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Climate Change Policy and Business in Europe Evidence from Interviewing Managers

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Abstract
This report presents new evidence relating to the effects of climate policy in Europe, particularly the European Union Emissions Trading Scheme (EU ETS). The evidence is based on new data from almost 800 phone interviews we conducted with managers in manufacturing plants in six European countries: Belgium, France, Germany, Hungary, Poland and the UK. The interview design follows an innovative method that has recently emerged in the study of management practices and that mitigates well-known biases found in more conventional survey designs such as paper-based or web-based questionnaires. This report describes the interview design in detail and summarises the responses. For further analysis, we link the interview data with company data from a range of secondary sources including transaction data from the official EU ETS registry and performance data from both commercial and government sources. We use the combined data to analyse three aspects of the EU ETS in depth, namely (i) the behaviour of firms in the EU ETS, (ii) the vulnerability of firms in terms of negative impacts on employment and carbon leakage, along with an assessment of how well the proposed EU legislation to protect vulnerable firms does at identifying them, and (iii) alternative criteria for the allocation of free emission permits during the next phase of the EU ETS.

Keywords: climate policy, firm behaviour, Europe
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Executive Summary

This report presents new evidence relating to the effects of climate policy in Europe, particularly the European Union Emissions Trading Scheme (EU ETS). The evidence is based on new data from almost 800 phone interviews we conducted with managers in manufacturing plants in six European countries: Belgium, France, Germany, Hungary, Poland and the UK. The interview design follows an innovative method that has recently emerged in the study of management practices and that mitigates well-known biases found in more conventional survey designs such as paper-based or web-based questionnaires. The principal feature of this technique is to involve the respondents in an open dialog, rather than asking them to choose from a set of pre-formulated responses. Responses are translated into ordinal performance scores by trained analysts using a detailed benchmark for each score. This method combines the richness and flexibility of an interview-based approach often adopted in case studies with a standardized measurement format that allows us to perform statistical hypothesis tests in a representative sample of firms. We guaranteed participants strict confidentiality of their responses to elicit truthful information on politically contentious issues such as the impact of climate change policy.

This report describes the interview design in detail and summarises the responses. For further analysis, we link the interview data with company data from a range of secondary sources including transaction data from the official EU ETS registry and performance data from both commercial and government sources. We use the combined data to analyse three aspects of the EU ETS in depth, namely (i) the behaviour of firms in the EU ETS, (ii) the vulnerability of firms in terms of negative impacts on employment and carbon leakage, along with an assessment of how well the proposed EU legislation to protect vulnerable firms does at identifying them, and (iii) alternative criteria for the allocation of free emission permits during the next phase of the EU ETS.

Firms in the EU ETS Our analysis shows that firms in phase I of the EU ETS did not consider the policy to be very stringent on average. Economists often take for granted that firms make rational decisions based on a comparison of the allowance price and their marginal abatement cost. In contrast, we find evidence suggestive of a "compliance mentality" among firms. About 30% of firms participate only passively in the ETS. This raises the concern that some firms with excess amounts of permits do not make them available to other market participants, thus raising the overall compliance cost. On average firms start to sell only if they have an excess supply of about 5000 permits. However, since firms with less than 5000 permits hold less than 10% of all excess permits, their reluctance to sell excess permits should not have had a large impact on the permit price.

Vulnerability to carbon leakage While full permit auctioning in phase III of the EU ETS is envisaged as the general rule, European lawmakers have recently published criteria for establishing that a sector is at significant risk of carbon leakage and hence entitled to free emission permits. These criteria are based on a sector's carbon and trade intensities. We examine the empirical content of these criteria and analyse their economic implications. We show that about half of the firms in our interview sample are "at risk" according to these criteria and hence entitled to free permits in phase III. We assess the accuracy of the Commission's criteria by examining their correlation with a score measuring the future impact of climate policy, which we construct from the interview responses. We argue that ours is a more direct measure of the detrimental policy impact that the Commission is trying to capture using carbon and trade intensities. Moreover, we show that this score is consistent with other, perhaps more objective, interview responses that capture exposure to climate policy, such as the degree of product market competition and the ability to pass on cost increases to customers. We find a statistically significant positive correlation of the future impact score with carbon intensity but not with trade intensity. However it is the latter criterion that accounts for the largest number of exemptions from permit auctioning. Hence, a large number of permits is given away for free to firms to firms that are not at risk. We calculate that a modification of the thresholds for exemption could increase the amount of permits that could be auctioned from about 40% to 60% while having a minimal impact on the risk of carbon leakage. At an allowance price of €30, we estimate that this could increase annual auction revenues by €7 billion.

Criteria for permit allocation A conceptual problem with sector-level criteria for free permit allocation is that they cannot account for heterogeneity within sectors. We document that there are a number of firms with rather high impact scores in sectors *not* exempt from auctioning whereas many firms that will be given permits for free reported no detrimental impact of climate change policy at all. This suggests that support to vulnerable firms could be provided in a more efficient way. We develop general principles of an efficient permit allocation at the *firm level*, based on the idea that permits should be allocated to firms where the last free permit has the strongest impact on the relocation decision. We derive optimal permit allocations in two ways, either by minimising free permits subject to a fixed level of leakage risk or by minimising leakage risk subject to a fixed number of free permits. We find that the leakage risk incurred under full grandfathering of all firms could be achieved by allocating 70-90% fewer free permits. In turn, given the total amount of permits the EU plans to hand out for free in phase III, we estimate that a simple reallocation across firms would decrease the expected emission leakage by more than 30% and the expected number of jobs at risk by more than 60%. In regards to the practical implementation of our scheme to improve permit allocation, we explore a strategy based on observable and objectively measurable firm characteristics.

1 Introduction

The reduction of greenhouse gas (GHG) emissions is an increasingly important policy objective for many governments. In particular, the member states of the European Union (EU) have been pushing for climate change policies more strongly than the rest of the world. The EU's flagship policy instrument is the European Union Emissions Trading System (EU ETS) which imposes an overall cap on CO_2 emissions of the power sector as well as on large industrial emitters. It also provides a framework for trading permits between different emitters and third parties. In theory, the cap-and-trade system ensures that the total costs of abating CO_2 emissions are minimised.

While establishing a cap creates certainty about the total amount of emissions, it leaves open how much it will cost firms to keep their emissions below the cap. In setting the cap, policy makers are thus concerned that they might impose too high a cost on the regulated emitters. The problem is exacerbated if – as is the case with the EU ETS – most other countries are not imposing similar policies so that market shares of regulated firms could be threatened by foreign competitors who are not subject to this regulation. In the extreme case, regulated firms could re-locate to locations outside the EU in order to dodge the regulation. As a result of this "carbon leakage", regulated countries face an excess burden of regulation in the form of job losses and diminished environmental benefits as global reductions of GHG emissions would fall short of the levels targeted by the regulation. To mitigate this risk, the EU has been using the practice of allocating permits for free to sectors deemed at a heightened risk of leakage.

Deciding which firms or sectors are at risk is not easy, however. The matter is complicated by the fact that the best informed actors – i.e. the regulated firms – face an incentive to exaggerate the actual costs of compliance in order to extract more rents in the form of free permits or to lobby for a more lenient overall cap. Free permit allocation has therefore followed simple but fairly ad hoc rules. In the past, permits were by and large allocated on the basis of historic emissions. For trading phase III of the EU ETS starting in 2013, the EU Commission plans to exempt from auctioning sectors that exceed certain thresholds in terms of emissions or trade intensity, or both. As these thresholds are set ad hoc, there is a risk that firms receive free permits even if they are not at risk of leakage. Conversely, it might be the case that firms that are actually at risk do not receive sufficient free permits.

Against this background, we conducted interviews with approximately 800 firms across six European countries with two principal objectives, namely (i) to gather new evidence on the actual risk of downsizing due to climate policies and how it relates to the criteria used by regulators and (ii) to elicit information on other aspects of firm performance related to emissions and climate change policies, including the behaviour of firms on the EU ETS market. The interview setup follows an innovative method developed recently in the study of management practices (Bloom and van Reenen, 2007; Bloom et al., 2009, 2010) with the aim to mitigate various types of biases that typically emerge in more conventional survey designs. The principal feature is to involve the participants in an open dialog rather than to have them choose from a set of pre-formulated responses. Responses are translated into ordinal performance scores by trained analysts using a detailed benchmark for each score.

The richness and flexibility of an interview based approach which features among the main strengths of the case study method can thus be combined with the ability to test more general hypotheses based on a representative sample of firms using econometric techniques. The method also allows us to elicit less biased information on politically contentious issues such as the impact of climate change policy. A further innovation in our approach is that we are able to link the interview data with company data from a range of secondary data sources such as the official EU ETS registry (known as the Community Independent Transactions Log, CITL) and with company performance data from both commercial and government sources.

To assess the risk of carbon leakage we discussed with firm managers their expectations about future climate change policies, how stringent such policies are perceived to be and if they have any plans for downsizing in response to such policies. We also discussed the impact of free permit allocations for firms that are part of the EU ETS. This revealed that for the largest fraction of firms, climate policies implemented so far did not require any deviations from "business as usual". The majority of firms in the EU ETS expect some minor adjustments to keep within the targets set in trading phase III after 2012.

We correlate this measure of leakage risk derived from the interview responses with the EU's criteria for free permit allocation, namely the sectors' carbon emission intensity and trade intensity. We find that while carbon intensity is a very good predictor of actual impact as measured by our measure, trade intensity is not. Yet under current plans of the Commission, most exemptions from auctioning would be granted on the basis of the trade intensity criterion alone. We calculate that by auctioning permits rather than giving them to firms whose leakage risk is not larger than that of non-exempt firms, European governments could raise additional revenue on the order of €7 billion every year.

We then develop a new framework to allocate permits efficiently. This is based on the simple but so far unappreciated economic logic that free permits should be given to those firms where they have the highest *marginal* impact on aggregate CO_2 leakage or job risk. Using data from our survey, we show that this marginal impact varies substantially between sectors and is not necessarily correlated with absolute impacts. We develop an algorithm that minimises the aggregate risk of either job loss or CO_2 leakage for a given amount of permits to be allocated for free. Simulations show that a much lower risk can be achieved through optimal allocation even when compared to a situation where all permits are handed out for free. We also consider the dual problem of minimising the number of permits handed out for free while constraining the aggregate risk. We find that the aggregate risk arising with free allocation could be achieved with a much lower fraction of permits being handed out for free. The mismatch between optimal and actual allocations is particularly severe when it comes to minimising the risk to jobs. This means that current plans by the Commission do too little to mitigate the risk to jobs that arises from the EU ETS.

The remainder of this paper is organised as follows. Section 2 surveys the literature on the effects of the EU ETS on firm behaviour and competitiveness. Section 3 discusses the methodology underlying our telephone interviews in more detail. Section 4 provides a variety of descriptive statistics on the various survey variables. We look at these variables separately for ETS and non-ETS firms, between different sectors as well as countries. Section 5 presents and discusses a number of results on the behaviour of firms in the EU ETS. Section 6 contains an evaluation of the EU Commission's suggested criteria for deciding if a sector is vulnerable to job losses or carbon leakage due to climate change policy. Section 7 introduces our framework for an optimised permit allocation process. Section 8 concludes.

2 Literature review

There is a growing literature analysing different aspects of the EU ETS and seeking to evaluate its effects on GHG abatement, employment , and international competitiveness. In what follows, we provide a brief review of this literature, giving more room to studies in the specific areas investigated here, namely the behaviour of ETS firms in the allowance market and the competitiveness effects.

Survey studies Surveys have been a common tool in the empirical analysis of the EU ETS since its beginnings, which is due in part to the initial lack of official data suitable for qualitative and quantitative analyses. Already in the summer of 2005 the EU Commission commissioned a mail survey among stake holders (see McKinsey and Ecofys, 2005). Among the 302 respondents were 167 industrial companies (including the power sector). Half of them reported that they added the cost of CO_2 allowances on to their product prices. About the same number of companies reported that carbon prices had a medium to strong impact on their long-term strategy and innovative activity. A majority of companies preferred long-term allocation rules (10-years and up) which reduce policy uncertainty and are more compatible with time frames for capital investment. Regarding future allocation rules, there was strong opposition against more auctioning after 2012, while benchmarking was considered feasible. Participants also favored an EU wide harmonization of the ETS allocation rules concerning new entrants and closures.

More recently, Kenber et al. (2009) interviewed senior managers of 9 large companies, 6 of which belonged to the ETS. They find that to date, the EU ETS has not resulted in significant costs to business, especially when compared to the impact of other factors such as energy price fluctuations and the economic downturn. While carbon prices are acknowledged in company decision-making, they have not induced a fundamental shift in strategy such as relocation or a reduction of the workforce. For the energy-intensive aluminum industry, there is however a noticeable indirect effect of carbon pricing through electricity prices. While heavy industrial emitters have fared well so far relative to their non-EU competitors, some of them fear possible competitive impacts in phase III of the EU ETS beginning in 2013.

Allocation At the core of any cap-and-trade scheme is the mechanism that determines the initial allocation of permits. Due to the multilateral nature of the EU ETS, the allocation process involves two dimensions, namely the allocation across countries and across sectors. Another fundamental aspect is whether permits are granted for free or at some cost, e.g. via a permit auction. Unless permits are auctioned off, a further decision has to be made on the micro-allocation of permits among firms within a sector. Under the EU ETS phases I and II, the cap is set in a decentralized way. Countries are called upon to draw up National Allocation Plans (NAP)s that both fix the national cap and determine the sectoral allocation. Ellerman et al. (2007) give a detailed account of the development of the NAPs under phase I in 10 European countries. The authors conclude that the principles applied by national governments have been rather consistent, as most opted for free permit allocations based on existing emissions. NAPs submitted for phase II exhibit more stringent caps but retain the allocation scheme. While there will be some more use of auctioning during phase II, it remains far short of what is allowed and the use of benchmarking still remains the exception (Ellerman and Joskow, 2008).

Apart from distributional aspects, there are important dynamic effects of a permit allocation scheme that derive from the treatment of installations that close and of new entrants. Åhman et al. (2007) analyse how the treatment of closures and entrants differs across EU Member States. They argue that the common practice of free allowances are inconsistent with general guidelines issued by the European Commission aiming to avoid distortions of firms' compliance behaviour. Åhman et al. propose stronger EU guidance regarding closures and new entrants, a more precise compensation criterion on which to justify free allocations, and a mechanism to guide a transition from current practice to an approach that places greater weight on efficiency.

Performance As official data on emission trading has become available, researchers have used resources such as the Community Independent Transaction Log (CITL) to evaluate the effectiveness of the EU ETS at reducing carbon emissions. The main difficulty with assessing the performance is to distinguish between real abatement and "over-allocation", i.e. an excess permit allocations larger than business-as-usual (BAU) emissions. Ellerman and Buchner (2008) construct an index of over-allocation by dividing the net of all long and short positions in an aggregate (a sector or country) by the absolute sum of all long and short positions. They use this index to identify countries where over-allocation was likely. In order to compute sectoral CO_2 abatement, these authors first compute a counter factual emission scenario extrapolating pre-ETS CO_2 emissions using data on GDP growth and trends in CO_2 intensity. In a second step they subtract actual emissions in phase I from counter factual emissions and obtain a tentative estimate of 130-220 Mt of CO_2 abated annually in 2005 and 2006. In a counter factual simulation for the power sector, Delarue and D'haeseleer (2007) obtain point estimates of 88 Mt and 59 Mt for the same respective years. Ellerman et al. (2010) use a macro approach as well as data on the electric utility sector to show the effectiveness of the EU ETS at reducing carbon emissions. In sum, there is some evidence that the EU ETS resulted in positive abatement even though the emission caps in phase I turned out not to be binding. Emission caps in phase II have been more ambitious so that the risk of over-allocation has been substantially reduced (Ellerman and Joskow, 2008).

Competitiveness A natural consequence of the implementation of the EU ETS is that firms in the ETS face higher carbon prices than their competitors outside the EU who are not subject to comparable regulation. This has led to worries about a possible loss of competitiveness of European industry. In this context, a loss of competitiveness is generally thought of as a loss of output and employment. Output declines because firms reallocated resources in order to comply with the ETS but also because of industry relocation to places outside the ETS member states. The latter effect is called production leakage. To the extent that production outside is more carbon intensive than within the ETS countries, there is also a carbon leakage effect in that carbon abatement inside the ETS is offset in part by increased emissions elsewhere.

A widespread approach to assessing these effects has been to calibrate computable general equilibrium models that are capable of predicting the consequences of differential carbon pricing across regions and the resulting carbon leakage. Most models of the first generation (with exogenous technical change) predict moderate leakage rates between 5 and 35% for the Kyoto Protocol commitments (Paltsev, 2001).

Another strand of research conducts ex ante analyses of the competitiveness effects of the EU ETS with particular attention to sectoral detail. McKinsey and Ecofys (2006) anticipate that the electric power sector benefits in the short and medium term, whereas the pulp and paper, and the steel industries experience detrimental effects on production. The effect on refining is neutral whereas the effect on cement could be positive or negative, depending on local patterns of competition that may or may not allow producers to pass through the cost of compliance. Primary aluminium production, though not directly regulated under phase I, is expected to be affected by higher electricity costs. Reinaud (2005) concludes that this sector is the most adversely affected by carbon prices given its high levels of electricity consumption and pass-through of carbon prices to electricity prices. Other industries with expected cost increases include the cement, newsprint and steel industries. In sum, these studies conclude that competitiveness effects are moderate as long as permit allocation is free of charge. As a larger share of permits will be auctioned in the future, the most energy intensive industries will be at risk of a competitiveness loss. Grubb et al. (2009) argue that such detrimental competitiveness impacts are limited to a small number of industry sectors.

A common aspect of the aforementioned studies is that they undertake *ex ante* evaluations of the competitiveness effects based on simulations or on analysis of ad-hoc criteria and statistics.[1] Because of the direct cost impact of environmental regulation, these studies predict that the competitiveness effects are likely to be negative, although this is not uniformly the case across sectors (see the survey by Oberndorfer et al., 2006). When the EU ETS is compared to alternative ways of implementing the Kyoto targets, it is often the case that adverse effects on competitiveness are offset by the efficiency gains from permit trade.

Few *ex post* evaluation studies of the competitiveness effects of the EU ETS have been completed to

[1]For example Grubb et al. (2009) look at carbon intensity and trade intensity. While plausible arguments can be constructed why these statistics are related to leakage risk there is no direct evidence of such a link. We come back to this issue in Section 6 below.

date. Demailly and Quirion (2008) and Anger and Oberndorfer (2008) study the impact of the EU ETS on production and profitability for the iron and steel industry and for in a sample of German firms, respectively. The former study finds modest competitiveness losses and wheras the latter finds no significant impact on revenues and employment of the regulated firms . Aldy and Pizer (2009) conduct an empirically based simulation study to estimate the magnitude of carbon leakage in response to a 15$/ton of CO_2 price. They use panel data on output, employment, net imports and energy prices for more than 400 4-digit SIC-72 industries in US manufacturing between 1986 and 1994 to identify the energy price elasticities of output and net imports. Subsequently they compute an estimate of carbon leakage as the difference between the simulated effects of carbon pricing on production and consumption, respectively. They find that a 15$ carbon price would lead on average to a 1.3% decline in production but also 0.6% decline in consumption, leaving the net leakage effect at 0.7%. There is no statistically discernible effect on employment for the manufacturing sectors as a whole.

3 Interviewing managers

3.1 Interview design

Our survey builds upon and substantially extends previous work on climate change policies and management practices by Martin et al. (2010). We conduct structured telephone interviews with managers at randomly selected manufacturing facilities in Belgium, France, Germany, Hungary, Poland and the UK. The interview setup follows the management survey design pioneered by Bloom and van Reenen (2007) in that the interviewer engages interviewees in a dialogue with open questions. On the basis of this dialogue, the interviewer then assesses and ranks the company along various dimensions. We adopt a double-blind strategy: interviewees do not know that their answers are being scored by the interviewers and interviewers do not know performance characteristics of the firm they are interviewing.[2] This interview format is designed to avoid several sources of bias common in conventional surveys (Bertrand and Mullainathan, 2001). For instance, experimental evidence shows that a respondent's answers can be manipulated by making simple changes to the ordering of questions, to the way questions are framed, or to the scale on which respondents are supposed to answer. By asking open-ended questions and by delegating the task of scoring the answers to the interviewer, we seek to minimize cognitive bias of this type. Possible cognitive bias on the part of the interviewers can be controlled for by using interviewer fixed effects in the regression analyses.

Another common observation with survey data is that respondents are tempted to report attitudes or patterns of behaviour that are socially desirable but may not reflect what they actually think and do. This problem may be exacerbated in situations where respondents do not have a firm attitude towards the issues they are asked about but are reluctant to admit that. Our research design addresses this issue

[2]Interviews were carried out by graduate and postgraduate students after they had been trained. The interviewers were paid according to the number of interviews conducted, encouraging them to do more interviews and discouraging any firm background research, thus preserving the double-blind nature of the survey.

in two ways. First, the interviewer starts by asking an open question about an issue and then follows up with more specific questions, or asks for examples in order to evaluate the respondent's answer as precisely as possible. Second, the results of the interviews are then linked to independent data on economic performance as a validation exercise.

3.2 Interview practice

3.2.1 Sampling frame

Using the ORBIS database maintained by Bureau Van Dijk[3] we obtained contact details for 44,605 manufacturing firms in Belgium, France, Germany, Hungary, Poland and the UK. We randomly selected companies from that list to solicit an interview. To ensure sufficient coverage of firms subject to the EU ETS (hereafter, EU ETS firms) we also sampled manufacturing firms at random from the Community Independent Transaction Log (CITL) in these countries.

3.2.2 Obtaining an interview

Interviewers made "cold calls" to production facilities (not head offices), gave their name and affiliation with the London School of Economics and then asked to be put through to the production or environmental manager. In the case of EU ETS firms, interviewers asked for the person responsible for the EU ETS. In some cases we had the name of this person from the CITL. At this stage, the terms "survey" and "research" were avoided as both are associated with commercial market research and some switchboard operators have instructions to reject such calls. Instead, we told them that we are doing "a piece of work" on climate change policies and their impact on competitiveness in the business sector and would like to have a conversation with the manager best informed.

Once the manager was on the phone, the interviewer asked whether he or she would be willing to have a conversation of about 40-45 minutes about these issues. Depending on the manager's willingness and availability to do so, an interview was scheduled. If the manager refused, he or she was asked to provide the interviewer with another knowledgeable contact at the firm who might be willing to comment. Managers who agreed to give an interview were sent an email with a letter in PDF format to confirm the date and time of the interview, to provide background information and assure them of confidentiality. A similar letter was sent to managers who requested additional information before scheduling an interview.

3.2.3 Scoring

An ordinal scale from 1 to 5 was adopted to measure various management practices related to climate change. For each aspect of management ranked in this way (see section 3.3for a detailed description) interviewers were instructed to ask a number of open questions. Questions were ordered such that

[3] See http://www.bvdep.com

the interviewer started with a fairly open question about a topic and then probed for more details in subsequent questions, if necessary. We provided exemplary responses that interviewers could consult when in doubt about giving a high versus a mid and a low score for the relevant dimension. The goal was to benchmark the practices of firms according to a few common criteria. For instance, rather than asking the manager for a subjective assessment of the management's awareness of climate change issues we gauged this by how formal and far-reaching the discussion of climate change topics is in current management. For consistency checks of interviewer scoring, a subset of randomly selected interviews were double-scored by a second team member who listened in.

3.2.4 Data collection

All interviewers worked on computers with an internet connection and used VOIP software to conduct the interviews.[4] They accessed a central interview database via a custom-built secure web interface that we programmed very similarly to Martin et al. (2010). The web interface included a scheduling tool and an interview screen with hyperlinks to a manual that provided the analysts with background information on each question . Interviewers scored answers during the interview. For all interviews, the scheduling history as well as the exact time and date, duration, identity of interviewer etc. were recorded. All interviews were conducted in the interviewee's native language.

3.3 Interview scope

The survey seeks to gather information on both the effectiveness and the competitiveness effects of climate change policies, particularly of the EU ETS, in a random sample of European manufacturing firms. The questionnaire (see appendix B) is divided in four sections. The first section examines the current and anticipated future effects of the EU ETS. The second section deals with prices for energy and CO_2, competition and other external drivers of climate change related management practices. The third section inquires about specific measures that were adopted by firms and those that were considered but eventually discarded. The last section gathers information on relevant firm characteristics. We discuss the questions in more detail in the following paragraphs.

3.3.1 Drivers

EU ETS impact, rationality of market behaviour and anticipation of phase III We started each interview with a specific module of questions regarding EU ETS participation which we asked the respondent to answer for a particular site.[5] In order to assess the stringency of the EU ETS, we asked the manager to describe, using examples, how difficult it is to comply with their emissions reduction target. For example, a low score would be business as usual whereas a high score would be justified by a fundamental change in the production process, or fuel switching, for example.

[4]A video clip showing interviewers at work is available online at http://www.eco.uc3m.es/~uwagner/McETS.mov

[5]For non-ETS firms, interviewers skipped directly to the"Awareness" section explained below.

Moreover, we sought to get a sense of whether the trading system has been fully understood as an economic tool that can be used to minimize compliance costs. We used two alternative routes to accomplish this, namely by asking specific (i.e. not open) questions about trading behaviour on the permit market including frequency, net balance, banking and borrowing of European Union Allowances (EUAs). We also asked an open question about how trading decisions are taken within the firm and assessed the response against a set of showcase behaviours characterized by an increasing degree of sophistication.

Finally, we asked firms about their expectations of the stringency of phase III of the EU ETS to begin in 2013. A low score was given if respondents did not expect the stringency of phase III to divert them from business as usual activities and choices, whereas the highest score was given to firms that expected strong sanctions, extensive use of auctioning and very stringent targets to prevail during phase III.

Awareness We started with a question about the management's awareness of climate change issues. A medium score reflects some evidence of a formal discussion, e.g. that this has been on the agenda of a management meeting. EU ETS firms were thus given at least a score of 3 on a scale from 1 to 5 due to the fact that they are insitutionally bound to participate in European level climate change policy. A high score was given only when it was evident that the management had studied the implications of climate change in detail and had integrated their findings into the strategic business plan. We also recorded if climate change and related policy were perceived as having a positive impact on the business.

Price expectations and impacts We asked managers about their expectations regarding energy and carbon prices by 2020. We recorded a band for such prices, e.g. answers such as "somewhere between 20 and 100 Euros per ton of CO_2" were possible and put bounds on the amount of uncertainty. We also asked about the impacts of different carbon prices on output and employment at the given production site. Specifically, we inquired about plans for outsourcing or closure in the near future and the role of climate policy and carbon price levels in such plans.

Competitive pressure Firms were asked to describe the geographic distribution of their competitors (home country, EU, rest of world) and more specifically the location of the head offices and production sites of their main competitor. Further, we inquired about the shares of production exported within the EU and to the rest of the world, respectively. We also asked them to estimate the percentage of an increase in energy or carbon prices which they could pass on to their customers in order to understand the market structure of the industries these firms compete in.

Other drivers We asked about the role of consumers in driving management decisions relevant to climate change. If told that consumers demand climate friendly products and practice, the interviewer gauged the extent of the pressure by inquiring about the information that customers demand (e.g. a mere label vs. hard data on GHG emissions). We distinguish between firms whose customers are businesses or final consumers. In order to determine whether management regards climate change and related policy as a business opportunity we asked whether the firm sells climate change related products and tried to gauge their importance in overall revenue. Related to this, we inquired about the importance of innovation in such products.

3.3.2 Measures

Monitoring and targets The first set of questions related to a firm's rigor in monitoring its energy use and GHG emissions. Monitoring can range from a glance at the energy bill (lowest score) to detailed monitoring of both energy use and carbon flows embodied in the firms products and intermediate goods. Highest scores were given to firms that used objective (external) agents to verfiy their energy/GHG accounting. If monitoring was in place, we asked whether management was given specific targets for energy use and for GHG emissions. We inquired about the stringency of such targets and the incentives provided to achieve them.

Measures to reduce energy consumption and GHG emissions We inquired about concrete measures taken on site to reduce GHG emissions and invited the manager to discuss in more detail the measure that had the biggest impact. The answers were not scored but classified according to the part of the production site it affected (heating and cooling, power generation, machinery, energy management, among others). We also recorded how the firm had learned about the measure and what motivated its adoption.

Mindful of the debate about the "energy efficiency gap" we asked managers about the reasons for not adopting a measure they had considered at some point and that would have enhanced energy efficiency.[6] We record the pay-back criterion as well as other factors if they were relevant.

Moving beyond adoption, we inquired about the intensity of process innovation related to climate change and energy on the production site. We also included a question about hypothetical further reductions in GHG emissions imposing either (i) economic viability or (ii) technical feasibility regardless of cost.

Management Previous research on energy efficiency points to a possible effect of organization structure on management of climate change issues (DeCanio, 1993; DeCanio et al., 2000; Martin et al., 2010). We collected information on the title and responsibilities of the highest-ranking manager dealing with climate change and energy issues. We also asked how many levels separate this manager from the CEO in the managerial hierarchy, and whether any aspects of this position had changed recently.

[6]The energy effieicency gap is generally described as the gap between a firm's actual energy use and its optimal energy use.

Country specific measures Each country module of the interview script contained a few country specific questions regarding national policies related to climate change. We asked firms whether they were subject to or participated in those policy schemes and how stringent they found them.

3.3.3 Firm characteristics

At the end of each interview, we went through a set of questions about firm characteristics that we wish to use as control variables. In particular, we collect information on firm size (global, national and local) in terms of employment, number of business sites and ownership. We also asked the manager about environmental indicators, such as the energy bill and energy cost share, renewable power purchases, and adoption of environmental management systems (ISO 14000 / ISO 14001) . Finally, we record characteristics of the interviewee, such as gender, the position held, tenure in the position held and within the firm, and educational background.

4 Data and descriptive statistics

4.1 Sample characteristics

To construct our sampling frame, we downloaded ORBIS data for all manufacturing firms with more than 50 employees in each of the six countries in our study. Possible interview partners were drawn at random from this database and contacted via phone, sometimes repeatedly, until an interview materialized or the firm explicitly refused to participate. We contacted a total of 1,451 firms in the six countries and interviewed 770 firms, thus obtaining a response rate of 52%. We deliberately oversampled EU ETS firms by drawing firms at random from the CITL. As a result, 438 (57%) of interviewed managers were working for firms participating in the EU ETS. Scheduling of interviews began in late August and the last interviews were given in early November of 2009. The bulk of interviews were conducted in September and October of 2009.

It is important for the rest of our analysis to show that our sample is not biased. EU ETS firms are different from non-ETS firms, but within these two categories, interviewed firms are not significantly different from non-interviewed firms in regards to the observable characteristics used in our analysis. Panel A of Table 1 shows regressions for each of the principal firm characteristics available from the ORBIS database (turnover, employment, materials, and capital) on an dummy variable indicating that a firm is part of the EU ETS, a dummy indicating that a firm was contacted and a full set of sector and year dummies. The estimated coefficients are small and statistically insignificant in all regressions except for materials. For the set of firms that either conceded or refused an interview, we ran analogous regressions to estimate an intercept specific to firms that granted us an interview. The results in Panel B of Table 1 show that none of these intercepts is statistically significant. We thus conclude that our sample is representative of the underlying population of medium-sized manufacturing firms in the six European countries covered by our study.

Table 1: Sample representativeness

	(1) turnover	(2) employment	(3) capital	(4) materials
A. All firms				
firm contacted	-0.0322	-0.0794	0.172	-0.272***
	(0.0786)	(0.0611)	(0.108)	(0.0807)
EU ETS firm	2.031***	1.452***	2.530***	2.009***
	(0.0948)	(0.0796)	(0.145)	(0.185)
number of observations	118874	107830	113771	15563
number of firms	12322	12921	11118	2284
R-squared	0.511	0.364	0.513	0.356
B. Contacted firms				
firm granted interview	-0.0983	-0.0373	0.0443	0.195
	(0.118)	(0.0957)	(0.150)	(0.152)
EU ETS firm	2.044***	1.547***	2.540***	2.069***
	(0.124)	(0.107)	(0.160)	(0.270)
number of observations	26114	23933	25815	3662
number of firms	1373	1420	1297	425
R-squared	0.659	0.589	0.618	0.689

Notes: Regressions in panel A are based on the entire set of manufacturing firms with more than 50 employees contained in ORBIS for the six countries covered by the survey. Each column shows the results from a regression of the ORBIS variable given in the column head on a dummy variable indicating whether a firm was contacted or not and a dummy variable indicating whether a firm was taking part in the EU ETS at the time of the interviewing. Panel B shows analogous regressions for the set of contacted companies and with an indicator for whether an interview was granted. All regressions are by OLS and include country dummies, year dummies and 3-digit sector dummies. Standard errors are clustered at the firm level and are robust to heteroskedasticity and autocorrelation of unknown form.* significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2: Interview response rates by country

	# of Interviews	# of Firms Interviewed	# of ETS Firms Interviewed	# of Non ETS Firms Interviewed	Total Firms Contacted	Refused	Response Rate
Belgium	134	131	89	42	178	47	0.74
France	141	140	92	48	238	98	0.59
Germany	139	138	98	40	337	199	0.41
Hungary	69	69	37	32	90	21	0.77
Poland	78	78	61	17	140	62	0.56
UK	209	204	61	143	468	264	0.44
Total	770	760	438	322	1451	691	0.52

Notes: There are more interviews than interviewed firms as we conducted several interviews with different partners in a small number of firms.

Table 2 provides an overview of the number of interviews and the response rates broken down by country and by EU ETS participation status. All analysts would first conduct interviews in the UK and only then go on to conduct interviews in another country, hence the larger number of interviews for this country. This practice allows us to separately identify dummies for country and interviewer, which control for interviewer bias as discussed previously. The last column shows the response rate, calculated as the ratio of interviews granted and the number of firms that were contacted. Response rates vary somewhat between countries. For example, they are particularly low in Germany (41%) and the UK (44%), whereas in Belgium or Hungary firms were more willing to participate (74 and 77%, respectively). Generally, these figures are very high compared to response rates achieved in postal or online surveys.

Table 3 summarizes interview statistics and response rates broken down by industrial sector, showing that in the majority of sectors, the response rate is above 50%.

Table 4 reports the descriptive statistics of the characteristics of the full sample of interviewed firms. This shows that we have a rather well stratified sample with firm age ranging from younger than 5 years and to older than 95 years and firm size ranging from less than 84 employees to more than 1900 employees.

Table 5 compares the sample means of each characteristic between EU ETS firms and non EU ETS firms. It also reports the results from a test of equality of means between those groups. We can see that EU ETS firms are systematically different from non EU ETS firms in that they are older and larger in terms of either employment or turnover. They also appear more profitable.

Table 3: Interview response rates by industry

	# of Firms Interviewed	# of ETS Firms Interviewed	# of Non ETS Firms Interviewed	Total Firms Contacted	Response Rate
Cement	66	57	9	97	68%
Ceramics	13	6	7	17	76%
Chemical & Plastic	125	67	58	240	52%
Fabricated Metals	47	7	40	113	42%
Food/Tobacco	110	71	39	208	53%
Fuels	16	16	0	25	64%
Furniture/nec	34	11	23	105	32%
Glass	33	32	1	70	47%
Iron & Steel	42	32	10	63	67%
Machinary & Optics	78	13	65	180	43%
Other basic metals	11	8	3	21	52%
Publishing	24	6	18	54	44%
TVCommunication	11	4	7	28	39%
Textile/Leather	21	12	9	50	42%
Vehicles	49	25	24	82	60%
Wood & Paper	91	72	19	171	53%
Other minerals	8	7	1	15	53%
Total	779	446	333	1539	51%

Table 4: Firm characteristics

Variable	Mean	Standard Deviation	Percentiles 10^{th}	50^{th}	90^{th}	Obs.
Age of company	103	355	5	23	95	750
Turnover (Millions of EUR)	485.31	2,772.05	10.09	77.72	786.24	699
Firm's number of employees	1,024	3,885	84	300	1,901	702
Earnings before Interests and Taxes (EBIT) (Millions of EUR)	16.80	81.11	-1.85	2.42	44.94	685
Number of shareholders	2	5	1	1	3	763
Number of subsidiaries	4	24	0	1	9	763
Turnover of firm's Global Ultimate Owner (Millions of USD)	23,400	53,500	151	5,948	57,500	243
Firm's Global Ultimate Owner's number of employees	46,248	71,927	446	15,211	106,931	230

Table 5: Firm characteristics by ETS participation status

Variable	ETS Firms Mean	Std. Dev.	Obs.	non ETS Firms Mean	Std. Dev.	Obs.
Age of company	120	391	426	81	299	324
Turnover (Millions of EUR) **	730.62	3,562.64	405	146.67	769.22	294
Firm's number of employees **	1,440	5,047	401	468	858	301
Earnings before Interests and Taxes (EBIT) (Millions of EUR) **	25.17	103.80	397	5.20	23.50	288
Number of shareholders	2	5	435	2	5	328
Number of subsidiaries	6	31	435	2	5	328
Turnover of firm's Global Ultimate Owner (Millions of USD)	30,900	66,100	144	12,300	21,900	99
Firm's Global Ultimate Owner's number of employees	49,286	70,860	134	41,943	73,569	96

Notes: Based on 2007 data. Stars next to a variable name indicate that the respective means for ETS and non-ETS firms are significantly different at the 10 (*), 5 (**), and 1(***) percent level.

Finally, Table 6 shows the wide variation in basic firm characteristics obtained from the interviews data. For example, while most firms report that they cannot pass on CO_2 related costs to their customers (row 23), there are some firms that report that they can pass on 100% of such a cost increase. Together with table 7 it also summarize the responses to the scored interview questions described above in the pooled sample of all countries. The various variables will be refered to and described further in the subsequent sections of this report.

4.2 Differences between EU ETS firms and others

Tables 8 and 9 report the mean and standard deviations for the interview responses separately for EU ETS firms and non EU ETS firms. Stars behind the variable names indicate that the means differ between the two groups in a statistically significant manner. We observe significant differences in a number of firm characteristics. For example, EU ETS firms report a higher expected impact of any climate change legislation in the future (row 1 in the panel on impacts). Further, EU ETS firms seem to perform better on a range of the "Measures" questions. This is consistent with the idea that participation in the EU ETS induces firms to pursue more aggressive measures to reduce emissions due to the price signal. However, we must be cautious with causal interpretations of the evidence in Tables 6 and 7, not least because we do not control for confounding factors such as sectoral differences between EU ETS and non EU ETS firms or the fact that EU ETS firms are typically larger.

Figure 1 illustrates how EU ETS and non EU ETS firms differ along various dimensions highlighted in our survey. The graphs controls for sector fixed effects at the 3-digit level and noise controls such as interviewer dummies. We can see that EU ETS firms are larger than non EU ETS firms and

Table 6: Interview Summary Statistics (Part 1)

	Variable	Mean	Standard Deviation	Percentiles 10th	50th	90th	Valid Responses
Characteristics	Number of production sites (worldwide)	57.05	318.45	1	6	85	692
	Number of production sites (EU)	19.12	108.66	1	4	30	641
	Number of production sites (country)	5.77	21.80	1	2	10	748
	Number of employees (worldwide)	19,666.49	49,807.61	100	1,750	55,000	653
	Number of employees (country)	2,725.11	18,915.14	90	450	4,000	714
	Number of employees (site)	598.73	1,451.80	64	240	1,200	751
Manager	Tenure in company (in years)	15.11	10.81	3	13	30	763
	Tenure in current post (in years)	7.04	6.91	1	5	15	761
ETS	Number of sites covered by ETS	3.93	7.71	0	1	10	459
	ETS Stringency Score	2.30	1.23	1	2	4	429
	ETS Rationality Score	2.57	1.19	1	3	4	369
	ETS Anticipation Score	3.23	1.00	2	3	4	365
Prices	Expected change in energy prices by 2020 (in %)	70.22	76.31	15	50	150	463
	Upper expected bound for energy price change in 2020 (in %)	93.53	134.44	10	50	300	140
	Lower expected bound for energy price change in 2020 (in %)	52.43	64.73	10	30	110	145
	Expected price per ton of CO2 in 2020 in EUR	44.44	46.60	20	34	90	171
	Maximum expected price per ton of CO2 in 2020 in EUR	60.03	90.90	20	49	100	139
	Minimum expected price per ton of CO2 in 2020 in EUR	25.48	18.79	10	20	50	119
Impact	Future Impact Score	1.87	1.29	1	1	4	729
	Future Impact 80% Free Allowance Score	1.74	1.03	1	1	3	273
	Future Impact Reliability Score	2.43	1.15	1	3	4	655
	Cost Pass-Through (in %)	24.46	38.04	0	0	100	562
Competition	Number of competitors (worldwide)	95.72	891.90	3	10	100	556
	Number of competitors (EU)	46.14	389.11	2	6	40	628
	Number of competitors (country)	23.63	172.52	0	3	20	712
	Non EU Competitors Share*	0.31	0.32	0	0	1	520
	Share of total export sales (world)	45.33	33.63	2	45	95	669
	Share of export sales to EU-member states	32.52	27.76	0	25	75	626
	Customer Pressure Score	2.27	1.31	1	2	4	751

Table 7: Interview Summary Statistics (Part 2)

	Variable	Mean	Standard Deviation	Percentiles 10th	50th	90th	Valid Responses
Innovation	Climate-Related Products Score	1.82	1.28	1	1	4	759
	Climate-Related Product Innovations Score	1.84	1.24	1	1	4	757
	Climate-Related Process Innovations Score	2.31	1.17	1	2	4	752
Measures	Energy Monitoring Score	3.73	1.27	2	4	5	756
	Energy Targets Score	2.58	1.27	1	3	4	744
	Five year energy reduction target (in %)	19.47	14.68	5	16.1	40.95	387
	GHG Monitoring Score	2.62	1.39	1	3	5	755
	GHG Targets Score	1.38	0.91	1	1	3	599
	Five year GHG reduction target (in %)	23.43	20.62	4	18.46	55.63	125
	Target Enforcement Score	2.42	1.29	1	2	4	614
	Variety sum of measures - measure creativity	3.36	2.09	1	3	6	763
	Energy reduction through most significant measure (in %)	14.00	15.54	2	10	30	461
	GHG reduction through most significant measure (in %)	16.72	19.69	2	10	50	333
	Possible energy reduction at zero cost (in %)	6.61	10.58	0	4	17.5	587
	Theoretically feasible energy reduction (in % of current energy consumption)	23.26	24.34	1	15	50	553
Investment	Required payback time for energy-saving investments (in years)	3.86	3.10	1.5	3	7	541
	Payback Time Stringency Score	2.69	0.90	1	3	3	553

Table 8: Interview Summary Statistics by ETS Status (Part 1)

	Variable	ETS Firms Mean	ETS Firms Strd. Dev.	ETS Firms Valid Resp.	non ETS Firms Mean	non ETS Firms Strd. Dev.	non ETS Firms Valid Resp.
Characteristics	Number of production sites (worldwide)	64.80	373.57	392	46.86	226.77	300
	Number of production sites (EU)*	24.27	130.66	379	11.61	63.79	262
	Number of production sites (country)	6.30	25.29	424	5.07	16.12	324
	Number of employees (worldwide)**	25,941.51	54,506.59	375	11,119.88	41,162.35	278
	Number of employees (country)	2,812.52	8,735.31	399	2,613.71	26,793.00	315
	Number of employees (site)**	773.20	1,772.33	424	371.23	820.93	327
Manager	Tenure in company (in years)	15.93	10.38	435	14.03	11.29	328
	Tenure in current post (in years)*	7.19	7.18	434	6.84	6.55	327
Prices	Expected change in energy prices by 2020 (in %)	76.77	75.03	261	61.71	77.31	202
	Upper expected bound for energy price change in 2020 (in %)	113.07	126.54	81	66.50	141.29	59
	Lower expected bound for energy price change in 2020 (in %)	64.28	72.14	84	35.72	48.36	61
	Expected price per ton of CO2 in 2020 in EUR**	42.79	47.59	144	53.24	40.57	27
	Maximum expected price per ton of CO2 in 2020 in EUR	58.98	91.38	125	69.50	89.20	14
	Minimum expected price per ton of CO2 in 2020 in EUR	24.73	18.00	109	33.80	25.66	10
Impact	Future Impact Score***	2.14	1.44	422	1.49	0.91	307
	Future Impact 80% Free Allowance Score	1.84	1.11	185	1.53	0.81	88
	Future Impact Reliability Score***	2.60	1.18	403	2.16	1.06	252
	Cost Pass-Through (in %)	23.83	37.09	325	25.33	39.38	237
Competition	Number of competitors (worldwide)	63.64	352.00	320	139.70	1,310.54	236
	Number of competitors (EU)**	24.29	117.66	366	77.05	587.49	262
	Number of competitors (country)**	13.28	111.68	403	37.24	228.66	309
	Non EU Competitors Share*	0.33	0.32	299	0.29	0.31	221
	Share of total export sales (world)	47.92	32.15	373	42.07	35.20	296
	Share of export sales to EU-member states	35.03	26.91	357	29.19	28.56	269
	Customer Pressure Score	2.28	1.32	423	2.26	1.29	328

Table 9: Interview Summary Statistics by ETS Status (Part 2)

	Variable	ETS Firms Mean	ETS Firms Std. Dev.	ETS Firms Valid Resp.	non ETS Firms Mean	non ETS Firms Std. Dev.	non ETS Firms Valid Resp.
Innovation	Climate-Related Products Score	1.84	1.27	432	1.81	1.29	327
	Climate-Related Product Innovations Score	1.87	1.25	429	1.80	1.22	328
	Climate-Related Process Innovations Score***	2.50	1.20	429	2.07	1.09	323
Measures	Energy Monitoring Score***	4.20	0.98	432	3.09	1.33	324
	Energy Targets Score***	2.82	1.21	428	2.25	1.27	316
	Five year energy reduction target (in %)**	17.87	13.12	247	22.33	16.79	140
	GHG Monitoring Score***	3.21	1.20	432	1.83	1.23	323
	GHG Targets Score***	1.58	1.08	354	1.11	0.49	245
	Five year GHG reduction target (in %)	22.06	20.55	86	26.59	20.70	39
	Target Enforcement Score***	2.66	1.37	372	2.05	1.07	242
	Variety sum of measures - measure creativity	3.43	1.97	435	3.28	2.23	328
	Energy reduction through most significant measure (in %)	13.91	16.18	283	14.16	14.49	178
	GHG reduction through most significant measure (in %)	17.04	19.83	232	15.96	19.44	101
	Possible energy reduction at zero cost (in %)	6.12	10.81	352	7.33	10.22	235
	Theoretically feasible energy reduction (in % of current energy consumption)	23.26	25.29	333	23.27	22.87	220
Investment	Required payback time for energy-saving investments (in years)	3.86	3.37	325	3.86	2.65	216
	Payback Time Stringency Score	2.69	0.89	333	2.70	0.90	220

systematically differ with respect to a variety of management practices relating to climate and energy matters. The figure

confirms the result in Table 8 that EU ETS firms report more pessimistically on the impact that climate change policies will have in the future (see Section 6 below for further analysis). Interestingly, EU ETS firms are expecting significantly lower CO_2 prices than non EU ETS firms. This finding is discussed further in section 4.3.2 below. Even after controlling for size and industry, EU ETS firms appear more exposed to the global market with higher export shares and higher fractions of non-EU competitors.

4.3 Attitudes and expectations relevant for climate policy

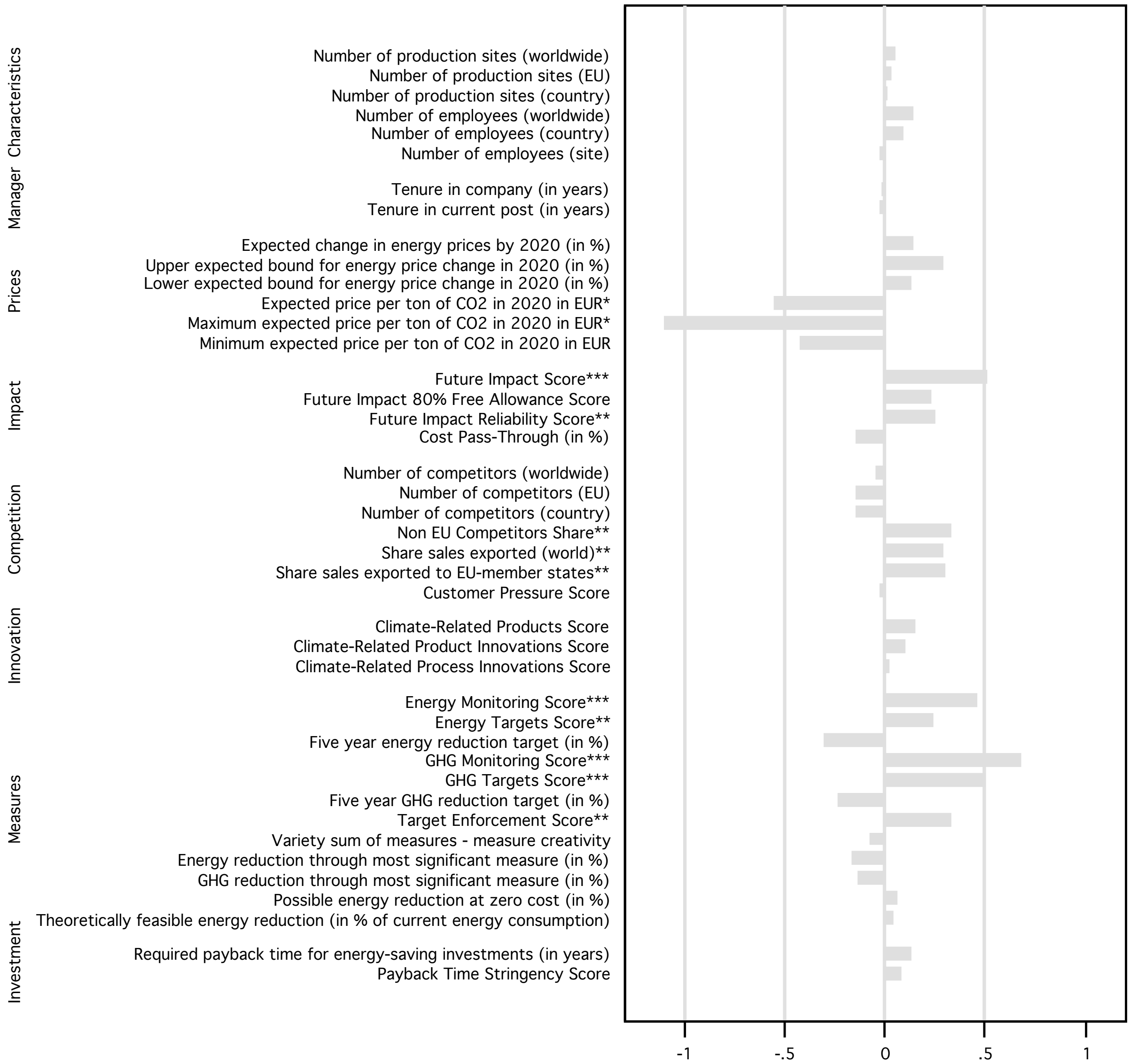
The way a firm copes with a long-run problem such as climate change will depend on its expectations about future policies. This sub section presents a number of stylized facts pertinent to these issues, which emerge from our interviews. In so doing, we mainly rely on comparisons of firms across countries and sectors.

4.3.1 Investment criteria and the "energy efficiency paradox"

Investment decisions are very relevant for the success of climate policies as they determine the energy and carbon intensities of the capital stock for many years. It is common among managers to decide on investment opportunities using a "payback time criterion", i.e. the number of years it takes the investor to recoup the cost of the investment paid upfront. Respondents were asked which payback criterion they applied in the economic evaluation of an energy efficiency enhancing measure that they considered but eventually failed to adopt (cf. question 24b in appendix B). On average, respondents required a payback within 3 years and 10 months, and there was no difference between firms in the EU ETS and those outside (cf. tables on page 22 and on the previous page). To put this into perspective, consider a project with a one-time investment cost, incurred at the beginning of the project's 15-year lifetime, and annual payoffs thereafter. For the investment cost to be recouped within less than 4 years, the internal rate of return (IRR) of the project must be 25% or higher. From the point-of-view of neoclassical investment theory, this IRR appears surprisingly high, especially since many energy efficiency upgrades are well-known technologies that do not command a high risk premium on top of the market rate. The rather short payback criteria we find is reminiscient of the "energy efficiency paradox", a term coined for the observation that firms routinely reject seemingly profitable investment opportunities in energy efficiency (see e.g. DeCanio, 1993).

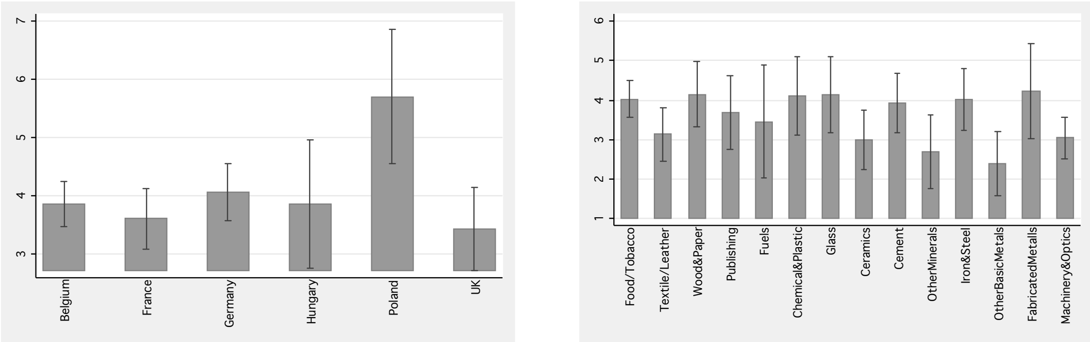
The implication of firms foregoing energy-saving investments in spite of a positive net present value is that the incremental cost of reducing their energy consumption is zero or negative. This is confirmed in the data in that repondents reported that they could reduce their GHG emissions or energy

Figure 1: Responses of ETS firms and non-ETS firms



Notes: Figure shows the average difference - conditional on 3 digit sector, interviewer controls and other noise controls - between ETS and non-ETS firms in terms of standard deviations of the respective variable; e.g. firms that are in ETS expect a carbon price that is approximately half a standard deviation lower than firms that are not in the ETS.

Figure 2: Payback time for energy efficiency projects



(a) by country (b) by industry

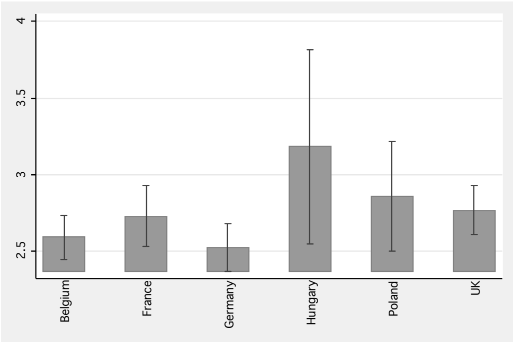
Notes: The bars represent the payback criterion (in years) for energy efficiency investments, averaged over firms in a given country (a) and 3-digit industry (b). Confidence bands are calculated at the 95% level.

consumption by 6.6% at zero cost (out of a technically feasible 23.3% on average). These findings speak to the presence of an energy efficiency paradox in our data and confirm results previously found for UK manufacturing firms (Martin et al., 2010).

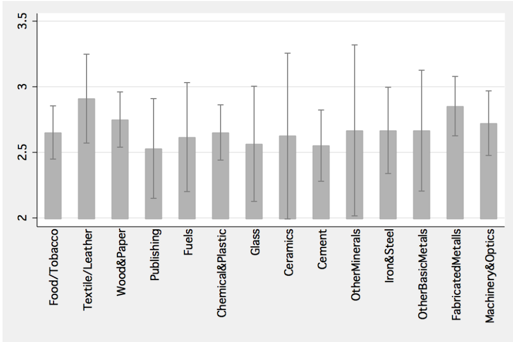
Next, we investigate how these patterns vary across countries and sectors. Figure 2a shows the average payback criterion by country. Payback criteria in France and especially in the UK are more stringent than the mean whereas Germany and Poland allow longer payback times of more than 4 or 5 years, respectively. Sampling error aside, these observations can have several explanations. For instance, a neoclassical economist might argue that energy efficiency projects command different risk premia due to cross-country differences in industrial structure, energy prices and government policies. A behavioural economist might want to add that an investor's attitude towards such investments is influenced by past experiences, cultural background, and by the organizational structure of the firm. The role of industrial structure is clarified by Figure 2b which displays how the payback criterion varies across 3-digit industries. Most industries allow 4 years for payback. Others require faster payback, like the textiles/leather, ceramics, other minerals and other basic metals sectors. In a comparison of criteria of the iron & steel vs. other basic metals industries, the 95% confidence intervals do not overlap. This begs the question of what is driving such differences in payback criteria. For example, it could be the case that energy efficiency investments are more material in some industries (e.g. those with high energy cost shares) than in others and hence longer payback times are tolerated.

In a related question (24c of the questionnaire) we asked whether payback criteria for investments in energy efficiency are more or less stringent than those applied to other investment projects. The scores given for this question average at 2.69 for both ETS and non-ETS firms, which is just below a score 3 corresponding to "no difference". The fact that the average score is below 3 points to a weak and not

Figure 3: Payback time stringency score



(a) by country



(b) by sector

Notes: The bars represent the payback stringency score, averaged over firms in a given country (a) and 3-digit sector (b). A score lower than 3 indicates that payback times are longer for energy efficiency project than for others, and vice versa. Confidence bands are calculated at the 95% level.

statistically significant tendency towards longer payback times for energy efficiency investments. This tendency could be driven by a lower-than-average risk of energy efficiency improvements. However, Figure 3 shows that there are difference across countries and sectors. For example, Figure 3a shows that firms in Belgium, France, the UK and Germany use significantly less stringent payback criteria in the evaluation of energy efficiency projects than for other projects. At a score of 2.5, German firms apply the least stringent criteria whereas Hungarian and Polish firms apply criteria above the average.

The sectoral picture in Figure 3b shows no significant deviations from the mean stringency. This suggests that behavioural difference are more likely to be driven by cross-country differences such as prices, policies and culture than by differences in the industrial composition.

4.3.2 Expectations about prices and policies

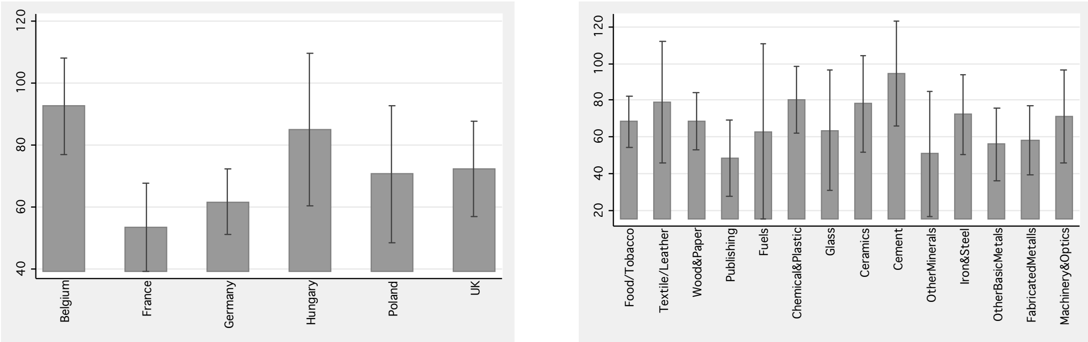
The Kyoto Protocol and phase II of the EU ETS both stipulate binding abatement commitments for the period from 2008 until 2012. Given that the planning horizon for investment projects usually exceeds 5 years, the measures firms take today in order to reduce their energy consumption and GHG emissions depend only in part on current regulation but to a large extent on their expectations about prices for energy and carbon beyond 2012. We asked the respondents about their expecations about energy price changes and about the level of CO_2 prices by 2020.

The average firm expects energy prices to grow by 70.2% until 2020. This expectation is somewhat higher in ETS than in non-ETS firms, but the difference is not statistically significant. Among the firms that gave bounds[7] for the expected energy price increase, the average upper bound corresponds to an almost doubling of energy prices by 2020 (93.5%). The lower bound averages at 52.4%. The spread in expecations is about 20 percentage points larger in ETS firms than in non-ETS firms.

Figure 4a displays the cross-country variation in the expected growth in energy prices. The expected

[7] While we did not explicitly ask for upper and lower bounds on energy and carbon prices, we recorded them whenever respondents mentioned them to us.

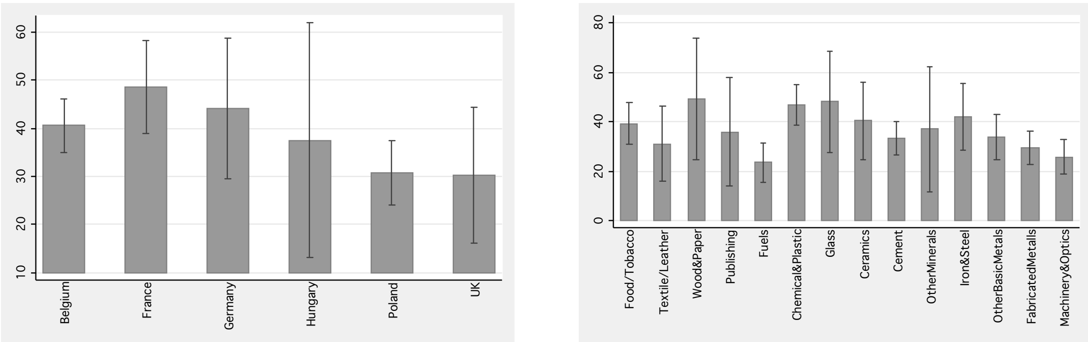
Figure 4: Expected energy price



(a) by country (b) by industry

Notes: The bars represent the expected energy price increase in percent, averaged over firms in a given country (a) and 3-digit sector (b). Confidence bands are calculated at the 95% level.

Figure 5: Expected carbon price in 2020



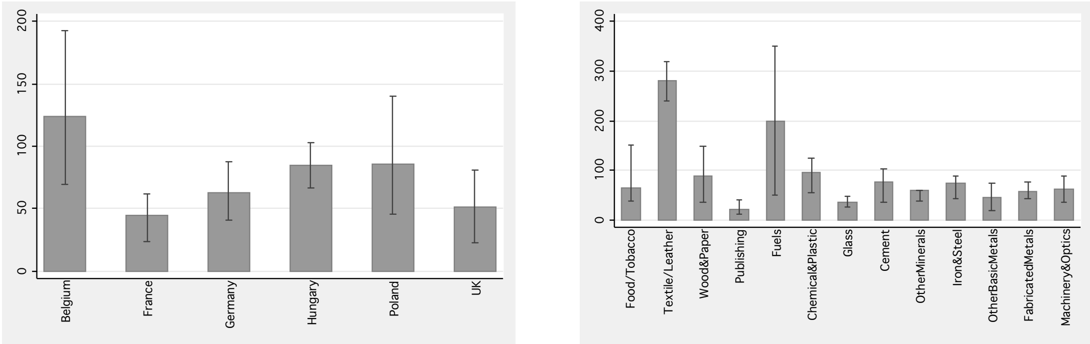
(a) by country (b) by industry

Notes: The bars represent the expected CO2 price in Euros per tons, averaged over firms in a given country (a) and 3-digit sector (b). Confidence bands are calculated at the 95% level.

price increase is lowest in France (perhaps because of the large share of nuclear energy in that country) and highest in Belgium (the 95% confidence intervals do not overlap). German firms expect the second-lowest price increases and Hungarian firms expect the second-highest. Furthermore, there is some heterogeneity in expectations across 3-digit industries (as depicted in Figure 4b). While the cement and the chemicals and plastics industries expect the largest price increases, expectations are lowest in the Publishing and Other Minerals sectors. However, the confidence bands are large and overlap.

Turning to CO_2 prices, the average expectation is at €44.4 per ton in 2020. ETS firms expect a lower carbon price of €42.7 than non-ETS firms (€54.2), and the difference is statistically significant at the 5% level. This heterogeneity in expectations is intriguing as it suggests that current exposure to the ETS shapes the firm's expecations about future climate policy and hence about carbon prices. An explanation for this could be the fact that many countries set rather generous caps for the ETS sector which resulted in relatively low permit prices (Klepper and Peterson, 2006). Firms outside the ETS may rationally anticipate that regulation for the non-ETS sectors must be more stringent in order to comply with the EU target of 20% emission reductions by 2020, and hence expect marginal abatement

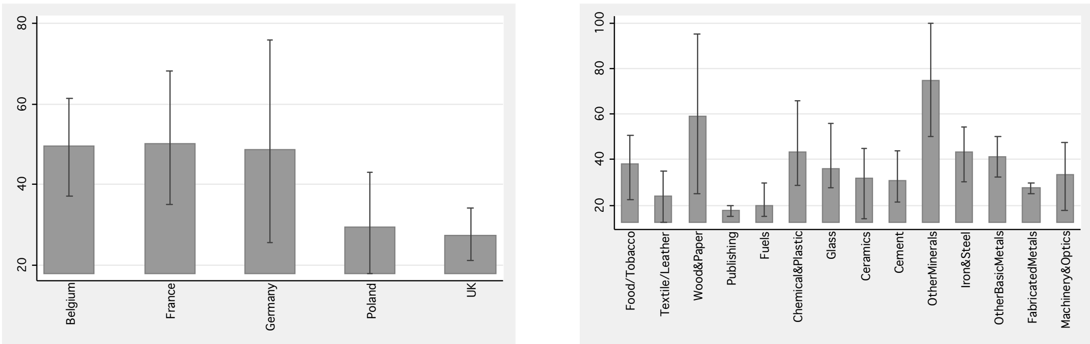
Figure 6: Bounds on the energy price change



(a) by country (b) by industry

Notes: The bars represent the expected energy price increase (in percent) by 2020, averaged over firms in a given country (a) and 3-digit sector (b). The bands represent the average difference between the reported upper and lower bounds on the price change.

Figure 7: Bounds on CO_2 prices



(a) by country (b) by industry

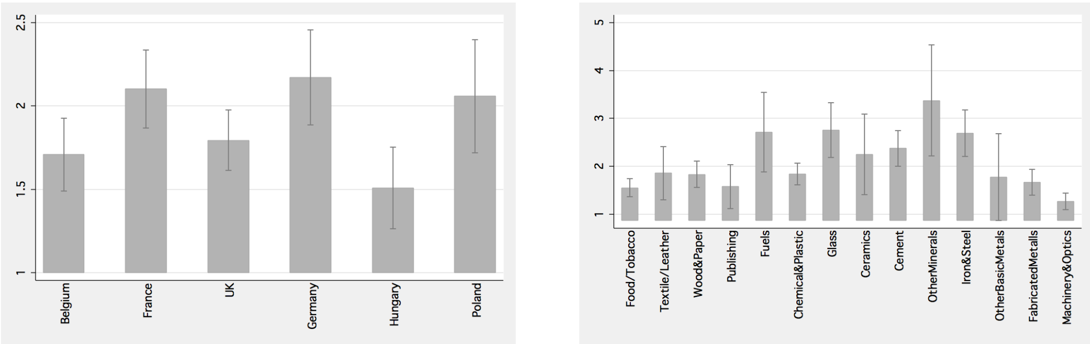
Notes: The bars represent the expected CO2 price in 2020, averaged over firms in a given country (a) and 3-digit sector (b). The bands represent the average difference between the reported upper and lower bounds on the carbon price.

costs to be higher. In addition, the expected carbon price should be higher if policies implemented in the non-ETS sector fail to be cost effective. An alternative explanation is that non-ETS firms simply over-estimate their marginal abatement costs for a lack of experience. Further research is needed to distinguish between these hypotheses. In the following sections we will see more evidence of this type of heterogeneity.

According to the theory of real options (Dixit and Pindyck, 1994), the level of investment into energy and carbon saving technologies should not only depend on the expectations about future energy and carbon prices but also on the uncertainty that investors face with regard to these prices. Figure 6 shows these bounds by country and industry along with the mean expectation across firms that reported bounds. The main variation in bounds is across countries, with Belgian and Polish firms exhibiting the largest uncertainty about the future energy price increase. Expectations are quite homogeneous across industries with the exception of the textile and fuels industries, which exhibit larger mean and spread expectations respectively.

Figure 7 displays the bounds on the expected carbon price by country and industry. Uncertainty about

Figure 8: Future impact of carbon pricing



(a) by country (b) by sector

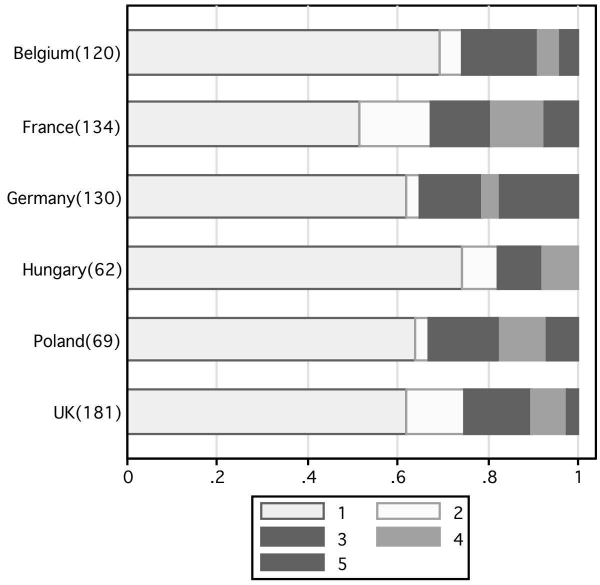
Notes: The bars show the average the average score in a given country (a) or 3-digit sector (b). Confidence bands are calculated at the 95% level.

CO_2 prices is largest in Germany, followed by France, Poland and Belgium. UK firms appear to have the most certain expectations of the carbon price in 2020. This may be related to the fact that this country, unlike other EU member states, has adopted legally binding targets for GHG abatement under national law (the UK Climate Bill). Expectations across sectors mostly vary between 20 and 50 Euros per ton, with large upward outliers in the wood and paper industry, chemicals and plastics as well as in the other minerals industries.

While expected carbon prices have the advantage of being easily comparable across firms, they do not convey any information about how firms are going to be affected by them. Clearly, a given level of the carbon price may have different consequences for different firms and sectors. This is why we also collected a more direct measure of the expected impact of future climate policies on outsourcing and relocation decisions (question 12 in appendix B). The mean score is 1.87 (on a scale from 1 to 5) but ETS firms expect a significantly higher impact of 2.14 than non-ETS firms (1.49). Along with the above-mentioned finding that ETS firms expect lower carbon prices, this demonstrates that carbon prices have heterogenous impacts and thus cannot serve as an impact measure themselves. For example, it could be that ETS firms are likely to be more carbon intensive and would therefore be more sensitive to climate policy, even at a lower carbon price. Moreover, ETS firms were judged significantly more reliable in answering this question (though at a low level).

Figure 8a displays cross-country differences in the future impact score. We find that German and French firms expect significantly stronger impacts of future climate policies than Hungary. However, there is less than a 5% chance that firms outsource more than 10% of their production levels in response to regulation. Figure 8b shows the impact across industries. Most affected are fuels and other minerals, glass, iron and steel industries. For all other industries the expected future impact is rather low. In neither case do we find that plant closure and complete relocation is in the 95% confidence interval. Figure 9 provides a more detailed picture of the distribution of the answers to these questions, by country and industry.

Figure 9: Future impact of climate policy



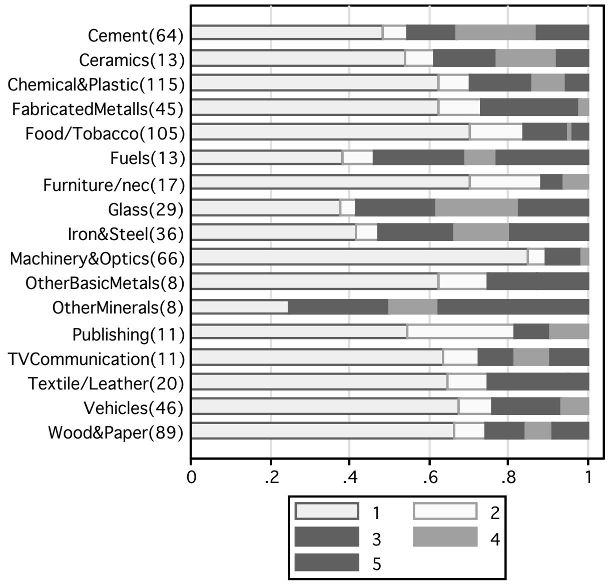


Figure 10a displays the deviation from the mean expected stringency by country after controlling for interviewer noise (left) and industry (right). After controlling for industrial composition, we find that only French firms expect significantly stronger-than-average impacts.[8] The main source of heterogeneity in the future impact questions answers are thus the sectoral differences shown in Figure 10b.

4.3.3 Country-level ranking of climate-friendliness

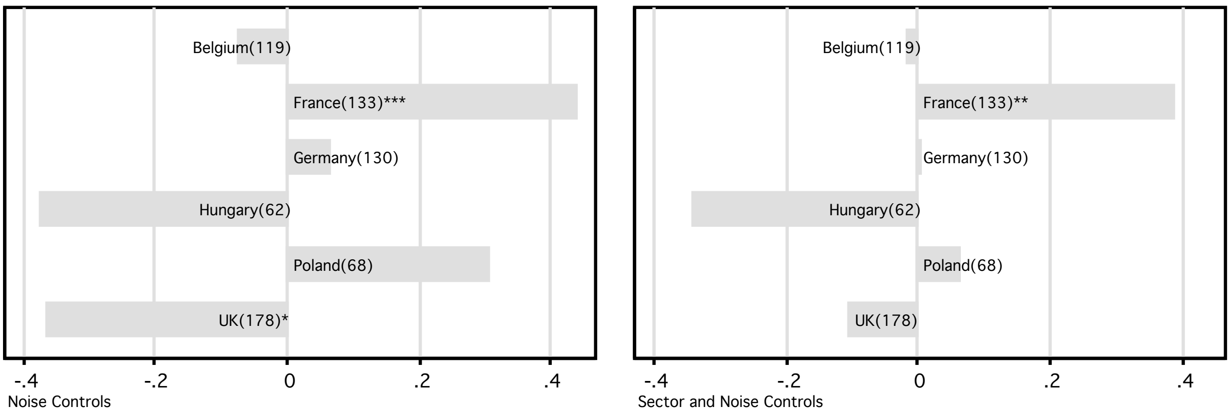
In order to compare the overall performance of countries in our sample we construct a "climate-friendliness" index for each firm by averaging over five components, namely (1) the average of energy and GHG monitoring and targeting scores (see Table 7); (2) the average of climate-related product and process innovation scores (see Table 7); (3) the score of having a lower payback time for climate investments than for others (described in Figure 3) multiplied by minus one; (4) the number of mitigation measures adopted; and (5) for EU ETS firms, the score of how rational they behave on the market (see Figure 15 below). Before averaging, we remove interviewer noise and control for the sector of the firm and then normalise all scores.

The climate-friendliness index varies widely across firms. Table 10 and Figure 11 reports the average index bycountry. It appears that France has the highest average normalised index score followed by Belgium. The country performing worst on this metric is Poland. Upon taking a closer look at the density function of the index plotted in Figure 12, we find that this ranking can vary along

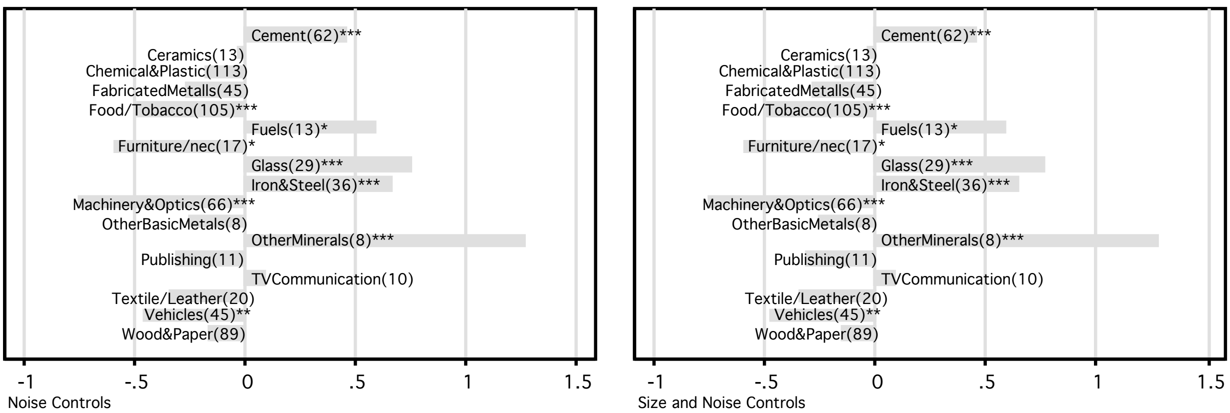
[8]This could be driven in part by the announcement close to the time of our survey by French president Nicolas Sarkozy to impose a carbon tax on the non-ETS sector of the French economy .

Figure 10: Differences in future impact of climate change policy score

(a) by country



(b) by industry



Notes: Figure a is based on a regression of the score on country dummies with additional controls for interview noise (left) and sector (right). The bars indicate the deviation of a country's intercept from the mean of country intercepts. Figure b is based on a regression of the score on industry dummies with additional controls for interview noise (left) and employment size (right). The bars indicate the deviation of an industry's intercept from the mean of industry intercepts.

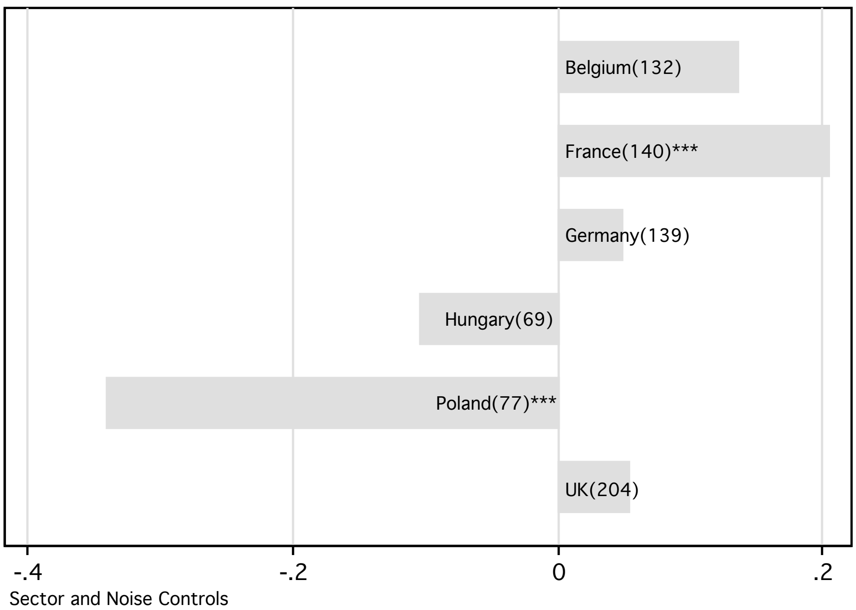
Table 10: Climate-friendliness index

country	climate friendliness index mean	median	standard deviation
Belgium	0.004	0.000	0.484
France	0.104	0.083	0.557
Germany	-0.013	-0.070	0.544
Hungary	-0.059	-0.169	0.454
Poland	-0.249	-0.282	0.500
UK	-0.025	-0.064	0.564

Notes: The Climate-friendliness index is constructed by averaging (1) the average of energy and GHG monitoring and targeting scores; (2) the average of normalised climate-related product and process innovation scores ; (3) the normalised score of having a lower payback time for climate investments than for others multiplied by minus one; (4) the normalised number of mitigation measures adopted; and (5) for EU ETS firms, the normalised score of how rational they behave on the market. Each of these scores is computed as the normalised residual of a regression of the raw score on interviewer and sector dummies.

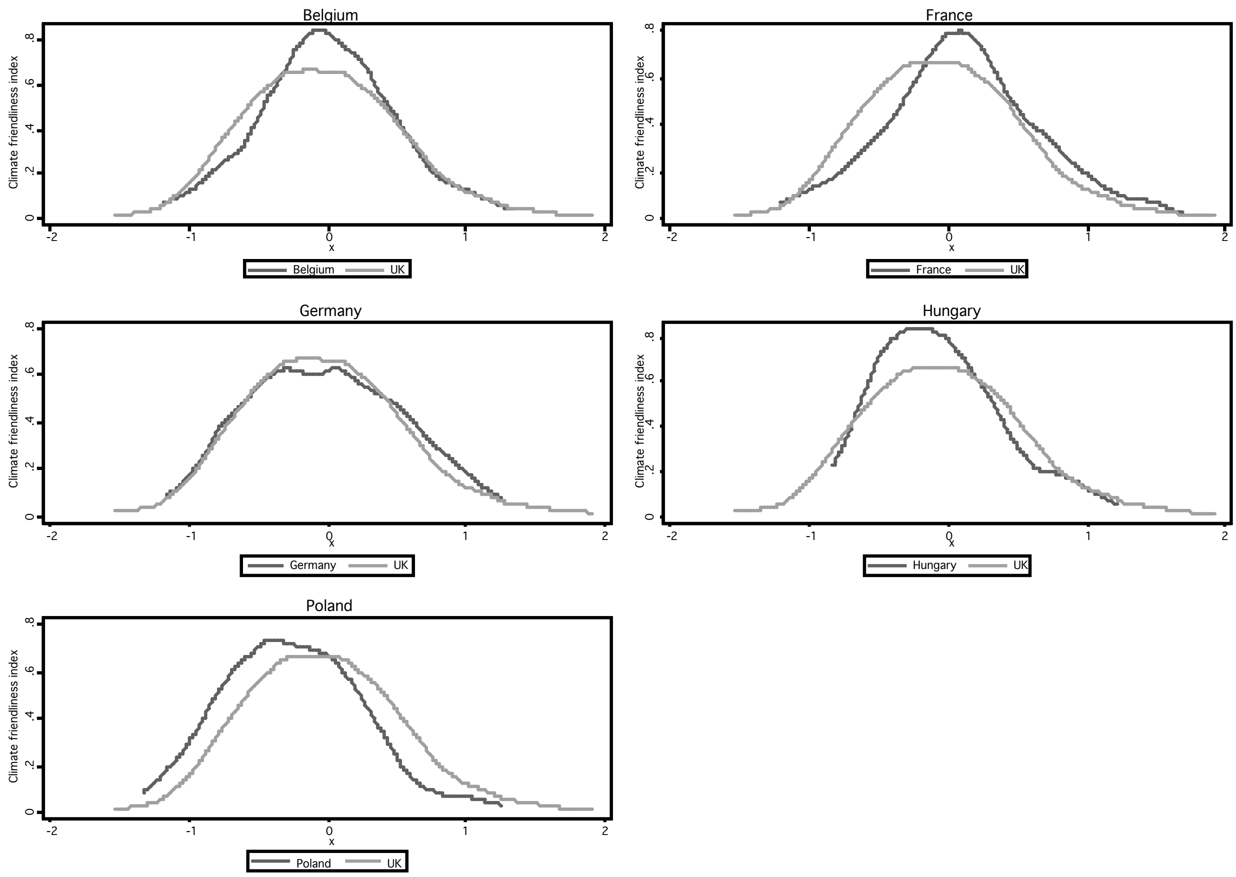
the distribution across firms. Polish firms in our sample perform worse (in the sense of first-order stochastic dominance) than UK firms. French firms appear to be more "climate friendly" across the distribution, except for the very best of UK firms that outperform all other firms in our sample. The average score index for UK firms is thus pulled down by a number of laggards. The distribution of Hungarian firms is skewed towards the left, but the top firms perform as well as those in non-Eastern Europe countries. In all countries, these results show the potential for large improvements if the laggards were to adopt the practices of those at the median.

Figure 11: Average climate friendliness index



Notes: Based on a regression of the score on country dummies with additional controls for interview noise and sector. The bars indicate the deviation of a country's intercept from the mean of country intercepts. The stars represent the significance of the coefficent on each country's dummy.

Figure 12: Climate-friendliness index density



Notes: Each graph shows the density of the climate friendliness index distribution for a given country relative to the UK distribution.

5 The behaviour of firms in the EU ETS

This section sheds light on the behaviour of EU ETS firm on the permit market. We first analyse the perceived stringency of current and future ETS targets and their relationship to other firm characteristics. We then relate these findings to the way firms manage compliance with their allocated emissions by trading on the allowance market.

5.1 Stringency of EU ETS targets

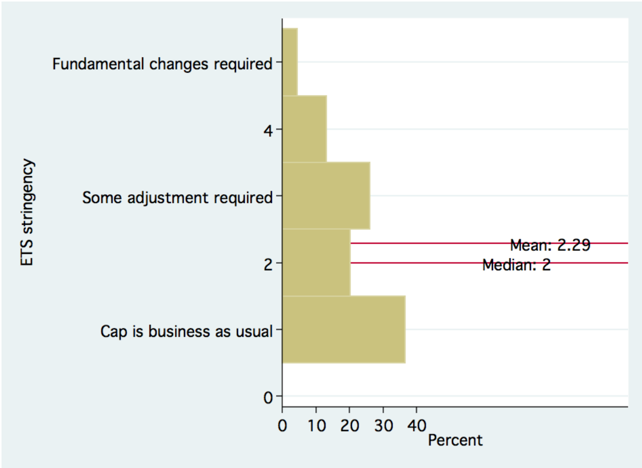
The stringency of the EU ETS depends on many aspects such as the initial allocation, the marginal abatement cost curve, the level and volatility of the permit price, the share of abatement and trading costs in total costs, and so on. Although the "independence principle" maintains that the initial permit allocation does not affect the efficiency of the trading system, academic economists have been advocating the use of auctions for distributing permits (Montgomery, 1972). In contrast, under the EU ETS grandfathering has been the dominant method of permit distribution thus far, and it is likely that this has given rise to very heterogeneous experiences for firms, ranging from windfall profits at overallocated firms to high compliance cost at underallocated firms. According to Brewer (2005) and McKinsey and Ecofys (2005) there was much uncertainty in the business community surrounding the implementation of the EU ETS, its functionality and also its credibility as a tool for reducing greenhouse gas emissions. Both these studies support the view that EU ETS participants' "market rationality" was likely hindered by the confusion over the design of current policy and stringency of future policy.

During our interviews, managers were scored based on their (open ended) assessment of how stringent the EU ETS has been for their firm. The median score of 2 and an average score of 2.29 presented in Figure 13a suggest that on average manufacturing firms have not had their businesses disrupted and are able to comply with relative ease. There are however around 50% of firms for which some adjustment was required.

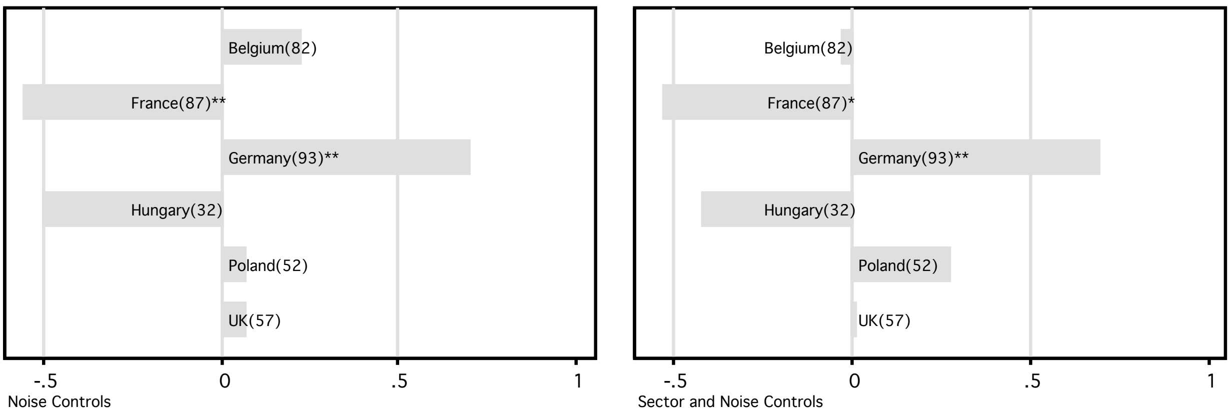
In panel b of Figure 13 we plot the deviation of the country intercepts from the mean intercept for the EU ETS stringency score, both with and without sector controls. Panel b displays the deviation of the industry intercepts from the mean intercepts with and without firm size controls. All else being equal, German and Polish firms perceive the EU ETS as more stringent than the average firm whereas French and Hungarian firms feel less under pressure. Furthermore, targets appear less stringent than average to firms in the chemical and plastics industries and to those producing basic metals.

Figure 14 displays the distribution of expectations about the stringency of phase III of the ETS after 2012. The median stringency score has increased to 3 compared to 2 for the current phase. Moreover, the fraction of firms answering that the cap they receive will allow them to continue doing business as usual declined from almost 40% (for the current stringency) to less than 10%. Nevertheless, most firms expect that only some minor adjustments would be needed to meet their cap even in phase III.

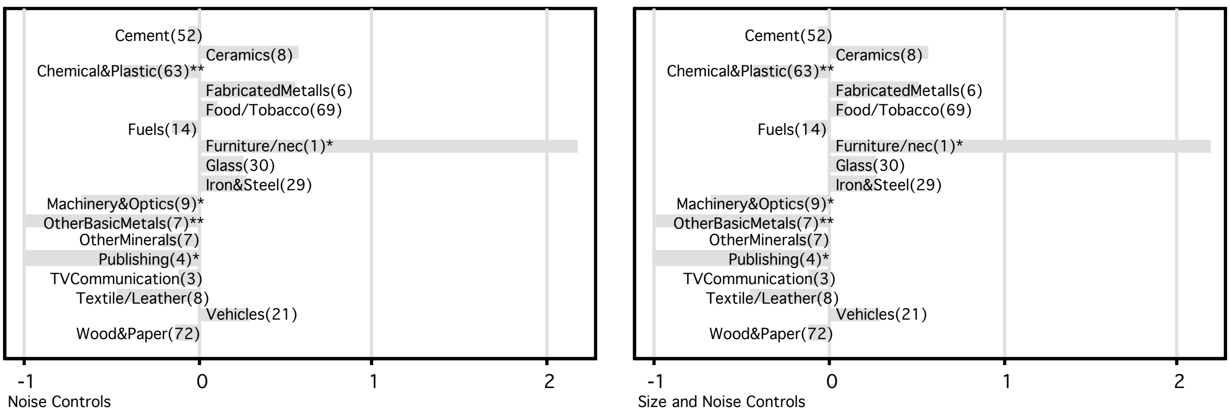
Figure 13: Differences in stringency of EU ETS score



(a) general



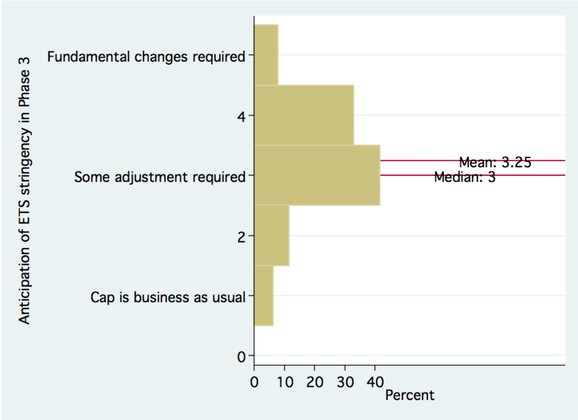
(b) by country



(c) by industry

Notes: Figure a presents the results to the question refering to the stringency of the EU ETS at present for the interviewed firms. Figure b is based on a regression of the score on country dummies with additional controls for interview noise (left) and sector (right). The bars indicate the deviation of a country's intercept from the mean of country intercepts. Figure c is based on a regression of the score on industry dummies with additional controls for interview noise (left) and employment size (right). The bars indicate the deviation of an industry's intercept from the mean of industry intercepts.

Figure 14: Anticipation of ETS stringency in phase III



5.2 Rationality of trading on the allowance market

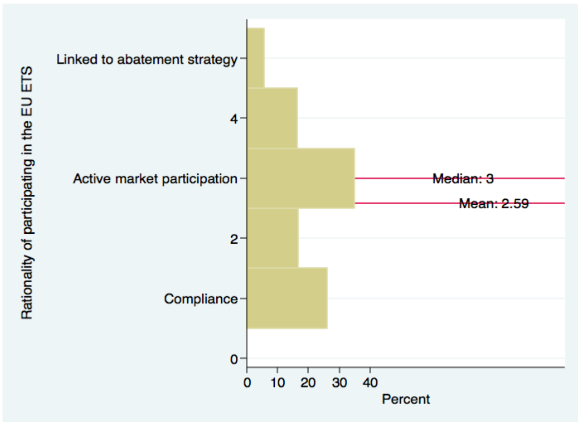
Several interview questions focus on the way manufacturing firms act on the allowance market. The score measuring the rationality of firms' trading behaviour averages at 2.57 (out of 5) and has a median of 3, as shown in Table 6 and in Figure 15a. This means that the average firm does not routinely use permit trading as a tool to reduce compliance cost or to generate extra revenues from excess abatement. About 30% of firms participate only passively in the ETS, meaning that they do not consider carbon permits as a financial asset that provides an opportunity to make a profit. These firms take their permit allocation as a target to be met, much in the spirit of "command-and-control" regulation. This is a problem because it prevents firms from minimizing their abatement cost which, on theoretical grounds, makes permit trading superior to command-and-control regulation. For example, the total compliance cost of a given emission cap will not be minimized unless firms rationally choose abatement levels such that their marginal abatement cost equals the permit price. While there are significant differences in ETS engagement between sectors, any differences between countries are not statistically significant, as shown in Figure 15c. In contrast, Figure 15d shows that some industries (i.e. cement, chemicals and plastics, fuels) are seizing permit market opportunities more efficiently than others.

A similar pattern arises when looking at the frequency of allowance trading across firms. Figures 16 and 17 show that the majority of ETS participants do not trade on the ETS market. Firms trade permits at least on a quarterly basis in five of the six sample countries across a variety of industries.[9] While some firms do not need to trade because their emissions exactly match their allocated allowances, other firms may have excess allowances that they do not supply to the market. Some policy makers are concerned that this behaviour exacerbates the shortage of allowances and hence drives up the allowance price. Failure to sell excess allowances can have different reasons. For example, firms might want to bank permits in order to hedge against future carbon price increases. It could also

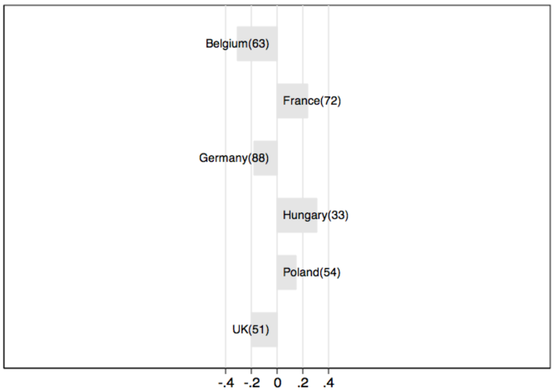
[9] Anecdotal evidence suggests that Polish firms failed to trade more frequently due to institutional barriers and delays, not because of a lack of aptitude or willingness to engage in the market. For instance, Skjærseth and Wettestad (2008) note that "Poland must be counted as figuring centrally among the ETS implementation laggards so far. It was seriously delayed in NAP I" (p. 281).

Figure 15: Rationality of EU ETS participation score

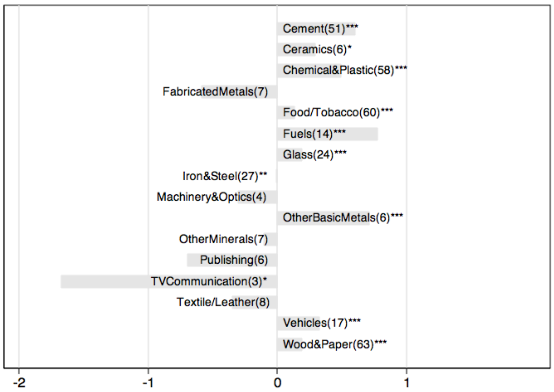
(a) general



(b) by country



(c) by industry



Notes: Figure a shows a histogram of the interview score measuring whether the firm is acting rationally on the EU ETS market. Figure b is based on a regression of the score on country dummies with additional controls for interview noise (left) and sector (right). The bars indicate the deviation of a country's intercept from the mean of country intercepts. Figure c is based on a regression of the score on industry dummies with additional controls for interview noise (left) and employment size (right). The bars indicate the deviation of an industry's intercept from the mean of industry intercepts.

Figure 16: EU ETS market participation

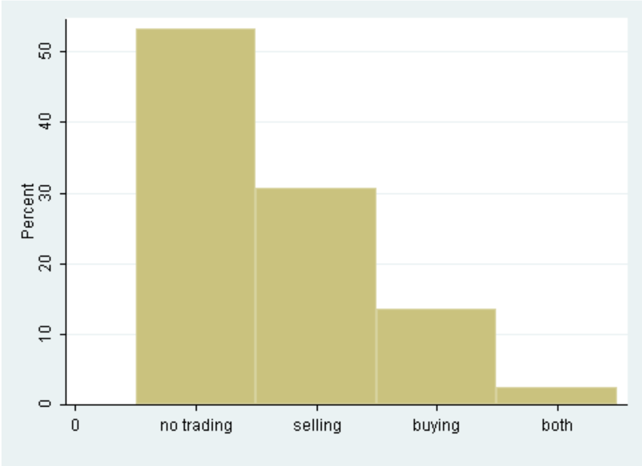
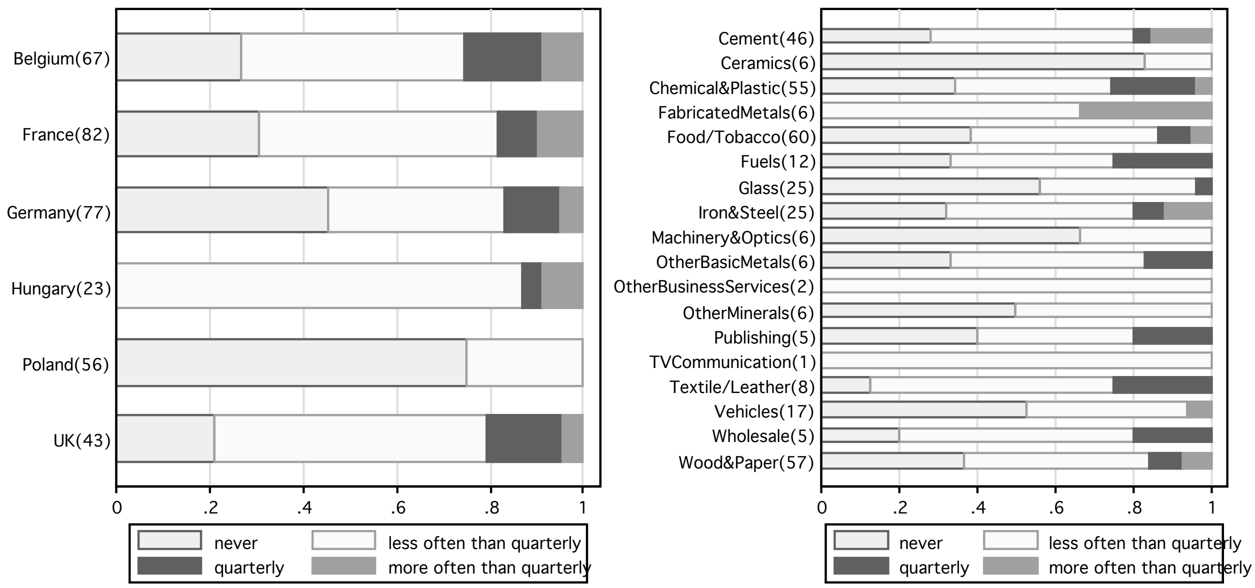


Figure 17: Frequency of permit trading



be the case that firms face high transaction and information costs related to trading or that they fail to optimise. Murphy and Stranlund (2007) suggest that an "endowment effect" – the overvaluation of items in one's possession – could prevent firms from selling permits they were allocated for free. A "status quo bias" (Kahneman et al., 1991; Samuelson and Zeckhauser, 1988) can have similar consequences.

We test for the presence of an endowment effect by running probit regressions on the binary event "Selling on the EU ETS market" derived from question 7 of the interview (see Appendix B). The main explanatory variables are a set of dummy variables calculated on the basis of the distribution of excess allowance allocations in 2008 given by

$$Excess_{i,2008} = Allo_{i,2008} - CO_{2_{i,2008}}$$

Table 11: Firms' trading decisions on the EU ETS

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	Buys or Sells in ETS			Sells in ETS	
CO_2 consumption					
lnCO2	0.032*	0.024	-0.008	-0.030	-0.035
	(0.019)	(0.019)	(0.018)	(0.022)	(0.022)
EU ETS Rationality Score		0.072***	0.074***		0.060**
		(0.026)	(0.025)		(0.026)
Overallocation in 2008 [number of permits]: 0-1685				0.162	0.174
				(0.115)	(0.117)
1685-4844				0.147	0.130
				(0.117)	(0.118)
4844-10661				0.411***	0.406***
				(0.094)	(0.096)
10661-27323				0.547***	0.528***
				(0.079)	(0.082)
>27323				0.491***	0.490***
				(0.093)	(0.094)
Observations	286	286	2 286	286	286

where $Allo_{i,2008}$ and $CO2_{i,2008}$ are taken from the CITL and denote the allowance allocation and actual emissions of firm i in 2008, respectively. We split firms with positive excess permits into five groups, each containing the same number of firms. The five groups are defined by the quintiles of the distribution of $Excess_{i,2008}$ (1,701; 5,387; 11,722; 32,100 allowances). Let each group be represented by a dummy variable $Q_{q,i}$, where the subscript q indicates the quintile, so that we can express the latent equation underlying the probit as

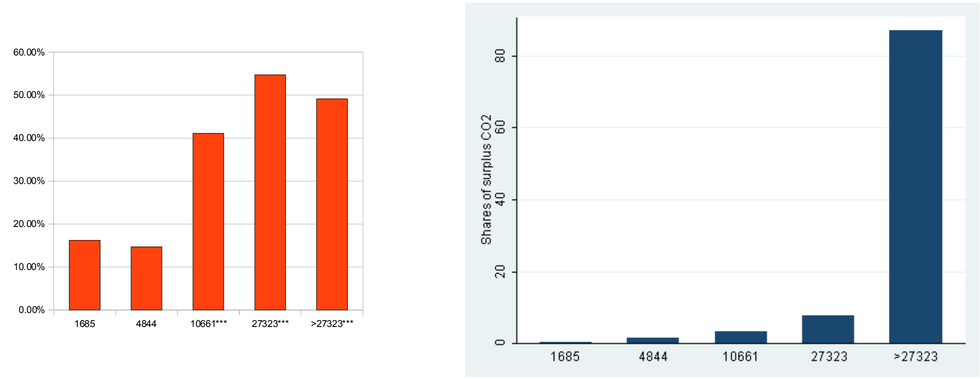
$$Propensity \quad to \quad sell_i = \sum_q \beta_q Q_{q,i} + \beta_x X_i + \varepsilon_i \tag{1}$$

and X_i is vector of additional control variables. Table 11 reports the results from estimating various versions of equation (1). The dependent variable in columns 1 and 2 is the binary event "Trading in the ETS", defined as buying or selling. Column 1 shows that trading is weakly correlated with the total amount of CO_2 emitted by the firm. Column 2 shows that it is more strongly correlated with the rationality score we derived from our interviews, which underlines the internal consistency of this score. In columns 3 to 5, we examine the decision to sell allowances on the EU ETS market. Columns 4 and 5 show that firms with excess allowance amounts in the 3rd quintile and higher have a heightened probability of selling allowances on the EU ETS market. Since the table reports marginal effects, the coefficient estimates imply that a firm with more than 4,844 allowances to spare is at least 41% more likely to sell some or all of those allowances on the EU ETS market than a firm that is not over-allocated. This implies that allowances are less likely to be traded when the revenue derived by their owners is small, a finding that could be rationalized by a fixed cost of trading.

How important is this issue on aggregate? To answer this question, we examine what share of the ex-

Figure 18: Firms' propensity to sell by quintile of the excess distribution

(a) Marginal effects (b) Distribution of excess permits



Notes: Figure a presents the coefficients of the probit regression of column (3) in Table , each bar representing the probability of a firm with excess permits within that range to sell permits on the EU ETS market. Figure b displays the proportion of excess permits held by firms in each quintile of the excess permit distribution.

cess allowances is held by firms in quintiles 1 and 2. Figure 18 illustrates this share in the distribution of excess allowances. We see that failure to sell excess allowances is of minor importance since far less than 10% of excess allowances fall into no trade categories given by the first two quintiles.

6 Vulnerability of sectors and firms to carbon leakage

6.1 The vulnerability of a sector to carbon leakage

In phases I and II of the EU ETS, tradable permits were handed out for free to existing business sites based on their historical emissions, on growth projections and on the Kyoto obligations of the countries they were located in. In contrast, the European Commission is committed to drastically increasing the share of permits that will be auctioned in phase III. This implies that the ownership of emissions will be transferred from incumbent polluters back to governments and, ultimately, taxpayers. Not surprisingly, it has proven difficult to defend this objective against the powerful interests of the affected firms and industries. In trying to lobby the EU law makers into exempting their industry from permit auctioning, these interest groups are able to exploit two genuine concerns for policy makers, carbon leakage and job losses.

In April 2009 the EU Parliament released Directive 2009/29/EC[10] following a proposal by the European Commission. The directive specifies the rules for determining which sectors[11] will be at significant risk of carbon leakage if the practice of free allocation of permits is given up in favour of auctions. In essence, the Commission proposes two criteria for establishing the risk of carbon leakage

[10] See `http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0063:0087:EN:PDF`

[11] Sectors are examined at the NACE 4-digit level where possible, with some at the NACE 3-digit level. NACE stands for "Nomenclature Generale des Activites Economiques dans I'Union Europeenne" (General Name for Economic Activities in the European Union).

and thus for determining the recipients of free permits: total CO_2 costs (both direct and indirect)[12] relative to the value added of a sector, referred to as "Value at Stake" (VaS)[13] hereafter, and the trade intensity of a sector (TI).[14] The construction of these metrics by the Commission are discussed in Section 6.2 below. Both metrics relate to factors that determine the business response to an increase in carbon prices and associated allocations of emission permits. One can distinguish between three such factors, namely (i) cost impact, (ii) demand response and (iii) factor specificity.

The cost impact of carbon pricing is proportional to a firm or sector's use of non-renewable energy. In the past this cost was not fully imposed on the firm or sector, as it received a large allocation of permits for free. With auctioning it will be exposed to the full costs of EUAs and the VaS metric is designed principally to capture this cost impact.

The demand response determines a firm's ability to pass on the cost impact to its consumers in the form of higher prices. For example, if the product the firm offers is highly traded between the EU and other countries it will be difficult for the firm to pass through the permit cost as consumers can easily switch to relatively cheaper products from non-EU competitors. The TI metric proxies for the degree to which foreign competition prevents pass-through of the cost impact.

Factor specificity denotes the extent to which a firm or sector uses production factors that are specific to EU countries. Examples include specific skills of the labour force, the presence of natural resource deposits, and benefits associated with industrial agglomeration. Clearly, a firm using such country specific factors more heavily is less likely to relocate in response to full auctioning than a firm that can easily set up shop elsewhere.

A shortcoming of the TI measure is that it potentially reflects the effects of factor specificity in the wrong way. To see this, notice that a high degree of factor specificity of a sector is likely to be positively correlated with its trade intensity. This is because a country is more likely to export goods that can only be produced in that country as it has an absolute advantage in their production (e.g. Swiss watches). In spite of being able to pass through the full cost of permit auctioning, this sector will look vulnerable according to the definition of trade intensity the Commission has suggested. In a similar vein, even firms operating in highly traded industries may have substantial scope to pass costs on to consumers if the product they sell is sufficiently differentiated from that of foreign rivals. Finally, VaS misses an important aspect of the cost impact as it depends not only on the energy intensity of a sector, but also on how easy it is to replace carbon intensive inputs by less carbon intensive ones. In sum, while there are good arguments both in favour of and against using the measures employed by the Commission, there is little direct empirical evidence that links them with the vulnerability of a sector to climate change policies.

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[12]Direct costs are the costs of total emissions, and indirect costs are electricity consumption multiplied by 0.465, the average emissions intensity of electric power for the EU27. Prices of EUAs are assumed to be 30 €/tCO_2 for all calculations.

[13]The term Value at Stake is borrowed from previous work by Sato et al. (2007).

[14]Trade intensity is defined as "the ratio between the total value of exports to third countries plus the value of imports from third countries and the total market size for the Community (annual turnover plus total imports from third countries", European Commission (2009), p. 24.

6.2 The EU Commission's definitions and data

Despite the best intentions of European lawmakers to implement full permit auctioning in phase III of the EU ETS, there will still be a significant amount of European Union Emissions Allowances (EUAs) allocated freely according to Community-wide harmonised rules for free allocation.[15] Specifically, the amended Directive 2003/87/EC[16] (implementing the EU ETS legislation) explicitly allows exemptions from EUA auctioning to prevent carbon leakage. This raises the question of which sectors or subsectors are deemed to be at significant risk of carbon leakage and should therefore receive free allocations of EUAs.[17] [18]

The Commission has adopted two metrics to identify such sectors or subsectors: the sum of direct and indirect additional costs induced by the implementation of auctioning, which we refer to as Value at Stake (VaS), and TI, the trade intensity of the sector or subsector. The direct costs are calculated as the value of direct CO_2 emissions (using a proxy price of 30€/tCO_2), and the indirect costs capture the exposure to electricity price rises that are inevitable on account of the full auctioning in the power generation sector. Indirect costs are calculated as electricity consumption (in MWh) multiplied by the European average emission intensity for electricity (0.465 tCO_2/MWh), and applying the same proxy EUA price (30€/tCO_2). The ratio between the sum of the direct and indirect costs and the gross value added of a sector is used as the metric gauging the sector's vulnerability to carbon leakage due to the cost burden full auctioning might impose. Trade intensity for each sector is calculated by dividing the total value of exports to third countries plus the value of imports from third countries by the total market size for the Community, with market size defined as annual turnover plus total imports from third countries. These figures are available at the 4 digit sectoral level from the EU Commissions Impact Assessment Report.[19] Following the methodology suggested by the Commission for the TI measure we also compute sectoral import and export intensity figures.

Note that the VaS and TI measures used by the Commission are very similar to those used by Sato et al. (2007) to evaluate the impacts of the EU ETS on competitiveness, and in some cases survival, of a subset of UK industries thought to be at risk of significant job losses and carbon leakage. While their study considers trade intensities of the given sectors by looking at both UK-intra EU and UK-extra EU trade flows, the Commission (and our study) treat the EU as a block and focus on trade between the EU and the rest of the world.

[15] The fact that these rules are to be harmonised at the EU level is already a major step in the right direction, as allocation plans were designed in the past at the Member State level and submitted to the Commission for acceptance.

[16] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2003L0087:20090625:EN:PDF

[17] Another question relates to what should be the basis of the harmonised rules for allocating EUAs. Article 10a of Directive 2003/87/EC specifies that ex-ante benchmarks calculated for products rather than for inputs shall be used so that incentives to reduce emissions and maximize energy efficiency savings remain aligned with the over-arching missions of the EU ETS to drive the transformation of the EU economy towards a low-carbon future.

[18] It is worth noting that the electricity generation sector – the largest sectors in the EU ETS by magnitude of emissions – is not eligible for free allocation and will have to purchase EUAs by auction.

[19] http://ec.europa.eu/environment/climat/emission/pdf/proportionate_ia_%20leakage_list16sep.pdf

6.3 Vulnerability analysis

The Commission uses a combination of thresholds for VaS and TI to determine if a sector is at risk of carbon leakage and hence are eligible for free permit allocation. Sectors are considered at significant risk of carbon leakage if their VaS is greater than 5% and their TI is greater than 10%, or either VaS or TI is greater than 30%. For the purposes of the subsequent analysis, we subdivide eligible sectors accordingly into three disjoint groups

A very high carbon intensity: VaS>30%

B high trade intensity and low to moderately high carbon intensity: VaS≤30% & TI>30%

C moderately high carbon and trade intensity: 5%<VaS≤30% & 10%<TI≤30%

Figure 19 illustrates the definition of these groups by plotting the location of 3-digit sectors in a diagram with VaS on the vertical and TI on the horizontal axis. This shows that a large number of sectors are in group B, receiving an exemption only on the basis of having a trade intensity higher than 30%. In panel a of Figure 20 we examine the relative size of the exemption groups in more detail by plotting the relative shares in terms of the number of firms, employment and CO_2 emissions. In all cases group B turns out to be the largest group with a share of at least 30%.

We are using two alternative measures for CO_2 emissions, derived either from the EU ETS registry known as the Community Independent Transaction Log (CITL) or from on the basis of the figures reported in the EU Commission' EU ETS Impact Assessment (IA)[20]. A key difference between the two measures concerns the share of CO_2 emissions that is not exempt from auctioning. Our figure based on the CITL would suggest that this share is 12% whereas the CO_2 figures from the IA suggest a share of about 40%. It is likely that the true value lies somewhere in between these figures. The IA figures include both emissions from sectors and firms that are regulated by the EU ETS and those that are not. As inclusion in EU ETS depends on the energy capacity of an installation, non-regulated sectors are likely to fall into the non-exempt category and therefore overestimate that group's emissions share.[21] On the other hand, our CO_2 measure based on the CITL is likely to be underestimating the non-exempt group. This is because in order to assign firms in the CITL to exemption groups we first have to identify the 4-digit NACE industrial sector they belong to as this information is not part of the current version of the CITL. For that purpose we match the CITL data with firm level information from the Bureau van Dijk ORBIS database.[22] Depending on the country this has to be done using string matching which implies that not all firms in the CITL will necessarily be matched.[23] It is likely that for larger firms the match is better, which would imply that a matched firm is more likely to be

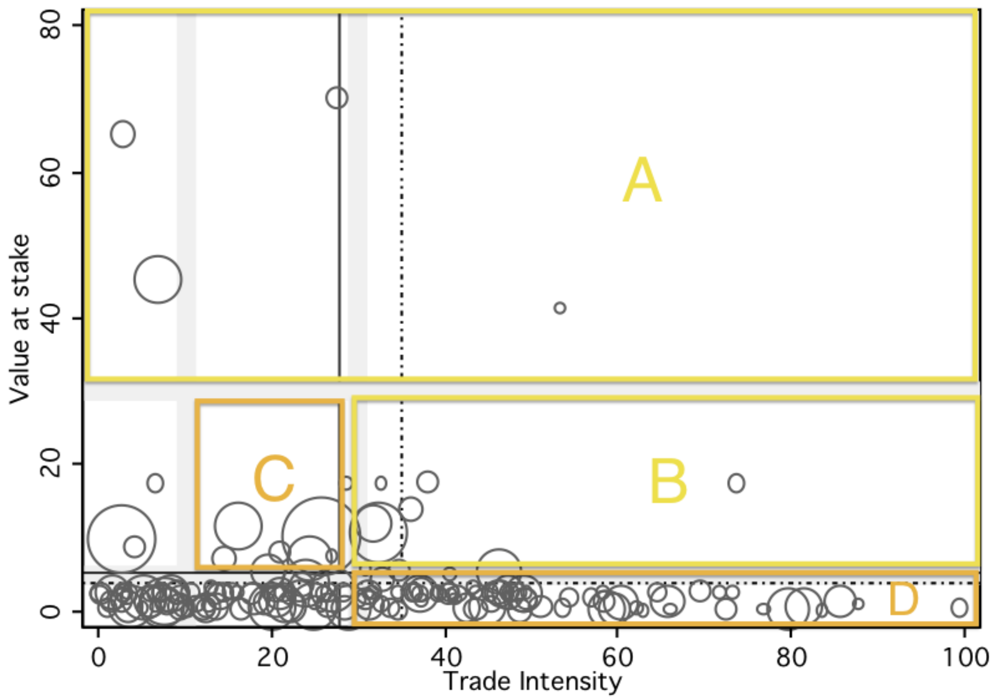
[20] see Footnote 19

[21] Installations with a capacity of more than 20MW are regulated under the EU ETS.

[22] The EU Commission uses a similar approach when computing their figures in the Impact Assessment. They augment the CITL figures with other information on sectoral CO_2 emissions, thereby including emissions from sources not regulated under the EU ETS.

[23] Moreover, at this point we have created a mapping from CITL to ORBIS only for firms located in the countries where we conducted our management interviews.

Figure 19: Value at Stake and Trade Intensity in our sample



Notes: The figure shows a scatter plot at the 3-digit (NACE 1.1) industry level based on our interview sample. The size of the circles is proportional to the number of firms in a given 4-digit industry. The figure reveals the position of various sectors in the plane spanned by the two criteria proposed to exempt sectors from auctioning of permits and allocate them for free.

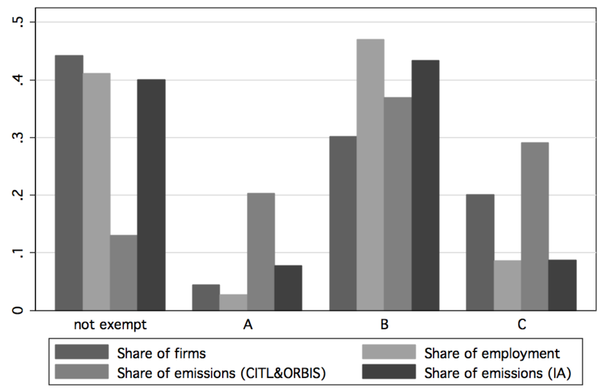
located in one of the exempt categories, thus underestimating the non-exempt share. Panel b of Figure 20 repeats the exercise for the sample of firms which are included in our interview sample. This leads to very similar distributions as for the ORBIS-matched CITL sample, confirming that our interview sample is representative of the underlying population. In panel b we report both CO_2 figures based on actual emissions as well as permits allocated in 2008. As permits were by and large allocated on the basis of emissions this leads to very similar results.[24]

We wish to evaluate whether or not the Commission's criteria (TI and VaS) are indeed good proxies to capture the risk of carbon leakage or job losses. Our survey question on the "Future impact of climate change policies" (FI) lends itself to this exercise as it provides a direct measure of what the Commission can only approximate by using the TI and VaS criteria (cf. question 12a in appendix B). Firms scored high on this question if they could convince the interviewer that future efforts to put a price on carbon will lead to a contraction or complete closure of the firm's activities at the current location. Thus, if the criteria of the Commission are accurate one would expect them to be positively correlated with the FI variable. This test can be implemented in a regression of the FI variable on these criteria as well as other explanatory variables:

[24] We cannot report CO_2 emissions based on on EU Impact assessment data as these are only available at the sectoral, not the firm level.

Figure 20: The relative size of exemption groups

(a) Among all ETS firms in the six countries under study



(b) Among interviewed ETS firms

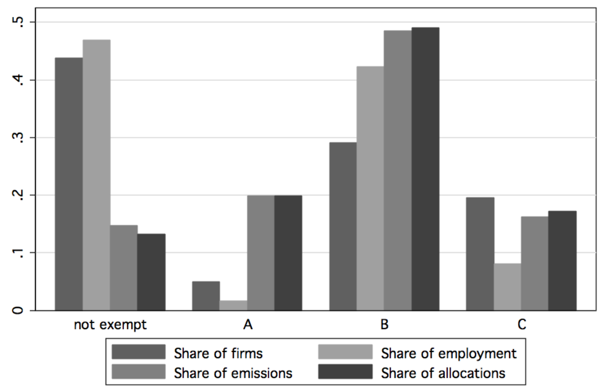


Table 12: Correlations between "Future Impact" score and other variables

	(1)	(2)
	Correlation with Future Impact of Climate Change Policy Score	
Variables	**All**	**ETS firms only**
1 Cost pass through	-0.107***	-0.109*
2 Non EU Competitors Share	0.141***	0.135**
3 Non EU Competitors	0.02	-0.06
4 Competitors	0.02	-0.14
5 Share of sales exported to non EU	-0.08	-0.03
6 Customers are mainly other Businesses	0.105***	0.166***
7 Multinationals	0.01	-0.06
8 CC Related Products	0.01	0.01
9 CC Related Product Innovation	-0.02	-0.04
10 CC Related Process Innovation	0.132***	0.108*
11 Energy Monitoring	0.169***	0.179***
12 Greenhouse Gas Monitoring	0.168***	0.1
13 Energy Consumption Targets	0.074*	0
14 Greenhouse Gas Targets	0.207***	0.160***
15 Enforcement of Targets	0.120***	0.1
16 Employment	0.02	-0.06
17 Firm is in ETS	0.623***	

$$FI_i = \beta_{TI} TI_i + \beta_{VaS} VaS_i + \mathbf{x_i'} \beta_\mathbf{x} + \varepsilon_i \tag{2}$$

where FI_i is the Future Impact score of firm i from our survey and $\mathbf{x}_i$ is a vector of other control variables.

Before estimating this equation, we first conduct a series of internal consistency checks on the FI variable. Specifically, we examine whether FI correlates in expected ways with other survey variables that, while also capturing vulnerability to policy, are arguably less subjective than FI. An example of such variables are those that measure the degree of international competition. Table 12 displays pairwise correlations between the FI score and other survey variables. The first row shows that a high cost pass-through – reflecting the better ability of firms to pass the cost impact on to its consumers – is associated with lower FI scores. Rows 2 to 4 show correlations with different variables representing competition from firms located outside the EU. Interestingly, it is only the share of EU external competitors in overall competitors that is positively associated with FI at a statistically significant level. This confirms the intuition that carbon leakage should only be a relevant concern for firms with competition from outside the EU. Rows 11 to 15 demonstrate that scores given for the "measures" questions are positively correlated with a high FI score in a statistically significant fashion. This is plausible as one would expect that firms affected more by climate change policies are more pro-active at pursuing measures to reduce their GHG intensity and permit liability. A similar argument applies for climate change related process innovation which is found to be positively correlated with FI in row 10. Finally, row 17 reveals that firms in the EU ETS report a higher expected impact of future

Table 13: Regressions of “Future Impact” score on TI and VaS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	**Future Impact of Climate Change Policy Score (FI)**						
Sectoral Trade Intensity (TI)	-0.015		0.053		0.063	0.036	0.425*
	(0.097)		(0.128)		(0.101)	(0.107)	(0.254)
Sectoral Value at Stake (VaS)		0.263***	0.525**	0.256***	0.322***	0.541***	0.023
		(0.059)	(0.230)	(0.059)	(0.095)	(0.127)	(0.122)
TI X TI			0.016				
			(0.084)				
VaS X VaS			-0.049				
			(0.040)				
TI X VaS			0.039		0.071	0.103	-0.003
			(0.102)		(0.090)	(0.135)	(0.110)
Import Intensity				0.078			
				(0.135)			
Export Intensity				-0.055			
				(0.132)			
Noise Controls	yes	yes	yes	yes	yes	yes	yes
Weights	no	no	no	no	no	EMP	CO2
Observations	363	363	363	363	363	363	363

climate change policy. The second column in Table 12 reports the same correlation coefficients based on a sample of EU ETS firms only. Although the statistical significance of the correlation is lower in some cases, the main qualitative results remain the same.

Having verified that the FI score is indeed a good measure of a firm’s vulnerability, we turn to the results of the regression equation 2, displayed in Table 13. Columns 1 and 2 display the results of univariate regressions of TI and VaS. The estimated coefficient on VaS indicates a positive and statistically significant correlation with FI whereas the coefficient on TI is not statistically significant. This finding holds up in column 3 where both measures are included simultaneously, as well as quadratic polynomial terms to explore if non-linearities matter. For instance, TI could matter for very high values of TI only, or only in interaction with high carbon intensity. There is no evidence of such effects. In column 4 we split the TI measure into export and import intensity. This yields a negative point estimate for import intensity and a positive point estimate for export intensity, neither of which is statistically significant. Columns 5 through 7 report the results from a specification with an interaction term and for different weights. Results from the unweighted regression are reported in column 5, employment weights are used in column 6 and weights based on CO_2 in column 7. Employment weights do not change the qualitative findings but give rise to a larger estimate for the impact on carbon intensity. This suggests that in particular larger firms with higher carbon intensity are relatively more at risk of downsizing. In contrast, CO_2 weights produce an insignificant coefficient on VaS and a weakly significant coefficient on TI. Driving this result must be a few very large emitters of carbon that tend to be more trade than carbon intensive. In sum, the results from regression equation 2 indicate that trade intensity is generally not a good indicator to measure the risk of downsizing or out-sourcing whereas carbon intensity is.

Table 14: Regressions of "Future Impact" score on sector groupings defined by the EU Commission

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent Variable	**Future Impact of Climate Change Policy Score (FI)**				**FI>2**		
Vas>30 (A)	1.191***	1.178***	1.868***	0.008	0.334***	0.592***	-0.111
	(0.297)	(0.305)	(0.460)	(0.412)	(0.098)	(0.120)	(0.177)
TI>30 & VaS>5 & VaS<30 (B)	0.323						
	(0.285)						
TI<30 & TI>10 & VaS>5 & VaS<30 (C)	0.140	0.154	0.439**	-0.945*	0.051	0.159	-0.313**
	(0.246)	(0.242)	(0.202)	(0.503)	(0.093)	(0.098)	(0.146)
B & VaS>5		0.727**	1.188***	0.769**	0.240**	0.512***	0.290**
		(0.365)	(0.303)	(0.383)	(0.109)	(0.140)	(0.137)
B & VaS<5		0.015	-0.166	-0.748	0.013	-0.011	-0.188
		(0.254)	(0.308)	(0.520)	(0.090)	(0.120)	(0.210)
Noise Controls	yes	yes	yes	yes	yes	yes	yes
Weights	no	no	EMP	CO2	no	EMP	CO2
Observations	363	363	363	363	363	363	363

It could be argued that the continuous relationship between FI, VaS and TI imposed in equation 2 is not appropriate for the Commission's threshold based approach. We thus modify the estimation equation to include a set of dummy variables representing the exemption categories (A,B,C) defined above and in Figure 19 instead of the continuous variables. The reference category in the new regression is thus given by firms that are not exempt from auctioning. Table 14 reports the results. Column 1 shows that only the highly carbon intensive group (A) has an average FI score that is significantly higher than the group without exemption – exactly how high is shown in Figure 21 which plots average values for the different exempted groups along with 95% confidence bands. Panel a corresponds to column 1 from Table 14 and shows that the average score for group A is still well below 3 whereas the upper boundary of the confidence bands just about reaches above 3.[25] Thus even in group A there is no dramatically high risk of downsizing or outsourcing for the average firm.

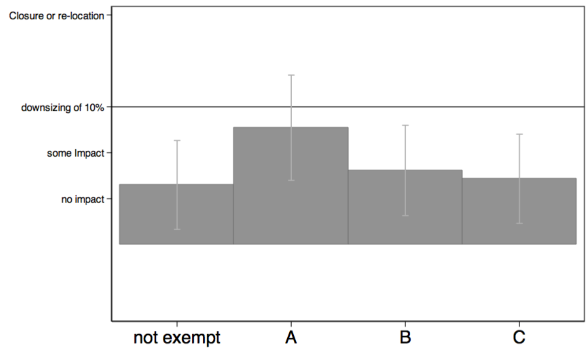
Based on these results one could thus conclude that handing out permits for free is justified only for firms in group A whereas sectors in groups B or C should all be subject to auctioning. However, group B is rather large and heterogeneous as it is comprised of a large fraction of firms and sectors with very low carbon intensity (VaS<5%) but also of a minority of firms with intermediate energy intensity (VaS>5 & VaS<30) (see Figure 19). In order to account for such heterogeneity, we further subdivide group B into a group with low carbon intensity and one with intermediate carbon intensity. Figure 22 plots the fraction of firms, employment and CO_2 emissions that fall into those categories. It turns out that while group B&VaS<5 accounts for more firms and employment, a much larger share of emissions – according to our measure of CO_2 emissions based on the CITL-ORBIS match – originates from group B&VaS>5. When using the impact assessment CO_2 figures it appears that the share of emissions in group B & VaS<5 is larger however.

Column 2 of Table 14 reports the regression results when these separate groups are included along with the groups A and C defined earlier. We find that the moderately carbon intensive part of group

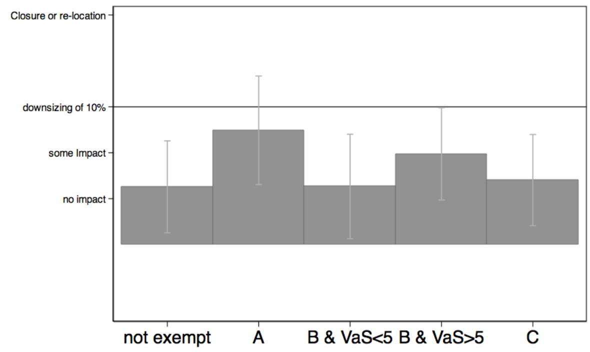
[25]Recall that the survey grid suggests "Significant reduction (>10%) in production/employment due to outsourcing" for a value of 3. See the full questionnaire in appendix B.

Figure 21: Impact measures across "at risk" groups

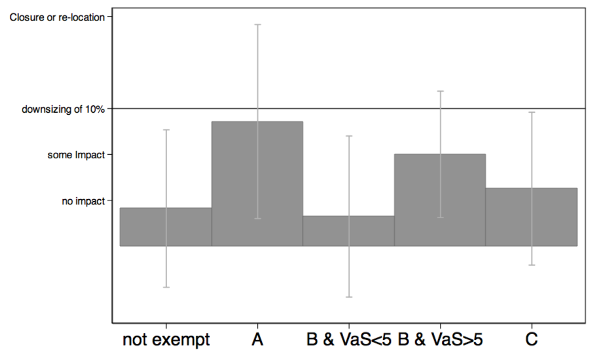
(a) Three exemption groups



(b) Four exemption groups



(c) Employment weights



(d) CO_2 weights

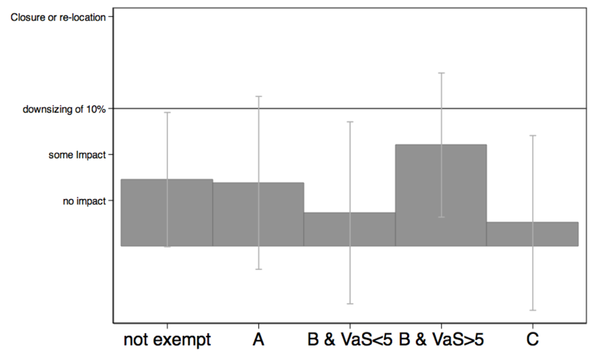
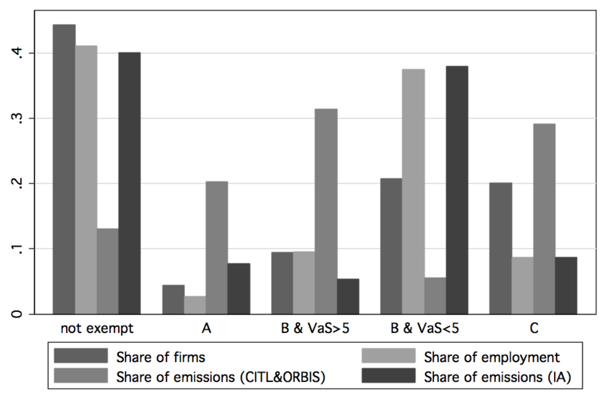


Figure 22: Subdividing the high trade intensity category



B has indeed a signficantly higher downsizing risk than the reference group. The absolute average FI score in that group is plotted in panel b of Figure 21. As is the case for group A, the risk of downsizing or closure does not attain dramatically high levels for the average firm. Columns 3 and 4 of Table 14 report results from employment and CO_2-weighted versions of the regression in column 2. The employment weighted regression in Column 3 confirms the results reported in column 2. That is, the effects for both group A and group B&VaS<5 become stronger, suggesting that some of the larger firms in terms of employment in those categories are more at risk. We now obtain a significantly positive coefficient for group C. In absolute values, this group's FI score is still far below the threshold of 3 points. Using CO_2 weights in column 4 yields an insignificant coefficient for group A while the coefficient for group B&VaS>5 remains significant. This echoes the earlier finding in Column 7 of Table 13, namely that there are a number of large emitters of CO_2 with some downsizing risk that have moderate carbon intensity but a high trade intensity.[26] Figure 21c reports the implied average scores all of which remain below 3. In sum, the changes in the regression coefficients when using different weights emphasize that there is substantial heterogeneity with respect to downsizing risk even within the more differentiated grouping into 4 exemption categories. This is illustrated as well by Figure 23 which shows the raw distribution of FI scores within each of the groups defined above. The reader should note that in every group there is a fraction of firms with a score of 3 or more.

In order to further distinguish between a slight increase in risk and a serious downsizing impact, we modify the regressions to accommodate the binary event that a firm has a score of 2 or larger. This approach is implemented as a Probit regression. The results are reported in columns 5 to 7 of Table 14 and confirm that only for groups A and B&VaS>5 there is some risk of downsizing to speak of.

On balance, the evidence presented in this section gives rise to three conclusions. First, the TI criterion proposed by the EU Commission is only of very limited value in proxying a sector's actual downsizing risk. Second, looking more closely at the different groups defined by thresholds given by the Commission we find that downsizing is an issue only for sectors with very high carbon intensity (VaS>30%) and for sectors with very high trade *and* moderately high carbon intensity. Third, this is suggestive of how the current Commission proposals could be improved with minimal changes to current definitions and criteria. If exemption was granted only to groups A and B&VaS>5 but not to group C, the amount of overall emission permits that could be auctioned would increase by at least 35 percentage points, from roughly 40% to 60% or more based on the shares reported in Figure 22 and depending on which CO_2 measure is used. While having a minimal impact on leakage risk, such a modification to the rules would generate additional revenue for governments that could be used to directly fund infrastructure or R&D relevant for GHG emissions reductions as well as to compensate lower income groups for the likely regressiveness of higher energy prices due to carbon pricing. We derive an estimate of savings for government using the following formula:

$$\Delta Revenue = (s_C + s_{B\&VaS<5\%}) \times CO2_{Manufacturing} \times P_{CO_2}$$

[26]Closer inspection reveals that this result is primarily driven by NACE 1.1. sector 2710 Manufacture of basic iron and steel and of ferro-alloys. See Table 15 on page 56 for a classification of sectors.

The formula multiplies the fraction of CO_2 emissions of industries in categories C and B&VaS<5% by an estimate of total manufacturing emissions times a permit price in the EU ETS. To estimate manufacturing emissions we subtract emissions from the CITL combustion sector from the total sum of emissions reported in the CITL. The rationale is that the combustion sector primarily (though not exclusively) includes power plants. Excluding the entire combustion sector should thus lead to a conservative estimate of total manufacturing emissions. For the permit price we assume €30 in line with the assumptions made in the Commission's Impact Asessment. This leads to an estimate of €7 billion when using the emission shares based on the CITL-ORBIS match and €9.4 billion when using shares based on the IA figures.

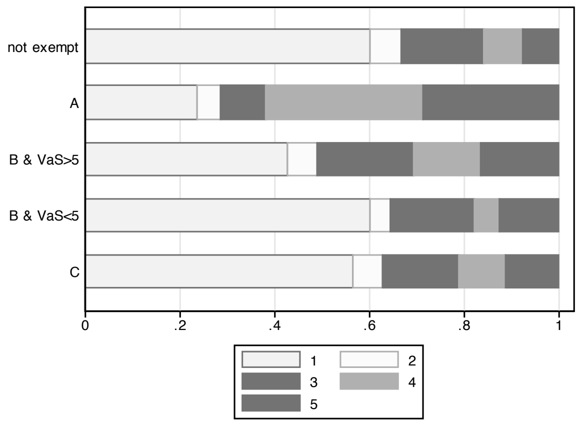
To conclude this section it is worthwhile to point out that even after splitting group B in two there still remains much heterogeneity in the policy impact within the groups defined by the various policy thresholds. Figure 23 illustrates this by reporting various distributions of the FI score for the different groups. We see that in each of the groups defined on the basis of the VaS and TI thresholds there are firms that report high FI scores and those that report no impact of future policy at all. This suggests that a lot might be gained by a more fundamental overhaul of the criteria that exempt firms from auctioning. For example it might be possible that more refined criteria based on trade could perform better. As we have seen in Table 13, splitting the trade criterion into exports and imports suggests that import intensity is somewhat more closely related to FI. A further refinement could be achieved by distinguishing between imports from other Annex I countries and emerging economies with less Climate Change related regulation such as China. We leave such refinements as a topic for future research. Regardless of how well sector-level criteria for free allocation are defined, however, the efficiency of these allocations could be improved if vulnerable firms were targeted directly instead of targeting the entire industry. This idea will be explored in detail in the next section.

7 Improving the permit allocation process

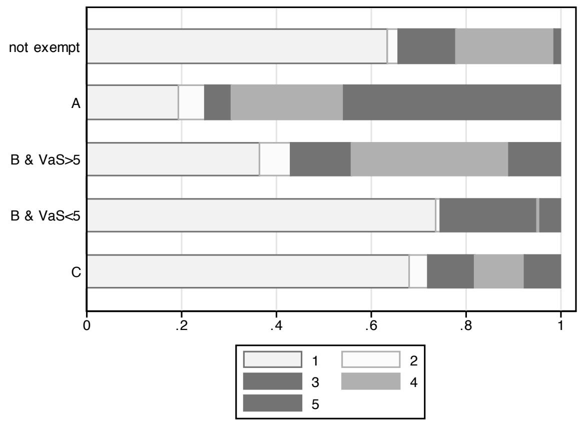
The previous section showed that most of the sectors exempt from auctioning under the latest plans of the EU Commission do not appear to be at increased risk of carbon leakage or threatened in their competitiveness. At the same time we saw that there is a great deal of heterogeneity in the vulnerability (FI) score. In fact, even within the group that is currently *not* exempt from auctioning, there are a number firms with rather high impact scores (see Figure 23). Conversely, in sectors that exhibited higher vulnerability on average, there are many firms that reported no impact of climate change policy at all. This suggests that allocating permits on a sectoral basis is too crude and that support to vulnerable firms could be provided - at least in principle - in a more efficient way. In this section we develop general principles of an efficient permit allocation at the firm level and examine by how much the optimal allocation improves upon the one envisioned by the EU Commission. In regards to the practical implementation of our scheme to improve permit allocation, we explore a strategy based on observable and objectively measurable firm characteristics.

Figure 23: Distribution of the FI score

(a) Shares in number of firms



(b) Shares in employment



(c) Shares in CO_2 emissions

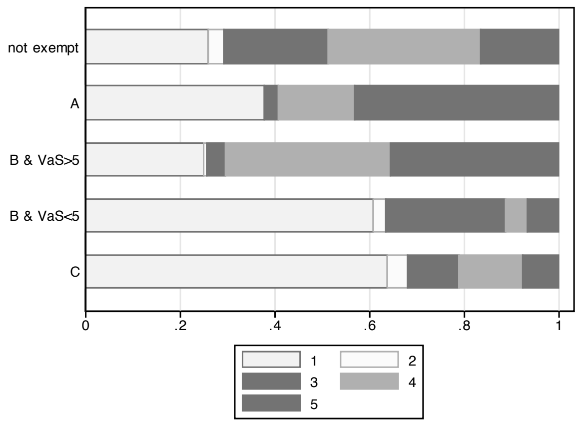


Table 15: Sector classification

Sector	NACE Sectors	CITL 2008 sectors
Food/Tobacco	15, 16	
Textile/Leather	17, 18, 19	
Wood&Paper	20,21	9
Publishing	22	
Fuels	23	2,3
Chemical&Plastic	24, 25	
Glass	261	7
Ceramics	262	8
Cement	264, 265,266	6
Other Minerals	267, 268	
Iron&Stee	271, 272, 273, 275	5
OtherBasicMetals	274	
Fabricated Metals	28	
Machinery&Optics	29, 30, 31,33	
TVCommunication	32	
Vehicles	34,35	
Furniture/nec	36	

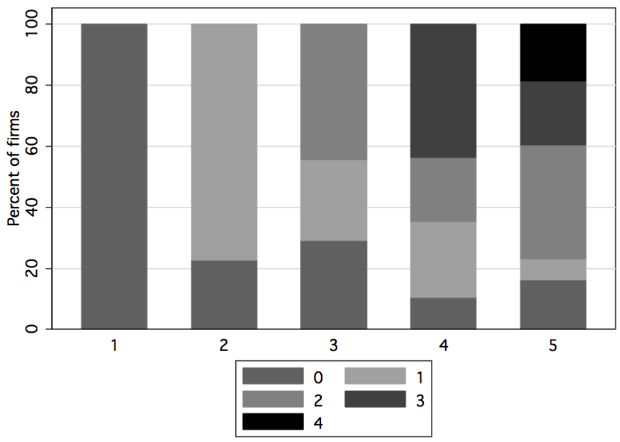
Notes: NACE Sectors refer to NACE 1.1

7.1 Towards an optimal permit allocation

To derive an optimal permit allocation we first need to define a criterion for comparing different allocations. The legislation behind the EU ETS stipulates that the system should be designed so as to avoid carbon leakage and minimise the risk to domestic jobs and competitiveness. As shown in Appendix A, this can be translated into an objective function for governments which depends on each firm's likelihood of exit multiplied by its size in terms of either employment or CO_2 emissions, or both. Much of the debate on emissions suggests that firms that are most at risk should receive more permits. However, as we show more formally in Appendix A, in order to allocate a given amount of permits most efficiently we need to equalise the marginal contributions of each firm to the government's objective function. For instance, there might be firms that are at a heightened risk of closing down or moving abroad because of climate change policy. Giving them additional permits for free, however, has little effect on this decision if the leakage vulnerability is driven by effects of carbon pricing on electricity prices or via upstream or downstream linkages. Clearly, the regulator's criterion for allocating free permits across firms should be based on the *marginal* impact of a free permit, i.e. the reduction in leakage risk achieved by the last free permit.

But how can the marginal impact of free permits on a firm's behaviour be determined? We are basing our assessment here again on the interviews with managers of EU manufacturing firms. We asked them not only to assess the likely future impact of climate change policy on their businesses but also whether this impact would be different if permits were allocated for free, rather than auctioned.

Figure 24: Impact of free allocation on the downsizing score



Notes: Grouping firms by their vulnerability score the bars shows by how much the vulnerability score would drop if a firm receives 80

Figure 24 illustrates the information we derive from this question. For every vulnerability score it reports the distribution of the change in vulnerability implied by a free allocation corresponding to 80% of a company's emissions. This shows for example, that almost 20% of the firms that responded that climate change policies were likely to force them to close down or re-locate also reported that receiving free permits would have no impact on this decision. On the other hand, for almost 20% of firms with a top score of 5, free allocation of permits would reduce the impact by 4 score points; implying that there would be no downsizing due to climate change policies.

7.2 Calculating marginal leakage probabilities

We translate the vulnerability scores into leakage risk probabilities as follows: A score of 5 is interpreted as a 99% probability that the firm will exit. The scores of 3 and 1 are associated with exit probabilities of 10% and 0% respectively. For scores 4 and 2 we simply interpolate between these numbers, as is shown in Table 16. We then assume a logistic probability model to describe the impact of free allocations on exit probabilities:

$$P_i(A_i) = \frac{1}{1+\exp(\beta_{0i}+\beta_{1i}A_i)}$$

Thus, the probability of exiting is a declining function of free permits A_i bounded between 0 and 1. Figure 25 illustrates this. We identify the parameters in this function, β_{0i} and β_{1i}, from the response to our questions regarding vulnerability with no permits and 80% free permits; i.e.

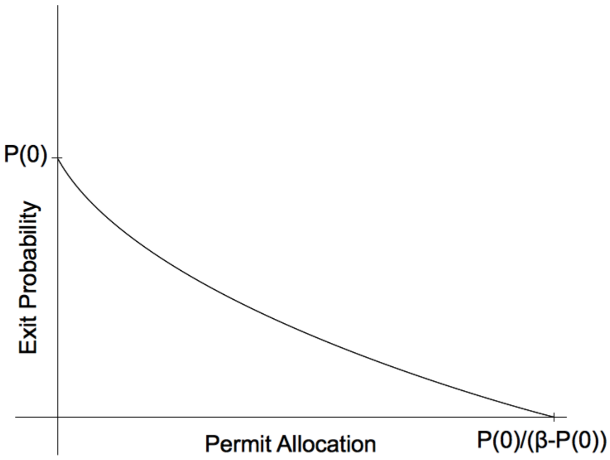
$$\beta_{0i} = \ln\left(\frac{1}{P_i(0)} - 1\right) \text{ and } \beta_{1i} = \left[\ln\left(\frac{1}{P_i(80\% \cdot CO_{2i})} - 1\right) - \beta_{0i}\right](80\% \cdot CO_{2i})^{-1}$$

The marginal impact on firm exit of an additional unit of free permits for firm i is given by

Table 16: Mapping vulnerability scores into exit probabilities

Vulnerability Score	Exit probability
5	99%
4	55%
3	10%
2	5%
1	0.01%

Figure 25: The shape of the exit probability function

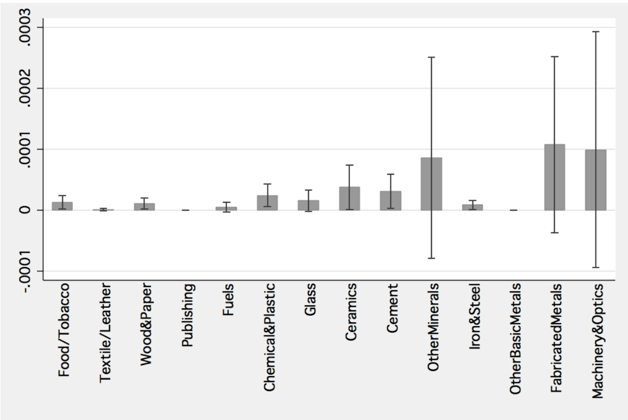


$$\frac{\partial P_i(A_i)}{\partial A_i} = \beta_{1i} \frac{-\exp(\beta_{0i} + \beta_{1i} A_i)}{(1 + \exp(\beta_{0i} + \beta_{1i} A_i))^2} \tag{3}$$

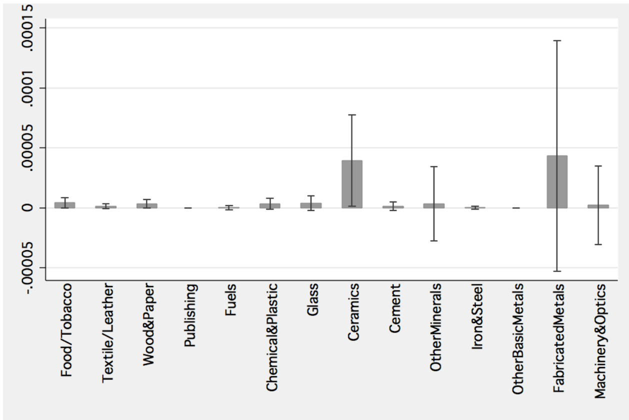
Note that this is always negative as allocating more permits for free can only reduce the exit probability. If a firm has no permits allocated yet, the marginal impact of the first unit is equal to $-\beta_i \frac{\exp(\beta_{0i})}{1+\exp(\beta_{0i})}$. Governments should allocate free permits first to firms where the absolute value of this marginal probability is highest. Figure 26 reports averages of the absolute value of the marginal impact at zero allocation across sectors. In panel (a) we see the marginal impact is highest in Other Minerals, Fabricated Metals, and Machinery & Optics. Panels (b) and (c) show averages weighted with firms' CO_2 emissions and employment, respectively. This highlights that a regulator concerned with either CO_2 leakage or employment, rather than firm exit as such, might adopt a different strategy. While Fabricated Metals keeps exhibiting high marginal impact in either case, Ceramics emerges as another sector worth supporting if CO_2 leakage is the prime concern. However, one should point out that, particularly for the CO_2-weighted case there appears to be substantial within sector heterogeneity, as indicated by the confidence bands. We therefore explore in the next sub-section how permits can be allocated more efficiently when these firm-level variations are more explicitly taken into account.

Figure 26: The marginal impact on exit probabilities

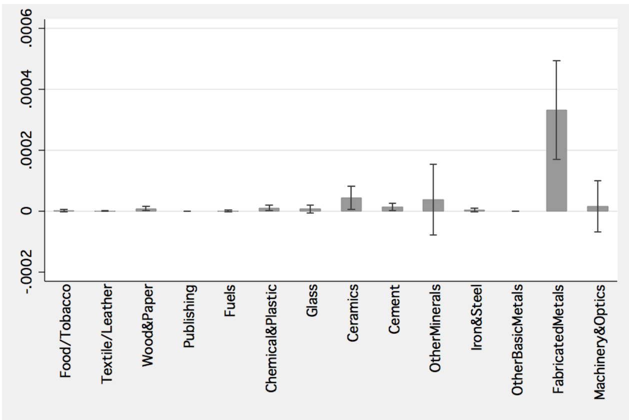
(a) Averages across firms



(b) CO_2 weighted averages



(c) Employment weighted Averages



7.3 Optimal permit allocations

This section shows how a given reduction in the risk of carbon leakage or job loss can be achieved with a minimal amount of permits. We also show how a given amount of permits can be allocated in a way that minimises leakage and jobs risks to levels far below that of current allocation proposals. The key idea is to allocate free permits only to firms where the marginal benefits of permit allocation are highest, thereby equalising marginal benefits.

In more formal terms we show results from optimising two types of objective functions:

1. Minimising allocated permits subject to a constraint on the risk of job loss or carbon leakage:

$$\min_{A_i} \sum_i A_i \text{ s.t. } \sum_i P_i(A_i) \times (\theta Employment_i + (1-\theta) CO_{2i}) = \tilde{O} \tag{4}$$

2. Minimising the risk of job loss and leakage subject to a constraint on freely allocated permits:

$$\min_{A_i} \sum_i P_i(A_i) \times (\theta Employment_i + (1-\theta) CO_{2i}) \text{ s.t. } \sum_i A_i = \tilde{A} \tag{5}$$

where θ measures the extent the government values job loss concern relative to carbon leakage concerns. In our results below we consider two extreme cases, namely that the government is either concerned about jobs only ($\theta = 1$) or about leakage only ($\theta = 0$).

Both programs require that all firms receiving free permits should have equal marginal impacts.[27] Since the marginal exit probabilities are non-linear and non monotonic in allocated permits, solving the program is not trivial. A detailed description of the solution algorithm is relegated to the appendix.[28]

Depending on the objective function and arguments to optimise we can derive a series of different optimal allocations. In this section we compare eight different types of such allocations which are detailed in Table 17. Thus, we derive two optimal allocations by holding the risk to jobs constant relative to complete free allocation and the 2009 proposal but minimising allocated permits. We derive another two by holding the CO_2 leakage risk constant. Further, we derive four allocations that minimise the risk of job loss or carbon leakage and holding the amount of permits fixed at two different levels.

In Figure 27 we compare those with both, complete free allocation of all permits as well as with

[27] There may be corner solutions where firms might not receive any permits at all because the marginal impact of giving them just one permit is insufficient.

[28] We use current data on employment and CO_2. Strictly speaking we should use values conditional on a potentially higher future carbon price which we will address in future research. Using current values is however a useful and conservative benchmark.

Table 17: Various optimal allocations

Objective	Constraint	*Value for θ*	*Reference Allocation*: Complete Free Allocation	*Reference Allocation*: EU proposal from 2009
min free permits	Risk to jobs	***θ=1***	o.1	o.2
min free permits	CO2 leakage risk	***θ=0***	o.3	o.4
min job risk	Aggregate number of permits allocated for free	***θ=1***	a.1	a.2
min CO2 leakage risk	Aggregate number of permits allocated for free	***θ=0***	a.3	a.4

the allocation implied by the recent Commission proposals.[29] In panel a we start by looking at the share of jobs (in employment at ETS firms) that are at risk due to carbon pricing. The first bar of the figure shows that even with complete free allocation of permits there remains a residual risk to jobs of more than 4%. From the second bar we see however that this risk can be reduced to just above 3% by allocating permits more efficiently; i.e. giving some firms more permits than their current carbon emissions and others less. For the allocation underlying the second bar we minimise the risk to jobs ($\theta = 1$) whereas in the third bar we have minimised only carbon leakage risk ($\theta = 0$). Comparing the second and third bar we see that the outcome in terms of jobs is the same. Thus optimising according to any criterion is much better for either objective compared to not optimising at all. In bars 4 to 6 we compare the allocation implied by the new EU allocation rules (bar 4) with two different allocations where the same number of permits is distributed efficiently. A similar pattern emerges in that free permits given only to sectors the Commission deems at risk leads to relatively high impact on jobs of just above 10%. Allocating the same number of permits optimally in turn brings down the risk to the risk incurred when allocating *all* permits in an optimised way – slightly over 3%. Again, there is no difference between applying either the jobs or carbon criterion.

Panel b examines carbon leakage risks across the same six allocations. This leads to a qualitatively very similar pattern. It is worth pointing out, however, that in terms of the carbon risk the increase between bar 1 and 4 – i.e. between allocating all permits for free and according to the latest Commission proposals – is smaller than for the job risk. This is because this allocation does not at all take

[29] In doing so we do not (yet) account for benchmarking but rather assume that in a sector that is eligible for free permits all firms receive allocations corresponding to their current emissions.

into account differences in employment size between different firms but only differences in carbon emissions.

In panel c we compare the share of permits that are handed out for free restricting either job or carbon risk to various levels. By definition, under complete free allocation, 100% of permits are allocated for free (bar 1). The same risk to jobs as this allocation could be achieved with a vastly lower price tag of about 30% of freely allocated permits as bar 2 shows. To achieve the same risk in terms of carbon leakage is slightly cheaper (bar 3). As shown by bar 4, the new allocation rules by the EU Commission imply that a large fraction of permits will continue to be allocated for free, which is consistent with the findings of the previous section.[30] Again, what is achieved with those permits could be provided at a much lower cost. This is particular true for job risk which, according to bar 5, is very similar to the risk incurred when about 10% of permits are allocated for free. Maintaining carbon leakage risk fixed at the levels induced by the latest EU proposals, bar 6 shows that in the best case an allocation of about 20% of permits for free is required.

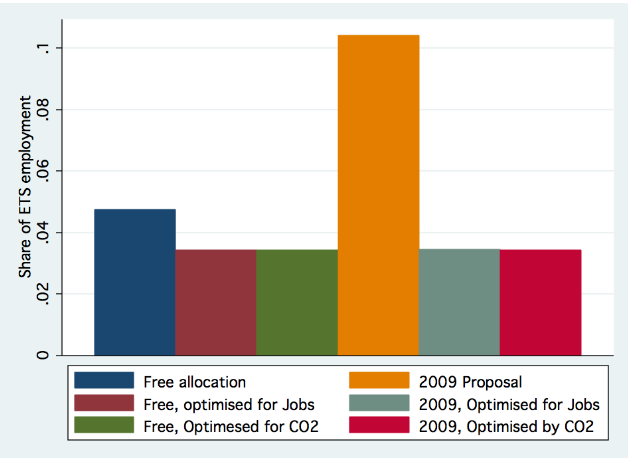
It is instructive to compare the various allocations with respect to their distribution effects. One way to think about free permits is as a subsidy firms receive. In Figure 28 we show histograms of the distribution of subsidies per job implied by the various allocations. For that purpose we follow the assumption of the EU Impact Assessment and assume a carbon price of €30 per tonne of CO_2. Consider first the distribution implied by complete free allocation shown in the top left of Figure 28. It is striking that some firms receive a rather large amount of money per employee. For example there are almost 20% of firms receiving between €10,000 and €100,000 per employee. A small fraction receives more than €100,000. This pattern is similar in the top right figure which reports the same statistics for the permit allocation implied by the 2009 proposals, with the difference that about 40% of firms receive no free permits. The histograms in the second row explore the distribution of free allocations that is needed to achieve the same risk to jobs as in row one, when allocating permits more efficiently. In very few cases would this justify allocating more than €100,000 per job to a firm. To achieve the same risk as the one implied by the 2009 proposals, few firms should receive more than €5000 per job. The last row shows the same figures when keeping CO_2 leakage risk to the same levels as in row 1. No firm would receive more than €100,000 per job.

The histograms in Figure 28 underline that giving out permits on the basis of current emissions can lead to excesses that are not supported by neither concern for jobs or carbon leakage. They also motivate that an improved allocation could potentially be achieved by taking into account not only the amount of emissions of a firm but also its size in terms of employment. We examine this idea in detail in the next section.

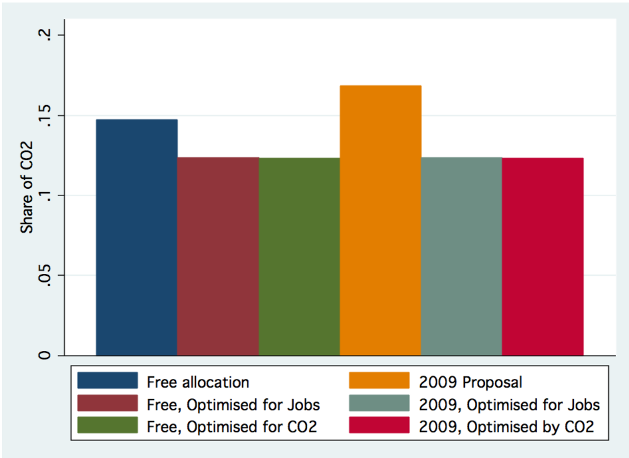
[30] The share of permits allocated for free is slightly larger than in Figure 20 in the previous section because in this section we consider the sample of firms that we interviewed and that can be matched to both ORBIS and CITL. In Figure 20 we considered the sample of CITL installations we could match to ORBIS which is a slightly larger sample.

Figure 27: Comparison of optimal and actual/planned allocations

(a) Share of jobs at risk



(b) Share of CO_2 at risk under various allocations



(c) Share of permits allocated for free

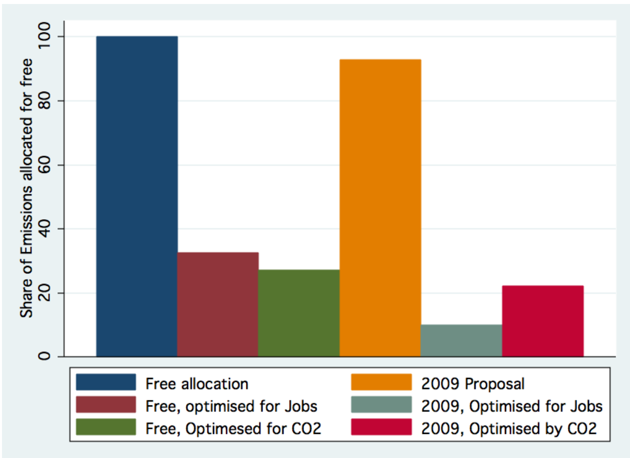
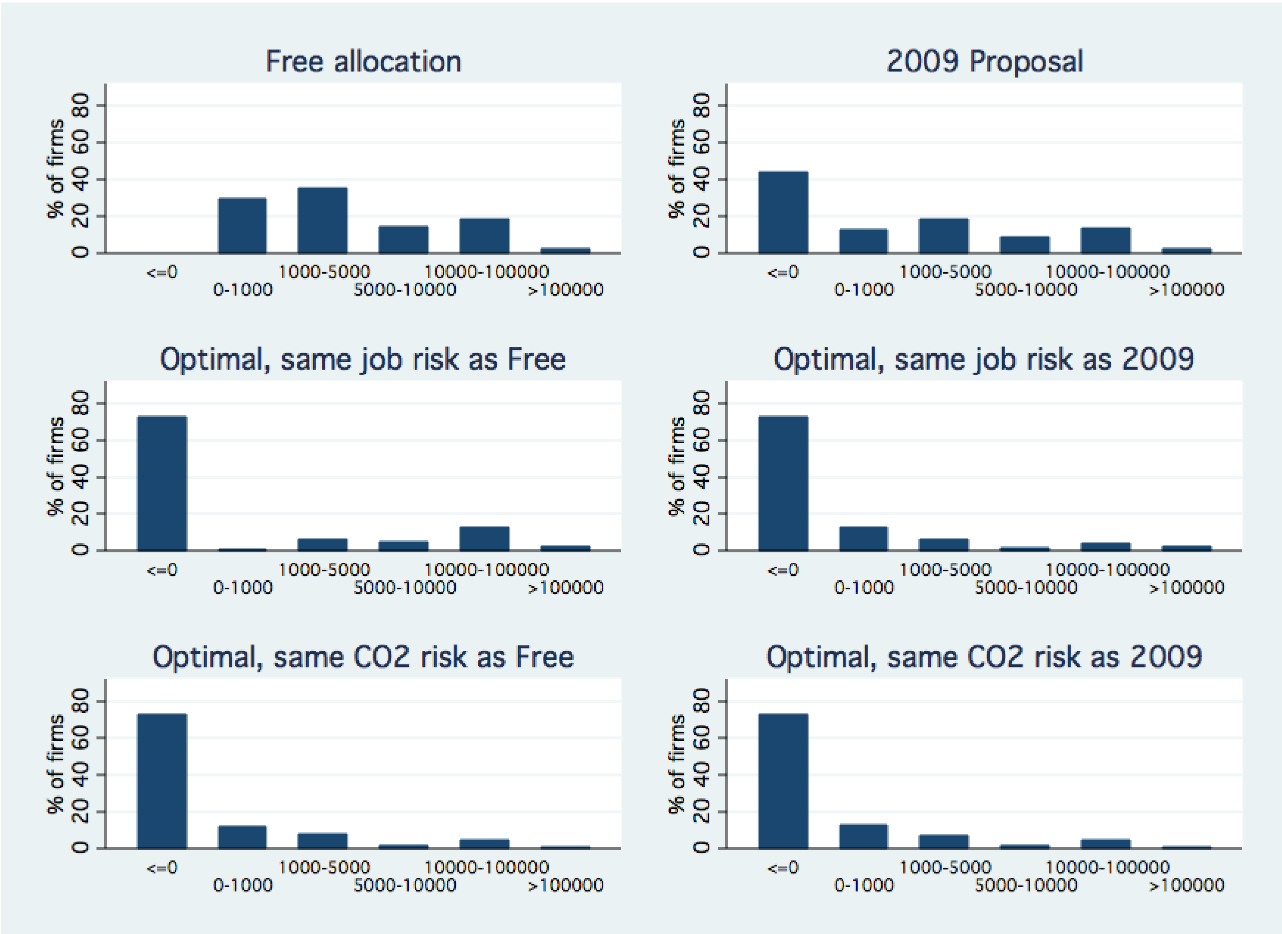


Figure 28: Implied subsidies per job



7.4 Feasible optimal permit allocation

In the computation of the optimal firm-level allocation of free permits we have used two scores from our interviews to estimate the (marginal) propensity to relocate. The practical implementation of our approach is complicated by the fact that it is difficult for the regulator to elicit truthful information on this from all firms in the EU ETS. Here we explore whether easily observable firm characteristics can be used as proxies to generate a similar allocation.

The approach we have in mind involves several steps. The first step taken by the regulator is to decide on the share of permits that will be handed out for free. For the purpose of this exercise, we assume this share to just under 30% which gives rise to the same risk of carbon leakage as allocating all permits for free following EU criteria (cf. the third bar in Figure 27c). The next step is to decide how to allocate this total amount across firms. We thus run a regression of the permit shares implied by our optimal allocations on firm level employment and CO_2 emissions as these are variables readily available to the Commission. The regression equation is given by

$$\frac{A_i^*}{\sum_i A_i^*} = \frac{1}{1+\exp\left(\beta_E \ln EMP_i + \beta_C \ln CO_{2i}\right)} + \varepsilon_i \tag{6}$$

where we use a logistic function to ensure that predictions from this regression are between 0 and 1. Finally, to obtain "feasible" firm level allocations, we multiply these shares with the total number of permits we wish to allocate.

Table 18 reports the parameter estimates from non-linear least-squares estimates of equation (6). Confirming intuition, the coefficient on employment is positive and significant (at the 10% level) in the regression proxying the allocation which is optimised to protect employment. In contrast, employment enters the regression in column 2 with a negative (though not significant) coefficient. The CO_2emission level enters both equations with positive and statistically signficant coefficients, indicating that both optimal allocation schemes assign more free permits to large emitters.

In Figure 29 we examine how well our proxy allocations perform when it comes to reducing risk to jobs (in panel a) and CO_2 leakage (in panel b). For ease of comparison, the first four bars report the leakage risk implied by each of the four allocations we consider. The last two bars in each figure refer to the two proxy allocations we consider; i.e. one which proxies for the optimal allocation based on job risk and one which proxies for the optimal allocation based on CO_2 risk. In both cases, the proxy allocations give rise to higher levels of risk than the respective optimal allocations (in bars 3 and 4). However, for job risk the proxy allocations remain below the risk levels implied by the 2009 proposal. For CO_2 they are somewhat above the 2009 levels. Note, however, that this is achieved while distributing just about one third of the amount of free permits stipulated by the 2009 proposal. Thus we conclude that basing permit allocation not only on CO_2 but also an index featuring employment could increase the efficiency of the allocation process considerably. Refining this index by considering further indicators and metrics at the disposal of the authorities will be a topic for future research.

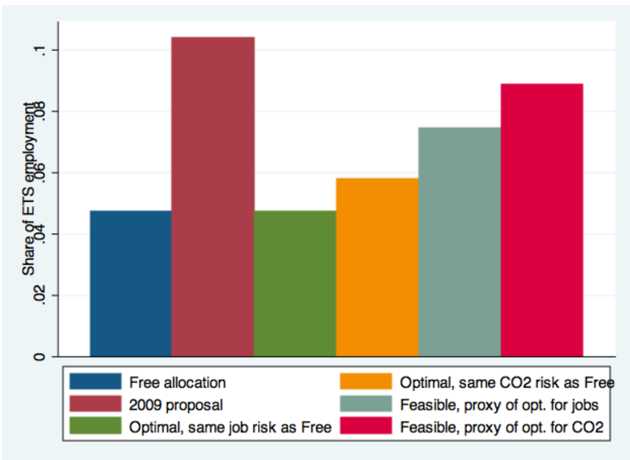
Table 18: Regressions of optimal allocations on employment and CO_2

	(1)	(2)
	Share of free permits optimised for	
	Jobs	CO_2
Employment	0.15*	-0.12
	(0.09)	(0.10)
CO2	0.40***	0.76***
	(0.07)	(0.12)
N	405	405
R^2	0.20	0.25

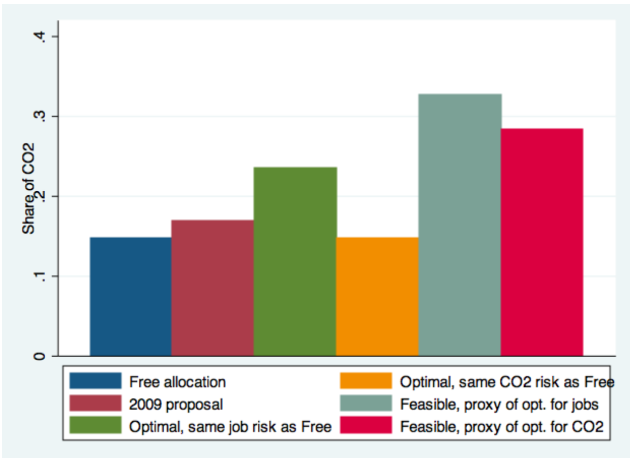
Notes: Non-linear least-squares regressions of equation (6).

Figure 29: Performance of proxy allocations

(a) Share of jobs at risk



(b) Share of CO_2 at risk



8 Conclusion

This study provides first results from a new evidence base for the evaluation of climate change policy in Europe. Using an innovative, bias-reducing method that emerged from research on management performance, we interviewed almost 800 European managers about aspects of firm performance and practices related to climate change. Focusing on the impact of the EU ETS on the competitiveness of firms, our study presents evidence that the criteria the European Commission has adopted in order to assess the negative effects of permit allocation on the competitiveness of firms and sectors are ill-defined. The likely consequences are sizeable windfall profits at the taxpayer's expense and welfare losses entailed by distortions to the market structure in the affected sectors. Hence there is a strong mandate for environmental regulation to mitigate such negative side effects.

To guide regulation, we have presented a normative model of permit allocation at the firm level. This model allows us to compute permit allocations that minimize the risk of job loss or the risk of carbon leakage for a given amount of free permits to be handed out. At the heart of our model is the insight that minimising exit risk requires that the *marginal* exit probabilities be equalised across firms. Simulations show that reallocating the permits earmarked for free distribution under EU plans in optimal ways can further reduce those risks by a substantial margin. Conversely, the risk levels implied by current EU plans can be achieved at a fraction of the cost in terms of foregone government revenue from permit auctions. To be sure, the practical implementation of the improved permit allocation scheme must be based on objectively measurable firm characteristics that are observable to the regulator.

The analysis in this paper can be extended in a number of directions in future research. First, a better understanding of firm behaviour on the allowance market is needed. This is worthwhile pursuing not only from an academic point-of-view but also because the cost-effectiveness of a cap-and-trade scheme crucially depends on firms equalising their marginal abatement cost to the permit price. If frictions prevent this adjustment, the price tag that comes with emissions trading might be higher than that of alternative regulatory instruments.

Another question to be answered in future research is the classical evaluation question: How effective has the EU ETS been at reducing greenhouse gas emissions. At the firm-level, abatement efforts can take different forms, such as changes in management practices, adoption of better technologies or more R&D into climate-friendly processes and products. Our interview dataset contains rich information on each of these channels.

Finally, improving the rules for allocating free permits is a pressing policy issue which can benefit tremendously from incorporating more economic wisdom. One way of achieving this objective is by refining the trade intensity criterion at the sector level in a way that better captures detrimental effects of foreign competition on competitiveness. Another way is to devise a feasible strategy for the regulator to implement optimal permit allocations at the firm level.

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A Optimal Permit Allocation

In a cap-and-trade scheme, the permit price is determined by the total cap and the marginal cost schedules of all regulated firms. Therefore, the way in which the total cap is allocated across firms has no bearing on marginal production decisions. However, the proportion of free permits a firm receives has a direct effect on firm profits and hence affects firm behaviour at the extensive margin. In Section 7 we proposed a normative framework that would allow for a more efficient allocation of free permits. This section details our solution algorithm. We start by proposing an algorithm for the problem described in equation (5); i.e. minimising the risk of either job loss or carbon leakage conditional on a limited amount of permits to be allocated for free. We then show that the reverse problem described in equation (4) can be solved with the same algortihm by slightly re-writing the problem.

To solve the problem in constrained optimisation program (5) we can minimise the Lagrangian function

$$\mathscr{L} = \sum_i P_i\left(A_i\right) \times D_i \text{ -}\lambda \left(\sum_i A_i - \tilde{A}\right) \tag{7}$$

where $\left(\theta Employment_i + (1-\theta)CO_{2i}\right)$ and λ is the Lagrange multiplier.

Given the assumptions on P_i, an additional free permit can always bring about a marginal reduction in the probability of relocation. Hence the shadow value of the permit, λ, is positive and the permit constraint holds with equality. The first-order conditions w.r.t. A_i are given by

$$P_i'\left(A_i\right) D_i \leq \lambda \qquad \forall i \tag{8}$$

The interpretation of inequality (8) is that the regulator seeks to equalize, in each firm, the expected gain in jobs and emission savings brought about by the last free permit allocated to the firm.[31]

Solution algorithm Because of the non-linearity and non-concavity of $P(\cdot)$ and the possibility of corner solutions, finding an analytical solution to the system of inequalities given by (8) is cumbersome. However, equation (7) is suggestive of how the problem can be solved numerically in an efficient manner. The structure of the problem is akin to a dynamic 'cake eating' problem (see e.g. Adda and Cooper, 2003), with the difference that the 'cake' is not distributed over time but among firms. For an arbitrary but fixed ordering of firms, we can write the problem in a recursive fashion using the value function

[31]To appreciate the emphasis on the marginal relocation probability, consider two firms with identical levels of employment and abatement but with different relocation probabilities. The first-order condition (8) implies that the government should not allocate most free permits to the firm with the highest propensity to relocate abroad but rather to the firm where these permits bring about the largest *reduction* in the relocation probability. Although this insight follows immediately from straightforward economic reasoning, it seems to have gotten lost in the heat of the public debate on free permit allocation.

$$V_i(C_i) = \max_{0 \leq A_i \leq C_i} \{-P_i(A_i) D_i + V_{i+1}(C_i - A_i)\} \quad (9)$$

where C_i is the amount of total permits left when reaching firm i in the sequence and $V_{i+1}(C_i - A_i)$ is the value of leaving the amount $C_i - A_i$ of permits to all remaining firms in the sequence.

To implement this computationally, we recursively solve equation (9) by working backwards from the last firm I in the sequence with value function

$$V_I(C_I) = -\Phi(-\Delta\pi_i - p^c C_I - \lambda)[\theta L_I(p^c) + (1-\theta) E_I(p^c)].$$

where Φ is a double exponential c.d.f., $\Delta\pi$ is the difference in firm profits due to carbon pricing and $p^C C_I$ is the subsidy a firm obtains in the form of free permits. Moreover, L denotes the number of workers in the firm and E is the amount of emissions, both expressed as functions of the permit price p^C. For firms earlier in the sequence, we recursively use equation (9) to choose the optimal A_i for each possible C_i.

For a given C_i there are $C_i + 1$ possible choices for A_i, assuming that permits cannot be split and that $A_i = 0$ is an option as well. Given the total number of permits A, C_i can take $A + 1$ possible values. Hence the number of outcomes to be compared in step i is given by

$$(A+1) + (A+0) + (A-1) + ... + 1 + 0 = \frac{1}{2}(A+1)A$$

and the total number of operations needed to solve the problem becomes $(I-1) \times \frac{1}{2}(A+1)A$ (as it is always optimal to give the last firm the full amount of remaining permits). This number grows linearly with the number of firms and quadratically with the number of permits, i.e. much slower than the number of possible allocations of permits to firms (equivalent to drawing a firm for each of the A permits with resampling), given by $\frac{(A+I-1)!}{I!(A-1)!}$.[32]

This approach can be applied to a range of different specifications of the relocation probability and objective functions. In particular we can re-write problem 4 so that we can solve it with the same approach. To see this note that by virtue of being a cumulative probability function, $P_i(\cdot)$ is monotone in A_i which means we can invert it and write the problem in Equation 4 as

$$\min_{R_i} \sum A_i(R_i) \text{ s.t. } \left(\sum_i R_i \leq \bar{R}\right)$$

where R_i is job or leakage risk contribution arising from firm i

$$R_i = P(A_i) D_i$$

and $\bar{R}$ is aggregate risk allowed.

[32]The computations are implemented in STATA 10 and the code – including a generic command called "cake.ado" – is available from the authors on request.

B Questionnaire

Questionnaire

Questions	Values	Coding description
I. Introduction		
1. A bit about your business		
(a) Is your firm a multinational? If yes, where is the headquarters?	no, list of countries, dk, rf	"No", if not a multinational; country where headquarters is located if a multinational
(b) On how many production sites do you operate (globally)?	number, dk, rf	Number of sites globally (approximate if unsure)
(c) How many of these sites are situated in the EU?	number, dk, rf	Number of sites in the EU
(d) How many of these sites are situated in the UK/B/FR/...?	number, dk, rf	Number of sites in current country
2. A bit about you		
(a) Job title	text	
(b) Tenure in company	number, rf	
(c) Tenure in current post	number, rf	
(d) Managerial background	commercial, technical, law, other	
3. EU ETS involvement		
As you might know, the European Union Emissions Trading System (referred to as EU ETS, hereafter) is at the heart of European climate change policy. (a) Is your company (or parts thereof) regulated under the EU ETS? (b) Since when?	no, list of years 2005-2009, yes dk year, dk, rf	
(c) How many of your European business sites are covered by the EU ETS?	number, dk, rf	
4. Site location		
For single plant firms and interviewees based at a production site: Could you tell me the postcode of the business site where you are based?	text	Records the postcode

Questions	Values	Coding description
For multi-plant firms where the interviewee is located at a non-production site: Some of the questions I am going to ask you next are specific to a production site within your firm. Please choose a particular production site and answer my questions for the particular site throughout the interview. The site should be the one you know best, the largest one, or the one nearest to you. If you are in the EU ETS, please pick a site covered by the EU ETS. Could you tell me the postcode of the chosen site?		

II. Impact of EU ETS

5. EU ETS stringency (If not an EU ETS firm, continue with question 9)

Questions	Values	Coding description	
(a) How tough is the emissions cap/quota currently imposed by the EU ETS on your production site? (b) Can you describe some of the measures you put in place to comply with the cap?	1-5, dk, rf, na	Low	Cap is at business as usual.
		Mid	Some adjustments seem to have taken place, however nothing which led to fundamental changes in practices; e.g. insulation, etc.
		High	Measures which led to fundamental changes in production processes; e.g. fuel switching; replacement of essential plant and machinery.
(c) What is the annual cost burden of being part of the EU ETS? For example, monitoring, verification and transaction costs; the cost of buying permits or reducing emissions. *If the manager does not understand the question:* Imagine your installation was not part of the EU ETS this year, what cost saving would your firm do?	number	Absolute number	
	percentage	Or percentage of annual operating cost	

6. EU ETS management

Questions	Values	Coding description
Ask only multi-plant firms: Is EU ETS compliance managed on the production site or elsewhere?	site, other site, national firm, european firm, dk, rf, na	

7. ETS trading

Questions	Values	Coding description
(a) In **March** of this year (i.e. **before** the compliance process),	long, short, balanced, dk, rf, na	
	text	If the manager happens to mention the detailed number of allowances, make a

Questions	**Values**	**Coding description**
what was your allowance position on this site? (b) Were you short or long in allowances?		note of it in this field.
(c) Before the compliance process in April, did you buy or sell allowances on the market or over the counter from other firms? (d) If not, why not?	buy, sell, both, no: only trading during compliance period, no: no need, no: image concerns, no: transaction costs, no: other, dk, rf, na	
(e) If yes, how frequently?	daily, weekly, monthly, quarterly, bi-annual, yearly, dk, rf, na	
(f) **In April this year**, what was your position after the compliance process?		
If answers "long": Did you bank permits for future years? Why?	banking to emit more in following years, banking to sell at a higher ETS permit price in future, banking dk why, long for pooling, dk, rf, na	Banking reason.
If answers "balanced/compliant" or "short": Did you borrow permits from next year's allowance? Why?	borrowing to emit less in following years, borrowing to buy at a lower ETS permit price in future, borrowing to be compliant, borrowing dk why, rf, dk, na	Borrowing reason. *Note: Only choose "borrowing to be compliant" if the manager is very short sighted and doesn't seem to understand he will eventually have to either emit less or buy permits*
If answers "short": Why did you remain short?	short for pooling, short and paid fine, other, rf, dk, na	Short reason.
	text	If “other”: why?
(g) Has this site exchanged emission permits with other installations belonging to your company that are part of the EU ETS? (pooling)	yes, no, rf, dk, na	
8. Rationality of market behaviour		
(a) How do you decide how many permits to buy or sell or trade at all? (b) Did you base this decision on any forecast about prices and/or energy usage? (c) Did you trade permit revenue off against emission reduction costs in your planning on this issue?	1-5, dk, rf, na	Low — Take their permit allocation as a target to be met as such and do not take into account the price of permits or the cost of abatement. Just sell if there is a surplus or buy if there is a deficit. Mid — Are in the process of learning how the market works and in the first years did not have any market driven attitude, but now have someone in charge of managing the ETS so as to minimize compliance cost. This

Questions	Values	Coding description	
			person has experience in financial markets and sometimes interacts with the production manager.
		High	Company has a thorough understanding of the site-specific CO2 abatement cost curve. Trading is used as a tool to reduce compliance cost and to generate extra revenues from excess abatement. Moreover, company forms expectations about permit price and re-optimizes abatement choice if necessary. Trader resorts to futures and derivatives to manage ETS permits as a financial asset.
9. Anticipation of phase III			
(a) Do you expect to be part of the EU ETS from 2012 onwards? *If not, continue with question 10*	yes, no, dk, rf, na		
(b) How stringent do you expect the next phase of the EU ETS (from 2012 to 2020) to be? (c) Will it be tough for your firm to reach such a target? Can you describe some of the measures you would have to put in place? (d) Do you believe the allowances will be distributed through an auctioning mechanism? (e) Is it likely that sanctions for non-compliance will become more stringent?	1-5, dk, rf, na	Low	Cap for phase III is anticipated to be comparable to business as usual. The manager believes there will be no additional sanctions and that they will receive the permits for free.
		Mid	Phase III is likely to trigger some adjustments, however nothing that will lead to fundamental changes in practices. Only a small part of permits will be auctioned and sanctions are not expected to be very high.
		High	The presence of strong sanctions, extensive use of auctioning and more stringent targets in Phase III is anticipated. It is likely to imply the adoption of measures which will lead to fundamental changes in production processes. It might also imply the closure of the plant, or redundancy of more than 20% of employment.
(f) Do you expect to transfer unused (banked) ERUs or CERs from Phase II to Phase III ? *Note: ERUs are Emission Reduction Units stemming from Joint Implementation projects. CERs are Certified Emission Reductions stemming from Clean Development Mechanism projects.*	EUAs, ERUs, CERs, EUAs and ERUs, EUAs and CERs, ERUs and CERs, all three, no, dk, rf, na		
10. Awareness			
(a) Are climate change topics discussed within your business? Can you give examples? (b) Are climate change related issues formally discussed in	1-5, dk, rf, na	*Note: Give minimum score of 3 to ETS firms and probe directly for 4 or 5, skipping (a) and (b).*	
		Low	Don't know if threat or opportunity. No awareness.
		Mid	Some awareness backed up by evidence that this is being

Questions	Values	Coding description	
management meetings? Can you give examples? (c) Do your strategic objectives mention climate change? (d) Did you commission reports or studies on how climate change will affect your business?			formally discussed by management.
		High	Evidence that climate change is an important part of the business strategy.
Mentioned positive impact:	yes, no		

III. Prices

11a Energy price expectations

By how many percent do you expect energy prices to go up or down by 2020?	percentage, dk, rf	Expected price change in percent of today's price. *Note: This price includes the effect of current and future climate change policies on the energy price.*
	percentage, dk, rf	Upper bound on expected price change – record only if interviewee mentions it.
	percentage, dk, rf	Lower bound on expected price change – record only if interviewee mentions it.

11b Carbon price expectations

(a) As you might know, the EU has committed to reducing greenhouse gas emissions by 20%-30% over the next decade. What price do you expect to pay for emitting one tonne of CO2 in 2020?	percentage, dk, rf	Expected price in Euros per ton of CO2.
	percentage, dk, rf	Or expected price change in percent of today's price.
	yes, no, rf, dk	Knows today's price of CO2.
(b) What price do you expect in the worst-case scenario?		Upper bound in Euros per ton of CO2.
(c) What price do you expect in the best-case scenario?		Lower bound in Euros per ton of CO2.

12. Future impact of carbon pricing

(a) Do you expect that government efforts to put a price on carbon emissions will force you to outsource parts of the production of this business site in the foreseeable future, or to close down completely?	1-5, dk, rf	Low	No impact of this kind.
		Mid	Significant reduction (>10%) in production/employment due to outsourcing.
		High	Complete close-down.
(b) What carbon price do you associate with this scenario? (Assume that you would have to pay for all allowances.) *Note: The price relates to the scenario given under (a). If answered "no impact" under (a), skip this question.*	number, dk, rf, na	Euros per ton	

<table>
<tr><th>Questions</th><th>Values</th><th colspan="2">Coding description</th></tr>
<tr><td rowspan="3">(c) How would your answer to the previous questions change, if you received a free allowance for 80% of your current emissions?
Note: If answered "no impact" under (a), skip this question.</td><td rowspan="3">1-5, dk, rf, na</td><td>Low</td><td>No impact of this kind.</td></tr>
<tr><td>Mid</td><td>Significant reduction (>10%) in production/employment due to outsourcing.</td></tr>
<tr><td>High</td><td>Complete close-down.</td></tr>
<tr><td>(d) Note: Only ask if answered "no impact" under (a).
At what carbon price level would you be forced to close your plant down?
If the manager has no idea or says it would need to be very high, try different prices, starting high, for example: If you had to pay 200 Euros/ton of carbon, would you need to close down?</td><td>number, dk, na</td><td colspan="2">Euros per ton</td></tr>
<tr><td rowspan="3">(e) How did you reach this conclusion?
(f) How concrete are the plans for outsourcing or closure?</td><td rowspan="3">1-5, dk, rf, na</td><td>Low</td><td>Gut feeling of the manager.</td></tr>
<tr><td>Mid</td><td>Response is based on a plausible argument. For example, interviewee discusses available technological options and associated cost and relates them to profit margins.</td></tr>
<tr><td>High</td><td>Commissioned a detailed study of abatement options and associated cost (in-house or external).</td></tr>
<tr><td>(g) What fraction of an energy price or carbon price increase can you pass on to your customers?</td><td>percentage, dk, rf</td><td colspan="2"></td></tr>
</table>

IV. Competition and customers

13. Competitors

(a) Can you tell me the number of firms in the world which compete with you in one or more local markets? *Note: For multi-product multi-plant firms refer to the market for the products created on the current site referred to during this interview. For instance, for multi-plant firms start the question with "For the products produced at the production site, can you tell me ..."*	number, dk, rf	
(b) How many of them are located within the EU?	number, dk, rf	
(c) How many of them are located in your country?	number, dk, rf	
(d) Location of main competitor (country)	list of countries, dk, rf, na	

Questions	Values	Coding description	
(e) Do you know in which country your main competitor does most of its production?	same, EU, non-EU, list of countries, dk, rf, na		
14. Location of Customers			
(a) Share of sales exported (to the EU and the rest of the world)	percentage, dk, rf		
(b) Share of sales exported to EU countries	percentage, dk, rf		
(c) Are your products sold mainly to consumers or to other businesses?	B2B, final customer, dk, rf		
15. Customer pressure			
(a) Are your customers concerned about your GHG emissions? (b) How do they voice this concern? (c) Do your customers require hard data on your carbon emissions?	1-5, dk, rf	Low	"B2C" - Not aware that emissions performance is of significant concern to consumers of their product. "B2B" - Not aware that businesses they supply to are concerned about the emissions of the plant; quality and price are the only considerations.
		Mid	"B2C" - The business is aware of the importance of climate-change issues in general and so are conscious that their customers may consider GHG performance to be important, although they do not expect or require data as proof. "B2B" - Customers set ISO 14001 as a precondition to suppliers. Evidence of environmental compliance is requested, but details of emissions figures are not required.
		High	"B2C" - Being seen to reduce GHG emissions is thought to be important in the purchasing decisions of the firm's consumers. This has been determined by market research or consumers have voiced their concern through other means. Customers also ask for certified data on emissions during production or usage. A customer-friendly system to recognize the best products in terms of energy efficiency is often available in the market (e.g. EU energy efficiency grade for home appliances). "B2B" - Customers ask for evidence of external validation of GHG figures. Customers request information on carbon emissions as part of their own supply chain carbon auditing. Customers conform to PAS 2050 or other national standard in carbon foot-printing and so require

Questions	Values	Coding description	
			detailed information on a regular basis.
16 Climate change related product innovation			
(a) Globally, is your company currently trying to develop new products that help your customers to reduce GHG emissions? (b) Can you give examples? (c) What fraction of your Research & Development funds are used for that? (Less than 10%, more than 10%?)	1-5, dk, rf	Low	No efforts to develop climate change related products.
		Mid	Some efforts but it is not the main objective of the firms R&D efforts.
		High	The firm is focusing all product R&D efforts on climate change.
V. Measures			
17. Energy monitoring			
(a) How detailed is your monitoring of energy usage? (b) How often do you monitor your energy usage? Since when? (c) Describe the system you have in place.	1-5, dk, rf	Low	No monitoring apart from looking at the energy bill.
		Mid	Evidence of energy monitoring as opposed to looking at the energy bill, i.e. there is some consciousness about the amount of energy being used as a business objective. However, discussions are irregular and not part of a structured process and are more frequent with price rises. Not more than quarterly monitoring of energy.
		High	Energy use is measured and monitored constantly and is on the agenda in regular production meetings. Energy use in the plant is divided up in space (by production line, machine or similar) and monitored over time (daily, hourly or continuously). The amount of energy rather than the cost is focused on.
	2000 and earlier, list of years 2001-2010, dk, rf, na	Start date (put "na" if score is "1")	
18. Targets on energy consumption for management			
(a) Do you have any targets on energy consumption which management has to observe? (e.g. kWh of electricity)	no targets, relative quantity targets, absolute quantity targets, absolute and relative quantity targets, only expenditure targets,	Type	

Questions	Values	Coding description	
	dk, rf		
(b) Can you describe some of the challenges you face in meeting the targets? (c) How often do you meet these targets? Do you think they are tough? *Note: If the manager replies they have EU ETS/CCA targets, ask "have these been translated into internal targets for management?"*	1-5, dk, rf	Low	No targets.
		Mid	Targets exist but seem easy to achieve.
		High	Evidence that targets are hard to achieve. Detailed.
(d) By approximately how much does this require reducing your current energy consumption in the next 5 years (10%, 25%, 50%)? *Note the timetable for the target (e.g. 5 years or other number given by interviewee).*	percentage, dk, rf, na		
	number, dk, rf, na	Horizon (number of years)	
(e) Since when do you have these targets?	2000 and earlier, list of years 2001-2010, dk, rf, na		
19. GHG monitoring			
(a) Do you explicitly monitor your GHG emissions? Since when? (b) How do you estimate your GHG emissions? (c) Are your GHG estimates externally validated?	1-5, dk, rf	Low	No specific GHG monitoring.
		Mid	Detailed energy monitoring with clear evidence for carbon accounting (at least firm level). Manager is aware that energy figures need to be scaled by carbon intensity.
		High	Carbon accounting of both direct and indirect emissions (supply chain emissions). External validation of GHG figures.
	2000 and earlier, list of years 2001-2010, dk, rf, na	Start date (put “na” if score is “1”)	
20. Targets on GHG emissions for management			
(a) Do you have any targets on GHG emissions which management has to observe?	no targets, direct emissions, indirect and direct, dk, rf		
(b) Can you describe some of the challenges you face in meeting the targets? (c) How often do you meet these targets? Do you think they are tough? *Note: If the manager replies they have EU ETS/CCA targets, ask:*	1-5, dk, rf	Low	No targets for GHG emissions.
		Mid	There is some awareness of the contribution of different energy sources and production processes to emissions, but this is a secondary consideration to cost focused energy targets. There is some degree of

Questions	Values	Coding description	
*H*ave these been translated into internal targets for management?			difficulty in the targets.
		HIgh	There are separate targets for GHGs, distinct from energy use. GHG emissions are a KPI (Key Performance Indicator) for the firm. The contribution of each energy source and the production process to GHG emissions is known and suggested improvement projects for the production are assessed on their potential impact on carbon as well as energy efficiency.
(d) By approximately how much do these targets require you to reduce your emissions in the next 5 years (10%, 25%, 50%) compared their current level? *Note the timetable for the target (e.g. 5 years or other number given by interviewee)*	percentage, dk, rf, na		
	number, dk, rf, na	Horizon (number of years)	
(e) When did you start having targets on GHG emissions?	2000 and earlier, list of years 2001-2010, dk, rf, na		
21. Target enforcement			
(a) What happens if energy consumption or GHG emission targets are not met? (b) Do you publicize targets and target achievement within the firm or to the public? Can you give examples? (c) Are there financial consequences in case of non-achievement? (d) Is there a bonus for target achievement?	1-5,dk,rf	Low	No targets or missing targets do not trigger any response.
		Mid	Both target achievement and non-achievement are internally and externally communicated.
		High	Target non-achievement leads to financial consequences internally and/or externally; including penalties, e.g. staff does not get bonus.
22. Emission-reducing measures			
(a) Can you tell me what measures you have adopted in order to reduce GHG emissions (or energy consumption) on this site? DO NOT PROMPT with the list if doesn't have an idea, rather ask: Have you bought any new equipment, or have you changed the way you produce?	List of tickboxes	<u>I. Heating and cooling:</u> 1- Optimised use of process heat 2- Modernisation of cooling/refrigeration system 3- Optimisation of air conditioning system 4- Optimisation of exhaust air system and/or district heating system	
		<u>II. More climate-friendly energy generation on site:</u> 1- Installation of combined heat and power (CHP) plant / cogeneration 2- Biogas feed-in in local combined heat and power plant or domestic gas grid 3- Switching to natural gas	

Questions	Values	Coding description
		4- Exploitation of renewable energy source III. Machinery: 1- Modernisation of compressed air system 2- Other industry-specific production process optimisation/machine upgrade 3- Production process innovation IV. Energy management: 1- Introduction of energy management system 2- Submetering / upgrade of an existing energy management system 3- (External) Energy audit 4- Installation of timers attached to machinery 5- Installation of (de-)centralised heating systems V. Other measures on production site: 1- Modernisation of lighting system 2- Energy-efficient site extension/improved insulation/introduction of building management 3- Employee awareness campaigns and staff trainings 4- Non-technical reorganisation of production process 5- Installation of energy-efficient IT-system 6- Improved waste management/recycling VI. Beyond production on site: 1- Introduction of climate-friendly commuting scheme 2- Consideration of climate-related aspects in investment and purchase decisions 3- Consideration of climate-related aspects in distribution 4- Customer education programme 5- Participation in carbon offsetting schemes
(b) Which one of these measures achieved the largest carbon saving?	measure code	*Fill in the code corresponding to the measure in (a) (e.g. II-4 for "Exploitation of renewable energy source").*
(c) By how much did this measure reduce your total energy consumption?	percentage, dk, rf, na	
(d) By how much did this measure reduce your total GHG emissions?	percentage, dk, rf, na	

Questions	Values	Coding description
(e) What motivated the adoption of these measures?	EU ETS, energy cost saving / high profitability, pollution reduction, reputation, customer pressure, employee initiative, public investment support, compliance with regulation, compliance with expected future regulation, other, dk, rf, na	Main motivation (select only ONE)
	text	Other motivation (if not in tick boxes, or second)
(f) How did you learn about this measure?	consultant, government, customer, supplier, employee, R&D project, competitor, other, dk, rf, na	Tick more than one option, if different sources mentioned
(g) When did you implement this measure?	2000 and earlier, list of years 2001-2010, dk, rf, na	

VI. Innovation, barriers to investment and management

23. Climate change related process innovation

(a) Do you dedicate staff time and/or financial resources to finding new ways of reducing the GHG emissions at your facility? Did you commission any studies for that purpose? (b) Can you give examples? (c) What fraction of your firm's global Research & Development funds are used for that? (less than 10%, more than 10%?) *Note: This does not include expenses for staff trainings or energy monitoring, but actual innovation.*	1-5, dk, rf	Low	No R&D resources committed to reducing GHG emissions.
		Mid	Evidence of R&D projects to reduce emissions.
		High	Evidence that this kind of R&D is an important component in the company's R&D portfolio (5 or higher).

24. Barriers to adopting energy-efficiency investments

(a) Can you give one example of a measure to enhance energy efficiency which was considered, but eventually not adopted?	List of tickboxes	Same list as for question 22a.
(b) Which payback time was required in the economic evaluation of this measure?	number, dk, rf, na	“Years”; if in months, put equivalent in years, e.g. record 6 months as 0.5.

Questions	Values	Coding description	
(c) Is this payback time longer or shorter than the one applied to non-energy related measures to cut costs?	1-5, dk, rf, na	Low	Longer, i.e. much less stringent
		Mid	Equal
		High	Shorter, i.e. much more stringent
(d) If different: why?	text		
(e) Was uncertainty about future prices or regulation important for the decision to reject?	no, yes_prices, yes_regulation, yes_both, dk, rf, na		
(f) What other factors were influential in the decision?	text		
(g) Has the current economic downturn affected your investment criteria for clean technologies? How?	no, favors clean, favours other, more stringent overall, less stringent overall, dk, rf, na		
25. Further reductions			
(a) By how much (in percentage points) could you - at current energy prices - further reduce your current GHG emissions without compromising your economic performance? (i.e. how much more emission reduction could be achieved without increasing costs)	percentage, dk, rf		
(b) If so, why have you not implemented these measures yet?	text		
(c) What further GHG emission reduction (in percentage points) would be technologically possible (although not necessarily at no extra cost)?	percentage, dk, rf	Notes: Assuming that production stays constant and that no processes are being outsourced. This should not include emission reduction achieved by switching to renewable electricity. Include emissions reductions through combined heat and power however.	
26. Manager responsible for Climate Change issues			
(a) At the management level, who is responsible for dealing with climate change policies and energy and pollution reduction in the firm nationally? What is the official job title? *Note: If several, ask for highest-ranking. If nobody, put title "no clear responsibility".*	text	Job title of the manager	

Questions	Values	Coding description
(b) How far in the management hierarchy is this manager below the CEO? (figure out through sequential questioning if necessary)	CEO, number, no clear responsibility, dk, rf	No of people between CEO and Manager, e.g. if reports directly to CEO, put 0
(c) Has there recently been a change in responsibilities for climate change issues? When?	no change, list of years 2000-2010, yes dk year, dk, rf	
(d) How far in the management hierarchy was this manager below the CEO? (figure out through sequential questioning if necessary)	CEO, number, no clear responsibility, dk, rf	
	text	Record past manager title if mentioned, but do not prompt for it.
VI. Firm Characteristics		
27. Firm/Plant Details		
(a) How many people are employed in the firm globally (including this country)? *Note: If a multinational, ask for the whole group's number.*	number, dk, rf	
(b) How many people does the firm employ in your country?	number, dk, rf	
(c) How many people are employed at the current site?	number, dk, rf	
(d) Annual Energy Bill-Annual:	number, dk, rf	
		Do not ask, but in case interviewee does not know the absolute number and answers with one of the following:
	percentage, dk, rf, na	Energy cost as percentage of ***turnover***
	percentage, dk, rf, na	Energy cost as percentage of ***costs***
(e) Total annual running costs (wage cost + materials, including energy):	number, dk, rf	
Answered (d) and (e) at the site level or at the company level?	site, company, na	
(f) Does your company purchase renewable power?	yes, no, dk, rf	*Note: Do not include electricity generated on site.*
(g) Does this site do any product R & D? *Note: Do not dwell on this question, make a judgement from first answer.*	yes, no, dk, rf	
(h) Is Marketing for your products done from this site? *Note: Do not dwell on this question, make a judgement from first answer.*	yes, no, dk, rf	
(i) Does this site have an environmental management system (ISO	yes, no, dk, rf	

Questions	Values	Coding description
14000)?		
VII. Country-specific policies		
UNITED KINGDOM		
UK.1 Participation in voluntary government climate change policies		
(a) Are you aware of voluntary government schemes to help businesses reduce GHG pollution? (b) Which ones? (c) Are you participating in any?	no, list of years 2001-2009, dk, rf, na	Carbon Trust Online Tools (Benchmarking Tools, Action Plan Tool) When?
	no, list of years 2001-2009, dk, rf, na	Carbon Trust Energy Audit or Advice? (CTaudit)
	no, list of years 2001-2009, dk, rf, na	Innovation grants from the Carbon Trust? When?
	no, list of years 2001-2009, dk, rf, na	Carbon Trust Standard
	no, list of years 2001-2009, dk, rf, na	Enhanced Capital Allowance scheme? (ECA)
UK.2 Participation in Climate Change agreement		
(a) Is your company (or parts thereof) subject to a UK Climate Change Agreement? (b) Since when?	no, list of years 2001-2009, dk, rf, na	
(c) How stringent is the target imposed by the CCA? (d) Can you describe some of the measures you had to put in place to comply with the cap?	1-5, dk, rf, na	Low: No targets. Mid: Targets exist but seem easy to achieve. High: Evidence that targets are hard to achieve. Detailed description of serious problems in achieving targets.
((e) Did you buy or sell emission rights via the UK ETS?	no because of image concerns, no because no capacity, no other, bought, sold, both, dk, rf, na	
BELGIUM		
B.1 Participation in industry agreements (accords de Branche/Bechmarkconvenanten)	no, list of years 2001-2009, dk, rf, na	

<table>
<tr><th>Questions</th><th>Values</th><th colspan="2">Coding description</th></tr>
<tr><td>(a) Is your company (or parts thereof) subject to an industry agreement?
(b) Since when?</td><td></td><td colspan="2"></td></tr>
<tr><td rowspan="3">(c) How stringent is the target imposed by the agreement?
(d) Can you describe some of the measures you had to put in place to comply with the cap?</td><td rowspan="3">1-5, dk, rf, na</td><td>Low</td><td>No targets.</td></tr>
<tr><td>Mid</td><td>Targets exist but seem easy to achieve.</td></tr>
<tr><td>High</td><td>Evidence that targets are hard to achieve. Detailed description of serious problems in achieving targets.</td></tr>
<tr><td>B.2 Do you benefit from any tax reduction from the Federal government because of investments that reduce energy consumption/loss? If yes, when?</td><td>no, list of years 2001-2009, yes dk year. dk, rf, na</td><td colspan="2"></td></tr>
<tr><td>B.3 Brussels: Have you had a grant for an energy audit or advice financed by the Brussels region? If yes, when?
Walloon: Have you had any energy audit (AMURE) or advice financed by the Walloon region? If yes, when?
Flanders: Have you received any advice or energy audit financed by VLAO (Vlaams Agentschap Ondernemen)? If yes, when?</td><td>no, list of years 2001-2009, yes dk year. dk, rf, na</td><td colspan="2"></td></tr>
<tr><td>B.4 Brussels: Have you benefited from an investment subsidy from the Brussels region for improving your building's or production process's energy efficiency ? If yes, when?
Walloon: Have you had a grant from the energy fund of the Walloon region for improving your building's or production process's energy efficiency? If yes, when?
Flanders: Have you received an ecological grant (Ecologipremeie) of the Flemish region for improving your building's or production process's energy efficiency? If yes, when?</td><td>no, list of years 2001-2009, yes dk year. dk, rf, na</td><td colspan="2"></td></tr>
<tr><td>B.5 Flanders: Do you have a heat and power certificate from the Flemish region (warmtekrachtcertificaat)? If yes, since when?</td><td>no, list of years 2001-2009, yes dk year. dk, rf, na</td><td colspan="2"></td></tr>
<tr><td colspan="4">FRANCE</td></tr>
<tr><td>F1. Are you part of the AERES (Association des entreprises pour la réduction de l'effet de serre) and have signed up to voluntary GHG emission reductions? If yes, since when?</td><td>no, list of years 2001-2009, yes dk year. dk, rf, na</td><td colspan="2"></td></tr>
<tr><td>F2. Have you had a grant for an energy audit or advice financed by ADEME? If yes, when?</td><td>no, list of years 2001-2009, yes dk year. dk, rf, na</td><td colspan="2"></td></tr>
</table>

Questions	Values	Coding description
F3. Have you benefited from a "FOGIME" guarantee for loans you have taken to invest into energy efficiency improvements or emission reductions ? If yes, when?	no, list of years 2001-2009, yes dk year. dk, rf, na	
F4. Have you benefited from a grant from ADEME for improving your building's or production process's energy efficiency ? If yes, when?	no, list of years 2001-2009, yes dk year. dk, rf, na	
GERMANY		
G.1 Renewable Energy Sources Act		
(a) In previous year, have you been granted a discount on your energy cost which reduces the energy cost apportionment embodied in the Renewable Energy Sources Act?	no, yes, dk, rf, na	
(b) Have you applied for the discount (also) in 2009?	no, yes, dk, rf, na	
(c) Did the certification process require you to upgrade your energy management system? *Note: Since 2009 the approval of the discount is subject to the certification of your energy management system by 30 June 2009.*	yes, no upgrade necessary, no had certificate before, dk, rf, na	
G.2 Public support programmes		
Have you participated in public support programs aimed at saving energy or at reducing GHG emissions?	no, list of years 2001-2009, yes dk year. dk, rf, na	Climate initiative
	no, list of years 2001-2009, yes dk year. dk, rf, na	ERP Environment and Energy Efficiency Programme
	no, list of years 2001-2009, yes dk year. dk, rf, na	Grant for independent energy audit from fonds for energy efficiency in SME
	no, list of years 2001-2009, yes dk year. dk, rf, na	Provision of cut-rate investment credit from fonds for energy efficiency in SME to implement identified energy-saving measures
	no, list of years 2001-2009, yes dk year. dk, rf, na	Support scheme of a federal state
	text	Other

Questions	Values	Coding description	
HUNGARY			
H1. Have you received government support for any of your investments to reduce emissions or implement energy efficiency measures or increase the use of renewables? If yes, when?	no, list of years 2001-2009, yes dk year. dk, rf, na	Környezetvédelmi Alap Célelőirányzat	
H2.(a) Have you received EU funds to support any of your investments to reduce emissions or implement energy efficiency measures or increase the use of renewables? If yes, when?	no, list of years 2001-2009, yes dk year. dk, rf, na		
(b) If yes, for which Operative Program; which call for proposal?	KEOP, KIOP, ERFA, dk, rf, na		
H3. Have you received funding from the Norwegian Fund for support? If yes, when?	no, list of years 2001-2009, yes dk year. dk, rf, na	EGT és Norvég Finanszírozási Mechanizmusok program	
POLAND			
P.1 Do you use the sectoral information brochures published by the Ministry of Environment that include the information about the best available technologies for different economic activity? Since when?	no, list of years 2001-2009, yes dk year. dk, rf, na		
P.2 Have you ever taken a technological credit provided by the Technological Credit Fund? If yes. when?	no, list of years 2001-2009, yes dk year. dk, rf, na		
P.3 Have you ever been co-financed or have taken a preferential credit from the National Fund of Environmental Protection and Water Management, Bank of Environmental Protection and EkoFund? If yes, when?	no, list of years 2001-2009, yes dk year. dk, rf, na		
P.4 Have you ever benefited from the subventions and tax reductions from the government for environmental purposes? If yes, when?	no, list of years 2001-2009, yes dk year. dk, rf, na		
VIII. Post Interview			
Interview duration (mins)	number	Minutes	
Interviewers' impression of interviewee's reliability	1-5, dk, rf	Low	Some knowledge about his site, and no knowledge about the rest of the firm.

Questions	**Values**	**Coding description**	
		Mid	Expert knowledge about his site, and some knowledge about the rest of the firm.
		High	Expert knowledge about his site and the rest of the firm.
Interviewee seemed concerned about climate change	1-5, dk, rf	Low	Not concerned.
		Mid	Somewhat.
		High	Very concerned.
Interviewee seemed skeptic about action on climate change	1-5, dk, rf	Low	Not skeptic at all.
		Mid	Somewhat skeptic.
		High	Very skeptic.
Mentioned other climate change related policies	text		
Moaned a lot about high energy prices	no, a little, a lot		
Number of times interview needed to be rescheduled	number		
Seniority of interviewee	Director, VP/General Manager, Plant/Factory Manager, Manufacturing/Production Manager, (Environmental), Health & Safety Manager, Technician		
Age of interviewee *Note: Do not ask, guess!*	number		
Gender of interviewee	male, female		
Interview language	English, French, German, Dutch, Hungarian, Polish		

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