EFFECTS OF "BEST PRACTICES" OF ENVIRONMENTAL MANAGEMENT ON COST ADVANTAGE: THE ROLE OF COMPLEMENTARY ASSETS

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Effects of "Best Practices" of Environmental Management on Cost Advantage: The Role of Complementary Assets

ABSTRACT

Empirical research on the effects of "best practices" of environmental management, which enable firms to simultaneously protect the environment and reduce costs, on firm performance has so far ignored the role of existing firm resources and capabilities. Drawing on the resource-based view of the firm, this study analyzes whether complementary assets are required to gain cost advantage from implementing "best practices." Using survey data from 88 chemical companies, results indicate that capabilities for process innovation and implementation are complementary assets that moderate the relationship between "best practices" and cost advantage, a significant factor in determining firm performance.

The costs of environmental protection for firms in the United States have increased considerably since the 1970s and are expected to increase even further in the future (Environmental Protection Agency, 1991; U.S. Department of Commerce, 1996). The substantial nature of environmental protection costs implies that strategies that affect these costs are an important determinant of a firm's competitive position. The environmental management literature suggests that firms can improve their competitive position and at the same time reduce the negative effects of their activities on the natural environment by implementing certain "best practices" of environmental management (Cairncross, 1992; Hart, 1995; Schmidheiny, 1992; Smart, 1992; Shrivastava, 1995b). Studies in the environmental management literature have identified these "best practices" from case studies of firms that have successfully created competitive advantage through their environmental strategies, such as 3M (Shrivastava, 1995b) or Dow (Smart, 1992). Yet, current research has not provided insights into precisely how these case-study firms manage the process of implementing "best practices" of environmental management to achieve the desired benefits. As such, developing a deeper understanding of the process of implementing these “best practices” seems key in determining whether such practices can confer competitive advantage on all adopting firms or only on those firms that possess existing assets that enable them to capitalize on such practices. That is, there may be something proprietary or unique about these successful case-study firms that might not be representative of, and thus generalizable to, a larger population of firms.

This paper takes a strategic management approach to this important implementation issue. While strategic management perspectives used to be absent from the natural environment literature (Hosmer, 1994; Shrivastava, 1994; Throop, Starik, & Rands, 1993), some recent work applies resource-based strategy perspectives to the analysis of environmental strategies (Aragón-Correa, 1998; Hart, 1995; Marcus & Geffen, 1998; Maxwell, Rothenberg, Briscoe & Marcus, 1997; Rugman & Verbeke, 1998; Russo & Fouts, 1997, Sharma & Vredenburg, 1998). Specifically, Reinhardt (1998) has argued that not all firms might be able to create competitive advantage from implementing environmentally responsible strategies and that more attention needs to be paid to the circumstances under which responsible environmental strategies contribute to competitiveness. His examples of environmental product differentiation suggest that whether or not a firm can gain differentiation advantage from being environmentally responsible primarily depends on *external* contingencies, such as the structure of the industry and characteristics of the product market in which the firm competes. Reinhard's (1998) external contingency focus complements this paper, which analyzes how factors *internal* to the firm affect the relationship between environmental practices and competitiveness.

This study employs the resource-based view of the firm (Barney, 1986, 1991; Dierickx & Cool, 1989; Rumelt, 1984, 1991; Penrose, 1959; Wernerfelt, 1984) and Teece's (1986) concept of complementary assets to address the question of whether a firm's existing assets moderate the relationship between "best practices" of environmental management and competitiveness. Complementary assets are defined as resources that are required to capture the benefits associated with a strategy, a technology, or an innovation. While much of the environment and strategy research suggests that there is a direct relationship between environmental best practices and firm performance, Teece's approach suggests that firms would need to possess complementary assets to gain competitive advantage from the implementation of "best practices" of environmental management.

This paper uses data collected through a mail questionnaire survey of business units operating in the chemical industry in the United States to empirically explore two issues. The first involves whether the implementation of the three "best practices" of environmental management directly contributes to a firm's competitive cost advantage. The second addresses whether complementary assets moderate the relationship between "best practices" of environmental management and cost advantage. The findings, which are discussed in the final section, suggest that complementary assets are required to successfully implement environmental ‘best practices” and explain why some firms get positive economic benefits from adopting such practices while others do not.

THEORY

"Best Practices" of Environmental Management and Competitiveness

A growing body of literature on environmental management focuses on identifying "best practices" of environmental management, which simultaneously reduce the negative impact of firms' activities on the natural environment and contribute to competitive advantage in product markets. According to this literature, different "best practices" of environmental management affect different types of competitive advantage. Porter's (1980) distinction between cost and differentiation advantages, which has previously been used to classify types of competitive advantages created by firms' environmental strategies (Stead & Stead, 1995; Shrivastava, 1995c), provides an useful framework for discussing these effects.

Cost advantage can result from adopting "best practices" that focus on firms' production processes (Hart, 1995; Stead & Stead, 1995). These process-focussed "best practices" include redesigning production processes to be less polluting, substituting less polluting inputs, recycling by-products of the process, and innovating less polluting processes (Ashford, 1993; Dechant & Altman; 1994; Florida, 1996; Hart, 1995; Porter & van der Linde, 1995a, 1995b). Such practices are intended to reduce the cost of production by increasing the efficiency of production processes and by reducing input and waste-disposal costs (Newman & Breeden, 1992; Smart, 1992; Hart, 1995; Shrivastava, 1995a, 1995b; Stead & Stead, 1995). Empirical results show that the primary economic motive for implementing process-focussed environmental practices is a firm’s desire to reduce costs (Stead & Stead, 1995). More comprehensive approaches to environmental management that consider the environmental impact of firms' operations throughout the entire life-cycle of its products – from product design through manufacturing, use, and disposal – can also contribute to cost advantage. These approaches, which include product stewardship (Hart, 1995, 1997) and ecocentric management

(Shrivastava, 1995a), feature such environmental practices as life-cycle-analysis (Davis, 1993), "cradle-to-grave" design, design for disassembly (Shrivastava, 1995b) and design for environment (Hart, 1997). In addition to manufacturing costs, these more comprehensive "best practices" can also lower a range of other costs such as potential liability costs, legal fees (Shrivastava, 1995a), and potential product-take-back costs. However, the cost advantages from implementing these "best practices" depend on environmental government regulations, which have not yet been instituted in many countries. For example, firms are required to bear the environmental costs associated with the disposal of their products only if government regulations require them to internalize the entire life-cycle costs of their products. While such regulations have been instituted in some European countries, such as Germany's product "take-back" law (Management Institute for Environment and Business, 1993), they do not yet exist in the United States.

Differentiation advantage can result from "best practices" of environmental management that focus on product characteristics and product markets (Shrivastava, 1995c; Stead & Stead, 1995, 1996). These product-focussed "best practices" include redesigning product packaging and products to be more environmentally responsible, developing new environmentally responsible products, and advertising the environmental benefits of the products (Dechant & Altman, 1994; Reinhardt, 1998; Shrivastava, 1995c; Stead & Stead, 1995, 1996; Throop et al., 1993). Differentiation advantage creates the potential for increasing product prices, which results in higher revenues. Empirical results show that revenue enhancement is the primary economic motivation for and outcome of implementing "best practices" focussing on product characteristics and markets (Stead & Stead, 1995).

Because different "best practices" of environmental management lead to different kinds of competitive advantage, it is important to focus on specific "best practices" and the particular advantages associated with them. This study concentrates on process-focussed "best practices" of environmental management and their effects on cost advantage for two reasons. First, it has been suggested that "best practices" of environmental management are path dependent and that there is a sequential logic to the implementation of environmental strategies (Hart, 1995, 1997). In particular, Hart (1995) suggests that firms will only be able to successfully adopt product-stewardship strategies and achieve differentiation through environmentally responsible products if they have first made significant progress in the implementation of pollution-prevention technologies, which is a process-focussed "best practice." Thus, process-focussed "best practices" can be seen as the basic precondition for the implementation of all other "best practices" of environmental management and as the most basic building block of a responsible environmental strategy. Second, the competitive effect of environmental strategies that managers might be most interested in are relatively short-term cost savings. External pressures from shareholders and analysts for profit improvement shorten the planning horizon of managers, and pressures for corporate downsizing and re-engineering cause managers to focus on the cost side of the profit equation. Process-focussed "best practices" can create cost savings faster than other "best practices" of environmental management.

The literature has mainly identified "best practices" of environmental management from case studies of firms that have successfully implemented them. Many case studies identify process-focussed "best practices" and try to quantify the associated cost savings. Case examples of companies that have gained cost advantage from the implementation of process-focussed "best practices" include 3M's Pollution Prevention Pays (PPP) program, which emphasizes pollution prevention, natural resource conservation, and continuous improvement (Hart, 1995; Shrivastava, 1995c; Stead & Stead, 1996). The PPP program has saved 3M $810 million since its inception in 1975 (Minnesota Mining and Manufacturing Company, 1998). Other environmental programs that focus on pollution prevention in the production process such as Dow's Waste Reduction Always Pays (WRAP) or Chevron's Save Money and Reduce Toxins (SMART) programs have also produced substantial cost savings (Stead & Stead, 1996).

The fact that researchers have exclusively selected companies that have successfully created cost advantage from their environmental practices for their case studies leads to two problems associated with sampling on the dependent variable: failure to establish causality and lack of generalizability. First, because sampling does not vary on the dependent variable, it is not possible to establish causality between the "best practices" and cost advantage. In order to establish causality it is necessary to analyze how the environmental practices of firms that fail to gain cost advantage from environmental strategies differ from the practices of more successful firms. Second, the case study companies that have successfully created cost advantage from their environmental strategies might not be representative of the overall population of firms. This implies that the normative conclusions drawn from these case studies might be not generalizable. Therefore, it is necessary to go beyond anecdotal evidence gained from studying only a small group of successful firms to larger, more diverse samples to understand how firms translate the adoption of environmental "best practices" into differential competitive advantage.

Several authors have used larger samples of firms to empirically analyze the competitive effects of environmental strategies. Most of these large-sample studies analyze the relationship between various measures of environmental *performance,* which can be interpreted as the *outcome* of environmental strategies, and measures of the firm's financial performance (Bowman & Haire, 1975; Bragdon & Marlin, 1972; Chen & Metcalf, 1980; Fogler & Nutt, 1975; Hart & Ahuja, 1996; Klassen & McLaughlin, 1996; Russo & Fouts, 1997; Spicer, 1978). Results of these studies are inconclusive. Some studies show no relationship between environmental and financial performance, some show a positive relationship, and some show a u-shaped relationship in which the middle polluters outperform firms that pollute the most and least. Only a few studies look at the effects of *environmental practices*, which can be seen as the *content* of environmental strategies, on measures of firm performance. Nehrt (1996) finds that one "best practice" of environmental management – early timing of environmental investments – significantly contributes to growth in profits, while the intensity of investment in pollution prevention – a process-focussed "best practice" – had an unexpected negative significant effect on profit growth. Stead and Stead (1995) find that for about 44 percent of the firms in their sample the implementation of process-focussed "best practices" had positive effects on revenues, while 56 percent reported no or negative effects. Thus overall, large-sample studies show inconclusive results regarding the effects of environmental performance and environmental practices on firm performance and competitiveness.

The inconclusive results of these large-sample studies can be attributed to two factors. First, researchers looking at effects of process-focussed "best practices" on competitiveness have not used measures of firm performance that are closely related to the anticipated effects of these practices on competitiveness, such as cost advantage. A variety of factors other than cost savings from "best practices" affect profit growth (Nehrt, 1996), which might account for the inconclusive results of his study. Revenues (Stead & Stead, 1995) are not at all related to the cost savings from implementing process-focussed "best practices." A second reason for the inconclusive results might be that some firms in the larger samples experienced positive effects of their environmental strategy and performance on competitiveness, while others did not, which will result in inconclusive results for the sample on average. This lack of resolution suggests that it is necessary to examine why some firms might experience positive effects from implementing processed-focussed "best practices" on cost advantage, while others do not.

Moderating Effects of Complementary Assets

This paper applies the resource-based view of the firm (Barney, 1986, 1991; Dierickx & Cool, 1989; Penrose, 1959; Rumelt, 1984, 1991; Wernerfelt, 1984) from the business strategy literature to the analysis of competitive effects of environmental strategies. The resource-based view of the firm suggests that differences in firm performance are primarily the result of resource heterogeneity across firms. Firms that are able to accumulate resources and capabilities that are rare, valuable, nonsubstitutable, and imperfectly imitable will achieve competitive advantage over competing firms (Barney, 1991; Dierickx & Cool, 1989; Rumelt, 1984). Firm resources are the inputs in the production process and can be seen as the most basic unit of analysis (Grant, 1991). Resources can be divided into physical, human, and organizational assets (Barney, 1991). Capabilities are capacities to deploy resources, usually in combination, to effect a desired end (Amit & Schoemaker, 1993).

More recently, researchers have noted the contribution of new applications and combinations of existing resources to competitive advantage (Kogut & Zander, 1992; Grant, 1996). Teece (1986) introduces the concept of complementary assets - resources or capabilities that allow firms to capture the profits associated with a strategy, technology, or innovation. He suggests that in order to commercialize the design for a new product in a profitable manner firms need access to complementary manufacturing and distribution facilities on favorable terms. The new product design is of little value in the absence of these complementary assets. The existence of complementary assets that are difficult to imitate by other firms can also contribute to the sustainability of the competitive advantage created by the firm's product design. Even if other firms can imitate the new product, they will not be able to gain competitive advantage from this imitation if they do not have access to the necessary complementary assets. Empirical support for the value of complementary assets has been found in studies of success of new entrants and incumbents in the medical diagnostic industry (Mitchell, 1989, 1991) and the typesetter industry (Tripsas, 1997) as well as in a study of the competitive effects of information technology implementation (Powell & Dent-Micallef, 1997).

An application of the concept of complementary assets to the study of environmental strategies could explain why only some firms might be able to gain competitive advantage from implementing "best practices" of environmental management. In the context of environmental strategies, complementary assets can be defined as assets that are required to gain competitive advantage from the implementation of the "best practices" of environmental management. If successful implementation of "best practices" requires complementary assets, only firms that possess such assets will be able the gain competitive advantage from implementing "best practices," while other firms will not. In other words, complementary assets will moderate the relationship between "best practices" and competitive advantage.

Process-focussed "best practices" of environmental management, such as pollution prevention and innovation of environmental technologies, are often difficult to separate from firms' other productive activities (Hart, 1995). This suggests that resources and capabilities that are developed and used in firms' other productive activities might be required to successfully implement process-focussed "best practices" of environmental management. Firms that do not possess these resources and capabilities may not be able to implement process-focussed "best practices" successfully and may consequently not be able to generate all of the potential cost savings associated with the implementation of these practices. Thus, those resources and capabilities that are developed and used in firms' other productive activities and that are required to successfully implement process-focussed "best practices" of environmental management are complementary assets. Firms do not develop these complementary assets as part of their environmental strategy, but rather in the course of their other productive activities, which are part of the firm's more general business strategy. Because they already play a central role in a firm’s business strategy, these complementary assets are available to be leveraged in the firm’s environmental strategy, thus potentially enabling firms to capture the value associated with the implementation of "best practices" of environmental management. In order to create competitive advantage, however, these complementary assets must not only be specific to the firm but also not be easily transferable to, or imitable by, other firms.

The role that complementary assets play in the relationship between environmental practices and firm competitiveness has not yet been empirically explored. Studies that have incorporated resource-based perspectives in the analysis of environmental strategies have focussed on other questions such as factors contributing to the creation of pollution-prevention capabilities (Marcus & Geffen, 1998), effects of firm strategies and firm characteristics on the implementation of environmental programs (Aragón-Correa, 1998; Maxwell et al., 1997), and how environmental strategies and performance contribute to the creation of resources and capabilities (Russo & Fouts, 1997; Sharma & Vredenburg, 1998). Most case studies of process-focussed "best practices" focus exclusively on the analysis of the firm's environmental strategy and its effects on cost advantage without placing the environmental strategy in the broader context of the firm's competitive strategy and the resources and capabilities created through this strategy. Thus, all of these studies ignore the role of complementary assets.

Analyzing the role of complementary assets as moderating variables will push further into the links of the causal chain between implementation of "best practices" and competitive outcomes. Previous empirical studies of the effects of environmental performance or strategy on competitiveness have not explicitly modeled the ways in which environmental strategies or environmental performance creates competitive advantage (Wood and Jones, 1995). As a result, these studies have been criticized for not considering the possibility that reverse causality is present (Ullmann, 1985). Environmental performance might not create competitive advantage, but rather competitive advantage in product markets and the associated superior financial performance might allow firms to implement environmentally responsible strategies. Considering the moderating effects of complementary assets and focussing on particular environmental practices - process-focussed practices - and on the specific type of competitive advantage associated with them - cost advantage - models some of the causal relationships more explicitly and makes reverse causality less likely.

HYPOTHESES

This section introduces the three process-focussed "best practices" of environmental management used in the empirical analysis. Hypotheses are first developed regarding the direct effects of environmental 'best practices" on cost advantage, based on the environmental management literature.

Then, hypotheses are developed regarding the potential moderating effect of firms-specific complementary assets that might be required to realize a cost advantage from the implementation of these three "best practices."

Direct Effects of the Three "Best Practices" on Cost Advantage

Best practice #1: Use of pollution-prevention technologies. Firms have the choice among a variety of technologies to reduce negative effects of their activities on the natural environment. These technologies can be classified by the means that they use to reduce pollution. Pollution can be reduced through *prevention* or through *control* (Hart 1995). Pollution prevention seeks to reduce, change, or prevent emissions and effluent discharges through better housekeeping, material substitution, recycling, or changes in the production process (Willig, 1994; Stead & Stead, 1995). Pollution-prevention technologies, which are also referred to as *source-reduction technologies* or clean technologies, minimize the creation of pollution and wastes in the production process. Pollution control seeks to trap, store, treat, and dispose of emissions and effluents using pollution-control equipment. Pollution and wastes are reduced after they originated by adding devices to existing production processes. These devices, which include incinerators and scrubbers, are frequently referred to as *end-of-the-pipe technologies*.

The environmental management literature emphasizes the use of pollution-prevention technologies as an important "best practice" of environmental management. The use of pollution-prevention technologies has the potential to increase the efficiency of production (Schmidheiny, 1992; Smart, 1992). Efficiency increases result from reduction of input costs through better utilization of inputs or substitution of less costly inputs, savings from recycling or reusing materials, and reduction of waste-disposal costs. Pollution prevention in production processes also may reduce cycle time by simplifying or removing unnecessary steps in the operations or reduce downtime through higher-quality monitoring equipment (Porter & van der Linde, 1995b). In addition, pollution-prevention technologies may cut emissions well below required levels, resulting in reduced compliance and liability costs. Pollution-control technologies, on the other hand, are investments in non-productive assets; added costs with no potential to increase the efficiency of production.

In addition, for cost advantage from environmental technologies to be sustainable, these technologies must be difficult to imitate by the firm's competitors (Lippman & Rumelt, 1982; Wernerfelt, 1984; Barney, 1991). End-of the-pipe solutions are frequently off-the-shelf solutions that can be acquired in the market and added to existing production processes. Thus, these technologies can be easily imitated by the firm's competitors and cannot be expected to lead to sustainable cost advantage. Pollution-prevention technologies, on the other hand, are mostly specific to particular production processes and therefore not easily imitable by competitors.

This suggests the following hypothesis:

H1: The higher a firm's use of pollution-prevention technologies, the larger will be its cost advantage from environmental strategies.

Best practice #2: Innovation of proprietary pollution-prevention technologies. The environmental management literature focuses on innovation of pollution-prevention technologies as another important source of competitive advantage from environmental strategies (Ashford, 1993; Porter & van der Linde, 1995a, 1995b). Innovation of technologies is fundamentally different from technology diffusion, which is the adoption of technologies that are already developed (Ashford, 1993). Internal innovation of pollution-prevention technologies can contribute to a firm's cost advantage in several ways. First, in the process of developing new pollution-prevention technologies managers might become aware of inefficiencies in existing production processes or products that were not previously recognized, which increases the potential for cost-saving efficiency improvements Porter & van der Linde, 1995a, 1995b). Second, the innovation of pollution-prevention technologies is likely to result in cost-saving changes in the production process. Third, firms are likely to be able to appropriate the rents that are created by internally developed pollution-prevention technologies, because these technologies are proprietary to the firm. The proprietary nature of these technologies stems from the protection through barriers to imitability, which include the aforementioned barriers to the imitation of pollution-prevention technologies, as well secrecy and legal protection through patents. This suggests the following hypothesis:

H2: The higher a firm's level of innovation of proprietary pollution-prevention technologies, the larger will be its cost advantage from environmental strategies.

Best Practice #3: Early timing. Starting to address an environmental issue earlier than competitors or before the enactment of environmental regulations can be expected to contribute to cost advantage in three ways. First, the environmental management literature argues that a strategy of anticipating future environmental regulation and implementing technologies to comply with that regulation before it is enacted will lower a firm's compliance costs with the regulation. This is because anticipation minimizes disruptions of the production process associated with developing and implementing compliance technologies (Ashford, 1993). Firms that respond to regulations late might face time-compression diseconomies (Dierickx & Cool, 1989; Nehrt, 1996, 1998) because they need to implement environmental technologies faster, which might result in more disruptions of the production process. In addition, if new regulations give firms only a short period of time to adjust, only firms that anticipate future regulations might be able to implement pollution-prevention technologies (Nehrt, 1996, 1998), because these technologies take more time to implement than pollution-control technologies.

Second, addressing environmental issues earlier than competitors will allow firms to gain cost advantage through learning curve effects (Lieberman & Montgomery, 1988; Nehrt, 1996, 1998). The earlier a firm starts to address an environmental issue and move down the learning curve for environmental technologies, the lower its cost of environmental protection will be relative to its competitors at a given time.

Finally, addressing environmental problems early and developing solutions to environmental problems before these problems are addressed by regulations can influence the future development of environmental regulations. These future environmental regulations can increase the costs of environmental protection for the firm's competitors that need to make investments to comply with them. Thus, by addressing problems early and influencing environmental regulations, firms can raise their rivals' costs (Salop & Schefman, 1983), thereby gaining relative cost advantage. All of these factors suggest the following hypothesis:

H3: The earlier a firm's timing of environmental strategies, the larger will be its cost advantage from environmental strategies.

Moderating Effects of Complementary Assets

In order to identify what particular complementary assets might moderate the relationship between the three "best practices" discussed above and cost advantage, it is necessary to analyze the nature of these "best practices." An important technical characteristic of pollution-prevention technologies is that they are *integrated* into the production process. Therefore, the implementation of pollution-prevention technologies requires significant changes in existing production processes or product designs. In contrast, pollution-control technologies are *added* to existing production processes and require little change in existing production processes.

This discussion suggests that successful adoption of the two "best practices" of using and innovating proprietary pollution-prevention technologies requires special capabilities to innovate and implement modifications in production processes. Firms that use or innovate pollution-prevention technologies without possessing these capabilities for process innovation and implementation might not be able to generate cost savings from the adoption of these "best practices" of environmental management. In fact, changing a well-running production process without having capabilities for process innovation and implementation might make the process less efficient than it was previously. Thus, capabilities for process innovation and implementation might be complementary assets that are required to gain cost advantage from implementing and innovating pollution-prevention technologies.

A firm's ability to benefit from the early timing "best practice" might also be affected by its capabilities for process innovation and implementation. Such capabilities may allow a firm to move down the learning curve for environmental technologies much faster than firms without such complementary capabilities and thus capture related advantages. However, firms that do not possess capabilities for process innovation and implementation might be better off delaying their environmental strategies in order to learn from and imitate early movers.

If capabilities for process innovation and implementation are indeed complementary assets, then theory suggests that the firms that are frequently used in the case studies of "best practices" of environmental management may possess high levels of these capabilities. Evidence from the case studies supports such a theory, in that one attribute that the case study firms share is innovativeness. The three chemical companies whose environmental practices were included in Smart's book (Dow, Du Pont, and Monsanto) are the three top-rated chemical companies for innovativeness in *Fortune's* Most Admired List (Fortune, 1998). 3M, which is also frequently analyzed in case studies (e.g., Porter & van der Linde, 1995; Shrivastava, 1995b), ranks number one within its industry and number seven of all companies included in *Fortune's* Most Admired List for innovation (Fortune, 1998). This suggests that these firms possess high levels of capabilities for process innovation and implementation, which allows them to gain cost advantage from the implementation of process-focussed "best practices."

This possible moderating effect of complementary capabilities on the relationship between the three "best practices" of environmental management and a firm's cost advantage results in the following hypotheses:

H4: The higher a firm's level of capabilities for process innovation and implementation, the larger its cost advantage from the use of pollution-prevention technologies.

H5: The higher a firm's level of capabilities for process innovation and implementation, the larger its cost advantage from the innovation of proprietary pollution-prevention technologies.

H6: The higher a firm's level of capabilities for process innovation and implementation, the larger its cost advantage from early timing of environmental strategies.

RESEARCH DESIGN AND METHOD

Level of Analysis and Choice of Industry

This study is concerned with the influence of firms' environmental practices on cost advantage. These effects could be analyzed at the corporate, business-unit, or plant level. For multidivisional firms, the arena of competition for sales and profits the business-unit level, where business units compete against other firms in the same industry (Schendel & Hofer, 1979; Porter, 1980). Thus, competitive advantage for multidivisional firms is created at the business-unit level. Empirical results confirm that firm performance is mainly determined at the business-unit level and not at the corporate level (McGahan & Porter, 1997; Rumelt, 1991; Schmalensee, 1985; Wernerfelt & Montgomery 1988). This suggests that the business unit is a more appropriate level of analysis for this study than the corporate level. Even though environmental practices are ultimately implemented at the plant level, plants within the same business unit are likely to use similar environmental practices. This is because they produce similar or related products, use similar production technologies, and are guided by the same general environmental strategy philosophies (Starik & Rands, 1995). Plants within the same business unit can also be expected to possess similar levels of complementary assets. Complementary assets are an outcome of the business unit's competitive strategy. They can be expected to be embedded in the organizational culture of the business unit and shared throughout all plants within the same business unit. Thus, for the purpose of this study, the business-unit level is the appropriate level of analysis for multidivisional firms and the corporate level for single-divisional firms.

Environmental strategies can be analyzed at the level of overall environmental strategies or at the level of individual environmental issues. The stringency of environmental regulation, the level of customer and public concern, as well as the firm's technological capabilities to address an issue differ across issues. Thus, a firm can be expected to choose different environmental strategies to address the different environmental issues it faces and experience different effects of its environmental strategies on cost advantage across issues. Accordingly, the level of individual environmental issues is the appropriate level of analysis in order to analyze the effect of environmental strategies on cost advantage.

The chemical industry (SIC code 28) was selected for this study because its costs of environmental protection are among the highest of all industries and thus constitute a strategic issue industry-wide. In 1994, the industry's combined environmental capital expenditures and operating costs of environmental equipment amounted to 2.3 percent of total industry sales in the United States, compared to 0.8 percent for all other industries on average (U.S. Department of Commerce, 1996).

Data Collection and Sample

Consistent data on firms' environmental practices and their costs and cost savings resulting from implementing these practices are not available from published sources. While many publicly held firms publish environmental reports that contain data on environmental investments and operating expenditures, these data are not comparable across firms and are not broken down to individual environmental issues. Thus, these data cannot be used to construct measures for this study. In addition, data on privately held firms are frequently not available at all. Therefore, a mail questionnaire survey of managers was used to collect data for this study.

The questionnaire was developed in a three-stage process. First, an initial, theory-based version of the questionnaire was designed. This version was reviewed by eight executives from different functional areas in two companies operating in the chemical industry during personal interviews. Second, the initial questionnaire was modified to accommodate the executives' comments and suggestions. The new version was pre-tested with ten chemical industry participants in an Executive M.B.A. program. Third, a final version of the questionnaire was designed based on their feedback, which was then mailed to sample firms.

The mail survey was administered to a sample of 512 business units of chemical companies operating in the United States. The sample included all business units listed in *Ward's Business Directory* (1995) that had at least $100 Million in sales in a four-digit industry segment within SIC code 28 and international operations. Given the focus of this study, the appropriate respondents were those managers in the organization that had adequate knowledge of a business unit's competitive strategy, resources and capabilities, and competitors. In addition, the individuals also needed to be familiar with the environmental issues affecting the business unit, environmental strategies, and the effects of environmental strategy on competitive advantage. The interviews in the initial phase of questionnaire design revealed that the head of the business unit was the most knowledgeable about these issues. Accordingly, the target respondents were the heads of the business units for multidivisional firms and the CEOs of the company for single-divisional firms as identified from the *Directory of Corporate Affiliations* (1995).

The "Total Design Method" suggested by Dillman (1978) was used to administer the survey, including follow-up letters and two follow-up mailings. Of the 512 mailed surveys, 25 were undeliverable or the company had left the chemical industry. Of the remaining 487 surveys, 98 were completed and returned, yielding a response rate of 20.1 percent. This response rate is higher than the 10 to 12 percent typical for mailed surveys to top executives of American firms (Hambrick, Geletkanycz, & Fredrickson, 1993) and compares favorably to other studies targeting CEOs (e.g., Dess & Davis, 1984; Nayyar, 1993). Because of incomplete information, only 88 of the 98 responses were included in this study. The names of these companies are listed in Appendix A.

The questionnaire asked the respondents to identify one environmental issue that had a great effect on their business unit. Because different environmental issues affect different segments of the chemical industry, this approach seemed more appropriate than specifying issues in the survey questionnaire. This approach also allowed the respondent to identify an issue that he or she was either especially knowledgeable about or interested in, which has been shown to improve the quality of the data collected and the response rate.

Representativeness of Sample

In order to derive general conclusions about the relationships between environmental practices and cost advantage from the data collected, it was important that the responding business units were representative of the mailing sample. Two types of tests were used to assess the representativeness of the respondents. First, I compared respondents to the mailing sample along three known characteristics. The respondents and mailing sample did not differ significantly in terms of business unit size measured by business unit sales, and industry membership at the three-digit SIC-code level. To test for differences in environmental performance between respondents and non-respondents, I compared changes in the amount of chemical releases for the two groups of firms between 1991 and 1994 using data from the Environmental Protection Agency's Toxic Release Inventory. The top ten chemicals released were included in this analysis. Significant differences were found for only two of the ten chemicals. For one of these chemicals (hydrochloric acid) respondent firms increased releases relative to non-respondents, whereas for the other one (carbon disulfide) they decreased releases. These results do not reveal systematic differences in the environmental performance between respondents and non-respondents.

Second, I used wave analysis to investigate whether a self-selection bias exists such that firms following certain environmental strategies or experiencing certain competitive effects from their environmental strategies were more likely to respond to the survey. This procedure is based on the observation that in mail surveys, non-respondents tend to be more similar to late respondents than early respondents (Fowler, 1993). Wave analysis gauges non-response bias by comparing respondents who respond readily to the survey to those who respond after the follow-up steps are taken. Comparisons of means and correlations for respondents to the first mailing and respondents to the third mailing reveal that the two groups do not differ significantly in either the level of the variables or in the relationships between the variables. These results provide evidence that the respondents are representative of the mailing sample and that a self-selection bias is unlikely to exist.

Construction of Measures

Many of the items used in the survey were adopted from the literature, while others were originally developed. Existing measurement scales were identified through a review of prior research. These measurement scales were adjusted to fit the variables included in this study. In addition, for some variables – in particular for measuring the competitive effects of environmental strategies – new measurement scales needed to be developed. Most measurement scales ask the respondent to rate his or her firm relative to its major competitors or on a 7-point Likert-scale (Likert, 1932).

Unidimensionality of the survey-based constructs was assessed using maximum likelihood factor analysis with varimax rotation of the survey items. Construct reliability was assessed using the Cronbach α coefficient (Cronbach, 1951). A summary of the scales and Cronbach α coefficients for the measures is provided in Appendix B. The Cronbach α coefficients for all the variables are 0.70 or higher, indicating sufficient reliability of the measures. In order to increase confidence in the validity of the measures based on self-reported data, the survey-based measures for two key variables were triangulated with financial data obtained from the COMPUSTAT database.

Cost Advantage. The dependent variable for this study is a subjective assessment of the cost advantage resulting from the firm's environmental strategy relative to the firm's major competitors. This measure is preferable to accounting measures of financial performance and to estimates of cost savings from environmental practices for the following reasons. First, many factors besides a firm's environmental strategy affect its financial performance. In order to isolate the effect of a firm's environmental strategy on competitiveness, a measure was developed that more narrowly captures the effect of the business unit's environmental strategy on cost advantage than a standard measure of financial performance. Second, cost savings from specific environmental practices do not capture how the implementation of these environmental practices affects the competitiveness of a firm within its industry. Even if a firm's environmental practices result in positive costs of environmental protection (i.e. the firm does not experience net cost savings from its environmental strategy), its environmental strategy will still improve cost advantage if its competitors incur higher costs of environmental protection. In order to capture the effect of the implementation of "best practices" on competitiveness of the firm within its industry, a reference group was selected against which cost advantage is measured. Rather than focusing on absolute cost savings through the environmental strategy, this measure assesses cost advantage relative to *the firm's major domestic and foreign competitors*.

Subjective performance measures are widely accepted in organizational research (Lawrence & Lorsch, 1967; Dess, 1987). Nevertheless, to check for possible common method variance problems, this measure of cost advantage based on self-reported data was triangulated with financial data at the corporate level obtained from the COMPUSTAT database. If the self-reported measure accurately reflects cost advantage there should be a positive relationship between cost advantage and returns to shareholdings, because cost advantage from environmental strategies contributes to firm performance and, thus, should be valued by the market. The correlation coefficient between the cost advantage measure and three-year returns on shareholdings from 1992 to 1994 for the 49 sample firms for which share price and dividend data were available in the COMPUSTAT database is positive and significant at the 10 percent level ($p=0.052$) (see Table 1). This significant positive correlation increases confidence in the self-reported measure of cost advantage.

"Best practices" of environmental management. Measures for the "best practices" of environmental management were developed through a factor analysis of eight survey items related to the firms' use of pollution-prevention technologies, their innovation of proprietary pollution-prevention technologies, and their timing of environmental strategies regarding this issue.

Complementary assets. The complementary assets of capabilities for process innovation and implementation were measured by five questionnaire items related to the general innovativeness of the company relative to its major competitors and the propensity of the company to update existing or implement new production technologies and equipment. Continuously updating existing or implementing new technologies and equipment can be expected to lead to the creation of capabilities for process innovation and implementation.

This self-reported measure was correlated with the three-year average earnings per share from operations from 1992 to 1994 for 56 sample companies for which the data was available from COMPUSTAT. Earnings per share from operations can be seen as an indicator of operational excellence, which requires capabilities for process innovation and implementation. The correlation between these two variables was positive (0.38) and significant at the 5 percent level. This increases confidence in the measure of complementary assets.

Control Variables. Business unit size is used to control for economies of scale in the design and implementation of environmental strategies. This variable is measured by the logarithm of annual business unit sales obtained from *Ward's Business Directory*. Environmental issues differ in the stringency and design of government regulations, and in the availability of environmental technologies to address an issue. To control for these issue characteristics, I classified the issues selected by the respondents in six categories: air pollution, water pollution, waste, product issues, issues related to the Superfund regulation, and others (where others includes issues that did not fit any category). A dummy variable was used for each issue to control for differences in issue characteristics.

Methods

Ordinary least squares regression analysis was used to test the hypotheses. The contingency relationships suggested in hypotheses 4 through 6 were tested using moderated regression analysis (Aiken & West, 1991). Interaction terms were formed by multiplying the complementary assets variable with the measures of the three "best practices" of environmental management. Each interaction term was included in a separate regression equation in order to minimize multicollinearity among the independent variables. Significant regression coefficients for the interaction terms and significant increases in the explanatory power of the model through inclusion of the interaction terms support the hypotheses regarding moderating effects. T-tests were used to assess the significance of regression coefficients and F-tests to assess the significance of the increase in the explanatory power of the models.

Preliminary Data Analysis and Checking Data Quality

Two additional checks were performed on the quality of the data before testing the hypotheses. The first assessed the extent of multicollinearity among the independent variables, and the second tested for common-method variance. The correlations among the independent variables shown in Table 1 were reviewed for multicollinearity. These correlations are generally low (below 0.3), with two exceptions.

The level of complementary assets is highly correlated with early timing, indicating that firms that focus on innovation as part of their general business strategy address environmental issues earlier than other firms. In addition, the correlation between innovation of proprietary pollution-prevention technologies and the product issue is positive and significant, indicating that firms address product environmental issues with a higher level of pollution-prevention innovation than other issues. The presence of multicollinearity in the data was also evaluated using several additional diagnostic tests suggested by Belsley, Kuh, & Welsch (1980). Examinations of condition indices and of variance inflation factors indicated that multicollinearity is not a problem.

Insert Table 1 about here

Common method bias can pose problems for survey research that relies on self-reported data, especially if the data are provided by the same person at the same time (Campbell & Fiske, 1959). One important concern in such cases is that common method bias may artificially inflate observed relationships between variables. Several procedures were employed to avoid common-method variance or to estimate its extent. First, the dependent variables were placed after the independent variables in the survey to diminish if not avoid the effects of consistency artifacts (Salancik & Pfeffer, 1977). Second, Harman's single-factor test (Harman, 1967, Podsakoff & Organ, 1986) was performed. If common-method variance existed in the data, a single factor would emerge from a factor analysis of all questionnaire measurement items or one general factor that accounts for most of the variance would result. The factor analysis revealed five factors with eigenvalues greater than 1.0, which accounted for 73 percent of the total variance. The first factor did not account for the majority of the variance (only 32 percent). These results suggest that common method variance is not a serious problem in this study.

RESULTS

Table 2 shows the regression results. The first equation includes only the control variables in order to have a point of reference against which to compare the other equations. The second equation adds the three "best practices" of environmental management to the control variables to test the hypotheses regarding the direct effects of the "best practices" on cost advantage. It can be seen that the inclusion of the "best practices" of environmental management does not increase the explanatory power of the model by much. The third equation includes complementary assets in addition to the variables included in equation (2) to have a point of comparison for the models with interaction effects. The three remaining equations each include one of the interaction effects to test the hypotheses regarding the moderating effects of complementary assets.

Insert Table 2 about here

Direct Effects of "Best Practices" on Cost Advantage

Hypothesis 1 and hypothesis 3 suggest that use of pollution-prevention technologies and early timing of environmental strategies contribute to cost advantage. The data does not support these hypotheses. Equation (2) shows that early timing has a positive, but not significant effect, and the use of pollution-prevention technologies has a marginal negative effect on cost advantage.

Hypothesis 2 suggests that innovation of proprietary pollution-prevention technologies contributes to cost advantage. The data supports this hypothesis. Equation (2) shows that the coefficient for innovation of proprietary pollution-control technologies is positive and significant at the 10 percent level.

Moderating Effects of Complementary Assets

Hypothesis 4 suggests that firms with high levels of complementary assets gain larger cost advantage from the use of pollution-prevention technologies than firms with low levels of complementary assets. The data supports this hypothesis. Equation (4) shows that the complementary assets – pollution prevention interaction term is positive and significant at the 5 percent level. The R^2 of the model increases from 0.21 without the interaction term to 0.26 with the interaction term. An F-test reveals that this incremental increase in R^2 is significant at the 5 percent level.

Hypothesis 5 suggests that firms with high levels of complementary assets gain larger cost advantage from the innovation of proprietary pollution-prevention technologies than firms with low levels of complementary assets. The data supports this hypothesis. Equation (5) shows that the interaction term between complementary assets and innovation of proprietary pollution prevention technologies is positive and significant at the 10 percent level. The R^2 of the model increases from 0.21 without the interaction term to 0.27 with the interaction term. An F-test reveals that this incremental increase in R^2 is significant at the 5 percent level.

Hypothesis 6 suggests that firms with high levels of complementary assets gain larger cost advantage from early timing of environmental strategies than firms with low levels of complementary assets. The data supports this hypothesis. Equation (6) shows that the complementary assets – early timing interaction term is positive and significant at the 5 percent level. The R^2 of the model increases from 0.21 without the interaction term to 0.25 with the interaction term. An F-test shows that this increase is significant at the 5 percent level.

DISCUSSION

This study applied the concept of complementary assets from the resource-based view of the firm to the analysis of competitive effects of environmental practices. Results show that "best practices" of environmental management generally do not lead to cost advantage for all firms. Two of the three "best practices" of environmental management included in this study do not significantly contribute to cost advantage. These results cast doubt on the broad applicability of "best practices" of environmental management that are supposed to simultaneously protect the environment and increase competitiveness. Results also indicate that firms need to possess complementary assets in order to create cost advantage from the implementation of "best practices" of environmental management. Capabilities for process innovation and implementation were found to be complementary assets that moderate the relationships between all three process-focussed "best practices" included in the study and cost advantage. Thus, the application of the resource-based view of the firm to the analysis of environmental strategies highlights the importance of heterogeneity in firm resources and capabilities – a variable that has so far been ignored in the analysis of the competitive effects of environmental strategies.

While the cross-sectional design of this study does not allow inferring causality from the regression results and from the correlations, some additional analysis was performed to rule out an alternative causal explanation for the results of this study. It is possible that the complementary assets that allow the firm to capture value from "best practices" are the same characteristics that are associated with well-run profitable firms. The likelihood of this alternative explanation was explored using stock market data from the COMPUSTAT database. If the alternative explanation were true, a significant positive relationship should exist between complementary assets and return to shareholders. For the 49 firms for which this data was available in the COMPUSTAT database the correlation between three-year share returns and complementary assets was very low (0.08) and not significant (Table 1). This indicates that well-run profitable companies do not have higher degrees of complementary assets. Thus, profitable companies cannot be expected to experience larger cost advantages from the implementation of "best practices" than low performing firms.

Another interesting causal relationship to examine is whether well-run profitable firms have more financial resources to implement the "best practices" of environmental management. If this were the case, significant positive correlations between the "best practices" of environmental management and three-year returns on shareholdings would be expected. However, for the 49 sample firms for which COMPUSTAT data was available, all three correlations between the "best practices" and three-year share returns were relatively small (between 0.06 and 0.11) and not significant (Table 1). This indicates that well-performing firms do not implement the "best practices" of environmental management to a larger extent than other firms do.

It is possible to interpret the significant positive correlation between cost advantage and financial performance as evidence that only well-run profitable firms can gain cost advantage from environmental strategies. However, the insignificant correlations between financial performance and the three "best practices" of environmental management and complementary assets suggest that profitable firms do not differ significantly from non-profitable firms in their environmental practices or in their levels of complementary assets. This suggests that the causality goes in the other direction; that is, cost advantage from environmental strategies is valued by the market.

Implications for Research and Limitations

The finding that competitive effects of environmental strategies differ across firms with certain characteristics has important implications for future research on environmental strategies. So far, most studies in the environmental management literature have focussed exclusively on firms' environmental strategies and have ignored the importance of firm characteristics that influence the effect of environmental strategies on competitiveness. The results of this study suggest that future research needs to analyze environmental strategies in the broader context of firms' existing resources and capabilities and their existing business strategies. Such a focus might lead to very different normative implications regarding the design and implementation of environmental strategies.

Studies should also analyze the environmental practices and the firm resources and capabilities of firms that fail to gain competitive advantage from their environmental strategies. This type of analysis can provide insights into why some firms are not able to gain competitive advantage from their environmental strategies. Identifying barriers to the creation of competitive advantage from environmental strategies can help to devise strategies to overcome these barriers and thereby may contribute to the successful implementation of environmentally responsible strategies by more firms.

This study has established the importance of capabilities for process innovation and implementation as complementary assets in the relationship between process-focussed "best practices" and cost advantage. However, the implementation of different environmental practices may require different complementary assets. For example, successful implementation of product stewardship that focuses on the whole life-cycle of the firm's products may require capabilities in cross-functional management (Hart, 1995). Future research needs to identify what particular complementary assets are required to gain different types of competitive advantage from different environmental practices and empirically examine their importance.

A limitation of this study is its focus on one industry, which affects the generalizability of the findings. The differences in the findings regarding the effects of early timing of environmental strategies between Nehrt's (1996) and this study suggest that the findings of this study could be specific to the chemical industry. Thus, further research needs to examine whether the relationships found here hold in other industries that have very different technological, competitive, and regulatory conditions.

The cross-sectional design of this study did not allow the direct examination of causal relationships. Longitudinal research that measures environmental practices and competitive advantage at different times can overcome this causality problem. Longitudinal research also allows researchers to examine dynamic effects of implementing "best practices" of environmental management on cost advantage. This study measures environmental practices and cost advantage at the same point in time and thus does not consider the difference between short-run and long-run competitive effects. It is possible that "best practices" require higher initial investments than other environmental practices, but that in the long run "best practices" lead to cost savings over other practices. This could also explain the absence of significant positive relationships between "best practices" of environmental management and cost advantage in this study.

Implications for the Practice of Environmental Management

The finding that competitive effects of environmental practices differ across firms also has important implications for the practice of environmental management. Firms should not blindly follow the recommendations made by some of the environmental management literature and try to implement "best practices" of environmental management with the expectation that these practices will help them to become "green and competitive." The results of this study actually imply that it might be more difficult for some firms to become "green and competitive" than most of the environmental management literature suggests.

The finding that complementary assets moderate competitive effects of environmental practices suggests that before deciding on environmental strategies firms need to examine their existing resources and capabilities. Firms should select environmental practices that fit with their existing resources and capabilities. Because complementary assets are created in the firm's business strategy, the starting point for the formulation of the firm’s environmental strategy has to be its business strategy and the resources and capabilities it creates. Firms that lack capabilities for process innovation and implementation may be better off implementing environmental strategies later than other firms, in order to learn from early implementers and imitate successful environmental practices.

The importance of complementary assets implies that some of the major obstacles for firms to become "green and competitive" are their business strategies and the resources and capabilities created by them. This obstacle suggests that firms will benefit from integrating environmental considerations into their general business strategy. This study demonstrates that a firm's resources and capabilities not only create value in the firm’s competitive strategy, but can also be leveraged in the firm’s environmental strategy, thereby creating positive spillover effects.

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APPENDIX A: RESPONDENT COMPANIES

Parent Company Name	No. of Divisions	Parent Company Name	No. of Divisions
Agrium, Inc.	1	Geon Company	1
Aldrich Chemical Co., Inc.	1	Glaxo Wellcome, Inc.	1
Allied Colloids, Inc.	1	Helena Chemical Company	1
Alpha Resins Corporation	1	IMC Global, Inc.	1
Amoco Performance Products, Inc.	1	ISK, Inc.	2
Arcadian Corporation	1	Insilco Corporation	1
Atotech USA, Inc.	1	J.R. Simplot Company	1
BP America, Inc.	1	Kerr-McGee Chemical Corporation	1
Baxter Diagnostics, Inc.	1	LeaRonal, Inc.	1
Benjamin Moore & Co.	1	Lonza, Inc.	1
Betz Inc.	1	Mallinckrodt Specialty Chemicals	1
Boehringer Mannheim U.S. Holdings, Inc.	1	McWhorter Technologies, Inc.	1
Buckman Laboratories Intl., Inc	1	Minnesota Mining & Manufacturing (3M)	2
Budd Company	1	Mississippi Chemical Corporation	1
Calgon Corporation	1	Monsanto Company	2
Cargill Fertilizer, Inc.	1	Monsanto Company	1
Ciba-Geigy Corporation	2	Morton International, Inc.	2
Cincinnati Milacron, Inc.	1	NL Industries, Inc.	1
Courtaulds Coatings, Inc.	1	North American Salt Company	1
Crompton & Knowless Corp	2	Occidental Petroleum Corporation	1
DSM Copolymer, Inc.	1	Ohmeda	1
Dexter Corporation	4	Olin Electronic Materials, Inc.	1
Diversey Corporation	1	Pfizer Inc.	1
Dow Chemical Company	2	Platte Chemical Company	1
Dow Elanco	1	Procter and Gamble	1
Du Pont De Nemours & Co., Inc.	1	Rhone-Poulenc	1
Eastman Chemical Ltd.	1	Sandoz Chemicals Corporation	2
Elf Atochem North America	1	Sterling Chemicals, Inc.	1
Eli Lilly & Co.	1	Systems Bio-Industries, Inc.	1
Engelhard Corporation	1	Technical Chemical Company	1
Exxon Company	1	Union Texas Petroleum Products Corp.	1
FMC Corporation	1	Unocal Corporation	1
Ferro Corporation	2	W. R. Grace & Company	3
First Mississippi Corporation	1	W.H. Brady Co.	1
Freedom Group Partnership	1	Wynn Oil Company	1
Gencorp Polymer Products	1	Zeneca Metalex, Inc	1
General Electric Company	1		1

APPENDIX B

Measures: Survey Items and Cronbach's á

Cost Advantage ***Cronbach á = 0.79***

1. We incur lower compliance costs with regulations of this issue in the U.S. than our domestic competitors.
2. Overall, our strategy addressing this issue improves our cost position relative to domestic competitors.
3. Overall, our strategy addressing this issue improves our cost position relative to foreign competitors.

Use of Pollution Prevention Technologies [Pollution-Prevention] ***Cronbach á = 0.70***

Which environmental technologies does your business unit currently use to address this issue? (1 not used – 7 used primarily)

1. Implementation of new cleaner processes.
2. Modification of existing processes.
3. In process recycling/recovery.

Innovation of Proprietary Pollution-Prevention Technologies [Innovation] ***Cronbach á = 0.78***

1. We address this issue mainly with technologies developed within the company.
2. To address this issue we mainly developed new process technologies and / or process changes.
3. To address this issue we mainly developed new or improved products.

Early Timing ***Cronbach á = 0.91***

1. We were one of the first firms in this industry in the U.S. to address this issue.
2. We were one of the first firms in this industry worldwide to address this issue.

Complementary Assets ***Cronbach á = 0.86***

Relative to our major competitors that manufacture in the U.S., we focus on:

1. Being the first in the industry to try new methods and technologies.
2. Using the latest technology in production.
3. Capital investment in new equipment and machinery.

Relative to our major competitors that manufacture in the U.S., we:

4. have been leaders in introduction of product innovations over the last three years.
5. have been leaders in introduction of process innovations over the last three years.

All items are rated on a 7-point Likert scale from 1 – strongly disagree to 7 – strongly agree unless otherwise noted.

TABLE 1

Means, Standard Deviations, and Spearman Coefficients

		N	Means	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Cost Advantage	88	0.00	0.86	1.00														
2	Pollution Prevention	88	0.00	0.84	-0.01	1.00													
3	Innovation	88	0.00	0.88	$0.21^{\dagger}$	0.01	1.00												
4	Early Timing	88	0.00	0.90	0.10	-0.01	0.02	1.00											
5	Complementary Assets	88	0.00	0.90	0.09	$0.20^{\dagger}$	0.10	0.42^{***}	1.00										
6	Complementary Assets * Pollution Prevention	88	0.15	0.94	$0.20^{\dagger}$	$-0.19^{\dagger}$	0.17	-0.13	$-0.18^{\dagger}$	1.00									
7	Complementary Assets * Innovation	88	0.08	0.78	0.12	0.22^{*}	-0.12	0.16	0.08	-0.29^{**}	1.00								
8	Complementary Assets * Early Timing	88	0.34	0.89	0.22^{*}	-0.16	0.13	0.16	0.03	0.34^{**}	-0.15	1.00							
9	Firm Size (log)	88	9.00	2.01	0.00	0.06	0.01	0.03	0.01	0.01	0.10	0.00	1.00						
10	Water	88	0.14	0.35	-0.01	-0.03	0.01	-0.06	-0.09	0.02	0.04	0.10	-0.13	1.00					
11	Waste	88	0.22	0.41	0.05	0.04	0.00	0.04	0.05	-0.16	0.05	-0.07	-0.06	$-0.21^{\dagger}$	1.00				
12	Product	88	0.09	0.29	-0.10	-0.21^{*}	0.35^{***}	-0.17	-0.15	0.25^{*}	-0.23^{*}	0.25^{*}	0.06	-0.13	-0.17	1.00			
13	Superfund	88	0.05	0.21	-0.37^{***}	0.13	-0.22^{*}	-0.04	0.07	-0.01	-0.08	-0.14	0.08	-0.09	-0.11	-0.07	1.00		
14	Other	88	0.11	0.32	$0.18^{\dagger}$	$0.20^{\dagger}$	0.08	0.04	0.04	0.00	0.05	-0.05	0.06	-0.14	$-0.19^{\dagger}$	-0.11	-0.08	1.00	
15	3-year stock returns (1992-1994)	49	0.22	0.42	$0.28^{\dagger}$	-0.08	-0.06	0.11	0.08	0.08	-0.21	0.19	0.00	-0.34^{*}	0.08	-0.09	-0.05	$0.26^{\dagger}$	1.00

*† p<.10   * p<.05   ** p<.01   *** p<.001*

TABLE 2

Results of Regression Analysis

	Dependent Variable: Cost Advantage					
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.01	0.02	0.01	-0.03	0.18	-0.04
	(0.42)	*(0.42)*	*(0.42)*	*(0.41)*	*(0.41)*	*(0.42)*
"Best Practices" of Environmental Management						
Pollution Prevention		-0.03	-0.04	-0.01	0.04	-0.02
		(0.11)	*(0.11)*	*(0.11)*	*(0.12)*	*(0.11)*
Innovation		0.19†	0.18	0.14	0.15	0.18†
		(0.11)	*(0.11)*	*(0.11)*	*(0.11)*	*(0.11)*
Early Timing		0.04	0.01	0.03	0.06	-0.02
		(0.10)	*(0.11)*	*(0.11)*	*(0.11)*	*(0.10)*
Complementary Assets and Interactions						
Complementary Assets			0.06	0.09	0.11	0.06
			(0.11)	*(0.11)*	*(0.11)*	*(0.11)*
Complementary Assets * Pollution Prevention				0.23*		
				(0.09)		
Complementary Assets * Innovation					0.24†	
					(0.13)	
Complementary Assets * Early Timing						0.22*
						(0.10)
Control Variables						
Firm Size (log)	0.01	0.01	0.01	0.01	0.01	0.01
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Water	-0.08	-0.11	-0.10	-0.09	-0.08	-0.18
	(0.27)	(0.27)	(0.28)	(0.27)	(0.26)	(0.27)
Waste	0.01	-0.02	-0.02	0.04	-0.03	-0.01
	(0.23)	(0.23)	(0.23)	(0.23)	(0.22)	(0.23)
Product	-0.35	-0.56	-0.54	-0.63†	-0.65†	-0.73*
	(0.32)	(0.36)	(0.36)	(0.35)	(0.34)	(0.36)
Superfund	-1.51***	-1.35***	-1.37***	-1.43***	-1.37***	-1.29***
	(0.43)	(0.44)	(0.44)	(0.43)	(0.43)	(0.44)
Other issue	0.35	0.30	0.30	0.29	0.26	0.30
	(0.29)	(0.30)	(0.30)	(0.29)	(0.29)	(0.29)
R^2	0.17	0.20	0.21	0.26	0.27	0.25
Delta R^2				0.05	0.06	0.04
F-Test for Delta R^2				5.73*	7.11*	4.61*

Standard errors are in parentheses.

*† p<.10 * p<.05 ** p<.01 *** p<.001 (all two-tailed tests)*

Biographical Statement

Petra Christmann is an assistant professor at the Darden Graduate School of Business Administration at the University of Virginia. She received her Ph.D. in strategy and international business from the Anderson Graduate School of Management at UCLA. Her research interests include the relationships between firm strategies and competitiveness, and international diffusion of management practices, with special focus on environmental issues.