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The impact of the European Emission Trading Scheme on multiple measures of economic performance*

Giovanni Marin† Claudia Pellegrin‡ Marianna Marino§

Abstract

The European emission trading scheme (EU ETS) has introduced a price for carbon and has thus led to an additional cost for companies that are regulated by the scheme. There is a growing body of empirical literature that investigates the effects of the EU ETS on firm economic performance. However, the results found to date are mixed.

The objective of this paper is to provide empirical evidence on the effect of the EU ETS on economic performance at the firm level. Differently from the previous literature, we test the effect of the EU ETS on a larger set of indicators of economic performance: value added, turnover, employment, investment, labour productivity, total factor productivity and markup. Moreover, we evaluate the extent to which the impact of the EU ETS differs depending on some observable features of firms.

Our results, based on a large panel of European firms, provide a comprehensive picture of the economic impact of the EU ETS in its first and second phases of implementation. The evidence suggests that the EU ETS had a positive impact on the scale of treated firms, whereas it had a negative impact on scale-free aspects of economic performance.

Keywords: European Emission Trading Scheme, economic performance, difference-in-differences, emission intensity, allowance trading, environmental patents

JEL: Q52, Q58

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1. Introduction

An Emission Trading Scheme (ETS), similarly to other alternative climate change policy instruments, is expected to lead to new costs for companies, because it requires firms to either buy permits to pollute or, alternatively, to bear the cost of abating emissions[1]. Therefore, according to the traditional view, an emission trading system is likely to decrease firm's economic performance (Coase, 1981; Baumol and Oates, 1988).

Indeed, companies subjected to the EU ETS, which is the scheme introduced by the European Union in 2005 to reduce greenhouse gas emissions, have always claimed the risks of losing jobs, reduced competitiveness and decreased market share relative to companies outside the EU ETS (with the extreme case of re-location to unregulated countries). Therefore, analyses that attempt to address this issue are of strong policy interest for both industrial emitters and policymakers (Martin et al., 2014a). In particular, it is relevant to analyze the economic effects of the European scheme, because this scheme constitutes the most important policy tool for climate change mitigation of the European Union and the largest carbon trading market implemented in the world thus far.

Empirical ex-post analyses on the impact of the EU ETS on firm performance have attained mixed conclusions. Certain studies have found positive or not significant effects of the EU ETS on economic performance of companies, whereas other papers have found negative effects or no impact at all (Martin et al., 2015, Convery, 2009).

Our paper investigates the effect of the EU ETS on firm-level economic and financial indicators. As opposed to other recent studies, we evaluate a larger variety of measures

[1] An ETS works in the following way: the Regulator, at the beginning of the compliance period, allocates a number of emission allowances (or permits) to the regulated plants, thus setting a maximum cap for pollution. The plants then can trade the allowances according to their pollution needs: plants that need to pollute more will buy permits, whereas plants that need to pollute less will sell permits. At the end of each compliance period, participants to the scheme are required to surrender as much permits as their verified emissions.

of performance. Thus, our paper describes a broader picture of the phenomenon under analysis and thus provides new insights into the mixed results found in the literature to date. Our analysis is based on a large panel of European firms and our results show how the economic/financial indicators of the ETS firms have evolved relatively to similar firms that were not involved in the ETS during the first and second phases of the EU ETS (2005-2007 and 2008-2012)[2].

The paper is organized as follows. Section 2 reviews the recent evidence on the evaluation of the impact of the EU ETS on firm performance. Section 3 describes the data used for our empirical analysis. Section 4 discusses the empirical strategy we adopt. Results are discussed in section 5. Finally, section 6 concludes.

2. Literature review

Martin et al. (2015) reviewed the empirical evidence on the impact of the EU ETS on various dimensions and pointed out that EU ETS ex-post evaluations are *"still very much work in progress".* Most empirical studies on the effect of the EU ETS on firm economic performance are very recent, and not many have previously passed the refereeing process of academic journals. These studies differ substantially in terms of empirical strategy, sectoral and geographical scope and the selection of indicators that they evaluate.

There are studies that focus solely on one European country. Wagner et al. (2014) found a negative effect of EU ETS on employment on a panel of French firms. In contrast, Petrick and Wagner (2014) found no significant effect of the EU ETS on employment for a sample of German firms. They also analyzed the impact of EU ETS on gross output and exports and found no effect on gross output in the first phase but a significant and positive effect in the second phase; however, a positive and significant effect of on export was found in both phases. Anger and Oberndorfer (2008) conducted

[2] The EU ETS is operative since 2005 (Directive 2003/87/EC). It started with a first pilot phase from 2005 to 2007, followed by a second phase from 2008 to 2012.

a similar analysis on revenues and employment on German firms related solely to the first phase of the EU ETS. They found no significant effects.

Other studies cover a larger selection of European countries. Abrell et al. (2011) investigated the effect of EU ETS on profit margins, value added and employment on a dataset of European companies; for their analysis, they combined data from the EU ETS Transaction Log with the Amadeus database (Bureau van Dijk). They found no significant impact of the EU ETS on profit margins and value added and a small, but significant, negative effect on employment.

Early studies solely investigated the first phase of the EU ETS. Commins et al. (2009) studied the impact of EU ETS on total factor productivity (TFP), returns to capital, employment and tangible investments on a sample of European firms. They found a negative effect for TFP and returns to capital but no significant effect for employment and tangible investments.

Martin et al. (2015) concluded that *"one priority for future research on the EU ETS is the further development of firm-level micro-data, in terms of both outcome variables available and geographical coverage".*

Our contribution to this emerging literature is manifold. Compared to existing studies, (i) we evaluate a larger selection of outcome variables, (ii) on a larger selection of EU countries, and (iii) we evaluate how the effect of the EU ETS differs according to various observable characteristics of firms.

3. Data

EU ETS allowances are allocated at the installation level, not at the company level[3]. Information regarding obligated installations, their respective account holders, compliance and transaction data is stored within the European Union Transaction Log (EUTL). For our firm-level analysis, it is essential to establish the link between these EU ETS accounts at the installation level and the corresponding parent companies.

[3] The EU ETS covers more than 11.000 installations that operate in emission-intensive sectors.

However, limited and/or incomplete information is provided on the associated firms in the EUTL[4].

The "*Ownership links and enhanced European Transaction Log dataset project*" (Jaraite et al., 2013) is the outcome of the matching of the EU ETS accounts at the installation level to their parent companies[5]. However, the years covered by this database are from 2005 to 2007, which corresponds to the first phase of the EU ETS. To extend the matching of this database to the second phase, we assume that new companies have not entered the market starting from the second phase and that companies participating in the first phase continue to participate in the second phase.[6]

The matching between installations and companies performed by Jaraite et al. (2013) assigns installations to the ultimate owner that can be linked to the company identifier of Bureau van Dijk's databases. Amadeus, by Bureau van Dijk, is a database of comparable financial and business information of European companies and includes standardized annual accounts (consolidated and unconsolidated), financial ratios, sectoral activities and ownership data. Because the EU ETS began in 2005 and because we want to observe a sufficiently large pre-treatment period, we extend the current release of Amadeus (extracted in July 2014, coverage 2004-2012) with a previous release of Amadeus (firms observed from 2002 to 2010).

Our operative sample is composed of 792 treated firms and 65,692 potential controls observed over the 2002-2012 period. We keep those firms based in EU ETS countries (EU28 plus Norway, Lichtenstein and Norway), whereas we include all sectors in the

[4] National unique identifiers of companies that own EU ETS installations, as reported in the 'List of installation in the Union Registry', are missing or assigned to direct owners rather than to ultimate owners. Moreover, they are not compatible with the usable identifier in Amadeus in many cases (we use Amadeus for the construction of our dataset, as explained fore after).

[5] The dataset is available at http://fsr.eui.eu/CPRU/EUTLTransactionData.aspx

[6] To check how important this assumption is, we evaluate the amount of emissions in installations that entered the scheme in phase 2 only (Table 13 in Appendix A). This amounts to only 7.5 percent of verified emissions in the period 2008-2012.

economy[7]: many firms that operate in typically non-ETS sectors (e.g., the service sectors) continue to own establishments that are covered by the EU ETS.

To reduce the heterogeneity of our sample, we keep only the companies that have, on average, more than 10 employees.[8] Depending on the variable of interest, the extent to which our panel of firms is unbalanced may change, perhaps substantially. Our choice about firms that cannot be observed over the entire period has been to keep, for each variable, only those firms that appear at least once in each of our periods of interest: pre-treatment period (2002-2004), first phase (2005-2007) and second phase (2008-2012). As a robustness check, we also keep only those firms (treated and controls) for which we observe our variable of interest for all years: this reduces the bias from attrition; however, in some cases, this substantially reduces the number of treated firms that we are consider (refer to paragraph 5.2).

4. Estimation approach

4.1 Identification strategy

The challenge related to the empirical ex-post policy evaluations of the EU ETS is to establish a causal link between the policy itself and the changes in the outcome variable: this means that any change in the outcome variable can be ascribed only to the policy and not to a third factor that affects all treated firms. To analyze the causal impact of the EU ETS, we apply a difference-in-differences approach with pre-treatment matching. The treatment group is constituted by the firms that own at least one establishment that

[7] The only exception is represented by the exclusion of the aviation sector (NACE code 51). The aviation sector (flights within and from the EU, Iceland, Norway and Lichtenstein) has been included in the scheme since year 2012. Differently from other sectors, for which fixed sources above certain thresholds are included, no matter the sector of operation of the firm, in the aviation sector permits and emissions refer to mobile sources (aircrafts). The difference in the timing of adoption of the policy, coupled with the substantially different potential impact on the sector, motivate this exclusion.

[8] By excluding firms with less than 10 employees (on average over the period), we exclude 138 firms. It should be noted, however, many of these firms would have been excluded anyways as they have many missing values in our variables of interest, much more, in relative terms, than bigger firms.

participates in the EU ETS, whereas the control group is composed of similar non-EU ETS firms.

As discussed by Calel and Dechezleprêtre (2015), matching on observable characteristics is problematic when dealing with establishment-level data. This is due to the assignment rule of the EU ETS: the scheme covers all plants operating in participating countries that have installed capacity above certain sector-specific thresholds[9]. This means that it is not possible to find a good match for an ETS establishment given that any other establishment with the same size (in terms of installed capacity) operating in the same sector should be treated too. As suggested by Calel and Dechezleprêtre (2015), however, the following situation may occur when the unit of observation is the company instead of the establishment: within the same sector and size class (not in terms of installed capacity, but in terms of employment, assets or turnover), there may exist at least one company that has one or more plants that are sufficiently large to be covered by the EU ETS and at least one company with no plants that meet the criteria for participating to the EU ETS. However, because the size and sector (and other features) of the company matters more for overall company performance than does installed capacity of each and every establishment, when using the firm as the unit of analysis, it is possible to have a common support between the treated and the control group in terms of observable characteristics.

The treatment begins in 2005. The first phase of the EU ETS (2005-2007) was a pilot phase: no banking or borrowing of permits with the subsequent phase was allowed and allowances were allocated for free ("grandfathering"[10]). The second phase began in

[9] Sector-specific thresholds are reported in Annex I of the Directive 2003/87/EC (and subsequent amendments). We just report two examples of sector-specific thresholds, that is combustion installations with a rated thermal input exceeding 20 MW (except hazardous or municipal waste installations) and installations for the production of pig iron or steel (primary or secondary fusion), including continuous casting, with a capacity exceeding 2.5 tonnes per hour.

[10] [10] "Grandfathering" is one of the possible methods of allocation of the pollution permits from the central authority to the emitters, at the beginning of the compliance period. Grandfathering consists in the free allocation of pollution permits, as opposed to the auctioning of permits.

2008 and incorporated some tighter provisions, e.g. higher penalty for non-compliance (from 40€ per ton of CO_2 in the first phase to 100€ per ton), inclusion of N_2O emissions and possibility of banking or borrowing of permits. Therefore, we expect more negative effects of the EU ETS on firm performance during the second phase. However, grandfathering remained the default allocation method also during the second phase.

We evaluate the impact of the EU ETS on the following list of measures of economic and financial performance: value added (VA), number of employees (L), turnover, investment (gross fixed capital formation - GFCF), labour productivity (VA/L), average wages (average labour compensation per employee), return on investment (ROI), total factor productivity (TFP)[11] and markup[12]. Monetary variables, expressed in euro, have been deflated to 2005 prices using country-sector-variable specific deflators from Eurostat.

To identify the impact of the EU ETS on firm's performance, we estimate the following econometric model:

$$Outcome_{it} = \alpha_i + \beta_1(treated_i \times phase1_t) + \beta_2(treated_i \times phase2_t) + \sum_s \gamma_s Trend_t + \sum_c \delta_c Trend_t + \tau_t + \varepsilon_{it} \quad (1)$$

where:

- α_i is the firm fixed effect;

[11] We estimate TFP using the procedure developed by Ackerberg et al (2006) after estimating a translog production function separately for each two-digit industry. As a lag in the input of the production function is needed, TFP can only be estimated from year 2003 onwards.

[12] Estimates of firm-specific markups are based on the procedure developed by De Loecker and Warzynski (2012). Markups are computed as the ratio between labour share of total costs and the elasticity of value added to labour input which is estimated with a translog production function. As a lag in the input of the production function is needed, markups can only be estimated from year 2003 onwards.

- $treated_i$ is a time-invariant dummy variable that equals 1 for firms that own at least one establishment subject to the EU ETS;
- $phase1_t$ represents a dummy that equals one for the years of the first phase of the EU ETS, i.e. 2005, 2006 and 2007 and zero otherwise; similarly, $phase2_t$ is a dummy for the years of the second phase, i.e. 2008, 2009, 2010, 2011 and 2012;
- $\sum_s \gamma_s Trend_t + \sum_c \gamma_c Trend_t$ are sector dummies and country dummies interacted with a linear trend;
- τ_t are year dummies;
- ε_{it} is the idiosyncratic error term.

Our parameters of interest are $\widehat{\beta_1}$ and $\widehat{\beta_2}$ that represent, respectively, the average treatment effect on the treated for phase 1 (2005-2007) and phase 2 (2008-2012) of the EU ETS compared with the pre-treatment period (2003-2004). We are also interested in testing whether a difference exists in the effect that we estimate for the two phases. This is done by testing the null hypothesis of equality between the average treatment effect on the treated for the two phases (H_0: $\widehat{\beta_1} = \widehat{\beta_2}$).

Although the time-invariant unobserved heterogeneity of firms is removed by including firm-specific fixed effects[13], it could be the case that there exist other unobserved time-varying components that correlate both with the likelihood of being treated and firm's performance. To control for these unobserved components, we include year dummies to control for EU-wide shocks that hit all countries and sectors in the same manner, country-specific linear trends that allow for differences in trends across countries (as a consequence, for example, to different macro-economic conditions or changes in the regulatory attitude that occurred within each country) and sector-specific linear trends that allow for differences in trends across sectors (due to, among other things, sector-specific trends in global demand and prices or to EU-wide changes in regulatory attitude towards specific sectors).

[13] The fixed effect is also particularly useful to control for panel attrition. Firms that are absent from the panel in particularly 'bad' or 'good' years could have influenced substantially our estimates of $\widehat{\beta_1}$ and $\widehat{\beta_2}$.

We match treated and control companies based on the propensity score (Rosenbaum and Rubin, 1985). The propensity score is the estimated probability of being treated given a set of observable characteristics of treated and untreated units. The use of a single synthetic variable that combines information about a variety of dimensions eliminates the dimensionality issue and allows to exploit efficiently the information contained in continuous variables. Conditional on the propensity score, the treatment is expected to be independent and the identification of the average treatment effect on treated is achieved.

We first estimate, by means of a probit estimator, a propensity score that is function of a basic set of variables measured in year 2003. We include the following variables: number of employees (in log), growth of the number of employees from 2003 to 2004, capital intensity (log of fixed assets per employee), value added per employee (in log), age of the company, country dummies and sector dummies (2 digits NACE rev 1.1).

[Tables and figures

Table 1 about here]

Results of the aggregate propensity score are reported in Tables and figures

Table 1. As expected, the probability of being covered by the EU ETS is significantly and positively correlated with size (number of employees), capital intensity (stock of fixed capital per employee) and age of the firm. Conditional on these characteristics, firms that grow faster (growth in employment between 2003 and 2004) are more likely to be covered by the EU ETS: this may indicate a potential systematic difference in trends between treated firms and other firms. Finally, (unreported) industry and country dummies are strongly significant in predicting the likelihood of owning EU ETS establishments.

To tighten the matching and to accommodate the different distribution of missing values for each of our measures of performance[14], we estimate a different propensity

[14] For each measure of performance, we estimate the propensity score on the sample of treated and potential control firms for which we observe the dependent variable at least once in each phase (pre-

score for each measure, in which we add to the basic set of covariates the pre-treatment level (2003) and growth rate (2003-2004) of the specific measure under scrutiny. In this way we are balancing the pre-treatment performance as well as the pre-treatment trends in the outcome variables.

After having estimated the propensity scores, we match each ETS firm a maximum of 10 nearest neighbours (in terms of estimated propensity score) non-ETS firms. To reduce the risk of selecting firms that are not sufficiently similar to treated firms, we also impose a caliper of 0.05: controls firms that are not sufficiently similar (i.e. the distance in terms of the estimated probability of being treated with the corresponding treated firm is greater than 5 percent) are not included in the counterfactual, even if they fall in the group of the 10 nearest neighbours. The number of treated and matched control companies by country is reported in Table 2, whereas Table 3 shows the number of treated and matched control companies by sectors. Interestingly, the number of EU ETS firms that have no suitable match within the caliper that we define (i.e. they are off support) is small for all variables, ranging from 8 firms for ROI, turnover and employment to 1 for investments. In accordance with Calel and Dechezleprêtre (2015), we decided to exclude these firms from our analysis rather than match them with substantially different untreated firms that could not act credibly as their counterfactual. Another interesting observation concerns the differences across different measures in terms of the number of treated and potential control firms. The smallest coverage is for markup and TFP. The estimation of these two measures requires observing their employment, capital stock, value added and turnover (also wage bill for markup) for at least two consecutive years. Coverage is also rather low for investment (GFCF) as many firms only invest sporadically. Finally, descriptive statistics about our set of performance measures are reported in Table 4.

[Table 2, Table 3 and Table 4 about here]

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treatment, phase 1, phase 2), as other firms would not be included in the difference-in-differences regressions.

In Table 5, we report pre-treatment differences in the level (2003) and growth rate (2003-2004) of our set of measures of performance between ETS and non-ETS firms. Differences are reported for the whole potential sample of 'control' firms ('unmatched') and for the sample that is matched based on the propensity score, as described above ('matched').

[Table 5 about here]

After matching, treated and control ('Matched') companies are not statistically different in the level and growth rate of our measures of performance, whereas the differences in the same dimensions between treated companies and the full sample of potential controls ('Unmatched') is large in magnitude and statistically significant for basically all variables. This finding means that the matching based on our estimate of the propensity score selects a sample of untreated matched firms that is, in principle, identical (on average) to the sample of treated firms, whereas the initial sample of potential controls is substantially different in all dimensions. Similarity in observable pre-treatment characteristics increases the credibility of the selected control firms as a appropriate counterfactual.

4.2 Validity of identifying assumptions: pre-treatment common trend and SUTVA

The validity of the difference-in-differences method relies on the assumption that the trend of the dependent variable would have been the same, in both the treatment and comparison groups, in the absence of the policy. The test about common pre-treatment trends is implicitly visible in Table 5, in which we test for differences in the pre-treatment growth rates of our set of measures of performance; in all cases, the matching forces the control group to have, on average, the same pre-treatment trend in the outcome variable.

Moreover, our $\widehat{\beta_1}$ and $\widehat{\beta_2}$ are unbiased estimates of the average treatment effect on treated if the treatment is expected to have no impact on untreated firms (Stable Unit Treatment Value Assumption - SUTVA). The failure of this assumption would bias our estimates of $\widehat{\beta_1}$ and $\widehat{\beta_2}$. Our empirical results may be partly affected by the possible

failure of the SUTVA, because matched firms are likely to operate in the same market of treated firms. For a given demand function, changes in the market share of treated firms necessarily implies changes (of opposite sign) in the market shares of firms belonging to the control group. This issue may be particularly relevant for markets/sectors that are characterized by high concentration. This would lead to opposite effects in terms of turnover, firm size and markups, between the two groups of firms (treated and control group) if we expect to be in a zero-sum game, thus leading to potentially upward biased effects.

5. Results

Before discussing the results of our estimates, it is worth evaluating descriptive trends in average measures of economic performance for treated and control firms (matched controls solely, weighted by matching weights) over the period that we consider (Figure 1).

[Figure 1 about here]

A few clear patterns appear by evaluating average trends in treated and control firms. First, the financial crisis has negatively influenced most measures of performance in 2008 and 2009, with the exceptions (no apparent break) for wages, employment and investments. Secondly, for the pre-treatment trend (2003-2004), all measures of performance appear to be very similar for all variables. Again, this crucially depends on the inclusion of pre-treatment growth in outcome variables in the estimate of the propensity score. Lastly, the largest observed differences between treated and control groups in the pattern of outcome variables after 2005 (first year of the treatment) are for employment, investment (GFCF) and turnover, whereas minimal differences are evident for other variables. These three substantial departures in trends between the two groups of firms are always 'in favour' of EU ETS firms, that have experienced a systematically greater growth in employment, turnover and investment compared with their counterfactual. This preliminary evidence, however, should be validated by statistical evidence.

5.1 Baseline results

Table 6 reports the results of our baseline estimates of equation 1 for our set of performance measures.

[Table 6 about here]

Aggregate descriptive evidence for employment, investments[15] and turnover is generally confirmed by our statistical analysis: the difference between treated and controls is already significant since the first phase for turnover and investments (and remains significant, larger and stronger in the second phase), though it becomes significant only in the second phase for employment. The acceleration of the divergence between the two groups from the first to the second phase of the EU ETS is significant for all three variables. The effects are rather big in magnitude: compared to their control group in the second phase of the EU ETS, treated firms, have increased their employment by 7.9 log points (8.2 percent), their investment by 23.7 log points (26.7 percent) and their turnover by 13.9 log points (14.9 percent).

Value added increased slightly less than turnover (5.8 log points, 6 percent); the effect is significant solely for the second phase of the EU ETS. This suggests that the EU ETS, while driving up sales, has also increased material and other variable costs (that represent the difference between turnover and value added) more than proportionally.

No significant effect on average wages and labour productivity (VA/L) is detected. We observe negative effects on TFP, profitability (ROI) and markups, the latter being significant only in the first phase. However, the magnitude of the effects is modest: TFP is reduced by about 1.6 percent in the first phase and by about 2.4 percent in the second phase, ROI is reduced by about 0.4-0.5 percent, that corresponds to less than one tenth of its sample interquartile range, in both phases. and markup is reduced by 1.5 percent.

[15] Results for investments should be interpreted with caution as this variable is intrinsically unbalanced: firms invest in fixed capital in an intermittent way, with large investments often followed by one or more periods (years) of absence of positive gross investments. As we only consider observations with strictly positive observed investments, our results for this variable can be generalized only to the population of firms that perform investments in every period.

All in all, the EU ETS appears to have positively influenced the scale of treated firms, measured in terms of turnover, value added, employment and investment. The only negative effects that are detected are on scale-free variables and they are small in magnitude. Summing up, our estimates suggest that the EU ETS, despite its negative (but small) impacts on productivity and profitability, has stimulated the growth of firms that own treated establishments.

An explanation for these results might be that the EU ETS, by imposing additional fixed costs, has increased the minimum efficient productive scale of treated firms (employment and investment) and, consequently, their turnover and value added. This result might suggest that larger companies have had the possibility to better react to the introduction of the EU ETS: these companies are the ones that are expected to increase their average costs less than smaller companies, for which the additional fixed costs imposed by the EU ETS represent a larger share of total costs.

To conclude, our results show mixed evidence on the overall impact of the EU ETS on economic and financial performance of firms. The effects go in both the directions, positive and negative, depending on the measure we are considering. However, our contribution resides in showing that the positive effects are related to the scale of the treated firms, whereas the negative effects are on scale-free aspects of economic performance.

We detect stronger positive effects in the second phase (except in the case of ROI): this means that the effect of the EU ETS as an incentive to increase the scale has reinforced during the second phase. The negative effects have reinforced only in the case of ROI.

5.2 Robustness checks

As a first robustness check, we also repeat our analysis while tightening the matching algorithm and considering only the closest, in terms of estimated propensity score, untreated firm for each treated firm (nearest neighbour approach). Although the combination of a large pool of potential control firms and the requirement for matched firm to lie within a caliper reduce the risk of matching firms that are too different from treated ones, one nearest neighbour matching may help in estimating a lower bound of

our effects, at the cost of selecting matches that are only 'accidentally' similar to treated firms. Results are reported in Table 7.

[Table 7 about here]

Although the direction of the effects remains unaffected, we observe some differences with respect to our baseline estimates for what concerns the actual magnitude of the effects as well as their statistical significance. The positive impact on investment and turnover now appears only in the second phase of the EU ETS. Conversely, the impact on value added and ROI turns out to be not statistically significant. Finally, the size and statistical significance of the effect for markup and employment for the first and second phases, respectively, are now larger and stronger.

As a second robustness check, we evaluate the stability of our results when considering only the samples for which we observe our outcome variable for all years (Table 8).[16]

[Table 8 about here]

For many variables we observe a rather large drop in the number of observations and in the number of treated firms as a consequence of imposing a balanced panel structure. Also in this case, results are qualitatively very similar to our baseline estimates. In contrast to our baseline estimates, however, we observe lack of significance in the first phase for turnover, investment and markup and in the second phase for employment.

The effect of the EU ETS on specific categories of firms

To have a more detailed and deeper understanding of the role played by the EU ETS in influencing economic performance of firms, we examine how the effect of the EU ETS varies with the following observable features of treated firms: firm-specific and sector-specific emission intensity, active involvement in the exchange of permits and propensity to innovate.

We expect negative interaction effects of ETS for larger emitters and sectors that are systematically more emission-intensive, positive ones for firms that are actively

[16] We also re-estimate our propensity scores to accommodate for the new samples.

involved in the trading of permits and for firms that patent in environment-related fields. Firms and sectors that rely on emission-intensive processes are likely to suffer more (or gain less) from carbon pricing because this represents a greater share of their costs relative to less emission-intensive firms and sectors.

We do not expect important gains for firms that are active in trading pollution allowances. Firms that are active in the permits market can profit from trading and, more generally, mitigate the ETS abatement costs in a more efficient way (Convery and Redmond, 2007; Martin et al., 2014b). However, companies that trade are the minority of all ETS companies. According to Martin et al. (2014b), EU ETS companies "*do not consider carbon allowances as a financial asset that could provide profit opportunities. Rather, they see the EU ETS as providing a cap on emissions which they need to comply with*". In our sample, companies that trade represent the 35% of all ETS firms.

Lastly, we expect a positive interaction effect for environmentally-patenting companies. Companies with environment-related patents may be able to gain from their innovations, which also include those induced by the EU ETS (Calel and Dechezleprêtre, 2014), thus reducing overall compliance costs (Porter and van der Linde, 1995).

Table 9 and Table 10 report results obtained by interacting the treatment variable with, respectively, firm- and sector-specific average emission intensity (logarithm of emissions per gross output). Data on emissions originates from the EU ETS registry for firm-level emissions and from Eurostat for sector-level emissions and output.[17] To ease

[17] We decided to use time-invariant features of firms to limit the risk that these 'mediating' variables are influenced themselves by the treatment. If that was the case, identification of the treatment effect would have been less reliable as these variable would have been 'bad controls' (Angrist and Pischke, 2009). Firm-level emission intensity is computed as the ratio between average verified emissions in all installations owned by the firm for the period 2005-2012 and average firm turnover for the same period. Sector-level (64 sectors of the NACE rev. 2 classification) emission intensity is computed using economic and environmental accounts from Eurostat for years 2009, 2010 and 2011 as the average of CO_2 emissions per euro of turnover for the EU27 as a whole.

the interpretation of the interaction terms, we re-scaled the emission intensity variables to have the minimum observed emission intensity (in log) equal to zero.

[Table 9 and Table 10 about here]

In the first phase, companies with higher emissions reduced their employment and ROI more than companies with lower emissions did, whereas a negative and significant interaction term is estimated for turnover in the second phase. Results for other variables are far from statistically significant. When examining differences across sectors that are characterized by different emission intensities, we estimate negative and statistically significant interaction effects of the EU ETS for value added, labour productivity and average wages, but a weakly significant and positive effect is found for ROI in the second phase only. Excluding this latter result, the other estimates confirm that emission-intensive firms and sectors have been generally penalized by the EU ETS. We observe a penalization in terms of wages and labour productivity. A doubling in the emission intensity corresponds, in the second phase, to a decrease in average wages of 2.8 percent and to a decrease in labour productivity of 5.3 percent.

A second dimension that we consider as a possible source of heterogeneity in the effect of the EU ETS on firm performance is the involvement of firms in trading pollution permits. The variable "Active" represents the trade activity status and is equal to one when the company has traded at least once in the market for permits during the first or the second phase. Data on trade activity status originates from the EUTL registry. Results are reported in Table 11.

[Table 11 about here]

Being active in trading emission permits has a minimal influence on the impact of the EU ETS on firm performance. We only find some differences, in the first phase, for employment (negative interaction effect), labour productivity and average wages (positive interaction effect). The absence of differential effects in the second phase may indicate the limited possibility of 'playing around' in the permits market to reduce the cost of compliance. This absence of effects may be partly explained by the large drop in the price of carbon that was observed in the second phase of the EU ETS, which limited the potential losses from non-trading and the gains from trading.

Finally, we consider whether the EU ETS had heterogeneous effects on performance, depending on the extent to which firms are involved in the invention and development of environment-related technologies. Our time-invariant variable for patenting is a dummy that is equal to one if the firm has applied for at least one environmental patent to the European Patent Office over the years of our analysis. Data on environmental patents originates from OECD-Regpat database and follows the OECD-ENVTECH taxonomy of environmental technologies, whereas we use the match between applicants and firms provided by the Amadeus database. Results are reported in Table 12.

[Table 12 about here]

An interaction positive effect for patenting firms is detected for labour productivity, ROI and markup (the latter only in the first phase). These differential effects tend to be large in magnitude. It should be noted that these effects involve only scale-free measures of economic performance. This is totally in line with the Porter Hypothesis, which states that more innovative companies gain in terms of productivity in comparison to non-innovative ones.

6. Conclusions

In this paper, we evaluate the impact of the EU ETS on the economic performance of firms that own facilities that participate in the scheme. Our empirical approach aims at creating a proper counterfactual for treated firms in order to obtain unbiased estimates of the treatment effect. Moreover, we attempt to identify differences in these effects across firms with different observable characteristics.

Our results suggest that the EU ETS has positively affected scale-related measures of economic performance and negatively, but slightly, influenced scale-free ones, especially so in the second phase. Our explanation for this finding is that the EU ETS, by imposing additional fixed costs, has increased the minimum efficient productive scale of treated firms.

Moreover, we observe that emission-intensive firms and sectors have been characterized by a slightly worse economic performance, firms that have been active in trading allowances have not improved their performance remarkably and, lastly, firms

that have patented in environment-related technology fields have witnessed a better performance in some scale-free dimensions of economic performance.

The results discussed in this paper provide a quantification on how the EU ETS influences a wide range of measures of performance. Further work is needed to better understand the mechanisms through which the EU ETS actually influence performance. The Porter Hypothesis (Porter and van der Linde, 1995) can be a possible explanation of a positive effect of the EU ETS on firm performance (in the cases of value added, employment and turnover). Porter and van der Linde (1995) stated that environmental policies that stimulate green innovation may lead to positive innovation-related outcomes, which can, in turn, more than offset the negative effect of compliance costs on competitiveness and economic performance. We partially capture this effect with the interaction effect between our policy and environmental patenting activity. Another possible explanation may be the lobbying activity exercised by EU ETS companies and sectors on European authorities (Markussen and Svendsen, 2005; Svendsen, 2005; BÖringer and Rosendahl, 2009). EU ETS companies and sectors may have been able to obtain favourable conditions. For example, they obtained the grandfathering of permits in the first two phases and exemption from auctioning in the third phase (2013-2020) for sectors deemed to be exposed to the risk of carbon leakage, (see Martin et al., 2014a). As suggested by Hepburn et al. (2006), these favourable conditions could have even reduced overall compliance costs for climate policies for emission-intensive EU ETS sectors compared with other non-ETS sectors. Finally, a third possible reason could be the low price of the pollution permits in the first two phases that reduced the cost of complying with the regulation (Koch et al., 2014).

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Tables and figures

Table 1 – Propensity score: baseline specification

	Pr(ETS=1)
log(empl)	0.328***
	(0.0111)
Growth empl (2003-2004)	0.0840**
	(0.0344)
log(K/L)	0.243***
	(0.0165)
log(VA/L)	0.0404
	(0.0293)
Age	0.00146**
	(0.000588)
Pseudo R sq	0.3075
N	58021

Table 2 – Firms by country

	Unmatched controls	Matched controls	Treated
Belgium	2,416	1,115	40
Bulgaria	685	210	18
Czech Republic	1,844	324	7
Germany	5,777	1,206	136
Denmark	698	417	21
Estonia	247	10	1
Spain	4,708	2,464	115
Finland	745	422	33
France	7,524	1,355	51
Italy	4,868	2,424	99
Latvia	256	11	2
Netherlands	2,028	556	33
Norway	1,423	162	4
Poland	3,214	946	43
Portugal	1,290	105	10
Romania	1,150	234	9
Sweden	2,416	1,315	80
Slovenia	145	120	6
United Kingdom	8,565	2,303	84
Total	49,999	15,693	792

Table 3 – Firms by sector (2 digits NACE rev. 2)

NACE	Potential controls	Matched controls	Treated	NACE	Potential controls	Matched controls	Treated
10	2,417	1,678	62	41	4,192	639	16
11	506	405	18	42	554	48	1
12	40	38	3	43	897	99	1
13	460	377	15	46	10,678	1,675	31
14	178	53	1	47	735	119	3
16	415	275	12	49	1,640	99	2
17	338	605	47	52	733	289	11
18	397	72	1	56	27	40	2
19	79	78	9	58	237	51	1
20	1,224	915	41	60	138	48	2
21	592	215	9	61	448	100	7
22	1,500	198	3	64	2,305	1,112	92
23	546	858	58	66	413	46	2
24	711	489	22	68	2,252	619	14
25	1,549	256	4	69	454	149	4
26	327	44	1	70	1,489	971	93
27	853	260	8	71	537	130	4
28	1,050	192	7	72	349	122	5
29	1,034	154	5	73	636	152	4
30	410	103	4	74	164	40	4
31	363	55	1	78	587	49	1
32	274	132	4	81	192	109	4
33	218	15	1	82	1,359	300	10
35	588	690	123	84	132	16	1
36	273	172	6	91	78	25	2
37	247	13	1	96	413	96	3
38	371	208	6	Total	49,999	15,693	792

Table 4 – Descriptive statistics

	Treated	Matched controls	Total
log(VA)			
Average	11.047	10.919	10.984
Min	1.901	1.154	1.154
Q1	9.242	9.446	9.331
Median	10.624	10.765	10.709
Q3	12.529	12.237	12.359
Max	17.972	17.575	17.972
SD	2.376	1.997	2.196
IQR	3.287	2.792	3.028
N firms	719	4121	4840
Off-support treated firms		7	
Unmatched controls firms		38608	
log(av wages)			
Average	3.660	3.643	3.651
Min	0.761	0.702	0.702
Q1	3.509	3.441	3.478
Median	3.770	3.772	3.771
Q3	4.006	4.036	4.020
Max	5.508	5.521	5.521
SD	0.616	0.668	0.642
IQR	0.497	0.595	0.542
N firms	688	3980	4668
Off-support treated firms		6	
Unmatched controls firms		37895	
log(GFCF)			
Average	9.824	9.584	9.704
Min	-4.646	-6.881	-6.881
Q1	7.999	7.926	7.962
Median	9.616	9.440	9.526
Q3	11.497	11.219	11.365
Max	17.804	17.373	17.804
SD	2.670	2.389	2.536
IQR	3.498	3.293	3.403
N firms	551	3060	3661
Off-support treated firms		1	
Unmatched controls firms		30710	

	Treated	Matched controls	Total
log(emp)			
Average	6.683	6.485	6.584
Min	0.000	0.000	0.000
Q1	4.977	5.165	5.050
Median	6.265	6.317	6.295
Q3	8.237	7.730	7.928
Max	13.159	13.193	13.193
SD	2.346	1.946	2.159
IQR	3.260	2.565	2.879
N firms	753	4274	5027
Off-support treated firms		8	
Unmatched controls firms		40503	
TFP			
Average	5.076	5.099	5.087
Min	2.754	2.743	2.743
Q1	4.769	4.814	4.790
Median	5.076	5.130	5.104
Q3	5.462	5.455	5.459
Max	6.114	6.116	6.116
SD	0.522	0.542	0.532
IQR	0.693	0.641	0.669
N firms	533	2824	3357
Off-support treated firms		3	
Unmatched controls firms		28745	
log(turn)			
Average	12.371	12.186	12.279
Min	0.013	-2.248	-2.248
Q1	10.630	10.765	10.701
Median	12.089	12.037	12.061
Q3	13.881	13.479	13.679
Max	19.670	19.263	19.670
SD	2.370	1.990	2.191
IQR	3.251	2.714	2.978
N firms	777	4548	5325
Off-support treated firms		8	
Unmatched controls firms		40001	

	Treated	Matched controls	Total
log(VA/L)			
Average	4.394	4.434	4.414
Min	1.266	1.216	1.216
Q1	4.019	3.919	3.970
Median	4.425	4.387	4.408
Q3	4.835	4.949	4.883
Max	7.244	7.253	7.253
SD	0.796	0.929	0.865
IQR	0.816	1.030	0.913
N firms	679	3907	4586
Off-support treated firms		5	
Unmatched controls firms		37386	
ROI			
Average	0.054	0.057	0.055
Min	-0.416	-0.452	-0.452
Q1	0.018	0.015	0.017
Median	0.046	0.049	0.047
Q3	0.083	0.091	0.087
Max	0.487	0.516	0.516
SD	0.071	0.082	0.077
IQR	0.065	0.076	0.070
N firms	778	4541	5319
Off-support treated firms		8	
Unmatched controls firms		40474	
Markup			
Average	1.404	1.382	1.393
Min	0.565	0.559	0.559
Q1	1.065	1.055	1.060
Median	1.346	1.299	1.324
Q3	1.695	1.623	1.661
Max	2.885	2.902	2.902
SD	0.441	0.437	0.439
IQR	0.630	0.568	0.601
N firms	497	2737	3234
Off-support treated firms		5	
Unmatched controls firms		28715	

Table 5 – Balancing properties of the propensity scores

Variable		ETS	Non-ETS	t-test	p-value
log(VA, 2003)	Unmatched	10.823	8.738	40.52	0.000
	Matched	10.92	10.845	0.66	0.507
Change (2003-2004) log(VA)	Unmatched	.06012	.12454	-3.51	0.000
	Matched	.07055	.06259	0.28	0.782
log(emp, 2003)	Unmatched	6.628	4.7565	37.65	0.000
	Matched	6.6946	6.5465	1.37	0.171
Change (2003-2004) log(emp)	Unmatched	-.0071	.03304	-2.16	0.031
	Matched	-.00385	.00787	-0.45	0.651
log(VA/L, 2003)	Unmatched	4.314	4.0128	9.02	0.000
	Matched	4.3074	4.3645	-1.19	0.233
Change (2003-2004) log(VA/L)	Unmatched	.07307	.08399	-0.63	0.532
	Matched	.07345	.06019	0.57	0.570
log(av wage, 2003)	Unmatched	3.5173	3.4711	1.71	0.086
	Matched	3.5546	3.5525	0.06	0.952
Change (2003-2004) log(av wage)	Unmatched	.05586	.06683	-0.97	0.333
	Matched	.0533	.05711	-0.27	0.784
TFP, 2003	Unmatched	5.1301	5.0591	4.13	0.000
	Matched	5.1289	5.141	-0.37	0.712
Change (2003-2004) TFP	Unmatched	.00577	.02036	-3.52	0.000
	Matched	.00568	.00088	0.87	0.386
ROI, 2003	Unmatched	.04814	.05909	-3.61	0.000
	Matched	.05001	.04907	0.28	0.782
Change (2003-2004) ROI	Unmatched	.01159	.00734	1.78	0.075
	Matched	.01089	.01096	-0.02	0.981
log(GFCF, 2003)	Unmatched	9.3572	6.455	37.51	0.000
	Matched	9.5879	9.5519	0.25	0.804
Change (2003-2004) log(GFCF)	Unmatched	.18295	.14261	0.76	0.446
	Matched	.13306	.12448	0.11	0.909
log(turnover, 2003)	Unmatched	12.006	10.143	39.35	0.000
	Matched	12.243	12.14	0.96	0.336
Change (2003-2004) log(turnover)	Unmatched	.0267	.1216	-4.91	0.000
	Matched	.01204	.01972	-0.19	0.849
Markup, 2003	Unmatched	1.4176	1.0538	28.04	0.000
	Matched	1.4123	1.3991	0.48	0.634
Change (2003-2004) markup	Unmatched	.02449	.02378	0.16	0.876
	Matched	.02504	.02578	-0.08	0.933

Figure 1 – Trends in economic and financial performance (non-ETS: matched control firms)

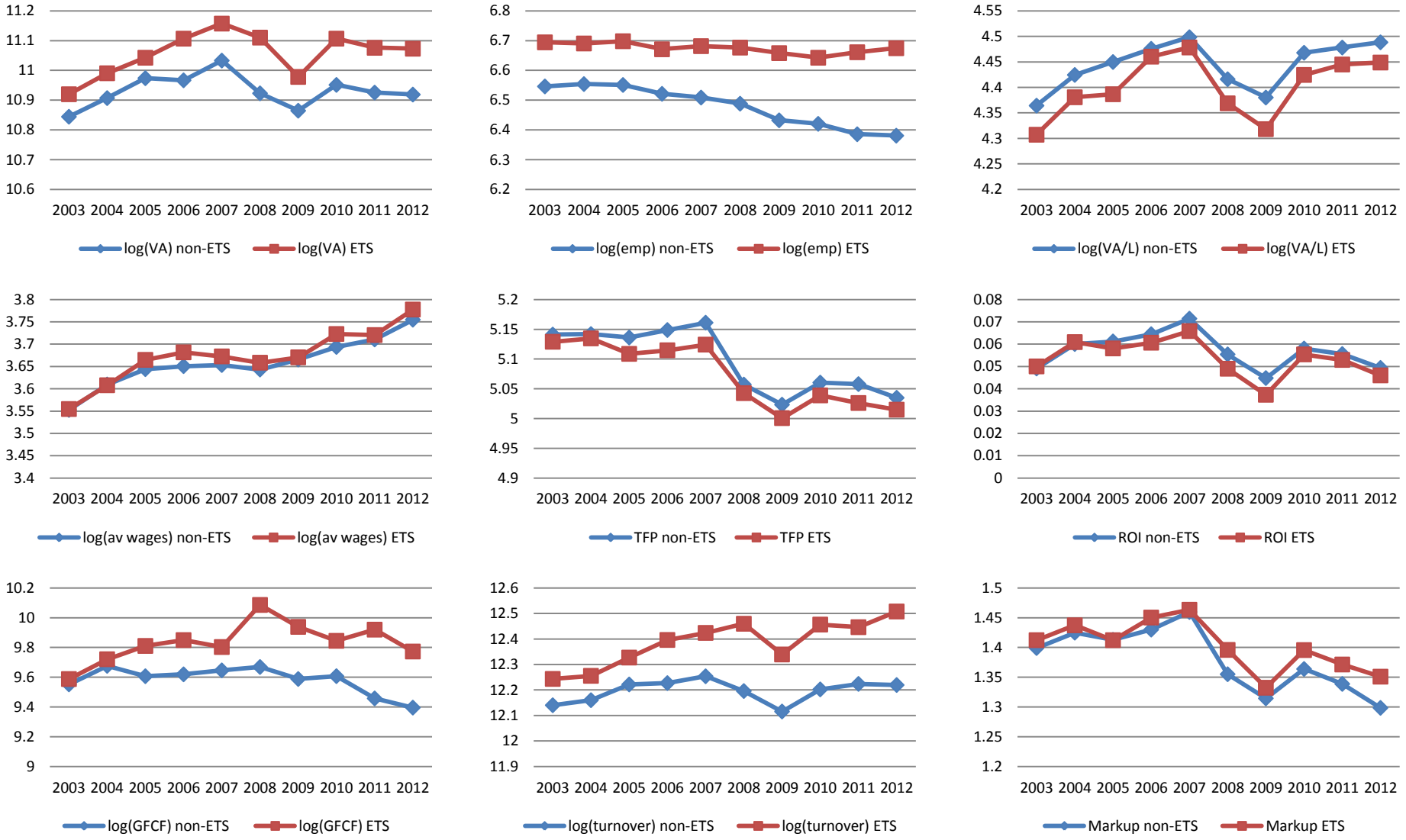

Table 6 – Baseline results

	Phase 1 (2005-2007)		Phase 2 (2008-2012)		Difference Phase 2 - Phase 1		N
log(VA)	0.0120	(0.0178)	0.0580**	(0.0260)	0.0460**	(0.0211)	49956
log(emp)	0.00499	(0.0269)	0.0788*	(0.0415)	0.0738**	(0.0347)	51473
log(VA/L)	-0.0108	(0.0162)	-0.0317	(0.0210)	-0.0209	(0.0169)	45910
log(av wage)	0.00476	(0.00927)	-0.00517	(0.0116)	-0.00992	(0.00835)	47310
TFP	-0.0158***	(0.00526)	-0.0237***	(0.00705)	-0.00790	(0.00502)	30491
ROI	-0.00441**	(0.00220)	-0.00487**	(0.00247)	-0.000457*	(0.00225)	55894
log(GFCF)	0.154***	(0.0474)	0.237***	(0.0542)	0.0827**	(0.0496)	31475
log(turnover)	0.0412*	(0.0235)	0.139***	(0.0336)	0.0978**	(0.0261)	56072
Markup	-0.0147*	(0.00873)	0.00640	(0.0109)	0.0211	(0.00915)	29313

Fixed effect model. Time dummies, industry-specific and country-specific linear trends included. Robust standard errors in parenthesis. * p<0.1 ** p<0.05 *** p<0.01. NN=10 with caliper.

Table 7 – Robustness check – One nearest neighbour matching

	Phase 1 (2005-2007)		Phase 2 (2008-2012)		Difference Phase 2 - Phase 1		N
log(VA)	0.00667	(0.0248)	0.0382	(0.0345)	0.0316	(0.0283)	13959
log(emp)	0.0107	(0.0380)	0.162***	(0.0587)	0.152***	(0.0468)	14626
log(VA/L)	-0.0247	(0.0218)	-0.0584**	(0.0267)	-0.0337	(0.0215)	12755
log(av wage)	-0.00325	(0.0131)	-0.00750	(0.0161)	-0.00424	(0.0126)	13161
TFP	-0.0138**	(0.00625)	-0.0179**	(0.00861)	-0.00408	(0.00628)	9075
ROI	-0.00201	(0.00311)	-0.000306	(0.00349)	0.00171	(0.00320)	15393
log(GFCF)	0.0888	(0.0634)	0.244***	(0.0814)	0.155**	(0.0713)	8935
log(turnover)	0.0247	(0.0313)	0.148***	(0.0549)	0.123**	(0.0489)	15546
Markup	-0.0258**	(0.0108)	-0.00435	(0.0133)	0.0215*	(0.0110)	8500

Fixed effect model. Time dummies, industry-specific and country-specific linear trends included. Robust standard errors in parenthesis. * p<0.1 ** p<0.05 *** p<0.01. NN=10 with caliper.

Table 8 – Robustness check – Strongly balanced panel

	Phase 1 (2005-2007)		Phase 2 (2008-2012)		Difference Phase 2 - Phase 1		N	N treated
log(VA)	0.0162	(0.0188)	0.0635**	(0.0286)	0.0472**	(0.0228)	33869	471
log(emp)	-0.00205	(0.0337)	0.0505	(0.0485)	0.0526	(0.0373)	33198	491
log(VA/L)	-0.00658	(0.0179)	-0.0336	(0.0225)	-0.0270	(0.0186)	25421	380
log(av wage)	0.00860	(0.0116)	-0.00758	(0.0127)	-0.0162*	(0.00970)	28336	414
TFP	-0.0160***	(0.00613)	-0.0243***	(0.00834)	-0.00826	(0.00592)	20750	359
ROI	-0.00510**	(0.00237)	-0.00786***	(0.00262)	-0.00277	(0.00239)	40964	582
log(GFCF)	0.0502	(0.0613)	0.217***	(0.0703)	0.167***	(0.0605)	13850	223
log(turnover)	0.0353	(0.0250)	0.124***	(0.0319)	0.0883***	(0.0232)	41800	589
Markup	-0.0156	(0.0106)	0.0111	(0.0134)	0.0267**	(0.0104)	19400	336

Fixed effect model. Time dummies, industry-specific and country-specific linear trends included. Robust standard errors in parenthesis. * p<0.1 ** p<0.05 *** p<0.01. NN=10 with caliper.

Table 9 – Interaction between EU ETS and firm-specific emission intensity

	log(VA)	log(emp)	log(VA/L)	log(av wage)	TFP	ROI	log(GFCF)	log(turnover)	Markup
Phase 1 (2005-2007)	0.0392	0.149**	-0.0247	-0.00320	-0.0195*	0.00581	0.104	0.128**	-0.0203
	(0.0371)	(0.0603)	(0.0292)	(0.0172)	(0.0104)	(0.00446)	(0.0944)	(0.0550)	(0.0163)
Phase 2 (2008-2012)	0.0620	0.168*	-0.0266	0.00392	-0.0326**	-0.00270	0.308***	0.323***	-0.00828
	(0.0495)	(0.0945)	(0.0362)	(0.0182)	(0.0128)	(0.00501)	(0.109)	(0.0764)	(0.0212)
Phase 1 (2005-2007)	-0.00420	-0.0224**	0.00216	0.00125	0.000588	-0.00158**	0.00798	-0.0133	0.000910
x log(emiss_int,firm)	(0.00567)	(0.00946)	(0.00454)	(0.00255)	(0.00143)	(0.000622)	(0.0136)	(0.00997)	(0.00239)
Phase 2 (2008-2012)	-0.000616	-0.0138	-0.000793	-0.00140	0.00142	-0.000334	-0.0115	-0.0283**	0.00237
x log(emiss_int,firm)	(0.00780)	(0.0151)	(0.00563)	(0.00291)	(0.00184)	(0.000718)	(0.0174)	(0.0137)	(0.00313)
N	49956	51473	45910	47310	30491	55894	31475	56072	29313

Fixed effect model. Time dummies, industry-specific and country-specific linear trends included. Robust standard errors in parenthesis. * p<0.1 ** p<0.05 *** p<0.01. NN=10 with caliper.

Table 10 – Interaction between EU ETS and sector-specific emission intensity

	log(VA)	log(emp)	log(VA/L)	log(av wage)	TFP	ROI	log(GFCF)	log(turnover)	Markup
Phase 1 (2005-2007)	0.0795**	-0.0405	0.0760**	0.0805***	-0.0183*	-0.00490	0.199**	0.0230	-0.0295
	(0.0324)	(0.0630)	(0.0304)	(0.0179)	(0.00937)	(0.00389)	(0.0910)	(0.0574)	(0.0186)
Phase 2 (2008-2012)	0.145***	0.120	0.0705*	0.0701***	-0.0154	-0.0122***	0.278**	0.199**	-0.0156
	(0.0546)	(0.0884)	(0.0399)	(0.0221)	(0.0133)	(0.00417)	(0.131)	(0.0837)	(0.0239)
Phase 1 (2005-2007)	-0.0184***	0.0117	-0.0236***	-0.0202***	0.000680	-0.00000822	-0.0114	0.00539	0.00361
x log(emiss_int, sect)	(0.00683)	(0.0126)	(0.00679)	(0.00401)	(0.00221)	(0.000874)	(0.0217)	(0.0113)	(0.00436)
Phase 2 (2008-2012)	-0.0240**	-0.0119	-0.0276***	-0.0200***	-0.00216	0.00191*	-0.0108	-0.0166	0.00546
x log(emiss_int, sect)	(0.0120)	(0.0186)	(0.00975)	(0.00549)	(0.00342)	(0.00108)	(0.0297)	(0.0170)	(0.00567)
N	49956	51473	45910	47310	30491	55894	31475	56072	29313

Fixed effect model. Time dummies, industry-specific and country-specific linear trends included. Robust standard errors in parenthesis. * p<0.1 ** p<0.05 *** p<0.01. NN=10 with caliper.

Table 11 - Interaction between EU ETS and 'trade-in-permits' activity status

	log(VA)	log(emp)	log(VA/L)	log(av wage)	TFP	ROI	log(GFCF)	log(turnover)	Markup
Phase 1 (2005-2007)	-0.00123	0.0466*	-0.0301	-0.00788	-0.0182***	-0.00464*	0.117**	0.0570**	-0.0190**
	(0.0190)	(0.0260)	(0.0187)	(0.00999)	(0.00563)	(0.00256)	(0.0559)	(0.0249)	(0.00915)
Phase 2 (2008-2012)	0.0352	0.128***	-0.0502**	-0.0141	-0.0204***	-0.00395	0.224***	0.162***	0.00719
	(0.0300)	(0.0412)	(0.0234)	(0.0112)	(0.00777)	(0.00290)	(0.0597)	(0.0359)	(0.0124)
Phase 1 (2005-2007)	0.0388	-0.122**	0.0594*	0.0387**	0.00724	0.000697	0.111	-0.0450	0.0140
x Active	(0.0348)	(0.0594)	(0.0304)	(0.0179)	(0.00951)	(0.00400)	(0.0815)	(0.0461)	(0.0188)
Phase 2 (2008-2012)	0.0677	-0.144	0.0571	0.0272	-0.00942	-0.00261	0.0380	-0.0668	-0.00248
x Active	(0.0516)	(0.103)	(0.0383)	(0.0230)	(0.0126)	(0.00441)	(0.107)	(0.0734)	(0.0221)
N	49956	51473	45910	47310	30491	55894	31475	56072	29313

Fixed effect model. Time dummies, industry-specific and country-specific linear trends included. Robust standard errors in parenthesis. * p<0.1 ** p<0.05 *** p<0.01. NN=10 with caliper.

Table 12 - Interaction between EU ETS and environmental patenting activity

	log(VA)	log(emp)	log(VA/L)	log(av wage)	TFP	ROI	log(GFCF)	log(turnover)	Markup
Phase 1 (2005-2007)	0.0120	0.0109	-0.0186	0.00599	-0.0174***	-0.00645***	0.147***	0.0396	-0.0196**
	(0.0184)	(0.0276)	(0.0166)	(0.00955)	(0.00526)	(0.00224)	(0.0487)	(0.0245)	(0.00901)
Phase 2 (2008-2012)	0.0540**	0.0949**	-0.0429**	-0.00635	-0.0199***	-0.00590**	0.218***	0.132***	0.00286
	(0.0269)	(0.0423)	(0.0215)	(0.0120)	(0.00669)	(0.00254)	(0.0567)	(0.0353)	(0.0110)
Phase 1 (2005-2007)	-0.0145	-0.120	0.130**	-0.0206	0.0198	0.0320***	0.0834	-0.00864	0.0886***
x Patents (dummy)	(0.0550)	(0.0807)	(0.0583)	(0.0298)	(0.0192)	(0.00760)	(0.152)	(0.0505)	(0.0286)
Phase 2 (2008-2012)	0.0287	-0.315	0.196**	0.0184	-0.0641	0.0173*	0.221	0.0317	0.0699
x Patents (dummy)	(0.102)	(0.231)	(0.0950)	(0.0416)	(0.0394)	(0.00989)	(0.209)	(0.0941)	(0.0527)
N	49956	51473	45910	47310	30491	55894	31475	56072	29313

Fixed effect model. Time dummies, industry-specific and country-specific linear trends included. Robust standard errors in parenthesis. * p<0.1 ** p<0.05 *** p<0.01. NN=10 with caliper.

Appendix A - Verified emissions in establishments active in the second phase only

Table 13 – Verified emissions by facility status in the first two phases of the EU ETS

Emissions	Active in phase I	Active in phase II only	Total
2005-2007	5,900 (100%)	NA	5,900
2008-2012	13,500 (92.53%)	1,090 (7.47%)	14,590
Total	19,400 (94.68%)	1,090 (5.32%)	20,490

Millions of tons of verified CO_2 emissions. Own elaboration on the EU-CITL data