Financial Crisis. Concurrently, it has been already discussed that the year 2009 marks the announcement of reforms for the EU ETS in preparation for Phase III (2013). Over the observed span, the emissions path exhibits a pervasive downward trend, signifying a positive signal for the EU ETS. However, it is important to note that while this downward trend is encouraging, it alone does not suffice to conclusively affirm the efficacy of this policy or to assert that it has not engendered adverse consequences on the operational efficacy of the encompassed firms.

This pivotal consideration forms the foundation for the initial emphasis on the quantity dimension in this work. The computation of the emission intensity indicator, which gauges emissions in relation to production volumes, serves as a strategic approach. By evaluating the metric of emissions per unit of production, a more sophisticated assessment emerges. This approach enables the research to delve beyond the overarching emissions trend and consider how and why emissions reduced.

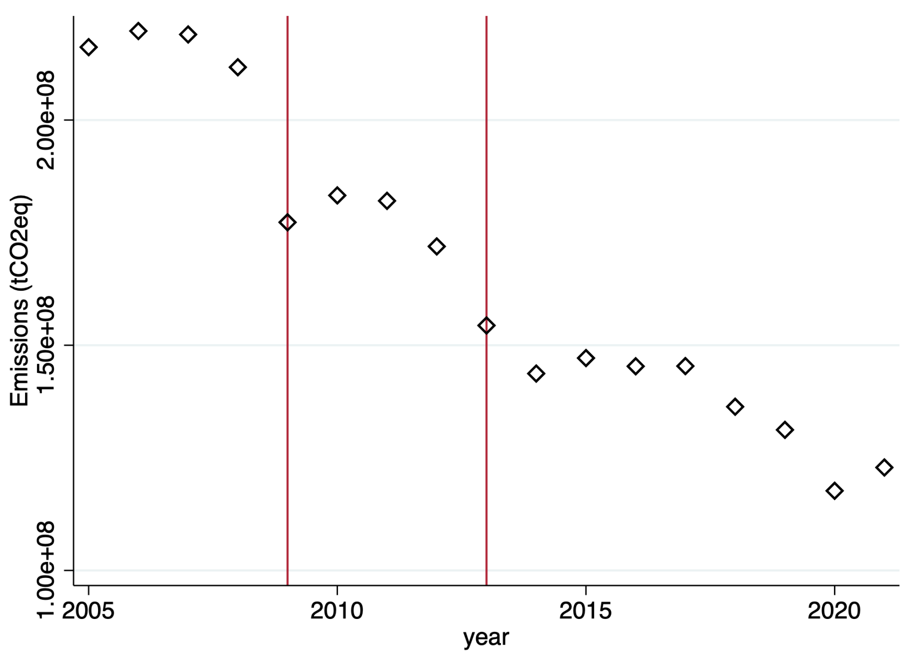

Figure 5: Path of Verified Emissions for the selected Italian sectors.

To precisely assess whether the observed trend reflects a transition to low-carbon production or underproduction, this paper builds the measurement of emission intensity. This measure is a valuable contribution to the literature: it is a novelty because based on quantity produced, data not generally available.

3.2 Methodology

Exploiting the unique features and richness of this dataset, the present paper creates the emission intensity (EI) indicator, computed as the ratio between emissions (e) and quantity (q) produced annually, both measured in tonnes. The only exception is for thermoelectric sector, where the output is measured in megawatt per hour. This is why it is treated separately, even if the measure of the indicator goes in the same ranges of the other sectors. Therefore, in a part of the analysis it is considered mixed with the others.

The emission intensity computation is described from the following equation:

$$EI_{i,t} = e_{i,t}/q_{i,t} \tag{1}$$

The EI indicator is therefore based on two components: emissions and quantity produced. The path of EI provides an important piece of information: considering an increasing or stable path in production quantities, if the emission intensity decreases over time it means that firms are investing in technologies and innovation for producing the goods in a more sustainable way. In this context, a decreasing emission intensity path is an hoped result for the EU ETS policy, because it represents a good signal of greener production without undermining economic performances and the production levels. On the contrary, an increasing path it is a bad signal for the environmental standards of the production, which is not desirable. Moreover, an increase in the EI is a possible scenario in period of crisis, where fixed environmental costs are constant (e.g., machinery that cannot be turned off) but production goes down.

The emission intensity indicator is used for answering to the main research question addressed in this paper: what is the role of free allowances on abatement behaviour of firms? In other words, the empirical exercise proposed assesses the effects of the reduction in the provision of free allowances on the emission intensity. Figure 6 illustrates the share of free allowances per sector over time. Notably, certain sectors, specifically paper, combustion (primarily comprising thermoelectric, agri-food, and textile industries), and glass, underwent a notable reduction in their allocation of free permits in 2013. Conversely, several other sectors maintained a substantial or complete share of allowances allocated without cost. This observation implies that, despite their formal inclusion within the EU ETS, these sectors do not fully or directly internalize the cost associated with emissions through the permit pricing mechanism. An interesting case is the refinery sector, which encountered a reduction in free allowances at the commencement of Phase II (2007). In 2013, the allocation of free allowances for refinery plants did not experience a shock. Therefore, the sectors allocated in the treated group are the ones that experienced a shock from the Phase II to the Phase III. Conversely, in the control group the sectors did not observe a significant change due to the Phase III amendment. The contextual circumstances presented provide a conducive environment for employing the difference-in-differences methodology as the chosen analytical approach.

The difference-in-differences approach is employed to disentangle the specific effect of interest. The treatment is the shock in free allowances allocation, wherein specific sectors encountered a substantial reduction in their free allowances in 2013, thereby necessitating the procurement of emission permits from the market. In this case, the treated sectors are paper, glass, agri-food and textile. In contrast, other sectors continued to receive substantial allowances, some even obtained them entirely free of charge: steel, refinery and ceramics.

Differences-in-differences regression constitutes a methodological avenue utilized to discern the causal impact of an event. This entails a comparative analysis between units that experienced the event (treated) and those that remained unaffected (control). This methodological approach is grounded in the foundational principle that in the hypothetical absence of the event, the discrepancy between the treated and control groups should remain constant over time.

The descriptive analysis intuitively suggests that generally the free allowance provision was massive and over-estimated up to 2013 (data source European Environmental Agency), as it is clearly showed in Figure 7. The over-estimation comes principally from the difficulties to estimate the allowance needs in advance. The estimates were based on historical emission data, however the collection of environmental data in Italy starts with the announcement of the EU ETS: before this policy, the dataset was scarce and not accurate. Furthermore, it is worth highlighting that the allocation of free allowances also extends to new entrants. This accounts for the observed peak in the ceramic industry, attributed to the inclusion of numerous new ceramic firms during the inception of the third phase.

The most significant decline in the proportion of free allowances is evident within the glass sector and the broader combustion industries, encompassing agri-food, textile, and thermoelectric sectors. While the thermoelectric sector primarily drives this reduction, a

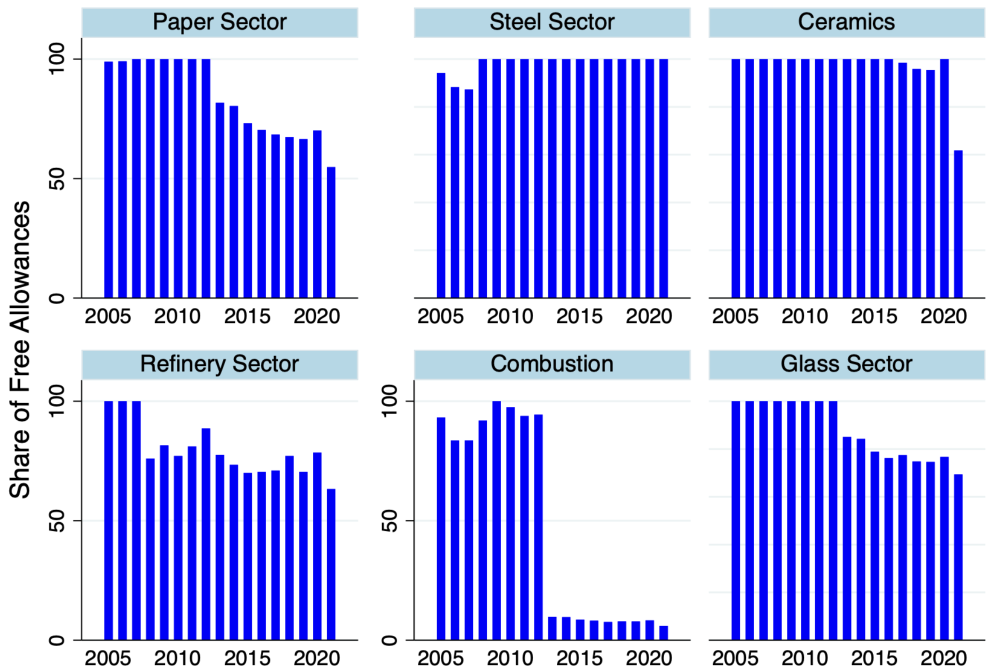

Figure 6: Share of Free Allowances for selected Italian Sector.

substantial drop is also verified in the agri-food sector in 2013.

3.2.1 Quantity and emissions in treated and control group

The quantity produced has an increasing trend both for the treatment and control groups. In levels, the quantity produced in the sectors belonging to the control group is higher than the treatment group ones, even if they have less production plants. This disparity in production quantity is attributed to the variations in production volumes, with the control group exhibiting higher volumes compared to the treated sectors.

Figure 8 illustrates a positive trend for both groups, signifying an encouraging trajectory. The upward trend observed in the quantity variable serves as a favorable indication for the efficacy of the ETS policy. The thermoelectric sector is excluded due to its distinct output measurement unit (MWh instead of tons).

Within the realm of carbon pricing, a prominent concern revolves around its potential impact on the economic performance of firms. Policymakers advocate for the implementation of such policies under the principle of *least cost*, implying that any reduction in emissions should not stem from diminished production output. Consequently, the ob-

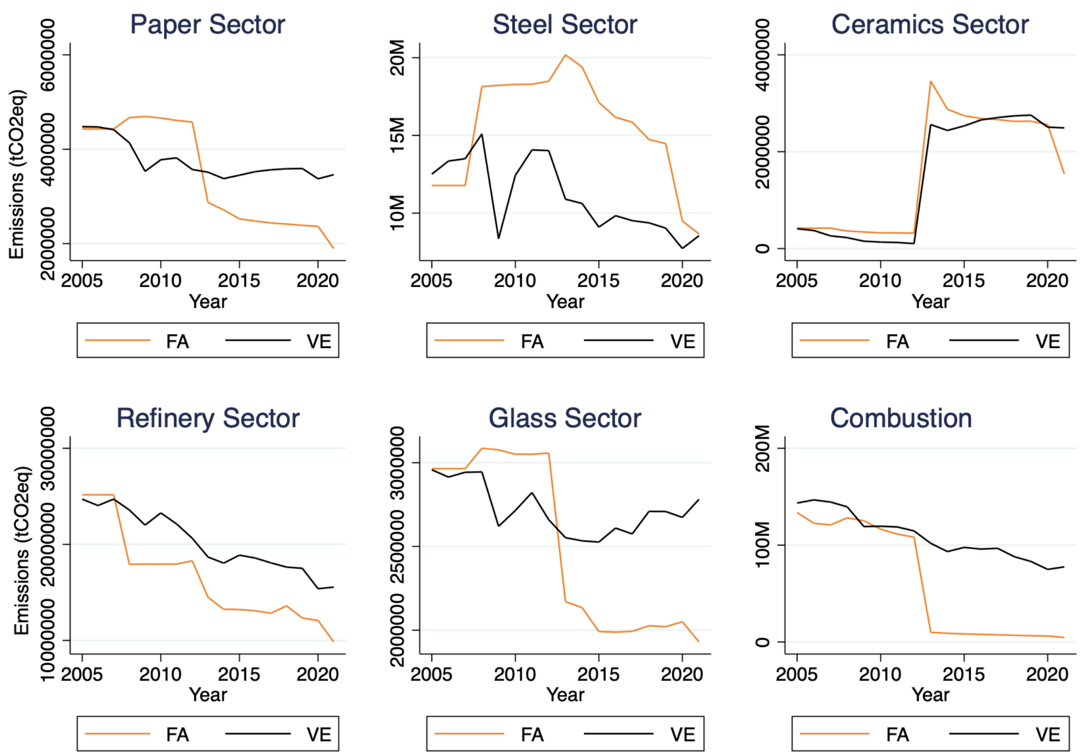

Figure 7: Free Allowances and Verified Emissions in Italian sectors.

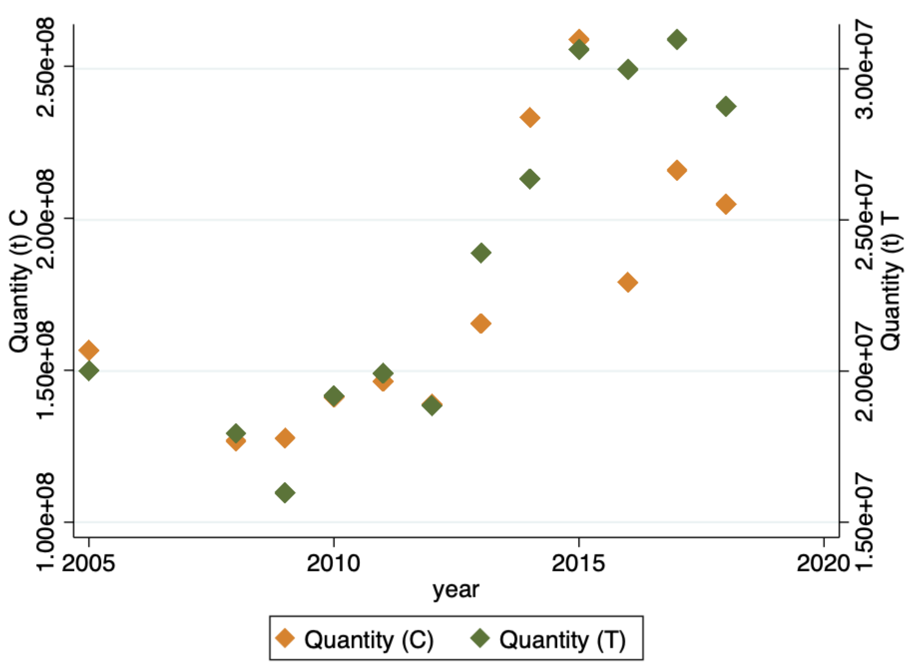

Figure 8: Quantity for the control and treatment groups, excluding thermoelectric.

served positive trends depicted in Figure 8 intuitively suggest that the implementation of the EU ETS has not adversely affected production levels. This would align with the broader empirical literature on the EU ETS, which commonly does not find a significant impact on the economic performance of firms. Prominent papers within this literature include Wagner et al. (2014) and Dechezleprêtre et al. (2023).

However, the progressive increase in production volumes portrayed in Figure 8 is not solely attributed to a surge in production intensity but is also influenced by the escalating number of EU ETS plants over time in the sectors considered. This dynamic becomes particularly apparent when considering the evolving count of plants, which displays an upward trajectory over the same period, as depicted in Figure 9. This trend is observable across both the treated and control groups.

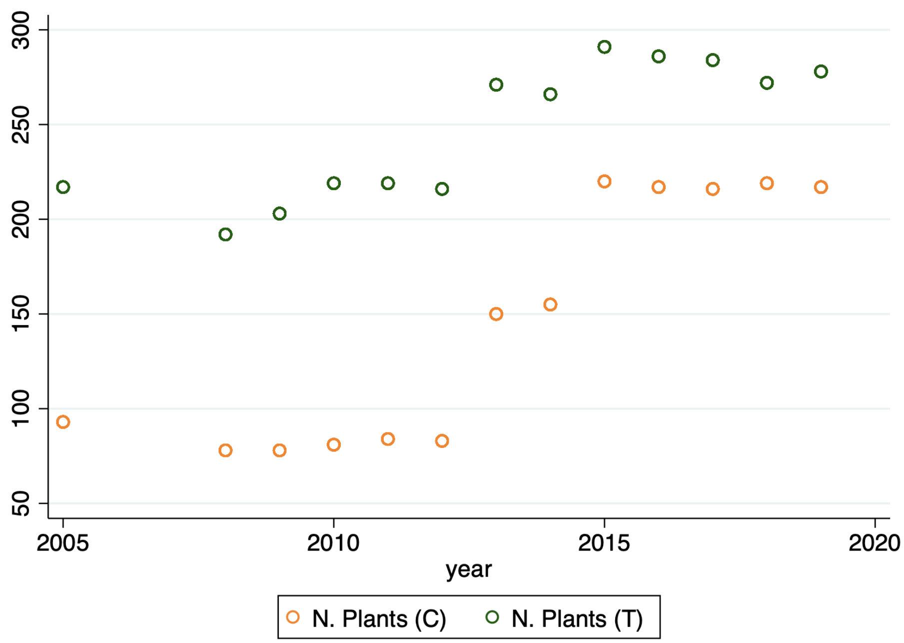

Figure 9: Number of plants in the treated and control groups, excluding thermoelectric.

Analyzing the emissions data, a significant reduction is predominantly evident within the control group. Conversely, the treated group showcases a marginal increase in emissions. However, these observations underscore the motivation underlying the focus of this work on emission intensity at the plant level. While an overview of these emissions data offers valuable insights, it is important to recognize that drawing conclusions about the impact of the EU ETS on abatement choices of plants necessitates a deeper approach. Emission intensity emerges as a pivotal metric, quantifying the ratio of emissions in metric tons to the quantity of product produced over time.

It is noteworthy that the thermoelectric sector exhibits a notable downtrend in both quantities produced and emissions. This trend is partly attributed to the significant number of plants that opted out of the EU ETS in the beginning of the Phase III (see Appendix 4.5.1 for further details).

Before delving into the findings pertaining to the aforementioned potential influence of the free allowances cut on emission intensity on the whole sample, the subsequent paragraphs elucidate the foundational mechanisms underlying the second research question: an exploration of the contributors to emission intensity reduction, specifically examining whether it stems from plants that have been part of the EU ETS since its inception in 2005 or from newly entered participants. In this study, these two distinct groups will be referred to as the "established" group, comprising plants that have been part of the EU ETS since 2005, and the "new entrants," encompassing recently incorporated plants that joined the EU ETS at a later stage (Phase III).

3.2.2 Emission Intensity

This study has thus far presented a descriptive analysis of the temporal trends in quantity and emissions within Italy over the years encompassing the EU ETS implementation. On initial examination, there emerges a perceptible increase in the overall quantity produced by firms operating within the ambit of the EU ETS framework, coupled with a corresponding decline in emissions. At face value, this observable trend suggests a positive trajectory in terms of the efficacy and outcomes of the EU ETS policy.

However, the core of this analysis delves beyond the surface interpretation. The underlying mechanisms driving these trends requires deeper exploration: it is interesting to investigate specific sectors that may lead these shifts. Furthermore, a more detailed analysis seeks to distinguish between two scenarios: the potential emission reductions by firms that have been participants since the inception of the EU ETS, versus the dynamic where cleaner producers entered over time while less environmentally friendly entities exited. Clarifying these intricacies is a fundamental objective in deciphering the impacts and mechanisms of the EU ETS policy.

Examining the trajectory of emission intensity as illustrated in Figure 10, it becomes evident that there is a discernible pattern. The graph displays a declining trajectory from 2009 until 2014, followed by a subsequent upward trend until 2018. This temporal evolution in emission intensity is indicative of a dynamic and potentially influential phenomenon.

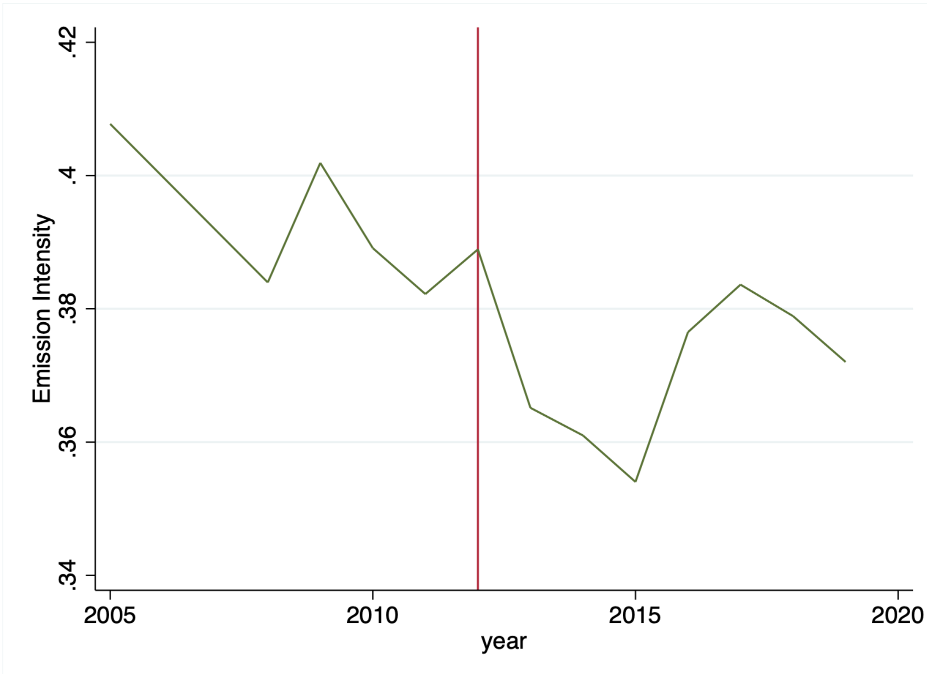

Figure 10: Path of Emission Intensity for the selected Italian sectors, except thermoelectric.

The figure that includes thermoelectric plants has a similar path (see the Appendix 4.5.1).

With the descriptive framework completed, the Section 4 will delve into the findings derived from the analysis.

4 Findings

This section presents the findings derived from the comprehensive analysis of the effects of free allowances reduction on emission intensity within the context of the EU ETS. Building on the preceding descriptive exploration, the following paragraphs delve into the core outcomes of this study. Specifically, it aims to unravel the intricate interplay between policy changes and industrial dynamics, shedding light on how these factors collectively shape the emission intensity trends. The analysis begins by examining the alterations in emission intensity across sectors within both the treatment and control groups. This examination serves as a foundational step in understanding the overarching patterns that might indicate policy-induced shifts. Additionally, the influence of new entrants is closely examined, as it is a factor that can significantly affect the outcomes of the analysis.

By dissecting the role of these entrants, this study aims to provide a perspective on how policy changes interact with industrial evolution, highlighting both anticipated and unforeseen consequences. Through these findings, this analysis contributes to a deeper understanding of the multifaceted impact of policy interventions within the EU ETS framework.

4.1 Balanced sample: EU ETS plants since 2005

An interesting research question is whether an increasing (decreasing) emission intensity is primarily driven by the efficiency (inefficiency) of new entrants, or if it stems from innovation within the plants that have been participants in the EU ETS since its inception. To address this question, it becomes imperative to examine a subset of the sample comprising plants that have remained within the EU ETS framework since its inception and are still operational today. In this work, this sample belongs to the ”established” group. By doing so, it becomes feasible to disentangle the effects of potential enhancements in carbon intensity among ETS ”established” plants, and to discern the influence of new entrants on this metric.

This subset comprises a total of 129 plants, with 87 falling within the treated group and 41 within the control group. It is important to note that observations for the thermoelectric and textile sectors are absent, and the food industry includes only one plant with complete data for the entire period, leading to its exclusion from the analysis. This refined sample ensures balance, encompassing observations spanning from 2005 to 2019, with the exception of 2006 and 2007 due to data gaps and under-reporting in the Italian Registry.

Figure 11 illustrates the distribution within the balanced sample. This subset excludes sectors lacking continuous plant data from 2005 to 2019 (such as thermoelectric and textile sectors). Additionally, the food industry sector, having only a single observation, was omitted for privacy considerations. It is evident from the figure that a significant proportion of the sample pertains to the paper industry, contributing 71 observations per year.

The behaviour exhibited by each sector concerning the components of interest holds paramount significance in comprehending the underlying mechanisms inherent to the analysis of the entire sample. Figure 12 provides an account of the sector-specific trends in emission intensity, quantity produced, and emissions within the established plant sam-

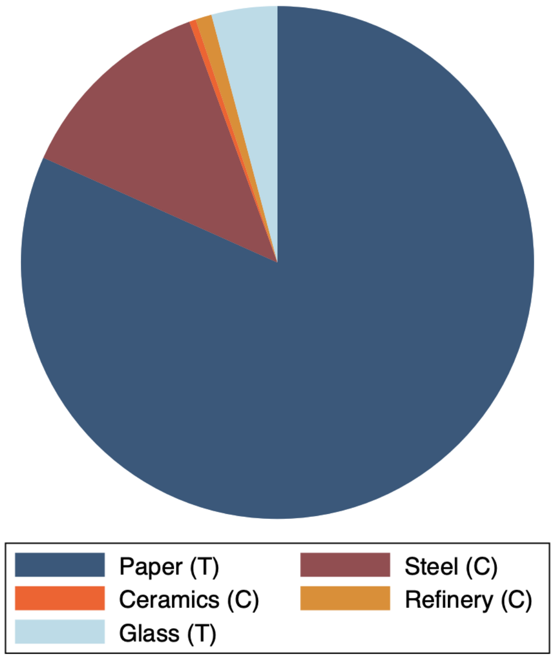

Figure 11: Sectoral composition of the balanced sample.

ple.

The sample is divided into control and treated plants. Control plants are those in sectors that did not experience a reduction in free allowances provision in the Phase III due to the amendment. Within the control group, the ceramics sector saw a decline in both emissions and quantity produced, subsequently leading to an increase in the average emission intensity over time. A similar trajectory is observed for the emission intensity of steel plants, which shows a slight upward trend. Notably, the refinery sector stands out as the top performer in the control group, showcasing a decreasing emission intensity trend, largely attributed to the concurrent increase in quantity produced. In the treated group, the emission intensity demonstrates a negative peak between the years 2012 and 2015, followed by a relatively stable pattern. However, the drivers behind these trends differ between the two sectors. For glass plants, emissions initially decrease from 2005 to 2009 before stabilizing, alongside a concurrent decrease in quantity produced. Conversely, the paper sector exhibits a slight upward emission trend, aside from an initial drop, coupled with an increase in quantity up until 2017.

The sector-specific descriptive analysis performed so far, while informative, does not provide a clear indication of whether the reduction in free allowances within the treated sectors had a discernible impact on production, emissions, and emission intensity. The

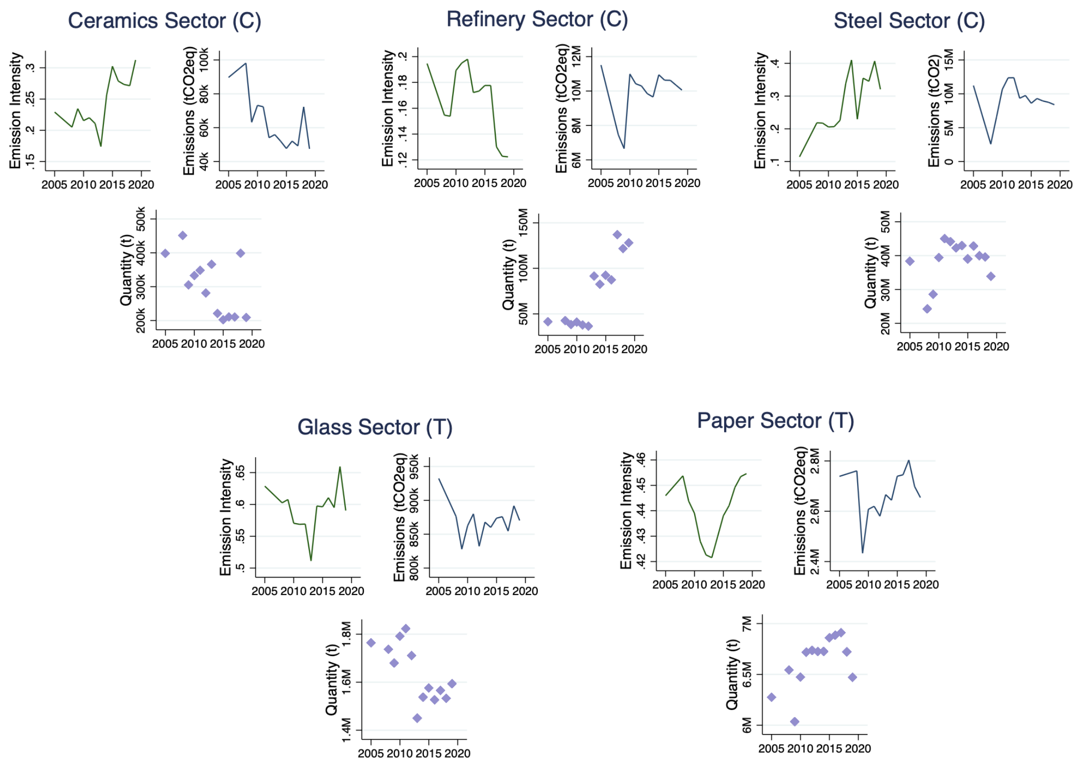

Figure 12: Description of balanced sample for each sector.

underlying question remains: did the treated plants manage to enhance their efficiency compared to other sectors that did not experience a change in free allowances provision? Maintaining a descriptive stance, the treated group of the established plants exhibits a consistent and stable average emission intensity over time, while in the control group there is an observable upward trend.

4.2 New entrants

Referring to the "new entrants", these are the plants that became part of the EU ETS in 2013. The subsequent analysis will involve a comparison between the average emission intensity of these new entrants and the established plants within both the treated and control groups. This analysis reveals one of the most compelling outcomes of this study: as depicted in Figure 13, the treated group of the new entrants exhibits lower emission intensity in comparison to the pre-existent Phase III plants within the same group. Conversely, the control group of the new entrants displays an emission intensity towards the higher end of the spectrum within their group. These findings align with the theoretical structure considered in the working paper by Ambec et al. (2023), suggesting that free allowances do not directly alter the incentives to abate emissions, but they facilitate the entry of environmentally less sustainable producers.

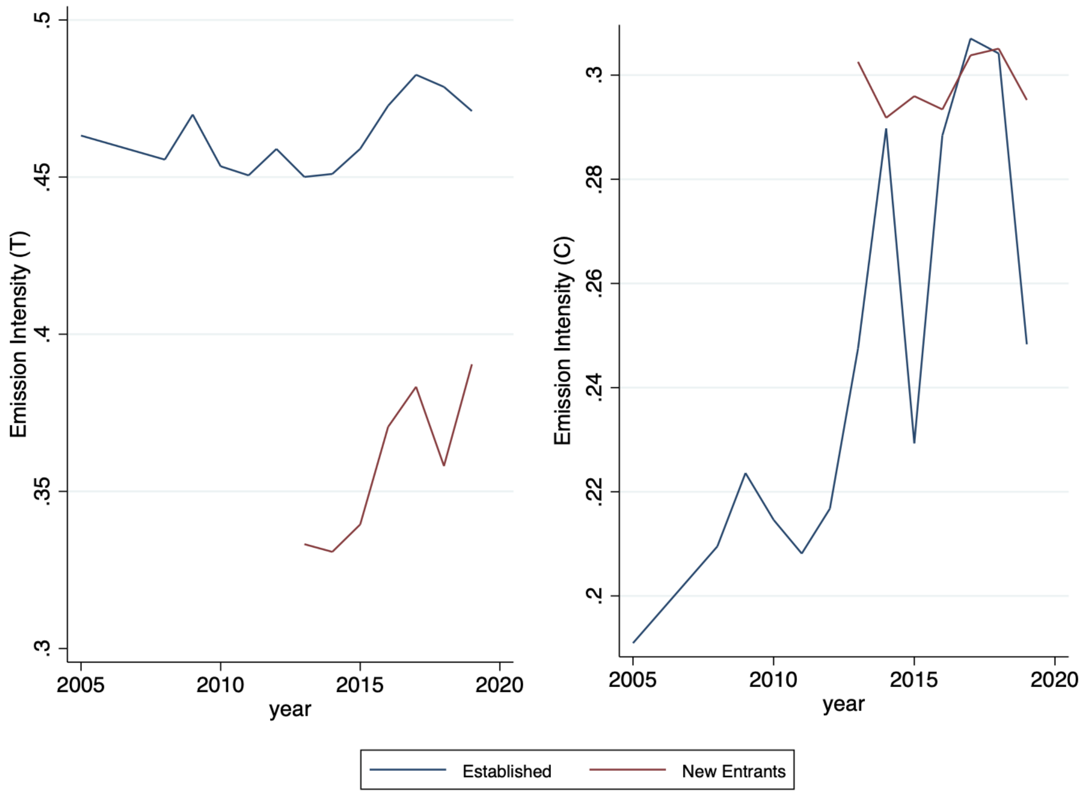

Figure 13: Established plants vs new entrants: behaviour of treated and control plants.

Who are the new entrants? The sectoral composition of the plants that opted into the EU ETS during Phase III is depicted in Figure 14. Approximately 38% of these new entrants belong to the agri-food sector, while textile accounts for 2%, paper for 7%, thermoelectric plants for 3%, steel for 21%, ceramics for 27%, and refinery and glass for 2%.

Compared to the sectoral composition of the balanced sample, the composition of new entrants appears to be well-distributed between the treated and control groups. Notably, ceramics and agri-food plants emerge as the primary categories of new entrants, followed by steel and paper production facilities.

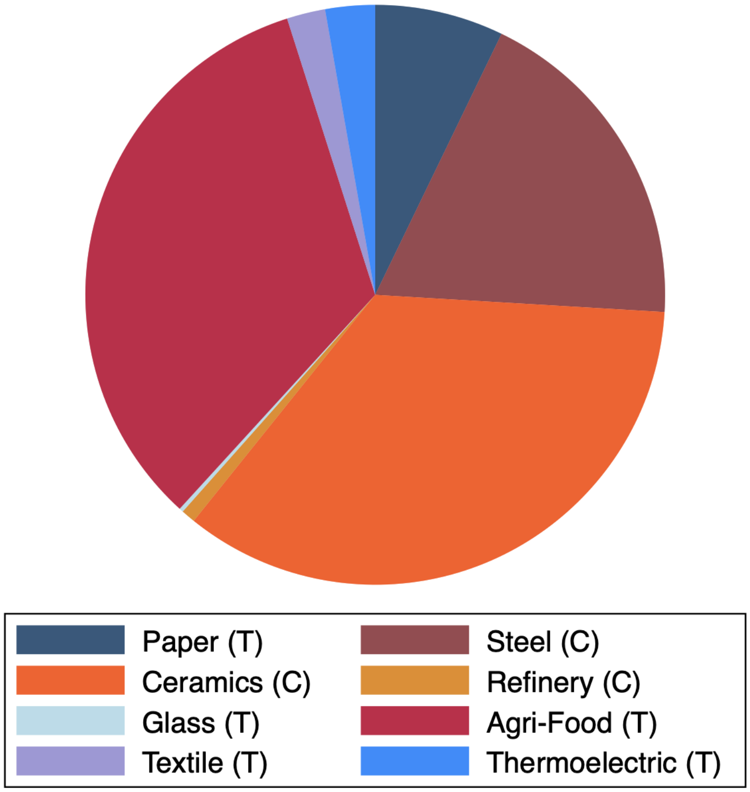

Figure 14: Sectoral composition of new entrants.

4.3 Emission Intensity

Emission intensity is calculated as the ratio of tonnes of CO_2 emitted to tonnes of quantity produced (or MWh for the thermoelectric sector). Including thermoelectric plants does not significantly alter the graph, as the scale of emission intensity remains consistent. The estimates of emission intensity exhibit a consistent alignment across sectors within both groups. Notably, the cement sector is excluded from the main manufacturing sectors due to the confluence of ETS Phase III changes with the Directive 2010/75 EU and the BAT Directive.

The result described in Figure 15 is apparently surprising: looking at the plant level data, it is not clearly observed a significant change in the energy mix in the established firms or a reduction in the emission factors of the different energy sources. Therefore, the factors that lead to this result not depend on direct incentives of the EU ETS on investment choice in greener technology or innovation. Therefore, the switch observed in the EI paths is mostly driven by the new entrants: the cut of free allowances fostered the entry of low-carbon technology plants in the sectors that face a lower or no share of free allowances in

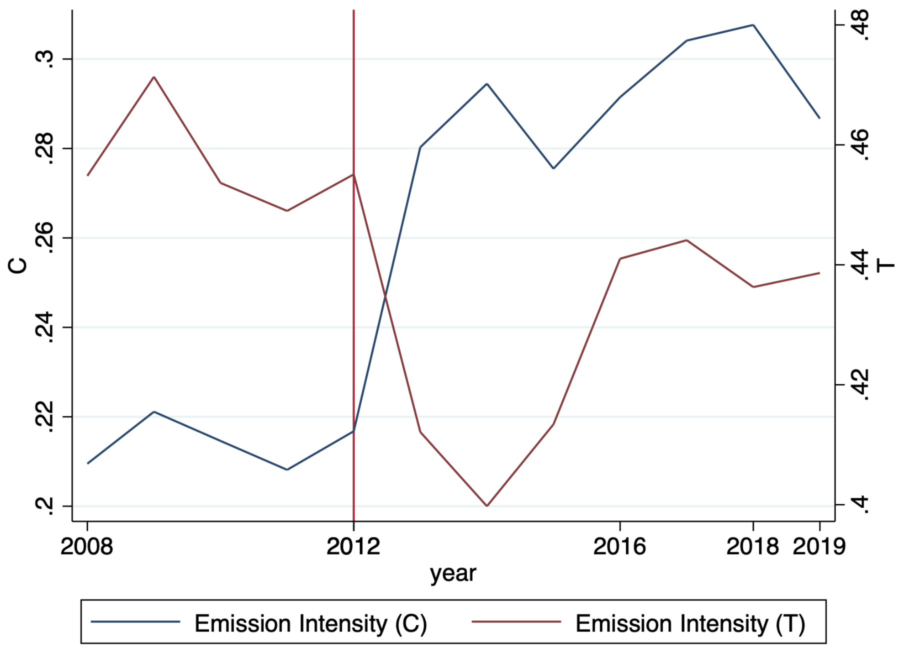

Figure 15: Emission Intensity, treated and control group (excluding thermoelectric).

the future. On the contrary, secotrs that kept a high share of free allowances experienced the entrance of dirty producers compared to the established ones.

The findings pertaining to the entire sample combined with the descriptive analysis of the previous section demonstrate that the alteration in emission intensity is primarily influenced by the new entrants within both groups. Figure 15 visually demonstrates a significant transition occurring at the onset of Phase III between the average emission intensity in the control group and in the treated group. the treated group consistently reduces its average emission intensity, while the control group experiences an increase in its value.

The Table 4.3 presented provides the estimates for the difference-in-differences regression, with the dependent variable being the emission intensity (EmissInt). The coefficient for the treatment group (T) is estimated to be 0.201, which is statistically significant. Additionally, the coefficient for the post-treatment period (POST) is estimated to be 0.0645, also significant. The coefficient for the treatment effect (did) is estimated to be -0.0541, indicating a significant impact on emission intensity. These results suggest that the change in free allowances policy had a significant effect on emission intensity. The findings are robust even when excluding the refinery sector and/or including thermoelectric plants.

	EmissInt
T	0.201***
	(0.0427)
POST	0.0645***
	(0.0143)
did	-0.0541***
	(0.0168)
Constant	0.225***
	(0.0330)
Observations	4,795
Number of plants	658

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

The inclusion of thermoelectric plants does not significantly alter the parallel-trends test or the regression coefficients. Similarly, excluding the refinery sector yields similar results, albeit with a slightly higher estimated treatment effect (-0.08).

Overall, these findings provide support for the hypothesis that the change in free allowances policy had a significant impact on emission intensity, particularly among the new entrants. Indeed, the inclusion of new entrants in the dataset can have a substantial impact on the results of the Difference-in-Differences regression analysis. New entrants, by their very nature, introduce a dynamic element to the study, potentially altering the treatment and control groups' characteristics over time.

When considering the impact of policy changes, such as the adjustment in free allowances provision, the presence of new entrants adds complexity to the evaluation. These entrants might be subject to different conditions, incentives, and trajectories compared to the established firms. In the context of the EU ETS, these new entrants could have joined the system with more recent knowledge about policy frameworks, technological advancements, and industry best practices. This can lead to differences in their emission intensity behaviors, production strategies, and overall performance. The observation of how new entrants influence the findings of the study is pivotal for a comprehensive analysis of the impact of policy changes. Figure 13 provides a visual representation of this influence. Within the treatment group, the newly entering plants exhibit lower emission intensity compared to their established counterparts. Several factors might have played a role.

Firstly, it's conceivable that these new entrants possess a heightened awareness of the policy landscape and the impending free allowances cut. Armed with this knowledge, they could have strategically aligned their production processes with the anticipated policy changes, resulting in a more environmentally efficient approach. Moreover, it is possible that the treated sectors were poised for technological enhancements that could be swiftly incorporated by new entrants, the observed lower emission intensity might be a manifestation of these readily implementable improvements.

On the contrary, within the control group, where no substantial reduction in free allowances was experienced, the dynamic between new entrants and established plants appears to diverge. Here, the emission intensity of new entrants tends to be skewed towards the higher end of the spectrum within their group. This discrepancy might be due to a range of factors such as a lack of immediate incentive to adopt cleaner technologies, different strategic goals, or even structural limitations that hinder rapid improvements in environmental performance.

These observations underscore the importance of accounting for the heterogeneous characteristics of new entrants when evaluating the effects of policy changes. Such considerations should be a fundamental component of the interpretation and implications of this study. This analysis contributes to a clearer understanding of how policy interventions interact with the evolving industrial landscape, shedding light on both intended and unintended consequences.

4.4 North vs South

Italy has an heterogeneous industrial structure, characterized by significant regional disparities. The southern regions are generally classified as less developed in manufacturing sectors and it is mostly populated by small-medium enterprises. A comprehensive analysis conducted by the Bank of Italy (Accetturo et al., 2022) analyses the current state of the art, while also highlighting a concerning trend of the growing economic disparity between the northern and southern regions of Italy.

Being a participant in the EU ETS implies, with the exception of sectors explicitly outlined in Annex I of the EU ETS Directive, adherence to production capacity criterion for plants. As expected, Figure 16 shows that in most of the sectors the EU ETS plants are mainly

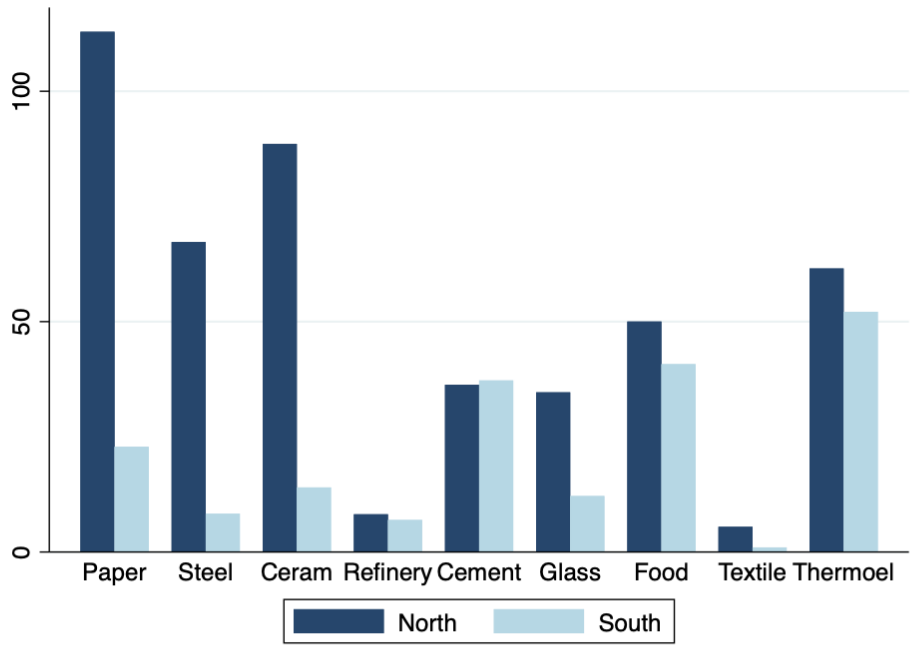

Figure 16: Number of plants by sector.

located in the northern regions.

Within Italy, the paper sector exhibits the highest number of EU ETS plants, primarily situated in the northern regions. This is succeeded by the ceramics and steel sectors. Conversely, the remaining industries are more evenly distributed across the country, each comprising 60 or fewer plants. This descriptive analysis suggests that most of the emissions are produced in the northern regions. Nevertheless, an important parameter is the emission intensity per quantity produced. In this way the analysis is not related to the level of the emissions, but on the emissions per unit (ton) produced.

Figure 17 illustrates the average emission intensity over time in each sector, comparing the north and the south of the country. In the sectors targeted in the control group (ceramics, steel and refinery) the northern regions of the country are generally more efficient in terms of Scope 1 emissions, compared to the southern plants. The gap is clear in ceramics and refinery plants, whereas for the steel sectors the emission intensity is mostly homogeneous across the country. On average, the southern regions demonstrate higher efficiency in the glass and textile industries. The thermoelectric, paper, and food sectors maintain a uniform emission intensity measure across the nation, exhibiting similar trends over time.

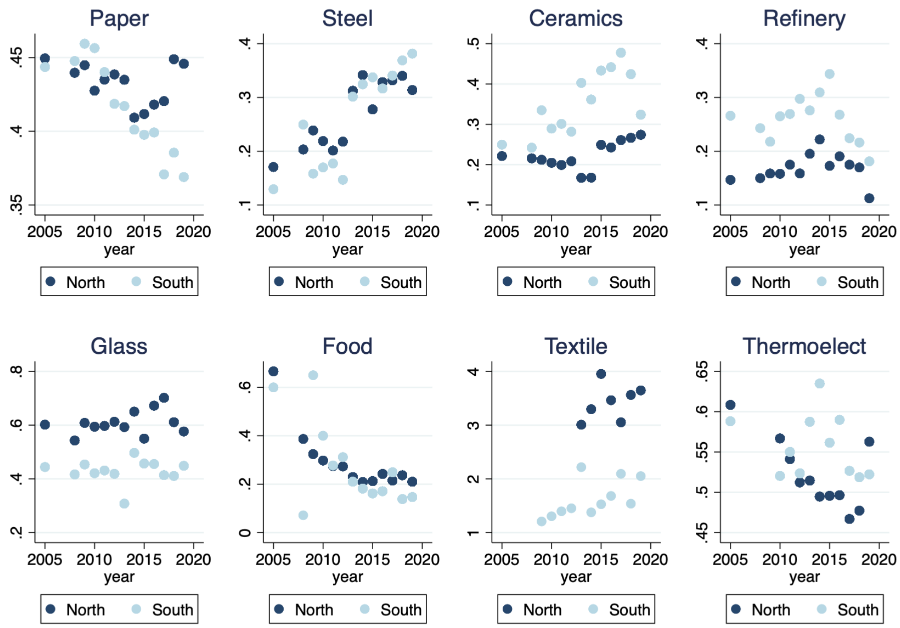

Figure 17: Emission Intensity over sector and location.

Considering the overall emission intensity, its path in the northern and the southern plants seems to be similar, as it is shown in the Figure 18. However, the result is mainly driven by the very high emission intensity of the textile plants in the north. Indeed, without considering the few textile plants, the north is overall more efficient (see the in the Appendix, Figure 20).

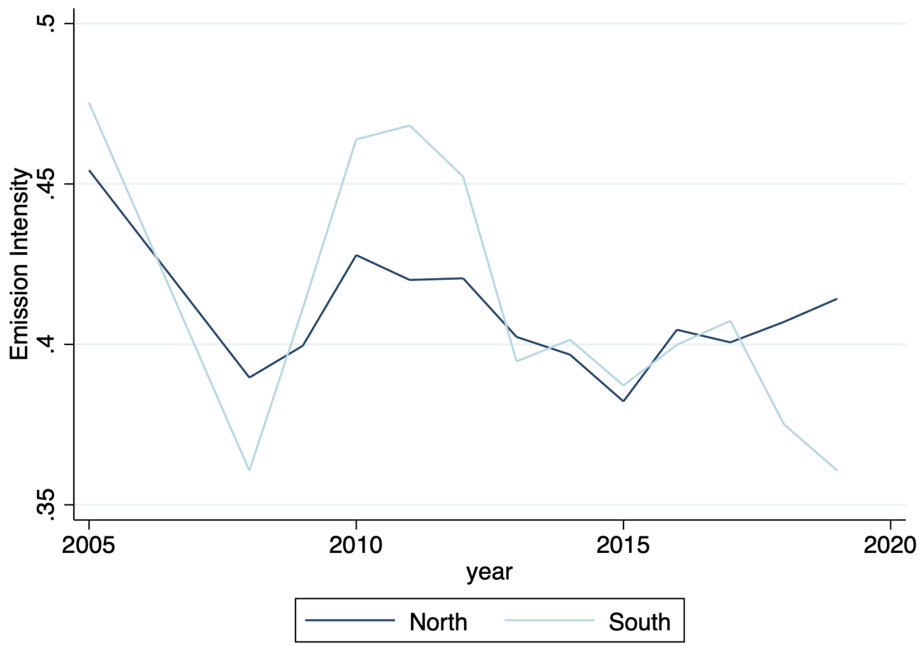

Figure 18: Emission Intensity North vs South.

Conclusions

This study has explored the effects of the reduction in the provision of free allowances on emission intensity within the context of the EU ETS. The analysis revealed that the change in free allowances policy had a significant impact on emission intensity, mainly driven by the new entrants. Sectors that experienced a relevant drop in the free allowances provision decrease their emission intensity, mainly due to the entrant of low-carbon emitting plants. On the contrary, sectors that kept a high share of free allowances do not abate their emissions and the new entrants are emission-intensive.

The presence of new entrants added complexity to the analysis, as they exhibited lower emission intensity compared to established plants in the treatment group. This could be attributed to factors such as heightened awareness of the policy landscape, the anticipation of policy changes, and the ability to adopt cleaner technologies more readily.

Overall, this study highlights the importance of considering the heterogeneous characteristics of new entrants when assessing the effects of policy changes. It provides valuable insights into how policy interventions interact with the industrial landscape and contribute to both intended and unintended consequences. These findings have implications for policymakers and industry stakeholders seeking to achieve environmental goals within emissions trading systems.

Future researches want to go further on the role of free allowances and their current phase out option pursued by the European authorities. The use of free allowances to avoid carbon leakage has raised concerns regarding the effectiveness of the EU ETS. The objective of the European Commission and Parliament is to avoid the issuance of free allowances and rely in the next future on other carbon leakage mitigation policy tools, such as the Carbon Border Adjustment Mechanism (CBAM). How to structure the CBAM, its interaction with free allowances and export rebates is the object of a large literature (Fischer and Fox (2012), Böhringer et al. (2022), Ambec et al. (2023)). The Phase IV will be therefore crucial in understanding the phase out option effects and the CBAM mechanisms. Additionally, the Phase IV is going to be an interesting object for research due to the price level: from 2020, the price has an increasing trend, reaching about 105 euros per ton in March 2023.

Appendix

4.5 Additional Figures

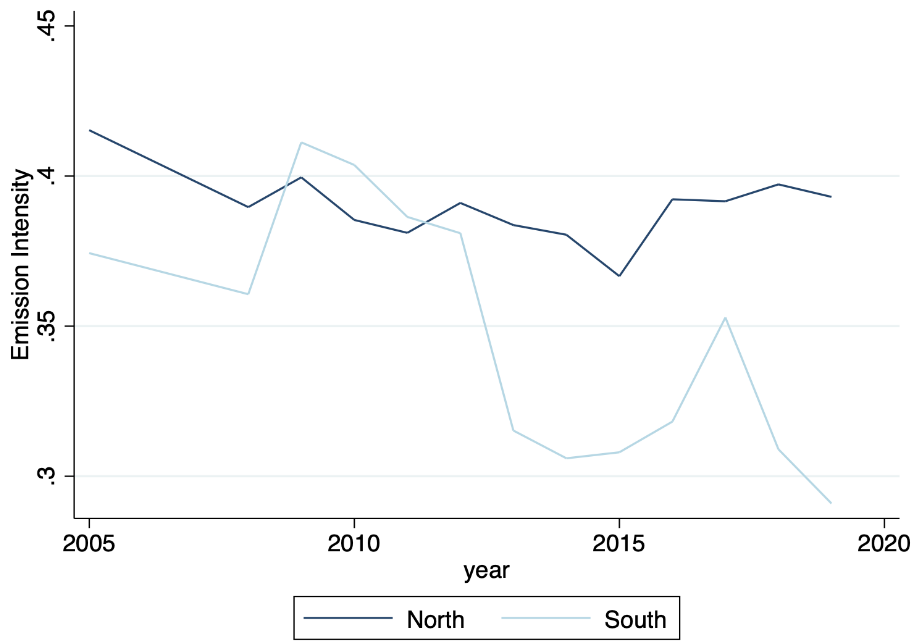

Figure 19: Emission Intensity North vs South, excluding thermoelectric.

4.5.1 Thermoelectric case

The quantity produced is decreasing over time, as showed in Figure 21. The main jump is in 2013, when 40 out of 140 electric plants opted out.

Figure 22 considers also the thermoelectric plants when computes the emission intensity average per year. Compared to Figure 10, it has slightly higher values and a similar decreasing path.

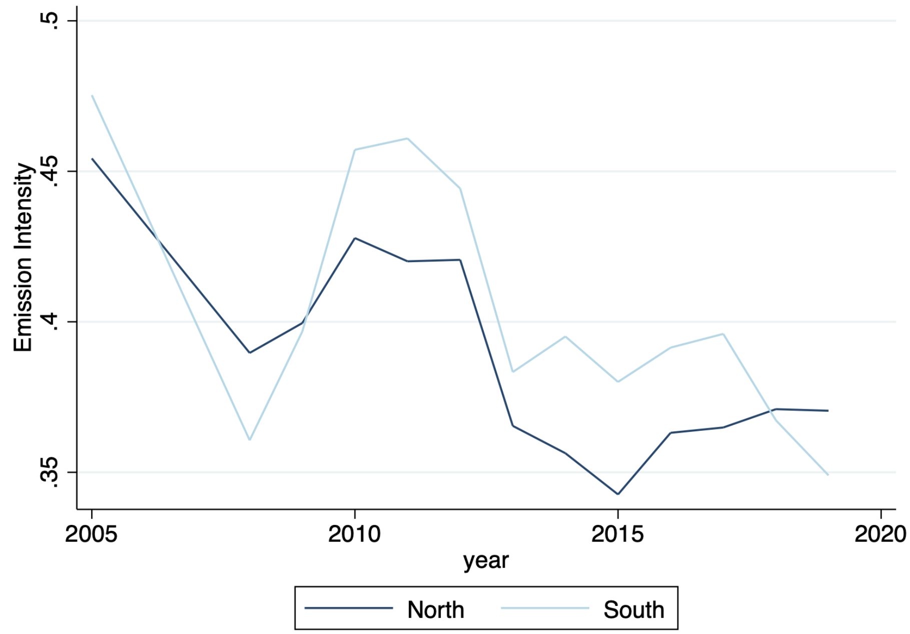

Figure 20: Emission Intensity North vs South, excluding textile.

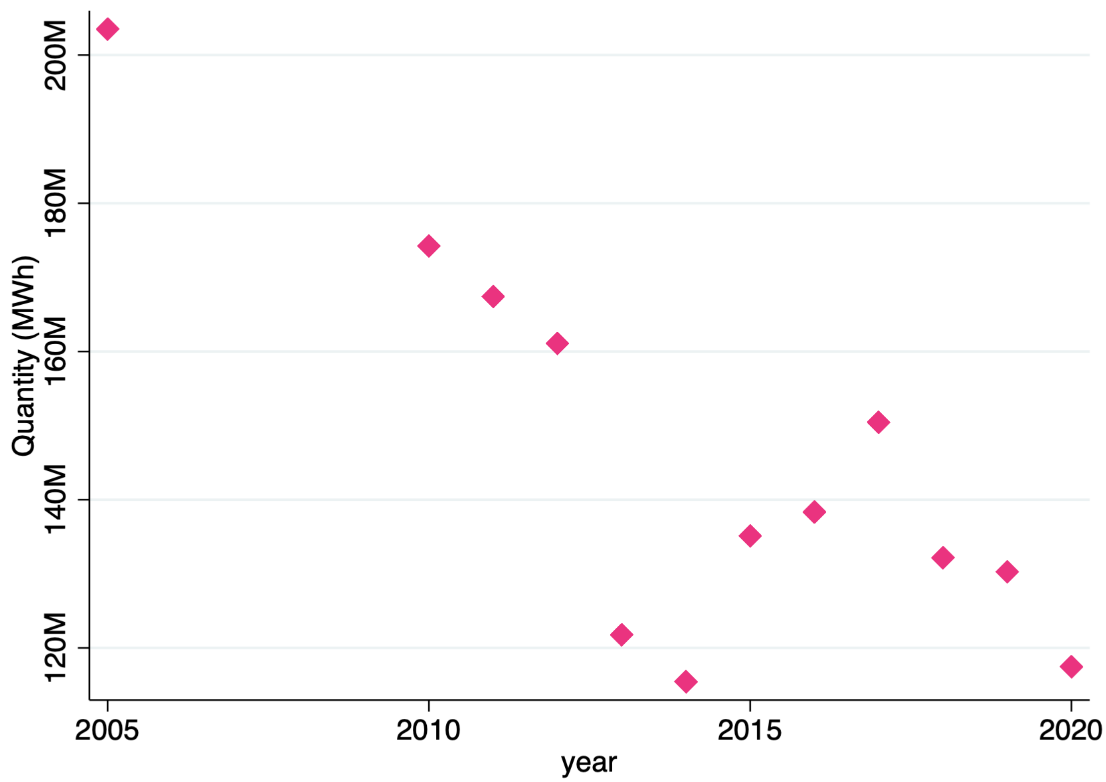

Figure 21: Quantities (MWh) for EU ETS Italian thermoelectric plants.

Figure 22: Emission Intensity considering also thermoelectric plants.

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