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Collaborative Dynamics in Environmental R&D Alliances

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Abstract
The use of environmental policies to facilitate research and development (R&D) collaborations that generate environmental innovations (EIs) is increasingly important for sustainable development. However, few studies have examined how the collaborative dynamics between R&D partners influence how they respond to environmental objectives. We address this gap by studying two Norwegian environmental R&D alliances and the development of their collaborative relationships in terms of the relative absorptive capacity, meaning their relative similarity with respect to *organizational structures, knowledge bases* and *dominant logics*. We find that R&D partners with higher relative absorptive capacity are more likely to respond coherently to policy objectives, whereas this is more challenging between partners with lower relative absorptive capacity. Further, our research shows that partners' use of power may change how an alliance responds to policy objectives. The implications of these findings are discussed.

Keywords: Environmental policy, environmental innovation, R&D alliance, relative absorptive capacity, power and dependence.

1. Introduction

A key challenge in the quest for sustainable societal development is developing and commercializing environmental innovations (EIs). EI may be defined as, *"the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organization (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resource use (including energy use) compared to relevant alternatives"* (Kemp and Pearson, 2007, p.7). Hence, EIs differ from traditional innovations in the sense that they produce both positive spillovers for the firm and positive externalities by improving the environment (Rennings, 2000). Although successful EIs become assets for the firm, some EIs do not generate revenue for the firm, but society benefits from less pollution. This "double externality problem" makes the government, as a policy maker and facilitator, an important actor in motivating the environmental development of firms (Rennings, 2000). To motivate all firms, regardless of industry, size, R&D experience, environmental attitudes, etc., environmental policies have different designs and objectives. Some policies are designed with the objective to stimulate the development of radical EIs (e.g., technology-push policies), while others are employed to motivate more incremental EIs (e.g., command-and-control policies) (Nemet, 2009). However, as EIs are complex and require specialized knowledge, they are more often developed in collaboration with external R&D partners, compared to other innovations (De Marchi, 2012). Because collaboration is so important for the development of EIs, exploring and understanding the complex collaborative dynamics between R&D partners is critical (Hagedoorn, 2002; Perkmann and Walsh, 2007; Smith, 2012).

This paper draws on two theoretical perspectives, *relative absorptive capacity* and *resource dependence theory* (RDT), which may provide input into how collaborative dynamics between R&D partners unfold. Relative absorptive capacity is in this context a measure of R&D partners' relative similarity with respect to *organizational structures, knowledge bases* and *dominant logics,* and suggests that the ability to learn from an R&D partner, and thereby develop innovations, is determined by these similarities. Although R&D partners with low relative similarity provide the most complementary knowledge, they are often the most challenging actors in collaborations because of conflicting interests related to the collaboration's objectives (Bjerregaard, 2010; Howells et al., 2012; Perkmann and Walsh, 2007). In cases of conflicting interests, RDT may shed light on the collaborative dynamics. RDT consists of the dimensions of power and dependence, which in this context express the balance (or imbalance) between R&D partners that may influence the collaborative relationships

(Casciaro and Piskorski, 2005; Pfeffer and Salancik, 2003). By employing these perspectives, this paper investigates the following research question: *"How do the collaborative dynamics between R&D partners influence how they respond to environmental policy objectives?"*

The research question is examined with longitudinal data from two Norwegian environmental R&D alliances that received public support. Both alliances have objectives related to creating EIs through collaboration between industries, universities and private research organizations. The alliances represent two "polar types" of policy intervention. Alliance 1 is primarily addressing command-and-control policies with the objective to lower emissions, while Alliance 2 addresses a technology-push policy with the objective to conduct long-term research of high international caliber to solve specific challenges in the energy sector. Due to notable differences in age and maturity, the alliances are analyzed as two embedded single-case studies.

By adding to the few in-depth studies on the dynamic relationship between R&D partners in general (Hagedoorn et al., 2000; Majchrzak et al., 2015; Smith, 2012) and EI partners in particular (De Marchi, 2012; Yarahmadi and Higgins, 2012), we contribute to the literature on environmental policies, R&D collaboration and EI in three distinct ways. First, by combining the two theoretical concepts of relative absorptive capacity and power and dependence, we take a multiple perspective on the EI process, as called for by Ford et al. (2014). Second, we find that R&D partners with higher relative absorptive capacity are more likely to respond coherently to policy objectives, whereas this is more challenging between partners with lower relative absorptive capacity. Third, our research shows that partners' use of power may change how an alliance responds to policy objectives.

The paper proceeds as follows. The next section presents our theoretical framework, which is followed by a presentation of our methods. In the fourth section, the empirical findings are presented in combination with our discussion of the scholarly literature. Finally, we present the conclusions and implications of our findings.

2. Theoretical framework

In contrast to "normal" innovations, the market often fails to generate environmental innovations; thus, environmental policy and regulations are important for motivating firms to develop EIs (del Rio et al., 2011; Jaffe and Palmer, 1997; Johnstone et al., 2010). To motivate all firms, regardless of industry, size, R&D experience, environmental attitudes, etc., the design of environmental policies is important. However, because of the magnitude and complexity of environmental challenges, designing effective policies is a multi-faceted and challenging task, and predicting the effects of such policies on the innovation process is difficult (Johnstone et al., 2012). Thus, this section reviews the literature on environmental policies and their relationship with EI, with an emphasis on the collaborative elements of the EI process through the theoretical lenses of relative absorptive capacity and power and dependence relations.

2.1 Environmental policies and innovation

Environmental policies are a complex, multidimensional issue that can be examined in numerous ways (Brunel and Levinson, 2016). These policies can be categorized according to what is regulated (e.g., air, water, land), the pollutants that are regulated (e.g., sewage, hazardous waste, toxic chemicals), who is targeted (e.g., households, firms, industries), the instruments that are used, the policy's design and characteristics, and their goals and outcomes. In general, policy makers have two basic means to motivate innovation in firms: regulations that rule out certain activities and policies that provide incentives for private actors to engage in specific actions (Fabrizio and Hawn, 2013). This can be linked to different policy instruments and the objectives behind the instruments. There is a multitude of environmental policy instruments, with different design features and different objectives. One example of a policy instrument is *command-and-control* regulations, where the main objective is pollution reduction through innovative activities in firms with limited resources or a willingness to pursue the opportunities created through proactive environmental policies (Zarker and Kerr, 2007). These regulations directly impose decisions on business choices and operations, either with technology standards - requiring operators to use a specific technology (De Serres et al., 2010) - or by setting

quantitative standards to reduce emissions (Bergquist et al., 2013). These regulations are often related to incremental innovations because when firms have achieved a particular standard or objective, there are few incentives for additional innovations (Singh et al., 2016).

Another example of a rather different policy instrument is the *technology-push* approach. This approach is usually enacted as public R&D funding with the objective to directly mitigate underinvestment in R&D (Peters et al., 2012) and reduce the private costs of producing innovations (Nemet, 2009), specifically costly energy technologies, such as solar power (Johnstone et al., 2010). During the early stages of development, cleaner forms of energy production, such as solar, bio and wind power, cannot compete with traditional energy sources in terms of cost (Nesta et al., 2014). Thus, the objective behind many technology push incentives is to stimulate the development and deployment of radically new technologies (Bergek et al., 2014; Bürer and Wüstenhagen, 2009). However, research on the effects of environmental policies has shown mixed results for how or whether policies have their intended effects, and there is a considerable gap in our knowledge of the relationship between policies and the innovation process (Bergek et al., 2014; Lettice et al., 2012). Due to this lack of research and conflicting evidence on the relationship between regulation and innovation, there is a call for alternative perspectives that include new explanatory factors (Ford et al., 2014). Our approach to the discussion on the relationship between policies and the innovation process is to explore how the collaborative dynamics between R&D partners influences how they respond to environmental policy objectives by employing the perspectives on relative absorptive capacity and power and dependence (Lane and Lubatkin, 1998; Pfeffer and Salancik, 1978; Yarahmadi and Higgins, 2012).

2.2 Relative absorptive capacity

Absorptive capacity is defined as a firm's *"ability to recognize the value of new, external information, assimilate it, and apply it for commercial ends"* (Cohen and Levinthal, 1990, p.128). This concept focuses on *how* firms absorb external knowledge from collaborative partners (Fosfuri and Tribó, 2008; Zahra and George, 2002). Lane and Lubatkin (1998) extend the definition of absorptive capacity to focus on *with whom* an alliance should be formed and propose the notion of *relative absorptive capacity*. This construct suggests that the firm's ability to learn from another partner and thereby develop innovations is determined by the relative characteristics of both firms in the collaboration, implying that the ability of one firm to learn from another partner depends on similarities between the firms' organizational structures, knowledge bases and dominant logics.

Organizational structure is defined as "*the formal allocation of work roles and the administrative mechanisms to control and integrate work activities including those which cross formal organizational boundaries"* (Child, 1972, p.2). Specifically, the organizational structure determines who has the decision-making rights in an organization. The overall decision-making right often lies with the board of directors or CEO, who distribute rights among decision-making agents in the organization (Jensen and Meckling, 1992). For decisions on environmental issues, Martin et al. (2012) studied UK manufacturing plants and found that firms are more likely to adopt climate-friendly management practices if this decision lies with an environmental or energy manager rather than the CEO.

Learning in alliances is easiest when the partners have similar basic, but different specialized *knowledge bases* (De Clercq and Sapienza, 2001; Lane and Lubatkin, 1998). Similar basic knowledge refers to a general understanding of the traditions and techniques within a discipline/industry, whereas specialized knowledge is related to knowledge in a specific technical domain. Similar basic knowledge enables firms to understand other actors' assumptions, which increases the firm's capability for evaluating the importance of new knowledge for its own ventures (Lane and Lubatkin, 1998). A challenge in EI processes is that they are complex and require information and skills that are distinct from the firm's traditional knowledge base (De Marchi and Grandinetti, 2013). This constraint makes collaboration essential for gaining access to new environmental knowledge (De Marchi, 2012; Foxon and Andersen, 2009). Accordingly, Cainelli et al. (2015) found that when collaborating with additional partners, there will be an increase in the likelihood of developing an EI. Ghisetti et al. (2015) further demonstrated that some knowledge variety is required for engaging in EI, but a too broad

knowledge search can expose a firm to redundant or inconsistent information that might discourage firms from adopting an EI.

Lane and Lubatkin (1998) argue that similarities in firms' *dominant logics* can affect interorganizational learning. A dominant logic is defined as "*a mindset, world view or conceptualization of the business and the administrative tools to accomplish goals and make decisions in that business*" (Prahalad and Bettis, 2002, p. 81). Lane and Lubatkin use this concept in relation to the similarities between partner firms' commercial objectives. When the dominant logics of firms are similar, it is easier to commercially apply new knowledge from the partner (Lane and Lubatkin, 1998). In R&D collaboration, different partners often have different dominant logics because no two firms will have identical dominant logics. This dominant logic will determine the "data" that the organization will focus on and act as a "filter" through which these data are selected (Bettis and Prahalad, 1995). Changing a dominant logic is difficult but often necessary for seizing new opportunities (Prahalad, 2004).

When partners are highly similar with respect to these three characteristics, they have high relative absorptive capacity. As the relative absorptive capacity between partners in R&D collaborations increases, collaboration often becomes easier. However, the innovations derived from these collaborations will likely be based on imitation and thus will be more incremental in nature (Lane and Lubatkin, 1998). Gluch et al. (2009) studied EI in the Swedish construction industry and found that firms in this industry primarily shared information with their closest partners. This strategy led to group thinking, which forced innovative capacity into a mimetic rut in which firms performed the same acts. The levels of relative absorptive capacity may have an important influence on how R&D partners respond to environmental policy objectives, which also might be influenced by power dependence relations between partners.

2.3 Resource dependence theory

RDT focuses on power imbalances and mutual dependence in partners' relationships (Pfeffer and Salancik, 2003). Mutual dependence helps us understand why firms seek long-term relationships, whereas power imbalances can explain why firms resist certain interorganizational actions (Casciaro and Piskorski, 2005). In RDT, the distribution of power and dependence is often discussed because interdependencies are not necessarily symmetric or balanced (Pfeffer and Salancik, 2003). When one actor controls the use of a resource, this may be a major source of power (Pfeffer and Salancik, 2003). However, an unbalanced relationship is unstable because it may encourage the abuse of power (Emerson, 1962), which can be damaging to the relationship (Gulati and Sytch, 2007). In this situation, it is important to build and sustain mutual commitment, which engages the collaborating partners in the value-creating coordination of interdependent activities (Holm et al., 1999). This is a time-consuming process that requires commitment from all parties to form a balanced, dependent relationship (Holm et al., 1999). Partners in dependent relationships tend to develop mutual empathy and a focus on joint success, which is important for the relationship's long-term sustainability (Gulati and Sytch, 2007). In this process, flexibility, the will and capability to respond to changing circumstances, is an important determinant (Czakon, 2009). With this flexibility and mutuality in the alliance, trust and understanding among partners evolves and can lead to a convergence of organizational structures (Biermann, 2008), enabling the partners to become more similar.

In summary, this chapter discusses environmental policies and their relationship with the collaborative parts of the innovation process. Because there is little knowledge on this relationship (Bergek et al., 2014; Lettice et al., 2012), the aim of this paper is to explore how the collaborative dynamics between R&D partners influence how they respond to policy objectives.

3. Methods

Case studies provide a comprehensive and realistic depiction of the effects of environmental regulations on the environmental innovation process (Kemp and Pontoglio, 2011). This paper employs a case study approach to enhance the existing framework and construct relevant theory (Yin, 2013). Theory-building case studies are well suited for examining new areas of research (Eisenhardt, 1989),

and although R&D collaboration has received increased attention, little is known about the nature of collaborative relationships (Majchrzak et al., 2015; Perkmann and Walsh, 2007; Thune and Gulbrandsen, 2014), especially in relation to the EI process (De Marchi, 2012).

3.1 Case selection

This study used a longitudinal case study design involving two environmental R&D alliances to explore how the collaborative dynamics between R&D partners influence how they respond to environmental policy objectives. Both alliances include firm and research partners, and the latter include universities and private research organizations (organizations that conduct contract R&D for private and public sectors) (see Table 1). The sample is drawn from a population of long-term R&D alliances that received public support from the Norwegian Research Council (NRC), where the main objective was to develop environmental innovations. Both cases are chosen based on theoretical sampling, in which the purpose is to choose cases that can either replicate or extend emergent theory (Eisenhardt, 1989). To build theory on collaborative dynamics in the EI process, we chose these two R&D alliances as cases to more easily observe contrasting patterns in the data because they represent "polar types" of policy intervention (Eisenhardt and Graebner, 2007).

Alliance 1 primarily targets command-and-control policies related to reducing emissions, while Alliance 2 targets a large research grant from the Research Council of Norway established to address a governmental resolution on climate and energy challenges (technology-push). The primary objective of Alliance 2 is to establish research centers that operate for eight years and conduct concentrated, focused and long-term, high-caliber, international research while promoting EI to address environmental challenges.

Despite their similarities, the alliances have notable differences in age and maturity. Alliance 1 is mature, while Alliance 2 is relatively new. These characteristics indicate that it would be problematic to draw conclusions from a cross-case comparison because the differences between the alliances could be due to age rather than policy. To address this challenge, we treat the alliances as two embedded, single-case studies rather than one multiple-case study. Using single-case studies is appropriate because our cases are both *critical* and *longitudinal.* They are *critical* because they are strategically important to the general problem under study (Flyvbjerg, 2006), and their *longitudinal* nature allows us to specify how specific conditions in the theoretical framework can change over time (Yin, 2013).

In addition, the embeddedness of the case studies strengthen the conclusions drawn from the single cases because embedded case studies provide the ability to examine sub-units that are situated within a larger case and to analyze these sub-units both separately and in a cross-case analysis (Baxter and Jack, 2008). In this study, we have two sub-units: one sub-unit that consists of a group of organizations that represent the firms and one sub-unit that consists of a group of organizations that represent universities and private research organizations. To explore how the collaborative dynamics between R&D partners influence how they respond to environmental policy objectives, we first separately analyze firm and research partners. Then, we analyze the overall alliances based on a cross-case comparison of the groups of firm and research partners.

Table 1
Research alliance characteristics

	Environmental policy	Policy objective	Participants	Funding
Alliance 1. Established by the industry in 1989.	Primarily command-and-control. Aims to pursue EIs that are needed to address present and future regulations.	To pursue environmental improvements and pollution reduction.	All firm partners in the business sector in Norway (6), a university, and a research organization as participants and hosts for each project.	Research grants from the Research Council of Norway (30-50%) and participation fees from firm partners (50-70%).
Alliance 2. Established by universities and research organizations in 2009.	Technology-push. Established to address a governmental resolution regarding climate and energy challenges.	To conduct high-level, long-term research to solve specific challenges in the energy industry and identify new, innovative solutions.	A university hosts the alliance. Each project includes universities (2), research organizations (5-8)[1] and firm partners (10-15)[1] that cover large parts of the industry's value chain.	Research grants from the Research Council of Norway (50%) and financing from the firm partners (25%) and research partners (25%).

3.2 Data collection

For both alliances, we developed interview questions based on a preliminary literature review and secondary data, including annual and evaluation reports, prior to conducting the interviews (Yin, 2013). For Alliance 1, prior to conducting the interviews, we observed the participants in a seminar arranged by the alliance, which included presentations and discussions of research projects. To obtain an in-depth understanding of how the collaboration process unfolded over time, we performed 55 in-depth interviews, including 28 from Alliance 1 and 27 from Alliance 2 (see Table 2). The interviews were conducted longitudinally; the first round occurred in 2011, with additional rounds conducted from September 2013 to February 2014. The follow-up interviews aimed to uncover changes in the collaborative dynamics between the R&D partners, and to provide additional information about topics that were identified in the first round of analysis as topics of interest.

Table 2
Informants interviewed (number of individuals in parentheses).

	Alliance 1		Alliance 2	
	Firm	Universities and private research organizations	Firm	Universities and private research organizations
Informants (2011)	CEOs (5) Researchers (4) Engineers (1) Policy managers (1)	Research partners (4)	CEOs (1) Technology managers (2) Project managers (2)	Research partners (8)
Informants (September 2013 - February 2014)	CEOs (4) Researchers (4)	Research partners (2)	CEOs (1) Technology managers (2) Project manager (1)	Research partners (8)
Total interviews	19	6	9	16
Secondary sources	Firm presentations Press articles Web sites	Project presentations Press articles Web sites	Annual reports Evaluation reports Newsletters Press articles Web sites	Annual reports Evaluation reports Newsletters Press articles Web sites

[1] An approximate number is provided to preserve anonymity.

The data collection for both alliances used a similar semi-structured interview guide with certain individual modifications. The questions were divided into themes related to the partners' motivation, expectations and involvement in the alliances; the interaction between the alliance partners; and the research and innovation activities. To account for the informants' different perspectives and to limit bias (Eisenhardt and Graebner, 2007), we designed and implemented two separate interview protocols: one for firm partners and one for research partners. The questions were designed to provide insights into the R&D collaboration processes from the perspectives of firm and research partners. The interview guide served as a checklist for ensuring that all relevant topics were covered, while the goal of the interviews was to establish a conversational style in which the interviewees discussed the topics as freely as possible (Patton, 2015). The interviews were always performed with two or more researchers from the research team to minimize interviewer bias.

We used a retrospective interviewing approach to gain insight into the evolution of the relationships between the R&D partners and obtain accurate information on the factors that might have influenced these relationships (Miller et al., 1997). Following a retrospective approach, we encouraged the informants to reconstruct past experiences (Fraenkel et al., 1993) and reflect on present situations. During the interviews, the questions were refined, and additional questions were added to the interview protocol (Eisenhardt, 1989). There were also situations in which we wanted the informants to provide more detail on key events or unclear statements. In these situations, we asked follow-up questions, such as "Why did you do that?" "Who was involved in that event?" and "When did this happen?" Using a retrospective approach has its limitations; specifically, the informants view the past through the lens of the present (Silverman, 2013). However, people rarely forget important events (Denzin and Lincoln, 2011). Finally, to avoid bias, we avoided using theoretical concepts in the interview setting.

3.3 Data analysis

The interviews were recorded and transcribed verbatim as a part of the data analysis process (Yin, 2013). We used qualitative data analysis software (NVivo 10) to assist with the coding and categorization process of the interview data. The coding began with a careful reading of the interviews, line by line and paragraph by paragraph, to name and code the empirical material. For coding the data, we integrated theory-driven deductive codes (e.g., dominant logic) with data-driven inductive (sub)codes (e.g., time horizon) (Langley, 1999). Accordingly, the theory-driven deductive codes were coded with theoretical dimensions (Eisenhardt, 1989), including critical characteristics and events that reflected how the collaborative dynamics between R&D partners influenced how they responded to environmental policy objectives. Relative absorptive capacity and resource dependency was employed as the primary theoretical perspectives for this study. Following Lane and Lubatkin (1998), the relative absorptive capacity between the firm group and the group of researchers was mapped with the following categories: organizational structure, knowledge base and dominant logic. Resource dependency was mapped by the power balance and mutual dependence between the firm group and the group of researchers (Pfeffer and Salancik, 2003). The coding procedure was discussed by the authors to increase the rigor of the analytical generalization of the empirical data. Triangulation of the data sources was achieved by comparing interview data with secondary data, including reports, newsletters, press releases and websites.

It is problematic to draw general conclusions based on two single-case studies, but the longitudinal and embedded nature of the cases suggests that they are likely able to provide clues about the *causal mechanisms* that explain how the collaborative dynamics between R&D partners influence how they respond to environmental policy objectives (Gerring, 2006). In contrast to measuring causal effects, identifying causal mechanisms occurs when we combine theoretical and empirical knowledge on the interrelations among variables (Gerring, 2006). As stated in the paragraph above, we compared our empirical data with the theoretical framework proposed in the theoretical framework. Hence, our in-depth results can be used to formulate hypotheses for additional research in other contexts or with different research methods.

4. Findings and discussion

Our analysis aims to explore how the collaborative dynamics between R&D partners influence how they respond to environmental policy objectives. First, we analyze the collaborative relationship in Alliance 1, followed by a more extensive analysis of Alliance 2, which experienced more changes in the collaborative dynamics over time. The case findings are integrated with the scholarly literature on relative absorptive capacity and power and dependence to clarify our theoretical arguments. Our analysis of R&D partners acknowledges that both alliances consist of two groups – firm and research partners, and the analysis is conducted both within and between these groups.

Alliance 1 targets policies related to emission reductions (command-and-control regulations) (Horbach et al., 2012), as illustrated in a quote from one of the research partners: *"The government has been a driving force. There are a lot of demands related to emissions."* The R&D partners in Alliance 1 choose to address these industry-specific regulations together: *"We do not have to invent the wheel separately"* (firm partner). We explain the coherent response to policy objectives from Alliance 1 with their high level of relative absorptive capacity (Table 3).

Table 3
Relative absorptive capacity in Alliance 1.

Organizational structures	Knowledge base	Dominant logic
Larger international corporations own four of the five firms, and the decision to participate in the alliance lies with the owner. *"It was a challenge to convince our owners* [to join the alliance]*"* (Firm partner). *"They* [the foreign owners] *are determined to have R&D activities in Norway as well… to enable us to solve problems in the future"* (Firm partner).	Because they operated in the same industry for several years, the firms and research partners possess similar basic knowledge. *"They* [the research partners] *have experience from the industry and understand how to start a dialogue"* (Firm partner). *"They* [the research partners] *need to have a foundation in the industry to do a good job"* (Firm partner). The research partners add specialized knowledge to the alliance: *"When we need specialized knowledge, we have researchers* [in the alliance] *that know about our industry and research questions that are relevant for us"* (Firm partner). *"They* [the research partners] *add knowledge, and it is very important for us to have such competent research partners"* (Firm partner).	Alliance 1 primarily follows the dominant logics of the firms, and the research partners are very aware of the firms' interests in the alliance. *"We have great influence on the projects and the premises of the collaboration"* (Firm partner). *"We influence the topics of the doctoral thesis"* (Firm partner). *"We are very attentive to the industry"* (Research partner). Because of long-standing close collaborations between the firms and research partners, the research partners have learned the firms' logic: *"When we have such a close collaboration with the industry, it is easier for us to understand what`s relevant and useful for the industry"* (Research partner). *"When we are working with and talking about the industry, we are talking about the same thing"* (Research partner). *"Some of us [researchers] have worked for a long time in the industry. We are therefore 'raised' in accordance with the objectives of the industry"* (Research partner).

First, we observe that four of the five firms in Alliance 1 have similar *organizational structures*, as they are owned by larger international corporations. Hence, the decision to participate in the alliance lies with the foreign owners. As the quotes in Table 3 show, this decision is easier for some firms than for others. However, once involved, the foreign owners were satisfied with the results from the alliance.

Second, the R&D partners in Alliance 1 share common basic knowledge with the firm partners because many of the individuals from the university and research organizations had worked in the industry at some point in time. The following quote from a research partner shows this effect: *"We who work at* [the University and the research organization] *have worked in the industry. So, at some*

point in time, we have been colleagues or classmates." This relationship indicates that research partners share basic knowledge that is important for learning in alliances with the firms (De Clercq and Sapienza, 2001; Lane and Lubatkin, 1998). However, having a broader range of specialized knowledge is important for innovativeness (Laursen and Salter, 2006). Because the industry faces stricter demands, it is important for the firms to collaborate with research partners who have similar basic knowledge of their problems and specialized knowledge to develop solutions. The firm partners state that they contribute to the collaboration with specialized knowledge from the research organization and university, as illustrated by the following quote: "[The alliance] *contributes to building and sustaining relevant knowledge within* [the research partners]. *Without the alliance, they would not have so many research projects.*"

Third, Alliance 1 follows the *dominant logic* of the firms and addresses the policy objectives: "*We have focused a lot on general problems such as environmental emissions… All firms struggle with diffuse emissions such as smoke and dust"* (firm partner). According to Bettis and Prahalad (1995), employing a common dominant logic allows the firms to anticipate their environments, as observed in Alliance 1, which keys into the debate on future regulations as an incentive for environmental innovation (Carrión-Flores and Innes, 2010; Horbach et al., 2012; Mickwitz et al., 2008). A firm partner summarizes this as follows: *"The whole industry has been proactive in environmental questions, and has the knowledge to anticipate what* [regulations] *are coming. In that way, we can position ourselves in relation to environmental issues."*

In summary, the collaborative relationships in Alliance 1 demonstrate that partners with high relative absorptive capacity respond coherently to environmental policy objectives by building on existing knowledge and improving processes.

The collaboration in Alliance 2 targets a technology-push initiative with the objective to *"establish time-limited research centers that conduct concentrated, focused and long-term research of high international caliber in order to solve specific challenges in the field"* (Research Council of Norway, 2015). We observe that the relative absorptive capacity in Alliance 2 is low and that this has an effect on the collaborative dynamics, where the R&D partners respond non-coherently to the policy objectives (see Table 4).

Table 4
Relative absorptive capacity in Alliance 2, years 1-3.

Organizational structures	Knowledge bases	Dominant logics
Generally, there are differences in organizational structures between the firms and research partners. The organizational structures vary across the firms, with a combination of interest organizations and firms as well as differences in ownership (private/public). *"It's hard to take into account the interests from 10-15 firms, and it's even harder when an interest organization represents 10-15 additional firms"* (Research partner). In addition, a few firms and interest organizations dropped out of the alliance for strategic or financial reasons. *"We knew firm X through a former EU project, and a couple of them* [their employees] *wanted to join the alliance and signed up on behalf of the firm. They stayed in the alliance for one year before they dropped out: The management thought the research focus* [in the alliance] *did not fit as well as they first thought"* (Research partner).	The firms and the research partners possess similar basic knowledge, but there are differences in specialized knowledge. *"There is a difference between the firms (…); firm X knows a lot about these processes. However, they complement their own knowledge with the research conducted in the alliance to create even more knowledge"* (Research partner). *"I have worked there [in the research organization]"* (Firm partner). *"A part of the reason [for joining the alliance] was the wish to preserve and build the sphere of competence because we could say that the research community [in Norway] is relatively small"* (Firm partner). *"We want to have a solid research community in our field that contributes to strengthening us commercially as a*	Alliance 2 is led by the research partners and follows their research objectives and dominant logic, whereas the industry wants more applied research. *"I think there is very little focus on product development in [the research alliance]. They focus on research for the sake of research. The focus should have been much more commercially oriented and rooted in the industry"* (Firm partner). *"We felt that we, and the industry we represent, could not influence the relevancy of the research activities. Only one of the 15 research projects conducted in the alliance is relevant for us"* (Firm partner). *"The alliance has not achieved any great innovations"* (Firm partner).

One of the firms has an R&D department and, consequently, has a structure that is similar to that of the research partners.

"There are many small actors in this industry. Many of the firm partners do not have their own R&D department or R&D personnel (…) We need them to dedicate more time to the research activities. The firms respond that they cannot allow employees to spend their time on R&D activities" (Research partner).

company. In certain cases, we need to approach a research community. That was a considerable driver for joining the alliance" (Firm partner).

"An important factor is the time horizon. They [the firm partners] *want to squeeze out some 'tricks' from us to save their financial position next year. That approach does not bring about much research"* (Research partner).

First, Alliance 2 consists of many diverse partners with different *organizational structures* (Gulbrandsen et al., 2015). A leading research partner describes the process of forming the alliance as completely new, as researchers across institutions and departments jointly constructed a larger research team: *"We pick the best people for the job, regardless of where they come from."* In addition to a broad research team, the alliance also included diverse firms and interest organizations. A work-package leader in the alliance highlights the advantage of having a variety of partners: *"When we are several [partners], we are able to look at the environmental influence across the industry* [the whole value chain]." However, this positive characteristic has a downside because including several actors with different organizational structures makes it difficult to manage varying interests and relations. This challenge is illustrated by a research partner: *"A challenge with this* [alliance] *is that it covers everything and has a long time horizon (…) The firm partners are interested in their part, and they have to work through a lot of 'noise' to get their little piece of the puzzle."* Across the firm partners, the organizational structure differs and may be confusing for the research partners. A quote from a research partner who witnessed a firm partner leave the alliance exemplifies this: *"I talked with the wrong person (…); the one that participated was not the decision maker. A subgroup made the decision to leave the alliance. That sort of firm structure is a challenge for us. I should have approached that subgroup directly, not indirectly."* Hence, we argue that the numerous organizational structures makes it more challenging for the partners to respond coherently to the policy objectives.

Second, many firm partners in Alliance 2 have a Ph.D. or Master of Science degree from a university, which makes their *knowledge bases* similar to the research partners with respect to basic knowledge (Lane and Lubatkin, 1998). However, because the alliance was created to encompass the entire value chain, there is a high degree of differences in specialized knowledge between the R&D partners. This is present both between the research partners: *"They* [another research partner] *have limited knowledge on our type of technology"* (research partner), as well as between the firms: *"Most of the firms [within the alliance] have distinctive processes"* (firm partner). We argue that the diverse specialized knowledge impedes a consensus on how to respond to the policy objectives.

Third, we observe that Alliance 2 follows the *dominant logic* of the research partners and addresses the challenges that they judge as important for developing new environmental knowledge, as described by a firm partner: *"The results from the alliance were pretty far from what we perceived as useful. There were few and quite narrow results."* Different partners often have different dominant logics and attend to different "data" (Bettis and Prahalad, 1995), which we also observe in Alliance 2. Because the commercial objectives are very different, aligning the dominant logics of the research and firm partners is a challenge in this alliance. This challenge is consistent with previous research, in which scientists were oriented toward the publication system, while firm partners focused on commercial imperatives for applying exploitable results through short-term applied research (Becker & Trowler, 1989; Perkmann & Walsh, 2007). A quote from a research partner exemplifies this sentiment: *"I think the clue is different expectations. The firms in general, or many of them, have an expectation to turn research into commercialized products in a short time horizon."* This is also consistent with Bjerregaard (2010), who found that firm and university partners have different interests, goals and time horizons for conducting R&D. Hence, the conflicting dominant logic also hampers a coherent response to the environmental objectives.

We observe that the relative absorptive capacity increased over time in Alliance 2, with changes in knowledge bases and (especially) dominant logics. We explain these changes through the

balance of power and dependence between the R&D partners. The power to decide the direction of the research process was given to the research partners based on the direction of the research grant (technology-push).

Across years 1 to 3 (see Table 5), there was an unbalanced power and dependence relationship in Alliance 2. The collaboration between R&D partners with low relative absorptive capacity is challenging, which is consistent with Howells et al. (2012), who showed that partners likely to provide the most complementary knowledge are also the most challenging actors with which to collaborate. In Alliance 2, the firms found that the research partners decided the direction of the research projects and that these projects were not relevant to the firms. Eventually, this led to a situation in which some firm partners withdrew from the alliance, which created trouble for the research partners because they depended on both data and financial contributions from their firm partners to perform the proposed research. This narrative is consistent with Pfeffer and Salancik's (2003) claim that, when a partner exerts power, it might destroy rather than create value. In reaction to this situation, the research partners had to relinquish some power and instead "please" the firms by making the projects more relevant for the firm partners. By giving away power and making the research more relevant to the firms, the research partners allowed the relationship between power and dependence to shift.

Table 5
Balance of power and dependence in Alliance 2

	Power	Dependence
Years 1-3	The power to decide the direction of the research resided with the research partners. *"The initiative mostly comes from the* [research partners], *and we do not receive much benefit from the output"* (Firm partner). *"Actually, we should have been positioned to have influence… I remember I asked the* [research partners] *to work on a special task relevant to us. They answered that it was interesting but that it had to be considered the following year. However, that was never done"* (Firm partner).	The research partners had large amounts of power and experienced high dependency on the firms for financing and access to relevant data. *"We are very dependent on the firms` willingness to give us [the research partners] access to firm data"* (Research partner). *"The firm partners have to be willing to contribute financial and with 'in-kind' resources to the [alliance]"* (Research partner).
Years 4-5	The firms attained more power to influence the alliance objectives. *"The alliance was not designed for our* [the firm] *needs. I think that experience was unexpected* [on the research partners] *in the mid-term evaluation"* (Firm partner). *"We have not committed ourselves* [the firm] *for the last three-year period. For that, we must see a change* [in the research activities]*"* (Firm partner). *"We* [the firm] *have pushed them hard, which they have taken into account…They have become better and more to the point"* (Firm partner). *"How much power should the firm partners have in the alliance? It is not stated anywhere. What is clear is that the firm partners need to be satisfied. However, how much time should I employ to satisfy a firm partner that contributes to only 2 percent of the budget? Then again, the 2 percent generates four to five times the amount* [from governmental and research partner funding]. *That balance is difficult"* (Research partner).	The firm partners (that did not drop out) became more involved in the alliance. With increasing influence, the alliance became more relevant for the firm partners, which again made them more dependent on the research partners. *"Now the research partners have much more dialogue with the firms, and they had to do that if they wanted to continue with the alliance after the mid-term evaluation"* (Firm partner). *"The research partners have become much more proactive"* (Firm partner). *"In principle, the alliance is a competence-building project. However, we conduct some development activities for the firm partners that actually should not have been done within the alliance. We do this to satisfy the firm partners"* (Research partner). *"We are dependent on them; it is hard for us to criticize* [the firm partners] *in return"* (Research partner).

Across years 1 to 3, the research partners not only had large amounts of power but also experienced a high level of dependence on the firm partners because they needed both data from the firms and their financial contributions. At the same time, the firm partners were in a situation in which they had little power over the direction of the research process and consequently believed that they did not need the results from the research to develop EIs in their own firms. In this situation, some partners exercised their power and exited or threatened to exit the alliance. This finding is supported

by Casciaro and Piskorski (2005), who found that power imbalances can explain why firms resist some interorganizational actions.

Over time, we observed a shift in power and dependence in Alliance 2. From years 4 to 5, the research partners accepted more of the demands from the dissatisfied firm partners and made the research more relevant to the firms. This approach resulted in a redistribution of power and dependence, which balanced the former power imbalance. The research partners now realized that they depended on industry funding to maintain the alliance and "gave" more power to the firms. This approach, in turn, made the alliance's response to the policy goals more coherent and made the firms more dependent on the alliance. This is in line with previous studies that have found that research partners' flexibility and willingness to respond to firms are crucial for maintaining the long-term sustainability of the collaboration (Czakon, 2009). Our findings show that balance in power and dependence develops over time and that this contributes to common understanding and a more unified response to the environmental objectives. In the process of balancing the relationship between power and dependence, the relative absorptive capacity also increased, especially in the knowledge base and dominant logic dimensions (see Table 6).

Table 6
Relative absorptive capacity in Alliance 2, years 4–5.

Organizational structures	Knowledge base	Dominant logics
Little change over time. *"We have addressed the need for more communication with the firm partners regarding the yearly work plan and the mid-term evaluation* (Research partner). *The research partners have now met the* [firm] *contact person, which is normally higher up on the organizational ladder, in addition to other relevant employees who took the time to meet us"* (Research partner). *"We have now dedicated more internal capacity to follow up on the research activities in the alliance"* (Firm partner).	There have been some adjustments to fit diverse knowledge bases. *"We previously received presentations that were too technical or too general. Lately, we have had presentations that have been a really good fit"* (Firm partner). *"I always get new ideas when I participate in the meetings* [with the research partners]*"* (Firm partner). *"We are now collecting data from all firm partners… After that, we are going to propose a suggestion for every single firm partner"* (Research partner).	The alliance increasingly followed the dominant logic of the firm partners. *"There have been some discussions regarding measurements* [in some of the firm partner's locations] *(…); these measurement campaigns are to some extent advanced consulting"* (Research partner). *"I think the alliance has improved firm partner involvement. I guess they* [the research partners] *have taken the feedback from the firms into consideration"* (Firm partner). In addition, the firm partners took the dominant logic of the research partners into consideration. *"We may have had inaccurate expectations when we entered* [the alliance]. *We expected commercial results, but we will not obtain that. We will get a direction and some interesting findings that we can use"* (Firm partner).

Over time, with the convergence of power and dependence between the firm and the research partners, the two sides improved their understanding of each other's problems and challenges. However, as the alliance increasingly followed the firm's dominant logic, the research partners also had to draw from the knowledge base that they had in common with the industry, which diminished the specialized knowledge that was used in the alliance. Consequently, the alliance did not achieve the intended policy goals; the research became more short term and the innovative outcomes more incremental.

5. Conclusion and implications

This paper builds theory on how the development of relative absorptive capacity and power relations between R&D partners influence how they respond to environmental policy objectives. By studying two Norwegian R&D alliances over time, we contribute to the debate on the dynamic relationship between EI partners (De Marchi, 2012; Yarahmadi and Higgins, 2012). First, we find a relationship

between levels of relative absorptive capacity in alliances and how R&D partners respond to environmental policy objectives. R&D partners with higher relative absorptive capacity are more likely to respond coherently to policy objectives because of their relative similarities in organizational structures, knowledge bases and dominant logics, whereas this is more challenging between partners with lower relative absorptive capacity. Second, we find that the levels of relative absorptive capacity are increased by balancing the power and dependence relationship, especially by ensuring that the dominant logics of both parties are considered, which creates a more coherent response to the environmental policy objectives. Hence, by combining the two theoretical concepts of relative absorptive capacity and power and dependence, we take a multiple perspective on the EI process, as called for by Ford et al. (2014). Taken together, our findings indicate that higher levels of relative absorptive capacity between R&D partners might have a unified effect on their response to policy objectives. However, this might influence the innovations deriving from the collaboration, as previous research on relative absorptive capacity has found that the innovative results from collaborations between partners with high levels of relative absorptive capacity are more likely to be incremental in nature (Lane and Lubatkin, 1998). Hence, although the partners respond more coherently to the policy objectives, they may not reach more radical objectives that are the intention of the technology-push policies in Alliance 2 (Bergek et al., 2014; Lettice et al., 2012).

5.1 Implications and limitations

Our results have potential implications for policy makers and organizations that engage in R&D collaboration for EIs. Policies designed to establish R&D collaborations between partners with different characteristics may have implications for the collaborative relationship. For example, partners that are too diverse may experience problems when collaborating, while partners that are too similar may experience problems when developing radical knowledge. Hence, different policies for increased R&D collaboration could be adopted depending on whether the aim is to develop incremental or radical environmental innovations. As collaborations between less similar partners may be more difficult to develop than collaborations between similar partners, we advise policy makers to create long-term R&D collaboration programs where parts of the program are fully financed by the government, aiming to develop radical new knowledge. This approach may reduce interdependencies between firms and research partners in the phase where researchers identify the principles that underlie technology development, which could be further developed in other parts of the program.

Our results have potential implications for firms that engage in environmental R&D collaboration. First, our findings indicate that different environmental policies motivate the formation of different R&D partnerships. On one hand, for command-and-control policies, firms could benefit from collaborating with similar R&D partners with whom they share a high relative absorptive capacity. On the other hand, for targeting radical policies, such as technology-push policies, firms could engage in R&D collaboration with more diverse partners. Further, our findings show that imbalances in power and dependence relations between R&D partners can result in collaborative challenges. Hence, R&D partners could both benefit from alliances by delegating power and increasing the relevance of the research for both partners.

Our study has several limitations. First, this paper is based on two cases that were influenced by two different policy approaches, which limits the transferability of the results. Future research should include more cases with different policy approaches to explore whether our results apply to other contexts. Another limitation is related to the qualitative nature of our research. Future research could statistically test whether our results are transferable to other environmental R&D alliances. However, more case studies are needed to explore the underlying collaborative processes between R&D partners.

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