Discussion Paper No. 16-062

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Why does emissions trading under the EU ETS not affect firms' competitiveness? Empirical findings from the literature

Eugénie Joltreau* and Katrin Sommerfeld**

Abstract

Environmental policies may have important consequences for firms' competitiveness or profitability. However, the empirical literature shows that hardly any statistically significant effects on firms can be detected for the European Union Emissions Trading Scheme (EU ETS). On the basis of existing literature, we focus on potential explanations for why the empirical literature finds hardly any significant competitiveness effects on firms, least not during the first two phases of the scheme (2005-2012). We also reason why the third phase (2013-2020) could reveal similar results. We show that the main explanations for this finding are a large over-allocation of emissions certificates leading to a price drop and the ability of firms to pass costs onto consumers in some sectors. Cost pass-through, in turn, partly generated windfall profits. In addition, the relatively low importance of energy costs indicated by their average share in the budgets of most manufacturing industries may limit the impact of the EU ETS. Finally, small but significant stimulating effects on innovation have been found so far. These different aspects may explain why the empirical literature does not find significant effects from the EU ETS on firms' competitiveness.

Keywords: Cap and Trade system, EU ETS, firm-level competitiveness

JEL-Codes: Q52, Q58, D22

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Acknowledgements: We thank Ulrich Wagner and seminar participants at ZEW for helpful comments, in particular Robert Germeshausen, Kathrine von Graevenitz, Peter Heindl, Benjamin Lutz and Philipp Massier. Financial support by ZEW within the project "Employment Effects of Environmental Regulation" is gratefully acknowledged. All errors remain the authors' responsibility.

1. Introduction

The European Union Emissions Trading Scheme (EU ETS) is the largest market for greenhouse gas emissions worldwide covering more than 11,000 manufacturing and power plants and about 45% of the EU's greenhouse gas emissions in 31 countries (DG CLIMA[1]). It serves as an important example for the design of other carbon markets such as the one in China. At the same time, there are strong concerns that carbon trading may entail negative side effects on competitiveness and employment of regulated companies. This is because regulated firms seem to face additional costs either because of abatement or because of purchasing emissions allowances. However, the empirical literature evaluating the EU ETS finds no significant negative effects on firm-level indicators for competitiveness, at least not for the first two trading phases. Therefore, this paper attempts to explain why – against ex ante expectations – no negative side effects of the EU ETS on firms' competitiveness have been documented empirically, so far.

Understanding the economic effects of emissions trading well is important for at least three reasons. First, understanding the economic side effects of environmental policies is vital for reducing the cost of achieving certain environmental goals. Put differently, efficient climate policy needs to achieve the policy goals at the least possible cost. Second, emissions trading has distributional effects such that certain firms or sectors may benefit while others may face additional challenges (Flues, Thomas, 2015). It is crucial to identify these likely winners and the sectors in need for additional support, in order to be able to implement a successful ambitious climate policy and minimise the risk of carbon leakage. Finally, policy-makers often use the argument of job losses or gains when trying to implement environmental policies. Special interest groups or lobbies also play a role in shaping concerns about potential job losses. Therefore, understanding the effects of climate policies on outcomes such as employment is important.

In theory, a cap-and-trade system imposes extra costs on firms (e.g., Deschenes, 2014). This is because they either have to implement abatement activities or to purchase emissions certificates unless there is free allocation. In addition, firms face transaction costs and costs for monitoring, reporting and verification of emissions (MRV). These costs may lead to a loss of competitiveness depending on the market structure and on the design of the policies, e.g. exemptions. Moreover, the effects are contingent on who is covered by the policy, e.g. whether it is a unilateral policy. It is of relevance whether (foreign) competition exists and which regulation competitors underlie. Notwithstanding, environmental policies could also have positive effects on firms' competitiveness. For example, these policies might trigger innovation with potentially positive consequences (Porter, 1995; Porter, van der Linde, 1996). Also, firms might benefit if emissions certificates are freely allocated and over-allocated, and have a positive value on the emissions market. Hence, there may be positive and negative partial effects from an emissions trading scheme where the overall effect is not generally clear.

While for the Clean Air Act Amendments in the US substantial negative effects on firm level competitiveness have been documented (e.g., Greenstone, 2002, 2012; Becker, Henderson, 2000), it is surprising that the empirical ex post literature on firm-level effects of the EU ETS shows hardly any significant negative impacts on the competitiveness of regulated firms during Phase I and II (for overviews see Venmans, 2012; Arlinghaus, 2015; Martin et al., 2016; also Dechezleprêtre, Sato, 2014; Jaraite, Di Maria, 2016). Still, there appear to be significant reductions in carbon emissions in manufacturing as a result of the EU ETS (Wagner et al., 2014; Petrick, Wagner, 2014; Ellerman et al., 2016). Meanwhile, hardly any negative effects on competitiveness can be detected. For Germany, no statistically significant negative effects of the EU ETS on employment or gross output or exports can be documented (Petrick, Wagner, 2014).

[1] http://ec.europa.eu/clima/policies/ets/index_en.htm, last retrieved 11/08/2016

There is also no indication that over- or under-allocation of EUAs significantly affects firm revenue or employment, at least not in the very early period of the EU ETS (Anger, Oberndorfer, 2008). Preliminary results for France show significant reductions in employment (on the order of -7%, see Wagner et al., 2014) which may be partly driven by carbon leakage and should be considered as the upper bound (ibid.). Negligible competitiveness effects have also been shown in a cross-sector comparison for the entire European Union (Abrell et al., 2011). Even when focusing on energy intensive industries, no negative effects on firm level competitiveness were found for cement or iron and steel industries (Chan et al., 2013). In the power sector, despite rising unit material costs, revenue might even have increased substantially (ibid.).

This study contributes to the literature by trying to determine why researchers do not find significant negative effects of the EU ETS on firm-level competitiveness between 2005 and 2012. Although the third trading period (2013-2020) is still running and there is thus no comprehensive empirical evidence for Phase III, yet, we reason about why this period could also reveal negligible effects on competitiveness, if any. We limit the analysis to competitiveness at the firm level thus excluding the country level perspective. By “competitiveness” we mean a firm’s long run profit performance as measured by turnover, value added or employment (Dechezleprêtre, Sato, 2014, p. 6). The focus is on direct effects from the EU ETS whereas indirect effects, such as through rising electricity prices, are covered only briefly. We proceed by presenting and then checking five potential explanations. As we base all arguments on existing literature, this present study is by itself also a literature review. While existing literature reviews constitute the starting point of this study, we go beyond these by screening five hypotheses explaining why almost no competitiveness effects could be documented so far.

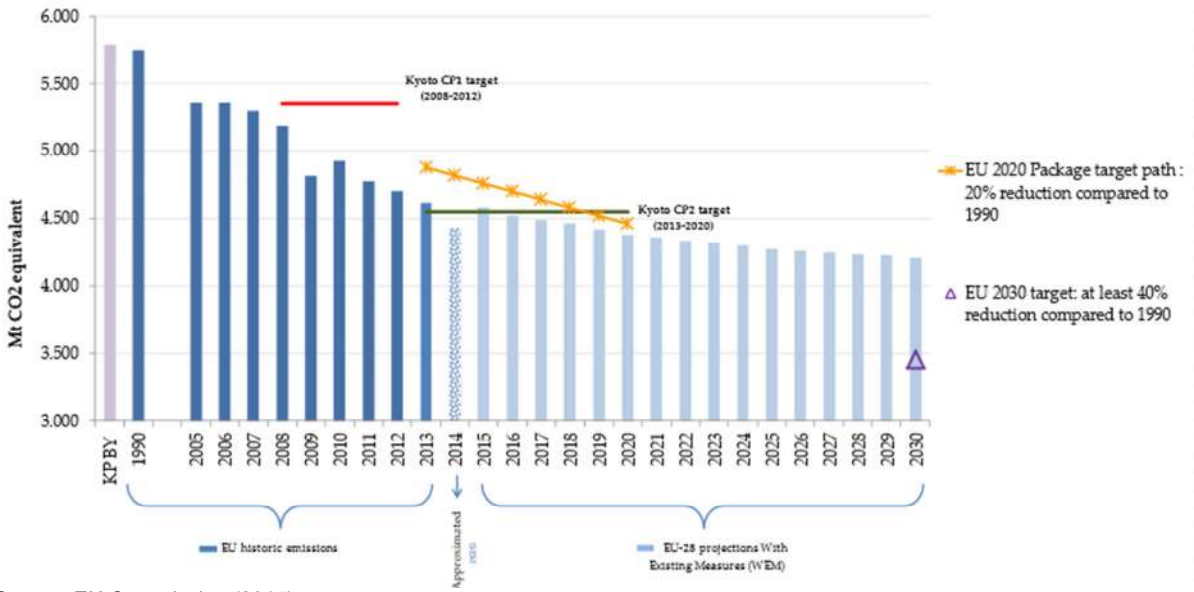
We start from the observation that emissions certificates have so far been mostly allocated for free. Thus, firms have hardly faced any costs of purchasing EUAs but only transaction costs and opportunity costs. Second, the results show that there has been a large over-allocation of emissions certificates leading to a price drop which, in turn, reduced the costs of buying additional certificates and with it reduced the incentives to abate emissions. Third, firms have been able to pass-through the costs of emissions trading onto consumers at least in some sectors, most prominently in the power sector. This fact in combination with large amounts of free allocation of certificates has generated windfall profits for some firms. Fourth, the energy cost share in production is on average rather low but this may hide distributional differences on the firm level. Fifth, small but statistically significant stimulating effects on innovation have been found, potentially small due to the low price of certificates. These results suggest that the EU ETS has effectively reduced greenhouse gas emissions without incurring significant negative competitiveness effects. . However, we leave the question open of whether costs and benefits of the scheme are balanced.

This paper is structured as follows: The next section gives a brief overview over relevant institutional aspects of the EU ETS. Then, section 3 presents an overview over the existing empirical literature on the effects of market-based environmental policies on firm-level competitiveness. Section 4 checks five hypotheses on the EU ETS, one by one, by collecting existing empirical findings. These are first free allocation, second over-allocation, third cost pass-through, fourth energy cost shares and fifth innovation. Finally, section 5 concludes.

2. Institutional background of the EU ETS

The EU Emissions Trading Scheme was launched by the European Commission in 2005 in the framework of the Kyoto Protocol (Directive 2003/87/EC[2]). It constitutes the largest carbon cap-and-trade system worldwide. The overall amount of carbon emissions is capped by allocating only a limited amount of emissions certificates called European Union Allowances (EUAs) which can then be traded. The first trading phase – which was considered a trial phase – ran from 2005 to 2008. Phase II ran from 2009 to 2012. Phase III is running from 2013 to 2020 and is seen as a reinforcement of the system. Country-specific National Allocation Plans (NAPs) used to define the cap as well as how allowances are allocated to individual installations, giving the EU ETS a highly decentralised character during Phase I and II (Kruger et al., 2007; Ellerman et al., 2016). Since Phase III, an EU-wide cap has been replacing the NAPs system, so as to reduce uncertainty.[3] In addition, auctioning has become the default allocation rule[4] replacing grandfathering. Several aspects of the design of the scheme are relevant for understanding the channels for potential competitiveness effects.

Figure 1: Past and projected emissions and emissions reduction targets



Source: EU Commission (2015), p. 4.

Figure 1 shows past and projected emissions together with emissions reduction targets. The initial target was to reduce emissions in CO_2 equivalents by 20% by 2020 as compared to 1990 levels. This joint reduction commitment was already over-achieved by the European Member States in the second period of the EU ETS (2008-2012). According to 2015 projections, emissions are estimated to be 24% lower by 2020 compared to the levels of 1990 (EU Commission, 2015), i.e. lower than the initial target of 20%.[5] While it is uncertain whether this is the result of costly abatement and cleaner production or production slowdown, the fact is that now this constraint may not be binding anymore. In response, the Commission set a more ambitious

[2] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32003L0087 , last retrieved 24/09/16

[3] Under the NAPs system, each country had to submit its NAP to the Commission for approval. This process turned out to be very time-consuming and complex as it led to protracted negotiations between the Commission and several Member States. See http://ec.europa.eu/clima/policies/ets/pre2013/nap/index_en.htm, last retrieved 17/08/2016

[4] However, free allocation still represents about half of allocated permits, since manufacturing sectors are exempted from full auctioning. See section 4.1 and http://ec.europa.eu/clima/policies/ets/allowances/index_en.htm, last retrieved 06/09/2016

[5] The current long-term target is a 21% reduction by 2020 compared to 2005. http://ec.europa.eu/clima/policies/ets/index_en.htm, last retrieved 11/08/2016

target according to which emissions need to be reduced by 40% by 2030 (compared to 1990 levels).[6] As part of this overall target, the emissions cap of the EU ETS will decrease annually by 2.2% from 2021 onwards instead of 1.74% so far. As the figure shows, this will require additional efforts of abatement.

In order to reach the emissions target, firms owning a regulated installation have to provide the amount of EUAs corresponding to the amount of emitted carbon dioxide on a yearly basis. Emission allowances were grandfathered at the beginning of the scheme and later partly auctioned, as detailed in section 4.1. Regulated industries are energy-intensive industries within the manufacturing and the power sector, i.e. combustion installations with a rated thermal input capacity of at least 20 MW, refineries, coke ovens, steel plants, and installations producing cement clinker, lime, bricks, glass, pulp, and paper. In total, the EU ETS covers about 50% of Europe's CO_2 emissions and 40% of its total greenhouse gas emissions (Schleich et al., 2007). Since 2012, the aviation sector has also been added to the EU ETS (Directive 2008/101/EC) taking into account some peculiarities of this sector.[7] While auctioning applies to power generators since 2013 and is said to represent the default allocation method of the third period, all manufacturing sectors receive allowances according to benchmarking. The benchmark value is product-specific and equals the average CO_2 emissions of the best performing 10% of installations for this product (European Commission Climate Action).[8,9] Manufacturing industries receive a decreasing[10] share of their historic production needs multiplied by the product benchmark. At the same time, there are exceptions in order to explicitly "safeguard the competitiveness of industries covered by the EU ETS" (European Commission Climate Action[11]). Since the third trading phase, these exceptions have been regulated according to the estimated risk of carbon leakage (under an amendment to Directive 2003/87/EC). Accordingly, a sector or sub-sector is deemed to be exposed to a significant risk of carbon leakage if it meets one of the following criteria[12]:

1) if direct and indirect costs induced by the implementation of the directive increase production cost, calculated as a proportion of the gross value added, by at least 5%; and the sector's trade intensity with non-EU countries (imports and exports) is above 10%.[13]
2) the sum of direct and indirect additional costs is above 30%
3) the non-EU trade intensity is larger than 30%

Installations in sectors exposed to carbon leakage risk are eligible to 100% free allowances up to the benchmark (de Bruyn et al., 2013). This preferential treatment concerns 154 out of 258 NACE-4 level sectors, representing 95% of 2005 and 2006 industrial emissions (ibid.).

Firms participating in the EU ETS can shift their unused allowances to subsequent periods. As defined by the European Commission: "Since phase 2 (2008), if an ETS participant has a surplus of allowances at the end of a trading-phase it can 'bank', or in other words carry forward, these

[6] http://ec.europa.eu/clima/policies/strategies/2030/index_en.htm, last retrieved 11/08/2016
[7] http://ec.europa.eu/clima/policies/transport/aviation/index_en.htm, last retrieved 22/09/2016
[8] http://ec.europa.eu/clima/policies/ets/cap/allocation/index_en.htm, last retrieved 11/08/2016
[9] This system is said to constitute a rewarding mechanism that may enforce incentives for innovation. Indeed, only the most efficient 10% of installations receive enough allowances to cover their needs. Less efficient firms have to pay for extra permits. Thus, they face the incentive to reduce their emissions at least up to the benchmark value (de Bruyn et al. 2010b).
[10] 80% in 2013 to 30% in 2020 (de Bruyn et al., 2013)
[11] http://ec.europa.eu/clima/policies/ets/allowances/leakage/index_en.htm, last retrieved 11/08/2016
[12] Moreover, sectors close to the threshold levels could ask for a qualitative assessment and potentially being considered at risk of carbon leakage (De Bruyn et al., 2013)
[13] http://ec.europa.eu/clima/policies/ets/allowances/leakage/index_en.htm, last retrieved 11/08/2016

allowances to count towards its obligations in the next phase." (EU ETS Handbook, Climate Action, p. 133[14]). Note that in the first trading period, permits could not be banked beyond 2007.

As an alternative to submitting EUAs according to the amount of verified emissions, installations could submit alternative offsets from the Kyoto Protocol during Phase II but only to a limited extent. These alternative offsets were Emission Reduction Units (ERU) generated from Joint Implementation (JI) activities or Certified Emissions Reductions (CERs) generated from the Clean Development Mechanism (CDM) project activity. Concerning the emissions reduction target for 2030, the Commission and the Parliament have proposed that using international offsets should not be a possible option to meet the 40% target (Carbon Market Watch, 2014).

3. Literature overview on competitiveness effects

Estimating the causal effect of the EU ETS is a difficult empirical challenge due to different reasons. First and above all, treatment assignment is not random but depends on capacity[15], a treatment assignment variable usually not observed by the researcher. Thus, regulated firms are systematically different from non-regulated firms. This challenge is often addressed by employing statistical matching procedures. Second, and equally important, for a methodologically clear comparison of regulated and non-regulated companies, there must be no spill-over effects, for example through energy prices. This would violate the stable unit treatment value assumption (SUTVA; see Rubin, 1978, 1980, 1990; Angrist, Imbens, Rubens, 1996) which is usually required for the econometric approaches in question. Third, it is difficult to separate the causal effect of the EU ETS from other policies' effects especially when introduced at around the same time. These confounding policies may be country-specific energy policies such as the Renewable Energy Sources Act (EEG) in Germany. Fourth, data availability and access are of crucial importance. We will now give a brief overview on empirical ex post evaluation studies. More details on the competitiveness and other firm-level effects of environmental policies can be found in the excellent reviews by Venmans (2012), Arlinghaus (2015) and Martin et al. (2016).

The empirical ex post literature on firm-level effects of the EU ETS finds hardly any indication for negative competitiveness effects, least not for the first two trading periods. Based on firm-level data for the manufacturing industries, Wagner et al. (2014) and Petrick and Wagner (2014) compare regulated to non-regulated companies in France and in Germany, respectively. Using differences-in-differences estimators with matching, they find significant reductions in carbon emissions in both countries for the first half of the second trading phase. Interestingly, while the preliminary results for France show significant reductions in employment on the order of 7% for the early second trading phase, no negative competitiveness effects can be detected in the analysis of Germany. This holds for employment as well as for gross output and exports. The effects on gross output and exports in Germany might even be slightly positive. One potentially important channel for finding negative results for France is carbon leakage as explicitly discussed by Wagner et al. (2014).[16] For Germany, Petrick and Wagner (2014) cannot separate the effects of the EU ETS from those of the changes made to the German Renewable Energies Act. For Germany, Anger and Oberndorfer (2008) analyse regulated German companies in the early period of 2004-2005 taking the ratio of EUAs to verified emissions as explanatory variable of interest. This indicator for over-allocation shows no statistically significant effects on changes in

[14] http://ec.europa.eu/clima/publications/docs/ets_handbook_en.pdf, last retrieved 11/08/2016

[15] More precisely, "capacity" refers to the rated thermal input for combustion installations and specific capacity thresholds for plants within specific industrial activities.

[16] According to Martin et al. (2014a), the risk of carbon leakage and thus job loss due to the EU ETS could be substantially reduced by means of an efficient permit allocation scheme.

firm revenue or in employment. However, their results could be biased by early abatement activities. For Lithuania – the most over-allocated country in the EU ETS – Jaraite and Di Maria (2016) also find no significant economic effects on regulated firms. They stress that this result also implies that there have not been any huge windfall profits for these firms. For the specific case of the Lithuanian power sector, they suspect a relevant amount of carbon leakage by means of closing one large reactor and increasing electricity imports from neighbouring countries. Abrell et al. (2011) empirically analyse manufacturing firms in the entire European Union. Using propensity score matching, they compare regulated firms to firms from all non-regulated sectors. Hence, sectoral trends could confound their results. These show no statistically significant effects of the EU ETS on firms' value added or profit margins. Still, for employment they detect a small but statistically significant effect of -0.9% for the first trading phase which appears to be driven by the non-metallic mineral sector. Considering only the industry sector for identification of ETS participation, Commins et al. (2011) report statistically significant negative effects on total factor productivity (TFP) growth for the first period of the EU ETS. However, keep in mind that treatment identification is very crude and driven exclusively by cross-sector differences.

Turning from manufacturing to more specific industrial sectors, Chan et al. (2013) study firms in the power, cement, iron and steel industries in ten large countries comparing ETS-regulated to non-ETS-regulated companies within these industries. Interestingly, they only find statistically significant results within the power sector where unit material costs are shown to have increased by 5% (Phase I) to 8% (Phase II). At the same time, they demonstrate that revenue has increased by a remarkable amount of 30%. Note that this study detects no negative effects on competitiveness in the other studied sectors which are very energy-intensive nor does it identify employment effects in any of the sectors. For major European power companies, also the returns on the stock market appear to be positively correlated with EUA prices (Veith et al., 2009 and Bushnell et al., 2013). These results could be an indication of a strong cost pass-through onto electricity consumers. At the same time, the results of these two studies have to be treated with caution due to their small samples. Yu (2013) analyses a larger sample of Swedish energy firms for the first two years of the EU ETS. Applying a differences-in-differences approach to the energy industry the study shows no significant impact of the introduction of the EU ETS on profitability in 2005 and a negative significant impact in 2006.

As for the Kyoto Protocol as a whole, Aichele and Felbermayr (2015) demonstrate important carbon leakage effects on a more aggregated level. They focus on carbon embodied in trade in the framework of a gravity model which they apply to country or industry level data showing that some sectors are more prone to carbon leakage than others (also Aichele, Felbermayr, 2012). Dechezleprêtre et al. (2014) also employ a rather rough identification strategy in order to analyse carbon leakage effects: They compare EU to non-EU companies based on self-reported survey data and find no significant carbon leakage from the EU ETS.

Evaluation studies on market-based environmental policies other than the EU ETS show similarly negligible effects (e.g., Pestel, 2014). Two recent studies focusing on Germany employ a regression discontinuity design (RDD), thereby comparing firms closely around a policy-relevant threshold. Using highly reliable large administrative firm census data for the manufacturing sector, they conclude that neither the electricity tax (Flues, Lutz, 2015) nor the Renewable Energy Sources Act (Gerster, 2015) exhibit statistically significant effects on firms' profitability. By estimating cross-price elasticities between electricity and heterogeneous labour for the German manufacturing sector, Cox et al. (2014) point to weak substitutability between electricity and labour when the production level is held constant. This would imply small employment losses due to the renewable energy surcharge which are inflicted in particular on medium and highly qualified employees. For the UK, the Climate Change Levy (CCL) has been evaluated by Martin et al. (2014c) for manufacturing plants, using panel data from the UK production census. While they

find a strong negative impact of the CCL regulation on energy intensity and electricity use of firms, they find no negative effects on economic performance or on plant exit.

These findings of small or negligible effects from the EU ETS are surprising given that for other international environmental policy schemes substantial effects have been documented. One of the most important policies in the US is the Clean Air Act which has triggered a large amount of related empirical literature. The early literature often used industry or county-level data finding inconclusive results or a zero effect of the Clean Air Act on employment (see Jaffe et al., 1995 for an overview). By means of simple panel methods and firm-level data, Greenstone (2002) finds significant negative effects of the Clean Air Act amendments on employment, capital stock and output in pollution-intensive industries. By means of similar methods, Berman and Bui (2001) analyse a particular air quality regulation in the LA air basin and find hardly any employment effect of this regulation. If anything, there could be a small positive employment effect. List et al. (2003), by contrast, stress the importance of using semi- or non-parametric methods and argue that the effects of the regulation may otherwise be biased upwards (also see Henderson, Millimet, 2007). Deschenes (2012) uses yet another approach by estimating cross elasticities between the electricity price and labour, finding weak negative effects of an increased electricity price on employment, which he interprets in light of the Clean Air Act. Concerning the effects of the stringency of this regulation on other competitiveness-related outcomes, significant negative effects have been found for total factor productivity (TFP; Greenstone et al., 2012) and plant births (Becker, Henderson, 2000). Meanwhile, the evidence is mixed for location decisions (Kahn, Mansur, 2013) and foreign direct investments (FDI; Henderson, Millimet, 2007; List, Co, 2000). Statistically significant but economically very small effects have been found for wages as a result of job transitions (Walker, 2013). Overall, modern semi-parametric methods generally show much weaker effects as compared to simple panel methods.

It remains an important open question why these international environmental policies display negative effects on firms' competitiveness whereas such negative effects have not been documented for the EU ETS? Because of this insight, this present study explores different reasons for which there may not be any substantial competitiveness effect from the EU ETS.

4. Hypotheses on the question: Why does the EU ETS not significantly affect firms' competitiveness?

As shown above, the literature finds weak or zero effects of environmental policies on firms' economic performance. These results run counter to traditional concerns saying that environmental policies destroy jobs and harm the competitiveness of exporting firms. This raises another question: Why do empirical researchers not detect any significant negative impact of market-based instruments on European firms' competitiveness? We answer this question in the framework of the EU ETS by analysing several hypotheses. We discuss them and try to find supporting evidence in empirical and theoretical findings. While the following five hypotheses may be linked, it is worth discussing their individual particularities and implications in the following.

4.1 Free allocation

Hypothesis No. 1: "Free allocation of emissions certificates reduces the cost burden of firms, and thus may help reduce negative effects of the EU ETS on competitiveness and economic performance."

When faced with the EU ETS regulation, firms have to either abate emissions or buy certificates. Therefore, firms traditionally consider environmental regulation an onerous economic burden, as it increases production costs and may have further repercussions on companies' employment level and performance. Three types of costs associated with a trading scheme implementation can be distinguished (following Clò, 2010): abatement costs[17], potentially higher electricity prices and the costs of buying certificates. Free allocation saves firms from bearing this last cost, i.e. from buying their permits on the carbon market. For this reason *free* allocation may help alleviating the potential negative impact on European plants.

Since the beginning of the scheme in 2005, free allocation has been the main allocation mechanism within the EU ETS. During the first years the cap of certified emissions was also seen as an adjustment variable so as to introduce the constraint gradually and to figure out how many allowances countries and industries needed. Allocation was applied according to grandfathering: emissions certificates were freely distributed according to past emissions. Afterwards, in particular since the start of the third trading period, allocation has aimed at protecting manufacturing plants that are globally trade-exposed, while energy firms have had to buy their permits at auction. In the case of manufacturing, free certificates have been distributed according to a benchmark figure and historical production data of installations. Most trade-intensive and carbon-intensive sectors have received 100% free permits up to the benchmark (see section 2.)

Free allocation was the most prevalent and nearly the only method applied between 2005 and 2012, and to a lesser extent also at the beginning of Phase III. The European Commission authorised EU member states to auction a maximum of 5% of their allowances in Phase I and up to 10% in the second trading period. Otherwise, free allocation was the default rule. For several reasons, such as the fierce opposition of European firms against auctioning, only four governments chose to auction or sell a small share of permits in Phase I (Denmark, Hungary, Lithuania and Ireland; see Ellerman, Buchner, 2007; Venmans, 2012). In all, auctioning accounted for an annual average of 0.13% of certified emissions (Ellerman, Buchner, 2007). In Phase II, only seven countries delivered information on auctioned allowances on the website of the European Commission.[18] The National Allocation Plans (NAPs) only envisaged that 3.1% of

[17] For example, firms may buy new equipment so as to adopt an eco-friendly production process and to control their level of pollution (Gray, 2015).
[18] DG CLIMA, Phase II auctions (2008-2012), http://ec.europa.eu/clima/policies/ets/pre2013/second/index_en.htm, last retrieved 11/08/2016

total allowances should be auctioned (Schleich et al., 2007; Venmans, 2012). The decentralised nature of the EU ETS apparently has given countries an incentive to allocate free allowances generously, as argued by Kruger et al. (2007) and Schmalensee, Stavins (2015).

We have seen that free allocation was clearly dominant in Phase I and II. The main difference between the first two phases and Phase III is that the electricity sector in general now has to buy permits at auctions (EU Commission, 2014a; Clò 2010). Manufacturing sectors receive allowances partially for free under benchmarking. Still, in 2013, manufacturing industries not classified at risk of carbon leakage received on average 80% of permits for free up to the benchmark.[19] This share is supposed to decrease smoothly to 30% by 2020. As for sectors "deemed at risk of carbon leakage" they receive 100% free allowances up to benchmark during the entire Phase III and thereafter, as long as they stay on the carbon leakage list.[20] 154 out of 258 NACE-4 sectors belong to this list, representing 85% (Martin et al., 2014a) up to 95% (de Bruyn et al., 2013) of CO_2 emissions from manufacturing. Overall, free allocation represents 43% of the total amount of certificates of Phase III (2013-2020).[21]

Should it be of concern that a large share of emissions certificates is allocated for free? This allocation method is challenged by some economists (e.g. Cramton, Kerr, 2002; Hepburn et al., 2006) who prefer auctioning. Free allocation may not reflect marginal abatement costs and thus create competitive distortions. Moreover, free allocation is often referred to as a subsidy in the literature (Jegou, Rubini, 2011; Neuhoff et al., 2006; Böhringer, Lange, 2005). In addition – depending on the allocation mechanism – free allocation could influenced by pressure from individual companies or other interest groups more heavily than auctioning. When combined with cost pass-through, free allocation may increase firms' profitability (see hypothesis no. 3). Auctioning could be more environmentally effective than free allocation because its positive price may induce greater investment in low-carbon technologies (Milliman and Prince, 1989, 1992; Cramton and Kerr, 2002, p.2). Still, under free allocation the opportunity costs of the emission certificates remain, thus generating incentives for abatement and investment signals (Requate and Unold, 2003). In particular, comparing free allocation and auctioning with identical caps, the difference between both allocation mechanisms is a distributional matter. As far as we know, no empirical ex post evidence stating that free allocation enables better economic performance than auctioning has been provided so far. Therefore, we leave this topic to future research. In conclusion, it is difficult to attribute the large amount of free allocation causally to the empirical findings which show no negative effects of the EU ETS scheme. Still, we have seen that this allocation method has prevailed by far since 2005. This result is important to remember for the subsequent two hypotheses which will be over-allocation and cost pass-through.

[19] DG CLIMA, Free allocation based on benchmarks http://ec.europa.eu/clima/policies/ets/cap/allocation/index_en.htm, last retrieved 11/08/2016

[20] Sectors deemed at risk of carbon leakage by the European Commission are defined in an official list (see paragraph « Carbon leakage list », DG CLIMA, Carbon Leakage http://ec.europa.eu/clima/policies/ets/allowances/leakage/index_en.htm, last retrieved 17/08/16)

[21] DG CLIMA, Free Allocation http://ec.europa.eu/clima/policies/ets/allowances/index_en.htm, last retrieved 11/08/2016

4.2 Over-allocation

Hypothesis No. 2: "An over-allocation of allowances to regulated firms has occurred and has largely eased the compliance constraint on these firms. Therefore, we may not find negative effects of the EU ETS on firms' competitiveness and economic performance."

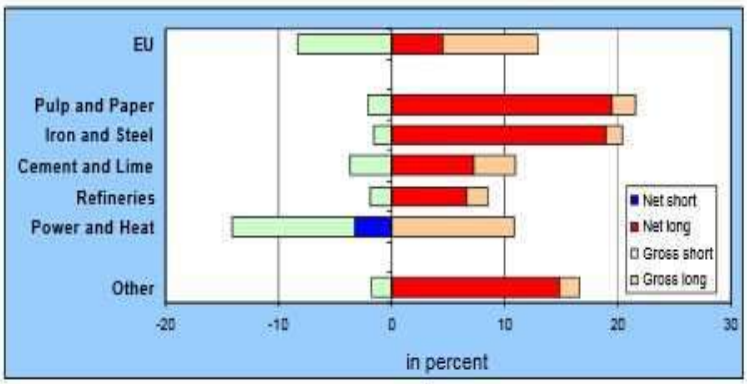
To what extent has over-allocation been taking place since the implementation of the EU ETS? Over-allocation would mean that the majority of the ETS firms have many more allowances than needed. Under auctioning over-allocation could be lower than under free allocation, as rational firms only buy as many permits as they need. However, depending on uncertainty and price expectations, there may also exist substantial over-allocation under auctioning. There is a strong indication for over-allocation of allowances in the EU ETS as we are showing step by step for all three trading phases.

Note that over-allocation is conceptually different from being long[22] (Ellerman, Buchner, 2008). In this paper we also consider a large-scale long position to be of interest, as it would represent a lightened burden for regulated firms.

I. Over-allocation in the first trading period (2005-2007)

The first trading period was considered a trial period and of all three trading periods so far, it is the one for which we have most empirical evidence available. There has been an excess of allowances at least during the first two years (Grubb et al., 2005). In 2005 the whole market was long with 95 million tonnes CO_2, corresponding to 4.5% of the allocated allowances[23] (Kettner et al., 2008). This average percentage hides disparities between Member States, sectors and individual firms. On the aggregate level of Member States, Lithuania exhibits the most pronounced long position with over 100% more allowances than needed (Anger, Oberndorfer, 2008). Ireland and the UK show the most pronounced short position with about 20% less allowances than needed (ibid.).

Figure 2: Positions by European sectors in 2005



Source: Data: CITL, National Allocation Plans and List of Installations; Graph from Kettner et al. (2008), p. 53.

As for disparities between sectors, Kettner et al. (2008) show that all sectors were long in 2005 except the power and heat sector (figure 2). The oversupply is particularly high for the pulp and paper as well as for the iron and steel sector. Some large companies belonging to these sectors were referred to as "carbon fat cats" by Morris and Worthington (2011), i.e. heavily over-allocated companies.

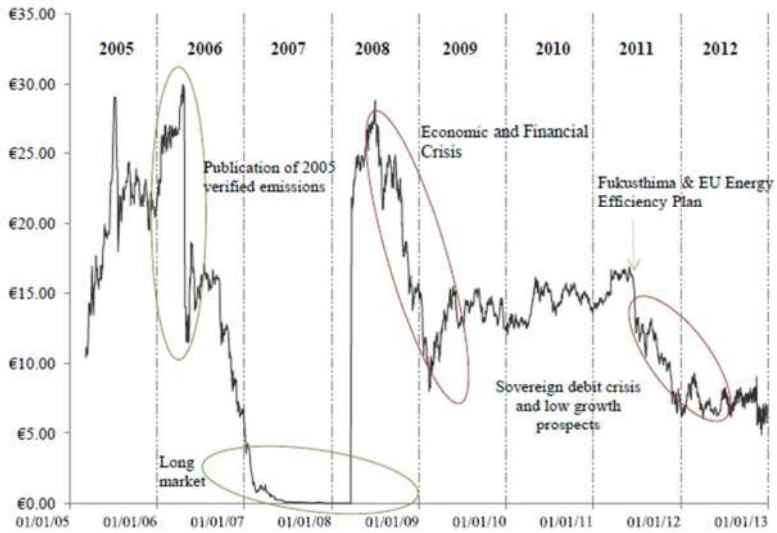
[22] A long position corresponds to the state of having more permits than needed. In a trading scheme, it is normal that some firms are long and others short, as installations have different marginal costs of abatement. Accordingly some chose to abate (become long) and other to emit and buy permits (become short). Economic conditions also play a role as firms producing less will need fewer allowances than expected. In contrast, over-allocation is the consequence of a misallocation (too many permits are allocated). It results in an excessively long position covering the whole market. It results in an excessively long position covering the whole market. This requires estimating a plausible business as usual (BAU) scenario for comparison (Ellerman, Buchner, 2008).

[23] These figures are based on installations for which data were available for both allocated EUAs and verified emissions for 2005 and 2006, see Kettner et al. (2008).

By contrast, the power sector is the only one that used more allowances than it received for free during the first two phases (Abrell et al., 2011). It was short by about 3% in 2005 (Ellerman, Buchner, 2008). The power sector is assumed to be hardly trade-exposed and governments believed that potential abatement was larger (Kettner et al., 2008), most likely due to its large volume of emissions. Therefore, most EU-15[24] countries provided a short allocation of EUAs to the electricity utility sector (Ellerman, Buchner, 2007). Kolshus and Torvanger (2005) indicate that sectors competing internationally were advantaged in terms of allocation.[25]

Behind the aggregated statistics on the country or sector level, on the *individual* firm level most firms are long but a few are short (see Kettner et al., 2008). On a more disaggregated level, there are also disparities between individual installations as Anger and Oberndorfer (2008) emphasise. Indeed, they reveal strong variations of the allocation factor between firms. Kettner et al. (2008) add distorting distributional impacts among installations according to their size. While small[26] plants tend to have a long position but with a high dispersion, large plants tend to be short, however with a smaller dispersion (ibid.). Possibly, the heterogeneity in long positions described here is linked to the effect heterogeneity with respect to firm size that the ex-post literature observes (Abrell et al., 2011; Chan et al., 2013; Martin et al. 2014a).[27] Moreover, the initial allocation of allowances is highly relevant for emissions reduction because firms that are short cut emissions to a greater extent than long firms and vice versa (Abrell et al., 2011).

Figure 3: Evolution of the spot price of EUAs (2005-2012)



Source: Civitelli (2016), p.11.

In April 2006, one after another, most of the EU members revealed long positions regarding EUAs, until the EU Commission released the complete version of verified emissions on May 15, 2006. It showed that in 2005 the whole market was long with 95 million tonnes CO_2 (Kettner et al., 2008). As prices reflect available information, the disclosures were swiftly followed by a sharp collapse of the EUA prices (see figure 3).

The EUA price was considered too low to exploit a large abatement potential by Kettner et al. (2008). At the same time, a low-carbon price reduces costs for those sectors or installations who are short. Note that the carbon price may still be significantly positive despite over-allocation, in

[24] Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the UK.

[25] For example, Czech "exposed sectors" received about 32% more than their past emissions while "non-exposed" sectors received only 3.5 %. Note that both got less than their BAU emissions. Kolshus and Torvanger (2005) define two aggregate groups of sectors as follows:
Exposed sectors: refineries, iron and steel, cement, glass, line, ceramics, pulp and paper and others.
Non-exposed sectors: electricity, district heating, energy, combined heat power, power, heat, cogeneration, steam.

[26] Small installations account for 5% of emissions in total, whereas the largest installations are responsible for 50% of emissions (Kettner et al., 2008)

[27] In addition, Heindl (forthcoming) documents that costs for monitoring, reporting and verification of emissions (MRV) are proportionally higher for small than for large firms.

case participants do not know about the over-allocation, or expect a higher stringency in the future.[28]

Next, we discuss whether this overall long position can be attributed to over-allocation (see footnote 22). Some authors find evidence of over-allocation and abatement at the same time (Ellerman, Buchner, 2008; Anderson, Di Maria, 2011). While this may sound counterintuitive, the authors argue that the two may co-exist, as abatement is linked to the CO_2 price and not to allocation.[29] To gauge the extent of over-allocation for the years 2005-2006, Ellerman and Buchner (2008) estimate a BAU scenario and propose a measure of allocation which uses past and verified emissions. Their thorough inquiry suggests that over-allocation might have reached a maximum of 125 million EUAs in 2005-2006. According to them, this length cannot be attributed to abatement or unexpected conditions. Moreover, they demonstrate that firms did abate emissions by between 50 and 100 million tonnes each year. The results by Ellerman et al. (2010, estimating 70Mt per year) and Anderson and Di Maria (2011) are well within that range. The latter estimate net abatement in 2005, 2006 and 2007 to be of around 84, 62, and 28 Mt CO_2 respectively, following the declining trend of the EUA prices. Ellerman and Buchner (2008) underline that over-allocation could have its roots either in an under-estimation of abatement or an over-estimation of emissions ex ante.

II. Over-allocation in the second trading period (2008-2012)

The second trading period was characterised by a fierce economic downturn. In consequence, there was once more a large excess of unused allowances as indicated by DG CLIMA (2013).[30] Due to the scarcity of studies focussing on the oversupply of allowances in the second trading period of the EU ETS, we use prices as an indicator. In fact, a low carbon price should reflect oversupply and vice versa.

Figure 4: EUA and CER price from January 2008 to November 2012.

Source: Haita (2013), p. 2.

Figure 4 depicts EUA and Certified Emissions Reduction (CER) prices (from Haita, 2013). The price decrease started with the European Commission's release, indicating that 2008 verified emissions were 3% below the 2007 level.[31] A first drop followed right after and may be largely explained by the 2008 financial crisis (Haita, 2013).

Although the economic downturn seems to have initiated the bearish trend, there may be many other reasons for its continuing decline such as the overlapping of different climate policies or the

[28] Another argument for a positive EUA price despite over-allocation is provided by banking. This was, however, not relevant in the first trading period.

[29] „In a trading system, it is not the allocation to an installation that causes a firm to reduce emissions, but the price that it must pay, even if in opportunity cost, for its emissions" Ellerman and Buchner (2008), p. 286.

[30] EU ETS factsheet, European Union, October 2013, p.4 "2nd trading period. […]the economic downturn cuts emissions, and thus demand, by even more. This leads to a surplus of unused allowances and credits which weighs on carbon price." Available at http://ec.europa.eu/clima/publications/docs/factsheet_ets_en.pdf, last retrieved 11/08/2016.

[31] http://europa.eu/rapid/press-release_IP-09-794_en.htm?locale=en, last retrieved 11/08/2016.

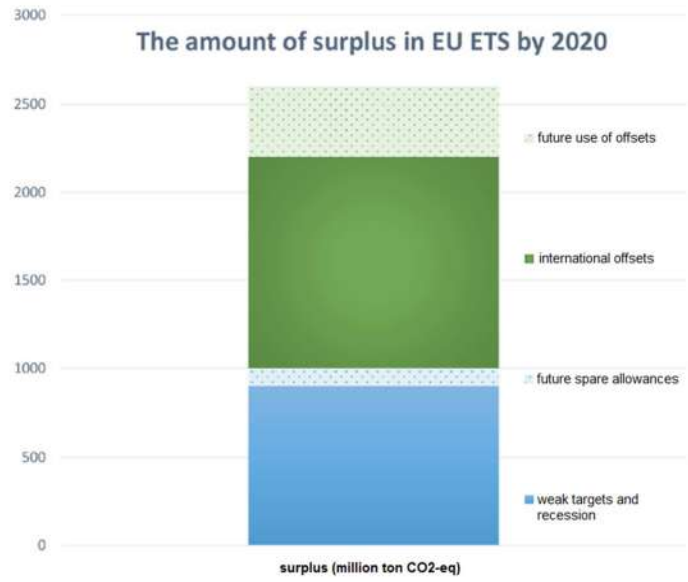
mild weather of the period (Haita, 2013). We also observe that the CER price is starting to decouple with the EUA price, making it cheaper for firms to buy carbon offset credits than permits. This could exacerbate the oversupply of EUAs. Due to the economic crisis, all BAU estimations constructed before became out-dated making it hard to pinpoint over-allocation as opposed to a long position.

What is important is the substantial oversupply of EUAs along with the possibility of banking these unused allowances to the third trading period. In fact, it can be rational for firms to bank emission allowances to future periods in order to minimise abatement costs over time (Ellerman et al., 2015). Morris (2011) reveals that 77% of EU ETS installations had a long position in EUAs in 2011. He estimates the surplus of allowances to have reached 855Mt CO_2 in 2011, of which 672 Mt CO_2 would be saved for Phase III. In early 2012, the accumulated surplus accounted for 955 million allowances, i.e. 406 million allowances when excluding international credits[32] for compliance (EU Commission, 2012). At the end of 2013, the overcapacity reached 2 billion allowances (Carbon Market Watch, 2014). This shows that banking entails the risk of extending a surplus of allowances to the subsequent period.

III. Over-allocation in the third trading period (2013-2020)

The third trading phase of the EU ETS is still on-going so we cannot provide final results regarding over-allocation or oversupply for this period. Moreover, we are not aware of any ex post empirical evidence on competitiveness effects during this period. Still, we document what we know so far and reason why this period could be similar to the previous ones, in spite of the Commission's attempt to make it more stringent.

Figure 5: The build-up of surplus in EU ETS by 2020



Source: Carbon Market Watch (2014), p. 4.

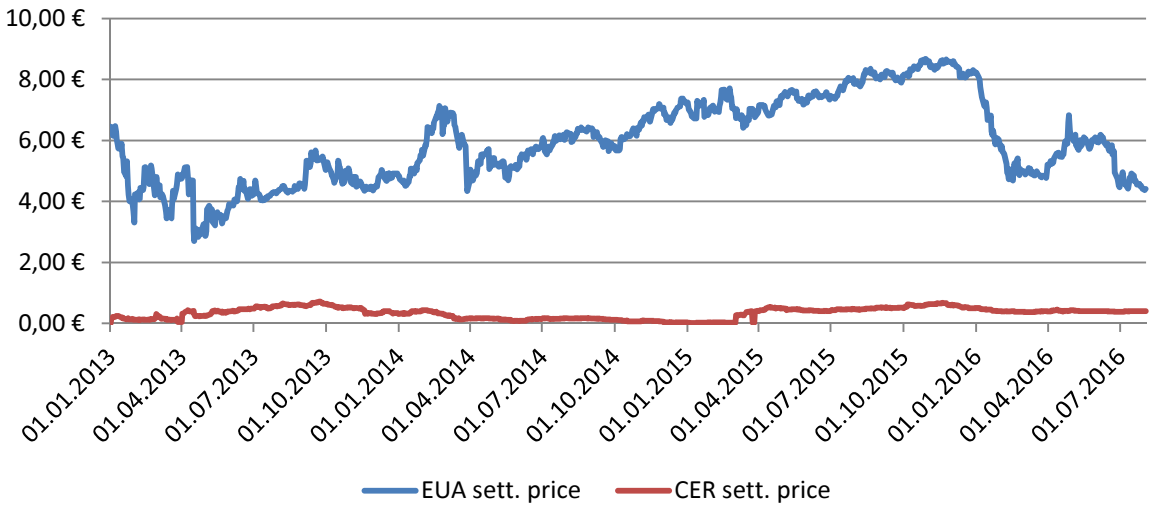
As expected, the allowance surplus of Phase II was banked into Phase III, which now has to deal with a massive surplus of 2.1 billion permits (figure 5; Carbon Market Watch, 2014). This surplus is expected to increase to 2.6 billion by 2020. According to the authors, this excess is further increased by the possibility of using international credit offsets, whose price was close to €0 in 2014 and thus lower than the permit price (around 5€) during the same period.

As we observe in figure 6, both prices (CER and EUA) are low, with the CER price close to 0€. When CERs are cheaper than EUAs, installations rather opt for the CER option (purchase international offset credits). This frees up their EUAs (either bought or received for free) which they can shift to Phase IV (2021-2030) or sell on the carbon market and thus achieve windfall profits. As a consequence, the EUA supply increases and its price falls. Even if the practice of buying CERs was limited at 1.6 billion CERs for Phase II and III by the Commission (Carbon

[32] "An international credit that is used for compliance frees up one allowance that does not need to be used for compliance. As such the use of international credits for compliance increases the surplus of allowances available to the market" EU Commission (2012).

Market Watch, 2014), it would still have significant consequences on the carbon market, as it is responsible for more than half of the expected 2020 EUA surplus (see figure 5). Note that the carbon price is far from reaching the price reference of 30 euros that the Commission employed for calculating which sectors are exposed to carbon leakage risk.

Figure 6: EU Emission Allowances and Certified Emissions Reductions Prices (Jan 2013-Aug 2016)



Source: Thomson Reuters Datastream, own graph.

An important characteristic of the third trading period is the application of exemption rules to sectors with a high risk of relocation. This may lead to an overcompensation of these sectors deemed at risk (Martin et al., 2014a). Martin et al. (2014a) show that for many firms, the propensity to relocate does not fluctuate with the amount of free certificates. In turn, this finding implies that these firms are overcompensated with free permits (Martin et al., 2014a). In addition, Martin et al. (2014b) show that the trade intensity criterion alone has not been well-suited for reflecting the carbon leakage risk and that only carbon intensity constitutes a good proxy. However, 134 out of 140 exempted NACE-4 sectors are exempted for the reason that they are trade-exposed while not appearing to be carbon intensive at all (Clò, 2010; see also Martin et al., 2014a,b). These results point to overcompensation if the aim of the exemption rules is to reduce the risk of relocation.

Summing up, we have documented a substantial surplus of emission allowances for all three trading phases. This carries three implications: First, plants that have a surplus of allowances could ignore abatement options but they have an incentive to reduce their emissions in order to sell the remaining certificates. Second, these firms could sell their excess of permits and thus increase their profitability ("windfall profits"[33]). Third, as oversupply causes prices to fall, other firms could benefit from cheap allowances on the carbon market. In addition, the low price of emission certificates reduces the scope of feasible abatement options to only the cheapest ones. These three circumstances may be the reason for not finding harmful effects of the trading scheme on competitiveness.

[33] We define windfall profits as an increasing profitability that can be explained by participation in the EU ETS, either through selling an allowance surplus or by passing through opportunity costs of the free allowances to consumers (also see hypothesis no. 3).

4.3 Cost pass-through

*Hypothesis No. 3: "When firms can **pass-through costs** to consumers they may earn profits from freely allocated emissions certificates. This may explain not finding negative effects of the EU ETS on firms' economic performance."*

When firms have the ability to pass ETS costs on to consumers, windfall profits may occur. This may happen if either one of the following two conditions is fulfilled: On the one hand, if there is free allocation of emissions certificates and firms use marginal pricing to pass on the opportunity cost of the certificates to consumers. On the other hand, windfall profits may occur under auctioning in case the pass-through rate is higher than 100%, i.e. the pass-through overcompensates for the purchase of the certificates (Sijm et al., 2011). Theory suggests that firms integrate the opportunity costs and the auction costs in like manner. Thus, in both cases, the price increase for consumers should be the same (Sorrel, Sijm, 2003; Klemperer, 2008; Fabra, Reguant, 2014).

The pass-through rate as well as the potential of increasing profitability depends on the market structure, namely on the number of competitors as well as on the demand and supply price elasticity (for details see Sijm et al., 2009). Theory suggests that when demand becomes less price responsive (inelastic) or the market becomes less competitive, the pass-through rate increases, potentially above 100%. Alternatively, a full pass-through rate (100%) is also expected in the case of perfect competition, when supply is fully elastic and the demand function linear (Sijm et al., 2011). Indeed, prices reflect marginal costs under full competition. We assume that if all firms are subject to these rising costs, none of them will lose competitiveness relative to others. Otherwise, price distortions may arise and regulated firms could lose market shares (Alexeeva-Talebi, 2010). Accordingly, the decision of fully passing through costs relies on strategic behaviour (short-term earnings versus long-term market share loss). To avoid losing customers in the long-run, firms may cut profit margins when possible, or they may relocate. Firms as rational profit-maximisers only pass-through costs as long as profits outweigh potential losses (de Bruyn et al., 2010a). Alexeeva-Talebi (2010) demonstrates that products' substitutability also plays its part in determining the PTR. In the same context of linear demand and constant marginal costs, a monopoly is expected to pass-through only 50% of costs. But its powerful position guarantees the monopolist a rent without losing clients. In addition, the literature identifies price rigidities as another potential source of incompleteness of passing through costs (Fabra, Reguant, 2014).

We now study the case of the power sector. Recall that Chan et al. (2013) find significant effects on increasing unit material cost and total revenues for the power sector in ten European countries, even though the sector was short as a whole. The authors conclude by saying that "both findings could reflect utilities passing the cost (from compliance) to consumers" (ibid, p. 1061).

The energy sector is a special case with respect to cost pass-through ability and market structure for two main reasons. First, electricity distribution is based on a national grid structure which prevents most international companies from competing (Clò, 2010). Therefore, many power firms used to have a historical monopoly in delivering electricity. This situation confers utilities a strong market position, especially on retail markets (Veith, 2009; EU Commission, 2011). Second, demand for electricity is highly price *in*elastic where price elasticity is usually lower for households than for the industry (Fan, Hyndman, 2011; Filippini, Pachauria, 2004; Filippini, 1999). In addition, low price rigidity facilitates the full pass-through of marginal costs. This is due to the organisation of electricity markets in the form of an auction. Due to its high market concentration and low price elasticity, the power sector is well-fitted for cost pass-through.

We now show empirical evidence of substantial pass-through rates (PTR) in the power sector. Fabra and Reguant (2013) study the Spanish electricity wholesale market at the beginning of the EU ETS (2004-2006). They find that carbon costs were almost fully transferred to final prices with an average PTR of 80%. Sijm et al. (2006) calculate empirical pass-through rates of between 60% and 117% for 2005 for Germany. When studying the power sector in the Netherlands, they find the pass-through rate to vary between 64% and 81%. Both studies demonstrate a higher PTR during high demand hours (on-peak hours). Furthermore, Fabra and Reguant (2013) reason that price changes only reflect changes in marginal costs. Another indication for windfall profits due to high pass-through rates in the power sector is the positive evaluation of increasing EUA prices on the stock market (Bushnell et al., 2013; Veith et al., 2009; Oberndorfer, 2009). These studies reveal that financial markets expect firms to pass compliance costs through and expect power generators to benefit from the regulation. The only exception is Spain as it experiences a negative EUA-to-stock relationship (Oberndorfer, 2009).

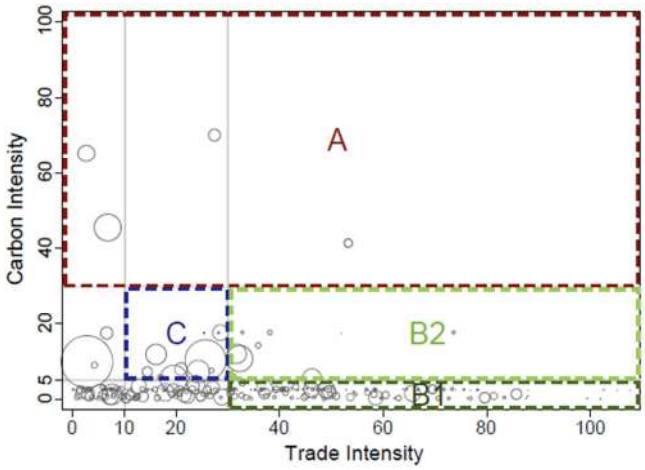
The electricity sector is found to not only pass-through opportunity costs, but it may on top benefit from an asymmetric cost pass-through (Zachmann and von Hirschhausen, 2008; Oberndorfer et al., 2010). Thus, producers may largely benefit from increased prices. Zachmann and von Hirschhausen (2008) as well as Mokinski and Wölfing (2014) provide evidence of an asymmetric cost pass-through of EUA costs in the German wholesale electricity market. The latter suggest that this asymmetry was the consequence of non-competitive pricing behaviour, as it disappeared after the competition authority decided to monitor electricity pricing. In contrast to these two studies, Oberndorfer (2009) shows that the European stock market does react symmetrically to the EAU price movement. They consider two possible explanations: either the German case might not be well comparable to other European countries or stock markets' agents might not be aware that prices are passed on asymmetrically.

Summing up, we find a strong indication of a very high cost pass-through rate in the power sector which implies windfall profits, at least for Phase I and II of the EU ETS when emissions certificates were almost fully allocated for free. More precisely, for Phase I, windfall profits for the UK power generation sector were estimated to reach about £800m/year (WWF, 2005). For Phase II, windfall profits of the European power sector were estimated to range between 23 and 63 billion euros, based on a carbon price of 21 to 32 €/t CO_2 and different pass-through assumptions (WWF, 2008). As for the third trading phase, the power sector now has to buy emissions certificates via auctioning, with the exception of power industries located in eight countries (Bulgaria, Cyprus, the Czech Republic, Estonia, Romania, Hungary, Poland, and Latvia).[34] The introduction of auctioning may reduce windfall profits in the power sector. Finally, note that public authorities may intervene to limit cost pass-through. For example the French government increased regulatory interventions to restrict the price increase of Electricité De France (Laing et al., 2013; Le Figaro, 2015[35]).

In contrast to the power sector, many manufacturing industries may be more exposed to competition. Therefore, manufacturing industries may be at risk if they increase output prices compared to non-EU competitors that are not facing a comparable CO_2 regulation. Therefore we will next discuss the manufacturing sector.

[34] CDC Climat, *Climate Brief* n°25 „Auction Revenues in EU ETS Phase 3: A new public resource", January 2013.
[35] Le Figaro, 15/07/2015, « Les tarifs d'EDF pourraient bondir de 3,5% à 8% » http://www.lefigaro.fr/conso/2015/07/15/05007-20150715ARTFIG00181-les-tarifs-d-edf-pourraient-bondir-de-35-a-8.php, last retrieved 11/08/2016

Figure 7: Manufacturing sectors split according to trade and carbon intensity[36]



Source: Martin et al. (2014b), p.81.

Figure 7 represents European manufacturing sectors divided according to their trade and carbon intensity (Martin et al., 2014b). Sectors deemed at risk by the EU Commission correspond to categories A, B and C. While a few seem to be carbon-intensive (A), more seem predominantly trade-exposed (category B). These latter sectors are internationally trade-exposed, i.e. exposed to competition from non ETS-regulated companies. Therefore, we do not expect them to be able to increase final output prices considerably, as this would risk losing market shares against foreign competitors. Fierce competition with foreign competitors may reduce the domestic pass-through potential. Instead of passing-through the costs of the EU ETS, companies may have to decrease profit margins, if possible, or may decide to relocate (Alexeeva-Talebi, 2010). Following neoclassical theories that consider firms as rational profit-maximisers, we assume that observing a positive PTR provides evidence of windfall profits if permits are allocated for free. Indeed, firms increase prices as long as profits are higher than losses (de Bruyn et al., 2010a).

First, we study the case of the *refining industry* which has been largely investigated (Alexeeva-Talebi, 2011; De Bruyn et al., 2010a; Oberndorfer et al., 2010). On the basis of country-level data of 14 EU Member States for Phase I of the EU ETS, Alexeeva-Talebi (2011) finds long-run elasticities of petrol prices with respect to EUA prices to vary between 0.01 and 0.09 across countries. According to the author, these numbers match the share of EUA costs in the production costs of refineries, estimated at roughly 2%, fairly well, implying a full pass-through rate, i.e. of 100% cost pass-through. The same conclusion is reached by de Bruyn et al. (2010a) who compare international prices for gasoline, diesel and gasoil. By contrast, Oberndorfer et al. (2010) estimate the PTR of UK refineries to amount to only 50% for diesel products and 75% for gasoline in 2005-2006, without evidence of asymmetric pricing. In parallel with these findings, we have seen that the European refining sector had on average a long position in 2005 (Kettner et al., 2008) with variations across countries (Alexeeva-Talebi, 2011). Overall, European refineries appear to have benefited from windfall profits in the first trading period, be it for passing through the opportunity costs of EUAs or for selling their allowance surplus.

Another important sector within manufacturing is the *iron and steel industry (basic metals)*. It is described as an oligopoly by de Bruyn et al. (2010a), so that firms within this sector can decide on the product price to a certain extent. The authors show evidence that these industries pass costs fully through, when studying EU prices between 2001 and 2009. This result runs counter to Fitz Gerald et al. (2009), who find basic-minerals to be price-takers and very vulnerable to foreign prices. De Bruyn et al. (2010a) conclude that this sector may have achieved substantial profits during Phase I and II, as a result of free allocation combined with a full PTR. They estimate that refineries as well as iron and steel industries may have earned up to €14 billion of profits in total

[36] The size of the circles is proportional to the number of firms in a given industry (Martin et al., 2014b, p. 81).

between 2005 and 2008, by fully passing through.[37,38] Moreover, the iron and steel sector is often referred to as a "carbon fat cat" (Morris, Worthington, 2010; Elsworth et al., 2011), meaning that it receives a substantial amount of allowances at no cost. In 2011, the ten most emitting iron and steel companies had a surplus of 172 million allowances that is estimated to represent €2.9 billion (Elsworth et al., 2011).

The *non-mineral branches* are expected to pass-through the carbon costs according to Fitz Gerald et al. (2009). Alexeeva-Talebi (2010) estimates the long-run PTR of production costs of German sub-sectors belonging to non-metallic minerals branches (hollow glass, glass fibres, other glass, cement lime and plaster), while taking into account trade exposure. The analysis, based on data from 1995 to 2008, reveals that PTRs vary between 24% (other glass) and >60% (hollow glass). Oberndorfer et al. (2010) find PTRs for the UK glass industry to be 0% (container glass) and 20-25% (hollow glass). Furthermore, the PTR is up to 40% for ceramic bricks and higher than 100% for ceramic goods (ibid.). Moreover, the ceramic good industry exhibits an asymmetric pricing behaviour. Both studies rely on the assumption that passing through input costs is a good proxy of carbon costs pass-through. With the exception of ceramic goods, these studies do not support high market power in setting prices and this way contrast with the results of Fitz Gerald et al. (2009).

Within the *chemical industry*, the production processes are very heterogeneous as de Bruyn et al. (2010a) argue. Therefore, impacts of regulation may widely vary within this sector. Oberndorfer et al. (2010a) study how the chemical industry is able to pass-through an input price increase on final prices of selected products between 2001 and 2007. They find PTRs of 50% (ammonium nitrate) and 100% (low density polyethylene), when using data from the UK industry and European data when available. De Bruyn et al. (2010a) find the PTR of chemicals to vary from 33% to 100% across selected products.[39] However, they are concerned that it may be the result of the cost pass-through of refineries and inorganic chemicals (suppliers). Accordingly, the studied chemical industries themselves may not benefit from increased prices. For Germany, Alexeeva-Talebi (2010) finds long-run PTRs to vary between 0% (perfumes and toilet preparation) and 42% (manufacture of plastics in primary forms).

As for other branches, there are only a few empirical results to the best of our knowledge. According to Alexeeva-Talebi (2010), long-term PTRs in Germany vary between 0% (paper and paper-board) and 75% (other rubber products). She emphasises that within manufacturing industries the PTRs vary strongly across sectors as well as between sub-sectors.

For manufacturing as a whole, there is additional direct evidence of increasing profits in addition to the evidence of cost pass-through. Bushnell et al. (2013) study the impact of the 2006 carbon price crash on stock prices of manufacturing industries and show that the dirtiest industries[40] experienced the largest negative effect on stock returns. They interpret this positive correlation between carbon price and stock prices as evidence that the EU ETS increases profitability because investors perceive the ETS as providing profits to some manufacturing industries. The magnitude of the correlation is for some industries even higher than for the electricity and gas sectors (ranked 10th).

[37] „if we would apply the here discovered full cost-pass-through rates to all products in the refineries and iron and steel sectors, it can be calculated that the total amount of windfall profits would equal €14 billion between 2005 and 2008." De Bruyn (2010a, p.60)

[38] Similarly, Demailly and Quirion (2008) find no competitiveness losses for the iron and steel sector based on a partial equilibrium model.

[39] Polyethylene, polystyrene, polyvinylchloride

[40] The 5 industries most affected by the price crash in terms of equity prices are: coal and lignite mining, crude petroleum extraction, basic metals, sewage and refuse and water transport.

Summing up, we have found evidence to suggest that the power sector is able to pass its costs on to customers with substantial rates while being sheltered from international competition. This supports our hypothesis that a high PTR coupled with free allocation to the power sector is very likely to explain why we do not find negative effects of the EU ETS in this sector during the first and second trading periods (e.g. Chan et al., 2013). Importantly, rising electricity prices can have indirect effects in the other sectors of the economy. In case regulated and non-regulated industries in manufacturing were equally affected by rising electricity prices, this could explain not finding significant differences between these two groups – at least not for this indirect channel. Regarding the manufacturing sector, results vary strongly across industries and sub-industries. Therefore, our conclusion is more nuanced. Some industries could pass-through the carbon costs, and were even over-allocated at the same time, so that they could achieve windfall profits through both channels. In this regard, we assume that cost pass-through holds for certain industries (e.g. refining and iron and steel) while it does not for others (e.g. some sub-industries from the chemical and from the pulp and paper industry).

4.4 Low share of energy costs

Hypothesis No. 4: "Energy costs represent a small share in firms' overall production costs. Therefore, an increase in energy costs as posited by the EU ETS is economically irrelevant to firms."

We show that this hypothesis holds on average, namely, energy cost shares are low in the aggregate. However, there are heterogeneities across sectors, with some being more exposed to energy cost increases.

Above all, energy cost shares in total costs are low compared to other inputs – at least on average. The European Commission estimates that energy costs made up a cost share of 4.6% in total production within the EU-27 in 2011 (figure 8).[41] These estimates are based on data from the World Input-Output Database and the International Energy Agency and calculate the energy cost share in basic prices[42] as a percentage of gross output. Further empirical evidence shows that, for example, in the German industry as a whole, the share of energy costs in gross value added amounted to about 5% (Thamling et al. 2010) to 8% in 2009 (BDEW, 2014). Similarly, in France, energy cost shares in production value have been shown to be lower and relatively modest as compared to the cost of wages for French manufacturing industries (Bureau et al., 2013). These different pieces of empirical evidence show that energy cost shares are low compared to other production inputs when considering averages over industries.

Figure 8: Energy cost shares in basic prices (in % of gross output)

	Total economy				Manufacturing				Manufacturing*			
	1995	*2000*	*2007*	*2011*	*1995*	*2000*	*2007*	*2011*	*1995*	*2000*	*2007*	*2011*
EU-27	3.0	3.2	4.1	4.6	3.8	4.8	6.3	7.5	2.3	2.2	2.8	3.0
China	5.2	5.9	7.7	7.7	6.2	7.0	7.8	8.1	4.4	4.7	5.7	5.9
Japan	2.8	3.3	4.8	5.1	3.4	4.6	7.3	8.0	2.9	3.3	4.6	5.4
US	2.8	3.6	4.6	4.6	4.8	6.5	10.2	11.3	2.3	2.8	3.1	2.9

*Note: * not including NACE Rev. 1 23 coke, refined petroleum and nuclear fuel.*

Source: European Competitiveness Report (2014) p. 194

In fact, not only is the share of energy costs low in European manufacturing industries, but it is on average even lower than the one Europe's main competitors face. The European Commission finds the mean share of energy costs in gross output to be lower in the EU-27 as compared to China, Japan and the US (figure 8). While the energy cost share added up to 7.5% in European manufacturing industries in 2011, it amounted to 11.3% in the US. When removing coke, refined petroleum and nuclear fuel (sector NACE no. 23), this percentage decreases to 3.0%, and is still among the lowest. In addition, the increase in the energy cost share over time appears to have been slower in Europe than in its main competitor countries. This suggests that European manufacturing seems to perform well in terms of competitiveness relative to its major competitors on average. Alternatively, this trend could be an outcome of the regulation in case energy intense firms move outside the EU. However, these aggregated numbers are not sufficient to judge whether this dynamic behaviour has indeed taken place and we are not aware of more detailed analyses.

Furthermore, the European Commission empirically analyses the relationship between the energy cost share and exports on the 2-digit industry level in 21 EU countries (European

[41] Chapter 6, section 2, of the annual European Competitiveness Report (2014) is devoted to this topic.
[42] Excluding taxes and margin.

Competitiveness Report 2014, p. 203 f.). According to their results, a one percentage point increase in the energy cost share goes along with a 0.8% reduction in exports. For energy-intensive industries, this relation is not statistically significant. Considering the fact that a one percentage point increase is larger than what has been observed on average for the EU-27 for the period from 1995 or from 2000 to 2011 (excluding coke), this correlation seems negligible.

It is, however, important to turn away from looking at average numbers to considering the heterogeneities across sectors as they may differ substantially (figure 9). Data provided by the European Union show that energy cost shares are low in many manufacturing industries but stand out in very few others. As hinted at before, the manufacturing of coke, refined petroleum and nuclear fuel stands out as the sector with by far the highest energy cost shares. Furthermore, chemicals and chemical products and other non-metallic mineral products also display relatively high energy cost shares. Still, for these two sectors the energy cost shares were well below 8% in the European Union in 2011 (Figure 9). Again, the energy cost shares are usually lower in European industries compared to competing non-European industries.

Figure 9: Energy cost shares by manufacturing industry in basic prices (in % of gross output)

	EU-27		China		Japan		US	
	1995	*2011*	*1995*	*2011*	*1995*	*2011*	*1995*	*2011*
Food, beverages and tobacco	1.7	2.5	1.3	1.5	1.5	2.3	1.8	2.0
Textiles and textile products	2.2	3.1	1.2	2.2	2.2	3.3	1.7	2.2
Leather, leather and footwear	1.1	1.4	0.5	1.2	1.6	2.0	1.2	0.8
Wood and products of wood and cork	2.0	2.8	3.1	3.1	1.9	2.5	2.1	3.1
Pulp, paper, printing and publishing	2.5	3.2	3.8	3.6	3.4	4.8	2.4	3.2
Coke, refined petroleum and nuclear fuel	47.8	62.0	56.9	72.2	20.8	47.0	62.2	67.9
Chemicals and chemical products	4.4	7.4	9.9	18.9	6.8	13.1	5.9	7.8
Rubber and plastics	2.5	3.5	2.8	3.3	3.1	3.3	3.0	2.5
Other non-metallic mineral products	5.6	7.4	10.5	15.5	9.2	16.8	4.6	5.8
Basic metals and fabricated metal	3.7	4.1	7.7	9.8	4.4	10.2	3.3	4.2
Machinery, n.e.c.	1.2	1.3	2.8	3.5	1.2	1.5	1.1	1.0
Electrical and optical equipment	1.0	1.1	1.3	1.4	1.6	2.2	1.3	0.5
Transport equipment	1.2	1.1	1.8	1.6	1.2	1.6	0.7	0.8
Manufacturing, n.e.c.; recycling	1.4	2.1	1.9	1.9	2.0	3.0	1.2	0.8

Source: European Competitiveness Report (2014), p. 195.

Taking a closer look at the coke, refined petroleum and nuclear fuel sector, we find a large energy cost share (62% of its gross output in 2011, see figure 9). Therefore, it may be more exposed to energy cost increases (e.g. exposure to the EU ETS), while other sectors may only experience a very moderate impact. However, when looking at emission allowance costs, we find that they also represent a very modest share of the total production costs of the European refining industry (Alexeeva-Talebi, 2011). Alexeeva-Talebi estimates it to be about 2%. To obtain this result, she uses net-of-taxes nominal retail prices (roughly 550€/1000L) and a carbon price reference of €20/t of CO_2. On top, this sector is on the carbon leakage list, i.e. it benefits from free allocation.

In conclusion, energy cost shares appear rather low for most industries when considering aggregate values. However, this may hide a more unequal distribution on the individual firm level. In particular, there is an indication that transaction costs (internal costs, capital costs, consultancy and trading costs; see Jaraite et al., 2010), as well as costs for monitoring, reporting and verification of emissions (MRV; see Heindl, forthcoming) in the EU ETS vary strongly across firm size in a way that affects small and medium sized firms most seriously. At the same time, small and medium sized enterprises tend to be less energy intensive and could display energy cost shares below average. Hence, firm size differences need to be further investigated. Still, for the average firm, energy costs and their increases due to the EU ETS are small but it is crucial to investigate more about their distribution across firms to learn about competitiveness impacts.

4.5 Innovation

Hypothesis No. 5 "The EU ETS may cause firms to become more competitive through increased innovation. Some evidence about the Porter Hypothesis."

Can the EU ETS induce innovation in such a way that it overcompensates otherwise negative competitiveness effects? If the innovation channel was very strong it might explain not finding negative competitiveness effects. This is what we study next.

According to the seminal Porter Hypothesis, "properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them" (Porter and van der Linde, 1995, p.98; also see Porter, 1996). The starting point of this theory is that pollution often stems from an inefficient use of resources, leading to their waste. Environmental regulation can limit resource misuse and enhance resource productivity (Ambec et al., 2013). Hence, clean innovation and thus improved productivity can offer an absolute advantage over non-regulated competitors.

Innovation and investment in low-carbon technologies represent one key objective of the EU ETS in order to influence long-term abatement and create a sustainable low-carbon path (Pizer and Popp, 2008; Calel and Dechezleprêtre, 2016; Martin et al., 2012). In addition, there may be a first mover advantage for "green" technologies (Fankhauser et al., 2013; Oberndorfer, Rennings, 2006; Beise, Rennings, 2005). For these reasons, the EU ETS intends sending a clear and strong signal to firms for developing green technologies and, in consequence, we would expect a positive effect on firms' economic performance.

Porter and van der Linde (1995) emphasize that green policies need to be "well-crafted" and stringent enough to induce innovative investments. There are different methodological challenges in measuring the stringency of a policy (Johnstone, Kalamova, 2010; Botta and Kozluk, 2014). In the context of the EU ETS, we suggest that the emissions reduction target and the permit price may represent good estimates for the scheme's stringency.

There is a large amount of literature on the innovation effects of environmental policies in general (Jaffe and Palmer, 1997; Brunnermeier, Cohen, 2003; Gagelmann, Frondel, 2005; Hamamoto, 2006; Acemoglu et al., 2012; Ambec et al., 2013; for a review see Popp, 2010). For the EU ETS in particular, Martin et al. (2012) show that regulated sectors facing a more binding constraint are more likely to innovate. This result is based on interviews with managers of 770 firms in 6 countries (Martin et al., 2012). They show that firms expecting higher stringency[43] in Phase III have a higher propensity for innovating. They study the causal characteristic of this correlation by using the exemption rules of Phase III. Above a certain threshold of carbon intensity or trade intensity (or a combination of both), firms are exempted from auctioning. Assuming that auctioning represents a higher constraint (greater costs) to firms than free allocation, they examine whether firms expecting to be exempted are less engaged in green innovations or not. They analyse the discontinuity around the threshold which might be due to the exemption. In doing so, they observe a jump in innovation right after the threshold. Therefore, they conclude that free allocation (lower constraint) leads to less clean innovation. This result is in line with other researchers stating that an overly generous allocation of free permits may reduce incentives to invest in new technologies (Schleich and Betz, 2005).

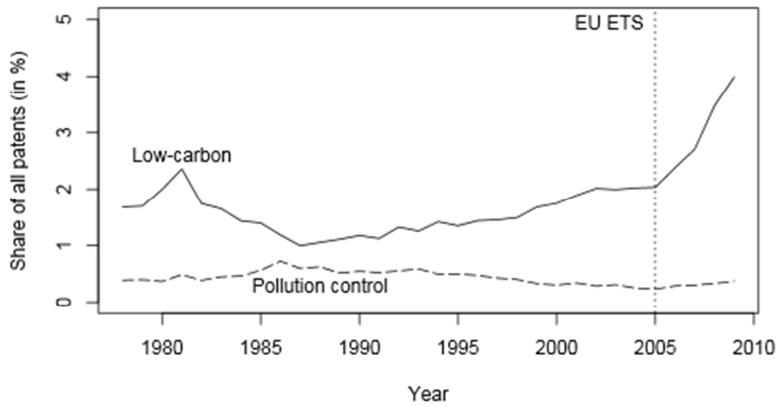
[43] They construct a stringency score depending on "(i) how costly it would be to reduce its emissions, on (ii) how many allowances it receives for free and on (iii) the price they expect on the market and therefore the expected overall allocation" (Martin et al., 2012, p.12)

In order to induce investments for innovation, a high carbon price is considered necessary (Popp, 2002). The carbon price is often pinpointed at about €30 per tonne of CO_2 (e.g. Ares, 2014). However, the EUA price has not been higher than 10 euros since 2013. The European Commission is concerned that the low price may prevent investments in low-carbon technologies and could even create carbon lock-in (EU Commission, 2014b).[44] Moreover, its continuing declining trend along with its volatility may not provide long-term credibility of a future high carbon price, which is necessary for stimulating green investment decisions (Laing et al., 2013).

Apart from a deficit of stringency and the low carbon price, another reason for limited innovation effects stemming from the EU ETS may be that many firms have adopted a wait-and-see strategy in the early phase, i.e. prudent investment behaviour (Pontoglio, 2010; Borghesi et al., 2012). Borghesi et al. (2012) analyse the impact of the EU ETS on environmental innovations of Italian manufacturing industries in 2006-2008, based on data from the Community Innovation Survey (CIS) provided by Eurostat. The authors examine both kinds of environmental innovations (EI), namely production-related EI (energy and CO_2 abatement) and consumption-related EI (reduced environmental impact of the product during its life). From their empirical results they conclude that the scheme was not strict enough to stimulate the adoption of carbon reduction technologies and rather triggered investments for EIs on the consumption side that are less radical and cheaper than innovations on the production side. Rogge et al. (2011) base their analysis on case studies with 19 German firms from the power sector for the years 2008-2009. Their results indicate that the innovation impact of the EU ETS is rather limited. They argue that this is the result of the system's lack of stringency and predictability as well as the important role of other context factors. Calel and Dechezleprêtre (2016) do not find evidence of the EU ETS causing spill-over effects on third parties' patenting activity. Therefore, they conclude that the scale of technological change might stay limited.

However, it seems that at least a small number of regulated firms reacted strongly to the new constraint, making significant changes on average (Petsonk and Cozijnsen, 2007; Calel and Dechezleprêtre, 2016). Petsonk and Cozijnsen (2007) point out that low-carbon solutions have been developed at an early stage**.** Calel and Dechezleprêtre (2016) observe a structural break of low-carbon patenting in 2005 presented in figure 10 and investigate whether this is a consequence of the EU ETS.

Figure 10: Share of low-carbon patents in total patents filed with the European Patent Office (1978-2009)



Source: Calel and Dechezleprêtre (2016), p. 177.

[44] "The surplus has resulted in an ETS price signal too weak to significantly affect the price of fossil-fueled power generation, which if it is not addressed will have a long lasting effect on the ability of the ETS to provide an incentive to invest in low-carbon energy technologies such as renewables. In combination with today's high gas to coal price ratio, it can lead to carbon lock-in." (EU Commission, 2014b), p. 169

To this end, they use the number of low-carbon patent registrations as innovation measure and apply a difference-in-difference design to a large sample of 3428 matched EU ETS firms. The evidence shows that the system boosted low-carbon patenting by 36.2% among regulated firms relative to non-regulated ones. This percentage drops to 8.1 % when extrapolating results to the whole non-matched sample of 5568 EU ETS firms, covering 80% of regulated emissions. In all, the EU ETS accounts for 1% of the surge in low-carbon patenting, depicted in figure 10. The percentage appears rather small on first sight, since EU ETS firms only account for a small proportion of low-carbon patents. Interestingly, the disaggregated level of data enables them to see that the average effect is only due to the strong reaction of a small group of firms. In parallel, they show that the EU ETS did not crowd out patenting for other technologies and even encouraged it moderately. Anderson et al. (2011) surveyed Irish EU ETS firms during the first phase and find that the system stimulated technological change and raised awareness about emissions reduction possibilities, despite decreasing carbon prices and uncertainty.

In conclusion, the empirical findings suggest that the innovation behaviour of regulated firms attributable to the EU ETS has been limited so far. This may be due to the low stringency of the scheme so far (low price, low target, generous free allocation). However, the ex-post literature can so far only measure effects on a rather short-term scale, whereas innovations may easily take a decade to unfold. Thus, long-term effects may only be detected later. At the same time, Phase III of the EU ETS is the first one to use benchmarking for the allocation of emissions certificates. This may induce firms to reduce their emissions at least up to the benchmark value (de Bruyn et al., 2010b). On top of this, Phase IV aims at lowering the cap of emissions in the EU ETS substantially suggesting higher stringency of the scheme. These two innovations may lead to more pronounced innovation effects of the EU ETS in the future.

4.6 Further hypotheses

There could be further economic arguments for finding no negative competitiveness effects of the EU ETS on firm-level economic performance. For these following arguments, we could, however, hardly find any empirical evidence and therefore keep the discussion short.

Theoretically, abatement costs could have been lower than expected. In that case, firms would have faced unexpectedly low costs of reducing emissions which might explain not finding significant effects on economic performance. This argument is hard to prove as abatement costs are rarely publicly known (Clò, 2010). In fact, the heterogeneity of abatement costs which are, however, unobserved to the policy maker (and researcher) is one of the advantages of introducing a cap-and-trade system in the first place because this policy equalises marginal abatement costs (Schmalensee, Stavins, 2015). Even firms themselves are often unaware of their abatement costs. For example, Engels (2009) reports that one third of EU ETS regulated firms participating in a survey covering four countries for the years 2005-2007 does not know its abatement costs (also see Martin et al., 2016). In fact, the introduction of the EU ETS may increase firms' awareness of their own abatement costs as they are required to monitor and report emissions. Similarly, the KfW/ZEW-CO2-Panel repeatedly reports very low shares of ETS firms whose abatement activities are driven by the goal of emissions reduction (Detken et al., 2009; Löschel et al., 2010, 2011 and 2013; Brockmann et al., 2012; Gallier et al., 2014 and 2015; Osberghaus et al., 2016). Instead, emissions reductions usually occur as a side effect of measures intended to, e.g., reduce production costs. While these survey results do not allow conclusions about the level of abatement costs, they show that abatement is not the main focus of emissions reduction, despite firms' participation in the EU ETS.

Another argument which might potentially explain finding no negative competitiveness effects of the EU ETS is related to the restricted entry of competitors: A large-scale environmental regulation may substantially increase the sunk costs for new entrants, deterring them to come into the market (Ryan, 2012). These sunk costs would include costs for learning about the requirements of the EU ETS, for entering into the allocation process as well as one-time costs for monitoring, reporting and verification (MRV) of emissions. If these costs were high, firms already under the ETS would rather be protected from new entrants to the EU market. This topic has not been much investigated by researchers, but Civitelli (2016) argues that the scheme discouraged the entrance of new competitors at the beginning of the scheme in Italy. Indeed, the Italian government should have established a public fund to finance emissions allowances for new entrants but did not. As a consequence, new entrants had to buy their permits while incumbent companies received them free of charge. However, the actual costs of entering the ETS remain uncertain and might have been low considering the low price of emission allowances.

In addition, the EU is generally characterised by high environmental standards which may also restrict the entry of new competitors (de Bruyn et al., 2010a). For the refinery sector, de Bruyn et al. (2010a) argue that few foreign competitors meet European standards such that these standards could act as a barrier to entry.

Furthermore, some "dirty" firms may have faced such high environmental costs from the EU ETS that they had to exit the market. In the end, only firms who were competitive in a clean environment could have kept business running. In the aggregate this would result in a more productive and cleaner business environment. This may explain finding no negative competitiveness effects on firms that have stayed in the market. However, no empirical evidence of carbon leakage or firm closures attributable due to the EU ETS has been documented so far. Calel and Dechezleprêtre (2014) and Wagner et al. (2014) find no supportive evidence for carbon

leakage within companies which have non-treated plants during Phase II. Nonetheless, the latter study suggests that there could still be carbon leakage between markets but cannot test it.

Finally, negative effects may be much larger for sectors outside rather than inside the EU ETS, as Oberndorfer (2009) argues. This is because under a generous cap of the EU ETS, non-ETS-regulated sectors have do contribute large emissions reductions in order to still meet the national targets set by the Kyoto Protocol (Oberndorfer, 2009; Böhringer et al., 2006). If this argument was to hold, it would substantially affect those empirical analyses that compare ETS-regulated to non-regulated firms, e.g. across industries. Put differently, if for some reason the control group faces higher constraints than the treated group, this would explain not finding a statistical effect in the comparison. However, in case the regulation differs only across industries then comparisons within industries are not affected by this argument.

5 Conclusions

Emissions trading is generally expected to impose costs on firms because these have to either abate emissions or to buy the required allowances. This would imply an increase in production costs for ETS-regulated *vis-a-vis* non-regulated firms. However, the empirical ex post literature finds no significant negative effects of the EU ETS on firm-level competitiveness during Phase I and II (Martin et al., 2016; Arlinghaus, 2015; Venmans, 2012). Also, there has been no indication so far of a relevant amount of carbon leakage (European Competitiveness Report, 2014; Dechezleprêtre et al., 2014). Therefore, this paper aims to explain this finding by reviewing existing literature on five hypotheses. We also reflect to what extent the third phase is similar to the previous periods. We find the following:

First, most emissions certificates in the European Emissions Trading System (EU ETS) have been allocated for free by means of grandfathering, at least in the first two trading periods. Only a small share of certificates has been auctioned and this share increases only slowly. Free allocation entails a higher risk of over-allocation as compared to auctioning.

Second, we document over-allocation of emission allowances for all three phases. Several factors can explain the oversupply of permits, in particular for Phase III. Accordingly, we expect no significant negative effects on competitiveness on average for this period. First, a large permit surplus from Phase II could have been banked forward into the third period. Second, installations have been able to use international credit offsets at almost no cost (at around 0.10€ in 2014), instead of buying allowances, whose price is also excessively low. Third, an excessive number of sectors seems to have been exempted (totally or partially) from auctioning (Martin et al., 2014b; Clò, 2010). Moreover, the EU Commission has used a proxy price of 30€/t CO_2 to estimate which sectors are at risk, which is way higher than the current price (<5€/t in the first half of 2016). Therefore, the relocation risk has likely been overestimated and thus too many certificates have been allocated (Martin et al., 2014a).

While the oversupply of allowances does not come as a surprise, this fact seems to have caused the observed price drop of EUA prices. In consequence, participation in the EU ETS is cheap even for firms who are short of certificates and incentives for abatement or innovation are reduced. On top of this, over-allocation combined with free allocation and a positive allowance price can generate windfall profits.

Third, firms in many regulated sectors have been able to pass-through the (opportunity) costs of the EU ETS onto their customers. Particularly high pass-through rates have been documented for the power sector thanks to its particular market structure. Within energy-intense manufacturing, some sectors display high pass-through rates (e.g. refining and iron and steel) while others do not (some sub-sectors from the chemical and from the pulp and paper industry). In case of a high (opportunity) cost pass-through, additional windfall profits may be incurred and the consumers bear the costs of the EU ETS. This might affect electricity consumers in households and in industry. In addition, in case rising electricity prices affected ETS-regulated and non-regulated firms alike, it would also make it difficult to empirically identify this indirect effect on competitiveness.

Fourth, energy costs make up about 5% of gross output on average. This may explain why increases in these costs via the carbon price may hardly affect firms' competitiveness on average. Some specific firms or sectors may still display high energy cost shares, such as the refining sector which is, however, protected by the carbon leakage list.

Fifth, we checked whether innovation is stimulated in such a way by the EU ETS so as to overcompensate otherwise negative competitiveness effects. However, so far only limited

innovation effects could be detected likely because innovations require a longer time horizon to unfold. Another reason for finding low innovation effects from the EU ETS is the low price for EUA certificates which may, in turn, be caused by the large oversupply of allowances. This is where the low carbon price may pose a problem, as clean innovation is the only way to switch towards a sustainable path in the long-term.

These findings show that the EU ETS has effectively reduced greenhouse gas emissions in the regulated sectors without incurring substantial competitiveness effects. This result holds for the current design of the EU ETS and in particular for the current level of the cap. In case the regulation turns to be more stringent in the future, this would likely change abatement activities as well as competitiveness effects.

Finally, this study focusses on direct effects of the EU ETS on firm level competitiveness. For example, a large part of the empirical ex post literature compares regulated to non-regulated firms within industries, assuming that non-regulated firms are less affected by the regulation. There could, however, be indirect effects of the EU ETS, most prominently through increased electricity prices. Studying such indirect effects is an important and difficult challenge which we leave to future research.

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