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Organizational adaptation to disruptions in the natural environment: The case of climate change

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Natural environment;
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Summary Dynamic and intensified changes in the global ecosystem result in significant disruptions to the natural environment. One of the most prominent examples of this is climate change and the resulting natural disasters. As firms are embedded within the natural environment, they need to adapt to any environmental disruptions that transpire. Using Swiss and Austrian electric utilities as case studies, this paper empirically explores the underlying organizational capabilities necessary to enable adaptation to climate-related disruptions to a firm's resource supply, production processes, and product distribution. Through a case- and literature-based iterative process of analytical induction, three organizational capabilities are derived: climate knowledge absorption as an essential information generating and internalizing capability, climate-related operational flexibility as a short-term adjustment capability, and strategic climate integration as a long-term, innovation-focused capability.

Introduction

The 4th assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007b) clearly states that the evidence for global climate change is 'unequivocal.' This requires both that civil society acknowledges a significant change in the global ecosystem, and that organizations embedded in the natural environment learn to cope with the consequences of this change. Recent natural disasters, such as the extensive flooding in the summer of 2002 and the extremely hot and dry summer of 2003 in Europe as well as the multiple hurricane landfalls in the US in 2005 and 2008, demonstrate three important features of this change in the natural environment: the change is very dynamic, it has intensified in the recent past and is expected to further intensify in future, and it results in substantial disruptions of an organization's surrounding environment. As a result of this environmental change, firms need to adapt. Focusing on firms in the electrical power industry, this exploratory study empirically investigates the consequences of climate change on a firm and examines an organization's capabilities to adapt to this change.

Every organizational change is influenced by external and internal conditions (Ginsberg, 1988). The external conditions relating to disruptions in the natural environment are predetermined by the changing ecological system (e.g., IPCC, 2007b). There is no direct cause—effect relationship between the individual behavior of an organization and the general magnitude of the (global) change in the ecological system and corresponding disruptions. However, it is important to note that organizations are embedded within the natural environment (Starik & Rands, 1995) and, as such, there is a causal relationship between the functionalities of the ecological system and the flourishing of organizations within this

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system. Therefore, with regard to internal conditions, organizations can develop strategies and mechanisms for reducing their exposure to such disruptions. Organizations have the ability to change their strategies in a proactive manner in order to prevent any potential negative impacts on the organizations' physical assets, facilities, and production processes. I base my arguments on this logic and draw on the resource-based view of the firm (Barney, 1991; Wernerfelt, 1984) and organizational capabilities (Amit & Schoemaker, 1993) as important organizational resources. More specifically, I refer to a literature stream in the domain of organizations and the natural environment, which analyses organizational capabilities and corporate proactive environmental strategies (e.g., Aragon-Correa & Sharma, 2003; Sharma & Vredenburg, 1998).

At the centre of this analysis is the following research question: what kind of capabilities do organizations require in order to adapt to disruptions in the natural environment? The analysis focuses on the organizations' exposure to climate change-related disruptions and the necessity of organizations to plan for and successfully navigate them. By analyzing electric utilities, I derive three organizational capabilities for adapting to climate change-related disruptions. I discuss these findings in light of the concept of absorptive capacity (Cohen & Levinthal, 1990), and provide insights for further inquiry into this area.

Theory

Organizational capabilities and the natural environment

The concept of organizational capabilities is rooted in the resource-based view of the firm. Based on the early work of Wernerfelt (1984), a variety of authors have contributed to the development of the resource-based view (e.g., Barney, 1991; Barney, Wright, & Ketchen, 2001; Foss, 1998; Helfat & Peteraf, 2003; Lavie, 2006; Makadok, 2001; Miller & Shamsie, 1996; Oliver, 1997; Peng, 2001; Peteraf, 1993; Prahalad & Hamel, 1990; Priem & Butler, 2001). By focusing on the tangible and intangible resources within organizations, the main question this theory seeks to address is why some firms outperform others (Barney & Clark, 2007). As an answer, it is suggested that organizations develop and deploy resources that are rare among competitors, imperfectly imitable, non-substitutable, and valuable in terms of exploiting opportunities and/or neutralizing threats (Barney, 1991). As such, the resource-based theory is centred on the issue of how a firm can achieve a competitive advantage. However, this is not a static consideration. Also discussed is the fact that according to resource-based logic firms have a sustained competitive advantage when the competitive advantage achieved is lasting (Barney & Clark, 2007). This notion becomes important when using arguments drawn from the resource-based view within the debate on organizations and their external surroundings: maintaining a sustained competitive advantage requires organizations to successfully adapt resources to a changing external environment.

Drawing on the resource-based view, some scholars have suggested that resources refer to the fundamental assets owned or controlled by the organization while capabilities, by contrast, refer to the organization's capacity to deploy and exploit its resources (e.g., Amit & Schoemaker, 1993; Hill & Jones, 1992; Makadok, 2001; Teece, Pisano, & Shuen, 1997). Following this line of thought, capabilities are information-based assets since they are based on "developing, carrying, and exchanging information" (Amit & Schoemaker, 1993). As such, organizational strategies and the corresponding desired outcomes depend upon specific capabilities (Barney & Hansen, 1994; Felin & Foss, 2009). Organizational capabilities are essential for any required organizational modifications (Wernerfelt, 1984) in response to a changing external environment (Barnett, Greve, & Park, 1994; Helfat & Peteraf, 2003; Levinthal & Myatt, 1994). Based on Cohen and Levinthal's (1990) seminal paper, absorptive capacity has emerged as a key construct in this context. This can be defined as "a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability" (Zahra & George, 2002). Based on a literature review reflecting the academic work in this domain since then, Volberda, Foss, and Lyles 2010 develop an integrative framework that identifies the dimensions, its antecedents and outcomes, and the contextual factors that can be related to absorptive capacity.

Transferring the resource-based view to the natural environment, Hart (1995) notes that companies require specific resources and capabilities in order to remain competitive under ecological constraints. Various more recent research identifies the organizational capabilities required for lowering companies' environmental impact and proactively responding to ecological challenges (e.g., Aragon-Correa, Hurtado-Torres, Sharma, & Garcia-Morales, 2008; Aragon-Correa & Sharma, 2003; Darnall & Edwards, 2006; Hall, 1993; Sharma & Aragon-Correa, 2005; Sharma & Vredenburg, 1998). A key conclusion drawn by this research is that it is sensible for organizations to develop and deploy capabilities in the natural environment context when the following two conditions are fulfilled: (1) there is a nexus between organizational behavior and issues related to the natural environment, meaning that firms can adapt to a changing natural environment and/or improve their environmental performance. (2) Managing these issues can generate a competitive benefit. This means that firms should implement proactive strategies that address the issues related to the natural environment.

Dynamic changes in the global ecosystem

Since organizations are embedded within the global ecosystem, they affect the natural environment and are in turn affected by changes in the natural environment (Winn & Kirchgeorg, 2005). The term 'carrying capacity' addresses the ability of the global ecosystem to absorb pollution discharges such as air emissions and it delimits the critical flows of these substances from the anthroposphere to the ecosphere. The carrying capacity of the natural environment is normally considered a stable business condition, i.e. organizations take a technocentric view and presume that the current status quo will remain stable within a given planning horizon (Gladwin, Kennelly, & Krause, 1995). However, recent dynamics in the global ecosystem constitute an increasingly salient driver of external change for organizations. The key question is whether these dynamics in the global ecosystem are substantively different to other environmental changes discussed in the organizational literature.

In early organizational studies, "closed-system rational and natural theorists took some account of environments, but neither had an explicit conceptualization of them" (Aldrich & Marsden, 1988: 363). However several developments, such as the contributions of political sociology or the growing interest in inter-organizational studies, spurred an increased interest in the organizations' environment (Aldrich & Marsden, 1988). In the early organization-environment debate, Aldrich (1979: 61) emphasized that "environments affect organizations through the process of making available or withholding resources". Based on Aldrich's (1979) six dimensions relevant to informational and resources perspectives of environments, Dess and Beard (1984) contributed to the debate by suggesting three environmental dimensions: munificence, complexity, and dynamism. These dimensions are important for understanding organizational behavior as these stimulate changes within organizations (Damanpour & Evan, 1984). Several theoretical approaches seek to explain and specify such changes from different angles. Such approaches include contingency theory, population ecology, institutional theory, resource dependence theory, transaction cost economics (for reviews see Aldrich & Ruef, 2006; Donaldson, 1995). In a recent article, Walsh, Meyer, and Schoonhoven (2006) critically reflected on the current stage of organizational theory, and highlighted how today's changing organizations can be understood as still being an important question for future research. In order to answer this question, scholars should view "organizations from a wider angle — seeing them as embedded historically, institutionally, culturally, and politically" (Walsh et al., 2006: 661). In the following, I will focus on viewing organizations as being embedded within the natural environment.

Certain dynamics in the broader natural environment context are quite similar to changes in the general organization-environment context. For example, a change towards more sustainable consumption patterns is not much different to any other consumer-related change. In both cases, a firm needs deeper knowledge of its customers' preferences. The sources of such dynamics within the general external environment context are usually socially constructed. As such, knowledge regarding how to respond to these dynamics can be routed in the sociopolitical context of an organization, such as "stakeholder demands, regulatory pressure, and external relationships" (Rothenberg & Zyglidopoulos, 2007: 40). Beyond this sociopolitical context it is important to be aware that organizations' daily operations also depend on the functionality of the ecological system. Disruptions within this system also require fundamental changes and adjustments of established business processes and routines. However, the ability to respond to such disruptions in the natural environment requires specific knowledge of ecology and natural science, which is significantly different to knowledge about changes in the general organizational environment to due to the following three reasons.

First, disruptions in the natural environment do not emerge in a continuous and predictable manner, and their long-term global consequences and potential reversibility are hard to anticipate as the ecosystem's dynamics are in general uncertain (Chichilnisky & Heal, 1998; Heal, 1998). More specifically, forecasting conditions in the natural environment such as ecological limitations or ecosystems' thresholds over the long-term are difficult: methodologies to deal appropriately with "external shocks, nonlinear responses, and discontinuous behavior" (Clark, 1986: 31) are scarce, and sufficient ex post data or long-term time series are often not available. Such knowledge is needed to reliably predict future changes within the natural environment and their related uncertainties. Second, specific knowledge of these uncertainties in an organizational context is difficult due to the problem of chaos and complexity (Clark, 1986; Prigogine & Stengers, 1984; Wheatley, 1999). It is a rule of ecology that everything is interconnected and each environmental insult will likely rebound on society (King, 1995). Therefore, concerns about the global ecosystem "lead to the generation of crude and difficult-to-operationalize axioms" (Gladwin et al., 1995: 891). Third, disruptions in the natural environment are usually rapid and massive. Exceeding sustainable limits could cause a sudden environmental collapse (Meadows, Meadows, Randers, & Behrens, 1972), a phenomenon which in organizational theory has been termed ecological surprise (King, 1995). Furthermore natural disasters are not necessarily static, isolated phenomena (Hannigan, 2006), they may constitute a threat of "massive discontinuous ecological changes" (Winn & Kirchgeorg, 2005: 233). It is important that organizations understand individual exposure to such ecological surprises and massive discontinuities and evaluate corresponding response options. In order to do so, organizations require specific knowledge of the emergence, extent, and intensity of such phenomena (Berkhout, Hertin, & Gann, 2006) and have to establish innovative learning processes (Halme, 2002). The literature on organization theory, however, has barely begun to systematically consider this (Winn, Kirchgeorg, Griffiths, Linnenluecke, & Günther, 2011).

Substantial disruptions due to an intensified change of the global climate

Focusing on one of the most dominant ecological issues, climate change, helps to illustrate that the described changes intensify: The Intergovernmental Panel on Climate Change (IPCC, 2007b) summarizes how changes in the atmospheric concentration of greenhouse gases and aerosols, in solar radiation, and in land surface properties alter the energy balance of the climate system. Carbon dioxide has been found to be the most important anthropogenic greenhouse gas. As empirical support for an altering climate system, reference is usually made to statistical evidence: eleven of the twelve years from 1995 to 2006 rank among the twelve warmest years since 1850. The total temperature increase from 1850–1899 to 2001–2005 is 0.76 °C. This has been correlated with an increase in natural disasters, sea level rise, and weather extremes. The already tangible economic effect has been a steady increase in economic losses resulting from natural disasters (Munich Re, 2009). The IPCC forecasts estimate that temperatures will probably increase by 1.8–4 °C by the end of the century. Further temperature increases could result in annual global losses in gross domestic product of anywhere between five and 20 percent in the long-term (Stern, 2006). These facts illustrate that — beyond substantial efforts to mitigate climate change

— adaptation measures seem to be an inevitable future necessity.

This change in the global climate system constitutes a sphere of substantial disruptions within an organization's surrounding environment (Busch & Hoffmann, 2007). Table 1 lists the possible impacts of these disruptions on the business environment and organizations as discussed in literature.[1] The table demonstrates a wide range of ways in which climate change can affect organizational processes and routines. In summary, a company's resource supply, production processes, and product distribution can be affected due to steady changes of mean temperatures and increasing frequency and intensity of extreme weather events (compare Fig. 1): within the supply chain, climate change-related disruptions can decrease the quantity and quality of required resources or even disrupt the supply chain entirely. Within production processes and facilities, organizations can be exposed to climate change-related disruptions in terms of physical damages and slowed or interrupted operation. In addition, climate change-related disruptions may affect the distribution and quality of products and services.

Table 1 Impacts of climate change on the business environment and organizations.

Discussed effects of climate change on the business environment and organizations in literature:
• Limited availability of natural resources (especially water) and raw materials
• Interrupted supply chains and logistic/transport systems
• Higher costs for maintenance, commodities, and O&M activities
• Lower effectiveness and efficiency of production processes
• Increased property loss and changing asset values
• Disrupted commerce and changing markets
• Change in customer demand for goods and services
• Increasing insurance premiums and withdrawal of risk coverage by insurers
• Consequences due to migration and damage of infrastructure

Source: Acclimatise (2006), Sussman and Freed (2008), Schwartz (2007), and van Bergen (2008).

Necessity for proactive organizational adaptation

The discussion thus far has illustrated that organizational responses to disruptions in the natural environment, such as climate change, require substantially different knowledge as compared to responses to other dynamics in the broader organization-environment context. Building on this, the main propositions of this paper are: (1) there is a nexus between organizational behavior and issues related to the natural environment, in this case climate change-related disruptions. As such, organizations are *in general* able to reduce their exposure to these disruptions by acquiring knowledge about them and implementing adequate adaptation measures. (2) Managing these issues can generate a competitive benefit. Thus organizations should in fact reduce their exposure to these disruptions from a *competitive point of view*. In order to avoid negative consequences on business due to physical damages, it is necessary for organizations to proactively adapt to climate change (Linnenluecke, Griffiths, & Winn, 2008). It therefore seems to be appropriate and sensible for organizations to develop and deploy capabilities in order to do so.

According to the IPCC (2007a: 869), adaptation is the "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." Organizations can adapt to climate change in three main ways: (1) anticipatory adaptation, which takes place before climate change impacts are observed; (2) autonomous adaptation, which does not constitute a conscious response to climatic change effects but is triggered by changes in natural and human systems; (3) planned adaptation, which is the result of a policy decision based on an awareness that climatic conditions have changed or are about to change and that human action is therefore required to return to, maintain, or achieve a certain state.

With respect to management strategies in the general ecological context, research has discussed the evolution of environmental strategies (e.g., Bansal, 2005; Child & Tsai, 2005; Haigh & Griffiths, 2009; Lenox & Nash, 2003; Pinkse, 2007; Rothenberg & Zyglidopoulos, 2007), environmental management practices and systems (e.g., Burritt & Saka, 2006; Delmas & Toffel, 2004; Handfield, Sroufe, & Walton, 2005; Schaltegger, Burritt, & Petersen, 2003), ecology-oriented investment decisions (e.g., Busch & Hoffmann, 2009; Laurikka & Koljonen, 2006; Scholz & Wiek, 2005), and the role of organizational capabilities (e.g., Aragon-Correa & Sharma, 2003; Darnall & Edwards, 2006; Hall, 1993; Sharma & Aragon-Correa, 2005; Sharma & Vredenburg, 1998). Explicitly focusing on direct effects of climate change, Porter and Reinhardt (2007) argue that companies also need to develop capabilities to proactively manage disruptions stemming from 'ecological discontinuities.' However, thus far little research has been conducted regarding the question of which capabilities organizations can build upon towards this end (Winn & Kirchgeorg, 2005). A few authors investigate climate change-related disruptions in specific industries and derive suggestions from an organizational capability perspective. For example, Hertin, Berkhout, Gann, and Barlow (2003) and Berkhout et al. (2006) consider the residential construction sector. In order to avoid disruptions in construction, the authors suggest builders possess the capability to prefabricate house parts off-site, change on-site building techniques, and shape the construction process in a flexible way. With respect to building damages, they suggest increasing the capability to change the building design, developing and/or using new building materials, and increasing insurance coverage. Arnell and Delaney (2006) investigate the water supply industry. In order for the industry to avoid water shortages, the authors propose developing new water sources, improving water utilization on the supply-side, improving water distribution and treatment, and undertaking demand-side measures to reduce water usage.

[1] This paper explicitly addresses physical (or direct) effects of climate change. Indirect effects such as governmental regulation are not investigated, although they also have a significant effect on the business environment (compare Busch & Hoffmann, 2007).

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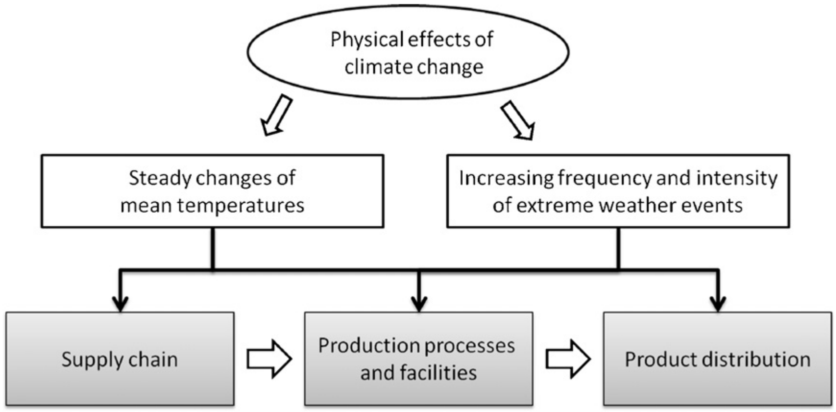

Figure 1 Physical effects of climate change on companies.

Beyond these industry-focused studies, the literature contains no generic set of organizational capabilities for adapting to disruptions in the natural environment. In order for organizations to develop such a set of capabilities, a system-wide perspective has to be taken: the organizational exposure to climate change-related disruptions must not be limited to the organization itself but also has to address disruptions beyond the corporate boundaries (Chegini, 2005; Sussman & Freed, 2008). When an organizational adaptation strategy and related capabilities are developed, it is therefore also important to incorporate supply chain and product distribution operations, for example, and to consider their sensitivity (the degree to which they are affected by climate-related stimuli) and vulnerability (the degree which they are unable to cope with related disruptions) (derived from IPCC, 2007b). Based on this theoretical background, this paper analyses firms in the electrical power industry and derives a set of organizational capabilities for adapting to climate-related disruptions in the surrounding natural environment.

Method

This paper addresses the phenomenon of organizational adaptation to climate change-related disruptions. In seeking to identify necessary organizational capabilities, the meaning and understanding of this phenomenon is empirically explored. For this purpose, qualitative research is important as "such exploration offers the possibility of stimulating the development of new understandings about the variety and depth with which organizational members experience important organizational phenomena" (Bartunek & Seo, 2002: 240). In order to develop an empirically based perspective on the necessary organizational capabilities, I applied analytical induction (Bansal & Roth, 2000; Eisenhardt, 1989; Manning, 1982; Yin, 2003). Using this approach, I began with the aforementioned theoretical background on organizational adaptation and disruptions in the natural environment and iteratively added empirical insights derived from case studies.

Sampling

Following the recommended approach to selecting case studies for analytical induction, I applied theoretical sampling (Bansal & Roth, 2000; Eisenhardt, 1989; Yin, 2003). Based on a two-step process, cases valuable to determining the necessary organizational capabilities were selected. First, the industry was specified. Not all industry sectors are equally sensitive to climate change-related disruptions. Sectors relying on certain seasonal and weather conditions and those affected by disruptions of infrastructure and resource supply are particularly vulnerable (Winn & Kirchgeorg, 2005). Companies within the electricity industry are particularly suitable for research on adaptation to climate change-related disruptions: the supply and operating conditions for both fossil fuel and renewable based electricity production and distribution technologies are directly exposed to the natural environment. They are therefore affected by environmental changes such as those caused by climate change (Bruce, 2008). As a result, studying electric utilities not only enabled me to investigate the exposure and adaptation to climate change-related disruptions of operational processes but also to cover supply chain and product distribution aspects.

Second, I found that electric utilities in Austria and Switzerland are particularly suitable for case studies as these regions have been exposed to climate change-related disruptions in the past and are expected to be increasingly exposed to them in the future. For example, the strong drought in the summer of 2003 led to power plant outages in Austria due to the decreased availability of water for both hydropower production and the cooling of thermal power plants (Rosenkranz, 2003). In the same summer, Swiss electricity production from nuclear power plants had to be reduced by 25 percent for two months due to nearby rivers providing insufficient cooling capacity (OcCC, 2007). Flooding in the summer of 2002 led to the shutdown of several Austrian hydropower plants due to excess water and physical damage (SN, 2002). Electricity distribution in parts of Switzerland was interrupted in August 2007 following the flooding of several transformer substations (NZZ online, 2008). Climate change is expected to have significant physical effects in both countries in future. For Austria, a decrease in precipitation in several regions (Formayer, Eitzinger, Nefzger, Simic, & Kromp-Kolb, 2001; Matulla, Formayer, Haas, & Kromp-Kolb, 2004) as well as an increase of the average ambient temperature (Kromp-Kolb, Formayer, & Clementschitsch, 2007) is expected. Switzerland will also face a rise in ambient temperature, more volatile precipitation, and an increase in frequency and intensity of climate extremes such as flooding and drought (OcCC, 2007). Consequently, there will be a stable or even increased amount of water available in Switzerland in the short-term due to glacier melting. In the long-term (until 2050), however, hydropower generation will decrease on average by seven percent and cooling capacity for power plants will be reduced due to limited water availability and increased river temperatures (OcCC, 2007). The choice of these two countries was important for the diversity of the electricity systems considered: Austria has no nuclear power and utilizes many different types of renewable energy sources, while Switzerland has almost no coal power but generates significant amounts of hydropower. From this, a generic and differentiated picture the electricity industry's exposure and adaptation potential to climate change-related disruptions could be drawn.

The sample consists of six Austrian and five Swiss electric utilities. It is a valuable characteristic of the sample that the companies cover 70 percent of electricity production in each country. A further benefit of the sample is that it is heterogeneous in terms of company size, region of operation, technologies utilized to produce electricity, and vertical integration (see Table 2). Company size, represented by electricity produced in 2007, ranges from 0.5 to 28 TWh (terawatt-hours), with seven companies producing less than 5 TWh, two between 5 and 10 TWh, and two over 20 TWh. Regarding technology, the sample includes companies that have a relatively high share of renewable energy-based power plants (i.e. either hydro or wind power) but also contains companies with a balanced mix of power plant technologies (i.e. a mix of thermal- and hydropower). The sample also covers every energy source used in thermal power plants (i.e. nuclear, coal, gas, and oil). As such, the cases comprised a variety of companies exposed to climate change-related disruptions in different ways. For reasons of confidentiality, statements are not attributed to specific companies and cases are referred to as A through K.

Data sources

Both archival documents and interviews were used as data sources. The case study research began with extensive research of archival documents from multiple sources. First, a content analysis (Neuendorf, 2002) of 140 electric utilities' responses to the Carbon Disclosure Project (CDP & IBM,2008) questionnaires of 2006 and 2007 was conducted. The results of this analysis provided a structured overview of all possible activities in the realm of climate change adaptation currently pursued by electric utilities. Furthermore, a literature review facilitated the gaining of industry and technology-specific insights, determining possible climate change-related disruptions of electric utilities, and investigating applied adaptation strategies. Second, research of publicly available information about the case companies (e.g., web pages and annual reports) provided specific knowledge on each company. The special focus of this research was on quotes regarding climate change management, climate change-related effects on operations, and current and future climate change-related projects.

This information was turned into a customized interview guide for each company, which was then used for semi-structured interviews. Each interview had the following structure: (1) general introduction about the project and the topic; (2) identification of climate change as an important issue for the company; (3) assessment of climate change-related disruptions to supply, production, and distribution; (4) individual response strategy to climate change-related disruptions. The number of interviewees per case and their responsibility within the respective company varied depending on the organizational setup of the company and the company-specific person in charge of climate change-related issues (see Table 3). Where a single person was responsible for

Table 2 Case profiles.

Characteristics		Case										
		A	B	C	D	E	F	G	H	I	J	K
Electricity sources	Hydro power	16%	37%	100%	16%	23%		9%	43%	100%	86%	85%
	Thermal power	84%	63%		84%	71%		90%	57%		14%	15%
	Wind power	<1%			<1%	6%	100%	1%	<1%		<1%	
Vertical integration	Electricity production	•	•	•	•	•	•	•	•	•	•	•
	Electricity distribution	•	•	•	•	•		•	•	•	•	•

Table 3 Interview profiles.

Function	Case											Total
	A	B	C	D	E	F	G	H	I	J	K	
CEO/Managing Director			•					•••	•			5
Corporate strategy/development					••	•	•••		•	••		9
Corporate risk management	•	•		•						••	••	7
Total	1	1	1	1	2	1	3	3	2	4	2	21

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climate change-related issues, only one interview was conducted. However, interviewees were always asked for other people within the company who were specialists on certain climate change-related aspects. Where such people were present, they were also interviewed in order to prevent any relevant information being missed. In total, 21 interviews were conducted. Each interview took about 1 h and was conducted via a face-to-face meeting, always by the same two researchers. The eleven case-studies were conducted sequentially in order to enable the application of insights gathered from each case to an improved interview guide for the subsequent cases. Each interview was recorded and transcribed. Each transcript was reviewed by the interviewee in order to detect potential misunderstandings and each interviewee was given the opportunity to make corrections where misunderstandings were identified. Follow-up questions were asked via e-mail or phone when clarification was needed or new aspects emerged in subsequent interviews.

Data analysis

Two researchers systematically analyzed the interview transcripts by categorizing emergent themes regarding organizational capabilities that relate to adaptation to climate change-related disruptions. As a first step, both researchers independently noted statements in the interview protocols that revealed adaptation-related organizational capabilities and generated a draft list of first-order themes. In addition, the two researchers also reverted to data obtained from archival sources such as companies' web pages and annual reports for triangulation purposes (Denzin & Lincoln, 1994) in order to confirm the reliability of interviewees' statements. Second, they independently summarized the draft list of identified first-order themes, drawing up a list of similar measures which was labeled second-order themes. Third, they compared their individual findings on second-order themes and agreed on a final list of these. Fourth, a single list of first-order themes was developed by unifying the two draft lists identified in step one. The two researchers then independently assigned this final list of first-order themes to the agreed-upon second-order themes. Inter-rater reliability analysis using Kappa statistics yielded Kappa coefficients of 0.83 and higher, thus demonstrating "almost perfect" agreement between the raters (Landis & Koch, 1977). Finally, in cooperation the two researchers generalized the results by further shortening the list of second-order themes as several could be assigned to the same construct, i.e. the list of final themes. As the aim of this research is to derive a general set of organizational capabilities, these final themes were formulated in a general manner, i.e. without direct reference to the cases. Furthermore, existing constructs from the literature were applied for the final themes, as this is recommended wherever possible (Eisenhardt, 1989).

Results

The electricity sector's exposure to climate change-related disruptions

All the electric utilities investigated state that they have experienced the negative impacts of climate change-related disruptions in the past to some extent, or expect to be increasingly exposed to them in the future (see Table 4). These disruptions relate to the increase of average ambient air temperature, the occurrence of more frequent and intense storms, changes of precipitation, and consequent droughts and floods. Both the production processes as well as other areas of the electric utilities' value chain are exposed to these disruptions.

Resource supply for electricity production (supply chain, compare Fig. 1) can be reduced or interrupted due to changes in resource quantity and quality, as well as due to physical damages to supply facilities. With regard to reduced resource quantity, the electric utilities interviewed state that they face a decrease in the availability of water. This in turn will negatively influence hydropower generation and the cooling capacity of thermal power plants. One interviewee indicated: "We do not expect a problem with water availability for hydropower generation in the short-term, as the decrease of water from precipitation is compensated with water from melting glaciers. But we are aware that this source will not be available in the long-term."

Electricity production (production processes and facilities) can be directly affected by physical damage to power plants resulting from storms or flooding. As a consequence of these climate change-related disruptions, the electricity production can be either reduced or interrupted. These effects of disruptions are reflected in interviewee remarks such as "flooding caused physical damages to our hydropower plants which in turn had to be shut down," and "more intense storms could damage our wind parks." The companies are aware of possible risks posed to the technologies they utilize for electricity production, as illustrated by the remarks of one manager: "Our overall exposure to direct climate risks depends on the share of the individual technologies in our total portfolio as well as on the geographical location and distribution of our power plants." Furthermore, electricity production faces the risk that the power plant capacities will prove insufficient to meet increased electricity demand. This could occur from heightened use of air-conditioning during hot periods.

Power distribution (product distribution) can also be directly affected by physical damages to power lines, e.g. downed lines from storms, which results in an interruption of the entire distribution system. One interviewee indicated: "It is not only grids above ground which are affected, power lines underground can also be damaged, e.g. by land slide." In addition, increased electricity demand also constitutes a risk for power distribution as the existing grid capacities might not be sufficient to meet it.

While some of the effects mentioned are not entirely new to the companies, the interviewees acknowledged that their more frequent and intense occurrence in future will impose severe constraints on them. Therefore, adaptation to climate change-related disruptions is already an important part of their current management efforts. However, in many cases not all of the identified areas are covered by adaptation activities, and many companies have "just started to look deeper into this specific area." Because of this, many interviewees attested that their company is planning to intensify and extend their organizational adaptation efforts in a proactive manner (cf., Aragon-Correa & Sharma, 2003; Sharma & Vredenburg, 1998).

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Table 4 Climate change-related disruptions in the electricity sector.

Affected area	Exemplary quote	Companies with supporting evidence
Supply chain		
Inadequate or excessive water for hydropower generation	"Some of our hydropower plants have faced the lowest production ever in 2006." "We expect a reduced electricity generation due to the more volatile water availability." "Since a couple of years electricity generation from hydro power does not achieve previous values." "In case of flooding the total or additional water cannot be used." "In case of flooding electricity production is reduced or must be shut down due to the higher water level in the underflow of the plant."	A, B, C, D, E, H, I, J, K
Reduced water for cooling thermal power plants	"We have problems with the cooling capacity of a thermal power plant when the nearby river has little water. In this case the launching temperature of the cooling water is too high for the river. Consequently we have to reduce power production." "We had to reduce power plant power output due to droughts." "In case of too little or no cooling water we have to shut down power plants."	B, D, E, G, H
Inadequate wind patterns	"In the recent time our wind parks do not face more frequent or more intense storms but more time with too little wind." "More volatile and turbulent wind patterns affect production of our parks." "The good wind months October and November have not been as fruitful as in the past due to more calm climate patterns."	A, F
Physical damages to resource supply facilities	"Decreased permafrost can lead to more rock falls into water reservoirs and consequently to more floating debris." "In case of droughts coal delivery to our coal power plant can be slowed or interrupted."	B, C, D, E, H, I, J, K
Production		
Physical damages to production facilities	"Flooding in August 2007 caused physical damages to a hydro power plant." "More intense storms could damage our wind parks."	B, E
Limited production capacity	"An increased electricity demand due to climate change can lead to production bottlenecks at times of power plant revisions."	B, E, J, K
Product distribution		
Physical damages to product distribution facilities	"Storm 'Lothar' caused damages to our power lines." "Not only grids above ground are affected by physical climate effects but also power lines underground can be damaged, e.g. by land slide."	B, C, D, E, H, J
Limited distribution capacity	"Climate change can lead to power grid capacity bottlenecks due to increased electricity demand for air-conditioning."	B, C, E

Organizational capabilities for adapting to climate change-related disruptions

As a result of the data analysis, I identified a set of three organizational capabilities relevant in enabling electric utilities to adapt to climate change-related disruptions in their surrounding natural environment: climate knowledge absorption, climate-related operational flexibility, and strategic climate integration (Table 5).

Climate knowledge absorption

The process of absorbing climate knowledge can be considered an essential condition for any organizational adaptation to climate change-related disruptions in the natural environment. In situations in which the anomaly and significance of disruptions in the natural environment increase, organizations need to internalize information about the dynamics, intensity, sources, consequences, and future developments of these disruptions. This information internalization process is essential in order to be able to prepare for adapting to climate-related disruptions (cf., Winn et al.,2011). As global warming was acknowledged as a business issue rather recently, firms do not yet possess much knowledge of how steady changes of mean temperatures and increasing frequency and intensity of extreme weather events will affect their business. Similar to any critical knowledge, the process of climate knowledge absorption is based on two knowledge sources, external and internal (cf., Volberda et al., 2010). Based on these sources, the climate knowledge absorption capability can be ascribed to two components: knowledge creation and utilization (Zahra & George, 2002).

The case studies indicate that the process of identifying climate change-related disruptions and determining the corresponding organizational exposure to these disruptions can be associated with both components of the climate knowledge absorption capability. With respect to knowledge

Table 5 Themes analysis of organizational capabilities.

First-order themes	Second-order themes	Final themes
Information regarding climate change-related disruptions: • Ability to map global climate change effects with involvement of external experts/consultants • Ability to predict global climate change effects with involvement of external experts / consultants • Obtaining external studies on climate change implications for energy generation • Attending conferences on climate change effects • Evaluating literature and media coverage on climate change effects • Bottom-up identification process where employees report possible or expected climate change effects imposed on their division • Establishing internal climate change management team • Ability to conduct climate risk-scenarios regarding power plant output volatility • Ability to conduct climate risk-scenarios for planned power plant projects and acquisition decisions • Forecasting water availability and corresponding output of hydropower plants • Forecasting water availability and corresponding reliability of thermal power plants • Assessing stability of hills around reservoir dams • Monitoring and controlling of land around water reservoir dams to prevent damages by landslide	• Ability to utilize and combine internal and external knowledge • Capability to determine probability that existing / planned operation facilities and other areas of the value chain will be affected • Capability to analyze the potential impacts on existing / planned operation facilities and other areas of the value chain	• Climate knowledge absorption
Short-term responses to potential climate change-related disruptions: • Building stocks of energy resources • Maintaining supply of energy resources by having redundant supply ways • Ability to switch energy resources within production of one power plant • Precautionary operational planning for electricity production by storing access-generated power • Incorporate decreased water inlet in short-term operational planning of hydropower production • Ability to temporarily compensate decreased power generation with production from power plants in different geographical region • Ability to temporarily compensate decreased power generation with production from power plants using other technology • Ability to temporarily compensate decreased power generation with purchased electricity from 3rd party • Maintaining energy supply for big cities and industry locations with redundant power lines • Utilizing financial instruments to hedge against temporary decreased power generation	• Ability to maintain resource supply for power generation • Capability to diversify power generation technologically and regionally • Ability to secure electricity distribution	• Climate-related operational flexibility

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Table 5 (*Continued*)

First-order themes	Second-order themes	Final themes
Long-term responses to potential climate change-related disruptions: • Ability to expand capacity and availability of existing power plants • Ability to optimize existing power plants' efficiency through technological innovations • Ability to adopt new cooling technologies for thermal power plants • Installing technical protection devices for power plants and supply facilities • Incorporating the consequences in the design of new power plants • Considering the consequences when choosing locations for new power plants • Exchanging power lines or switching to higher voltage level to increase transport capacity • Repositioning power grid into ground at highly exposed locations • Improving design and placing of new power grids	• Ability to secure or increase output of existing power plants • Capability to protect existing production and distribution facilities • Capability to adjust design and location of new production and distribution facilities	• Strategic climate integration

creation, it is important that organizations gather and combine internal and external knowledge on how the supply chain, production processes, and product distribution are affected both presently and in the future. On the one hand, the knowledge of the electric utilities' investigated includes external knowledge from experts and consultants on climate change-related developments and general consequences for the business environment. Some companies source external knowledge by conducting studies in cooperation with external experts. For example, one electric utility has conducted a study in cooperation with a nearby university on the future availability of water for hydropower generation in its geographical operational area. On the other hand, the utilities initiate an internal bottom-up process whereby employees from the various divisions regularly report experienced exposure to and expected consequences of climate change-related disruptions to corporate management.

Within the further adaptation process, the companies utilize such information in two ways: (1) to determine the probability that existing and planned operation facilities and other areas of the value chain will be affected; (2) to analyze the potential impacts on them. The cases illustrated that in fact all utilities of the sample use such information on their existing electricity production processes and distribution facilities. For example, all companies with hydropower plants assess the availability of water for electricity production in both the short- and long-term. Regarding planned facilities, a few companies explicitly address resource supply as an important issue. For example, one company stated that it assesses the possibility of a 'no-water-situation' at the nearby river as part of the process of planning a new coal power plant.

Climate-related operational flexibility

Generally, operational flexibility can be defined as the ability of a manufacturing system to cope quickly with changing circumstances or instability caused by the organizations' external environment (Gupta & Goyal, 1989). For each of the various types of possible changes and instabilities in the external environment, organizations require particular types of flexibility in order to adapt successfully to the change (Beach, Muhlemann, Price, Paterson, & Sharp, 2000; Gerwin, 1987). Accordingly, various authors have discussed different types of operational flexibility. Excellent summaries are provided by Beach et al. (2000) and Zhang, Vonderembse, and Lim (2002). In the context of climate change, disruptions might emerge quickly and result in a severe change in the organizations' external environment. This dynamic change can affect an organization's own production processes as well as other areas of the value chain, while the exposure of each area is determined by the extent to which it is embedded in the natural environment. In order to adequately respond to such dynamic changes, organizations need the capability to quickly switch the required input resources, production processes, or distribution channels. As such, climate-related operational flexibility enables organizations to adapt to climate change-related disruptions in the short-term.

The case studies revealed that electric utilities can use climate-related operational flexibility as an organizational capability to adapt to climate change-related disruptions in three different ways: supply flexibility, routing and process flexibility, and distribution flexibility. Supply flexibility describes the ability of an organization to provide a variety of inbound resource sourcing and warehousing (Day, 1994; Langley & Holcomb, 1992). This flexibility can be applied as a response to a slowed or disrupted supply of resources that stems from climate change-related disruptions. Furthermore, supply flexibility can be accomplished by diversifying the resource supply channels and by stocking resources. For example, some electric utilities diversified the delivery of coal to its power plants by using ships and trains or different train routes. Other companies stock the amount of coal sufficient for a certain duration at the power plant site. For example, one company has the policy of keeping a storage level adequate for at least a year's electricity production in its water reservoirs. For electric utilities that purely rely on natural energy sources such as wind and water, supply flexibility is less relevant as the potential to stock the resources is limited.

Routing and process flexibility aim at continuation of production should the necessary input resources become either unavailable or only partially available. For electric utilities' short-term operational planning, details on when vital input resources will be unavailable or restricted constitute important information. With regard to climate change-related disruptions, utilities can focus on technological and geographical diversification of production facilities. Routing flexibility is the ability to continue producing by rerouting production to other production sites (Browne, Dubois, Rathmill, Sethi, & Stecke, 1984; Gerwin, 1987). For example, a hydropower company incorporates the expected water availability into its short-term operational planning. If a shortage occurs, the loss in production is compensated for by increased production from other thermal power plants. Process flexibility is the ability to continue producing the same products/services by using a different production system or technology (Barad & Sipper, 1988; Browne et al., 1984). For example, one electric utility is able to continue its production if an input resource is not sufficiently available by switching from oil to gas and vice versa. This, however, requires that utilities do not rely on one single energy source, as it is the case with company F which uses only wind power.

Distribution flexibility is the ability to secure the delivery of products and services in order to meet customer needs (Day, 1994; Lambert & Stock, 1993; Langley & Holcomb, 1992). This flexibility is important for electric utilities when climate change-related disruptions result in slowed or interrupted product distribution. It can be accomplished by diversifying the distribution channels to customers. For example, some utilities distribute electricity to big settlements and industrial sites with redundant power lines in order to maintain electricity supply when one line is interrupted. In recent years this was often the case due to massive winter storms in the Alps.

Strategic climate integration

Strategic climate integration refers to the organizational capability to address and incorporate climate change into the continuous, long-term innovation process. Continuous innovation can be defined as the "changing experiential base of organizational activities, routines, and goals [targeting the long-term optimization of] technologies, processes, specifications, inputs, and products" (Sharma & Vredenburg, 1998: 741). As such, the capability to strategically integrate climate change consists of two basic components: the ongoing improvement of existing processes and the development of new process configurations (Boer & Gertsen, 2003). Improvements relate to organization-wide processes and are essentially a cluster of behavioral routines (Bessant & Francis, 1999) aimed at efficiency gains (Benner & Tushman, 2003) and enhancement of business performance (Dabhilkar & Bengtsson, 2007). While improvements correspond to incremental innovation, they do not necessarily stimulate radical innovations (Benner & Tushman, 2003) as those require considerably different processes and resource configurations (Peng, Schroeder, & Shah, 2008). Radical changes can usually be achieved by developing new processes, which require a set of identifiable and specific organizational routines (Eisenhardt & Martin, 2000) and technological capabilities (Lall, 1992). Both components of strategic climate integration are important for long-term organizational adaptation to disruptions in the natural environment. In this context, the question of whether improvements or new processes are more important for effective organizational adaptation to climate change is raised. The punctuated equilibrium model of technology diffusion (Brown & Eisenhardt, 1997; Romanelli & Tushman, 1994) can be applied in this context, which suggests that long periods of incremental improvements are interrupted by short periods of radical new developments.

The case studies highlighted that electric utilities utilize both components of the strategic climate integration capability in order to adapt to climate change-related disruptions. With regard to improvements, the ability to secure or increase the output of existing power plants and to protect existing production and distribution facilities is an important area for optimization. For example, many companies increase the efficiency of their water-cooled thermal power plants in order to reduce the risk of not having enough cooling water. Beyond this, one company considered installing a 'water-fence' in order to cool the inlet air to its gas turbines. To protect against more frequent and intense flooding, a few utilities adapt their flood protection at existing operational facilities. In order to adapt the electricity distribution, all companies examined relocated those power lines that were highly exposed to climate change-related disruptions below ground. With regard to new process developments, the adjustment of design and location of new production and distribution facilities turned out to be a relevant area. For example, one company plans to build its new thermal power plant at the same location as the old one (next to a river) but with a cooling tower as the main cooling source rather than utilizing water from the river. Another company is avoiding the deposition of floating debris in a water reservoir by building a bypass gallery to transport this debris into the underflow. All electric utilities state that they intend to build power grids with more capacity to handle expected increased electricity use and transportation. Furthermore, many companies state that they will increase the height and strength of the power poles they build in order to prevent damage by trees felled during storms.

Discussion

This paper contributes to the literature on organizations and the natural environment. The analysis illustrates the exposure of electric utilities to climate change-related disruptions, and discusses detailed organizational capabilities for adaptation measures which firms require in order to address the outside-in effects of climate change (Porter & Reinhardt, 2007; Winn & Kirchgeorg, 2005). As a result of the empirical case studies, I derive a set of three organizational capabilities a firm requires in order to adapt to climate-related disruptions in the natural environment. It has been emphasized that all three capabilities require specific knowledge in the ecology domain. As organizations do not per se possess this knowledge all three capabilities can be aligned to the concept of absorptive capacity, the main concern of which is how organizations are able to acquire, assimilate, transform, and exploit knowledge (Cohen & Levinthal, 1990; Jansen, Van den Bosch, & Volberda, 2005; Zahra & George, 2002).

Zahra and George (2002) distinguish two key components of absorptive capacity: while potential absorptive capacity corresponds to an organization's receptiveness to new knowledge (acquisition and assimilation), realized absorptive capacity describes an organization's capacity to transform absorbed knowledge internally (transformation and exploitation). The case studies indicate that the process of identifying climate change-related disruptions and determining the corresponding organizational exposure to these disruptions (climate knowledge absorption capability) can be associated with the first component of absorptive capacity. Thus, potential absorptive capacity in the climate context is important for organizations in order to gather and combine internal and external knowledge on how the supply chain, production processes, and product distribution are affected both presently and in the future. Furthermore, the case studies have shown that the companies are able to pursue two implementation efforts (climate-related operational flexibility and strategic climate integration capability), which can be related to the second component of absorptive capacity. Thus, realized absorptive capacity in the climate context is important for organizations in order to effectively utilize gained knowledge and adequately adapt to climate change-related disruptions.

The question arises of whether the three capabilities are subsequent or intertwined components of a holistic climate change adaptation strategy. With respect to corporate environmental management, Halme (2002) discusses the idea that the process of cognitive learning in organizations does not necessarily have to precede operational action. In fact, "in order to learn new environmental core values and beliefs, the organization must engage in action because learning from experience as well as testing and refining new ideas in practice are essential for the emergence of new knowledge" (Halme, 2002: 1103). The data obtained throughout the interviews allow no final conclusion in the climate change adaptation context: for production processes the same intertwined logic as in the general corporate environmental management context may hold. The firms interviewed demonstrated that they have already implemented adaptation measures while also continuously gathering new information. With respect to further value chain aspects, climate knowledge absorption could be interpreted as the necessary precondition for the adaptation process beyond corporate boundaries. The case studies revealed that very few companies have detailed information on how their supply chains and distribution channels may be affected by climate-related disruptions. Without this essential knowledge, firms lack the required information on existing and potential risks and corresponding response options. It may be rather difficult to obtain this knowledge simply through experience as disruptions in the supply chain and product distribution are rather costly and often require long-term decisions. For example, one company assesses the risk of having no cooling water available in a nearby river when deciding where to build a new power plant. This is a rather long-term decision that requires specific pre-knowledge and does not allow much testing and refining.

Climate-related operational flexibility and strategic climate integration constitute the two organizational capabilities for actual adaptation to climate-related disruptions in the natural environment. Climate-related operational flexibility is more suitable for short-term adjustments and quick responses to unexpected disruptions. Based on this capability, organizations can minimize the negative effects of global warming on their physical assets and production processes. However, the organizations are still exposed to the disruptions, which may still result in negative consequences. For example, an electric utility from the case studies increased its operational flexibility by enabling itself to switch between two different fossil fuels. Nevertheless, should the supply chains of both fossil fuels be disrupted there would still be a process interruption. Strategic climate integration on the other hand targets long-term innovation-focused solutions in order to fully adapt the organizations' assets and processes to the changing environment. Building on this capability, organizations can eliminate their exposure to climate change-related disruptions. In the context of the above example, the energy utility would also target improvements to the supply infrastructure. Are these therefore two subsequent capabilities? The case studies provided some evidence that most companies are likely to prefer starting with short-term adjustments (climate-related operational flexibility). However, firms in highly dynamic environments have been found to be more likely to adopt environmental innovations (Rothenberg & Zyglidopoulos, 2007). As such, with the negative effects of climate change intensifying (Pinkse & Kolk, 2009; Sussman & Freed, 2008), it is likely that an increasing number of companies will switch strategies and instead focus on innovative approaches to eliminate their climate change exposure (strategic climate integration). Therefore both climate-related operational flexibility and strategic climate integration have to be considered as generally compatible, but in the long run as rather interchangeable capabilities.

A limitation of this analysis stems from the fact that the findings on each of the firms based on interviews with specific individuals were generalized. Although publicly available information on the case study companies was also used within the analysis, the individual perceptions of the interviewees were taken for granted. This excludes the notion that different individuals within the organization may have alternative views of the same level of analysis, i.e. the exposure to and strategies for addressing climate change. Moreover, the same respondent might even have varying perceptions of the issue depending on the timing of the questions (Dansereau, Yammarino, & Kohles, 1999). This study is also limited by uncertainty regarding the relevance of its results for other industries. Therefore, future research could build on the three capabilities and test them with quantitative methods in different industry settings and over time. Additionally, the arguments herein are built on the resource-based view of the firm. One of this view's important preconditions is to regard organizational capabilities as rent-earning resources. Consequently, quantitative investigations could test this relationship, exploring whether organizations whose organizational capabilities for climate change adaptation are highly sophisticated do in fact financially outperform organizations lacking these capabilities. Finally, the results were reflected on by referring to the concept of absorptive capacity. However, absorptive capacity is a multilevel construct and the emergence of absorptive capacity is affected by managerial, intraorganizational, and inter-organizational antecedents, as well as prior related knowledge (Volberda et al., 2010). With this analysis I elaborated on the three organizational capabilities identified with respect to potential and realized absorptive capacity and their interaction within organizational processes. Future research may further explore how the three capabilities are related and rooted in the different antecedents and dimensions of the concept, putting special emphasis on the question of to which extent the cognitive learning processes are intertwined with operational action. Such insights could further facilitate management's efforts in specifying and harnessing the relevant knowledge sources.

This paper focuses on organizational capabilities for adaptation measures from an outside-in perspective on climate change (Porter & Reinhardt, 2007; Winn & Kirchgeorg, 2005). However, the inside-out perspective on climate change is also important when analyzing climate change-related organizational capabilities. This means that firms also require specific capabilities with regard to fostering the transition towards a low-carbon economy. Firms need to develop proactive strategies towards climate change mitigation, especially as governments increasingly seek to regulate corporate greenhouse gas emissions. Moreover, initiatives such as the Carbon Disclosure Project further illustrate that such corporate strategies are also increasingly of interest to financial stakeholders. As such, the organization's surrounding environment also changes in this inside-out sense. Future research may focus on these changes in detail and investigate the required organizational capabilities for climate mitigation. Drawing on insights from this study, scholars could seek to derive a holistic set of necessary climate-related capabilities reflecting both the outside-in and the inside-out perspective of the strategic management of climate change.

Conclusion

Dynamic and intensified changes in the natural environment require organizations to develop and deploy organizational capabilities that enable them to adapt to the resulting disruptions. Building on eleven case studies in the electricity sector, this study not only addresses the exposure and adaptation to climate change-related disruptions of operational processes, but also covers supply chain and product distribution aspects. As a result, I derive three organizational capabilities: climate knowledge absorption is the essential information generating and internalizing capability. Climate-related operational flexibility and strategic climate integration constitute the two basic interchangeable organizational capabilities for actual adaptation to disruptions in the natural environment. The former is more suitable for short-term adjustments and quick responses to unexpected disruptions, while the latter targets long-term solutions in order to fully adapt the organization to the climate-related disruptions in the natural environment.

Organizational literature has discussed the fact that the path by which organizations develop capabilities is often slow and evolutionary (Amit & Schoemaker, 1993). However, the intensification of disruptions caused by global climate change requires organizations to start adapting to them immediately. Consequently, it is important that organizations acknowledge the strategic relevance of ecological issues such as climate change and accelerate their efforts to develop and deploy capabilities required for the adaptation process. Notably, it is vital to emphasize that specific knowledge is required regarding both the sources of a changing natural environment and their consequences for business. As such, an organization's absorptive capacity regarding knowledge about global warming, corresponding effects on the business environment, and related corporate response options has to be viewed as an essential component of a successful long-term strategy — in terms of the organization's climate change exposure as well as in terms of its sustained competitiveness.

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