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The role of the regulatory framework for innovation activities: The EU ETS and the German paper industry

Fraunhofer ISI

Abstract

Based on a research framework which combines environmental economics and innovation studies, we explore the relevance of the regulatory framework for innovation activities in the German paper industry, with a focus on climate policies. Innovation activities considered include research and development, adoption and organizational change. Empirically, we mainly rely on the survey data of paper producers and technology providers. Findings suggest that innovation activities are mainly governed by market factors and (as yet) are hardly affected by the European Emission Trading System and other climate policies. Also, the impact of these policies on innovation activities is lower for technology providers than for paper producers. However, the majority of companies expect the effects of the regulatory climate policy framework on innovation to increase by 2020.

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1 Introduction[1]

In 2005, the EU launched the EU Emission Trading System (EU ETS) as its key climate policy instrument in addressing climate change (EU 2003).

The EU ETS represents a market-based instrument and as such is the preferred choice of economists, because putting a price tag on carbon emissions is expected to result in cost-efficient outcomes and to provide adequate innovation incentives to adopt and develop new, more energy- and carbon-efficient technologies and services (Baumol and Oates 1988, Requate 2005). Thus, the EU ETS reflects a demand-oriented regulation which leaves the technology selection process to the market rather than to the regulator (see Box).

Building on theoretical environmental economics literature (e.g. Malueg 1989, Jung et al. 1996, Fischer et al. 2003), the innovation impact of the EU ETS was expected to be rather low in its first phase (Gagelmann and Frondel 2005, Schleich et al. 2009). This anticipated limited impact is traced back to the scheme's design features (Schleich and Betz 2005, Schleich et al. 2009). However, the empirical evidence on the actual innovation impact is limited and focuses – with the exception of Pontoglio (2010) – on the power sector. For this sector, studies show that initially the EU ETS' actual effects on technological innovation have been limited, but that the scheme resulted in noticeable organizational changes (Hoffmann 2007, McKinsey&Company and Ecofys 2006, Rogge and Hoffmann 2010, Rogge et al. 2011, Cames 2010).

In this paper, we intend to expand the understanding of the innovation impact of the EU ETS for industry sectors, using the case of the German pulp and paper industry. In doing so, we apply a research framework that takes into consideration not only the EU ETS, but also other policies of the regulatory framework, market factors and public acceptance (Rogge et al. 2011).Our descriptive anal-

1 This research was funded by the German federal state of Baden-Württemberg within the research program "Lebensgrundlage Umwelt und ihre Sicherung". The study also benefited from a parallel research project on the innovation impact of international climate policy jointly conducted by Fraunhofer ISI and ETH Zürich and funded by the Volkswagen Foundation. The paper has been accepted for publication in: International Journal of Technology Policy and Management, Special Issue on "Laws, Regulation and New Product Development – the Role of the Regulatory Framework for the Management of Technology and Innovation, edited by A. Brem, J. Horbach and K. Rennings. We are indebted to two anonymous reviewers and to Klaus Rennings for their insightful comments and suggestions.

ysis is based on a survey of German paper producers which participate in the EU ETS, as well as their technology providers.

The remainder of the paper is organized as follows. Section 2 describes the German pulp and paper sector in the context of the EU ETS. Research framework and methodology appear in sections 3 and 4, respectively. Empirical findings are presented in section 5 and discussed in section 6. Section 7 offers conclusions.

2 The German pulp and paper industry in the EU ETS

The pulp and paper industry in Germany is the largest in Europe and comprises about 180 companies and 42,000 employees (VDP 2010). Most companies are small and medium-sized, with large companies contributing most to the total turnover of the industry. Total turnover in 2009 was about € 12.5 billion, and total output around 21 million tonnes. Graphic paper and packaging paper and board account for a production share of ca. 44% each, while the share of sanitary and household paper and of other paper and board products is about 6% each. Germany exports about 60% of its pulp and paper products and imports most of the pulp used (54%).

Box: The EU ETS and incentives for innovation

The EU ETS currently covers about 11,000 large greenhouse gas emitting installations in the energy and industry sectors and represents the world's largest and first multi-country emission trading scheme (Skjaerseth and Wettestad 2008). The EU ETS is made up of consecutive phases, which differ by duration, stringency and allocation rules.

Installations participating in the EU ETS are issued emission allowances (EUA) and companies must surrender the number of allowances equivalent to the amount of emissions caused by their installations during a particular year. Otherwise, they have to pay sanctions. Companies may emit more emissions than their initial allocation of allowances if they purchase extra allowances on the market. Likewise, companies have an incentive to reduce emissions in order to sell their surplus allowances, as long as the costs of their abatement measures are below the price for allowances. To fulfill their obligations under the EU ETS, companies may also use credits from offsets, such as emission reduction projects in developing countries under the Clean Development Mechanism

(CDM). In phase 1 there was no limit on the use of such offsets in Germany, while in phase 2 their use is restricted to 22% of a company's allocation. Unless international climate negotiations progress sufficiently, no additional offsets will be allowed in phase 3, but companies may transfer credits from offsets from phase 2.

The price for allowances also sets monetary incentives to adopt new, more energy- and carbon-efficient technologies and services, and to develop fundamentally new or significantly improved solutions. Incentives for innovation are not only driven by the allowance price which reflects the stringency of the emission target (the cap), but also by the actual rules for allocating allowances[2].

In the first phase (2005-2007), EUA allowance prices averaged around €15/EUA in 2005, but dropped significantly once it became known that the amounts of EUA allocated (ET budget) were substantially larger than verified emissions (Betz et al. 2006, Ellerman et al. 2010). In phase 2 (2008-2012), due to stricter emission budgets (e.g. Schleich et al. 2009), the price for EUAs reached a level of around €25 in early 2008. In response to the economic crisis, the price for EUAs dropped in the fall of 2008 to a level of €15/EUA and below. Current prices for futures for 2013 range around €13 /EUA, but the stringency of the ET budget in phase 3 will also depend on the future progress of international climate negotiations.

The following types of installations from the pulp and paper industry are obliged to participate in the EU ETS: installations for producing pulp from timber or other fibrous materials and installations to produce paper or cardboard with a production capacity exceeding 20 tonnes per day. In addition, since many pulp and paper producers rely on onsite heat and electricity generation (often from CHP), their combustion installations with a rated thermal input capacity of at least 20 MW are covered by the EU ETS as well. With currently 129 installations for paper production (incl. 5 for pulp production) participating in the EU ETS in Germany, the sector is in third place behind the energy sector with more than 1,000 installations and the ceramic sector with 137 installations (DEHSt 2010), and accounts for about 15% of all European pulp and paper installations participating in the EU ETS (DEHSt 2010, EU 2010). Pulp and paper installations ac-

2 See Schleich et al.(2009) for a detailed analysis of the incentives of key design features in the EU ETS for innovation.

count for about 6% of emissions by industrial installations and 1.6% of overall emissions covered by the EU ETS in 2008 (in Germany 1.3%).

In phase 1 and 2 of the EU ETS (2005-07, 2008-12) pulp and paper mills received allowances needed to cover emissions from their existing and new installations free of charge. Table 1 summarizes the general allocation rules for existing and new installations in the pulp and paper sector (and for CHP installations) in Germany for the different phases.

Table 1: General allocation rules for installations in the pulp and paper sector

	Phase 1 (2005-2007)	**Phase 2 (2008-2012)**	**Phase 3 (2013-2020)**
Existing installations			
Pulp and paper	Free allocation based on either average emissions in base period (2000-2002), adjusted downward by 7.4%, or based on projected emissions calculated via installation-specific BAT emission factor and projected capacity use	Free allocation based on average emissions in base period (2000-2005), adjusted downward by 1.25%	Free allocation based on EU-wide product-specific emission benchmarks by paper product types and on historic production levels
CHP	Same general rule as for pulp and paper installations, but additional free bonus allocation for co-generated electricity	Free allocation based on separate emission benchmarks for electricity and heat and on historic capacity use	Free allocation based on EU-wide emission benchmark for heat and on historic production; no free allocation for electricity
New installations			
Pulp and paper	Free allocation based on installation-specific BAT emission factor and on projected capacity use	Free allocation based on installation-specific BAT emission factor and on standardized capacity use	Free allocation based on EU-wide emission benchmarks by paper product types and on standardized capacity use
CHP	Free allocation based on separate benchmarks for electricity and heat and on projected capacity use	Free allocation based on benchmarks for electricity and heat and on standardized capacity use	Free allocation based on EU-wide benchmark for heat and on standardized capacity use; no free allocation for electricity

Further, for small emitters (< 25.000 t CO_2 per year in base period) the adjustment factor of 1.25% (see Table 2) is not applied in phase 2. About half the installations in the German pulp and paper sector benefited from this rule. As Table 2 shows, free allocation significantly exceeded actual verified emissions in Germany and at the EU level, in particular in phase 1 (see also DEHSt 2009a, 2009b, 2010). Also, paper producers have made only limited use of credits from CDM projects.

Table 2: The German paper industry in the EU ETS

Country	Trading period	Allowances distributed	Share DE	Verified emissions	Share DE	Surrendered allowances	Share DE	Surrendered CERs	Share DE	Surplus allocation	
		[EUA]	[%]	[t CO_2e]	[%]	[EUA]	[%]	[CER]	[%]	[EUA]	[%]
EU	Ø 2005-07	37,137,663		29,769,041		31,426,031		0		7,368,622	19.8%
	2008	37,798,802		31,352,095		28,745,603		2,218,337		6,446,707	17.1%
DE	Ø 2005-07	7,107,822	19.1%	5,220,326	17.5%	5,241,075	16.7%	0	-	1,887,496	26.6%
	2008	6,780,794	17.9%	6,033,271	19.2%	5,612,382	19.5%	448,377	20.2%	747,523	11.0%

Source: Own calculations based on EU (2010)

Allocation rules for phase 3 foresee that the share of free allocation be phased out from a level of 80% by 2013 to 30% in 2020 and to 0% in 2027. However, installations from the pulp and paper sector and from other sectors which face international competition from regions which do not implement comparable climate policies will not be subject to the “free allocation phase out factor” and will continue to receive a high share of allowances for free. No additional factor will be applied to the number of free EUAs determined via EU-wide product-specific benchmarks (last column in Table 2). Pulp and paper installations emitting less than 25.000 t of CO_2 per year may be excluded from the EU ETS from 2013 on, but the specific conditions for such an opt-out will not be known until 2011.

3 Research framework

In order to investigate the innovation impact of the EU ETS, we rely on Rogge et al. (2011) and employ a research framework which combines insights from environmental economics (Jaffe et al. 2002, Popp et al. 2010) and innovation studies (Fagerberg and Verspagen 2009).

Following the Oslo Manual (OECD 2005), we differentiate between three main innovation dimensions: research, development and demonstration (RD&D), adoption and organizational change. The first two dimensions are used in neoclassical and evolutionary economics (Oltra and Saint Jean 2005, Requate

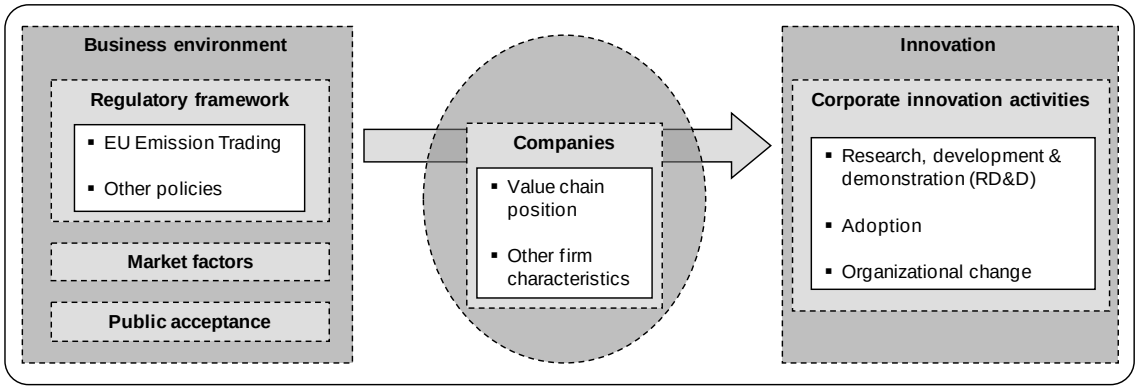
2005). RD&D activities encompass basic laboratory research, the testing of a new technology in pilot projects and the first large-scale demonstration of a new technology. For adoption, we differentiate between the investment in new plants and modernization of existing plants. For the third dimension, organizational change, which originates from innovation studies (Armbruster et al. 2008, Christensen and Rosenbloom 1995, Edquist 1997), we distinguish between procedural, structural and vision change.

The research framework differentiates between firm-external and firm-internal determinants in the business environment of companies (del Río González 2009, Horbach 2008). Regarding firm-external determinants, we distinguish between the regulatory framework, market factors and public acceptance. The regulatory framework does not only include the EU ETS, but also other policies, such as other climate policy elements, technology-specific regulations or innovation policies. Market factors address prices and availability of fuels and resources, product prices and demand, and equipment prices. Finally, public acceptance of technologies is included as a third element of the business environment because of its potential importance for companies' innovation decisions (Hekkert et al. 2007).

Since, depending on the sectoral pattern of technological change, companies from more than one value chain position are relevant for innovation (Pavitt 1984, Mazzanti and Zoboli 2006), we use the value chain position as one dimension of firm-internal determinants. Specifically, for the pulp and paper industry we distinguish between paper producers participating in the EU ETS and providers of technologies for the paper production process. Other important firm characteristics include a company's technology portfolio (Christensen and Rosenbloom 1995) or firm size, but these are not the focus of this study.

Figure 1 summarizes our research framework to study the role of the EU ETS as an element of the regulatory framework in the larger business environment to determine companies' innovation activities and how these corporate responses differ according to firm characteristics.

Figure 1: Research framework



Source: Adopted from Rogge et al. (2011)

4 Methodology

Our research design combines qualitative and quantitative methods, using a 'sequential exploratory strategy' (Creswell 2003) with an initial phase of qualitative data collection in the form of case studies (Yin 2002), followed by a survey. The case study findings form the empirical basis for constructing the survey questionnaires and help interpreting survey results. Since this quantitative phase was given a higher priority in the research design, this paper focuses on the survey results.

4.1 Company case studies

We conducted company case studies to explore the impact of the EU ETS on RD&D, the adoption of low-carbon technologies, and the integration of CO_2 into the organization. Between June 2008 and September 2009 company case studies were carried out with ten interview partners from three paper producers and four technology providers.

The company case studies consisted of an up-front detailed analysis of background information of the participating companies (e.g. press clippings, or CITL data[3]). Then, a semi-structured interview guide was tailored to the company-specific information. Interviews were typically conducted face to face, and two

[3] The Community Independent Transaction Log (CITL) webpage is available at http://ec.europa.eu/environment/ets/. Pulp and paper producers are classified within the main activity 9.

researchers were present. Afterwards interviewers combined notes into a common interview protocol which was then analyzed.[4]

4.2 Survey

In the second research phase, we conducted a survey of paper producers and their technology providers.

4.2.1 Data collection and analysis

In order to identify the paper producers to be invited to participate in the survey, we used the CITL. For technology providers we conducted a database search (particularly Creditreform Markus) via key words and industry codes. Thereby, we included all technology providers which deliver components or systems for any position of the pulp and paper production value chain.

We then called the identified companies' information desk to verify the information and gather contact details for the appropriate expert. For most paper producers, this was the manager responsible for process innovations in the business unit production / generation / technology. For companies with less than 50 employees, the appropriate contact person was the general manager. With technology providers we asked for the manager of sales / marketing.

We constructed two survey questionnaires for paper producers and technology providers, relying on three types of input.[5] First, the theoretical research framework served as the basis for finding operationalizable variables. Second, as far as possible, we adapted questions from established innovation surveys to our context. Third, we utilized the findings and sector know-how gathered through our company case studies. For quality control we asked several experts from research institutes to check the questionnaires and also conducted a pre-test with industry representatives. The surveys were implemented in the software EFS survey and conducted between November and December 2009.

To obtain a high response rate, we followed Dillman's tailored design method (Dillman, 2006). We initially sent a personal postal invitation to the contact per-

4 The data analysis and results are described in detail in Schleich et al. (2010).

5 To allow for the comparison of findings across sectors, the basis of our surveys was the survey jointly developed by Fraunhofer ISI and ETH Zurich for the power sector (see Schmidt et al. 2010).

sons of the 92 paper producers and 88 technology providers identified in the previous step, providing them with access codes. Shortly thereafter, we sent a personal e-mail invitation. A week later we sent an e-mail reminder, and two weeks later we contacted company representatives by phone. A final e-mail reminder was sent out shortly before the survey was completed.

In total, we received 19 answers from paper producers (response rate of 20.7%) and 17 from technology providers (response rate of 19.3%). As the sample is rather small, the analysis is restricted to descriptive statistics. Hence, multivariate analyses which allow controlling for other factors are not feasible. When interpreting the results it should also be kept in mind that findings are unlikely to be representative. That is, the answers of those responding to the survey may not be characteristic for the entire sectors of paper producers or technology providers.

4.2.2 Characteristics of the sample

a) Paper producers

Of the 19 pulp and paper producers who participated in our survey, only 2 companies produce pulp and paper, while the vast majority (90%) produces only paper.[6] In terms of company size, 42% employ between 50 and 249 employees, and 58% more than 250 employees. Similarly, the annual turnover of 16% of the paper producers ranges between €10 and 50 million, of 74% between €50 and 500 million and 10% are even larger. Hence, no company with less than 50 employees or turnover of less than €10 million is included in the sample.

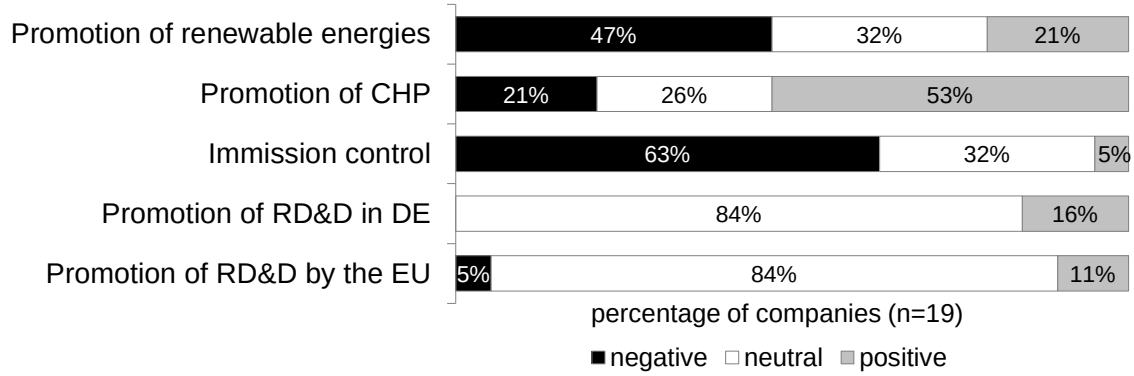
Regarding the product portfolio, 47% of the participating paper producers include graphic paper, 47% offer packaging paper, 32% supply special papers, and 16% produce some other pulp and paper products. None of the companies produces sanitary paper.

For the majority of paper producers (79%), the share of energy costs in their turnover ranges between 10% and 20% and for 11% the energy cost share is even higher, illustrating that this sector is rather energy-intensive.

6 For simplicity, we refer to the pulp and paper producers as paper producers only.

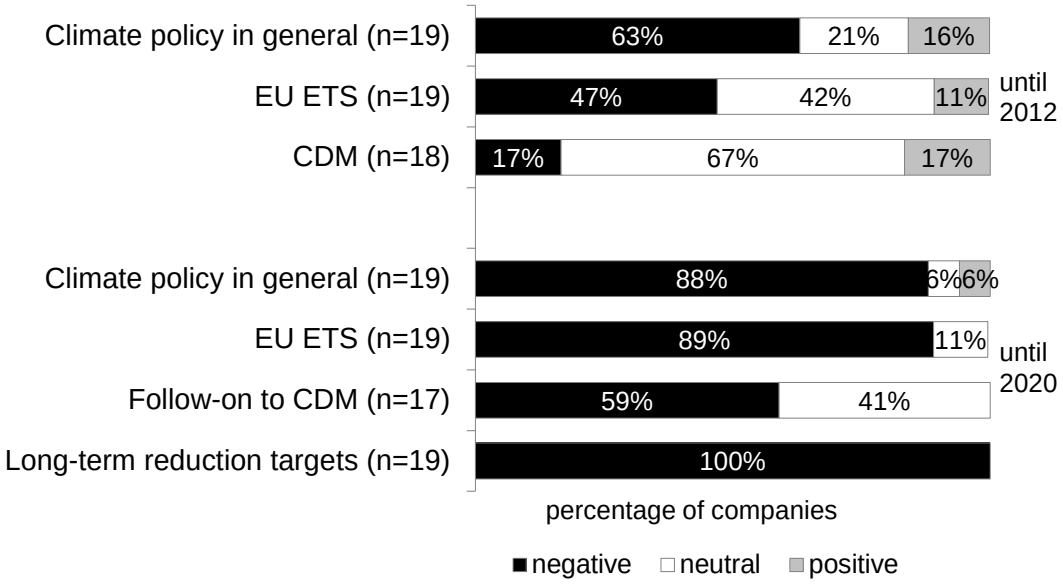
As for the effect of the regulatory framework (see Figure 2 and Figure 3), the majority of participating paper producers feel positively affected by the promotion of combined heat and power (CHP) and negatively affected by immission control regulation. In contrast, only few companies are affected by German and European RD&D policies. About half the paper producers feel negatively affected by the promotion of renewable energies.

Figure 2: Affectedness of paper producers by the regulatory framework in 2005-09



Question: Please estimate the extent to which your company was negatively or positively affected by the following aspects over the last five years (2005-2009).

Figure 3: Affectedness of paper producers by short-term and long-term climate policy



Question: To what extent is your company negatively or positively affected by the following climate policy instruments?

Regarding the affects of different climate policy elements up to 2012 perceived by paper producers,, the picture is – with the exception of the CDM – more negative than for the other regulatory framework conditions. In the longer term (until 2020), the majority of paper producers feels negatively affected by all climate policy elements, primarily by long-term targets.

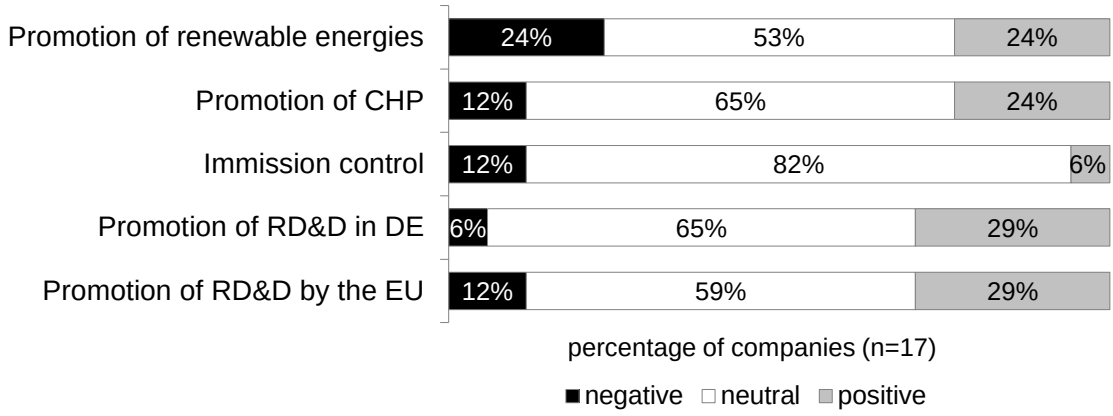
b) Technology providers

In terms of company size, the sample is more equally distributed for technology providers (n=17) than for the paper producers. The majority of technology providers are medium-sized companies (53% with 50-249 employees, 41% with a turnover of €10- 50 million about one third are small companies (< 50 employees, < €10 million turnover), and the remainder are large companies.

Regarding the product portfolio, the technology providers offer technologies for the entire production process, such as paper machines (29% of companies), systems for producing pulp (6% mechanical pulping, 18% chemical pulping, 18% recycling), drying technologies (41%), heat recovery (18%), energy management (12%) or other components and systems for the pulp and paper industry (59%).

In contrast to the paper producers, most technology providers feel unaffected by the regulatory framework conditions (see Figure 4). For all but immission control policies, the share of positively affected technology providers is larger than, or at least as large as, the share of negatively affected providers.

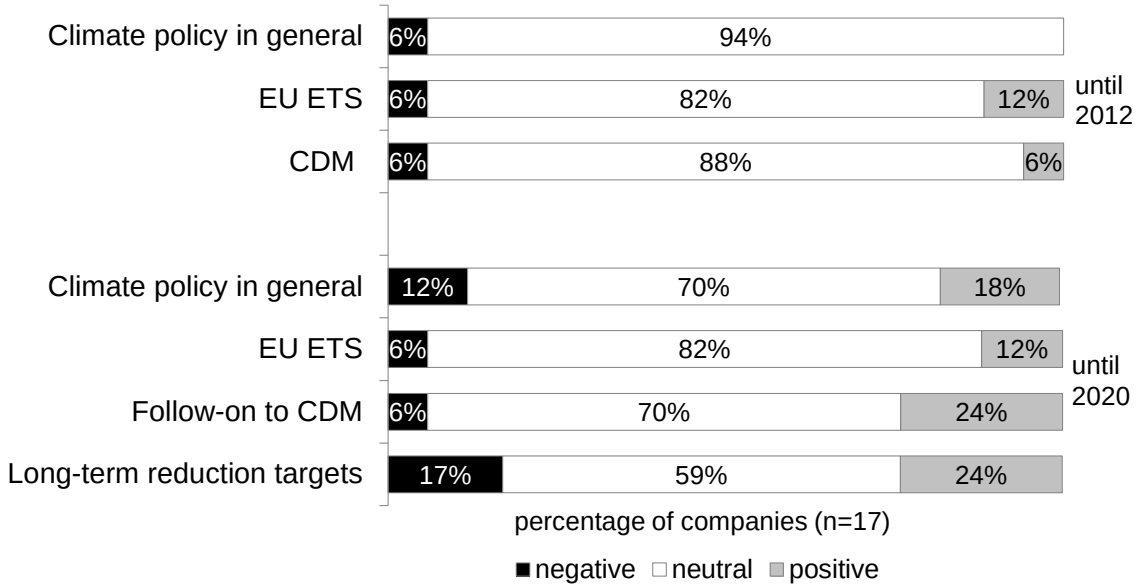
Figure 4: Affectedness of technology providers by the regulatory framework in 2005-09



Question: Please estimate the extent to which your company was negatively or positively affected by the following aspects over the last five years (2005-2009).

As for technology providers being affected by different types of climate policy, the general picture remains the same (see Figure 5): the majority of technology providers feels unaffected by climate policies, with the share decreasing from 2012 to 2020. Also, the share of technology providers feeling positively impacted by climate policies is larger than the share feeling negatively impacted.

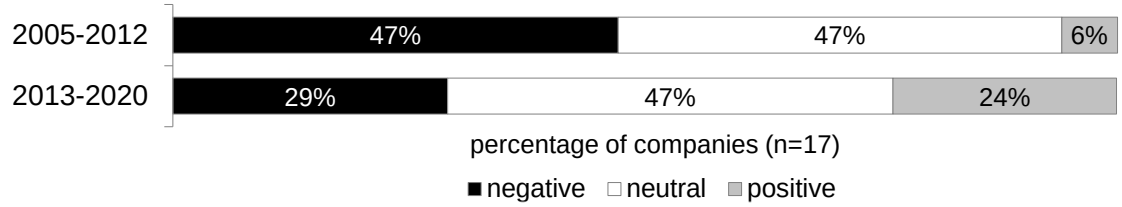
Figure 5: Affectedness of technology providers by short- and long-term climate policy



Question: To what extent is your company negatively or positively affected by the following climate policy instruments?

When comparing the long-term perceived impacts of climate policies on technology providers and paper producers, we see that the latter feel much more negatively affected (cp. Figure 3). This is confirmed by Figure 6 which shows that technology providers assign a higher negative impact by climate policies to their customers than to themselves. However, they conjecture that their customers' negative impacts will decrease in the long term, which contrasts with the paper producers' own assessment.

Figure 6: Affectedness of customers' of technology providers by climate policy



Question: Please estimate the impact of climate policy on the end users of your products: To what extent are they positively or negatively affected by climate policy?

5 Results

This section presents the main findings from our survey, focussing on the impact of the regulatory framework on the various types of innovation activities.

5.1 Technological innovation

5.1.1 Research, development and demonstration

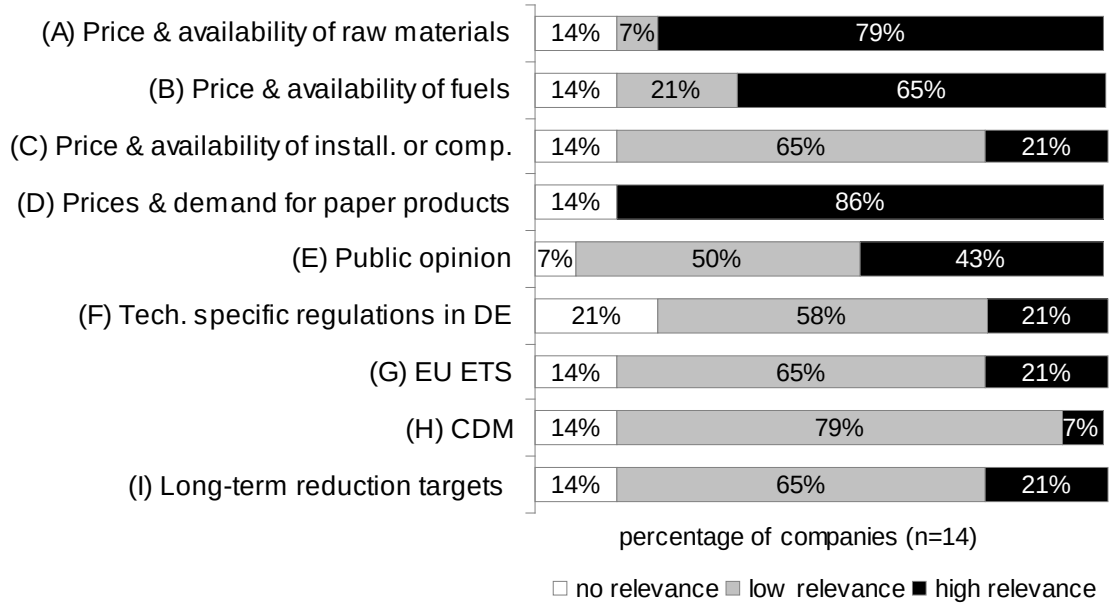
a) Paper producers

More than two thirds of paper producers (68%) invested in research, development and demonstration activities (RD&D) during the period of 2000-2009. In the year 2008, the mean share of R&D expenditures on turnover was 1.6%, while 3.3% of employees were active in R&D. During the five year period since the introduction of the EU ETS (2005-2009), about 20% of the paper producers experienced a decrease, 30% an increase and 50% no change in the RD&D investment volume compared to the five year period before.

Figure 7 shows the importance of a set of factors for paper producers' RD&D activities.[7] The most relevant factor is price and availability of paper products, followed by prices and availability of raw materials and price and availability of fuels. Hence, the three most important factors are all market factors. Public opinion ranks fourth, while the regulatory framework, including climate policies, is seen as the least relevant factor for RD&D investment.

7 Since the question does not imply a direction of the impact, the factors may be supportive or inhibitive.

Figure 7: Relevance of factors for RD&D decisions of paper producers in 2005-09



Question: What relevance did the following factors have for your company's considerations to invest in RD&D activities (incl. pilot/demo projects) over the last five years (2005-2009)?

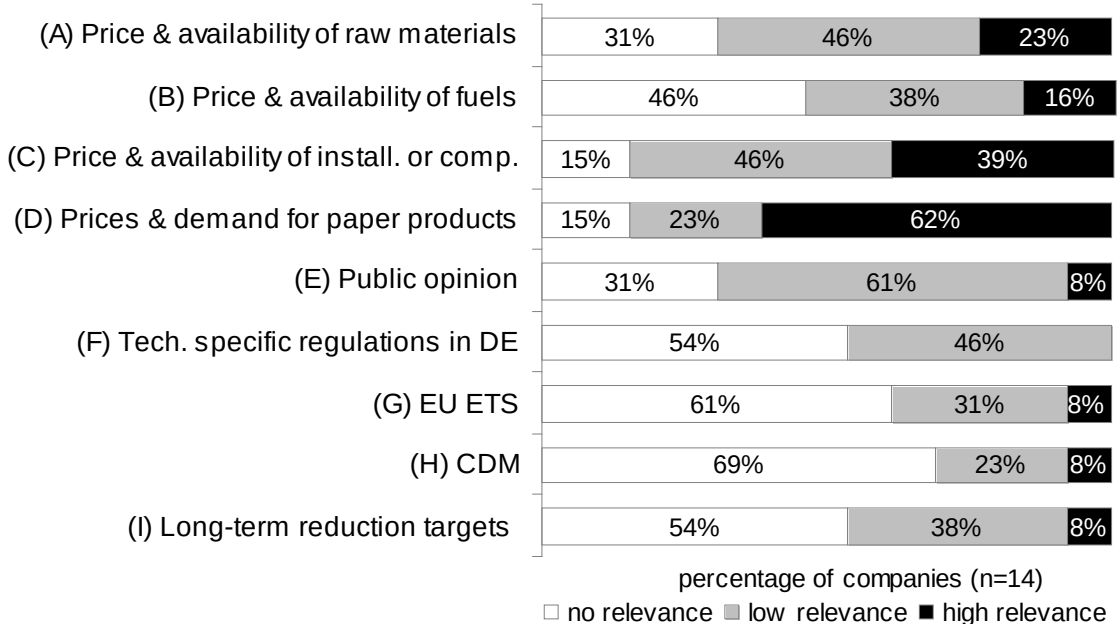
b) Technology providers

In the last 10 years (2000-2009), almost all participating technology providers (82%) have invested in RD&D for the pulp and paper industry. In 2008, the mean share of R&D investments relative to turnover was 10%, while 12% of employees were active in R&D. For about two thirds of technology providers, the investment volume in RD&D did not change from 2005-2009 compared to 2000-2004, while 20% reported a decrease and 13% an increase.

As was the case for paper producers, market factors are clearly the dominating factors for technology providers' RD&D activities (see Figure 8). Likewise, the most important factors are prices and demand for paper products. However, in contrast to paper producers, the second most important deciding factor is price and availability of installations or components. In general, the percentage of technology providers assigning a high relevance to deciding factors other than prices and demand for paper products is much lower than for paper producers. Also, the relevance of public acceptance is as low as that assigned to climate policies. In addition, technology-specific regulations in Germany hardly play a role, and are even less important than climate policies. In general, the regulato-

ry climate policy framework appears to have no relevance for the majority of technology providers in determining their RD&D activities.

Figure 8: Relevance of factors for RD&D decisions of technology providers in 2005-2009

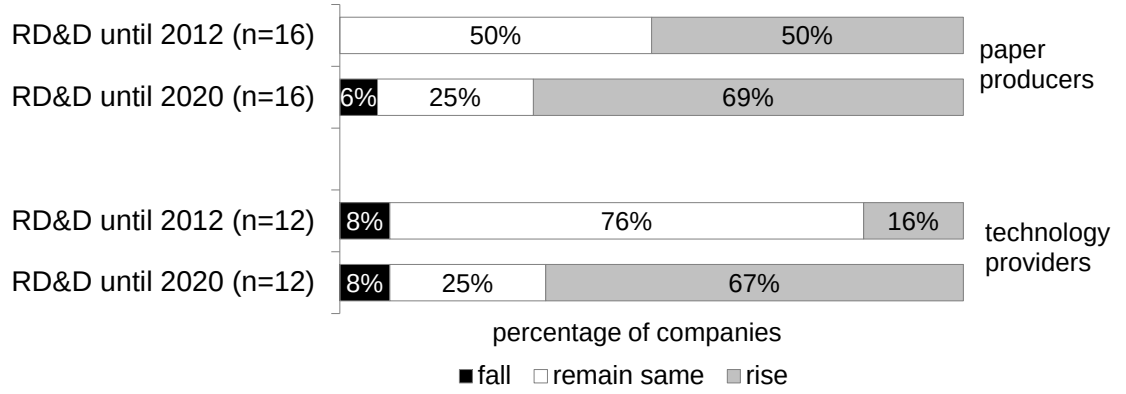


Question: What relevance did the following factors have for your company's considerations to invest in RD&D activities (incl. pilot/demo projects) for the pulp and paper industry over the last five years (2005-2009)?

c) Outlook: Role of climate policy

For the long-term future (2020), about two thirds of paper producers and technology providers expect the relevance of climate policy for their RD&D decisions to increase (see Figure 9). However, in the short term, half the paper producers and three quarters of technology providers expect no changes in the low relevance of climate policy for RD&D decisions.

Figure 9: Change in relevance of climate policy for RD&D decisions (2012 and 2020)



Question: How do you think the relevance of climate policy will change in the future for your decisions to invest in research and development for the pulp and paper production?

5.1.2 Adoption

a) Paper producers

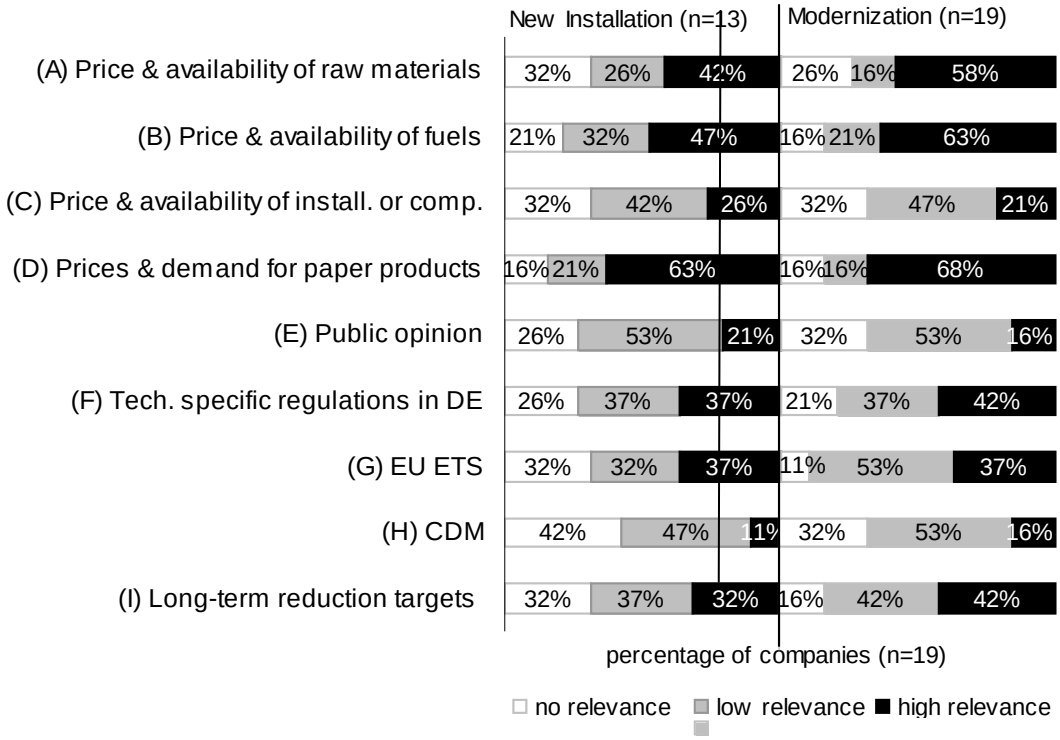
Over the period 2000-2009, all paper producers modernized (some of) their existing plants and almost two thirds invested in a new installation.

When the investment volumes before the introduction of the EU ETS (2000-2004) is compared with the first five year period after the implementation of the EU ETS (2005-2009), about half of paper producers invested less in new plants in 2005-2009 compared to 2000-2004, while almost 40% increased their investment volume and the rest kept it unchanged. The change in investment volume for modernizations shows a similar, but somewhat more dispersed pattern. About one third reported no change, while some 40% reported a decrease in modernization activities, while about 20% reported an increase.

The factors relevant for adoption decisions of paper producers in 2005-2009 show similar patterns for investments in new plants and modernization activities (see Figure 10). Market factors are most relevant both for new installations and modernizations. For most paper producers prices and demand for paper products are most relevant, followed by price and availability of fuels and price and availability of raw materials. The least relevant factors are CDM and public acceptance. The EU ETS has about the same relevance as technology-specific regulations in Germany, but appears to be slightly more relevant for modernization activities than for investments in new installations. Finally, long-term reduc-

tion targets are rated about as important as the EU ETS for both types of adoption activities.

Figure 10: Relevance of factors for adoption decisions of paper producers in 2005-2009



Question: What relevance did the following factors have for your decision to adapt your generation portfolio by investing in new facilities or investing in modernization in the period 2005-2009?

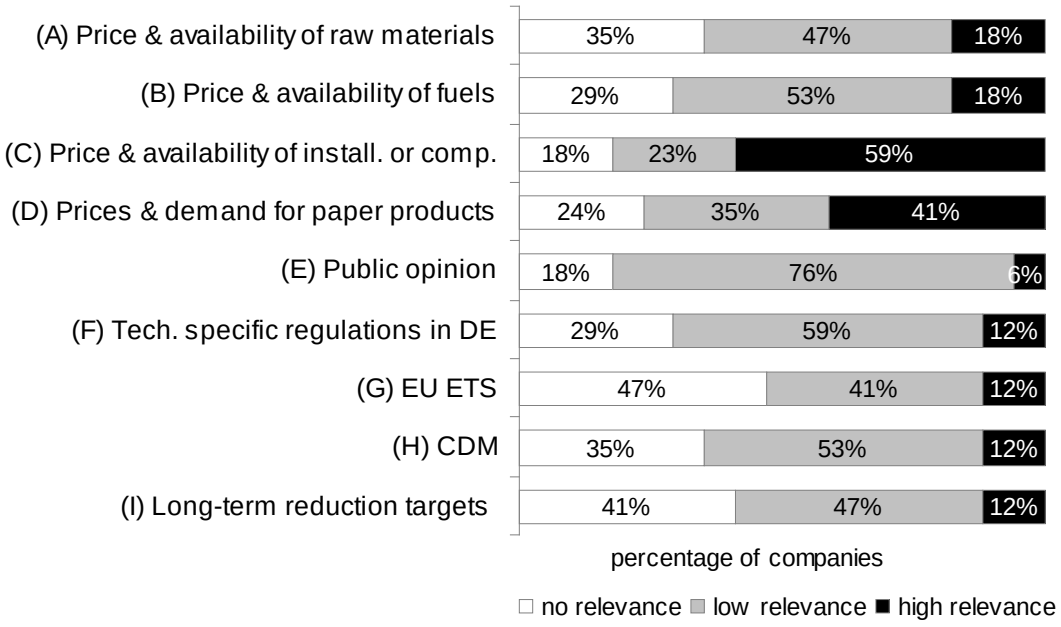
Finally, paper producers were asked about the relevance of receiving allowances for free for their decision-making for investments in new plants and modernization. The results show that about half of paper producers assign a high relevance to the free allocation of allowances for their investment decisions, while about one third see no relevance at all.

b) Technology providers

The sales of technology providers' products for the paper industry decreased for about half of the companies between the periods 2000-2004 and 2005-2009 and thus after the introduction of the EU ETS, while they increased for a third of them and remained unchanged for the rest.

Again, market factors were mentioned as the most relevant factors in the development of demand for products for pulp and paper production, with the price and availability of installations and components being most relevant, followed by prices and availability of paper products (see Figure 11). Public opinion of technologies had the lowest share of companies assigning it a high relevance, and was closely followed by the slightly more relevant regulatory framework. Among those, the EU ETS was judged to be the least, and technology-specific regulations as the most important.

Figure 11: Relevance of factors for demand development of technology providers in 2005-09



Question: What relevance did the following factors have for the overall demand development for your pulp and paper industry products over the last five years (2005-2009)?

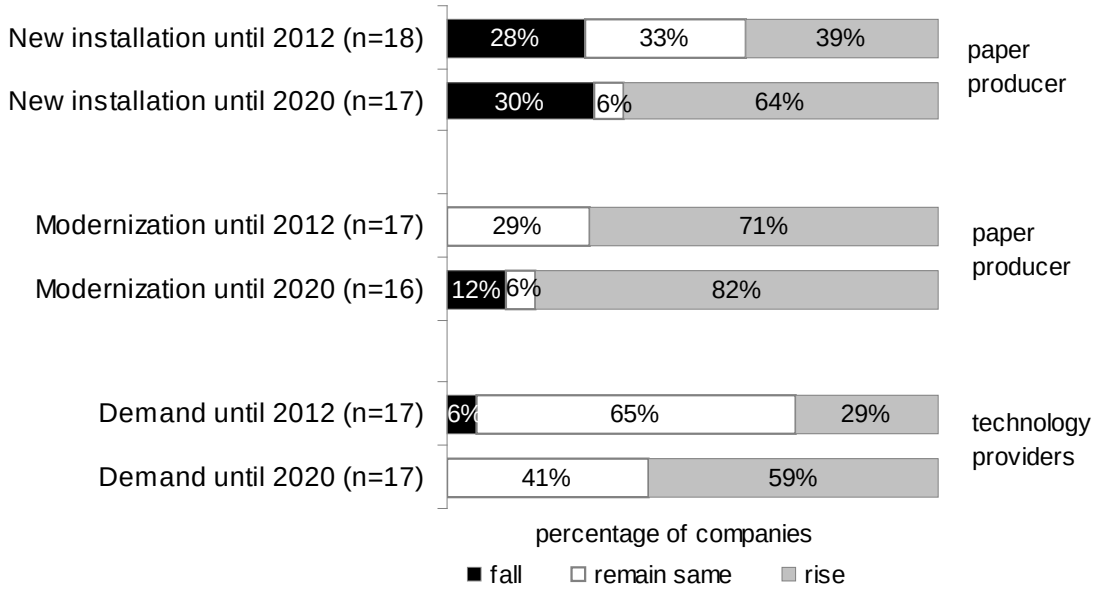
c) Outlook: role of climate policy

In general, paper producers and technology providers alike expect that the relevance of climate policy for adoption decisions will increase both in the short term (2012) and even more in the long term (2020) (see Figure 12).

Considerably more paper producers expect an increase in the relevance of climate policy for modernization activities than for investments in new plants. Somewhat less than a third of the paper producers expect the relevance of climate policy for new installations to decrease.

As for the technology providers, the majority expect no change in the relevance of climate policy on demand for the pulp and paper industry in the short term, but an increase in the relevance in the long term.

Figure 12: Change in relevance of climate policy for paper producers' adoption decisions and technology providers' demand (2012 and 2020)



Question:

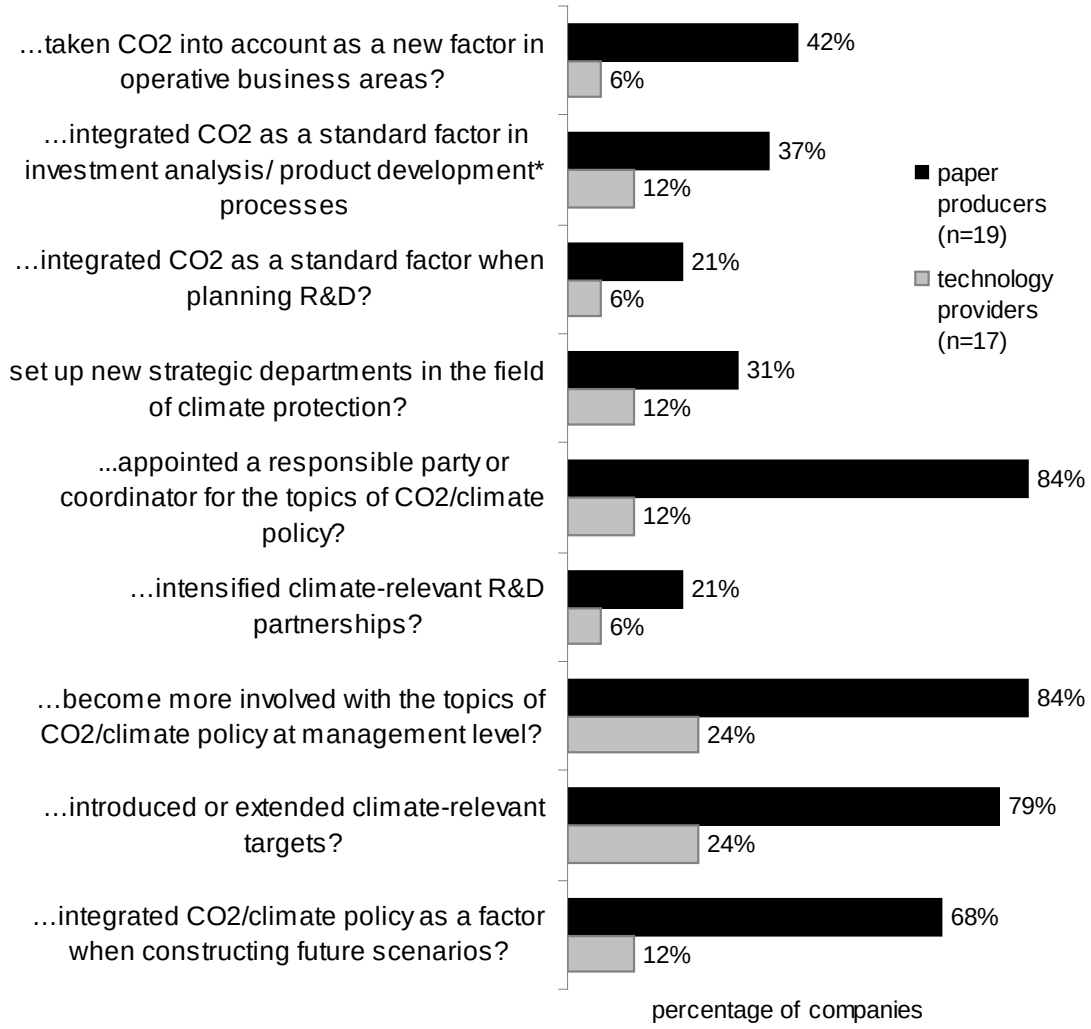
Technology providers: How will the importance of climate policy as a driver for the demand for the pulp and paper sector products change in the future?

Paper producers: How do you think the relevance of climate policy will change in the future for your decisions to invest in new installations and modernizations?

5.2 Organizational innovation

In terms of organizational innovation, our research framework distinguishes between the dimensions procedural, structural and vision change. The surveys included identical questions for paper producers and technology providers alike to capture the change in each dimension over the period of 2005-2009 (see Figure 13).

Figure 13: Organizational change of paper producers and technology providers in 2005-2009



Question: In the last five years (2005-2009) has your company…
(* product development for technology providers)

5.2.1 Procedural change

In Figure 13, the first three questions refer to procedural change. Accordingly, less than half the paper producers are now taking CO_2 into account as a new factor in their operative business or as a standard factor in investment. Several paper producers have also integrated CO_2 as a standard factor when planning RD&D activities. By comparison, hardly any technology provider reports procedural change in response to climate concerns.

5.2.2 Structural change

Questions 3 to 5 in Figure 13 refer to structural change. Accordingly, almost all paper producers have appointed someone responsible or a coordinator for CO_2/climate policy. Yet, only one out of three paper producers has set up a new strategic department in the field of climate protection, and one out of five has intensified climate-relevant RD&D partnerships. As was the case for procedural change, hardly any technology providers have changed their structures due to the new carbon constraints.

5.2.3 Vision change

The final three questions in Figure 13 relate to the dimension of vision change. Accordingly, the vast majority of paper producers stated that management level has become more involved with CO_2/climate policy and that firm-internal climate-relevant targets have been introduced over the last five years. Also, about two thirds of the paper producers have integrated CO_2/climate policy as a factor when constructing future scenarios. Compared to the other dimensions of organizational change, vision change appears to be slightly more prevalent for technology providers, but at a very low level.

To sum up, we find that paper producers have adopted or intensified more CO_2-related organizational changes than technology providers over the last five year period from 2005-2009. Also, we find that the most pronounced changes were those concerning visions.

6 Discussion

In this section we discuss the findings of our surveys. We compare them with insights gained in the company case studies (Schleich et al., 2010) and findings for eco-innovation in the pulp and paper industry (del Río González, 2005, Thollander and Ottosson, 2008).

6.1 Research, development and demonstration

Our survey results for the German paper industry show that technology providers tend to invest more money and personnel (relative to turnover and employment) in RD&D activities than paper producers. This is in line with our case study findings and confirms a supplier-dominated sectoral pattern of technologi-

cal change (Pavitt, 1984), in which technology providers are the most important for innovations in machinery. However, both survey and case study results show that paper producers are also quite active in RD&D activities, with the majority of their efforts typically focusing on product innovations and incremental process innovations.[8]

For both types of actors we find that the regulatory framework in general and the EU ETS in particular do not significantly influence RD&D activities. Instead, the survey results clearly show that market factors have the highest relevance for RD&D decisions. The case study findings indicate that ongoing CO_2-relevant research activities appear to be mainly driven by fuel prices rather than the EU ETS, but – as a side effect – may also improve the CO_2 performance of technologies.

Finally, the survey results highlight that the regulatory framework appears to be less relevant for technology providers than for paper producers, which was also indicated in the case study analysis. This may simply reflect that policies are primarily targeted towards technology users rather than towards technology suppliers, and that technology providers' main markets tend to be outside Europe. Thus, a significant reorientation of technology providers towards low- and zero-carbon technologies may largely depend on the extent to which climate policy translates into a change in global and not just European demand for their products.

6.2 Adoption

Our survey results show an overall decrease in investments or sales in the German pulp and paper industry over the last five years. This may reflect developments in the business environment, mainly connected to market factors such as decreasing paper sales and price competition due to overcapacities in the German paper industry.

The survey findings clearly show that market factors are the most relevant factors for adoption decisions, while the relevance of the regulatory framework is rather low. More specifically, technology-specific regulations targeting renewable technologies and CHP are regarded with the same low relevance as the EU

8 Unlike for example power producers, paper producers tend to significantly change the original technologies (e.g. paper machines) to customize them to the specific requirements of their product portfolio.

ETS. This is rather surprising, since findings from our case study and the few existing studies on the paper industry for other countries, notably for Spain (del Río González 2005) and Canada (Doonan et al. 2005), highlight the relevance of the regulatory framework for the adoption of sustainable technologies.

While the descriptive survey results cannot explain the reasons for the low relevance of the EU ETS for companies' innovation activities, case study findings suggest that the low CO_2-price has contributed to this finding. Also, the periodic nature of the EU ETS appears to have caused regulatory uncertainty, which conflicts with the longer investment cycles in the paper industry. Finally, we also found that paper producers seem to focus on investment costs rather than on operating costs when it comes to adoption decisions. Hence long-term operating costs which also include the (opportunity) costs for CO_2 emissions may not be fully considered in the investment appraisal, thus weakening the innovation incentives of the EU ETS.

As was the case for RD&D activities, our overall results suggest that the impact of the regulatory framework for adoption seems to be rather weak in the paper industry, in particular for technology providers.

6.3 Organizational change

Our survey results clearly show that companies directly affected by the EU ETS have realized more CO_2-related organizational change than companies that are further away from the point of regulation, i.e. technology providers. These differences in the intensity of change between paper producers and technology providers are not surprising and are also in line with the company case studies.

Despite the differences in the intensity of change, the pattern of organizational change appears to be quite similar between both actor types. The survey findings show that for both value chain positions, vision changes are by far the most prominent dimensions of organizational change. That is, since the introduction of the EU ETS in 2005, climate friendliness seems to have moved from a nice-to-have topic to the agenda of top management and may have contributed to setting firm-internal CO_2-reduction goals. When combining this finding with insights from studies pointing out the importance of management's involvement (del Río González 2005) and the existence of a long-term energy strategy (Thollander and Ottosson 2008) for the adoption of sustainable technologies, our findings suggest that the impact of the EU ETS on adoption may increase in the future.

However, so far these vision changes hardly translate into changes in the operational business of companies. This is surprising, since economic theory suggests that the introduction of a carbon price should automatically lead to a full integration in investment appraisals or other business routines. The question arises, why the new cost factor CO_2 has only partially been integrated into the operative business. The case study findings offer some potential explanations. One explanation may be the perceived difference between the real costs of trading arising from a shortage of allocated allowances, on the one hand, and the opportunity costs of CO_2 on the other hand. Other possible reasons include organizational slack, a low stringency of the EU ETS in its first two phases, or high transaction costs associated with such an integration process.

6.4 General tendencies

Overall, our survey findings show that the regulatory framework, including the EU ETS and other climate policy instruments, is among the least relevant decision factors for technological innovations in the German paper sector. Similarly, CO_2 has only to a limited extent been incorporated into organizational structures and procedures, but it seems to have had a significant impact on corporate visions. Clearly, market factors – and here in particular prices and demand for paper products – remain most relevant for innovation and adoption decisions.

Keeping in mind the relatively small number of observations, the regulatory climate policy framework seems to have differentiated effects on the types of innovation. Effects appear to be somewhat higher for modernization activities than for new investments, and lowest for RD&D. The effects also appear to differ between value chain positions, with the relevance of climate policy typically being more pronounced for paper producers than for technology providers for all innovation dimensions. These two findings underline the usefulness of differentiating between different innovation dimensions and the value chain positions.

Although most survey respondents stated that the impact of climate policies on innovation activities was rather small, the majority of paper producers and technology providers expect the relevance of climate policies for RD&D and adoption to increase by 2020. Yet it is an open question whether these expectations are based on the actual and expected design features of the EU ETS for the third phase, or whether they are based on companies' conjecture that policymakers will increase the stringency of the climate policy mix in the future. The fact that about one third of paper producers expect climate policy to become

less important for their investment decisions for new installations is somewhat at odds with the unambiguous expectations of increased climate policy stringency for the sector.

Finally, we find that public acceptance does not play a large role in the German pulp and paper industry, with the exception of the RD&D decisions of paper producers. That is, in contrast to the power sector, public opinion does not tend to work as a corrective of potentially CO_2-counter-productive policies or investment trends (Rogge et al. 2011).

7 Conclusion

For the companies in the German pulp and paper industry which participated in our survey and case study interviews, the EU ETS and international climate policy have (as yet) barely affected their innovation activities. Instead, companies' adoption and RD&D decisions tend to keep them on established and primarily market-factor-driven technological business-as-usual trajectories. Likely reasons for the stated low relevance of the EU ETS include the low prices for CO_2, a high share of free allocation, and regulatory uncertainty. Yet, the observed organizational changes in corporate visions regarding the newly established carbon constraints may serve as the basis for more far-reaching changes in the future than those currently observed.

Thus, increasing the stringency and predictability of the current policy mix would be expected to contribute towards bringing the pulp and paper industry onto a path towards decarbonization. As the regulatory conditions for the EU ETS are already determined up to 2020, in the short to medium term policy-makers are left with complementary policies. In particular, innovation policies and thus technology-push policies could assist in guiding RD&D activities towards low-carbon paper production technologies at competitive costs. In addition, achieving a globally binding climate treaty that sets ambitious long-term reduction targets would also be a complementary step. Ideally, such a treaty would lead to a global carbon price and hence at the same time address concerns by paper producers about competitiveness and lead to a larger international demand for low-carbon technologies for technology providers.

The research framework developed in Rogge et al. (2011) and originally applied to the power sector allows for a more complete understanding of how and to what extent the EU ETS affects innovation activities. Since the framework also

considers other factors in companies' business environment, the relative impact of the EU ETS on innovation activities could be assessed. Further, incorporating different value chain positions offered instructive insights into the role of the regulatory framework. For example, we found that in the pulp and paper industry the regulatory pull of the EU ETS has so far barely trickled down to technology providers. Finally, combining quantitative with qualitative analyses allowed us to compare and corroborate descriptive survey results with case study findings.

This study has limitations and caveats remain for generalizing some of its findings. First, our study was performed in one country and one industry sector only. Hence, findings may not hold for other sectors or other countries. Second, our survey is unlikely to be representative and the sample size is too small to allow for multivariate analyses. Such analyses, however, could help to disentangle the effects of climate policies from other elements of the framework regulating innovation activities. Similarly, a larger sample size may allow us to identify the relation between company characteristics or specific technologies and the impact of the regulatory framework. Future research could address these shortcomings by conducting cross-sector and cross-country comparisons involving larger sample sizes and thus allowing for multivariate statistical analyses.

References

Armbruster, H.; Bikfalvi, A.; Kinkel, S.; Lay, G. (2008): Organizational innovation: The challenge of measuring non-technical innovation in large-scale surveys. Technovation, 28 (10), 644-657.

Baumol, W.J.; Oates, W.E. (1988): The Theory of Environmental Policy. Cambridge University Press, Cambridge.

Betz, R.; Rogge, K.; Schleich, J. (2006): EU emissions trading: an early analysis of national allocation plans for 2008–2012. Climate Policy, 6 (4), 361-394.

Cames, M. (2010): Emissions Trading and Innovation in the German Electricity Industry. PhD Thesis, TU Berlin.

Christensen, C.M.; Rosenbloom, R.S. (1995): Explaining the Attackers Advantage - Technological Paradigms, Organizational Dynamics, and the Value Network. Research Policy, 24 (2), 233-257.

Creswell, J.W. (2003): Research Design: Qualitative, quantitative, and mixed method approaches. Sage, Thousand Oaks.

DEHSt (2009a): Emissionshandel: Auswertung der ersten Handelsperiode 2005-2007, Deutsche Emissionshandelsstelle (DEHSt), Berlin.

DEHSt (2009b): Kohlendioxidemissionen der emissionshandelspflichtigen Anlagen im Jahr 2008, Deutsche Emissionshandelsstelle (DEHSt), Berlin.

DEHSt (2010): Kohlendioxidemissionen der emissionshandelspflichtigen Anlagen im Jahr 2009 in Deutschland, DEHSt, Berlin.

del Río González, P. (2005): Analysing the Factors Influencing Clean Technology Adoption: A Study of the Spanish Pulp and Paper Industry. Business Strategy and the Environment, 14 (1), 20-37.

del Río González, P. (2009): The empirical analysis of the determinants for environmental technological change: A research agenda. Ecological Economics, 68 (13), 861-878.

Dillman, D.A. (2006): Mail and Internet Surveys. The Tailored Design Method. John Wiley & Sons, Hoboken.

Doonan, J.; Lanoie, P.; Laplante, B. (2005): Determinants of environmental performance in the Canadian pulp and paper industry: An assessment from inside the industry. *Ecological Economics*, 55 (1), 73-84.

Edquist, C. (1997): Systems of Innovation Approaches – Their Emergence and Characteristics, in: Edquist, Charles (Ed.) , Systems of Innovation: Technologies, Institutions and Organizations. Routledge, London, New York, pp. 1-35.

Ellerman, A.D.; Convery, F.J.; de Perthuis, C. (2010): Pricing Carbon. The European Union Emissions Trading Scheme. Cambridge University Press, New York.

EU (2003): Directive 2003/87/EC of the European Parliament and the Council of 13 October 2003 Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and Amending Council Directive 96/61/EC. Official Journal of the European Union, L275, 32-46.

EU (2010): Community Independent Transaction Log: National reports on verified emission and surrendered allowances. Online: http://ec.europa.eu/environment/climat/emission/citl_en.htm.

Fagerberg, J., Verspagen, B. (2009): Innovation studies—The emerging structure of a new scientific field. *Research Policy*, 38 (2), 218-233.

Fischer, C.; Parry, I.W.H.; Pizer, W.A. (2003): Instrument choice for environmental protection when technological innovation is endogenous. *Journal of Environmental Economics and Management*, 45 (3), 523-545.

Gagelmann, F.; Frondel, M. (2005): The Impact of Emission Trading on Innovation - Science Fiction or Reality? *European Environment*, 15 (4), 203-211.

Hekkert, M.P.; Suurs, R.A.A.; Negro, S.O.; Kuhlmann, S.; Smits, R.E.H.M. (2007): Functions of innovation systems: A new approach for analysing technological change. Technological Forecasting and Social Change, 74 (4), 413-432.

Hoffmann, V.H. (2007): EU ETS and Investment Decisions: The Case of the German Electricity Industry. European Management Journal, 25 (6), 464-474.

Horbach, J. (2008): Determinants of environmental innovation - New evidence from German panel data sources. Research Policy, 37 (1), 163-173.

Jaffe, A.B.; Newell, R.G.; Stavins, R.N. (2002): Environmental policy and technological change. Environmental & Resource Economics, 22 (1-2), 41-69.

Jung, C.H.; Krutilla, K.; Boyd, R. (1996): Incentives for advanced pollution abatement technology at the industry level: An evaluation of policy alternatives. Journal of Environmental Economics and Management, 30 (1), 95-111.

Malueg, D.A. (1989): Emission Credit Trading and the Incentive to Adopt New Pollution-Abatement Technology. Journal of Environmental Economics and Management, 16 (1), 52-57.

Mazzanti, M.; Zoboli, R. (2006): Economic instruments and induced innovation: The European policies on end-of-life vehicles. Ecological Economics, 58 (2), 318-337.

McKinsey&Company; Ecofys (2006): Review of EU Emissions Trading Scheme - Survey Results, European Commission, Directorate General for Environment, Brussels.

OECD (2005): Oslo Manual: Guidelines for collecting and interpreting innovation data. 3rd edition. OECD, Paris.

Oltra, V.; Saint Jean, M. (2005): Environmental innovation and clean technology: an evolutionary framework. International Journal of Sustainable Development, 8 (3), 153-172.

Pavitt, K. (1984): Sectoral patterns of technical change: Towards a taxonomy and a theory. Research Policy, 13 (6), 343-373.

Pontogolio, S. (2010): An early assessment of the influence on eco-innovation of the EU Emissions Trading Scheme, in: Mazzanti, Massimiliano and Anna Montini (Eds.), Environmental Efficiency, Innovation and Economic Performances. Routledge, London, New York, pp. 81-91.

Popp, D.; Newell, R.G.; Jaffe, A.B. (2010): Energy, the Environment, and Technological Change, in: Hall, Bronwyn H. and Nathan Rosenberg (Eds.), Handbook of the Economics of Innovation. Elsevier B.V., Amsterdam, pp. 873-937.

Requate, T. (2005): Dynamic incentives by environmental policy instruments - a survey. Ecological Economics, 54 (2-3), 175-195.

Rogge, K.; Schneider, M.; Hoffmann, V.H. (2011): The innovation impact of the EU Emission Trading System — Findings of company case studies in the German power sector. Ecological Economics, 70 (3), 513-523.

Rogge, K.S.; Hoffmann, V.H. (2010): The impact of the EU emission trading scheme on the sectoral innovation system for power generation technologies - Findings for Germany. Energy Policy, 38 (12), 7639-7652.

Schleich, J.; Betz, R. (2005): Incentives for energy efficiency and innovation in the European Emission Trading System. ECEEE 2005 Summer Study - What works& who delivers? - Panel 7 New economic instruments, 2005, 1495-1505.

Schleich, J.; Rogge, K.; Betz, R. (2009): Incentives for energy efficiency in the EU Emissions Trading Scheme. Energy Efficiency, 2 (1), 37-67.

Schleich, J.; Rogge, K.S.; Borkel, F.; Haussmann, P.; Reichardt, K.; Roser, A.; Reitze, F.; Frahm, B.-J.; Duscha, V.; Marscheider-Weidemann, F. (2010): Wirkungen neuer klimapolitischer Instrumente auf Innovationstätigkeiten und Marktchancen baden-württembergischer Unternehmen, Fraunhofer ISI, Karlsruhe.

Schmidt, T.; Schneider, M.; Rogge, K.S.; Hoffmann, V.H. (2010): Explaining the effect of market-based environmental policy on technological change - a framework applied to the European power sector, Paper presented at the International Schumpeter Society Conference 2010 on "Innovation, organisation, sustainability and crises", Aalborg, June 21-24, 2010.

Skjaerseth, J.B.; Wettestad, J. (2008): EU Emissions Trading: Initiation, Decision-Making and Implementation. Ashgate, Aldershot.

Thollander, P.; Ottosson, M. (2008): An energy efficient Swedish pulp and paper industry-exploring barrieres to and driving forces for cost-effective energy efficiency investments. Energy Efficiency, 1 (1), 21-34.

VDP (2010): Facts on Paper 2010, Verband Deutscher Papierfabriken, Bonn.

Yin, R.K. (2002): Case Study Research: Design and Methods. Sage Publications, London.

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