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Corporate investments and environmental regulation: The role of regulatory uncertainty, regulation-induced uncertainty, and investment history

Juan Miguel Rodriguez Lopez [a], Alice Sakhel [b], Timo Busch [b, *]

[a] Centre for Globalisation and Governance, University of Hamburg, Institute of Sociology, Grindelberg 5, 20144 Hamburg, Germany
[b] Chair of Management and Sustainability, University of Hamburg, Von-Melle-Park 9, 20146 Hamburg, Germany

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ABSTRACT

The relation between uncertainty related to environmental regulation and corporate investments has received considerable attention in the academic literature. Previous quantitative studies, however, have not distinguished between different types of perceived regulation-related uncertainty and do not consider the potential influence of prior investments on firms' investment decisions. Therefore, this paper analyzes how decision makers' perception of two types of uncertainties – regulatory and regulation-induced uncertainty – affects corporate investments in measures to reduce environmental impact. We analyze survey data from a sample of more than 250 companies participating in the EU Emissions Trading System. The data set includes firms from different industries and countries, and covers the first two periods of the trading scheme. Regression results reveal that regulation-induced uncertainty is positively related to a firm's decision to invest, while we find no statistically significant relation to regulatory uncertainty. Moreover, we find that investment history is positively associated with investments in a specific year, but does not moderate the uncertainty–investment relation.

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1. Introduction

Environmental regulation[1] and awareness of future policy developments are among the most important drivers of corporate responses to ecological challenges (e.g., Kolk & Pinkse, 2004; Okereke & Russel, 2010). Yet, at the same time, policy frameworks often lack predictability and may have unforeseen consequences for the broader competitive landscape. The observation that such uncertainties impact corporate investments has fueled a debate on how firms respond to regulation-related uncertainties (Engau & Hoffmann, 2009). For instance, since the corporate sector is one of the main contributors to global warming, the introduction of climate policies is intended to spur company investments in carbon abatement measures. However, research has disputed whether such policies actually fulfill their purpose, because the uncertainty inherent in the regulation prevents companies from accurately planning and reduces their willingness to commit resources to such investments (Marcus, 2009; Rogge, Schneider, & Hoffmann, 2011).

This paper examines the relation between uncertainty resulting from environmental regulation and companies' propensity to invest in abatement measures. We define abatement measures as conscious efforts that a firm undertakes for the purpose of reducing its ecological footprint. By conducting a quantitative analysis of different uncertainty-related effects on firm investment behavior, we investigate two important aspects within this relation. First, unlike several previous empirical studies, we do not treat uncertainty as a broad and homogeneous construct. Instead, we build on the definition presented by Hoffmann, Trautmann, and Schneider (2008) and study two different sub-dimensions of regulation-related uncertainties: regulatory and regulation-induced uncertainty. The former describes the uncertainty related to the overall characteristics of and changes in a regulation, such as its scope and rules. The latter represents uncertainty about the indirect consequences of a regulation once it has been implemented, such as changes in market conditions and prices.

* Corresponding author.
E-mail addresses: miguel.rodriguez@uni-hamburg.de (J.M. Rodriguez Lopez), alice.sakhel@wiso.uni-hamburg.de (A. Sakhel), timo.busch@wiso.uni-hamburg.de (T. Busch).

[1] By using the term "environmental regulation", we make reference to legislation that regulates business activities in order to reduce the impact on the natural environment.

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Second, we analyze how a firm's investment history influences firm investments given regulation-related uncertainties. While different research streams have shown that a firm's previous decisions are related to future decisions (Vergne & Durand, 2010), so far the literature reveals very little on how regulation-related uncertainty may affect this relation. Specifically, we argue that incorporating investment history into our analysis provides insights into the mechanisms underlying the uncertainty–investment relation. This paper accordingly addresses the following two research questions: do the two different subjectively perceived dimensions of regulation-related uncertainty increase or decrease a firm's propensity to invest in abatement measures? And, in the presence of these uncertainties, what role does a firm's investment history play in its investment decisions?

In order to answer these questions, we analyzed survey data from a sample of more than 250 companies across different sectors and countries (Denmark, the Netherlands, the United Kingdom, and Germany). The data covers the first two phases of the EU Emissions Trading System (EU ETS). Our study contributes to the literature on the uncertainty–investment relation in two main ways. First, we provide a more nuanced perspective on how the two dimensions of subjectively perceived regulation-related uncertainty affect investment decisions. In particular, we show that regulation-related uncertainty may actually drive, rather than, impede corporate investments: in the context of the EU ETS, regulation-induced uncertainty has a positive impact on abatement investment decisions, while regulatory uncertainty does not show a significant effect. Second, we find a highly significant positive influence of investment history on abatement investment decisions – independent of any regulation-related uncertainty. This implies that for effective carbon abatement investments it is central that firms have prior investment experience. Firms without such an investment history might feel compelled by regulation-induced uncertainty to address their inert abatement investment behavior.

The remainder of this article is organized as follows: the second and third sections review relevant literature and derive a number of hypotheses related to the concept of regulatory and regulation-induced uncertainty. The fourth and fifth sections provide background information on the research setting, and present the sample and data, the statistical model, and the analyses' results. In the sixth section, we discuss our results, highlight our main contributions, as well as present some limitations and avenues for future research. The paper ends with a short conclusion in section seven, which concisely summarizes our findings.

2. Literature review: uncertainty and corporate investments in an environmental policy context

The question of how uncertainty affects corporate investment decisions has been the subject of a large number of empirical and theoretical studies. While uncertainty can stem from a number of different sources, a considerable amount of research focuses on how environmental regulations impact firms' decisions. The debate has yielded two opposing views with some scholars arguing that uncertainty discourages firms from investing, while others suggest the uncertainty encourages investment.

The general intuition underlying the former perspective is that, if the outcome of a process is uncertain and potentially detrimental for a company, the option value of waiting to invest increases, which rationally compels the company to postpone investments until uncertainty is partly or fully resolved (Bernanke, 1983; Dixit & Pindyck, 1994). This holds under the assumptions that (a) investments are at least partly irreversible and therefore involve sunk costs, and that (b) firms are flexible when it comes to the timing of their investments (e.g., Dixit & Pindyck, 1994; Pindyck, 1991b).

A considerable number of studies have found empirical evidence for such a postponement strategy (e.g., Pindyck & Solimano, 1993; Pindyck, 1991a; Rodrik, 1991). The real options approach is a common methodology to empirically investigate the uncertainty–investment relation (Dixit & Pindyck, 1994, 1995; Laurikka & Koljonen, 2006). In the context of environmental policies, researchers usually model regulation-related uncertainty as exogenous stochastic fluctuations in carbon prices simulated by means of dynamic programming. Fuss, Johansson, Szolgayova, and Obersteiner (2009), for example, apply a real options model to analyze the adoption of electricity-generating technologies under climate policy uncertainty. Through experimental computation with secondary data, they simulate 10,000 carbon price paths and show that more frequently changing prices (i.e. more uncertainty) enhance the expected value of information and thus result in an increasingly postponed investment in low-carbon technologies. Similar results are obtained by Blyth et al. (2007a) and Kettunen, Bunn, and Blyth (2011), who show that uncertainty in climate policies (e.g., in the form of frequently changing carbon prices) may result in postponed low-carbon investments.

The research advocating the postponement logic stands in contrast to a smaller number of conceptual and empirical studies, which suggest that firms continue to invest – or even enhance the level of investment – despite uncertainty. The theoretical argument for this claim is mainly rooted in the resource-based view of the firm (Barney, 1991; Wernerfelt, 1984). For example, based on a review of the literature, Aragón-Correa and Sharma (2003) develop a theoretical model that shows how characteristics of the general business environment influence the development of a proactive environmental strategy. They propose that in the face of environmental instability firms seek to develop valuable capabilities that help them gain a competitive advantage.

The claims by Aragón-Correa and Sharma (2003) have been supported by a number of empirical studies. Carrera, Mesquita, Perkins, and Vassolo (2003), for instance, looked at the 33 largest Argentinian companies' strategies, analyzing data derived from historical evidence, surveys, and in-depth interviews with chief executive officers. The authors show that uncertainty regarding regulations and the general business environment during four major time periods induced these companies to increase investments in corporate portfolio expansion in order to spread risk. Hoffmann, Trautmann, and Hamprecht (2009) conducted a case study on corporate investment behavior comprising five companies in the German energy sector that participate in the EU ETS. In face-to-face interviews, interviewees were asked questions concerning their perception of regulation-related uncertainty and their investments in technologies that are more pollution efficient. The authors show that in cases of companies wanting to secure competitive resources, leverage complementary resources, or alleviate institutional pressure, regulatory uncertainty did not postpone but actually accelerated investment.

In sum, there is still room for further research on the relation between regulation-related uncertainty and companies' investment decisions. In particular, we see four main issues in the literature that require further attention. First, previous research either defines regulation-related uncertainty narrowly by modeling it, for example, as a price uncertainty, or very broadly by simply referring to it as policy uncertainty. To our knowledge, very few studies make a particular distinction between different dimensions of regulation-related uncertainty. However, a more differentiated investigation of the different uncertainty dimensions could provide a more nuanced picture of uncertainty–investment relation and thus enhance our understanding of the real underlying effects.

Second, earlier studies applying real option models have treated regulation-related uncertainty as an externally given variable, implying that it is constant across individuals. However, prior research indicates that there are differences among individuals in their perceptions of and tolerance for uncertainty (Adorno, Frenkel-Brunswik, Levinson, & Sanford, 1950; Hambrick, Finkelstein, & Mooney, 2005). It therefore seems plausible that it is the subjectively perceived uncertainty of decision makers, rather than an exogenously determined uncertainty, that drives investment decisions of firms. Currently, however, there is only one quantitative study that incorporates the idea of uncertainty perception in a firm's investment decision (Koetse, van der Vlist, & de Groot, 2006).

Third, although the idea of building resources and capabilities was brought forward by qualitative and conceptual studies as a main driver for investments in times of uncertainty (Aragón-Correa & Sharma, 2003; Hoffmann et al., 2009), we still know surprisingly little about how a firm's prior investments influence its investment behavior in times of uncertainty. The literature suggests that companies' past investment decisions are connected to current and future investments (Vergne & Durand, 2010). As a result, investment history may also have an influence on how uncertainty affects a company's investment activities. Including investment history also in quantitative studies may therefore help us better understand the relation between uncertainty and corporate investments.

Finally, while empirical evidence on the uncertainty–investment relation has been addressed in the management literature, previous investigations have had a narrow focus on one particular sector – mainly the energy sector – and/or a single country. Yet the effect of regulatory uncertainty may vary across different industries and may also be contingent on the specific implementation of a policy in a country, thus making it difficult to compare study findings. Small sample sizes additionally limit the generalizability of study findings. In this study, we therefore attempt to address these issues with a cross-country research setting and a larger sample.

3. Hypotheses development

3.1. Regulatory vs. regulation-induced uncertainty

Based on Milliken's (1987) notion of "state uncertainty", defined as the perceived inability to forecast the future state of the general environment, Hoffmann et al. (2008) divide uncertainty in the regulatory context into two categories: regulatory and regulation-induced uncertainty. Hereby, the focus lies on the subjectively perceived dimension of uncertainty (Boyd, Dess, & Rasheed, 1993), acknowledging that the decisions of corporate actors driven by a subjective stimulus may differ from those decisions based on a more objective calculus (Adorno et al., 1950; Hambrick et al., 2005).

Regulatory uncertainty concerns a corporate decision maker's perceived uncertainty about the state of the different attributes and elements of a certain policy or regulation. In this respect, regulatory uncertainty is defined as "an individual's perceived inability to predict the future state of the regulatory environment" (Hoffmann et al., 2008: 714). In more detail, regulatory uncertainty refers to uncertainty stemming directly from a policy, hence from its characteristics in terms of the basic legislative direction (e.g., its stringency), specific rules and measures (e.g., exemption rules), but also the implementation process, and interdependencies with other regulations.

Regulation-induced uncertainty describes the notion that uncertainty about the state of the regulatory environment (e.g., about the design of a regulation) may imply an imperfect understanding of the interdependence between the regulatory environment and elements in the non-regulatory environment (Milliken, 1987). Elements of the non-regulatory environment can be understood as variables that are not directly targeted by, but are still affected by, a regulation. In this regard, an existing regulation creates uncertainty in the non-regulatory environment that prevails even after uncertainty over the future state of a regulation has been resolved. Thus, regulation-induced uncertainty can be defined as "an individual's perceived inability to predict the future state of the non-regulatory environment that is caused by a regulation" (Hoffmann et al., 2008: 714). In the context of environmental policy, the development of electricity and carbon prices are examples of elements that can be subject to regulation-induced uncertainty (Hoffmann et al., 2008; Kolk & Pinkse, 2005).

3.2. The effect of regulatory uncertainty on abatement investments

In addition to other gains – such as the cost savings through efficiency gains – complying with regulatory requirements is one of the most important rationales for abatement investments (Porter & Van der Linde, 1995). However, uncertainty over the regulation's design hampers planning reliability about investment decisions and, therefore, potentially delays regulations' intended innovation effects (Okereke, 2007).

As prior research has pointed out, regulatory uncertainty is mainly owed to the segmented nature of a policy making process. Instead of determining the final design of a regulatory framework in one step, the policy-making process consists of sequential phases, beginning with the incurrence of a subject and continuing to the political debate, the final definition, and enforcement of a policy (Schulman, 1975). Thus, regulatory uncertainty stemming from the policy-making process is subject to discontinuous resolution (Engau & Hoffmann, 2009). The phenomenon of phases of relative steadiness interrupted by phases of transformation has been referred to as 'punctuated equilibria' in the literature (Doh & Pearce II, 2004; Gersick, 1991; Romanelli & Tushman, 1994). According to this definition, incertitude is suddenly reduced or resolved when specific targets and implementation measures, i.e. the regulatory framework, have been defined for a certain period. However, this uncertainty resolution only holds temporarily, until the point when policy makers renegotiate and amend individual elements of a regulation. Environmental regulations are a prime example of this segmented process, since policy makers themselves perceive an exceptionally high degree of uncertainty: steadily evolving scientific findings induce policy makers to periodically conduct regulatory adjustments (Hoppmann, Huenteler, & Girod, 2014; Tarui & Polasky, 2005).

So, how do firms respond to the uncertainties in the segmented political process? The literature suggests that firms tend to postpone abatement investments and engage in wait-and-see or lobbying strategies. First, the segmented nature of the policy process creates a situation with plenty of potential outcomes – some of which can even be influenced by firms. In this situation, it appears more advantageous to postpone strategic decisions and wait for more certainty (Collis, 1992; Wernerfelt & Karnani, 1987). In cases where the outcome of a policy process is potentially detrimental for a company, the value of postponing investments is particularly high. Especially if investments involve sunk costs and if firms have the possibility to delay investment decisions during a phase of uncertainty, it pays off to wait until more information becomes available (Dixit & Pindyck, 1994; Pindyck, 1991b). This is because policy uncertainty creates a risk premium on investments, which diminishes with the reduction of uncertainty (Blyth et al., 2007a).

Second, during a phase of regulatory uncertainty, firms may be reluctant to allocate resources to abatement investments as committing resources to lobbying activities is perceived as more effective (Damania, 2001). The existing literature suggests that participation in political debate is an effective response by corporate actors to uncertainty regarding upcoming regulatory changes.

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Companies have successfully applied different forms of lobbying in environmental policy making processes in order to influence negotiations so that outcomes are in their favor (Michaelowa & Butzengeiger, 2005). Lobbying is especially relevant in the case of a segmented policy process, which allows companies to repeatedly engage in political negotiations.

In sum, we therefore argue that regulatory uncertainty prompts corporate decision makers to follow wait-and-see and/or lobbying strategies. As a consequence, abatement investments are postponed. Accordingly, we hypothesize:

Hypothesis 1. *The relation between perceived regulatory uncertainty and a firm's propensity to invest in abatement measures is negative*.

3.3. The effect of regulation-induced uncertainty on abatement investments

While the previous section suggests a negative relation between regulatory uncertainty and corporate abatement investments, we expect the opposite effect for regulation-induced uncertainty. We base our argument on the range of possibilities firms have to respond to regulation-induced uncertainty, which we regard as considerably narrower than in the case of regulatory uncertainty. This is due to two main reasons.

First, in contrast to regulatory uncertainty, regulation-induced uncertainty is a time-consistent issue. The perceived inability to predict the future state of different policy-affected elements in the non-regulatory environment continues to exist even if uncertainty over general policy characteristics is (temporarily) resolved (Hoffmann et al., 2008). In fact, even policies that are not subject to regulatory uncertainty usually introduce additional complexity — and thereby uncertainty — in the non-regulatory environment. For example, when implementing a carbon tax, policy makers add a new element to electricity price formation with the result that the overall uncertainty in electricity prices is persistently higher after the policy is introduced. The fact that regulation-induced uncertainty is not resolved at any stage eliminates the value of postponing investment decisions to a later point in time (Bernanke, 1983).

Second, regulation-induced uncertainty is more complex than regulatory uncertainty. This is because elements in the non-regulatory environment are not only subject to uncertainty induced by regulations, but also strongly depend on the interaction of many non-regulatory factors. For instance, climate policy has an indirect effect on electricity prices. These prices, however, are also subject to uncertainty regarding several non-regulatory market factors, such as demand, quantity, and volatility, as well as operating costs (Karakatsani & Bunn, 2008). Uncertainty about these factors interacts with the additional uncertainty resulting from climate policy (Sijm, Bakker, Chen, Harmsen, & Lise, 2005). This interplay of different types of dynamics and inherent uncertainties makes it more difficult, or nearly impossible, to predict the future state of policy-affected elements in the non-regulatory environment. This, in turn, diminishes the number of appropriate responses at hand. Moreover, regulation-induced uncertainty is not amenable to companies' influence. While companies can engage in negotiations regarding a policy's framework design, such negotiations are not possible for factors in the non-regulatory environment.

As a result of these characteristics, regulation-induced uncertainty cannot be reduced or easily avoided (Engau & Hoffmann, 2011). In order to fully avoid this uncertainty, firms would need to move their business activities from uncertain to more predictable business environments (Miller, 1992). Indeed, the threat of "pollution flight" — i.e. a company relocating to a country with laxer regulation — has been widely discussed in the context of unilateral climate policies (Clapp & Dauvergne, 2005; Copeland & Taylor, 1994). However, in reality the geographical mobility of many industries is rather limited. Particularly those industries with the largest environmental footprint, such as electricity, aluminum, concrete and chemical production, are very capital-intensive and subject to high transport costs, fixed plant costs, and economies of industry agglomeration (Ederington, Levinson, & Minier, 2005). These factors make relocation of plants very costly, and lead to a high stickiness of capital allocation. In addition, even if relocation is feasible, it is often not a reliable long-term solution: environmental regulations in alternative locations may also become more stringent over time as the salience of environmental issues increases (Ederington et al., 2005).

In sum, we expect that the most reliable way for a company to cope with regulation-induced uncertainty is to focus on internal adjustments. By following such a strategy, a company can alleviate or eliminate its vulnerability in light of this uncertainty. In the case of environmental regulations, this implies that firms invest in abatement measures that effectively improve the firm's environmental footprint. We therefore hypothesize:

Hypothesis 2. *The relation between perceived regulation-induced uncertainty and a firm's propensity to invest in abatement measures is positive*.

3.4. The role of history in investment decisions in the context of uncertainty

Besides regulation-related uncertainty, investments may also be influenced by a company's investment history. The role of history, i.e. past events, as a determinant of future decisions has been widely studied in the social sciences. Specifically, management and organizational research stresses the impact of history at the macro (institutions), meso (technology and governance), and micro (organizational resources and capabilities) levels of analysis (Vergne & Durand, 2010). Historical investment decisions are the foundation for organizational pathways, and therefore influence future investment decisions (Dierickx & Cool, 1989). This implies that investing is a persistent process in the sense that prior investments increase the probability of realizing further investments in related areas at a later point in time (Dierickx & Cool, 1989). We therefore reason that investments in abatement measures also follow a persistent process: a company is more likely to invest today if there have been prior investments.

Clearly, past investments may also discourage subsequent investments if the past investment turned out unfavorably. Rugman and Verbeke (1998), for example, argue that firms are worried about making green mistakes, which may prevent them from investing in subsequent abatement measures. However, we argue that ecological concerns have become more salient over time (Marcus & Fremeth, 2009), such that, once initiated, a low-impact investment path will be continued. Particularly for persistent ecological concerns, such as climate change, we would assume that past mistakes do not preclude a firm from investing into abatement measures in the future. Rather, we expect mistakes to trigger corporate learning related to the investment process (e.g., more careful screening and hedging) and alternative technologies, which improves firms' ability to make future investments. We therefore hypothesize:

Hypothesis 3. *The relation between a company's prior investment in abatement measures and the propensity to invest at later points in time is positive*.

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Finally, a firm's investment history may also be relevant for the uncertainty–investment relation for two reasons. First, firms that have invested in the past have built capabilities that enable subsequent investments (Helfat, 1994). A key rationale to reduce or postpone investments is to avoid strong commitments in times of uncertainty (Dixit & Pindyck, 1994). If a firm has experience with abatement measures in the past, however, new investments will require fewer resources and may even be highly complementary to past investments (Christmann, 2000). As a result, the risk of making mistakes may at least be partly alleviated if a firm has invested in the past. Firms may therefore be less inclined to reduce investments in response to regulatory uncertainty. Similarly, investing in abatement technologies in response to regulation-induced uncertainty may seem even more beneficial when a firm already possesses the necessary knowledge.

Second, besides enhancing a firm's ability and lowering the resources required to make new investments, prior investments may also change decision makers' perception of uncertainty (Barr, 1998). If a firm has made investments in abatement technologies in the past, uncertainties about environmental regulation and its impact on the non-regulatory environment may be perceived as less negative. On the contrary, for a firm that has already invested in abatement technologies, political discussions about regulation may be seen as a sign that the firm is already on the right trajectory, and may therefore encourage further investments (Porter & Van der Linde, 1995). Accordingly, for firms that have already made investments in the past, the negative impact of regulatory uncertainty might be weaker and the positive one of regulation-induced uncertainty stronger. This is reflected by our last two hypotheses:

Hypothesis 4a. *Investment history moderates the negative relation between perceived regulatory uncertainty and a company's propensity to invest*; *this relationship will be weaker for firms that made prior investments in abatement measures.*

Hypothesis 4b. *Investment history moderates the positive relation between perceived regulation-induced uncertainty and a company's propensity to invest*; *this relationship will be stronger for firms that made prior investments in abatement measures.*

4. Method

4.1. Research setting

To test our hypotheses, we analyzed data from firms regulated under the EU ETS. This scheme is particularly well suited to test our hypotheses as it represents an important environmental policy designed to encourage firm investments in carbon reduction. At the same time, the scheme has been criticized because of its potential for perverse incentives that could lead companies to defer making investment decisions as a consequence of the uncertainty involved (e.g., Neuhoff, Martinez, & Sato, 2006).

The EU ETS was initiated in 2003 by the Directive 2003/87/EC, and came into force in 2005. To date the system covers around 12,000 installations (i.e., power plants and production facilities) in high-emitting industries across 31 European states (EC, 2014). As an emissions quota trading system, the EU ETS sets a cap on the permitted total number of emissions and dispenses a respective amount of allowances to participating states' national authorities. Although National Allocation Plans specify how to distribute EU allowances to individual installations within a country, the EU ETS still concedes a high level of strategic flexibility to participating companies, since allowances can be freely traded. Thus, in theory, a cap and trade system can be highly effective by setting a specific target, yet allowing for flexibility in how companies reach this target.

An important feature of the EU ETS is the set-up of different trading periods (phase I: 2005–2007; phase II: 2008–2012; phase III: 2013–2020). Each trading period applies new allocation rules, standards, and implementation principles (Clò, 2010; Ellerman, Convery, & De Perthuis, 2010). Consequently, the EU ETS has periods of relative certainty – when rules are set in the beginning of a new trading phase – that alternate with periods of instability and renegotiations – during rule formulation on the way to the next phase. Therefore, it serves as a good example of discontinuous uncertainty resolution (Hoffmann et al., 2009).

4.2. Sample and data

Data was gathered through surveys that were sent to companies from all industries subject to the EU ETS in the trading years 2006, 2007 (phase I) and 2012 (phase II) in four countries (Denmark, Netherlands, United Kingdom, and Germany). The questionnaires contained questions on specific EU ETS aspects and were sent immediately after the completion of each trading year. Although we collected data at three points in time, our focus was on studying firm investment propensity in 2007 and 2012. Since response rates differed throughout the trading years, we finally obtained responses from 293 companies for the year 2007 and from 258 companies for the year 2012 (i.e., a total of 551 company-year observations). The data from 2006 was only collected in order to control for the firms' investment history. All companies that responded to our request in phase II had previously responded in phase I.

To compile our sample, we used information obtained from the Community Independent Transaction Log (CITL). The CITL used to be a central and publicly accessible register run by the European Commission, which tracked all transactions taking place within the trading system, and recorded information on freely allocated emission certificates, verified emissions, and surrendered permits on an installation level. The CITL also contained contact information for representatives in charge of emissions trading within a company. These representatives worked at a strategic level and were responsible for the administration and the control of all company-wide installations. Therefore, identifying installations with the same contact details allowed for company-level aggregation of stand-alone installations. By this means, it was possible to identify a list of companies operating in the four observed countries to which questionnaires were sent. In 2012, the CITL was transformed into the European Union Transaction Log (EUTL), which provides less personal information about the managers in charge of corporate emissions trading. To update our company contact list we used additional internet search tools, in particular, Google Search and LinkedIn. A few contacts that could not be found were not included in the final analysis.

To test sector and country representativeness, we compared our sample to an independent database generated by Jaraite, Jong, Kažukauskas, Zaklan, and Zeitlberger (2013). This database contains data from the CITL and the EUTL registers, but covers the complete universe of EU ETS participants. It therefore served as a useful tool to test whether the composition of our sample was representative in terms of industries and countries, in order to support the claim of generalizability of our results. The database reports data on the installation level, i.e. plants and production facilities, rather than on the company level. As part of our representativeness check, we compared the sector and country classification of all installations in our sample – 670 installations in year 2007 and 567 installations in year 2012, for a total of 1237 – with those included in the database of Jaraite et al. (2013).

In order to determine the industry distribution within our

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Table 1
Sector representativeness (installation level).

Aggregated sectors	Sector classifications: NACE rev1.1 (NACE rev.2)	Jaraite et al. (2013)	Installations by sector		
			Own database		
		(in %)	2007 & 2012 (in %)	2007 (in %)	2012 (in %)
Energy	11, 23, 40 (5–9, 19, 35)	47.52	44.43	42.58	46.73
Pulp & paper	20, 21 (16–18)	1.5	8.65	9.85	7.17
Manufacturing	14, 15, 17, 24–35 (10–12, 13–15, 20–33)	47.2	40.2	41.40	38.74
Services & others	60, 63, 64, 74, 75, 80, 85, 90, 93 (49–53, 84, 85,86, 36–39)	3.78	6.72	6.17	7.36
Total		100	100	100	100
T-test p-values			0.1705	0.1596	0.1560

Sources: Jaraite et al. (2013) and own EU ETS Study database in 2007 and 2012 (installations in Germany, the UK, the Netherlands and Denmark).
Note: Sector representativeness is reported on the installation level; null hypothesis: sample distribution different from distribution of Jaraite et al. (2013); p-values are two tailed.

sample, we used the NACE (Statistical Classification of Economic Activities in the European Community) code indicated by our respondents. Moreover, all NACE classified installations were consolidated into four industrial sectors based on their economic activities: Energy, Pulp & Paper, Services & others, and Manufacturing. Tables 1 and 2 provide an overview of the installations covered in the two databases and report the results of the *t*-tests we used to check the sector and country representativeness of our sample. *T*-test results reveal that the mean difference between the two samples does not significantly deviate from zero, on a significance level of 0.05%.

We chose the last two years of EU ETS trading phases I and II (2007 and 2012 respectively) as observation periods since we assumed that comparable levels of heightened uncertainty were experienced at these two points in time. Both years marked the end of a respective trading period and, as such, the transition to the next expected policy change. Final decisions on important regulatory features of the coming trading phase are made shortly before or after this point (this was, for example, the case for Backloading[2]). Here, two vital points that decisively influence the conditions of a whole EU ETS trading period have to be considered: the determination of the overall cap's level and the design of the National Allocation Plans (Ellerman et al., 2010). Therefore, during these two points in time, companies faced high uncertainty about the conditions of the following trading phase (Blyth, Yang, & Bradley, 2007b).

In 2007, for instance, there was uncertainty about the regulatory design of trading phase II (2008–2012). This was especially apparent because it coincided with the first compliance period of the Kyoto Protocol. With the Kyoto protocol a new level of stringency and many new implementation measures were introduced, such as the accreditation of the limited use of Kyoto credits for compliance with EU ETS requirements (EC, 2014). In 2012 there was uncertainty about the long-term political direction expected in the post-Kyoto period and its impact on the design of regulations within the EU ETS. This concerned, for example, the future of the Kyoto flexible mechanisms (Klepper, 2011). To summarize, observations from trading years 2007 and 2012 were used because at these points in time companies were subject to especially high levels of uncertainty due to the imminent transition into a new EU ETS trading phase. In order to account for investment history in 2007, investment data from 2006 was included.

[2] The term "Backloading" describes the postponement of the sale of 900 million carbon allowances from the years 2014–2016 until 2019–2020. This tool was first proposed by the European Commission at the end of phase II, in November 2012 (EC, 2014).

4.3. Variable description

4.3.1. Dependent variable

In order to generate the dependent variable "abatement investment", companies were asked to indicate whether they had undertaken investments in the years 2007 and 2012. We measured abatement investment as a binary outcome variable, for reasons of theoretical fit and data collection. First, the core question in the

Table 2
Country representativeness (installation level).

Countries	Installations by country			
	Jaraite et al. (2013)	Own database		
	(in %)	2007 & 2012 (in %)	Year 2007 (in %)	Year 2012 (in %)
Germany	50.74	58.12	50.90	66.67
United Kingdom	27.88	16.98	17.16	16.75
Denmark	10.37	15.12	20.00	9.35
Netherlands	11.02	9.78	11.94	7.23
T-test p-values		0.0739	0.0832	0.0691

Sources: Jaraite et al. (2013) and own EU ETS Study database in 2007 and 2012 (installations in Germany, the UK, the Netherlands and Denmark).
Note: Country representativeness is reported on the installation level; null hypothesis: sample distribution different from distribution of Jaraite et al. (2013); p-values are two tailed.

Table 3
Descriptive statistics (company level, years 2007 and 2012).

Variable	Observations	Mean	Std. dev.	Min	Max
Abatement investment	549	0.40	0.49	0	1
Regulatory uncertainty	540	1.03	0.72	0	2
Regulation-induced uncertainty	540	0.89	0.66	0	2
Investment history	453	0.34	0.47	0	1
Abatement cost knowledge	537	1.00	0.82	0	2
Size	541	2.38	0.78	1	3
Internationalization	550	0.20	0.40	0	1
Allocation position	550	1.37	0.89	0	2
Energy	550	0.39	0.49	0	1
Pulp & paper	550	0.10	0.30	0	1
Manufacturing	550	0.38	0.49	0	1
Services & others	550	0.11	0.32	0	1
Year 2012	550	0.47	0.50	0	1
Year 2007	550	0.53	0.49	0	1
Germany	550	0.71	0.46	0	1
United Kingdom	550	0.12	0.32	0	1
Denmark	550	0.11	0.31	0	1
Netherlands	550	0.01	0.10	0	1

Note: Descriptive statistics are reported on the company level. The numbers of observations vary due to missing values.

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academic debate is whether or not companies invest in times of uncertainty (Dixit & Pindyck, 1994). This question implies an empirical setup that measures investment as a binary outcome variable rather than the actual amount of investment. Measuring investments as amount would imply that large investments by individual firms gain a stronger weight in the analysis. Second, we chose to measure investments as a binary variable to avoid asking our respondents for strategically relevant information. From interviews with company representatives, we knew that companies are reluctant to share information on the amount of money they spend on carbon reducing or avoiding technology solutions. Thus, to keep the response rate as high as possible, we refrained from asking about concrete carbon reduction investments in monetary terms.

To ensure that companies only indicated investments related to the environmental regulations, the survey included several investment options that cover the spectrum of technological solutions to reduce or avoid carbon emissions, such as the optimization of carbon-intensive production processes or raw materials substitution.

4.3.2. Independent variables

We measured the two uncertainty constructs using different items to capture distinct uncertainty dimensions and to be able to clearly differentiate the two constructs. For the operationalization of the first explanatory variable, "regulatory uncertainty", we built an index of companies' perceived uncertainty related to their participation in the EU ETS. This was measured by two items: uncertainty about the "lack of transparency of the policymaking process" and uncertainty about potential "regulatory changes". Companies were asked to indicate whether they perceived uncertainty about both, one, or neither of the items. The answers were aggregated into one variable to represent the extent to which companies perceived uncertainty about the regulatory framework.

With respect to "regulation-induced uncertainty", this study exclusively considered corporate decision makers' perceived uncertainty about the development of future carbon price levels, i.e. the price per European Emission Allowance (EUA). Although the future level of the EUA is significantly determined by the design of a climate policy (Hoffmann et al., 2008), the design directly aims at influencing carbon demand, and therefore only indirectly affects the price of carbon itself. Moreover, because it is traded as a commodity, the price level of carbon is additionally influenced by a multitude of other factors in the non-regulatory environment, such as electricity and fuel prices, technological developments, allowance banking restrictions, and general economic activity (Blyth & Bunn, 2011). We assumed that carbon price uncertainty stems from the difficulty to forecast the future EUA price in the long and/or short term. Thus, the corresponding price uncertainty index consisted of two equally weighted items: perceived uncertainty about "long-term price development" and "short-term price volatility". The answers were aggregated into one variable to represent the extent to which companies perceived uncertainty about carbon price developments.

Finally, we introduced a binary variable, "investment history", to measure whether a company had, in previous trading years, invested in abatement measures. To account for investment decisions preceding 2007, we drew on data from the survey conducted in 2006. For the second observation we used investment data from trading phase I and related it to the year 2012 (phase II).

4.3.3. Control variables

Our analyses included additional regressors to control for other possible influencing factors besides the hypothesized effects. The variable "abatement cost knowledge" was integrated, since we expected that the degree to which companies were aware of the overall costs of alternative abatement measures affected their investment decisions regarding technological abatement solutions (Smale, Hartley, Hepburn, Ward, & Grubb, 2006). The expertise of respondents served as proxy for this control variable. Respondents were asked to state to what extent they were familiar with the company's costs of reducing CO_2 emissions: "not at all", "more or less", "fully".

"Company size" has been identified as an important determinant of investment volume in general, including investments seeking to improve a firm's environmental performance (DeCanio & Watkins, 1998; Moon, 2007). Survey respondents were asked to indicate the company's size by choosing between three options: small (up to 49 employees), medium (between 50 and 249 employees), and large (250 and more employees).

Prior research has demonstrated that operating internationally provides stronger incentives for companies to adopt more environmentally sustainable behaviors, independent from regulations and inherent uncertainty (Christmann & Taylor, 2001). One reason for this is that internationalization implies exposure to pressures from a broadened range of institutions and external stakeholders (Kostova & Zaheer, 1999). Moreover, in the face of intensified (international) competition, the pursuit of a proactive environmental strategy can be a source of competitive advantage (Russo & Fouts, 1997). "Internationalization" was approximated by a binary variable, indicating whether companies owned subsidiaries in other countries.

We further included the variable "compliance status" to control for the potential effect of a company having already achieved regulatory compliance. In particular, we considered companies with sufficient or excess permits to be compliant with the EU ETS. In this case, firms have fewer incentives to invest (further) in emission abatement (Clò, 2010; Neuhoff et al., 2006). Compliance status was operationalized by the emission-to-cap ratio, calculated as the difference between allocated allowances and verified emissions per company and year. Companies could either be in a short, long, or balanced position. A short position indicated that, at the end of a trading year, the need for allowances surpassed the initially free allocated amount of allowances. A long position implied an excess of allowances. In a balanced position, verified emissions equaled allocated emissions.

Finally, we included several dummy variables to control for year effects ("Year 2012" and "Year 2007"), country effects ("Germany", "United Kingdom", "Denmark", and "Netherlands"), and sector effects ("Energy sector", "Pulp & paper", "Manufacturing", and "Services & others"). Accounting for year effects was important, especially due to the financial crisis that occurred during the second phase of the EU ETS and that could have impacted companies' investment behavior in various ways. The economic crisis resulted in significant reductions of total greenhouse gas emissions and, as a result, in the decline of the carbon price (EEA, 2010), which ultimately may have discouraged companies from investing in abatement measures. However, while the overall economic downturn could have generated general investment reluctance, the cut in key interest rates may have actually spurred investments.

4.4. Model estimation

Since our dependent variable was binary, in line with prior work on strategic investments, we used a probit model to test whether a set of variables influences companies' investment propensity (Bocquet, Le Bas, Mothe, & Poussing, 2013; Hoetker, 2007). The following model is estimated:

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$$Abate\_invest_{i,t} = \beta_0 + \beta_1 \mathrm{Regulatory\_}unc_{i,t} + \beta_2 \mathrm{Regulation} - induced\_unc_{i,t} + \beta_{3 Invest\_hist_i} + \beta_{4 Invest\_hist_i} {*}\mathrm{Regulatory\_}unc_{i,t} + \beta_{5 Invest\_hist_i} {*}\mathrm{Regulation} - induced\_unc_{i,t} + \beta_6 Abat\_know_{i,t} + \beta_7 Size_{i,t} + \beta_8 Internat_{i,t} + \beta_9 Alloc\_pos_{i,t} + \beta_{10} Energy\_sector_{i,t} + \beta_{11} Paper\_sector_{i,t} + \beta_{12} Manufact\_sector_{i,t} + \beta_{13} Year\_2012_{i,t} + \beta_{14} Germany_{i,t} + \beta_{15} UK_{i,t} + \beta_{16} Denmark_{i,t} + e_{i,t}$$

For this model, i and t represented the observed company and year respectively. For the basic model calculation, the dependent variable, abatement investment, was regressed on the control variables (Table 4, Model 1). In the next stage, we introduced each independent variable and interactions separately (Models 2 to 6). The full model was estimated by simultaneously regressing the dependent variable on all independent and control variables (Model 7). We estimated the regression with firm-clustered standard errors to control for firm specific effects. This is suitable when the sample consists of a high number of firms relative to the number of year, industry, and country controls (Petersen, 2009). We included two widely used concordance measures: Somer's D and Kendall's Tau (Peng & So, 2002). Finally, we tested for multicollinearity by calculating variance inflation factors.

In addition, we conducted several different calculations in order to check the robustness of our model. As a means of evaluating if single year observations influence our results, we conducted a probit regression for each of the trading years 2007 and 2012 separately. We also calculated the model with stepwise removal of control variables in order to examine whether the main results were strongly dependent on certain controls.

5. Results

Table 3 reports the descriptive statistics, including means and standard deviations. Correlations between variables can be found in the appendix. Results of the probit regression are presented in Table 4. Hypothesis 1 suggests a negative influence of perceived regulatory uncertainty on investment decision in abatement measures. We do not find support for this hypothesis since the coefficients for the corresponding variable are negative but insignificant.

Hypothesis 2 predicts that perceived regulation-induced uncertainty positively relates to investment in abatement measures. Our results support this hypothesis since the coefficients of the variable “regulation-induced uncertainty” are positive and significant throughout all models (e.g., Model 7, $\beta_2 = 0.30$, $p < 0.05$).

Hypothesis 3 posits that, independent of regulatory or regulation-induced uncertainty, investment history should influence a firm's investment in abatement measures. Indeed, we find support for this hypothesis, since investment history shows a consistently strong and statistically significant positive relation with future investment propensity (e.g., Model 7, $\beta_3 = 0.73$, $p < 0.05$).

Finally, hypotheses 4a and 4b suggest a moderating effect of firm's prior investments on the relationship between regulation-induced uncertainty and firm investments. We do not find support for either hypothesis since the coefficients for the interaction terms in Models 5 to 7 are insignificant.

Regarding the control variables, firm size has a significantly positive impact on investment decision, but only for Models 1 to 3. Energy sector affiliation is negatively related to the propensity to invest, which may be the result of lower investment incentives due to the sector's high degree of ability to pass carbon costs through to consumers (for a review see Laing, Sato, Grubb, & Comberti, 2014). However, statistical significance only holds for Model 1. In contrast, companies that operate in the pulp & paper sector have increased their propensity to invest in carbon abatement, except for Model 1. Dummy variables for year and country are significant throughout all models. More specifically, all firms show a higher investment propensity in 2012, while firms based in Denmark and the United Kingdom are more prone to invest in carbon abatement. None of the other control variables shows significant coefficients, whereas the relation between the constant and the dependent variable is persistently negative and statistically significant.

The results remain stable throughout all alternative models. Single year observations, as well as models with a lower number of control variables, do not bring about substantial changes in statistical significance or coefficient values of the main results. Variance inflation factors never exceed a value of five, indicating a low probability that multicollinearity exists[3].

6. Discussion

6.1. Implications for the uncertainty-investment debate

Our study makes two main contributions to the research on the relationship between regulation-related uncertainty and investments. First, we show how different types of uncertainty may affect corporate investments differently. We find that when distinguishing between the two types of perceived uncertainty – regulatory and regulation-induced uncertainty – the latter increases investment propensity while the former does not show any significant effect. These findings suggest that companies primarily invest in abatement measures if the uncertainties they face cannot be eliminated or reduced in an alternative, more cost-effective way. In the case of regulatory uncertainty, firms may not need to invest in abatement measures when they can engage in lobbying and/or wait-and-see strategies. While we expected firms to reduce investments in times of regulatory uncertainty, our finding that firms do not change their investment behavior may indicate that, especially in the case of the EU ETS, firms had ample opportunities to shape the regulatory framework (Pinkse & Kolk, 2007). In contrast to this, regulation-induced uncertainty – such as uncertainty about carbon prices – encouraged firms to invest in abatement measures, to eliminate their exposure to risk. We argue that this is the case because firms lack alternative means of dealing with or reducing these uncertainties. Our study thus indicates that differentiating between different types of uncertainties may be important to reconcile the contradicting results in the literature studying the uncertainty–investments relation.

Second, our study highlights the important role a firm's history plays in driving firm investments in times of regulation-related uncertainty. Previous research in other contexts has widely demonstrated that firms' past and future investment behavior is related, because firms tend to do “more of the same” (Dierickx & Cool, 1989). In line with this research, we show that firms that have previously invested in abatement technologies show a significantly higher likelihood of making additional future investments. Interestingly, however, we find that this effect is independent of the perceived regulation-related uncertainty. Contrary to our expectations, previous investments in abatement measures do not enhance firms' propensity to make abatement investments

[3] Results of robustness checks are available upon request.

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Table 4
Results of probit regression for abatement investment (company level).

Explanatory Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Regulatory uncertainty		−0.07			−0.04	−0.05	−0.03
		(0.08)			(0.11)	(0.10)	(0.11)
Regulation-induced uncertainty			0.18**		0.23**	0.30**	0.30**
			(0.09)		(0.10)	(0.13)	(0.13)
Investment history[a]				0.54***	0.57**	0.69***	0.73**
				(0.14)	(0.24)	(0.22)	(0.30)
Investment history × regulatory uncertainty					−0.03		−0.04
					(0.19)		(0.19)
Investment history × regulation-induced uncertainty						−0.16	−0.70
						(0.20)	(0.20)
Abatement cost knowledge	0.07	0.10	0.10	0.03	0.05	0.05	0.05
	(0.07)	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)
Size	0.17*	0.19**	0.17*	0.13	0.14	0.13	0.13
	(0.10)	(0.10)	(0.10)	(0.11)	(0.11)	(0.11)	(0.11)
Internationalization[a]	0.17	0.15	0.18	−0.01	0.02	0.03	0.03
	(0.16)	(0.16)	(0.16)	(0.17)	(0.17)	(0.17)	(0.17)
Allocation position	0.01	0.01	0.00	0.00	−0.02	−0.02	−0.02
	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)	(0.07)
Sector[a,b]							
Energy	−0.39*	−0.34	−0.35	−0.35	−0.29	−0.30	−0.30
	(0.23)	(0.24)	(0.23)	(0.24)	(0.26)	(0.26)	(0.25)
Pulp & paper	0.41	0.45*	0.48*	0.50*	0.60**	0.59**	0.59**
	(0.26)	(0.27)	(0.27)	(0.28)	(0.30)	(0.30)	(0.30)
Manufacturing	−0.09	−0.03	−0.04	−0.12	−0.08	−0.08	−0.08
	(0.21)	(0.22)	(0.22)	(0.22)	(0.23)	(0.23)	(0.23)
Year 2012[a,c]	0.24**	0.30***	0.31***	0.23*	0.32**	0.32**	0.32**
	(0.11)	(0.12)	(0.12)	(0.13)	(0.14)	(0.14)	(0.14)
Location[a,d]							
Germany	0.08	0.06	−0.00	0.14	0.04	0.04	0.04
	(0.26)	(0.26)	(0.27)	(0.27)	(0.27)	(0.27)	(0.27)
United Kingdom	0.80***	0.78**	0.72**	0.87***	0.73**	0.72**	0.72**
	(0.31)	(0.30)	(0.31)	(0.31)	(0.32)	(0.32)	(0.32)
Denmark	0.70**	0.69**	0.68**	0.69**	0.63*	0.63*	0.63*
	(0.31)	(0.31)	(0.31)	(0.32)	(0.32)	(0.32)	(0.32)
Constant	−1.00**	−1.08**	−1.20***	−1.07**	−1.28***	−1.29***	−1.30***
	(0.42)	(0.42)	(0.42)	(0.43)	(0.45)	(0.45)	(0.45)
N	524	516	516	437	429	429	429
Chi^2	50.06***	55.23***	57.57***	62.21***	66.12***	68.11***	68.12***
Somer's D	0.33	0.33	0.33	0.47	0.50	0.50	0.50
Kendall's Tau	0.15	0.15	0.15	0.22	0.23	0.23	0.23

Note: Regression results are reported on the company level. The numbers of observations vary due to missing values.
Standard errors are reported in brackets.
Significance levels: *$p < 0.1$. **$p < 0.05$. ***$p < 0.01$.
[a] Dummy variables, applicable = 1.
[b] Reference variable: Services & others.
[c] Reference variable: Year 2007
[d] Reference variable: Netherlands.

in the context of both regulatory and regulation-induced uncertainty. While one might expect firms with history in abatement technologies to be more inclined to invest during periods of uncertainty, our findings do not support this view. Instead, regulation-induced uncertainty proves effective in stimulating abatement investments for firms irrespective of their prior investment experience. This implies that firms without an according investment history might feel compelled by regulation-induced uncertainty to address their inert abatement investment behavior.

6.2. Limitations and future research

Our study has several limitations, which open up avenues for further research. First, a question of key importance is whether our findings are generalizable to a wider set of environmental regulations other than emission trading systems. Policy makers made use of a large number of different policy instruments, such as taxes or standards. We would argue that, similar to the EU ETS, these instruments exhibit uncertainty about the design of a regulation (e.g., the actual taxing mode, exemptions, etc.), but also about developments in the non-regulatory environment (e.g., changes in energy prices and general competitive effects) (Hoffmann et al., 2008; Kolk & Pinkse, 2005). Therefore, we would expect these instruments to have similar effects in the non-regulatory environment, as in the case of a certificate trading system, with the sole distinction that there is no flexible pollution price and therefore no uncertainty about the price. Nevertheless, we concede that our findings' generalizability may be restricted in the way that they only hold within an already existing regulatory setting subject to ongoing amendments. In a case where uncertainty spawns from the initiation of new environmental policies, regulatory uncertainty might be more strongly related to abatement investments (Jotzo, Jordan, & Fabian, 2012).

Second, the persistently negative and statistically significant relation between the constant and the dependent variable points to the existence of other determinants influencing investment decision in periods of regulation-related uncertainty, which were not identified by our model. Moreover, our investigations illustrate companies' attitudes towards abatement investments at a point in time which is closest to the next expected policy stage (i.e. the start

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of a new trading phase) and is, as such, characterized by a high degree of uncertainty (Blyth et al., 2007b). It might be of interest for future research to reverse this logic and examine companies' willingness to invest after characteristics and targets of a new policy stage have just been set.

Third, future research may conduct a more fine-grained analysis regarding different investment types and properties. For instance, the innovation impact of environmental policy can vary across technologies (Rogge et al., 2011) and may include different investment types aimed at the reduction or prevention of environmental impact. Another distinction could be made between reversible and irreversible investments. It appears likely that under uncertain conditions companies prefer abatement investments with a higher degree of reversibility (Bell & Campa, 1997; Dixit & Pindyck, 1994). Future research may also account for the size of investments: given that small- and large-scale investments require diverse degrees of financial resource commitments (Hoffmann, 2007), and investment cycles vary across technologies (Egenhofer, 2007), one may speculate that they are differently affected by uncertainty appertaining to environmental regulation.

Finally, we measured uncertainty in a way that allowed us to distinguish between the different dimensions of uncertainty and that was easy to understand for the survey's participants. Other papers have used more comprehensive measures of uncertainty, including Likert scales. Future research could utilize alternative measurements of uncertainty and build upon our research to provide additional insights into how different dimensions and manifestations of uncertainty impact corporate investments.

7. Conclusion

Previous research has highlighted the important role of uncertainty for business planning – both in general as well as in the regulatory context. Analyzing survey data from a sample of EU ETS-participating companies across different industries, countries, and trading years, this article adds two new aspects to our knowledge regarding the relationship between regulation-related uncertainty and corporate investments. First, we show that different types of regulation-related uncertainty may differently trigger firm investments in abatement technologies. Specifically, regulation-induced uncertainty (e.g., uncertainty in carbon prices) has a positive effect on corporate abatement investments, while we do not find an effect of regulatory uncertainty (e.g., uncertainties about political processes). Second, we identify investment history as an important factor that affects firms' propensity to invest in abatement technologies – independently of the presence of regulation-related uncertainties. We cannot contest the possibility that more stringency and more certainty about the long-term direction and concrete design of a policy itself would further accelerate abatement investments in the business world. However, by disentangling different dimensions of uncertainty and by adding the component of investment history to this specific debate, our study provides evidence that uncertainty of environmental regulations might be less relevant for corporate abatement investments than is often argued by practitioners.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.emj.2016.06.004.

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