

**THE TIP OF THE ICEBERG:
ENVIRONMENTAL STRATEGIES AND COMPETITIVE ADVANTAGE**

ABSTRACT

While abundant literature evaluates how the adoption of sustainable practices affects corporate performance, we have little understanding of the organizational mechanisms that link environmental strategies to competitive advantage. In particular, it is unclear how environmental strategies relate to other management strategies that could lead to a competitive advantage. Here, we analyze capabilities that underlie a firm's ability to generate competitive advantage from the adoption of proactive environmental strategies. We develop and test a model where absorptive capacity facilitates the development of proactive environmental strategies that result in competitive advantage. Results from a survey of 157 German chemical firms strongly support the model.

Keywords: Absorptive Capacity, Environmental Strategy, Competitive Advantage, Chemical Industry, Structural Equation Modeling

INTRODUCTION

Whether firms can benefit from being green has become an important question in the business strategy literature as exemplified by the considerable empirical research that has looked at the link between sustainable or environmental strategy and financial performance (Damania, 2001; Dowell, Hart, and Yeung, 2000; King and Lenox, 2001; Konar and Cohen, 2001; Margolis and Walsh, 2003; McWilliams and Siegel, 2000; Orlitzky, Schmidt, and Rynes, 2003; Russo and Fouts, 1997; Waddock and Graves, 1997). This line of research, however, has produced mixed results. While some studies find a positive link between sustainable strategies and financial performance (Russo and Fouts, 1997), others depict an insignificant or even negative relationship once a firm has harvested low hanging fruits (Damania, 2001; McWilliams and Siegel, 2000).

Some have argued that one reason for these mixed results might be that the question has been phrased in the wrong terms (King and Lenox, 2001; Margolis and Walsh, 2003; Reinhardt, 1999). Instead of asking whether it pays to be green, we ought to be asking about the conditions that support successful environmental strategies. While the empirical literature on the link between environmental strategies and financial performance, mostly rooted in economics, emphasizes external drivers such as regulation, we still have little understanding of the organizational mechanisms that link the adoption of environmental management practices or strategies to competitive advantage (Marcus, 2005).

Practitioners within the emerging industry of Socially Responsible Investing (SRI) provide an interesting perspective on the debate. They argue that environmental strategies not only reflect a firm's stance towards the natural environment but also represent a good proxy of a firm's management capabilities.¹ Firms that are well managed also manage their environmental strategies well. If this is true, are

¹ According to InnoVest Strategic Value advisors, a leader in Socially Responsible Investing research, "Companies' ability to handle political, environmental, labor, and human rights risks are powerful proxies and leading indicators for their overall management

sustainable strategies just the tip of the organizational iceberg? By focusing solely on environmental strategies, are we missing the essential foundations of their success? In this study, we argue that we need to look beneath the surface to get a better understanding of the organizational capabilities that support the emergence of successful sustainable strategies.

Research in organizational theory has started to highlight the importance of organizational factors as predictors of the adoption of sustainable management strategies (Delmas and Toffel, 2008; Lenox and King, 2004; Sharma and Henriques, 2005). However, only a few studies have analyzed the organizational mechanisms that link the adoption of an environmentally proactive strategy to competitive advantage (Christmann, 2000; Hart, 1995; Sharma and Vredenburg, 1998). Marcus (2005) recently pointed out that “though an impressive amount of work has been done, additional research is needed in understanding [...] how [an environmental competence] is created, what the capabilities upon which it is based are [and] why they might lead to competitive advantage” (Marcus, 2005: 31). Similarly, Sharma (2005) explains that “we need research that identifies different configurations of co-specialized and complementary capabilities that generate proactive environmental approaches and competitive advantage” (Sharma, 2005: 21).

This lack of research, however, is problematic. For management researchers, it is important to find out whether differences in environmental strategies and their consequences regarding a firm’s competitiveness originate from different resource requirements and endowments. Also for practitioners, it is important to be aware of the resource requirements for the implementation of a successful environmental strategy. Otherwise, such strategies are likely to result in adverse effects on the firm’s competitive advantage.

quality – or the lack thereof.” http://www.innovestgroup.com/index.php?option=com_content&task=view&id=34&Itemid=32
Accessed on October 20, 2008.

In this paper, we open the organizational black box and analyze the capabilities that underlie a firm's ability to generate a competitive advantage from their environmental strategy. More specifically, we argue that a firm's absorptive capacity, defined as the "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990: 128), provides the foundations for a successful environmental strategy.

We investigate how a firm's absorptive capacity can impact the adoption of proactive environmental strategies such as "anticipating future regulations and social trends and designing or altering operations, processes, and products to prevent negative environmental impacts" (Aragon-Correa and Sharma, 2003: 73). We further investigate the relation of proactive environmental strategies to a firm's ability to generate competitive advantage, i.e., comparative cost, innovation, and reputation benefits, from such a proactive approach. From there, we propose a model that predicts a positive relationship between a firm's level of absorptive capacity and the proactivity of a firm's environmental strategy and competitive advantage.

To test our model, we surveyed 763 firms in the German chemical industry. Results based on responses from 157 firms – including responses from multi-respondents within 54 of the firms – strongly support our hypotheses. Our results show that both the development of more proactive environmental strategies and the generation of competitive advantage from this proactivity depend significantly on the level of absorptive capacity. We find that our model, which links absorptive capacity to environmental proactivity and competitive advantage, has a much higher predictive power than the alternative and more conventional model that only links environmental proactivity to competitive advantage. These results suggest that absorptive capacity facilitates the adoption of proactive environmental strategies that can lead to competitive advantage.

In both its theoretical and empirical domains, this paper extends existing research. First, we contribute to the “pays to be green” debate by combining research on the link between environmental strategy and competitive advantage to the research seeking to explain the adoption of environmental proactivity. Our findings suggest that both environmental proactivity and competitive advantage are to some extent attributable to the same underlying general organizational capability: absorptive capacity. Our research reveals the fundamental role of organizational foundations for successful proactive environmental strategies. Second, we mutually connect two previously separated research streams. We extend the concept of absorptive capacity beyond the technological and managerial domain by outlining the natural environment as a field of applicability.

The remainder of this paper is organized as follows. First, we review the literature on corporate environmental strategy. Second, we develop hypotheses linking absorptive capacity, environmental proactivity, and competitive advantage. Third, we describe our methodology and results. A concluding discussion follows.

Literature Review

Firms can adopt (1) environmental strategies of conformance that focus on complying with regulations and adopting standard industry practices, or (2) proactive environmental strategies that seek to reduce the environmental impacts of operations beyond regulatory requirements (Sharma, 2000). We focus on the latter and base our argumentation on four constituting elements of environmental proactivity: (1) environmental reporting, (2) operational improvements, (3) organizational changes, and (4) regulatory proactivity. First, proactive firms actively promote external and internal reporting by consultants and employees (Henriques and Sadorsky, 1999) by means such as internal and external audits or the release of a sustainability report. Proactive firms can also design or alter products and/or organizational and operational processes to reduce or prevent negative environmental impact (Aragon-Correa and Sharma, 2003) through

means such as pollution prevention or through collaborative interactions with stakeholders (Sharma and Vredenburg, 1998). Finally, proactive firms not only aim at improving their own operations but also at guiding others by initiating changes and pointing the way for future development (Aragon-Correa, 1998). This can be achieved by employing a life-cycle perspective or by contributing to best available techniques or new environmental regulation.

The literature has identified several opportunities for proactive environmental strategies to benefit shareholders directly. These include cost savings achieved by preventing pollution, value creation strategies achieved through the development of greener products (Klassen and Whybark, 1999; Reinhardt, 1998), or benefits resulting from non-market strategies to influence government regulation so that their rivals are at a disadvantage (Shrivastava, 1995). However, we argue that – as with any strategy within a firm – the success of these proactive environmental strategies will depend on the firm’s organizational capabilities that determine corporate success more generally. For example, given the conceptual similarity between pollution prevention and Total Quality Management, it may be possible to accelerate the accumulation of resources in the former by integrating it into the latter (Roome, 1992). In firms that do not have well-developed quality-management processes, there could be barriers to implementing pollution prevention because the strategy requires the voluntary involvement of large numbers of people, especially line employees, in continuous-improvement efforts.

Research has examined drivers for the adoption of proactive environmental strategies. Many researchers have focused on the influence of external stakeholders such as regulators, customers, or environmental Non-Governmental Organizations (NGOs). They have investigated how the adoption of proactive environmental strategies is influenced by environmental legislation and regulations (Carraro, Galeotti, and Gallo, 1996; Delmas, 2002; Majumdar and Marcus, 2001; Rugman and Verbeke, 1998; Russo, 1992), customers (Christmann and Taylor, 2001; Delmas and Montiel, 2009), and the desire to

improve or maintain relations with their communities (Florida and Davison, 2001; Henriques and Sadorsky, 1996). Others have shown that managerial perceptions of the importance of various stakeholder pressures were associated with a more proactive environmental stance (Henriques and Sadorsky, 1999; Sharma and Henriques, 2005). However, while the management literature has identified these various drivers of the adoption of more proactive environmental strategies, there is little empirical evidence on whether and how organizational capabilities enable firms to adopt such strategies. Cordano and Frieze (2000) focus on managers' attitudes about pollution prevention as an important antecedent to pollution prevention activity. Darnall and Edwards (2006) show how firms' capabilities, resources, and ownership structure impact the cost of the adoption of an environmental management system. Delmas and Toffel (2008) identify both institutional pressures and organizational characteristics as predictors for the choice of a firm's environmental strategy. Lenox and King (2004) analyze how absorptive capacity facilitates the adoption of pollution prevention practices among manufacturing facilities within the information and communications technology industry. The empirical research investigating the underlying capabilities that enable firms to develop a competitively valuable environmental strategy is even scarcer. One exception is the work by Christmann (2000) that shows the importance of complementary assets to gain cost competitive advantage.

There is a need to go further to understand the capabilities that form the basis for environmental proactivity (Sharma, 2005). Hart (1995) points out that environment-specific knowledge is typically found outside the firm's boundaries and is often of a tacit nature. He concludes that learning from external sources through means such as collaboration is essential to allow firms reach a higher level of environmental proactivity. As such, firms not only need to acquire knowledge on environmentally proactive technologies. They also need to learn how to build up processes that enable them to absorb relevant environmental knowledge. Marcus and Geffen (1998) explain how such mechanisms have helped firms to become more

environmentally proactive. They describe how the railway company Burlington Northern used its high competence in searching for talent, technology, and ideas to become more environmentally proactive.

To enable the uptake and integration of external knowledge – which was outlined as pivotal for a proactive environmental strategy by Hart (1995) – firms require absorptive capacity, a crucial firm-level capability in knowledge-based competition. Absorptive capacity can also be conceptualized as an integrated system in which several individual elements jointly allow a firm to learn from external sources (Jansen, van den Bosch, and Volberda, 2005). Zahra and George (2002) have advanced our understanding of this process by suggesting that absorptive capacity is a multidimensional construct with comprises two main components: potential absorptive capacity and realized absorptive capacity. Potential absorptive capacity enables a firm's receptiveness to external knowledge, while realized absorptive capacity corresponds to a firm's capacity to transform absorbed knowledge into innovation outcome.

Todorova and Durisin (2007) detail four main related steps that define absorptive capacity: knowledge acquisition, knowledge assimilation, knowledge transformation, and knowledge exploitation. Knowledge acquisition triggers the uptake of new external knowledge, knowledge assimilation refers to the ability to integrate new knowledge, and knowledge transformation refers to the ability to derive new insights and consequences from the combination of existing and newly acquired knowledge (Todorova and Durisin, 2007). While assimilation simply adds new knowledge to the existing knowledge base, transformation creates new knowledge from a novel combination of new and existing knowledge. Finally, knowledge exploitation represents the ability to apply and commercialize acquired, assimilated, and potentially transformed knowledge by creating new operations, products, or services, or by altering existing ones.

Another important insight from the literature on absorptive capacity is that prior knowledge allows the uptake and integration of new knowledge (Cohen and Levinthal, 1990). The main idea is that absorbed expertise in one field will ease the absorption of further knowledge in related fields (Cohen and Levinthal,

1990). A firm with established connections to various sources of knowledge will be more able to assimilate related knowledge than a firm that has not established such connections. In addition, having built up such prior expertise helps the firm understand advances in related fields and identify commercial potential (Cohen and Levinthal, 1990). For example, in the chemical industry technological, environmental, and general management issues are often closely related. In such a case, prior knowledge in one area is also applicable in another and therefore fosters the firm's absorptive capacity similarly across these different domains.

While previous literature has shown the importance of absorptive capacity to turn previously external knowledge into a commercial outcome in high technology environments (Lane, Koka, and Pathak, 2006; Lane, Salk, and Lyles, 2001), it has not yet attempted to link absorptive capacity to other types of knowledge such as knowledge related to environmental strategies. The only exception is the work of Lenox and King that shows how the distribution of knowledge within the firm, and the role that managers play in administering information to organizational subunits, can facilitate the adoption of pollution prevention practices (Lenox and King, 2004). When investigating the development of new or altered strategies by combining new and existing knowledge it is important to consider the political processes within an organization such as decisions of power-holders upon courses of strategic actions (Child, 1972). As such, while absorptive capacity allows generating knowledge about the current state and optional future pathways for a firm there is still a need for management support. Only if such support exists, the firm will make a constructive use of its absorptive capacity.

In this paper, we expand this previous literature by demonstrating how absorptive capacity can not only facilitate the acquisition, assimilation, transformation, and exploitation of knowledge related to the natural environment through proactive environmental strategies, but can also lead firms to gain competitive advantage from such a strategy. We argue that absorptive capacity facilitates the adoption of successful

environmental strategies because environmental strategies require the combination of knowledge from various sources that are often outside of the firm. Managing environmental problems is complex and cuts across accepted organizational, functional, and disciplinary boundaries (Kemp, 1997). The interdisciplinarity of environmental issues requires access to different competencies that exist mostly outside of the firm. Furthermore, the nature of environmental issues requires the firm to understand not only consumer but also social demands in a proactive way.

HYPOTHESES

Absorptive capacity and environmental proactivity

The ability to absorb and transform knowledge is particularly relevant to processes and products related to the environment because environmental processes span multiple fields of expertise (Hart, 1995; Russo and Fouts, 1997). In addition, this knowledge is often complex, tacit, new to the firm, and implies profound changes in business processes (Hart, 1995; Russo and Fouts, 1997). We argue that absorptive capacity can help firms design or alter operations, processes, and products to reduce or prevent negative environmental impact. Such proactive environmental strategies include the implementation of environmental reporting systems, the design of closed-loop waste management processes, the participation in environmental partnerships with other companies and governmental agencies, or the adoption of life cycle analysis and assessment.

Research has shown that knowledge in one field can ease the absorption of new knowledge in related fields (Cohen & Levinthal, 1990). Firms that have developed organizational capabilities to acquire new knowledge in their field will be better able to acquire knowledge related to environmental practices and technologies than firms that have not developed such capabilities. For example, firms that have developed capabilities in establishing research partnerships can build on these capabilities to launch new partnerships focused on emerging environmental technologies. Expertise in building partnerships will lower the cost of

establishing new partnerships. Such firms might also feel more comfortable with the idea of engaging in collaborations outside their immediate set of expertise than firms that have never established external partnerships. In addition, high levels of absorptive capacity, especially in the form of knowledge assimilation and transformation capabilities will ensure the adequate understanding and application of external knowledge. Such absorptive capacity is not simply the sum of individual capacities within the firm. The way in which knowledge is distributed within the organization and the structure of communications are just as significant (Lenox and King, 2004). Because environmental processes span across multiple fields of expertise, firms with good intra-organizational communication will be more likely to assimilate and transform external knowledge related to the environment than firms with weaker organizational communication. It will be easier, for example, to conduct a product life cycle assessment for a firm where information flows easily across departments and the supply chain. This is because to implement a life cycle assessment, a company needs to obtain information regarding the environmental impact of a product throughout its product's life and its various components. Finally, knowledge exploitation capabilities allow the firm to reap commercial benefits from environmental proactive strategies. This can be achieved, for example, through participation in the design of best available techniques that will be chosen by regulatory agencies as the industry standard.

In conclusion, absorptive capacity in the form of knowledge acquisition, assimilation, and transformation and exploitation is crucial to facilitate the development of proactive environmental strategies. We illustrate these arguments with an example from the nanotechnology unit of the German chemical company BASF.² The company participates in several national and international collaborative partnerships involving other chemical companies and regulatory bodies to examine the environmental and health impact

² BASF's portfolio ranges from chemicals, plastics, performance products, agricultural products, and fine chemicals to crude oil and natural gas.

of nanoparticles.³ Through these partnerships, BASF aims at preventing the potential harmful environmental impact of its products. According to the head of the nanotechnology unit, these partnerships allow BASF to access external knowledge vital to developing a proactive environmental strategy related to nanotechnologies.⁴ First, the assessment of the impact of nanoparticles on human health cannot be performed by BASF alone because the firm does not have access to all technological knowledge in that area. Second, the research projects will develop standards for future potential regulations in this area.

BASF's absorptive capacity facilitated the creation and success of these partnerships. BASF's ability and willingness to participate in such partnerships was made possible because of its involvement in previous partnerships related to the health and environmental impacts of its chemical products.⁵ In addition, BASF could bring into play its research expertise in this area, as it has been engaged in safety research for many years and is known to be a pioneer in the field of occupational safety. Finally, BASF's prior expertise in the field of toxicology and occupational safety, as well as the high level of internal coordination between BASF's research and operational units allowed the firm to understand and assimilate the knowledge generated through these research projects.

This example illustrates that the firm's ability to reach a higher level of environmental proactivity was driven by the firm's absorptive capacity. As pointed out by Marcus and Geffen (1998), the ability to integrate innovation from diverse sources and to combine innovation, knowledge experience, and materials in ways not previously combined is facilitated by the firm's absorptive capacity. From here, we derive our first hypothesis:

³ This includes (i) the German Ministry of the Environment's "NanoDialog" initiative, in which stakeholders from politics, industry, science, as well as regulators and interest groups discuss the opportunities and risks of nanomaterials and develop recommendations for the responsible handling of nanomaterials; and (ii) the European Commission's "Sustainable Chemistry" technology platform, with the involvement of stakeholders such as regulators, the scientific community, non-governmental organizations, and industry, in order to establish framework conditions for a sustainable chemistry in Europe.

⁴ Interviewed by authors in January, 2007.

⁵ BASF has been involved in organizations such as the German chemical industry association (VCI), the European Chemical Industry Council (Cefic), and the American Chemical Council (ACC). BASF experts also participate in OECD and ISO working parties.

Hypothesis 1: Hypothesis 1: The higher the level of absorptive capacity the greater the environmental proactivity of the firm.

Absorptive capacity and competitive advantage

As outlined in the previous section, we see absorptive capacity as an enabler for firms to develop environmental proactivity. In addition, we see absorptive capacity as facilitating the generation of competitive advantage from environmental proactivity. We base our investigation on two strategies that outline the possible strategic spectrum to reconcile competitiveness and environmental proactivity: comparative cost reduction, and value creation strategies aiming at innovation and product differentiation.

Comparative cost reduction is one strategy that firms can pursue. Empirical evidence shows that environmentally proactive firms can realize significant savings in production costs by preventing pollution compared to reactive firms (Christmann, 2000; Hart and Ahuja, 1996; Klassen and Whybark, 1999). Pollution prevention may save not only the cost of installing and operating end-of-pipe pollution-control devices, but it also may increase productivity and efficiency (Porter and van der Linde, 1995; Shrivastava, 1995; Smart, 1992). Less waste means better utilization of inputs, resulting in lower costs for raw materials and waste disposal. Moreover, environmental proactivity might help firms reduce the probability or the cost of uncertain but adverse outcomes such as environmental accidents that could lead to business interruptions, liability, punitive regulation, or damage to corporate reputations (Hart and Milstein, 2003).

We argue that absorptive capacity can leverage comparative cost advantages from proactive environmental strategies. Firms with highly developed absorptive capacity are likely to leverage cost advantages when implementing environmental changes because of their improved access to a wider variety of technologies and resulting flexibility in capability deployment (Zahra and George, 2002). Moreover,

absorptive capacity can help to better assess the benefits of new technologies with respect to their ability to reduce potential liability costs, legal fees or product take-back costs, or to leverage production efficiencies and waste reduction. Knowledge exploitation ensures the smooth implementation of these new technologies. The higher the level of absorptive capacity, the more easily and the more widely a firm will generate cost benefits from environmental proactivity.

Besides objectives of comparative cost reduction, firms can pursue value creation strategies by aiming at innovation and product differentiation benefits (Christmann, 2000; Hart, 1995; Porter and van der Linde, 1995) or by seeking an improved image and reputation based on environmental proactivity (Menon and Menon, 1997; Reinhardt, 1998; Shrivastava, 1995). Firms can also aim at imposing a cost on their competitors through more stringent regulations if they have already invested in technologies required by forthcoming regulation (Shrivastava, 1995; Vogel, 1995). Absorptive capacity can enable firms to realize differentiation and reputation advantages through proactive environmental strategies (Shrivastava, 1995). However, to realize these benefits, a firm needs to value, acquire, and assimilate knowledge to understand market trends. Further, the firm has to use its transformation and exploitation capability to draw conclusions from these market trends and to develop or alter processes, products, or services that eventually result in a competitive advantage.

Finally, whether the firm is able to generate competitive advantage depends on the extent to which competitors are able to replicate such a strategy. Because both absorptive capacity and environmental proactivity depend on processes that are complex and often tacit (Hart, 1995; Szulanski, 1996), they are difficult to imitate (McEvily and Chakravarthy, 2002). Additionally, in strong regimes of appropriability, a firm can protect its innovation derived from absorptive capacity through patents (Cohen and Levinthal, 1990). Then, the cost for knowledge replication is increased for rivals, leading to performance differences across firms (Zahra and George, 2002). Christmann has outlined that such strong conditions of

appropriability exist in innovation-driven regimes, e.g. where firms are environmentally proactive. She explains that firms were able to create proprietary solutions and to benefit from those (Christmann, 2000).

Returning to the BASF example, while the participation of the firm in research projects to assess the environmental impact of nanoparticles has clear implications for the competitive advantage of the company, this competitive advantage would not unfold if such participation were not based on the firm's high level of absorptive capacity.⁶ The combination of BASF's competencies in several research areas, in partnership management, and in the internal coordination and diffusion of knowledge, is intangible and difficult to imitate.

Summing up, a high level of absorptive capacity enables a firm to turn environmental opportunities into competitive advantage, especially comparative cost, innovation, and reputation advantages. From there, we state our second hypothesis:

Hypothesis 2: Hypothesis 2: The higher the level of absorptive capacity the greater the competitive advantage generated from environmental proactive strategies.

Insert figure 1 about here

Figure 1 illustrates our hypotheses. This figure shows that a firm's absorptive capacity explains both the adoption of environmental proactive strategies (H1) and competitive advantage derived from these

⁶ As BASF states in its "on dialogue" online publication: "Our success rests on products that offer benefits to customers and consumers. Further important prerequisites are political framework conditions that do not put us at a disadvantage in worldwide competition as well as social acceptance of new technologies. In constructive cooperation with politics, authorities, and other stakeholders, we wish to help in developing these conditions for a sustainable utilization of nanotechnology." In dialogue. Nanotechnology at BASF. August 2008 page 2 <http://www.corporate.basf.com/en/innovationen/felder/nanotechnologie/>

strategies (H2). We therefore do not anticipate the relationship between environmental proactivity and competitive advantage to be direct but rather inferred from absorptive capacity.

METHOD

Industry choice

To limit variance and increase comparability, we focus our empirical analysis on one industry in one country: the German chemical industry. This industry was chosen because of the salience of environmental concerns in the chemical industry (Christmann, 2000, 2004; Hoffman, 1999; King and Lenox, 2000; Nehrt, 1996). The chemical industry has a high environmental impact due to, for example, the industry's toxic emissions. The German chemical industry is affected by environmental regulation such as the new European chemicals policy EC/2006/1907 on the registration, evaluation, authorization, and restriction of chemicals (REACH). With an average R&D budget of 5.5 % of sales, the chemical industry is one of the most research-intensive industries in Germany (VCI, 2007), which points towards the importance of knowledge management and absorptive capacity. In addition, in 2006 the German chemical industry was the world's leading exporter of chemical products for the fourth year in a row with 119.6 billion Euros (VCI, 2007) which highlights a strong national and international competitive edge. Finally, with roughly 3500 companies and total sales of about 162.2 billion Euros (VCI, 2007), the population of firms in the industry is sufficiently large for empirical analysis.

Measures

As archival data was not available in our industry context in order to proxy absorptive capacity, proactive environmental strategies, and competitive advantage, we opted for a survey approach with a

multi-item scheme and multi-respondents for each firm. This alternative has proved useful in previous research exposed to the same challenge (Aragon-Correa, 1998; Christmann, 2000; Delmas and Toffel, 2008; Jansen *et al.*, 2005; Sharma, 2000).

As we describe below in more detail, for each of the different variables, i.e., absorptive capacity, environmental proactivity, and competitive advantage through environmental proactivity, we introduced variables based on constructs developed by scholars in similar contexts. We transformed these constructs to ensure their validity in our setting by a process involving eight industry experts who iteratively assessed the applicability of each construct. We measured each item with a 7 point Likert-scale (all items are included in Appendix 1).

Measurement of absorptive capacity. Researchers measured absorptive capacity using various indicators. For example, Cohen and Levinthal (1990) chose R&D intensity as their proxy. Others used a survey approach involving a five-item scale measuring absorptive capacity (Lane & Lubatkin, (1998) Szulanzki (1996)). Because absorptive capacity consists of several sub-capabilities, we decided to measure these individually. We therefore combined the constructs from Jansen *et al.* (2005) with a measure from Jaworski and Kohli (1993). As such, we included four separate constructs for knowledge acquisition, assimilation, transformation, and exploitation.

Measurement of environmental proactivity. There are a variety of criteria to measure the proactivity of an environmental strategy (Hart, 1995, 1997; Hunt and Auster, 1990; Roome, 1992). Sharma and Vredenburg applied these criteria to the oil and gas industry and developed a comprehensive set of constructs (Sharma, 2000; Sharma and Vredenburg, 1998). We complemented their constructs with another that reflects the level of regulatory proactivity, adapted from the study by Khanna, Koss, Jones, and Ervin (2007). The items were adapted to the chemical industry setting by using industry experts as outlined above.

The procedure resulted in indicators for four constructs: environmental reporting, regulatory proactivity, improvement of operations, and environmental partnerships.

Measurement of competitive advantage through environmental proactivity. Constructs for estimating the competitive advantage gained from an environmental strategy have been used in a variety of studies (Christmann, 2000; Darnall and Edwards, 2006; Russo and Fouts, 1997). Because we included both private and publicly traded firms, we could not use accounting measures. Instead, we used constructs for innovation and comparative cost advantages from Christmann (2000) that are based on a multi-item scheme and complemented these with items for innovation and reputation from the Sharma and Vredenburg (1998) study. The constructs again were adapted to the chemical industry setting using industry experts as outlined above. During this process, we dropped and modified a number of items. The procedure resulted in indicators for three main constructs: comparative cost benefits, innovation and differentiation, and reputation and customer relations.

Controls

Firm size. Firm size has been hypothesized to influence both environmental and business performance of firms (Aragon-Correa, 1998; Orlitzky, 2001). We controlled for company size through using the logarithm of annual sales.

Management support. Researchers have shown the roles of gatekeeper and boundary spanner, both inside and outside the firm and between different entities within the firm, as drivers of a firm's absorptive capacity (Lenox and King, 2004). Management support has also been found to influence environmental activities and has been thoroughly addressed in strategic management research both theoretically and empirically in case study research (Henriques and Sadorsky, 1999; Hunt and Auster, 1990; Roome, 1992; Wartick and Cochran, 1985). In our case, our construct builds on the study conducted in the policy domain by Khanna et al. (2007).

Sample selection and response rate

For our empirical analysis, we chose member firms of the chemical industry association of Germany, the Verband der Chemischen Industrie (VCI), with research and production operations based in Germany: 1143 member firms at the time of the evaluation (July 2007).⁷ This represents roughly a third of all chemical companies in Germany, and close to 90% of all employees in the German chemical companies. Thus, members of the German chemical industry association tend to include the largest chemical companies in Germany.

In the following step, we identified the mail addresses and telephone numbers of the companies listed in the directory. In order to obtain a number of independent knowledge sources, we contacted the 1143 companies by phone and requested contact information for the most knowledgeable people in the areas of firm competitiveness, environmental strategy, and knowledge management. Typically, the contact people were the CEO for firm strategy, the R&D director for knowledge management, and the director of the environmental department for the firm's environmental strategy.

We eliminated 30 firms because the respondents stated that an assessment of the actual state of the overall company was not viable due to a recent merger or larger restructuring processes. Finally, we removed 350 firms that stated that they had an internal policy not to participate in any voluntary survey. These actions reduced the sample to 763 firms.

Subsequently, we administered a personalized questionnaire survey in order to collect firm information for the dependent and independent variables from independent knowledge sources. As such, most firms received three individual letters: one to the CEO, one to the director of R&D, and one to the director of the environmental department. For each letter, the set of questions depended on the contact

⁷ Verband der Chemischen Industrie www.vci.de

person's position and included either the constructs that assessed competitive advantage, environmental proactivity and management support, or absorptive capacity. In cases where we could identify a single contact person only, e.g., in smaller companies where the CEO was responsible for all areas, we sent a survey questionnaire containing all sets of questions to the identified single respondent. Each package held a cover letter, the survey, and an addressed and stamped return envelope. Additionally, the cover letter offered the options to fill in the survey by fax, online, or via phone.⁸ Four weeks later, we conducted a second round of phone calls as a first reminder. Finally, an additional four weeks later we sent a last reminder via email.

Two hundred seventy-one firms delivered at least one part of the questionnaire, which represents a response rate of 35.5%, while 157 firms delivered all parts of the questionnaire, which represents a response rate of 20.6%. This result represents a satisfactory response rate (Delmas and Toffel, 2008; Hoskisson *et al.*, 2004; McEvily and Chakravarthy, 2002). Out of these 157 firms, 33 firms had two or three respondents (21%). We tested sample representativeness in several ways. First, we searched for differences in the compositions of the original and responding sample as there might be a potential bias for greener firms to be more likely to respond to such a questionnaire. We randomly chose 3 of the 22 sector-associations of the VCI and labeled the different firms in the total and responding sample with dummy variables. We also tested for the representativeness of firms participating in the Responsible Care initiative of the chemical industry, a special initiative to reduce environmental impact. To test if such a membership had an influence on the responding behavior, we performed a binary logistic regression with the dummy variable for response or non-response as dependent variable. The results show no significant bias regarding any of the investigated sector-associations or participation in Responsible Care.⁹ Next, we compared the size distribution of the respondents in our sample to the German chemical industry and found a higher representation of larger companies. This outcome confirmed our expectations: our sample was based on

⁸ 62 percent of the respondents answered by postal mail or by fax and 38 percent responded by filing the online questionnaire.

⁹ Results available from the authors (Appendix 2 Table 1).

members of the German chemical industry association, which includes the largest German chemical firms. We assigned each firm to a predefined size group and performed a paired t-test, which revealed differences at a significance level of $p=0.043$.

We are able to dispel concerns of common method bias in our data that occur when the instruments the researcher employs enter into or affect the score or measures that are being gathered. First, 21% of our data includes two or three different respondents, which means that there is no common method bias in this subsample of our respondents.¹⁰ Second, we tested for potential common bias in the remaining 80% of the data. For this, we calculated single-factor scores for the main variables absorptive capacity, environmental proactivity, and competitive advantage and performed a regression between pairs of them. So for example, we would use competitive advantage as a dependent variable and absorptive capacity, environmental proactivity, number of respondents, and sales as independent variables. If common method bias was present, the variable “number of respondents” would be significant (Podsakoff *et al.*, 2003; Spector, 2006). The variable number of respondents was not significant in any of the models. We can therefore dismiss concerns of common method bias.¹¹

Structural model. We employed structural equation modeling (SEM, AMOS Version 7, via maximum likelihood estimates) because of the ability of this technique to analyze models based on several latent variables that are more complex than multiple regression models (Hardy and Bryman, 2004). Structural modeling addresses structural and measurement issues frequently found in survey-designed research and is increasingly being used in strategic management research (Capron, 1999; Cordano and Frieze, 2000; Delmas and Toffel, 2008; Sharma, 2000; Shook *et al.*, 2004; Simonin, 1999).¹²

¹⁰ Our data originates from a varying number of independent sources (respondents). 24.0% of the data (40 responses) used to assess the relation between absorptive capacity and environmental proactivity, 19.1% of the data (31 responses) used to assess the relation between absorptive capacity and competitive advantage, and 20.2% of the data (33 responses) used to assess the relations between environmental proactivity and competitive advantage stems from independent sources, the rest stems from a single respondent.

¹¹ Results available from the authors (Appendix 2 Table 2).

¹² The structural model is available from the authors upon request (Appendix 2 Figure 1).

Structural diagnostics. Based on a number of tests, we found a good overall fit of the model. For example, the model has a χ^2/df ratio of $1108/796=1.44$ which is lower than 2 and therefore implies a good fit of the model (Marsh and Hocevar, 1985). We find that the χ^2 is statistically significant ($p=0.000$), which could suggest some misspecification of the model although it is well recognized that this statistic is sensitive to sample size (Arbuckle and Wothke, 1999). We consider other structural diagnostics for the overall fit of the model that are not sensitive to sample size (Bentler, 1990). We calculated the root mean squared error of approximation (RMSEA), an estimate of the discrepancy between the original and reproduced covariance matrices in the population (Steiger, 1990). Cudeck and Browne (1983) suggested that an RMSEA of 0.05 represents a close fit and that an RMSEA of less than 0.08 represents a reasonable fit. In our model, the RMSEA of 0.05 is within an acceptable range. Likewise, we found an incremental fit index (IFI) (Bollen, 1989) of 0.91, a Tucker Lewis index (TLI) (Tucker and Lewis, 1973) of 0.90, and a comparative fit index (CFI) (Bentler and Bonett, 1980) of 0.91. Each of these indices is above the common threshold of 0.90 that designates an acceptable fit. In sum, these structural diagnostics indicate a very good relative fit of the theoretical model to the underlying data.

Measurement model

The measurement model describes the construction of the latent variables from the observed variables. We constructed the 15 latent variables from a set of 41 items (see Table 1 in Appendix 1).¹³ We created our three main latent variables (absorptive capacity, competitive advantage, and proactive strategies) from these 15 latent variables as shown in Table 1 below.

Insert table 1 about here

¹³ We performed the confirmatory factor analysis using principal component analysis with Varimax rotation, which confirms the loading of our items on the latent variables (details provided in Appendix 1).

RESULTS

Table 2 presents the results for the hypothesized relations between the main variables. We find significant relations for absorptive capacity and environmental proactivity, for absorptive capacity and competitive advantage, for absorptive capacity and management support, for management support and environmental proactivity, and for environmental proactivity and competitive advantage. Looking at the relation of absorptive capacity and environmental proactivity, we find an additional strong mediation effect by management support.

Insert table 2 about here

Hypothesis 1. The results for the main relations provided in Table 2 confirm hypothesis 1 that predicted a positive effect from absorptive capacity on the generation of environmental proactivity. The path between absorptive capacity and environmental proactivity is positive and significant ($\beta = 0.15$ $p = 0.043$). However, a closer look infers a mediating role of management support. In fact, variations in levels of the independent variable, absorptive capacity, significantly account for variations in the presumed mediator management support ($\beta = 0.31$ $p = 0.005$). Further, variations in the presumed mediator significantly account for a variation in the dependent variable, environmental proactivity ($\beta = 0.70$ $p < 0.001$). Moreover, to function as a mediator the direct relation between the independent and the dependent variable needs to weaken substantially when including the mediating variable (Baron and Kenny, 1986). We confirmed this condition in a separate model that assessed the influence of absorptive capacity on a firm's environmental

proactivity after removing the variable management support. While all structural diagnostics remain similar, the significance of the relation between absorptive capacity and environmental proactivity increases ($\beta = 0.36$ $p = 0.004$). Thus, we find strong support for hypothesis 1, yet mediated by management support.

Hypothesis 2. The results confirm the predicted relationship that absorptive capacity has a positive effect on the generation of competitive advantage from a proactive environmental strategy. The path between absorptive capacity and competitive advantage is positive and significant ($\beta = 0.32$ $p = 0.020$). For completeness, we evaluated the existence of a mediating role of the firm's environmental proactivity on competitive advantage. For this we removed the variable environmental proactivity from the model and found an increased significance of the relation between absorptive capacity and competitive advantage ($\beta = 0.44$ $p = 0.006$), implying a mediating role of the firm's environmental proactivity (Baron and Kenny, 1986).

To compare our model to a more classic test of the effect of environmental strategies on competitive advantage, we developed a second alternative model in which we omit absorptive capacity. In this model the significance of the *direct* relationship between environmental strategies and competitive advantage increases ($\beta = 0.540$, $p < 0.001$). However, this alternative model yields fit statistics that are worse than our original model. In sum, our original model adds significant explanatory power to a more traditional approach.

Robustness. To ensure the robustness of our data we validated the findings using a number of alternative approaches. First, we wanted to confirm that the result would hold for the population of 271 firms. For this, we repeated the different analyses with the larger data sample considering all responses from the 271 firms by taking advantage of AMOS' full information maximum likelihood (FIML) estimation routine to handle missing data, which allows taking into account all information observed. The model yielded better fit indices than the conservative model with 157 firms and supported the two hypotheses even

more strongly. While the relationship between environmental proactivity and competitive advantage decreases in significance, the relationships between absorptive capacity and environmental proactivity as well as competitive advantage become even more significant. As such, this model also highlights the strong underlying value of absorptive capacity to generate value through environmental proactivity.¹⁴

To ensure the results obtained for the different variables reflect organizational measures we asked each respondent for an additional but reduced rating for all three main variables (i.e. absorptive capacity, environmental strategy, and competitive advantage; between four and six items per variable). From there, we calculated the mean values for these reduced ratings for each firm and performed a correlation analysis between them and the respective general factor score for each variable in our more comprehensive assessment (based on a single respondent for each variable).¹⁵ All correlation coefficients were above 0.57 and significant at a p-value < 0.001 indicating high applicability of our constructs also on an organizational level.

Second, we wanted to test whether the results were driven by specific elements of environmental proactivity, absorptive capacity, or competitive advantage. To gain a better insight into the details of the first hypothesized relation, we used the factor scores of the different sub-variables of competitive advantage, environmental proactivity, and absorptive capacity and conducted two multivariate analyses (MANCOVA). First, we used the four different individual elements of absorptive capacity as well as the interaction term of these elements as independent variables and the measures for environmental proactivity as dependent variables. In addition, we conducted another MANCOVA exploring the different sub-constructs of absorptive capacity and competitive advantage. We controlled again for number of respondents and company size. Table 3 displays the results.

¹⁴ Results available from the authors (Appendix 2 Table 3 and 4).

¹⁵ Results available from the authors

Insert table 3 about here

The MANCOVA results reflect the findings from the structural equation model but allow a more detailed view of the mode of action of absorptive capacity. The individual elements do not contribute a certain share each to the value of absorptive capacity. Instead, the value of absorptive capacity seems to result from the combined effect of all elements. As such, we find that absorptive capacity is able to unfold only when all four elements are present.

These results further confirm the finding drawn from the structural model. We find that the combined effect of all elements turns absorptive capacity into a valuable capacity. Interestingly, we also find that some of the elements taken individually might be costly to the firms but that their combined interaction might not. For example, the construct “exploitation” has a negative and significant effect on cost reduction, but the effect becomes positive when “exploitation” is combined with the other elements of absorptive capacity.

Third, to test our hypotheses we used data that we gathered contemporaneously. In the original model, we include paths extending from absorptive capacity to environmental proactivity and competitive advantage. To examine whether our results are robust to the inclusion of the reverse paths, we developed an alternative model. Specifically, we added paths from the sub-constructs of competitive advantage and environmental proactivity to the main construct of absorptive capacity and to the main construct of environmental proactivity. Neither of the new reverse paths was statistically significant and the results of this model yielded nearly identical estimates of the original hypothesized relationships.

Fourth, another potential concern derives from heterogeneity within our sample that is not controlled for in our structural equation model. Specifically, because our sample includes facilities from

several sub-industries and structural equation modeling techniques do not allow for industry dummies, it is possible that unobserved differences between these industries may account for some of our results. To test whether our results were sensitive to unobserved industry differences, we estimated regression equations corresponding to the paths of the structural equations. In these regression analyses we included additional control variables such as firm size (measured as logarithm of annual sales), R&D Budget (in share of sales), sub-industry (as dummy variables for, e.g., pharmaceuticals, coatings, etc.), and environmental budget. All control variables had no impact on the findings. The result of these regression analyses confirmed the findings of the structural model. All hypothesized relationships remain statistically significant ($p < 0.001$) with the predicted sign.

DISCUSSION AND CONCLUSIONS, AND FUTURE RESEARCH

We started by asking what constitutes the basis for successful proactive environmental strategies. We argued that by studying the link between proactive environmental strategies and competitive advantage independently from the firms' more general capabilities, researchers might just be looking at the tip of the iceberg and missing the most fundamental element of the success of environmental strategies. We presented a model that relates a firm's environmental proactivity and the competitive advantage generated from it to absorptive capacity. We find that the adoption of proactive environmental strategies depends on the firm's level of absorptive capacity, mediated by management support. Similarly, the generation of competitive advantage from such a proactive approach seems largely fueled by the firm's absorptive capacity. These results hold contributions for both theory and practice.

First, we contribute to the "pays to be green" debate by combining research on the link between environmental strategies and competitive advantage to the research seeking to explain the rationale for the adoption of environmental proactivity. The results suggest that absorptive capacity states a capability that helps to develop environmental proactivity and to link it with competitive advantage. To some extent, the

results also suggest spuriousness regarding the relation between environmental proactivity and competitive advantage as both variables rely on the same organizational capability. Moreover, while environmental proactivity holds potential for the generation of competitive advantage, such a beneficial outcome is not automatic. Instead, it takes additional and more general competencies of external knowledge acquisition and utilization to generate competitive benefits from a proactive environmental strategy.

In addition, we widen the context of application of the absorptive capacity concept. While many scholars have made use of absorptive capacity in a technological context, little research has extended the application of the concept beyond this domain (Lane *et al.*, 2006; Lenox and King, 2004; Zahra and George, 2002). Here, we apply the concept of absorptive capacity beyond a purely technological or managerial domain to an external and complex area that simultaneously requires the consideration of social, technological, and managerial issues. Whereas the core of the literature on absorptive capacity emphasizes the processes of building up technological knowledge within and outside the firm, our work stresses that absorptive capacity can facilitate the acquisition of external expertise in the social and regulatory domain. In addition, we find that absorptive capacity is only realized if upper management is driving the process. This confirms what the literature has been claiming on the role of management as boundary spanner, both inside and outside the firm and between different entities within the firm (Lenox and King, 2004; Rosenkopf and Nerkar, 2001; Todorova and Durisin, 2007).

Our third contribution is of a practical nature, as the findings give strategic guidance for firms. Those firms that aim at strengthening their environmental competencies without forfeiting their competitiveness should not initially invest in environmental measures but rather in their absorptive capacity. Having a strong stand in acquiring, assimilating, transforming, and exploiting knowledge seems a valuable precondition to realize benefits from a proactive environmental strategy. The applicability of our approach is further supported by the fact that the different elements of absorptive capacity relate to distinct knowledge

management tools. For example, knowledge acquisition refers to access to knowledge networks such as universities, participation in research alliances, or direct knowledge acquisitions, e.g., firm or patent acquisitions. Moreover, the concept of absorptive capacity suggests that knowledge contributes best to a firm's competitive advantage if the respective processes are fully integrated within the firm. Consequently, a firm's environmental strategy needs to be integrated in the firm's standard business processes. Only then can the knowledge created through the firm's environmental activities be transferred to other knowledge domains of the firm and have a positive economic impact. Conversely, an isolated environmental division is unlikely to transfer knowledge to other units. Our work can also provide practical guidance to investors who are seeking to understand the link between environmental and financial performance. Our results confirm socially responsible investors' intuition that environmental proactivity rests on solid managerial foundations.

Our work is not without limitations. One should consider the path dependency of absorptive capacity. Building up more competencies in the firm's environmental strategy – which is an outcome of the firm's absorptive capacity – increases the firm's absorptive capacity through extending the firm's knowledge base. Therefore, the existence of feedback loops as part of a longer process needs further investigation. Moreover, in other settings than the chemical industry, measuring absorptive capacity of the different contexts, i.e., environmental versus general, might be more difficult. In the chemical industry, environmental issues are more salient than in other industries. Future research could test our model in other industries. Finally, we focused on a single national context. It would be interesting to analyze the effect of differing national regulatory settings on the relations between absorptive capacity and successful proactive environmental strategies.

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FIGURE 1

Figure 1. Absorptive capacity, environmental strategies and competitive advantage

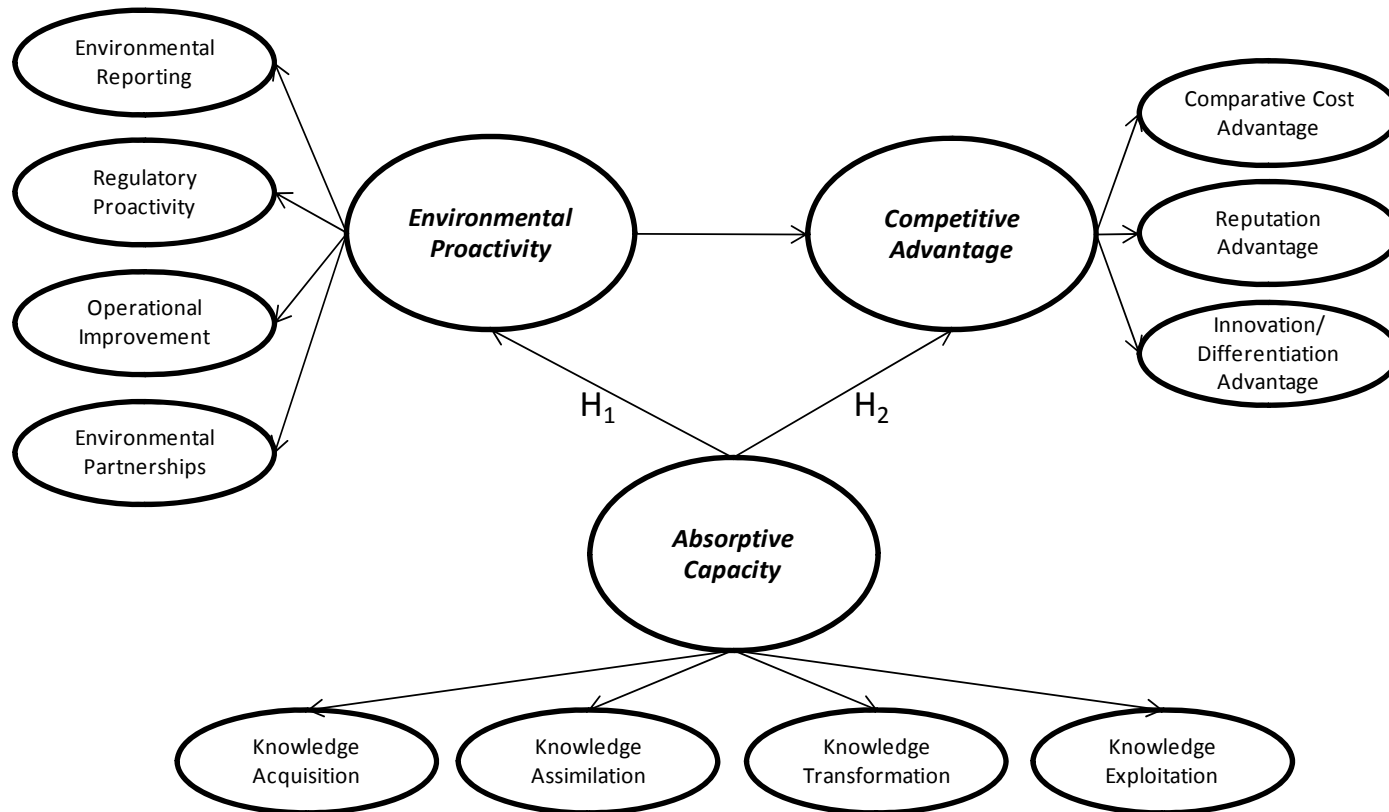


Table 1. Measurement paths

Measurement paths	Unstandardized regression weight	Standard error	Critical ratio	Standardized regression weight	p-value
Absorptive Capacity					
→ Knowledge Acquisition	1 (fixed)			0.58	
→ Knowledge Assimilation	2.6	0.7	3.7	0.77	***
→ Knowledge Transformation	3.7	1.0	3.9	0.98	***
→ Knowledge Exploitation	3.3	0.9	3.7	0.95	***
Management support					
→...provide incentives and assistance for environmentally friendly practices and technologies?	0.8	0.05	15.8	0.84	***
→...encourage facilities to participate in voluntary environmental programs? (e.g. with other departments, other companies, etc.)	1 (fixed)			0.97	***
→...allow facilities to make environmental investments to go beyond legal compliance?	0.7	0.06	12.6	0.75	***
Environmental Proactivity					
→ Environmental Reporting	1.7	0.2	7.0	0.90	***
→ Regulatory Proactivity	1 (fixed)			0.75	***
→ Operational Improvement	1.1	0.2	5.4	0.77	***
→ Environmental Partnerships	1.2	0.2	6.3	0.82	***
Competitive Advantage					
→ Cost	1 (fixed)			0.50	***
→ Reputation	1.0	0.2	4.6	0.84	***
→ Innovation/Differentiation	1.2	0.2	4.8	0.83	***

Notes: *** = $p < 0.001$.

Table 2. Results of the Structural Model

Antecedent variable → Consequent variable	Regression weight	Standard error	Critical ratio	p-value	Standardized regression weight
<i>Hypothesized Relations</i>					
Absorptive Capacity → Environmental Proactivity	0.50	0.25	2.0	0.043	0.15
Absorptive Capacity → Competitive Advantage	0.68	0.29	2.3	0.020	0.32
<i>Control Relationships</i>					
Environmental Proactivity → Competitive Advantage	0.22	0.09	5.6	0.011	0.35
Absorptive Capacity → Management Support	1.96	0.71	2.8	0.005	0.31
Management Support → Environmental Proactivity	0.37	0.06	6.6	***	0.70
Company Size → Absorptive Capacity	0.05	0.03	1.8	0.067	0.17
Company Size → Management Support	0.51	0.15	3.4	***	0.26
Company Size → Environmental Proactivity	0.26	0.07	4.0	***	0.25
Company Size → Competitive Advantage	-0.04	0.06	-0.6	0.529	-0.06

Notes: *** = p < 0.001; company size in logarithm of sales

Table 3. MANCOVA Absorptive Capacity – Environmental Proactivity/Competitive Advantage

Indep. Variables	Environmental Proactivity					Competitive Advantage					
	Dependent Variables	Multiv. Tests ¹ F (Sig.)	B ³	Tests of Between-Subject effects		Dependent Variables	Multiv. Tests ¹ F (Sig.)	B ³	Tests of Between-Subject effects		
			F	Partial η^2	Sig.			F	Partial η^2	Sig.	
Corrected Model	Environmental Reporting		8.46	0.389	.000	Comp. Cost		5.37	0.260	.000	
	Regulatory Proactivity		6.00	0.311	.000	Reputation		4.21	0.216	.000	
	Operational Improvement		6.70	0.335	.000	Innovation		3.95	0.205	.001	
	Environmental Partnerships		5.11	0.278	.000						
Intercept		6.06 (.000)					0.62 (.603)				
	Environmental Reporting		-0.91	19.30	0.172	.000	Comp. Cost	-0.30	1.71	0.016	.193
	Regulatory Proactivity		-0.96	17.16	0.156	.000	Reputation	0.00	0.00	0.000	.985
	Operational Improvement		-0.55	6.23	0.063	.014	Innovation	-0.01	0.00	0.000	.977
	Environmental Partnerships		-0.69	8.20	0.081	.005					
Knowledge Acquisition		0.41 (.800)					2.31 (.080)				
	Environmental Reporting		0.07	0.49	0.005	.484	Comp. Cost	0.22	4.32	0.039	.040
	Regulatory Proactivity		0.08	0.53	0.006	.470	Reputation	0.22	3.83	0.035	.053
	Operational Improvement		-0.01	0.01	0.000	.926	Innovation	0.08	0.48	0.004	.492
	Environmental Partnerships		0.13	1.16	0.012	.285					
Knowledge Assimilation		1.54 (.198)					1.58 (.198)				
	Environmental Reporting		0.11	1.03	0.011	.313	Comp. Cost	-0.13	1.08	0.010	.301
	Regulatory Proactivity		0.05	0.15	0.002	.700	Reputation	0.15	1.30	0.012	.256
	Operational Improvement		0.23	3.79	0.039	.055	Innovation	0.20	2.18	0.020	.143
	Environmental Partnerships		0.26	3.79	0.039	.054					
Knowledge Transformation		1.13 (.350)					3.25 (.025)				
	Environmental Reporting		0.01	0.00	0.000	.955	Comp. Cost	0.40	7.75	0.068	.006
	Regulatory Proactivity		-0.02	0.01	0.000	.917	Reputation	0.05	0.12	0.001	.735
	Operational Improvement		0.27	3.09	0.032	.082	Innovation	0.25	2.53	0.023	.115
	Environmental Partnerships		-0.01	0.01	0.000	.932					
Knowledge Exploitation		2.07 (.091)					1.54 (.209)				
	Environmental Reporting		0.23	3.70	0.038	.057	Comp. Cost	-0.13	1.12	0.010	.293
	Regulatory Proactivity		0.13	1.00	0.011	.320	Reputation	0.14	1.24	0.011	.268
	Operational Improvement		-0.10	0.67	0.007	.416	Innovation	-0.05	0.13	0.001	.719
	Environmental Partnerships		0.08	0.35	0.004	.555					
ACAP Interaction²		3.08 (.020)					4.00 (.010)				
	Environmental Reporting		0.04	2.79	0.029	.098	Comp. Cost	0.05	5.63	0.050	.019
	Regulatory Proactivity		0.08	7.27	0.073	.008	Reputation	0.07	9.82	0.084	.002
	Operational Improvement		0.08	8.33	0.082	.005	Innovation	0.04	3.25	0.029	.074
	Environmental Partnerships		0.06	4.22	0.043	.043					
Logarithm of Annual Sales		7.04 (.000)					3.40 (.021)				
	Environmental Reporting		0.42	22.67	0.196	.000	Comp. Cost	0.22	6.47	0.057	.012
	Regulatory Proactivity		0.42	18.00	0.162	.000	Reputation	-0.03	0.13	0.001	.721
	Operational Improvement		0.29	9.85	0.096	.002	Innovation	0.12	1.72	0.016	.192
	Environmental Partnerships		0.25	6.29	0.063	.014					
Number of Respondents		0.92 (.456)					0.6 (.613)				
	Environmental Reporting		0.09	0.55	0.006	.458	Comp. Cost	-0.11	0.64	0.006	.426
	Regulatory Proactivity		0.18	1.74	0.018	.190	Reputation	-0.03	0.04	0.000	.839
	Operational Improvement		-0.07	0.27	0.003	.606	Innovation	-0.15	1.13	0.010	.290
	Environmental Partnerships		0.18	1.63	0.017	.204					

¹ Multivariate tests: Pillai's trace, Wilks' Lambda, Hotellings's Trace, Roy's Largest Root (all values converged)

² (Acquisition*Assimilation*Transformation*Exploration)

³ Parameter Estimate

APPENDIX I

Latent variables items	Mean	s.d.	Number of items	Cronbach's alpha	Variance explained	Standardized Regression weight	Significance
<i>Absorptive capacity</i>							
<i>Knowledge acquisition</i>							
			4	0.77	59.1%		
# 1	Business units and functional groups strongly interact with upper levels to acquire new knowledge	4.6	1.3			0.80	***
# 2	Different departments (business units/ functional groups such as procurement, legal, different R&D) strongly interact with each other to acquire new knowledge	4.7	1.3			0.96	***
# 3	The company collects industry information through informal means (e.g. lunch with industry friends, talks with trade partners)	5.1	1.3			0.38	<i>fixed</i>
# 4	The company regularly organizes special meetings with third parties (customers, consultants, etc) to acquire new knowledge	4.9	1.5			0.45	***
<i>Knowledge assimilation</i>							
			3	0.86	77.6%		
# 5	We quickly recognize shifts in our market (e.g. competition, regulation, demography)	5.2	1.2			0.79	<i>fixed</i>
# 6	New opportunities to serve our clients are quickly understood.	5.5	1.1			0.87	***
# 7	Consequences of technological progress are quickly understood.	5.1	1.1			0.79	***
<i>Knowledge transformation</i>							
			4	0.83	66.6%		
# 8	The company regularly considers the impact of changing market demands for the portfolio of products and services (e.g. employees full-time dedicated as part of product management, regular meetings, etc.)	4.5	1.5			0.64	***
# 9	The meetings held regarding new operations and products are highly effective (meeting goals are set and achieved, etc.).	4.5	1.2			0.68	***
# 10	Newly acquired knowledge is documented and shared within the whole company.	4.4	1.5			0.83	***
# 11	The applicability of new knowledge to existing knowledge is quickly recognized.	4.6	1.2			0.88	<i>fixed</i>
<i>Knowledge exploitation</i>							
			3	0.67	60.1%		
# 12	The processes (e.g. procedures, etc) for all kinds of activities are clearly known (e.g. face-gate-process, standard operating procedures, etc).	5.0	1.5			0.65	<i>fixed</i>
# 13	We experience difficulties in implementing client requests (e.g. product modifications, etc.)– inverted -	5.0	1.2			0.53	***
# 14	We constantly consider how to better exploit knowledge (e.g. lessons learned processes).	4.2	1.4			0.70	***
<i>Management support</i>							
			3	0.89	82.0%		
# 15	...provide incentives and assistance for environmentally friendly practices and technologies?	3.4	1.8			0.84	***
# 16	...encourage facilities to participate in voluntary environmental programs? (e.g. with other departments, other companies, etc.)	3.3	1.8			0.97	<i>fixed</i>
# 17	...allow facilities to make environmental investments to go beyond legal compliance?	3.4	1.7			0.75	***
<i>Environmental Proactivity</i>							
<i>Environmental Reporting</i>							
			3	0.81	73.2%		
# 18	Internal assessment of the environmental impact of operations	4.1	2.1			0.87	<i>fixed</i>

Latent variables items	Mean	s.d.	Number of items	Cronbach's alpha	Variance explained	Standardized Regression weight	Significance
# 19 Comprehensive external environmental audit	3.5	2.4				0.86	***
# 20 Do you release a public environmental or sustainability report (yes/no)	0.2	0.4				0.60	***
Regulatory Proactivity			3	0.73	65.9%		
# 21 Adopted comprehensive product life cycle analysis	2.5	1.6				0.47	***
# 22 ...participate in the development of new environmental regulation?	2.1	1.7				0.73	fixed
# 23 ...contribute to the design of new best available techniques?	2.6	1.8				0.95	***
Operational Improvement			4	0.76	57.8%		
# 24 Investment in additional pollution/emission control equipment	3.8	2.1				0.64	fixed
# 25 Closed-loop waste use within the organization	3.8	2.0				0.72	***
# 26 Closed-loop waste use with other organizations	2.7	1.8				0.60	***
# 27 Implementation of other processes/technologies to reduce waste	4.0	1.8				0.70	***
Environmental Partnerships			5	0.88	67.4%		
# 28 With companies within the chemical industry	2.3	1.7				0.77	fixed
# 29 With companies outside the chemical industry	2.1	1.5				0.66	***
# 30 With suppliers and distributors	2.8	1.7				0.79	***
# 31 With industry associations	2.8	1.9				0.84	***
# 32 With government/local communities	2.3	1.7				0.76	***
Competitive Advantage through Environmental Proactivity							
Cost			3	0.87	79.1%		
# 33 We incur lower compliance costs with regulations of environmental issues relative to our domestic competitors.	3.5	1.3				0.88	fixed
# 34 Overall, our environmental strategy improves our relative cost position to domestic competitors.	3.5	1.3				0.90	***
# 35 Overall, our environmental strategy improves our relative cost position to foreign competitors.	3.0	1.4				0.72	***
Reputation			3	0.83	74.9%		
# 36 Overall company reputation or goodwill	5.0	1.0				0.70	fixed
# 37 Loyalty of existing customers	4.5	0.9				0.83	***
# 38 Attraction of new customers	4.7	1.0				0.84	***
Innovation/Differentiation			3	0.86	77.5%		
# 39 Development of new technologies	4.7	1.0				0.84	fixed
# 40 Development of new or improvement of existing processes and operations	4.8	1.0				0.80	***
# 41 Development of new or improvement of existing products	4.8	1.1				0.80	***