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Katrin Sommerfeld

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**Eugénie Joltreau**
*Université Paris-Dauphine, PSL Research University, LEDa-CGEMP*

**Katrin Sommerfeld**
*ZEW and IZA*

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**IZA – Institute of Labor Economics**

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

# ABSTRACT

## Why Does Emissions Trading under the EU ETS Not Affect Firms' Competitiveness? Empirical Findings from the Literature*

Environmental policies may have important consequences for firms' competitiveness or profit-ability. 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). We explain why there are arguably no significant competitiveness effects on firms, at least not during the first two phases of the scheme (2005-2012). We also reason why the third phase (2013-2020) is likely to reveal similar results. We show that the main explanations for this finding are a large over-allocation of emissions allowances leading to a price drop and the ability of firms to pass costs onto consumers in some sectors. Cost pass-through combined with free allocation, 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.

**JEL Classification:** Q52, Q58, D22

**Keywords:** employment effects, firm-level competitiveness, environmental policies, EU ETS

**Corresponding author:**
Katrin Sommerfeld
Centre for European Economic Research (ZEW)
L7, 1
68161 Mannheim
Germany
E-mail: sommerfeld@zew.de

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## 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 (EU Commission, 2016). It serves as an important example for the design of other carbon markets such as the one in China. Significant emissions reductions have been found as a result of the EU ETS (Wagner et al., 2014; Petrick, Wagner, 2014; Ellerman et al., 2016). However, there are strong concerns that carbon trading entails negative side effects on competitiveness and employment of regulated companies. This is because regulated firms face additional costs either for abatement or for purchasing emissions allowances. Nevertheless, 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 answer the question why there are so far arguably no negative side effects of the EU ETS on firms' competitiveness.

Why is it important to understand a phenomenon that displays a zero effect? Finding no negative effects from the EU ETS on firms runs counter to past arguments of industry lobby groups (Monjon, Quirion, 2011; Hanoteau, 2014). Also, in economics "there is no free lunch" so there may be hidden negative side effects from the emissions reductions. In fact, positive and negative side effects from the EU ETS on firms may cancel each other out. For example, negative effects from increased costs may, in theory, be overcompensated by positive innovation effects. Therefore it is important to understand the different channels at work. In parallel, emissions trading has distributional effects such that certain firms or sectors may benefit while others may face additional challenges (Flues, Thomas, 2015). This is important to understand in order to be able to direct additional support and this way implement a successful ambitious climate policy while minimising the risk of carbon leakage. Generally speaking, an understanding is vital for reducing the cost of achieving certain environmental goals. Finally, some special interest groups or lobbies have an interest in shaping concerns about potential negative competitiveness effects such as job losses. Therefore, understanding the channels of the effects of climate policies on outcomes such as productivity and employment is important – even (more so) when these effects are unexpectedly close to zero.

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 allowances 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 may trigger innovation with potentially positive consequences (Porter, 1996; Porter, van der Linde, 1995). Also, net selling firms benefit if emissions allowances are freely allocated and over-allocated, and have a positive price 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.

Surprisingly, the 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). For Germany, no statistically significant negative effects of the EU ETS on employment, gross output or exports can be documented (Petrick, Wagner, 2014). 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). While for Germany no negative competitiveness effects can be detected, preliminary results for France show significant reductions in employment (Wagner et al., 2014) which could be partly driven by carbon leakage (ibid.). A cross-sector comparison for the entire European Union shows negligible competitiveness effects (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.).

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 production capacity, 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 also be found in the excellent reviews by Venmans (2012), Arlinghaus (2015) and Martin et al. (2016).

This study contributes to the literature by explaining why there appear to be no 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 is likely to 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. Also, this survey cannot provide a full-fledged cost-benefit analysis.

We start from the observation that emissions allowances have so far been mostly allocated for free. Thus, firms have hardly faced any costs of purchasing EUAs but transaction costs and opportunity costs. Second, 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 free allocation of allowances 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.

This paper is structured as follows: The next section gives a brief overview over relevant institutional aspects of the EU ETS. Section 3 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 4 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). The overall amount of carbon emissions is capped by allocating only a limited amount of emissions allowances called European Union Allowances (EUAs) which can then be traded. The first trading phase – which was considered a trial phase – ran from 2005 to 2007. Phase II ran from 2008 to 2012. Phase III is running from 2013 to 2020 and is seen as a tightening of the system.[1] 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).

The initial target was to reduce emissions in $CO_2$ equivalents by 20% by 2020 as compared to 1990 levels which was already over-achieved by the European Member States in the second period of the EU ETS. Emissions are now estimated to be 24% lower by 2020 compared to the levels of 1990 (EU Commission, 2015).

In order to reach the emissions target, firms owning a regulated installation have to provide the amount of EUAs corresponding to the equivalent amount of emitted carbon dioxide on a yearly basis. 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. Since 2012, the aviation sector has also been added to the EU ETS (Directive 2008/101/EC). Emission allowances were grandfathered at the beginning of the scheme and later partly auctioned (benchmarking). Full auctioning applies to power generators since 2013.

Since Phase III, all manufacturing sectors receive allowances according to benchmarking[2] but there are exceptions in order to explicitly maintain the competitiveness of EU ETS-covered industries and prevent carbon leakage (Directive 2009/29/EC, Article 10a).[3] These exceptions are regulated according to the estimated risk of carbon leakage.[4] Installations in sectors exposed to carbon leakage risk are eligible to 100% free allowances up to the benchmark (*ibid*). This preferential treatment concerns 154 out of 258 NACE-4 level sectors, representing 85% (Martin et al., 2014a) up to 95% (de Bruyn et al., 2013) of $CO_2$ emissions from manufacturing. Still, in 2013, also manufacturing industries not classified at risk of carbon leakage received on average 80% of permits for free up to the benchmark (EU Commission, 2016).

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.

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[1] Country-specific National Allocation Plans (NAPs) were 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.

[2] The benchmark value is product-specific and equals the average CO2 emissions of the best performing 10% of installations for this product (EU Commission 2015b, p.40).

[3] We follow Marcu et al. (2013) and the definition by the DG Climate Action according to which "Carbon leakage refers to the situation that may occur if, for reasons of costs related to climate policies, businesses were to transfer production to other countries with laxer emission constraints. This could lead to an increase in their total emissions." Available at: https://ec.europa.eu/clima/policies/ets/allowances/leakage_en, last retrieved 16/10/2017.

[4] According to Directive 2009/29/EC (Article 10a), sector or sub-sector is deemed to be exposed to a significant risk of carbon leakage if it meets one of the following criteria:

1) 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 is above 10%.
2) the sum of direct and indirect additional costs of the regulation is above 30%.
3) the non-EU trade intensity is larger than 30%.

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

As shown above, the literature finds surprisingly 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 are there seemingly no 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.

### 3.1 Free allocation

*Hypothesis No. 1: "Free allocation of emissions allowances 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[5], the costs of buying emission allowances, and potentially higher electricity prices. Free allocation saves firms from bearing the cost of buying their permits on the carbon market. For this reason *free* allocation may help alleviating the potential negative impact on European plants.

Free allocation was by far the most prevalent 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. Auctioning accounted for an annual average of 0.13% of certified emissions in Phase I (Ellerman, Buchner, 2007). 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). In Phase II, free allocation represents 43% of the total amount of certificates (EU Commission, 2017).

Should it be of concern that a large share of emissions allowances is allocated for free? This allocation method is challenged by some economists (e.g. Cramton, Kerr, 2002; Hepburn et al., 2006). 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). 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. In conclusion, it is difficult to attribute the choice of grandfathering 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.

[5] E.g., firms may buy new equipment to adopt an eco-friendly production process and to control their level of pollution (Gray, 2015).

## 3.2 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, there may be no 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 corresponding to their emissions. Under auctioning over-allocation could be lower than under free allocation, as rational firms only buy as many allowances as they are required to submit. 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 for all three trading phases.

*In the first trading period* there has been an excess of (freely distributed) 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 (Kettner et al., 2008). 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. When the EU Commission released the complete version of verified emissions on May 15, 2006, the EUA price collapsed (Kettner et al., 2008). The EUA price was then considered too low to exploit a large abatement potential by Kettner et al. (2008). The low-carbon price reduced potential gains of selling EUAs of the apparently overallocated majority of firms, but at the same time, reduced costs for those fewer sectors or installations who were short.

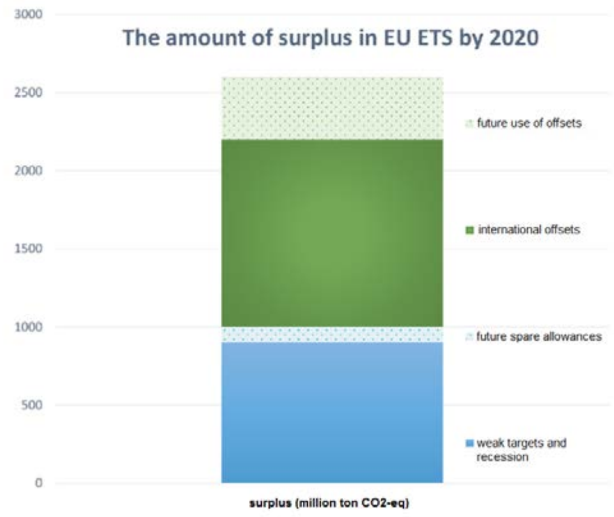
The power sector is the only one that used more allowances than it received for free during the first two phases (Abrell et al., 2011). It was short by about 3% in 2005 (Ellerman, Buchner, 2008). The power sector is assumed to be hardly trade-exposed and governments believed that potential abatement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

*The second trading period* was characterised by a fierce economic downturn. In consequence, there was once more a large excess of unused allowances (EU Commission, 2017). The second major allowance price decrease started with the European Commission's release, indicating that 2008 verified emissions were 3% below the 2007 level (EU Commission, 2009). The price drop may be largely explained by the 2008 financial crisis that caused oversupply of EUAs (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 mild weather of the period (Haita, 2013). We also observe that the CER price started to decouple with the EUA price, making it cheaper for firms to buy carbon offset credits rather than allowances. This could exacerbate the oversupply of EUAs.

What is important is 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). At the end of 2013, the overcapacity reached 2 billion allowances (Carbon Market Watch, 2014; see figure 1). This shows that banking entails the risk of extending a surplus of allowances to the subsequent period.

Figure 1: The build-up of surplus in EU ETS by 2020




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

*Phase III* now has to deal with a massive surplus of 2.1 billion permits (figure 1; Carbon Market Watch, 2014). 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 (at around €0.10) and thus lower than the allowance price (around 5€) during the same period.

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) show that for most 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).

To address this surplus, the Commission has postponed the auctioning of 900 EUAs until 2019-2020 (“Backloading”, EU Reg. 176/2014), which will be added to the “market stability reserve”, starting in 2019 (Decision 2015/1814, Art. 1).

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 still 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, all the more so if they received these permits for free. 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 allowances 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.

### 3.3 Cost pass-through

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

The intention of a carbon trading scheme may be to have the consumers pay for the emissions reductions. This is achieved when firms can pass on the costs of the carbon trading scheme. On top of abating emissions at zero costs, firms may incur windfall profits. This may happen if either one of the following two conditions is fulfilled: On the one hand, if there is free allocation of emissions allowances 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 (e.g. Sijm et al., 2006). 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). However, Wang and Zhou (2017) show theoretically that benchmarking would allow lower pass-through rates (PTR). The PTR 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., 2012). In addition, the literature identifies price rigidities as another potential source of incompleteness of passing through costs (Fabra, Reguant, 2014).

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 et al., 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).

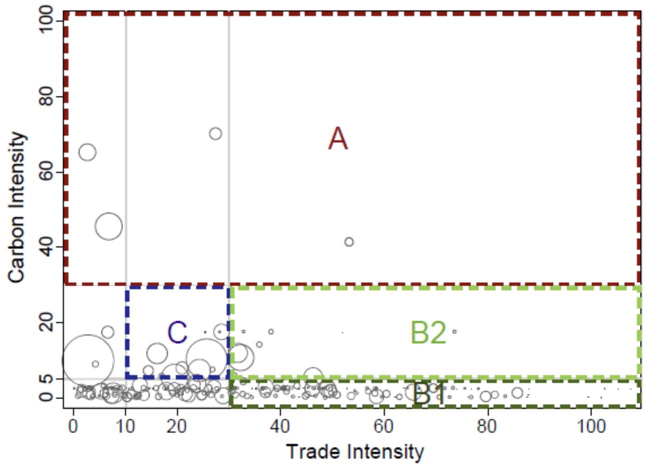
High pass-through rates in the power sector are confirmed empirically for Spain, Germany and the Netherlands. For Spain, for the period 2004 to 2006, Fabra and Reguant (2014) find that carbon costs were almost fully transferred to final prices with an average PTR of 80%. Sijm et al. (2006) calculate empirical pass-through rates between 60% and 117% for 2005 for Germany. For the Netherlands, they find pass-through rates between 64% and 81%. 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 electricity sector is found to not only pass-through opportunity costs, but it may on top benefit from an asymmetric cost pass-through according to which price increases are passed on to consumers while price decreases may not (Zachmann and von Hirschhausen, 2008; Oberndorfer et al., 2010; Mokinski, Wölfing, 2014). Thus, producers may largely benefit from increased prices.

Phase I of the EU ETS 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. The introduction of auctioning may substantially reduce windfall profits in the power sector. Finally, note that public authorities may intervene to limit cost pass-through.

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. Moreover, and 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. Overall, all relevant factors vary strongly across industries and sub-industries within manufacturing.

Figure 2: Manufacturing sectors split according to trade and carbon intensity[6]




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

Figure 2 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).

Empirical studies of the *refining industry* show pass-through rates of about 100%, i.e. full cost pass-through (Alexeeva-Talebi, 2011; De Bruyn et al., 2010; Oberndorfer et al., 2010). Overall, European refineries appear to have benefited from large profits in the first trading period, be it for passing through the opportunity costs of EUAs or for selling their allowance surplus.

Substantial windfall profits have also been documented for the *iron and steel industry (basic metals).* De Bruyn et al. (2010) estimate that refineries as well as iron and steel industries may have earned up to €14 billion of profits in total between 2005 and 2008, by fully passing through (also see Demailly, Quirion, 2008). 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).

Within the *non-mineral branches,* Alexeeva-Talebi (2010) estimates 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.).

Within the *chemical industry*, the production processes are very heterogeneous as de Bruyn et al. (2010) argue. Therefore, impacts of regulation may widely vary within this sector. Oberndorfer et

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

al. (2010) 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. (2010) find the PTR of chemicals to vary from 33% to 100% across selected products. 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.

### 3.4 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 energy cost shares are low in the aggregate. However, there are heterogeneities across sectors, with some being more exposed to energy cost increases. 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 3).[7] 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).

Figure 3: 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

Besides, 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 3). 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 but these aggregated numbers are not sufficient to judge whether this dynamic behaviour has indeed taken place.

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 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 and consider the heterogeneities across sectors as they may differ substantially (figure 4). Data provided by the European Union show that energy cost shares are low in many manufacturing industries but stand out in the manufacturing of coke, refined petroleum and nuclear fuel. 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

[7] Chapter 6, section 2, of the annual European Competitiveness Report (2014) is devoted to this topic. 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 (excluding taxes and margin) as a percentage of gross output.

Union in 2011 (Figure 4). Again, the energy cost shares are usually lower in European industries compared to competing non-European industries.

Figure 4: 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 4). Therefore, it may be more exposed to energy cost increases (e.g. exposure to the EU ETS). However, emission allowance costs also represent a very modest share of the total production costs of the European refining industry, estimated it at about 2% (Alexeeva-Talebi, 2011).[8] On top, this sector is on the carbon leakage list, i.e. it benefits from free allocation, and appears to be able to achieve full pass-through (see 3.3).

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, 2017) 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 likely very small but it is crucial to investigate more about their distribution across firms to learn about competitiveness impacts.

[8] To obtain this result, she uses net-of-taxes nominal retail prices (roughly 550€/1000L) and a carbon price reference of €20/t of $CO_2$.

### 3.5 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.

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). Environmental regulation can limit resource misuse and enhance resource productivity (Ambec et al., 2013). Hence, clean innovation and thus improved productivity may offer an absolute advantage over non-regulated competitors. Still, Porter and van der Linde (1995) emphasize that green policies need to be "well-crafted" and stringent enough to induce innovative investments.

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, we would expect a positive effect from the EU ETS on firms' economic performance.

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.[9] First, they demonstrate that firms expecting higher stringency in Phase III display a higher propensity for innovating. Above a certain threshold of carbon intensity or trade intensity (or a combination of both), firms are exempted from auctioning and the authors observe a jump in innovation right after the threshold. Therefore, they conclude that a 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).

In order to induce investments for innovation, a high carbon price is considered necessary (Popp, 2002). The target 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, 2014).[10] 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).

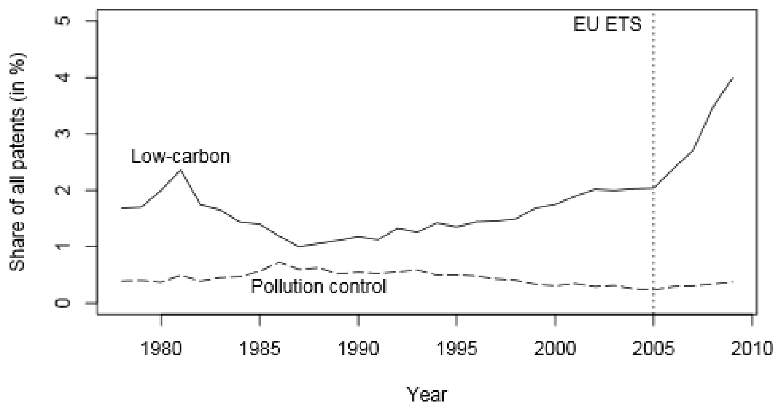
The deficit of stringency and the uncertainty characterising the EU ETS in its early-phase may have led firms to adopt a wait-and-see strategy, i.e. prudent investment behaviour (Pontoglio, 2010). Borghesi et al. (2012) conclude that the scheme was not strict enough to stimulate the adoption of carbon reduction technologies and rather triggered investments for environmental innovations on

[9] This result is based on interviews with managers of 770 firms in six countries (Martin et al., 2012).
[10] "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, 2014, p. 169).

the consumption side that are less radical and cheaper than innovations on the production side. Rogge et al. (2011) add 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, too, conclude that the scale of technological change will likely stay limited.

However, it seems that at least a small number of regulated firms reacted strongly to the new constraint (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**.** A structural break of low-carbon patenting is observed in 2005, at the start of the EU-ETS (Figure 5). Calel and Dechezleprêtre (2016) investigate whether this is a consequence of the EU ETS applying a difference-in-difference design to a large sample of 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 5. This one percent increase 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 shows 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.

Figure 5: Share of low-carbon patents in total patents filed with the European Patent Office (1978-2009)




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

In conclusion, the empirical findings suggest that the innovation behaviour of regulated firms attributable to the EU ETS has been limited so far. 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.

### 3.6 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 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 entry 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. In addition, the EU is generally characterised by high environmental standards which may also restrict the entry of new competitors (de Bruyn et al., 2010).[11] This topic has not been much investigated by researchers, but the actual costs of entering the ETS remain uncertain and might have been low considering the low price of emission allowances.

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. If firms exit the market for the purpose of relocating to places where environmental regulation is less restrictive (or non-existent), this is called the **Pollution Haven Hypothesis** (PHH; e.g. see Eskeland, Harrison, 2003; Cole, 2004; Wagner, Timmins, 2008; Millimet and Roy, 2011; Kozluk and Timiliotis, 2016; Yoon, Heshmati, 2017). The PHH posits that "dirty" firms tend to flock to pollution havens. Most of the time, these pollutions havens are located in developing countries, where lower environmental standards apply. In the case of the EU ETS, the PHH is supported if significant evidence of **carbon leakage** attributable to the EU ETS is established. If firms were to start emitting more once relocated, we could observe an increase in

[11] For the refinery sector, de Bruyn et al. (2010) argue that few foreign competitors meet European standards such that these standards could act as a barrier to entry.

total emissions, making the EU ETS an ineffective mechanism**.** No empirical evidence of carbon leakage or firm closures attributable due to the EU ETS has been documented so far. Dechezleprêtre et al. (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, when focusing on the European primary aluminium sector, Sartor (2012) shows that the carbon price level did not lead to carbon leakage.

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 to 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.

## 4. 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, there appears to be no significant negative effects of the EU ETS on firm-level competitiveness during Phase I and II as documented by the empirical ex post literature (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 allowances 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, instead of buying allowances, whose price is also excessively low. Third, a seemingly excessive number of sectors has been exempted (totally or partially) from auctioning. 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. Therefore, the relocation risk has likely been overestimated and, thus, too many certificates have been allocated (Martin et al., 2014a). On top of this, over-allocation combined with free allocation and a positive allowance price can generate large 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 high PTR together with free allocation of EUAs, regulated firms are able to reap windfall profits. Opportunity costs are therefore borne by end users, such as households and industries. 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. Apparently, under the current design of the EU ETS and in particular for the current level of the cap, over-allocation of allowances (mostly for free) has limited the negative effects for firms to lie very close to zero. This is because firms have passed on costs to consumers or because emissions were reduced at a cheap price. While innovation effects are found to be positive and statistically significant, they appear too small in magnitude so as to overcompensate any other large negative effects. In case the regulation turns to be more stringent in the future, this would likely change abatement activities and potentially also competitiveness effects.

Possibly, firms abated emissions without those abatement activities showing up negatively in ex post studies on competitiveness effects. This could also in parts be due to different challenges to the empirical identification of an effect: treatment is not randomly assigned, other policies may confound the effect, there may be spill-over effects and data availability is limited. 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 spill-over effects of the EU ETS, most prominently through changed electricity prices. Studying such indirect effects is an important challenge which we leave to future research.

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