Exploring the Relationship between Environmental Operations and Supply Chain Practices, Complementary Assets, and Performance

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ABSTRACT

Operations-related research in environmental management has its roots in pollution control and regulatory compliance going back to the 1950s. Formalization of this movement came with the creation of the environmental management system or ISO 14001 in 1994. Today because of the issues and concerns over the depletion of natural resources, global warming, water pollutants and hazardous waste; the environmental focus has now become more valuable and significant to researchers. This dissertation is focused on examining how environmental management system and environmental supply chain practices can be enhanced for better performance by other internally-driven managerial actions and programs. In particular, it is hypothesized that complementary assets and capabilities, such as quality practices, just-in-time practices and flexibility will positively moderate the relationship between environmental practices and environmental as well as operational performance.

Using a survey based methodology; data is collected from 246 US firms from a diverse set of industries. Using rigorous multivariate statistics and regression techniques, we first confirm that sound environment based systems and supply chain practices do indeed enhance performance. Furthermore, our research findings suggest that quality practices significantly moderate environmental practices for both environmental and operational performance. In contrast, preventive maintenance and volume and worker flexibility were found to only moderate environmental practices and environmental

performance. Only quality practices were found to moderate both environmental supply chain practices and operational practices.

The recommendations emerging from this research take the extant research a step further by explaining why in many firms the usage of environmental practices have limited outcomes. Investments in other organizational practices like quality programs, preventive maintenance, and resource flexibility are also needed to promote higher effectiveness. It specifically attempts to investigate, analyze and expand on Reinhardt's (1998) position that "instead of asking whether it pays to be green, we ought to be asking about the *circumstances* under which it might pay." This research therefore has widespread implications beyond those industry sectors where the impacts are "clear and for all to see" such as chemicals and waste treatment.

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CHAPTER ONE

1.1 INTRODUCTION AND MOTIVATION FOR THE STUDY

In this era, stakeholders, customers and the general public are becoming increasingly aware of the impact of managerial actions on reducing negative effects on the environment. We understand as a society that business and nature are inextricably linked, and that all products come from something grown or mined. Manufacturing firms and organizations such as Toyota, Hermann Miller, Xerox, Hewlett Packard and BMW are minimizing the negative impact of their products and operations on the natural environment by developing innovative new products and incorporating environmentally conscious practices (Vachon and Klassen, 2008). Their actions provide sufficient evidence that understanding environmental operations is both relevant and strategic. As a result, many firms have moved away from the perception that environmental management is a cost or regulatory requirement, to a more comprehensive point of view where being environmentally competent can result in higher efficiencies and competitiveness (Porter and van der Linde, 1995). Environmental management, once considered as a distinct and separate program, is now known to contribute to the success of the entire enterprise (Corbett & Klassen, 2006).As early as 1991, Michael Porter (1991) documented an essay with his thoughts on American policy and the conflict between environmental protection and economic competitiveness as a "false dichotomy." He strongly suggested that the environment is yet another arena where the U.S. is competitively hampered due to our own reluctance to see environmental protection mandates as investments that will stimulate our economy, instead of impeding its progress. He comments that several American firms see the Environmental Protection Agency (EPA) simply as regulators and an adversary, as opposed to being an initial facilitator of a journey towards better competitiveness. Evidence of this competitive advantage was already seen by Porter (1991) through the progress of other industrialized nations, such as Japan and Germany, as well as other European nations, in patenting and exporting environmental technologies.

Currently, firms are striving to better understand the benefits of a proactive approach to environmental initiatives in hopes of becoming more resource efficient, as well as to improve their corporate image (Montabon et al., 2008). However, the forces behind environmental initiatives are not always driven from a purely altruistic concern. Many firms implementing environmental initiatives are reacting to increasingly difficult environmental regulations and external pressures, rather than to internal concerns and pressures such as reducing their carbon footprint and utilizing resources more efficiently (Angell, 2001; Rondinelli and Vastag, 1996).

Delmas (2001) found a strong linkage between the involvements of external stakeholders, including customers, in the implementation of an ISO-certified environmental management system and the degree of competitive advantage resulting from the ISO 14001 certification. He regarded this stakeholder involvement as a valuable organizational capability in a resource-based perspective, and found that stakeholders played a significant and positive role in assisting firms to gain a competitive advantage from their environmental management system (EMS) implementations. Additionally, some firms are reluctant to pursue an aggressive action plan to embrace environmental operations, policies and practices due to a perceived lack of evidence that benefits of environmental strategies do indeed exceed costs (Montabon et al, 2008).

Operations-related research in environmental management has its roots in pollution control going back to the 1950s (Kleiner, 1991; Florida, 1995). Formalization of this movement came with the creation of the EMS in the 1990s (e.g. ISO 14001). Today because of the issues and concerns over global warming, water pollutants and hazardous waste; the environmental focus has now become more valuable and significant to researchers. In a publication about the history and future of environmental thinking Hart (2005) discusses the evolutionary path of environmentalism and coins the term "beyond greening" (see Fig. 1.1). This figure represents an environmental lens to business operations that is not just a "feel good" approach, but an essential viewpoint of environmental business strategy in the modern world.

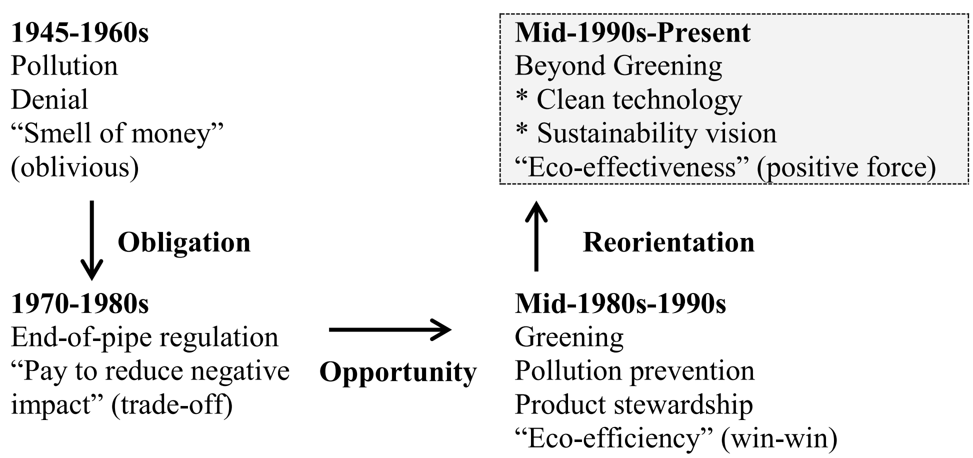


Fig. 1.1: Beyond Greening (Source: Hart (2005) "Capitalism at the Crossroads")

Numerous researchers have subsequently studied environmental operations practices and their impact on performance (Montabon et al, 2008; Sroufe, 2003, Klassen and Whybark, 1999; Klassen and McLaughlin, 1996; Florida, 1995). However empirical evidences of the relationships between environmental activism and firm performance are still immature and the need exists for more comprehensive research. For instance, Wilkinson et al. (2001) recognized that environmental and operations management needed more widespread consideration beyond only those industry sectors where the impacts are "clear and for all to see" such as chemicals and waste treatment. Florida (2001) concluded that an environmental management system (EMS) can provide real tangible benefits in the form of improved compliance, reduced environmental risks, improved stakeholder management and better community relations. Further, he considered environmental management as a tool that must be part of the ***full package*** of practices and systems required of innovative and high-performing business organizations. Sroufe (2003) concluded that there is a shortage of research that empirically examines relationships among key EMS constructs. He demonstrated that the environmental department within the facility could leverage their position as a "benefit and not a cost" to the organization. His work confirmed that environmentally-conscious operations are strategic in nature, and become an opportunity to improve performance rather than be viewed as a burden to economies and firms.

Interestingly, environmental initiatives follow patterns similar to the evolution of the quality movement just decades earlier. However, where environmental management systems differ from quality management systems is in the presence of an imposed and ever-tightening regulatory system (Corbett, 2000). Although the drivers for this movement are wider in scope and typically arise from regulatory requirements, customer demands and waste reduction; many of the implementation activities are similar. Just as in the science of quality, environmental improvement inevitably makes manufacturers look at their operations as part of a larger system in order to plan, check, and act prior to planning another improvement. Contemporary thinking supports the integration of the environment into operations as a systematic process encompassing the "entire production process," rather than isolated individual operations (Curkovic, 2003). People on the shop floor must be trained to recognize these issues-and managers must listen to their solutions (Kleiner, 1991). To truly benefit a company, environmental questions-about products, information and process-must be integrated into everyday decisions that reach across a wide range of management arenas such as the supply chain and supplier relationships, manufacturing design and processes, employee and stakeholder involvement, as well as distribution. Figure 1.1 shows such linkages.

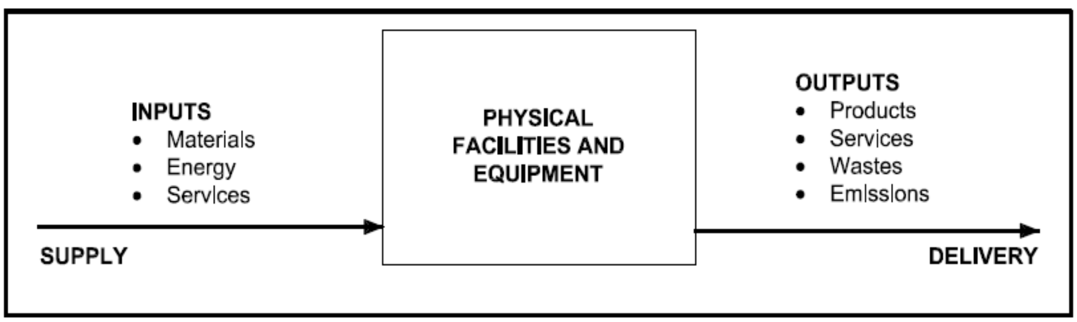


Fig. 1.2: The Organization's Operations (Source ISO 14031)

In recent years, the U.S. government also recognized the importance of the involvement of manufacturing in waste reduction and environmental protection, and has joined forces with industry to provide oversight and support to improvement programs. In 2003, an innovative and collaborative model between the Environmental Protection Agency (EPA) and industry was established called the Green Suppliers Network. This association is aimed at enhancing the competitiveness of US manufacturers in the global market, while improving organizational material and resource efficiencies. By combining lean manufacturing and pollution prevention (P2) techniques, the Green Suppliers Network focuses on improving supplier productivity, capacity building, efficiency, and environmental performance (ref: http://www.greensuppliers.gov). Through on-site reviews by the network, suppliers continuously learn ways to increase energy efficiency, identify cost-saving opportunities, and optimize resources and technologies to eliminate waste. Organizations report that results of these partnerships create more effective processes and products while generating higher profits. Additionally, these activities eventually result in fewer negative environmental impacts.

Corbett and Klassen (2006) suggested that the reason environmental research has struggled to enter mainstream operations management is due to a paradox of the "law of the expected unexpected side benefits." These authors suggested that payback from adopting environmental initiatives "usually materializes in unexpected forms and hence are usually greater after the fact than can be predicted in advance." This was the case in an EPA study (2000) where Boeing had not tracked, highlighted or quantified the resource productivity improvements associated with energy, raw materials, and non-product output produced by its lean initiatives. They did not track these efforts primarily because these improvements and measurements were not part of the core business case for implementing lean manufacturing. *This example reflects a notion that environmental improvement is intrinsically related to the process of improving manufacturing.* Further, Kleiner (1991) remarked that pollution prevention makes sense for the planet because it makes sense for the business; and that to be good to the environment one must already know how to be very good at production. He further commented that it seems obvious that designing nonpolluting processes will also ultimately prove cheaper than manufacturing processes that pollute, and that clean processes presuppose efficiencies. This condition is further understood by adopters of lean production, because the goal of both lean manufacturing and environmental improvement is reduction of waste.

Sroufe and Montobon's (2007) theorize that the need for improved environmental performance and the accompanying measurement introduces its own set of issues. So, in the study of environmental management many propositions remain to be analyzed. Linkages between environmental practices and performance have been studied and established, although many times contradictory findings have been reported (Cordeiro and Sarkis, 1997; Melnyk et al. 2002). But, little is known about other complementary assets and their contribution to the relationship between environmental practices and organizational performance. Christmann (2000) defines complementary assets as "resources that are required to capture the benefits associated with a strategy, a technology, or an innovation."

Many researchers have called for the need to investigate the complementary assets or resources needed by an organization to gain competitive advantage and improved performance from the best practices of environmental management (Reinhardt, 1998; Klassen and Angell, 1998; Melnyk et al., 1999; Christmann, 2000; King & Lenox, 2001b; Aragon-Correa and Sharma, 2003; Vachon and Klassen, 2008). No research to-date has investigated these relationships fully. So in 2012, the study of environmental management is still important, essential, and relevant. Much is still to be learned about best practices, implementation, and systems. The questions posed below consequently form the basis for the research contained in this dissertation.

1. What programs, activities and practices are being employed by organizations?

2. How do environmentally-related programs and practices interact with other assets or capabilities to impact operational and environmental performance?

3. What operational benefits do companies observe as a result of such an implementation?

1.2 RESEARCH OBJECTIVES & MODEL

Specifically for the purposes of this dissertation, we hope to investigate how environmental practices and moderating complementary assets achieve both better environmental efficiency and more resourceful and beneficial manufacturing as stated in the questions above. Christmann (2000), based on Teece's theory of complementary assets, defines complementary assets as "resources that are required to capture the benefits associated with a strategy, a technology, or an innovation." Therefore an asset is a useful and desirable thing or quality and can be vested as an "*Organizational ability.*"

This investigation is not only needed, but is relevant to an organization's operations and its ability to remain competitive in light of global warming theories and market directives such as WEEE (Waste from Electrical and Electronic Equipment) and RoHS (Reduction of Hazardous Substances). The purpose of this dissertation is to create a research model utilizing established constructs, and bring an understanding to the benefits of a relationship between environmental practices, complementary assets and organizational performance (characterized in terms of both environmental and operational performance). Therefore, this dissertation research attempts to understand some of the important elements of how environmental practices interact with existing organizational practices in order to contribute to operational and environmental performance gains. Previous research in this area is lacking and mostly anecdotal, and the studies that do exist do not fully capture all the constructs that are useful for future researchers or provide an understanding of these relationships (Reinhardt, 1998; Klassen & Angell, 1998; Melnyk et al. 1999; Christman, 2000). The constructs and model developed in this dissertation draw upon previous research, and provide other researchers with a framework to gain better insight for future studies. The objectives of this current research are:

1. To understand the effect of environmental practices on operational and environmental performance, and the resulting organizational performance.
2. To understand what organizational complementary assets moderate the effect of environmental practices on operational and environmental performance.

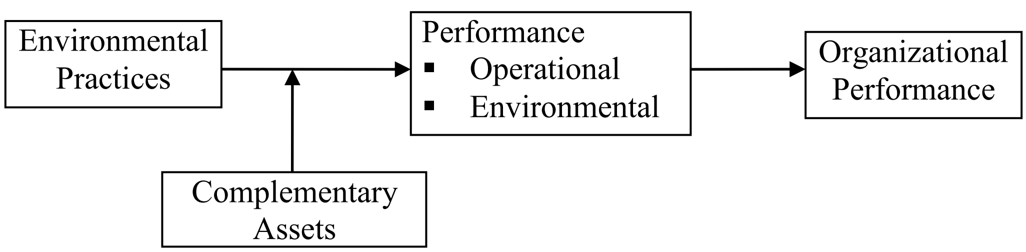


Fig. 1.3: Elements of the Conceptual Research Model

This research is of particular interest given that many researchers have called for future research to understand the effect of complementary assets and capabilities on the effect of environmental practices and performance (King and Lenox, 2001b; Reinhardt, 1998; Klassen & Angell, 1998; Melnyk et al. 1999; Christman, 2000, Aragon-Correa and Sharma, 2003). We will therefore explore whether or not those companies perceiving most success from environmental initiatives have other complementary assets in place, and how they derive higher levels of performance improvement.

1.3 DISSERTATION OUTLINE

This research is arranged as follows. Chapter 2 is a thorough review of the environmental literature and its emerging themes. Chapter 3 presents the environmental performance model that provides an integrated look at the environmental practices constructs that have been created by previous authors and which will be used in this research. A review of the literature that provides empirical support for the complementary assets and capabilities is also presented in this chapter. Lastly, this chapter states the research hypotheses.

Chapter 4 will outline the research design and data collection process including key respondents, and target sample frame. Methodologies of validation of the constructs, regression, and preliminary results are also detailed in this chapter. Chapter 5 will present the testing of the research model, and Chapter 6 will examine the hypotheses. Chapter 7 states the final conclusions and suggestions for future research.

CHAPTER TWO

Literature Review

2.0 INTRODUCTION

Research of environmental management systems and processes has grown in depth and understanding over the past decade as business leaders begin to actively pursue environmental initiatives. Concerns for the environment are now being included into mission statements and integrated into corporate strategies (eg. Dell, Starbucks). As an example, Wal-mart has pledged to 1) be supplied 100 percent by renewable energy; 2) to create zero waste; and 3) to sell products that sustain our people and the environment (Wal-mart website). Managers worldwide realize that these programs create competitive advantages and new opportunities for success and growth.

However, the field of environmental operations is still relatively novel. We will discuss through the review of numerous studies which have broadened the subject from one primarily founded in regulatory concern, to one examining the global, industrial and organizational aspects of environmental systems. These systems provide operational and financial benefits for the firm. As the world moves towards deregulation, private initiatives and global markets; environmental advancement requires shifts in corporate attitudes and new ways of doing business that extends to shareholders, employees, interested parties and supply chains.

Research in environmental management has roots in pollution control and regulation going back to the 1950s. Formalization of the movement to environmentally improve our production facilities came with the creation of the environmental management system (EMS) in the 1990s, and through the creation of the ISO 14001 standard by the International Organization for Standardization (ISO) in 1996. Because of relevant issues and concerns over global warming, water pollutants and hazardous waste; management of the environment has over time become more important to researchers and businesses alike.

Similarly, operational environmental management research has beginnings in the field of pollution control going back to the 1950s (White; 1958). An essay by Porter (1991) also was timely and significant by calling for America to understand how regulatory requirements could result in the patenting and manufacturing of environmental technologies, thus creating product growth markets and fostering competitiveness. In this article, Porter emphasized how other countries such as Germany and Japan were already exporting air pollution control equipment to the U.S.

Prior to the abundance of supply chain research, Klassen (1993) documented a framework for environmental management and its relationship to government agencies and third parties, such as customers and stakeholders (see Fig 2.1). Recently, in the 1990's, due to the ISO 14001 standard, environmental management system registrations have grown in both number and importance as international enterprises have become committed to pollution prevention and continual improvement of the environment for reasons both internal and external. Currently because of highly publicized concerns over global warming, water pollutants, hazardous waste and sustainability; the environment continues to be a fundamental research topic for operations management.

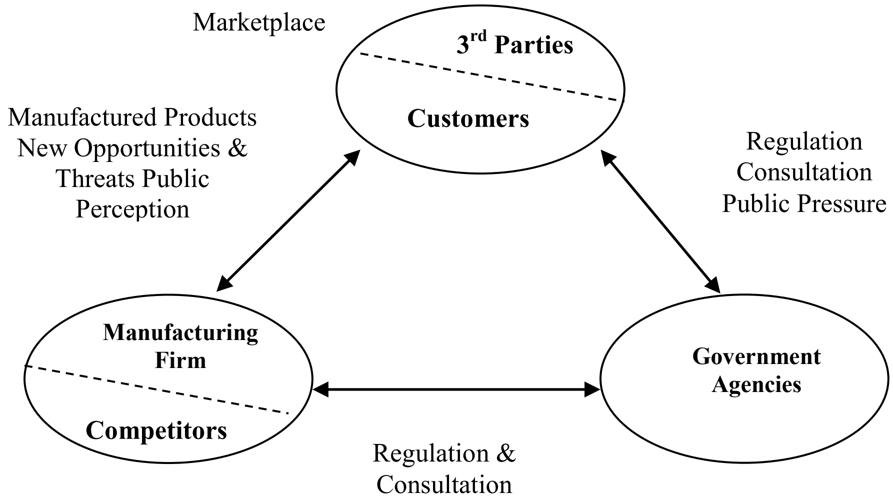


Fig. 2.1: An open-systems model of environmental management and manufacturing: external interactions. (Source Klassen, 1993)

Several researchers have relentlessly pursued the study of environmentalism in the last decade. Corbett and Klassen (2006), who are well regarded researchers in environmental technologies and systems comment "now given the enormity of the issues ranging from concerns over global warming to mandated product take-back in Europe to local problems with water pollutants and hazardous waste, there are signs that research is just beginning to move to the fourth phase (crisis and the emergence of new theories), with increasing controversy, diversity of insights and emergence of new theoretical frameworks." Sarkis (2001) considers the opportunity for advancement in both academic and practitioner implications of environmental systems, stating that the field is both interdisciplinary and cross-functional and that the "development of theory from a variety of fields will be necessary to advance the body of knowledge." Jimenz and Lorent (2001) believe that since many of the environmental capabilities are derived from the manufacturing operations area; it is this area that is principally responsible for accomplishment of environmental objectives. In fact "small and mid-sized manufacturers (SMMs) produce over half of this country's manufacturing output, and unfortunately, SMMs also contribute to over half of the environmental impact attributable to manufacturing (source: SCMEP Questline, 2007).

The role of complementary assets and capabilities as a moderator of the effect of environmental practices and performance is perhaps the most unknown relationship of environmental research to-date. Only two empirical studies to-date investigate in some manner complementary resources and their moderating effect on the relationship between environmental practices and performance (Zhu and Sarkis, 2004; Christmann, 2000) Other authors (Klassen and Angell, 1998; Melnyk et al., 1999; Aragon-Correa and Sharma, 2003; Vachon and Klassen, 2008) suggest that environmental management and other capabilities may prove to be complementarities (Table 2.1). Klassen and Angell (1998) suggest that different bundles of capabilities may be important. There is no current research that investigates how other organizational assets and capabilities do indeed moderate this relationship.

Table 2.1: Suggested complementary capabilities

Author(s)	Suggested Complementary Capability
Klassen and Angell (1998)	Quality and/or quality systems; bundles of capabilities; manufacturing capabilities; flexibility; cost and delivery leadership
Melnyk et al. (1999)	Quality/TQM, cross functional management
Aragon-Correa and Sharma (2003)	Organizational and human resources
Vachon and Klassen (2008)	Internal quality management practices

Corbett and Klassen (2006) discuss the evolution and developmental path of environmental research in operations management as it relates to streams of total quality management (TQM) and supply chain management (SCM) research. They conclude that environmental issues will force more interdisciplinary research in operations management, and that environmental research and practice will also experience expanding boundaries of analysis just as both TQM and SCM have in the past decade.

In support of Porter's (1991) initial recognition of environmental initiatives, Gupta and Sharma (1996) comment that "instead of looking at environmental management as a cost, businesses can use it as an opportunity to improve their position by eliminating waste, removing non-value-added materials and equipment, and reducing both short-term and long-term liability." This literature review will examine common themes of the extant research of environmental strategies, programs and practices, and its interaction with the field of operations management.

2.1 DEFINITIONS OF ENVIRONMENTAL MANAGEMENT TERMS

The widespread and advancing field of environmental management has created the use of many terms and definitions supporting the research that is summarized in this literature review. As documented in Table 2.2, the term environmental management is an all encompassing term.

Table 2.2: Definitions of Environmental Management

Author	Focus	Definition
Gupta (1994)	Internal	Environmental management should be viewed as a continuous process of improving environmental corporate policies and programs by taking into account the regulatory, technical development, scientific developments, and it must be fully integrated with operations management along with other functional areas.
Wu and Dunn (1995)	Value-chain	Integrative environmental management means that every element in the corporate value chain is involved in minimization of the firm's total environmental impact from start to finish of the supply chain and also from beginning to

		end of the product life cycle.
Klassen & McLaughlin (1996))*	Life-cycle	Environmental management encompasses all efforts to minimize the negative environmental impact of the firm's products throughout their life cycle. Environmental management is one significant component of functional strategies, particularly operations.
Christmann (2000)	Economy	Environmental management research focuses on best practices that simultaneously reduce the negative impact of firms' activities on the natural environment and contribute to competitive advantage in product markets.
Melnyk et al. (2002)	Stewardship	Environmentally responsible management: A corporate system that integrates product and design issues with issues of production planning and control and supply chain management in such a manner as to identify, quantify, assess, and manage the flow of environmental waste with the goal of reducing and ultimately minimizing its impact on the environment, while also trying to maximize resource efficiency.
Yang et al. (2010	Manufacturing Competiveness	Environmental management can be regarded as a mechanism through which continuous improvement and supplier management practices reinforce their contribution to manufacturing competitiveness.

* Adopted definition for this dissertation

As these definitions show, environmental management is a holistic approach to the interaction of society and its impact on the environment. Environmental management "systems" are a subset of environmental management. EMS's endorse the integrative functions and activities such as the "plan, do, check and act" (PDCA) cycle made popular by W. Edwards Deming and historically inherent to management systems (see Table 2.3).

Table 2.3: Definitions of Environmental Management System (EMS)

Author	Definition
Sroufe (2000)	An environmental management system (EMS) involves the formal system and database which integrates procedures and processes for the training of personnel, monitoring, summarizing, and reporting of specialized environmental performance information to internal and external stakeholders of the firm. The documentation of this "environmental" information is primarily internally focused on design, pollution control and waste minimization, training, reporting to top management and the setting of goals.
King & Lenox (2001a)	EMS's emphasize formal monitoring and improvement of facility waste streams with opportunities for collaborative problem solving and

	continuous improvement.
Florida & Davidson (2001)	An EMS is a formal system for articulating goals, making choices, gathering information, measuring progress and improving performance. It is increasingly being recognized as the most systematic and comprehensive mechanism for improving environmental and business performance
Tam et al (2002)	Part of the overall management system which includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving and reviewing, and maintaining environmental policy.
ISO 14001 (2004)*	Part of an organization's management system used to develop and implement its environmental policy and manage its environmental aspects. Note: a management system is a set of interrelated elements used to establish policy and objectives and to achieve those objectives. Note: a management system includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources.

* Adopted definition for this dissertation

Environmental practices are also a subset of environmental management system dealing with definitive activities that typically describe specific methodologies or concepts which impact environmental outcomes. Environmentally responsible manufacturing represent practices that are devoted to the manufacturing activities of an organization, and include the recognition of the environment in most common manufacturing practices, roles and responsibilities. Table 2.4 presents the diverse and wide ranging definitions of these practices.

Table 2.4: Definitions of Management Practices Relevant to the Environment

Author	Definition
Shrivastava (1995)	Redesigning production systems to reduce environmental impacts, using cleaner technologies, using higher-efficiency production techniques, minimizing fuel and energy efficiency
Sarkis & Rasheed (1995)	Environmentally conscious manufacturing, or ECM, involves planning, developing, and implementing manufacturing processes and technologies that minimize or eliminated hazardous waste and reduce scrap.
Christmann (2000) *	Environmental best practices simultaneously reduce the negative impact of firms' activities on the natural environment and contribute to competitive advantage.
Curkovic et al.	Environmentally responsible manufacturing is defined as an economically

(2000)	driven, system-wide, and integrated approach to the reduction and elimination of all waste streams associated with the design, manufacture, use and/or disposal of products and materials.
Melnyk et al. (2001)	A corporate system that integrates product and design issues with issues of production planning and control and supply chain management in such a manner as to identify, quantify, assess, and manage the flow of environmental waste with the goal of reducing and ultimately minimizing its impact on the environment while also trying to maximize resource efficiency.
Sroufe et al. (2002)	Environmental management practices are defined as the formal systems to integrate environmental procedures and processes for the training of personnel, for monitoring and controlling environmental impacts and for summarizing, integrating and reporting environmental performance. (at operational, tactical and strategic levels)
Pun (2006)	Environmental responsible operations (EROs) are management efforts that build upon expanded focus of TQM on the design, manufacturing and delivery of environmentally-friendly products and services.
Montabon et al. (2007)	EMPs are the techniques, policies and procedures a firm uses that are specifically aimed at monitoring and controlling the impact of its operations on the natural environment.

* Adopted definition for this dissertation

Environmental technologies (Table 2.5) presents a broad concept that deals with the usage and knowledge of equipment, methods and tools and their usage to affect an organization's ability to control the environment. These definitions support the notion that an environmental technology is the application of environmental science to the conservation of the natural environment.

Table 2.5: Definitions of Environmental Technologies

Author	Definition
Shrivastava (1995)	Environmental technologies are defined as production equipment, methods and procedures, product designs, and product delivery mechanisms that conserve energy and natural resources, minimize environmental load of human activities, and protect the natural environment.
Klassen (2000) *	Environmental technologies are defined as production equipment, methods, practices, product designs and delivery systems that limit or reduce negative impacts of products or services on the natural environment.

* Adopted definition for this dissertation

A recent research direction is environmental performance evaluation (EPE) which develops environmental metrics to capture the sometimes intangible and difficult to quantify measures of environmental management results (Sroufe and Montabon, 2006). This evaluation revolves around the creation and use of metrics that will not only meet regulatory requirements, but will also become drivers for business managers and other organizational stakeholders (Table 2.6).

Table 2.6: Definitions of Environmental Performance Evaluation (EPE)

Author	Definition
Klassen & McLaughlin (1996)	Environmental performance measures how successful a firm is in reducing and minimizing its impact on the environment.
ISO 14031 (1999) *	Environmental performance evaluation (EPE) process to facilitate management decisions regarding an organization's environmental performance by selecting indicators, collecting and analyzing data, assessing information against environmental performance criteria, reporting and communicating, and periodically reviewing and improving this process. EPE focuses on describing the environmental performance of an organization.
Lokkegaard (1999)	EPE is an internal management process and tool designed to provide management with reliable and verifiable information on an ongoing basis.
Tam et al (2002)	EPE is used to generate valuable information, against which management can then use to set specific, measurable goals and objectives to the various stages of the EMS process, including planning, implementation, monitoring, measurement and management review.
Sroufe &Montabon (2007)	Performance measurement systems provide performance evaluation that includes not only measurement, but also clarification and direction, and identification of opportunities for environmental improvement.

* Adopted definition for this dissertation

Pollution prevention (see Table 2.7) became a term more widespread in research after the EPA passed the Pollution Prevention Act of 1990, thereby creating more awareness. Pollution prevention establishes practices that reduce or eliminate the creation of pollutants through (1) increased efficiency in the use of raw materials, energy, water, or other resources, or (2) protection of natural resources by conservation (ref: www.epa.org).

Table 2.7: Definitions of Pollution Prevention	
Author	**Definition**
Gupta & Sharma (1996)	Pollution Prevention (also called source reduction). This approach focuses on preventing pollution at the source (in products as well as manufacturing processes) rather than removing it after it has been created. Source reduction focuses on the production process itself rather than the management or control of waste. The basic idea is to prevent the creation of waste, rather than managing waste after it has been generated.
Klassen (2000b) *	Pollution prevention technologies reduce or eliminate pollutants by using cleaner alternatives than those currently in place. These technologies can be classified as product or process adaptation.
Christmann (2000)	Pollution prevention refers to efforts to reduce, change, or prevent emissions and effluent discharges through better housekeeping, materials substitution, recycling or changes in the production process. Pollution prevention technologies, which are also referred to as source reduction or clean technologies, minimize the creation of pollution and wastes in production processes.

* Adopted definition for this dissertation

Pollution control (Table 2.8) is also a term found in environmental research. It depicts the control of pollution in an opposing light to pollution prevention discussed above. Pollution control is "after the fact" and attempts to control emissions into the air, water or soil to minimize its effect on the natural environment. Klassen (2000b) finds that pollution control bears a resemblance to the traditional emphasis on quality inspection, in that monitoring and rework occurs only at the end of the process.

Table 2.8: Definitions of Pollution Control	
Author	**Definition**
Klassen (2000b) *	Pollution control technologies treat or dispose of pollutants or harmful by-products at the end of a manufacturing process.
Christmann (2000)	Pollution control refers to efforts to trap, store, treat, and dispose of emissions and effluents using pollution control equipment. Firms reduce pollution and wastes after they originate by adding devices to existing production processes. These devices, which include incinerators and scrubbers are frequently referred to as "end-of-pipe technologies"

* Adopted definition for this dissertation

In the field of environmental management, other terms are used to define and describe environmental activities. Some of these terms are listed below in Table 2.9.

Table 2.9: Definitions of Miscellaneous Environmental Concepts	
Author	**Definition**
Gupta & Sharma (1996)	***Recycling Program:*** This approach suggest that the waste products and emissions can be (1) recycled as raw material in either the same or a different production process, (2) processed with the intention of recovering and reusing material, and (3) used for a different useful application within the facility.
Rothenberg (2001)	***Environmental efficiency:*** The reduction of environmental impact through more efficient use of materials and natural resources in manufacturing, driven by process and operational decisions that fall under the category of pollution prevention
Min & Galle (2001) IJOPM	***Green purchasing:*** an environmentally conscious purchasing practice that reduces sources of waste and promotes recycling and reclamation of purchased materials without adversely affecting performance requirements of such materials.
Shrivastava (1995)	***Industrial Ecosystems*** consist of a network of organizations linked to each other through an ecological logic. Organizations within the network use each other's wastes, byproducts, and outputs, to reduce the total use of energy and natural resources, and reduce the total waste and pollution from the system.
Corbett & Klassen (2006)	**Industrial ecology** holistic view of material and energy flows and the concomitant aim to reduce the environmental impact of products from cradle to grave
Sleeswijk and Heijungs GMI (2003)	***Life Cycle Assessment (LCA)*** LCA of products is a tool for the quantitative assessment of the environmental impacts of products throughout their life-cycles, 'from cradle to grave'. The assessment consists of four phases: goal and scope definition, inventory analysis, impact assessment and interpretation
Hagelaar et al. (2004)	***Environmental Supply Chain Management (ESCM)***: the set of supply chain management policies held, actions taken, and relationships formed in response to concerns related to the natural environment with regard to the design, acquisition, production and distribution, use, reuse, and disposal of the firm's goods and services.
Linton et al. (2007)	***Sustainability:*** generally defined as using resources to meet the needs of the present without compromising the ability of future generations to meet their own needs.
Vachon and Klassen (2008)	***Environmental collaboration***: the direct involvement of an organization with its suppliers and customers in planning jointly for environmental management and environmental solutions.

The definitions presented in this chapter provide us with an understanding of the comprehensive and diverse field of environmental management and the many terms, processes and practices involved in research conducted to date.

2.2 THEORETICAL PERSPECTIVES OF ENVIRONMENTAL MANAGEMENT

2.2.1 The Environment and Manufacturing Operations

The goal of environmentally conscious manufacturing is to achieve effective utilization of natural resources, minimize waste, and achieve a cradle-to-grave approach to manufacturing (Madu, 2004). This approach is not limited to the production process, but spans operations through distribution, consumption and recovery, and successful disposal of waste and waste by-products and processes. Given that planning for the environment starts at the design stage of the product where every effort is made to ensure that the product is environmentally friendly, how does operations management contribute to environmental objectives and success? This section will discuss 1) historical research of the linkages between environmental practices and manufacturing operations; 2) extant empirical research and; 3) future directions for researchers in operations management.

Historically, environmental and manufacturing roles and responsibilities have been managed autonomously in the manufacturing facility as firms are commonly organized functionally into segregated production and environmental responsibilities and activities. These relationships are sometimes adversarial. Gupta (1994) commented that the "overriding reason for developing environmental management programs and policies should be to support the operations strategy, and thereby help the operations manager to develop a distinctive competence and obtain a competitive advantage." Similarly, various authors (Florida; 1996; Klassen, 2000) have argued that integrating environmental management practices with firm operations are more likely to result in lasting improvements in environmental performance. Florida (1996) hypothesized that firms that are innovative and adopt advanced manufacturing practices can simultaneously realize improvements in productivity and environmental performance.

In the past five years, many researchers have proposed the likelihood of a synergistic effect between the connection of environmental management and the firm's operational activities. Environmental management is now a key element of manufacturing strategy and will continue to be so in the future (Gonzalez et al., 2003; Klassen and Whybark, 1999b; Newman and Hanna, 1996). But as Klassen (2001) notes "our understanding of factors that foster strong environmental management practices within a firm, particularly with operations at the plant level, still remains limited despite the fact that manufacturing is often the primary functional area responsible for many ecological impacts."

The extant research of environmental initiatives in operations management provides support for environmental programs and activities as a beneficial strategic direction (Table 2.10). The studies investigate manufacturing activities such as lean manufacturing, quality management, and manufacturing flexibility as potential agents of employing environmental issues and programs for competitive advantage.

Table 2.10: Empirical Studies of Environmental Initiatives in Operations		
Author(s)	**Sample/Methodology**	**Findings**
Newman & Hanna (1996)	Exploratory survey, n=400 executive managers; various industries	Only 13% of executives include environmental goals in corporate strategy. Authors suggest that environmental issues are of relevance to the development and implementation of manufacturing strategy through model creation.
Klassen & Angell (1998)	2 surveys (US & Germany); n= 218; factor analysis; surveys from separate research initiatives; results can be considered exploratory and need further confirmation.	Manufacturing flexibility supports an increased level of environmental ambition for environmental initiatives in the U.S. but not in Germany. In the U.S. increased ability to adapt to external change resulting from manufacturing flexibility supported a broader integration of environmental management into manufacturing.
Klassen (2000a)	Survey of single industry (furniture); n=83; regression	Increased investment in JIT systems significantly lowered releases and transfers of toxic chemicals (likely tied to reduced process wastes that resulted in excess inventory).
Klassen (2000b)	2 Canadian industries (small machine tool and non-fashion textiles); n=93, 5 regression models; CFA for technology investment	Managers viewed environmental technologies as ancillary investments with environmental technologies only being pursued after other higher priority competitive needs were addressed. The influence of quality-systems were linked to greater investment in recycling programs.
King & Lenox (2001a)	1987-1996; n=652; probit model; secondary data from EPA's TRI	Facilities that adopt lean production systems (measured by 9001 adoption) reduce their environmental emissions.
Rothenberg & Maxwell (2001)	Survey; 1992-1993; 31 plants (paint operations); regression	Different aspects of lean manufacturing-buffer minimization, work systems and human resource practices-contribute to improved resource efficiency (but not statistically significant). The authors conclude that the relationship between manufacturing management practice and environmental performance is complex.
Curkovic (2003)	CFA, n=269 & 257 SIC 3714	ERM measurement model based 1) strategic systems, 2) operational systems, 3) information systems & 4) results to develop contrasts.

Newman and Hanna (1996) take an environmental perspective of the order-winning and order-qualifying criteria made popular by Terry Hill (1994) as it relates to making corporate decisions. In an exploratory survey of manufacturers from a wide variety of operating circumstances, they drew parallels between order winners for dedicated processes, as well as general purpose processes, and found that integrating environmental considerations can influence manufacturing decisions in the form of cost reductions, conformance to quality, flexibility, and delivery reliability and speed. They concluded that there are indeed synergies between environmental management and operations, and that managers were clearly aware of the advantages and disadvantages of taking an environmental perspective on operations.

Empirical work exploring the intersection of environment initiatives and practices as they interact with decisions such as manufacturing flexibility, just-in-time (JIT) systems, quality and lean production manufacturing operations were found to impact performance (Klassen and Angell, 1998; Klassen, 2000a; Klassen, 2000b; King and Lenox, 2001a; Rothenberg and Maxwell, 2001). A review of the literature conclusively agrees that environmental decision-making must become part of the global operational domain, and that the performance objectives of both the environment and operations can be compatible and reinforcing.

Klassen and Angell (1998) conducted a study of the impact of manufacturing flexibility on environmental ambition of U.S. and German manufacturers. They found that in the U.S., an increased ability to adapt to change resulting from manufacturing flexibility supported environmental integration into manufacturing. They concluded that "internal and external pressures force operations managers to intertwine environmental and operating decisions, yet little is currently known about the way that environmental issues influence operating decisions" The same authors in another work (Angell and Klassen, 1999) initiated a focus group of environmental and operations management researchers to create an agenda for research in operations management." These researchers agreed that operational strategies, objectives and decisions should be reviewed in the context of the environment in order to understand and take advantage of all possible opportunities.

Also contributing to the environmental influences on manufacturing decision-making, Klassen (2000a) looked at the influencing factors of just-in-time (JIT) systems and quality systems on environmental investment and technologies. The first study in the furniture industry supports the paradox (later articulated by Corbett and Klassen; 2006) that an investment in JIT systems significantly reduced releases of toxic wastes most likely tied to reduced process wastes. The second study of small machine tools and textile companies (Klassen, 2000b) found that organizations highly oriented towards pollution-control, viewed environmental technologies as ancillary investments only after more competitive needs were addressed. However, the authors observed that if an organization had a quality system in place; it could be linked to greater interest in recycling. This finding supports this dissertation in its effort to discover which other complementary assets may also be beneficial. Klassen (2000b) also commented that manufacturing managers generally pursued initiatives to improve manufacturing performance, while leaving environmental initiatives to others. These manufacturing managers saw environmental issues as significant, but *peripheral* to their responsibilities.

Two studies investigated the role of lean manufacturing on environmental performance. King and Lenox (2001a), using data from the EPA's toxic release inventory (TRI), observed through a series of years (1987-1996) that a company's inventory of toxic material emissions were reduced as a possible response to the company's adoption of ISO 9001. ISO 9001 was a measure of lean production for this research. Rothenberg and Maxwell (2001) concluded that different aspects of lean manufacturing such as buffer minimization, work systems, and human resource practices contributed to improved resource efficiency. However, their research results were not statistically significant.

Lastly, in research that integrates operations management and the environment, Curkovic (2003) created a measurement model for environmentally responsible manufacturing (ERM) based on the Malcolm Baldrige Quality Award criteria. These studies and their results support contemporary thinking that integrating the environment into operations is systematic, and requires the "*entire production process*" rather than isolated individual operations. Additionally this experiential research begins to provide researchers with measurement constructs and validated scales for ERM, supporting Sroufe and Montabon's (2006) belief that a system of environmental metrics is the next foreseeable step in driving an understanding of environmental initiatives.

Researchers are making inroads into understanding the benefits of operations management and environmental programs and initiatives that intersect with one another. Corbett and Klassen (2006) speculate and make some predictions about the future of environmental research in operations management. First, they conclude that "environmental management in operations will have become an established and accepted part of mainstream Operations Management by 2015, and that it will have received widespread acceptance as an integral part of core courses and mainstream textbooks in the Operations Management field." Additionally they conjecture that in the immediate future, a significantly higher proportion of research papers focusing on Operations

Management and environmental issues will be coauthored in an interdisciplinary fashion with scholars in other disciplines.

2.2.2 Environment Management Systems (EMSs) and Operational Performance

In the era of global competitiveness, environmental decision-making in manufacturing is evolving from one grounded in legal and regulatory requirements to one that is focusing on adding-value, being more environmentally proactive, and learning how our actions impact the environment. Various authors have made the claim that "green" is profitable to the manufacturer (Porter and van der Linde, 1995; Kleiner, 1991). The implementation of the environmental management system standard ISO 14001 has helped companies realize that every resource used in the manufacturing process that does not become part of the finished product becomes waste, and that handling or removing waste creates expense. The goal of these initiatives is to incorporate environmental best practices directly into the manufacturing process for the sole purpose of reducing and eliminating waste which would ultimately boost profits and productivity, and also reduce the environmental footprint. The focus of ISO 14001 (as opposed to lean manufacturing) is setting objectives and targets around the identification of those organizational activities that have the greatest potential for environmental impact.

While environmental systems and activities have been employed for years by environmentally-conscious firms, the International Organization for Standardization (ISO) published a standard requirements model designated as ISO 14001 in 1996. Implementers and adopters of this standard must address its environmental aspects and their subsequent impacts on the environment. The ISO 14001 standard demands a comprehensive, business-wide program that establishes the deployment of specific objectives and targets. It embodies an approach that relies on organizational commitment, focus and performance, rather than on coercion from compliance-oriented regulatory bodies. Most importantly, it is a voluntary standard and those that implement it are taking a positive stance toward the environment, because of both internal and external influences (e.g. shareholders, customers, corporations, etc.). ISO 14001's requirements entail an implementation framework strategy encompassing five essential areas (policy, planning, implementation and operation, monitoring and measurement (checking), and management review and responsibility), with the end result ultimately contributing to continual improvement of environmental impacts (see Fig. 2.2). The ISO 14001 framework also relies on positive motivation, and a desire to "do the right thing" rather than a blind obedience to regulations or corporate directives (Cascio, 1996).

It is also important to understand that environmental management systems strongly support life-cycle thinking (e.g. cradle to grave), even though there is no absolute requirement about life-cycle assessments in the ISO 14001 standard. According to the ISO 14001 standard, the significant environmental aspects associated with activities, products or services should be identified.

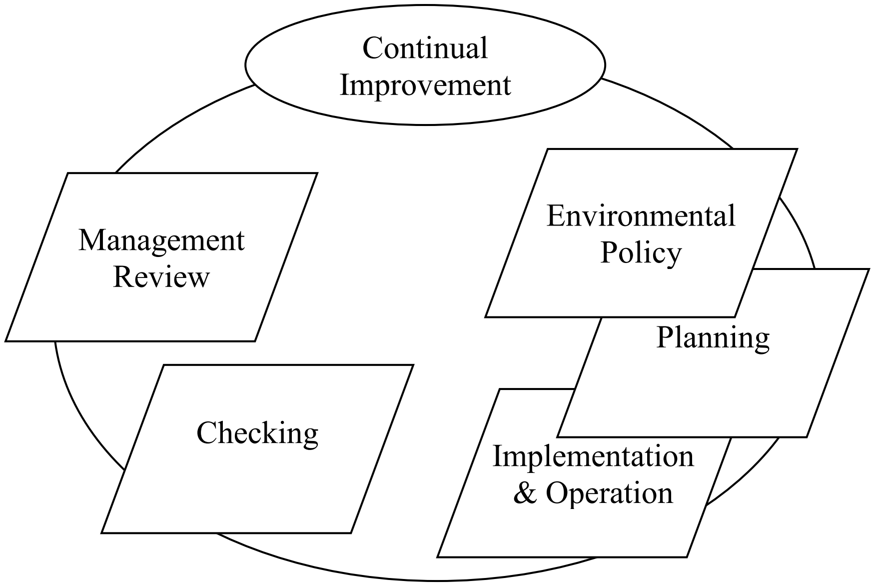


Fig. 2.2: ISO 14001 Framework (Source: ISO 14001:2004)

Empirical research demonstrates that environmental management systems in general have a positive effect on operational performance (see Table 2.11). Sroufe (2003) constructed a structural equation model to test the relationship between an EMS, environmental activities such as recycling practices, design practices and waste practices, and their end effect on operational performance measures. He concluded that an EMS is indirectly related to operational performance through the environmental practices in which the firm is involved. Further, he concluded that operations measures such as quality, costs, position in the marketplace, better products and equipment selection decisions were impacted by the use of an EMS, thus having real benefits that overcome the associated costs.

Table 2.11: Empirical Studies of Environmental Management Systems (EMSs)		
Author(s)	**Sample/Methodology**	**Findings**
Florida (1996)	Survey; n=450	Developed a link between advanced manufacturing, productivity and environmental performance. Findings suggest that manufacturing process improvement and productivity improvement efforts create substantial opportunity for improved environmental performance.
Klassen & McLaughlin (1996)	Event study 1985-1991 Wilcoxon-signed ranks	Significant positive financial returns were measured for strong environmental management as indicated by environmental performance awards. Significant negative returns were measured for weak environmental management as indicated by environmental crises (stock market performance).
Melnyk et al. (1999)	Survey; n=15; wide range of industries.	Overall, environmental management systems are not seen in a positive light. These systems are seen to negatively affect the major strategic dimensions of poor performance (e.g. lead time, costs and quality).
	Case study	ISO 14001 certification has a positive impact on firm performance in terms of reduced costs and improved quality.
Melnyk et al. (2002)	Survey; SIC 20-39; n=1510 Regression	ISO 14001 certification tends to have a greater impact on several dimensions of corporate performance (market position, reputation, reduced production waste)
Melnyk et al (2003a)	Survey; SIC 20-39; n=1510; ANOVA & regression	Results strongly demonstrate that firms in possession of a formal EMS perceive impacts well beyond pollution abatement and see a critical positive impact on many dimensions of operations performance. Results also show that firms having gone through EMS certification experience a significantly greater impact on performance than do firms that have not certified their EMS (costs, quality, reputation).
Sroufe (2003)	Survey; n=1118; SEM	Studied EMS and performance while considering the effects of environmental practices. Results indicate that the degree to which a firm is involved in EMS activities is positively related to the degree to which it is involved in environmental practices.
Montabon et al. (2007)	Data from corporate reports; n=45; Content analysis	Examined corporate environmental reports and found significant and positive relationships between environmental practices and measures of firm performance.

Similarly to studying the effect of an EMS on performance, Melnyk et al. (2003a) conducted a comparison of firms that have (1) no formal EMS present; (2) formal EMS present; and (3) formal certified EMS present. They found a significant benefit to having ISO 14001 certification. Although there were performance benefits to both formal EMS and a certified EMS; the results indicated that having an externally certified system resulted in significant performance benefits (e.g. costs, lead times, quality, marketplace position, reputation, product and process) compared to those firms that had no formal EMS. An early study, Melnyk et al. (1999) found in contrast to the above that overall, environmental management systems are not seen in a positive light. They found that environmental systems are seen to negatively affect the major strategic dimensions of poor performance (e.g. lead time, costs and quality).

The studies shown in Table 2.11 also support the base relationship between environmental management systems and performance that will be investigated with moderators in this dissertation. Melnyk et al. (2002) compared the performance impacts across several different voluntary environmental programs to conclude that the highest performance results occurred from those systems that followed the requirements of ISO 14001. One of the reasons given for this result was that ISO 14001 certification "helps the firm enhance its corporate image and improve its public relationships." An event study (Klassen & McLaughlin, 1996) reinforces this conclusion by showing a causal positive link between environmental awards (such as ISO 14001 certification) and the firms perceived financial performance (as indicated in financial markets). Additionally Klassen and Vachon (2003) concluded that the ISO 14001 certification process was significantly and consistently related to more extensive investment in environmental management systems, thereby improving outcomes.

Research conducted by Sroufe (2003) and Montabon et al. (2007) focused on environmental practices rather than the entirety of an EMS as documented by ISO 14001. In both studies, positive relationships between environmental and operations performance measures was clearly established. Sroufe looked at recycling, design and waste practices, while Montabon et al. (2007) tested a broader range of practices (33 in total) and found six that were statistically significant (e.g. recycling, proactive waste reduction, remanufacturing, environmental design, specific design targets and market surveillance for environmental issues).

2.2.3 Linking Quality Management to Environmental Management

Table 2.12: Empirical Studies Linking Quality Management to Environmental Management

Author(s)	Sample/Methodology	Findings
Curkovic (1998)	Survey; n=526, SEM	Findings support that there is a relationship between TQM and ERM based systems, and that the presence of a TQM based system encourages the emergence and acceptance of an ERM based system.
Angell and Klassen (1999)	Focus Group	Considerations related to the natural environment are integrated into all transformation processes, at both strategic and tactical levels, so that these processes are increasingly efficient and effective, thereby creating value for all stakeholders.
Corbett & Cutler (2000)	Case study	This study suggests that having a quality management system in place can facilitate the development of an environmental management system and its goals.
King & Lennox (2001a)	1987-1996; n=652; probit model	Manufacturing and technology strategies that enhance quality and efficiency also impact environmental performance levels positively.
Florida & Davidson (2001)	Survey; n=583 manufacturing plants	Plants with both an EMS and pollution prevention program in place were more innovative in an extensive adoption of TQM and JIT.
Angell (2001)	Case study; n=10; MBNQA companies	Key to both successful quality and environmental initiatives was inter-functional coordination during design and implementation. Drivers of successful environmental implementation are different from drivers of successful quality initiatives.
Vachon & Klassen (2008)	Plant-level survey of package printing industry in N.A.; n=84	Environmental collaboration with customers was predominantly linked to better quality performance.

Table 2.12 shows the empirical studies that have studies the linkage between quality management and environmental management. It shows that the evolution of total quality management in operations management provides a striking parallel with the principles of environmental management (Klassen & McLaughlin, 1993; Corbett and Klassen, 2006). The environmental movement is analogous to the progression of the quality field over the last several decades. Quality guru Edwards Deming believed that quality can never rely on inspection at the end of the manufacturing process, but that it must be built into every aspect of the business, from design through manufacturing, sales and servicing. The "zero defects" approach of the total quality management (TQM) philosophy closely corresponds to the elimination of waste and process inefficiencies in environmentally-responsible manufacturing. This conventional wisdom also applies to the proactive and strategic reductions of environmental risks and impacts in the manufacturing arena.

Thinking of environmental issues as a natural extension of quality suggests that the tools and principles of TQM apply equally to the improvement of environmental performance (Klassen & McLaughlin, 2006). These authors noted that both TQM and environmental management are strategic initiatives that must be integrated within the business in order to be successful. Sroufe et al. (2002) made a comparison of TQM and environmental management practices (EMPs) by describing both as ways of transforming an organization for competitive advantage and costs benefits. EMPs include a philosophy that seeks this transformation through techniques such as recycling, waste reduction, life cycle analysis (LCA), risk analysis, communication, environmental recognition, corporate policy, mission statements, and long-term planning.

Similar to research streams in quality management, environmental researchers have recognized the importance of including environmental costs to the capital budgeting process, thereby improving its ability to make factual decisions about the business (Curkovic and Sroufe, 2007; Montabon and Sroufe, 2007). These authors support the need for their framework on the old adage from TQM that "what gets measured, gets managed." Fundamentally, environmental inefficiency is waste and strategies such as just-in-time (JIT) and total quality management (TQM) address the improvement of processes, activities, and products that generate waste and counteract the value stream. These authors argue that understanding wasteful environmental impacts will draw attention to additional costs savings and benefits for firms. To further develop this idea, Curkovic and Sroufe (2007) developed a conceptual framework to determine the feasibility of a total cost assessment evaluating Total Quality Environmental Management (TQEM) investments.

The body of empirical research on this topic has investigated the synergistic effects of looking at TQM and environmental initiatives as complementary practices. A study by King & Lenox (2001a) found that companies with a quality management system (QMS) generated less environmental waste, and that these firms were more likely to adopt an environmental management system such as ISO 14001. They discuss how closely quality and environmental standards parallel each other (e.g. documented policy, management responsibility, measurement, etc.) and that they are managed with similarly structured reporting systems and information evaluation models. A reader familiar with the requirements of both standards, ISO 9001 and ISO 14001, can attest that many of the requirements directing the system are indeed the same (e.g. internal audits, management review and corrective action).

Similarly Florida and Davidson (2001) found that high adopters of advanced environmental practices were more innovative in general, and twice as likely to have a total quality management program. Angell and Klassen (1999) examined the integration characteristics of quality and environmental management systems and put forward a research proposition that "a strong quality management program is a necessary condition for a strong environmental management program." Corbett and Cutler (2000) conducted case studies of seven firms and found that managers seemed to have grasped the philosophy of the quality management paradigm and transferred it to their fledgling environmental management systems. Also, they commented that the two systems share many common aspects that appear to accelerate the transfer of organizational learning.

Equally, Curkovic (1998) found that the presence of a TQM-based system encouraged the emergence and acceptance of environmentally-responsible manufacturing, and that "ERM systems are viewed as being modified TQM systems to deal with environmental issues." Curkovic (1998) stated that since the two concepts share a similar focus, it makes sense to use many of the same tools, practices, and techniques of TQM when implementing ERM.

In order to understand the different approaches and drivers to quality and environmental initiatives, Angell (2001) compared the implementation of successful and unsuccessful programs. She observed similarities and differences between both manufacturing and service firms, and reported that drivers of successful environmental initiatives are not the same as those for successful quality initiatives. Her research indicated that while quality and environmental management systems shared a related focus and implementation strategy, environmental projects are initially less formal and systematic, and also tend to be more successful due to external pressures (e.g. customers, regulators, activists). Angell described the environmental initiative process as more "grass roots" oriented.

Unique to previous research regarding the linkages of environmental management to quality management; Vachon and Klassen (2008) incorporated the environmental supply chain into their study. Essentially, their study hypothesized that the direct involvement of an organization with customers and suppliers in planning jointly for environmental management and environmental solutions would result in positive performance improvement (e.g. cost, quality, delivery, flexibility, and environment). Specifically, collaboration with customers was associated with greater quality improvement as measured by reduced scrap rates, and collaboration with suppliers resulted in an improvement in product durability and conformance to specifications.

2.2.4 Environmental Technologies and Competitive Advantage

In the last decade, including the environmental issues into the general business strategy is no longer simply an issue of reluctant and blind compliance with regulatory requirements. Companies now endeavor to evaluate and improve products, processes and designs to avoid the potential for environmental problems *before* they arise. Environmental initiatives have increasingly emerged as potential mechanisms for gaining competitive advantage, as well as an important aspect of strategic management (Sarkis and Rasheed, 1995; Vachon and Klassen, 2008). In 1995, Porter and van der Linde (1995) described the prevailing view of the inherent trade-off of ecology and the economy as an "arm wrestling match," where the regulators try to make the laws tougher while others lobby for the opposite. These authors argued that environmental standards can trigger innovation, which in turn lowers the cost of the product while at the same time improving its value. The ultimate outcome of utilizing resources more productively makes companies more competitive, not less. Porter et al. (1995) commented that the environment is not static, and can be improved and enhanced to result in innovative products, processes and technologies. As taxpayers, we can acknowledge Porter's progressive thinking by recognizing initiatives implemented by organizations such as the U.S. Treasury which gives tax breaks to citizens that purchase environmentally-friendly products such as automobiles and air conditioners.

Another pioneer in the field, Shrivastava (1995) discussed competitive advantages provided by environmental technologies such as cost reduction, revenue enhancement, supplier partnerships, quality improvement, competitive edge, social and health benefits, public image, and the reduction of liabilities. His research strived to bring attention to the impact manufacturers can have by focusing on environmental considerations routinely and as a fundamental part of current business strategy. As early as 1997, Arnst and Reed (1997) documented in Business Week that those manufacturers who incorporated ecologically sound business practices such as reducing toxic runoffs, air pollution and solid wastes found positive results in productivity and profitability.

Shrivastava (1995) and Klassen & Whybark (1999b) (see Table 2.13) have researched the influence of environmental technologies on competitive advantage. Shrivastava (1995) conducted a case study of the experiences of 3M, and concluded that integrating environmental technologies into strategic management offered many competitive advantages. 3M focused on a total systems approach to environmental management by conserving natural resources and energy, recycling materials, reducing the use of hazardous and virgin materials, and eliminating the use of CFCs. Originally the motivation was to reduce costs and comply with regulation, but then 3M realized tremendous cost savings from a variety of initiatives, and therefore designed and approved every environmental project with the objective to save money. The end result was improvement in product efficiency, environmental-friendly production processes, new and innovative product and package designs, and waste recycling. 3M achieved a competitive cost structure and ultimately influenced the competitive dynamics of their industry.

Table 2.13: Empirical Studies of Environmental Technologies and Competitive Advantage

Author(s)	Sample/Methodology	Findings
Shrivastava (1995)	Case study	Integrating environmental technologies into strategic management are collectively affecting the competitive landscape (cost reduction, revenue enhancement, supplier ties, quality improvement, competitive edge, reduction of liabilities, social and heath benefits, public image).
Klassen & Whybark (1999b)	n = 69 (furniture) Hierarchical linear regression	Capability to implement pollution ***prevention*** technologies was a strategic resource, whereas implementing pollution ***control*** offered no competitive advantage

Klassen and Whybark (199b) also examined the relationship between environmental technologies and manufacturing and environmental performance outcomes. They created and developed an "environmental technology portfolio," allocated by either pollution prevention or pollution control technologies. Results of this study indicated that better environmental and manufacturing performance was found in those plants where management investment in the environmental technology portfolio was increasingly allocated toward pollution prevention technologies, and that performance worsened as the proportion of pollution technologies increased.

2.2.5 Environmental Performance Links to Financial Performance

Academic authors discussing and supporting the financial link to environmental performance is abundant. One of the first researchers to tackle this subject, Porter (1995), argued that stringent but efficient environmental regulation can result in a competitive advantage and subsequently better economic performance for firms that can successfully innovate. He discussed how German and Japanese automakers responded to environmental improvement as an economic and competitive opportunity by designing lighter and more-efficient vehicles, while U.S. automakers chose to "dig in their heels" and resist the need for new standards. Russo and Fouts (1997) took a resource-based view of the firm and found that higher environmental performance was associated with higher financial performance (dependent variable was return on assets; ROA) and that the relationship strengthened as industry growth rose.

The empirical research on the relationship between financial and environmental performance however, has been controversial and contradictory. Two arguments that emerged are related to costs of environmental compliance and emission reductions (Walley & Whitehead, 1994). These authors believed that costs related to environmental improvement would negatively impact a company's bottom line. We now know that this mindset is very limited in scope. The authors at the opposite end of the spectrum saw efficient pollution control as a direct means to efficient production (Porter, 1995; Klassen and McLaughlin, 1996).

Wagner et al. (2001) conducted an in-depth analysis and review of the comparability and consistency of empirical studies that have focused on the relationships between environmental and economic performance (see Table 2.14). They found that although the studies involved large variances in statistical, methodological and data issues; studies reviewed did indeed conclude that a significant relationship existed between environmental and economic performance. Their research also concluded that the empirical research gives no clear indication about whether this relationship is positive or negative.

Table 2.14: Empirical Studies of Environmental Performance Linked to Financial Performance

Author(s)	Sample / Methodology	Findings
Klassen & McLaughlin (1996)	Event study; 1985-1991; Wilcoxon-signed ranks	Awards for environmental performance lead to superior financial market outcomes in the form of positive abnormal stock returns.
Hart & Ahuja (1996)	Regression 1989-99	Efforts to reduce emissions were significantly related to an increase in operating performance after 1 year and an increase in financial performance after 2 years.
Russo & Fouts (1997)	Regression n=243	Found a relationship between environmental performance and economic performance that strengthens in high-growth industries.
Wagner et al. (2001)	Review of empirical studies	The relationship between the environment and economic performance has been studied but no conclusive results emerged.
King & Lenox (2001b)	n=652; Event study, regression	Shows support for a connection between some means of pollution reduction and financial performance but also suggests that the reason for this connection remains to be established.
Gil et al. (2001)	EFA, cluster analysis, subjective scale	Found in the Spanish hotel industry that there is a positive relationship between environmental management practices and firms' financial performance.
King & Lenox (2002)	1987-1996; 652 firms; TRI data; Financial data	Pollution prevention activities are significantly related to financial performance.
Clemens (2006)	Steel industry; 76 firms; Regression, subjective scale	Small firms that perform better environmentally are also the most successful financially.

Research conducted by King and Lenox (2001b) corroborates Wagner et al. (2001) findings in that there is a relationship between environmental and financial performance. But there is also the question whether this observed relationship could really be due to the complexities of some other underlying firm attribute that contributed to this phenomenon (e.g. clean facilities vs. facilities in clean industries). They suggest that firm attributes and different strategies for environmental improvement may moderate the apparent link. Klassen and McLaughlin (1996) also conducted an event study, but studied market evaluations of financial performance (e.g. stock returns) as a reaction to environmental performance (e.g. an environmental award). These authors concluded that significant positive returns were measured for strong environmental management as indicated by environmental performance awards, and significant negative returns were measured for weak environmental management as indicated by environmental crises (e.g. spills, high emissions, etc.).

Academic researchers (King & Lenox, 2002; Clemens, 2006; Gil et al., 2001; Hart & Ahuja, 1996) all offer an examination of the relationship between environmental activities and financial performance using various measures. King and Lennox (2002) compared return on assets (ROA) and the company's emissions as reported by EPA's Toxic Release Inventory (TRI) database, and found that waste prevention leads to financial gain. Clemens (2006) and Gil et al. (2001) use multi-item subjective scales to collect financial and environmental performance of small firms in the steel and hotel industries to conclude that a positive relationship exists between environmental and financial performance. Lastly, Hart and Ahuja (1994) made use of financial measures such as firm return on sales (ROS), return on assets (ROA), and return on equity (ROE) and publicly available emissions reduction data to analyze a time-based relationship between environmental and financial performance. Since the results of the study showed that reducing emissions had an effect on financial performance , they reasoned that firms with very low manufacturing emissions relative to competitors may be able to gain a first-mover advantage in emerging green product markets.

2.2.6 Environmental Performance in the Supply Chain

Most manufacturers today rely on suppliers for materials, parts and components -- sometimes by means of complex and integrated systems or global supply chains. Buyer companies may request and require a certain level of environmental responsibility in the core business practices of their suppliers, especially since the customers and stakeholders do not always distinguish a company from its suppliers. Ultimately these supply requirements will play a role in governing the buyers' own environmental performance and efficiency because firms must acquire and use products that meet their own standards, policies and procedures, and the requirements of foreign nations. The ability to manage the various suppliers and other players in the supply chain can eventually affect firm competitiveness. Companies that manage their supply chain well have an advantage in the marketplace.

Supply chain management has been researched and explored extensively in the literature (e.g. Robinson and Malhotra, 2005; Narasimhan and Jayaram, 1998) and is a critical and timely topic. Environmental performance is now a valued component in supply chain research since companies are proactively managing environmental quality while abiding by government and customer-driven requirements. They are also controlling recycling relationships and reducing the harmful effects of products and production systems on the environment. As a commitment to environmental excellence, Ford Motor Company required all of its suppliers to implement and certify an environmental management system to the ISO 14001 standard by the end of 2001. Organizations must understand and comply with environmental regulations in the countries in which their products are eventually transported and sold. Manufacturers also need to understand their suppliers' environmental practices and associated wastes since the manufacturer must assure environmental quality throughout the supply chain. As shown below in Table 2.15, Dell and Hewlett Packard have both initiated environmental components in their supply chains.

Table 2.15: Environment and Dell and Hewlett Packard Supply Chains	
Dell	"Worldwide growth and complexity of Information Technology (IT) and Consumer Electronic (CE) products are resulting in the corresponding worldwide growth and complexity of regulations and standards related to environmental performance" http://www.dell.com/content/topics/global.aspx/corp/environment/en/program_policy
Hewlett Packard	In 2002, HP established and released its Supply Chain Social and Environmental Responsibility (SER) Policy, which built on our own internal Human Rights and Labor Policy. When developing the HP Supplier Code of Conduct in 2002, we benchmarked the codes in the footwear, apparel and telecommunication industries. Our approach is founded on the supplier requirements stated in the HP Supplier Code of Conduct and our General Specification for the Environment (GSE), which address product and operational environmental issues such as restrictions on materials used in HP products. http://www.hp.com/hpinfo/globalcitizenship/gcreport/supplychain/supplyapproach.html

As evidence of academic interest in green supply chains, Linton et al. (2007) wrote an article on sustainable supply chains discussing the concepts, challenges of sustainability, and future directions of supply chains. The authors discussed the limitations of current research that sustainability poses, and how focusing on the supply chain (e.g. manufacturing by-products, product end-of-life and recovery processes) is a step toward understanding more about sustainability.

Table 2.16: Environment and Supply Chain Management Research		
Author(s)	**Sample / Methodology**	**Findings**
Melnyk et al. (1999)	Survey; n=1510, professional society	EMSs are internally oriented, with relatively little attention being devoted to environmental problems within the supply chain.
Rao (2002)	Survey, SEM, n=52	Found a positive relationship between the degree of dissemination of environmental knowledge by supply chain buyers and environmental performance.
Klassen & Vachon (2003)	n = 202 (CA) CFA, Regression, 9001/14001 firms	Customer-initiated collaborative activities increased plant-level investment in environmental management and was increasingly allocated toward pollution prevention.
Zhu and Sarkis (2004)	Regression, convenience sample, n=186 Chinese firms	Found a positive link between green SC practices and both environmental and economic performance.
Rao & Holt (2005)	Survey, SEM, regression, 14001 firms; n=52	The analysis identified that greening the different phases of the supply chain leads to an integrated green supply chain, which ultimately leads to competitiveness and economic performance.
Zhu et al. (2005)	Survey, EFA, n=314	Focused on four practices 1) internal EM; 2) external GSCM; 3) investment recovery and; 4) eco-design practices. Concluded that Chinese enterprises have increased their environmental awareness due to regulatory, competitive, and marketing pressures and drivers. However, this awareness has not been translated into strong GSCM practice adoption.
Klassen & Vachon (2003)	n = 202 CFA, Regression, 9001/14001 firms	ISO 14001 certification was significantly and consistently related to more extensive investment in environmental management. Customer-initiated collaborative activities increased plant-level investment in environmental management.
Vachon & Klassen (2008)	Plant-level survey of package printing industry in North America; n=84	Environmental collaboration with customers was predominantly linked to better quality performance.

As shown In Table 2.16, empirical research involving the environmental side of supply chains has grown significantly in the past 5 years. In a study to analyze why firms employ environmental practices (EMPs), Sroufe et al. (2002) commented that “despite an increase in academic research and practitioner interest in supply chain management, the environmental supply practices studied in their research score relatively low." The authors believed that this result may be caused by firms experiencing a learning–curve effect with regard to supply chain management and environmental management practices, as well as early adoption stages of integrative EMP's. Similarly, an exploratory study by Zhu et al (2005) in China found that green supply chain management (GSCM) is still in its infancy. The companies surveyed had an awareness of environmental practices and felt pressure by customers and stakeholders to incorporate these practices into the manufacturing process. But the firms have lagged in the implementation stages of putting these principles and techniques into practice.

Several authors researched the benefits of collaborative partnering among firms. Klassen and Vachon (2003) concluded that both customer and plant-initiated collaboration in the supply chain with suppliers and customers resulted in a significant difference in the level of investment that these companies made in environmental technologies (e.g. pollution prevention). Rao & Holt (2005) studied the linkages in green supply chains as an initiative for environmental enhancement, economic performance and competitiveness amongst a sample of companies in South East Asia. Specifically, the conceptual model included "inbound logistics," "outbound logistics" and "greening of the internal supply chain" and the positive effects of these activities on competitiveness and economic performance. Similarly, Zhu and Sarkis (2004) studied the effect of GSCM (green supply chain management) on environmental and economic performance in China. They found a significant relationship between green supply chain practices and performance.

Rao (2002) in an exploratory survey of South East Asian firms found that buyers were motivated to work as partners and hold environmental awareness seminars for suppliers in order to improve environmental performance of their supply base, and ultimately their own competitiveness and performance. The above studies reviewed green supply chain practices in Asian firms (Rao, 2002; Zhu and Sarkis, 2004; Rao & Holt, 2005). One of the contributions of this dissertation will be to study green supply chain practices of small to medium-sized companies in the United States and the activities that moderate this relationship.

2.2.7 Motivation for the Adoption of Environmental Programs (EMS/ISO 14001)

We conclude from our literature review that forces that drive firms to utilize an environmental management system are not always associated with known or perceived financial or performance benefits such as higher efficiency, lower costs, reduced wastes and emissions. Adoption of environmental management systems may also be driven by other non-performance drivers including regulatory and customer compliance, improved relations with customers, stakeholders and government agencies, improved public image, risk reduction, and even responding to pressures from internal stakeholders. Table 2.17 summarizes research on the adoption of Environmental Programs.

Melnyk et al. (2003b) conducted research investigating the motivations of firms to adopt ISO 14001 certification. They found that non-adopters were driven by economic factors, and saw the benefits of such an implementation as only potential and not "certain." The authors commented that this response is typical of a "wait and see" attitude toward certification.

On the other hand, some adopters were more likely to invest in the environmental program without the guarantee of immediate economic or performance benefit. These companies were more culturally-oriented to see the use of environmental improvement programs as being the "right thing to do." Secondly, the adopters pursued ISO 14001

Table 2.17: Environmental Program Adoption Research		
Author(s)	**Sample/Methodology**	**Findings**
Quazi et al. (2001)	Survey, discriminant analysis n=61; electronic & chemical firms in Singapore	Study investigated and identified a number of variables which would be able to predict the motivation of organizations in adopting the ISO-14000 standards. Predictive factors of cost savings, top management concern, following head office environmental practices, and meeting environmental regulations were significant. Meeting customer expectations, concern over trade barriers, employee welfare, and gaining competitive advantage were not significant.
Corbett & Kirsh 2001	Regression; 63 countries	Study of international companies pursing ISO 14001 showed that factors driving certification patterns are not environmental in nature. 9001 adoption promotes 14001 certification.
Melnyk et al. (2003b)	Survey of data from US managers, logit analysis.	Study identified and explained antecedents impacting the decision to pursue certification for some of the first plants certified in the US. For those sites that decided to pursue attaining this new certification, this decision was based on either non-economic reasons or the expectation that certification will eventually become a requirement of doing business with the plant's industrial customers.

certification because of the belief that it would set the stage to eventually improve their performance. The third motivation observed was customer influence and pressures (e.g. Ford mandate) to have a certified system in order to continue to do business. Similar to the results of Melnyk et al. (2003b), another study conducted by Quazi et al. (2001) in the electrical and chemical industries also reported motivating drivers for firms to adopt the ISO 14001 environmental management system standard. Their study reported 1) top management, 2) environmental practices of the head office and; 3) environmental regulations as the top three drivers of certification.

A study of motivational drivers of ISO 14001certification was also conducted by Corbett & Kirsch (2001). They concluded that ISO-9001 quality management system certification and the firm's propensity to export are significant predictors of ISO 14001 adoption; thus concluding that firms don't implement an environmental management system *solely* for environmental performance improvement reasons alone. Their study proposed that since the 14001 standard is in its early stages, more research is necessary to understand motivational attributes.

2.3 Conclusion

The extant research in environmental operations has been presented in this chapter to establish the prior view and critical research streams of this field. Another objective of this review was to begin the process of understanding how complementary assets (or moderating effects) of other organizational programs or activities interact with environmental programs and practices to support the performance attributes of such implementations. Clearly, the research examines and supports the notion that environmental management is a field of great opportunity, not only in the US but as a motivator of new innovative solutions that can be developed and transferred to other industrial countries that are decades behind the US and Europe in terms of environmental conscientiousness. These countries will ultimately affect the sustainability of our planet, and it is important to understand how to effectively improve firm performance through environmental practices and performance. The US "grew up dirty" so to speak, and we now have the opportunity through research such as that presented in this literature review and in this thesis to impact other nations and lessen the "dirtiness" with which they evolve and mature. Secondly, the literature review demonstrates the newness of this field and the ample opportunity for future work to continue to discover and examine how the environment will play a significant role in business sustainability and field of study in the Operations Management arena.

The next chapter will discuss the dissertation research model and attempt to identify some of these other moderators that play an important role in employing environmental techniques, programs, and practices.

CHAPTER THREE

The Environmental Performance Model

3.0 Introduction

This chapter presents the research model, defines the constructs, and proposes the research hypotheses. This research will build upon previous theoretical perspectives of environmental management, and will expand on research conducted by Melnyk (1999, 2002), Sroufe (2003), Christmann (2000), Zhu and Sarkis (2004) and others. We will investigate the moderating effect of complementary assets and capabilities on the relationship between environmental practices and performance.

We propose here that there may be different combinations of environmental practices and complementary assets and capabilities which have a bearing on environmental and operational performance. This research takes the extant research a step further by understanding through moderated effects why firms have environmental practices in place with varying degrees of effectiveness. It specifically attempts to investigate, analyze, and expand on Reinhardt's (1998) position that "instead of asking whether it pays to be green, we ought to be asking about the *circumstances* under which it might pay." The general research question becomes *"How can environmental practices be enhanced for better performance by other internally-driven managerial actions and programs."*

3.1 The Environmental Performance Model

The literature discussed in this dissertation exemplifies how environmental practices in the operations arena contribute to firm performance, and how firms can improve their competitive positions while at the same time reduce the negative effects of their activities on the natural environment. However, an in-depth understanding of the causal underlying and moderating relationships between environmental practices in a manufacturing environment and performance has not been fully explored or understood.

Many environmental studies have focused on the performance benefits of environmental practices, technologies and systems but have not observed the importance of other firm characteristics. Assets, resources and capabilities, such as managerial or quality capabilities, might influence and moderate the effect of these practices and strategies. For instance, King and Lenox (2001b) observed that there is a relationship between the environment and performance, but could not conclude whether this relationship was due to the complexities of some other underlying firm attribute (such as the firm's strategy for environmental improvement). In their study they determined that there is relationship between pollution reduction and financial gain, but could not determine the direction of causality. Additionally, they concluded that "the relationship between underlying capabilities and environmental management is likely to be complex and contingent, and that environmental management and other capabilities may prove to be complementary."

Realistically, there are also some challenges inherent to an investigation such as the one proposed in this research. Hanna et al. (2000) agree that there is an overlap between the performance results attributed to both the environmental and operational departments, and that measured performance is usually the result of the operational system rather than measures of each entity separately. EPA practitioner studies also reveal that this overlap is intrinsic to the core concepts of improving operations, and that ultimately operational improvement will effect environmental enhancement (EPA, 200b) if measures are captured.

The conceptual research model shown in Figure 3.1 is a moderating model which proposes that an organization's environmental and operational performance will vary based upon firm's complementary assets. The environmental performance model builds upon the base relationship between environmental practices and performance, and that this relationship is influenced by complementary assets that are expected to improve both operational and environmental performance. We anticipate that the implication of complementary assets can support (or hinder) the performance of the firm.

Teece (1986) discussed the resource-based theory of complementary assets to describe the process of commercializing an innovation and the required know-how in conjunction with other capabilities and assets. As an example for the purposes of this study, one might theorize that due to the structure achieved by a firms' experience in installing quality practices such as quality procedures or statistical process control (SPC); it might have distinct performance benefits owing to experience and proficiency in environmental activities such as documentation control, employee competence, and internal auditing. This research will test and examine such theorized complementary interactions (for a selected set of variables) between the base relationship of environmental practices and performance.

The research rationale, constructs to be used for environmental practices, complementary assets and performance displayed in the model, will now be defined. The items for each construct will be presented in Chapter four.

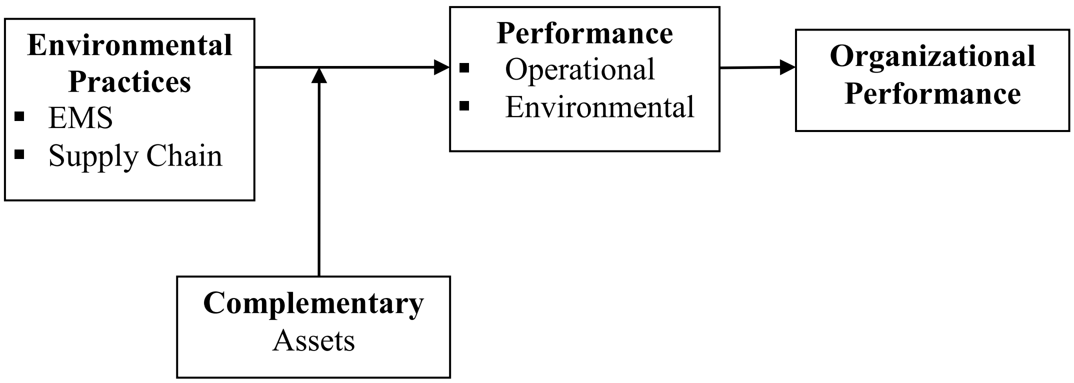


Fig. 3.1: Elements of the Conceptual Research Model

3.2 Research Rationale for the Environmental Performance Model

3.2.1 Justification of the Relationship between Environmental Practices and Performance

The relationship of the environmental performance model proposes that employing environmental practices will positively affect firm performance. Research to-date has demonstrated this claim and base relationship (Melnyk et al., 2003; Zhu and Sarkis, 2004; Montabon et al., 2007). This assertion is one that has evolved and undergone some debate in the last two decades (see Table 3.1). Many firms today are still reluctant to take a more aggressive posture to environmental practices due to a perceived lack of evidence that the benefits exceed the costs of these initiatives (Montabon et al., 2007). Therefore this dissertation will contribute to the body of knowledge by examining the role of complementary assets and other activities of a firm that contribute to the environmental practice-performance relationship.

Table 3.1: Early Environmental Research	
Author(s)	**Results/Comments**
Walley & Whitehead (1994)	Argue that the environmental "win-win" opportunities are insignificant in the face of the enormous environmental expenditures.
Cordeiro & Sarkis (1997)	Demonstrate a significant negative relationship between environmental proactivism (using TRI) and earnings-per-share.
Melnyk et al. (1999)	Overall, environmental management systems are not seen in a positive light. These systems are seen to negatively affect the major strategic dimensions of poor performance (e.g. lead time, costs and quality).

Environmental awareness and attitudes are evolving. It is undeniable that in today's business world and economy, companies are making efforts to reduce resource use and cut wastes. Environmental performance has become an undeniable driver for most firms in many nations worldwide to become innovative and more productive, and simply to improve the bottom line. Some researchers initially argued whether the improvement of environmental performance is an improvement or a detriment to operational performance (Walley & Whitehead, 1994; Porter & van der Lind, 1995; Cordeiro & Sarkis, 1997). One early prevailing attitude was that if organizations shift their attention to enhancing environmental performance, they are drawing resources and management effort away from other core areas of the business. This early mindset suggested that investments in environmental programs thereby represented non-core expenditures that interfered with other competitive improvement initiatives (Pil & Rothenberg, 2003).

Historically, environmental policies were designed and delegated simply to meet the regulatory requirements of the government (e.g. U.S. Environmental Protection Agency). As was true with the quality movement in the early 1980's; some industries believed that there would be increased costs to producing higher quality products (Crobsy, 1979). Similarly, costly trends, such as EMS's, associated with environmental policies also emerged, increasing the discussion of financial ramifications in the environmental arena (Cordeiro & Sarkis, 1997).

1. ever-increasing regulatory expenses;
2. stringent disclosure requirements to shareholders;
3. escalating civil and criminal penalties; and
4. environmental liability costs.

In the 1990s, views began to change as studies reported that companies were looking at the environment as less of a trade-off but as a necessity for future growth and innovation. Researchers (Hart, 1995; Shrivastava, 1995; Klassen & Whybark, 1999b) conducted studies viewing the implementation of environmental strategies and initiatives as a source of competitive advantage for the organization. Gupta (1994) concluded that the dominant reason for developing environmental management programs and policies should be to support operations strategy and assist operations managers in developing distinctive competencies for obtaining a competitive advantage. Sheridan's (1992) survey found that 91% of corporate executives recognized that good environmental stewardship was important to corporate image. Additionally, 33% of these executives also reported spending more time on environmental issues.

More recent studies (Zhu and Sarkis, 2004; Montabon et al., 2007) reflect the research trend of utilizing more modern *measures* of environmental performance such as waste reduction, energy consumption, and process and product innovation that will be employed in this research. These measures differ greatly from traditional measures such as the TRI (toxics release inventory) database, earnings per share, return on equity (ROE), and return on assets (ROA) measures found in earlier studies (Cordeiro & Sarkis, 1997; Hart & Ahuja, 1994). Environmental measures used by organizations to measure environmental impact are still in early stages of development. Sroufe and Montabon (2007) suggested that the body of knowledge is still novel, warranting further development. These researchers concluded that "the need for environmental performance and the accompanying measures introduces its own set of issues." The performance measures used in many of these earlier studies fail to account for the recent development and implementation of programs and practices such as environmental management and environmental design, just to name a few.

In the past decade, the results of environmental studies on the practice-performance relationship have been of great interest to industry and researchers alike, as firms endeavor to employ and understand a proactive approach to environmental policies and regulation. The development and integration of these practices is still relatively new to academics and researchers in management and engineering fields. Sarkis (2001) stated that the development of research streams for environmentally conscious business practices is still occurring and there is ample opportunity for advancement in this area.

3.2.2 Justification for the Moderation Effect of Complementary Assets

Environmental researchers who have studied various environmental practices, activities and methodologies (Aragon-Correa and Sharma, 2003; Vachon and Klassen, 2008) have suggested the need to know and understand more about the internal managerial linkages to the practice-performance relationship. We will now introduce the support for how complementary assets and capabilities will affect the strength of the relationship between environmental practices and performance. As shown in Table 3.2, there are several studies (Christmann, 2000; Zhu and Sarkis, 2004; Zhu and Sarkis, 2007) that investigate complementary assets with a moderating effect. The dependent variables in these moderating studies vary presenting an inconsistent representation of the effect of moderation.

Table 3.2: Empirical Studies with Moderating Effect

Author(s)	Moderating Variables	Findings
Russo and Fouts (1997)	Industry growth	Environmental performance is positively linked to economic performance. Industry growth moderates this relationship.
Christmann, (2000)	Process and production innovation	Study analyzes the effect of complementary assets on the relationship between environmental management practices and cost advantage. Moderating complementary assets included process innovation, product innovation, use of new methods and technologies and capital investment.
Zhu and Sarkis, (2004)	Quality management and JIT	Study analyzes the effect of complementary assets on the relationship between green supply chain management and firm performance. Moderators included quality management and JIT systems implementation in Chinese industries.
Zhu and Sarkis, (2007)	Institutional pressures	Study analyzes the effect of complementary assets on the relationship between green supply chain management and firm performance. Moderators included institutional pressures (market, regulatory, competitive) in Chinese industries.

In these studies, researchers test the base relationship between environmental practices and performance and further determine that there is a need for understanding the effect of moderating assets. The studies in Table 3.3 on complementary resources also support this claim for further research. King and Lenox (2001b) could not conclusively determine the direction of causality between financial performance and pollution prevention and commented that additional research is needed to explore how underlying firm characteristics and assets affect the relationship between relative environmental performance and financial performance. Specifically, the more important question might be *when* does it pay to be environmentally proactive?

Table 3.3 Research Support for Complementary Resources	
Author(s)	**Supporting Comments**
Klassen & Angell (1998)	Future research needs to explore whether operational capabilities, such as quality also support environmental management.
Reinhardt (1998)	▪ Instead of asking whether it pays to be green, we ought to be asking about the circumstances under which it might pay. ▪ A business's behavior with respect to the environment, like any other aspect of strategy or management, should be considered in the light of the basic economic situation of the business: the structure of the industry in which it competes, its own position within that industry, and its *internal organizational capabilities.*
Angell & Klassen (1999)	Examined the integration characteristics of quality and environmental management systems and put forward a research proposition that states that "a strong quality management program is a necessary condition for a strong environmental management program.
Melnyk et al. (1999)	The progress of a plant attaining ISO 14001 certification is influenced by past success with ISO 9001, TQM and the degree to which cross-functional programs and teams are used.
Christmann (2000)	Firms should select environmental practices that fit with their existing resources and capabilities.
King & Lenox (2001b)	▪ The relationship between underlying capabilities and environmental management is likely to be complex and contingent. ▪ Environmental management and other capabilities may prove to be complementary. Depending on industrial conditions, different bundles of capabilities may be important.
Sroufe (2002)	▪ Despite an increase in academic research and practitioner interest in supply chain management, the environmental supply practices studied in their research score relatively low." ▪ Believed that many firms are still experiencing a leaning–curve effect with regard to supply chain management and environmental management practices, and those firms are in the early stages of integrating EMP's

Aragon-Correa and Sharma (2003)	Complementary capabilities have performance implications in terms of lower costs, improved reputation, and strategic alignment with future changes in the general business environment.
Zhu and Sarkis (2004)	▪ Positive relationship between green supply chain management (GSCM) practices and environmental performance is stronger in enterprises that have higher levels of quality management practices (not supported). ▪ Positive relationship between GSCM practices and environmental performance is ***weaker*** in enterprises having more JIT practice adoption than in enterprises having less JIT practice adoption (supported for internal environmental management practices)
Vachon & Klassen (2008)	Little research has been conducted on the potential link between environmental activities in the supply chain and internal quality management practices.

Reinhardt (1998) discussed environmentally preferable products and product differentiation, and came to a similar conclusion as King and Lenox (2001b) that internal organizational assets must be considered from an economic standpoint in order to entice consumers to become willing to pay an increased price for environmental quality.

Christmann (2000) researched the effect of complementary assets on the base relationship of environmental practices and cost advantage in the chemical industry. She studied the best practices of pollution prevention, innovation and early timing and their effect on cost advantage using the following moderators: product innovation, process innovation, new technologies and methods, and capital investment in new equipment. She found that the capabilities of process innovation moderated the base relationship between environmental practices and cost advantage. She concluded that future research should analyze existing assets and resources in a broader context in order to understand and overcome barriers to competitive advantage.

Zhu and Sarkis (2004) researched the interaction effect of quality management and JIT practices on the relationship between green supply chain management (GSCM) practices and environmental and economic performance of Chinese firms. The results of

Zhu and Sarkis (2004) reflect a different result from that hypothesized in this study. We instead propose that environmental performance will be enhanced when "green" supply chain practices are moderated by quality management.

This dissertation will look beyond Christmann (2000) and Zhu and Sarkis's (2004) research and investigate the interaction (i.e., moderation) effect of several organizational assets and capabilities on the relationship between environmental practices and operational, as well as environmental, performance. This dissertation will break down the JIT and TQM moderators into substantive practices, unlike the study by Zhu and Sarkis (2004). The study will also contribute to this body of knowledge by focusing on several industries containing small to medium-sized firms in the United States as opposed to Chinese firms studied in Zhu and Sarkis (2004), or a single industry (i.e. chemical) as utilized by Christmann (2000).

Other research studies support the need to continue to explore supportive complementary assets such as quality initiatives (Klassen & Angell, 1998; Melnyk et al., 1999). Klassen and Angell (1998) studied the effect of manufacturing flexibility on environmental management and foresaw the need for the exploration of other organizational capabilities, such as quality, as a supportive mechanism for environmental progress. In research examining the implementation of ISO 14001, Melnyk et al. (1999) suggested that firms that have experience in quality management systems will be a positive factor in implementation of an environmental management system. Vachon & Klassen (2008) also suggested that there is a link between plant quality management practices and the environmental supply chain. They concluded that although this topic has been established by King and Lenox (2001a), little research has been conducted on the potential link between environmental activities in the supply chain and internal quality management practices.

Lastly, Aragon-Correa and Sharma (2003) supported the need for understanding complementary capabilities and argued that organizations must also focus on human resources and organizational capabilities in addition to pollution control and prevention technologies as a means of generating proactive environmental strategies.

3.2.3 The Resource Based View of Environmental Activities

In resource-based theory, competitive advantage is rooted within the firm in assets that are valuable, rare, inimitable (i.e. cannot be copied) and non-substitutable (Barney, 1991). A resource-based view (RBV) of strategic management literature examines the resources and capabilities of firms that enable them to generate exceptional performance and sustainable competitive advantage. A firm's internal capabilities or competencies and management's abilities to position these assets to produce superior performance determine the firm's competitive advantage (Russo and Fouts, 1997). Further, as a definition of a competitive-enhancing resource, Barney (1991) stated "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc., controlled by a firm that enables the firm to conceive of and implement strategies that improve its efficiency and effectives," as well as "reporting structures, formal and informal planning mechanisms, controlling and coordinating systems and informal relationships among groups within a firm." Several researchers have discussed RBV theory within the environmental domain (see Table 3.4).

This dissertation will utilize the resource-based theory to propose that firms that utilize environmental management practices will see greater performance outcomes if they have assets and resources in place to leverage the capabilities of operational environmental practices.

Table 3.4 Research on the Resource-Based View of Environmental Activities		
Author(s)	**Sample / Methodology**	**Findings**
Hart (1995)	conceptual	Creates conceptual framework of a natural-resource-based view. The natural RBV is operationalized through the strategic capabilities of pollution prevention, product stewardship and sustainable development.
Russo & Fouts (1997)	n=243; FRDC data; regression	Use the resource-based view to investigate the relationship between environmental and economic performance exploring industry growth as a moderator. Found that firms that tend toward a compliance-mode as opposed to a prevention-mode in their policies will differ in resources and affect the firm's ability to generate profits.
Christmann (2000)	n=98; chemical industry; regression	Results indicate that capabilities for process innovation and implementation in the chemical industry are complementary assets that moderate the relationship between best practices and cost advantage.
Delmas (2000)	n=52 corporate respondents	ISO 14001 can be an intangible resource. Stakeholders' involvement in a firm's ISO 14001 becomes a valuable organizational capability.
Aragon-Correa & Sharma (2003)	conceptual	Propose a theory of how the characteristics of the general business environment (munificence, uncertainty, complexity) influence the development of the capabilities of a proactive environmental strategy and its impact on competitive advantage.
Sroufe (2003)	n=1510	Proposed conceptual model based on RBV and the natural resource based-view of the firm.
Bowen & Sharma (2005)	conceptual	Draw from behavioral and the resource-based views to argue that the type of resource (i.e. dynamic or strategic and capability bundles) most useful for developing and implementing a corporate environmental strategy is likely to be contingent upon the characteristics of that strategy.
Crowe & Brennan (2005)	n=558; 17 countries, survey	Draw on the resource-based view to establish the strategic importance of environmental management and to explore links with innovation and manufacturing performance. Found that respondents with ISO 14001 certification use more technologies and work processes than those that don't.
Clemens & Douglas (2006)	n=107; steel industry; regression	Explored institutional theory and resource-based views to find that internal superior firm resources, such as more intensive monitoring of waste streams and training (inimitability, rare, valuable, non-substitutable), are positively related to voluntary green initiatives.
Vachon & Klassen (2008)	n=84; printing & packaging industry	Explored environmental collaboration in the supply chain based on two extensions of RBV (relational view and natural resource-based view).
Wu et al.	N=1453; 5	Examine the core resources that make environmental

(2008)	SIC codes	management systems a potential basis of sustainable competitive advantage.

3.2.4 The Theory of Complementary Assets

Integral to the theory of resources, Teece (1986) discussed the concept of complementary assets to address the role of an organization's existing assets, and how these assets moderate the relationship between best practices of an innovation and competitive success. He suggested that firms need to possess complementary assets in order to achieve competitive advantage from the implementation of an innovation (see Fig. 3.2). Teece (1986) described complementary assets in terms of being either generic or specific in nature.

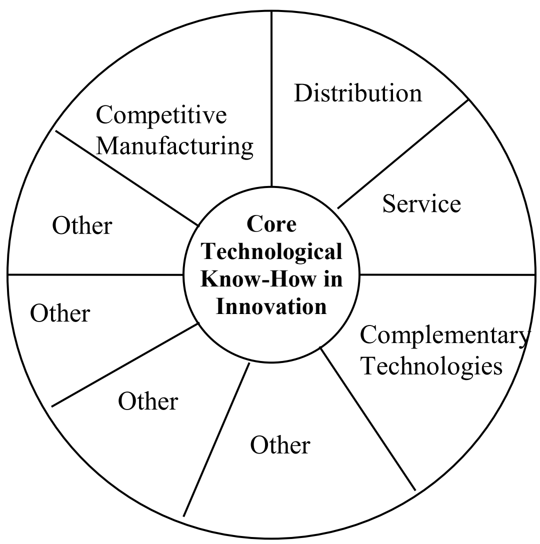


Fig. 3.2 Complementary assets needed to commercialize an innovation. Source: Teece (1986)

Christmann (2000), based on Teece's theory, defines complementary assets as "resources that are required to capture the benefits associated with a strategy, a technology, or an innovation." Christmann (2000) conducted an analysis of environmental best practices (i.e. pollution prevention, innovation and early timing of environmental strategies) on cost advantage. She concluded that two of the three best practices (i.e. pollution prevention technologies and early-timing) did not significantly contribute to cost advantage, but that the "results also indicate that firms need to possess complementary assets in order to create cost advantage from the implementation of such practices." Additionally King and Lenox (2001a) concluded that their "findings support the idea that potential complementarities exist among operational practices, and that firms should consequently consider adopting these practices in bundles.

Consideration of previous environmental research suggests that resources that display the properties of the RBV can theoretically create a sustained competitive advantage (Russo and Fouts, 1997). These two theories of the resource-based view and complementary asset theory jointly offers a sound theoretical lens from which we can better understand the potential of underlying organizational resources and capabilities in improving performance of environmental practices. Companies are limited in the number of resources they can employ, so it is important to understand those that complement the practice-performance relationships.

In the resource-based view, resources are classified as tangible, intangible and personnel-based (Grant, 1991). Intangible resources include reputation, technology and human resources in which the latter include culture, the training and expertise of employees and their commitment and loyalty (Russo and Fouts, 1997). Further Russo and Fouts, (1997) stated that the RBV needs to consider organizational capabilities – abilities to assemble, integrate, and manage these bundles of resources.

For the purposes of this dissertation, our application of the resource-based view will consider human resources (management practices) and organizational capabilities such as quality practices, just-in-time manufacturing practices, flexible operations, and the skills required to implement them based on the research need stated in Table 3.3. The hypotheses will investigate if organizations that exhibit these additional organizational assets or resources benefit through enhanced performance.

3.3 Definition of Constructs

The following section will establish the constructs for (1) environmental practices, (2) complementary assets and (3) performance. The definition of the constructs and the basis for their measurement will be presented.

3.3.1 Environmental System Practices

One of the objectives of this dissertation is to conceptualize an environmental practices construct and develop a scale which organizes and groups principal environmental management practices that impact both operational and environmental performance. As a basis for developing this construct, Sroufe et al. (2002) developed a framework investigating a subset of practices at multiple levels of the firm (i.e. strategic, tactical and operational). We will adopt the definition of Sroufe et al. (2002) environmental management practices (EMPs) as "the formal systems that integrate environmental procedures and processes for the training of personnel, for monitoring and controlling environmental impacts, and for summarizing, integrating and reporting environmental performance." This definition works well to identify activities and practices employed by firms pursuing environmental initiatives and to build an environmental practices construct. Sroufe et al. (2002) helps us to understand the extensive field of environmental operations management by describing several ways to "label environmental programs and systems," all of which employ environmental practices. By reviewing the many topics researched in this field; one can see that this field is broad enough to encompass many diverse topics, philosophies, activities and directions.

Implementation of environmental practices can be a signal that a business has strong intentions towards improvement and sustainability of the environment. But prior history in quality programs and initiatives in the last three decades will tell us that none of these practices by themselves will guarantee business success (Corbett and Kirsch, 2001). Today, even with more stakeholders such as customers and regulatory agencies actively supporting environmental management and ISO 14001 programs; there are questions about the risks and rewards of environmental conformance. Due to immature environmental measurement systems and lack of key performance indicators (Sroufe & Montabon, 2007), the savings are less tangible for example than quality improvement that can be quantified as a result of quality management or ISO 9001 implementation.

A review of environmental research includes a wide array of environmental management practices. For the purpose of selecting environmental practices that reflect current literature, this dissertation will draw from the multi-organizational environmental management practices (EMP's) documented by Sroufe et al. (2002; 2007), environmental practices identified by Sarkis (2001) and Theyel (2000), and the literature review in Chapter 2. These sources will be used to identify environmental practices that can be utilized to create an environmental practices construct (see Table 3.5). It is apparent from the referenced work of these three authors and the extant literature that there are differences in how practices are segregated in the literature (i.e. strategic, operational and tactical vs. plant-level). The differences in categorization reflect the newness of environmental research, and demonstrate overlapping views, categories, and classifications. For example, the table shows that different approaches are also not well-understoood and established (i.e 14001 vs. EMS) which are considerably the same set of practices which Sarkis (2001) identified as two unique practices.

Table 3.5: Environmental Management Practices

Strategic		
Sroufe et al. (2007)	▪ Integration with long-term business strategy ▪ Corporate policies and procedures ▪ Environmental mission statement ▪ Employee programs	▪ Environmental department/teams ▪ Surveillance of the market for environmental issues ▪ Strategic alliances
Operational		
Sroufe et al. (2007)	▪ Recycling, waste reduction (proactive and reactive), remanufacturing and substitution ▪ Consume internally ▪ Packaging ▪ Spreading risk to 3rd party or expert	▪ Creating a market for waste products ▪ Energy, energy conservation, efficiency, recovery ▪ Environmental information ▪ Rewards as incentive for environmental project.
Sarkis (2001)	▪ Reduce, recycle, reuse, reclaim & remanufacture ▪ Environmental performance measures ▪ TQEM	
Theyel (2000)	▪ Total quality management for P2 ▪ Pollution prevention plan ▪ P2 employee incentive program	
Tactical		
Sroufe et al. (2007)	▪ Supply chain management ▪ Early supplier involvement ▪ Environmental standards for suppliers ▪ Environmental audits of suppliers ▪ Environmental awards/recognition ▪ Environmental participation ▪ Life cycle analysis or design for environment	▪ Product development and innovation ▪ Design eco efficient products ▪ Specific design targets ▪ Environmental risk analysis ▪ Environmental management systems (EMS) ▪ Communication
Sarkis (2001)	▪ Design for environment (disassembly, etc.) ▪ EMS	▪ ISO 14000 ▪ Green supply chains ▪ Life cycle analysis
Theyel (2000)	▪ Waste audits ▪ Employee P2 training program ▪ R&D in the plant for P2 ▪ P2 requirements imposed on suppliers	▪ Total cost accounting ▪ Designated pollution prevention manager ▪ Life-cycle analysis

Since the goal of this dissertation is to identify and investigate the complementary assets and capabilities that inspire firm performance, only a subset of the identified practices listed in Table 3.5 will be studied. This study will select environmental practices that 1) have shown a positive relationship to performance in extant research (Klassen & Vachon, 2003; Sroufe, 2003; Zhu and Sarkis, 2004; Vachon & Klassen, 2008), and 2) are tactical in nature. This dissertation will draw from the list of tactical environmental practices as those that are likely to be employed by American companies investigated in this study. The environmental practices used for purposes of this dissertation are categorized as the following:

1. Environmental System Practices

   also referred to as:

   - ISO 14000 (Sarkis, 2001)
   - ISO 14001 (ANSI/ISO ISO 14001:2004)

2. Environmental Supply Chain Management Practices

   also referred to as:

   - "Green supply chains" (Sarkis, 2001)
   - "Supply chain management" (Sroufe et al., 2002)

3.3.1.1 Environmental System Practices

The environmental management system construct captures a firm's involvement in utilizing a documented program for environmental activities. A sizeable amount of research has dealt with the implementation and operation of environmental management systems and ISO 14001 adoption (Melnyk et al., 2003a; Sroufe 2003; Melnyk et al. 2002; Klassen & McLaughlin 1996). Any organization may implement an ISO 14001 EMS since the program is not limited to companies operating in environmentally high-risk sectors or running what are considered as highly polluting operations. The standard does not impose performance requirements, and is not regulatory in nature. Services such as the Charleston, SC Water Works and the City of Dallas have both implemented and certified their management systems to ISO 14001.

ISO 14001 is one of the many published standards initiated in 1996 by the International Organization for Standardization (Fig 3.3) pertaining to a company's processes and products. A study of Canadian companies concluded that only 62% of the respondents who have implemented an ISO 14001 registered EMS were operating in an environmentally high-risk sector (Berthelot & Coulmont, 2004). The authors reinforced the fact that the purpose of an ISO 14001 EMS is not to simply zero in on critical activities that could have a major environmental impact (such as the discharge of water or air pollutants or accidental spills); but that an EMS examines all firm processes that could have environmental impacts (e.g. conservation of water, raw materials and energy).

Table 3.6: ISO 14000 Series of Standards

Standard	Title/Description
14000	Guide to Environmental Management Principles, Systems and Supporting Techniques
14001	Environmental Management Systems - Specification with Guidance for Use
14010	Guidelines for Environmental Auditing - General Principles of Environmental Auditing
14011	Guidelines for Environmental Auditing - Audit Procedures-Part 1: Auditing of Environmental Management Systems
14012	Guidelines for Environmental Auditing - Qualification Criteria for Environmental Auditors
14013/15	Guidelines for Environmental Auditing - Audit Programs, Reviews & Assessments
14020/23	Environmental Labeling
14024	Environmental Labeling - Practitioner Programs - Guiding Principles, Practices and Certification Procedures of Multiple Criteria Programs
14031/32	Guidelines on Environmental Performance Evaluation
14040/43	Life Cycle Assessment General Principles and Practices
14060	Guide for the Inclusion of Environmental Aspects in Product Standards

Environmental practices and performance has been explored by many researchers in the past decade (Melnyk et al., 1999, 2002, 2003a; Sroufe, 2003; Klassen & McLaughlin, 1996). Several researchers have demonstrated that a relationship exists between an EMS (or 14001 certification) and performance. Melnyk et al. (1999) found a positive impact on cost reduction and improved quality in a case study of EMS implementation. The researchers also found that companies employing a registered (also known as "certified") EMS experience a greater impact on performance (i.e. cost, quality, lead time) than those firms that are not certified. Melnyk et al. (2003a) and Melnyk et al. (2002) concluded that 14001 certification had a greater relative impact on corporate performance. Further, an event study conducted by Klassen & McLaughlin (1996) studied the positive returns as indicated by environmental performance awards. The strongest results linking practices to performance were documented by Sroufe (2003), while Watson et al. (2004) found no significant difference between the financial performance of EMS and non-EMS adopters. The above studies emphasized the relationship between environmental management systems and firm performance, thereby supporting the base relationships.

It is important for purposes of this dissertation to shed light on the distinction between the all encompassing topic of "environmental management" and the more limited environmental management system (EMS/ISO 14001). An EMS and the associated practices are only a subset of topics in the domain of environmental management. The key to comprehending the difference is the essence of the word "system," because an EMS represents a company-wide, integrated, coordinated and managed effort. This could be equated to the installation and operation of a company's material requirements planning (MRP) or enterprise resources planning (ERP) in comparison to the field of "operations management". Conversely the all-inclusive domain and focus of environmental management can entail any method that a firm utilizes to control its impacts or footprint on the environment. Below are just two of the definitions presented in Chapter 2 that delineate these distinctions.

> ***Environmental Management*** (Klassen & McLaughlin, 1996: Environmental management encompasses all efforts to minimize the negative environmental impact of the firm's products throughout their life cycle. Environmental management is one significant component of functional strategies, particularly operations.
>
> ***Environmental Management System*** (ISO 14001:2004): Part of an organization's management system used to develop and implement its environmental policy and manage its environmental aspects.
>
> Note: a management system is a set of interrelated elements used to establish policy and objectives and to achieve those objectives.

These definitions also call attention to the fact that the EMS is an important, but not necessarily an adequate condition for environmental management. The EMS is a methodology that can be used to manage the environmental initiatives of the firm, but is not a required condition for environmental management (Klassen & McLaughlin, 1996). Rather, it is a systematic approach to achieving objectives concerning environmental performance, and supports a firm's effort to meet its environmental regulations and obligations and includes many "practices." In addition to systems, environmental management may encompass other strategies, programs, philosophies or activities such as sustainability and life-cycle assessment. But these are not strategies that are explicit in the standard.

The EMS is a process-oriented and requirements-based standard that supports continual improvement of the environment and a coordinated "system" to manage the integrated effort, but does not dictate specific environmental initiatives or programs. A company implementing the requirements of ISO 14001 can also determine whether or not to pursue certification by a third-party registrar (unless this certification is mandated by a customer). Otherwise an organization can self-certify their system to the ISO 14001 standard. For the purposes of this study, EMS practices are an approach that can be considered as a subset of strategic environmental management and includes operational and tactical level tasks and activities.

To create an EMS construct, this dissertation will use previous work that found a positive relationship between EMS and operations performance (Melnyk et al., 1999; Sroufe, 2003). This research, Sroufe (2003) commented that there is a shortage of work that empirically investigates EMS relationships.

3.3.1.2 Environmental Supply Chain Management Practices

Environmental supply chain management focuses on the environmental component of supply chain management research. Supply chain management involves the integration of activities needed to procure materials, transform them into intermediate and final products, deliver and distribute them (Robinson & Malhotra; 2005). Since the business environment today is extremely challenging and businesses must compete on the basis of quality, cost and speed; organizations must now align themselves with both suppliers and customers at each stage of operations from design to delivery to more efficiently deliver products and services. In today's business environment no longer can companies say "that's not really our business" when referring to their suppliers' operations nor claim not to know what is contained in supplier products. Inherent to creating and forging relationships in the supply chain are several activities that lend themselves nicely to environmental opportunities (Madu, 2004).

(1) selecting suppliers that are chosen not solely based on cost, but on additional expectations of quality, speed and environmental efficiencies (i.e. reduction of hazardous materials and wastes);

(2) information sharing that also considers the sharing of environmental opportunities;

(3) long-term partnerships where both parties understand the environmental benefits; and

(4) product life-cycle that is broken down into environmental "cradle to grave" for design, disassembly, recyclability, remanufacturing and product recovery.

The development of environmental-thinking as a component of supply chain integration is still immature. Many authors have commented that there is lack of research considering environmental supply chain management practices (Sroufe et al., 2002; Zhu et al., 2005). Melnyk et al. (1999) agreed that even research on environmental management systems are internally-oriented, with relatively little attention being devoted to environmental problems within the supply chain. These researchers perceived the many opportunities of incorporating the topic of the environment awareness into life cycle thinking as it interacts with all links and activities in the supply chain. Klassen and Vachon (2008) commented that "literature characterizing environmental management within the supply chain has been slowly building, but remains sparse" (see Fig. 3.4).

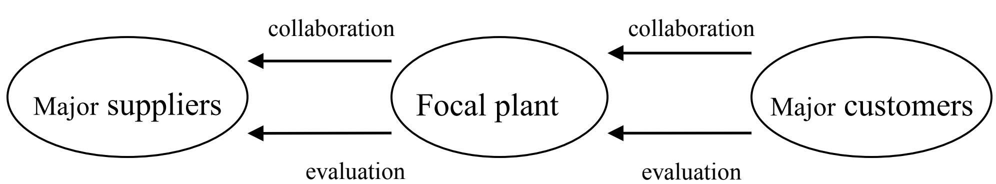


Fig. 3.3 Directionality of Supply Chain Activity Constructs
Source: Klassen and Vachon (2003)

To support the foundation of studying the effect of environmental supply chain management (ESCM) on firm performance, we can review not only the research that exists but also programs established by the Supply Chain Council (SCOR) and the Global

Environmental Management Initiative (GEMI). The Supply Chain Council (SCOR) has fundamentally recognized the impact of the environment on the supply chain and published the GreenSCOR concept (Fig. 3.5). The membership of this organization includes over 800 multi-industry worldwide companies, consulting firms, software providers, government organizations, and educational institutions. This framework, devoted to the topic of SCM, defines a supply chain as an integrated set of processes of "plan," "source," "make" and "deliver," that span the value chain from the supplier's supplier upstream to the customer's customer downstream. SCOR's prescribed analysis of supply chain processes can be employed by managers to characterize, analyze, configure, and describe the depth and breadth of a supply chain, as well as form the foundation for decisions leading to improvement.

The SCOR model illustrates the linking of value-adding processes that exist in supply chain networks within a firm's departments (intra-organizational), and between firms (inter-organizational). This model reinforces the idea that each linkage and node in the chain has an environmental contribution, thus supporting the Environmental Management Model.

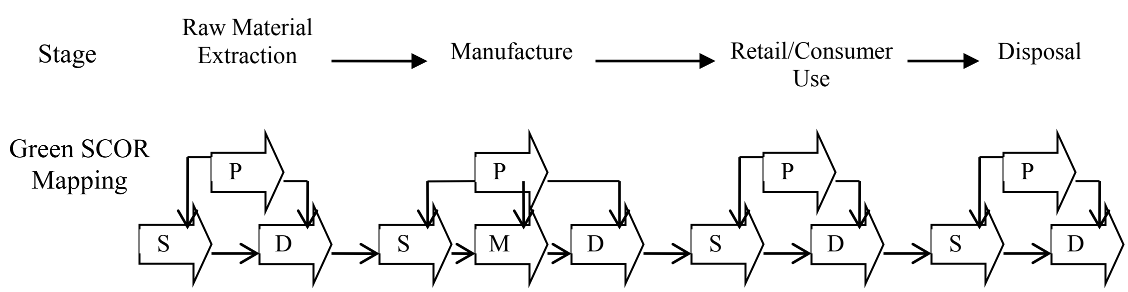


Fig. 3.4: GreenSCOR Concept

The Global Environmental Management Initiative (GEMI) is another non-profit organization of companies dedicated to fostering environmental, health and safety excellence and corporate citizenship worldwide (GEMI, 2004). This group believes that as the scope and cross-functional integration of SCM increases, there is also a need to consider the environment throughout the capabilities in all supply chain business processes. They call this "value-creation" and present some experiences of their member firms. One can see that process improvements have real environmental benefits.

- Duke Power worked with its cable supplier to devise an innovative "reel-less" cable technology that eliminates the use and disposal of wooden reels, and reduces supply chain costs by $500,000 per year.

- Intel has saved millions of dollars annually by developing lighter-weight plastic trays that are used to move microprocessor units through the fabrication process and deliver them to customers.

This group believes that in order for firms to realize such benefits, management needs to foster improved collaboration between environmental health/safety and supply chain management professionals. In addition, pollution prevention can be a natural outcome of environmental process improvements in the supply chain. They concur with Sroufe (2002) and Melnyk (1999) that the potential role that environmental health and safety (EHS) professionals play in improving supply chain performance is "untapped." This "green" supply chain is a method to design and/or redesign the supply chain incorporating recycling and remanufacturing into the production process, thus reducing the environmental impact from start to finish.

Melnyk et al. (1999) also supported the relationship of ESCM and performance by discussing the internally-oriented nature of an EMS. At present, most environmental management systems are implemented using a separate, formal department that is responsible for data collection, reporting, performance measurement, and tools. They tend to focus on tactical and operational problems, and their stance is primarily reactive which comes into play once a problem has occurred. In general, these systems are negatively affecting the major strategic dimensions of performance (i.e., lead time, costs, and quality) but they are also not seen as enhancing the firm's ability to sell its products internationally (Melnyk et al., 1999). Further, Rao & Holt (2005) studied the linkages between green supply chain management as an initiative for environmental enhancement, economic performance and competitiveness amongst a sample of companies in South East Asia. They found that environmental supply chain management leads to improvements in environmental performance.

3.3.2 Complementary Assets

For the purposes of this research, three distinct complementary assets or capabilities are proposed: (1) Quality Practices, (2) Just-In-Time Practices, and (3) Flexibility. We include these complementary assets in this study because they have been frequently cited in relevant literature discussed in Chapter 2 as supporting environmental practices and performance. Additionally, several of the authors listed in Table 3.3 support the need for quality programs as complementary assets in environmental management. Further, Barney (1991) stated that resources can be divided into physical, human and organizational assets. King and Lenox (2001b) acknowledged that environmental management and other capabilities may prove to be complementary, and that different bundles of capabilities may be important. This research will investigate the effect of environmental practices on performance as leveraged by capabilities.

3.3.2.1 Quality Management Practices

This dissertation will draw from management practices that have been frequently cited in the relevant literature as supporting environmental and/or quality and operational performance. The work of researchers that have developed constructs for management practices in the environmental arena are listed in Table 3.7.

As a means to selecting management practices from the research displayed in Table 3-6, a national quality award can be used to further pare down the selection process for the purposes of this dissertation. The Malcolm Baldrige National Quality Award (MBNQA) identifies best practices of U.S. firms, and a portion of the award criteria is dedicated to management practices. The seven criteria of this award are:

1. Leadership
2. Strategic Planning
3. Customer and Market Focus
4. Information and Analysis
5. Human Resource Focus
6. Process Management
7. Business Results

Table 3.7: Environmental/Quality Management Practice Research

Author(s)	Constructs and Concepts
Samson and Terziovski (1999)	TQM Elements: Leadership, people management, customer focus, and strategic planning are positively related to performance.
Klassen & Whybark (1999a)	Management system orientation: Systems analysis and planning, organizational responsibility, management controls are positively related to performance and impacted the investment in environmental technologies.
Kitazawa & Sarkis (2000)	Cultural change: empowerment, team-based approach, problem-solving skills, process conscious approach, open-communication and feedback, cross-functional integration, continuous improvement. They are all needed for pollution source reduction.
Hanna et al. (2000)	Key to a positive relationship between operational and environmental performance is employee involvement.
Angell (2001)	Successful environmental initiatives appear to benefit from cross-functional implementation teams.

Quazi (2001)	Factors influencing EMS certification: Top management, head office environmental practices, environmental regulations, cost savings, customer expectations, competitive advantage, employee welfare, trade barrier.
Daily & Huang (2001)	Human resource factors affecting an EMS are top management support, environmental training, employee empowerment, teamwork, and rewards.
Chinander (2001)	Infrastructural operational issues in measuring, monitoring and managing environmental performance are top management involvement and responsibility, communication & training, reporting and control, and perceived impact of environmental actions on performance.
Russo & Harrison (2005)	Organizational design and environmental performance: reporting relationship (environmental manager reports directly to the plant manager), inclusion of environmental quality managers in discussions concerning key strategic processes.

This dissertation shall select the management practices of a) customer focus, b) leadership, and c) human resource focus or people management to represent the management practices construct. These three were selected based on the suggestions from the researchers in Table 2.1. As a moderating lever, we propose that integrating environmental management can be more successful if the firm has management practices in place such as a) customer focus, b) leadership, c) people management and, d) quality information.

3.3.2.1.1 Customer Focus

Customer focus can be defined as the extent of involvement and the process of how an organization builds and maintains strong and lasting relationships with its customers. Samson and Terziovski (1999) defined customer focus as how well the organization can determine current and emerging customer requirements and expectations. Focusing on the customer would include proactively managing the relationship and monitoring customer satisfaction. This dissertation intends to investigate the resultant effect on performance when firms utilize the contribution and involvement of these stakeholders in their environmental programs and initiatives. Melnyk et al. (2003) conducted research on the antecedents of EMS certification and found that industry customers were a primary reason and a driving force for organizations to implement environmental management practices and obtain certification.

Much environmental literature is devoted to studies of the impact of customer focus and involvement in the implementation of environmental management n processes (Zutshi and Sohal, 2003; Christmann & Taylor, 2001; Geffen & Rothenberg, 2000; Flynn et al., 1995; Polonsky and Ottman, 1998). In general, the research shows that the influence of such stakeholder involvement is positive. The importance of this complementary resource can be supported by the following studies (Table 3.8).

Table 3.8: Environmental Research involving Customer Focus

Author(s)	Sample / Methodology	Findings
Polonsky & Ottman (1998)	Survey, n=119, manova	Stakeholder groups included competitors, end customers, employees/unions, state and local government, owners/shareholders, special interest groups, suppliers and top management. Authors found that there is limited formal interaction between the firm and its stakeholders (different than reacting to their needs)
Geffen & Rothenberg (2000)	Case study of automotive firms	Suggested that relations with suppliers aid the adoption and development of innovative environmental technologies. In addition the interaction of customer and supplier staff, partnership agreements and joint research and development lead to improvements in environmental performance.
Christmann & Taylor (2001)	Survey, China firms (n=101)	Firms that export and sell to foreign customers are a driver to improve environmental performance and implement ISO 14001
Zutshi & Sohal (2003)	Case study n=9	Involvement of stakeholders during the EMS adoption process affects the success of its implementation
Present Study (2012)	Survey	To understand the moderating effect of customer focus on the environmental practices-performance (environmental and operational) relationships.

Zutshi and Sohal (2003) conducted case study research designed to explore the extent of involvement of organizational stakeholders such as employees, customers and suppliers during the environmental management system (EMS) adoption process. They hoped to understand how the contribution and involvement of employees in environmental management programs result in the effective reduction of waste and the successful implementation of the system. After a series of interviews, these authors concluded that employees, as well as suppliers, should be involved in the decision-making process during the adoption process in order to make the change successful. Additionally customers and final consumers can affect the decision-making process, for example by pressuring management to prove that their products and services are not harmful to the environment. Similarly Flynn et al. (1995) concluded that supplier relationships and involvement were significant to product quality.

To examine the influence of external stakeholders, Christmann and Taylor (2001) studied the effect of globalization on the environmental pressures of firms in China. These authors concluded that multinational ownership and firms that export a large proportion of their output to developed countries are more likely to adopt ISO 14001 than other Chinese firms. Similarly Geffen and Rothenberg (2000) pursued case study research because "very little research and theory development has been done on the role of suppliers in environmental innovation." Although the focus of this research was innovative technology, the authors found that trust and giving greater responsibility to suppliers is important for facilities desiring to improve their performance. The study reinforces the need for partnerships amongst stakeholders, such as customers.

3.2.2.1.2 Leadership

In the environmental field, leadership and management commitment has been a construct that has seen great debate (Walley & Whitehead, 1994; Porter & van der Lind, 1995; Cordeiro & Sarkis, 1997). Primarily the debate entails the question of whether management commitment is dedicated to meeting environmental regulations and lessening the potential for fines, or is it truly innovative such that managers commit to reducing the negative effects of their organizations on the natural environment. Further, do managers understand the potential advantages of innovation and investment, or do they view environmental technologies merely as a cost with no substantial benefits. Standards writers recognized the need for management commitment and documented such a requirement for management commitment in ISO 14001 that must be fulfilled by the registered company. Both consultants and practitioners alike understand that the depth of commitment shown by management is not typically evident by the 14001 registration alone.

Management leadership and commitment to further the implementation and success of an organizational activity is well documented (Flynn et al., 1995). In the environmental field, management commitment has been included as a requirement of the environmental management system standard, ISO 14001, that must be fulfilled by the certified company. Researchers have also investigated the reliability of this notion. In a conceptual model, Daily and Huang (2001) proposed a model that identified top management support and leadership as a key contributor to the implementation success of an environmental program. Quazi et al. (2001) conducted a study that supported the presence of management support for firms adopting an EMS and the requirements of ISO 14001. Melnyk et al. (2003b) examined the antecedents impacting a firm's decision to put into action an EMS. They looked at both economic factors and reasons primarily motivated by qualitative reasons and found that organizations are driven to implement not only because of customers, but by the desire to "do the right thing." Other researchers have explored the relationship of management orientation towards the environment to understand how management orientation impacts the implementation of manufacturing technologies (see Table 3.9).

Klassen and Whybark (1999) reported that managers more oriented to the environment are proactive and will balance the use of technologies between pollution control and pollution prevention. They contrasted this result to management that is more reactive in nature and reliant on primarily prevention control measures of controlling environmental waste. Klassen and Angell (1998) also tested the nature of managerial support, or ambition, for environmental initiatives based on the level of manufacturing flexibility (i.e. new product, mix, volume, delivery) in the facility amongst U.S. and German firms. They defined environmental ambition as the scope and depth to which management integrated environmental concerns into the manufacturing system and value chain. They found that an increased level of environmental ambition for environmental initiatives in the U.S. is supported by manufacturing flexibility.

Table 3.9: Environmental Research involving Leadership Activities

Author(s)	Sample / Methodology	Findings
Klassen & Whybark (1999)	Discriminant analysis	Management orientation is intrinsically related to the investment in environmental technologies. ▪ Plant mgrs who adopted a proactive orientation implemented a balanced portfolio of pollution prevention and pollution control technologies ▪ Plant managers who adopted a reactive orientation selected portfolio dominated by pollution control
Quazi et al. (2001)	Stepwise discriminant analysis	Investigated and identified a number of variables which would be able to predict the motivation of organizations in adopting the ISO 14000 Standards. Top management, environmental practices of the corporate office, and environmental regulations are push factors.

Daily & Huang (2001)	Conceptual Model	Proposed a model that identifies top management support, environmental training, employee empowerment, teamwork and rewards systems as key elements of the implementation process of an EMS.
Melnyk et al. (2003b)	Logit model	Identified and explained antecedents impacting the decision to pursue certification for some of the first plants certified/registered to ISO 14001 in the US. ▪ Those plants not actively pursuing ISO 14001 certification are driven primarily by economic factors. ▪ Plants that pursued ISO 14001do it for following reasons (1) "right thing to do" (2) improving performance of current systems (3) industry customers
Present Study (2008)	Survey	To understand effects of leadership on the environmental practice-performance relationship.

3.2.2.1.3 People Management

This construct involves including employees in order to improve awareness of the environmental program and as a step towards integrating and sharing ownership of the facility's environmental initiatives. Flynn et al. (1995) used the term "workforce investment" and included this as an infrastructural element and foundation in their study as an element supportive of JIT and TQM initiatives. The construct includes items involving employees who are engaged in team work, improvement, and problem-solving. This construct will depict a level of employee empowerment in the firm's operations as a way to examine its influence upon producing positive performance benefits.

In general, literature discussing the involvement of employees is generally positive and optimistic (Chinander 2001; Angell, 2001). Organizational structures, cultural change and internal motivators are resource capabilities often credited to the success of an organizational initiative. Hart (1995) believed that the successful implementation of product stewardship focusing on the whole life cycle of a firm's products may require capabilities in cross-functional management. The intent of the ISO 14001 environmental management system standard is not only to require the commitment of management to continually improve, but to also adopt an environmental policy that is known and understood by all employees, thus emphasizing the role of employees in the accomplishment of environmental activities. Improved awareness of the environmental program by all employees is a step towards integrating shared ownership of the facilities' environmental performance into day-to day policies and activities. Involving employees into the corrective action and improvement processes is essential to continual improvement of the management system once the "low hanging fruits" have been identified and addressed. Several empirical works study the intersection of the environment and organizational involvement (see Table 3.10).

Table 3.10: Environmental Research Involving People Management

Author(s)	Sample / Methodology	Findings
Kitazawa & Sarkis (2000)	Case study	An organization culture that includes the major TQM elements should exist for source reduction to be successful.
Hanna et al. (2000)	N=349 case studies	Found a strong relationship between meeting operational goals and staff involvement on environmental management.
Chinander (2001)	Case study (steel mfg)	Internal drivers such as communication, values, alignment of rewards and punishment and accountability, will influence a firm's environmental performance.
Angell (2001)	Quality and Environmental Managers in 10 Malcolm Baldrige award firms	Found that successful quality and environmental initiatives typically involve cross-functional teams during design and implementation, and that environmental initiatives rely more heavily on cross-functional teams than quality initiatives.
Russo & Harrison (2005)	Regression	Considered how the process of environmental management could be improved by use of proper formal reporting relationships. Environmental performance is enhanced when there is a tie between environmental performance and pay (weak support) —but only for facility managers, *not* for environmental quality managers.
Present Study	Survey	To understand effect of people management on the environmental practice-performance relationship.

Russo and Harrison (2005) used a congruence model of organizational design and studied organizational reporting relationships. They found some support that environmental performance improved when there was a link between plant manager compensation and environmental performance in the form of reduced emissions. Similarly Chinander (2001) studied a steel manufacturer and developed several propositions about drivers of a firm's internal environmental awareness. She found that there is a difficulty in aligning accountability and objectives for environmental performance. She stated that a significant gap existed between manager and employee perception of environmental performance and rewards, thus signifying some disconnect between top management commitment and the priority given at the operational level. Her research developed propositions suggesting that employees are a key to the achievement process in that they must see a link between their daily activities and performance, including accountability for a given performance level including an understanding of and accountability for environmental consequences. Thus, this research concluded that organizations must involve employees and culturally embrace the environmental program.

Hanna et al. (2000) discussed how operational performance and environmental performance have been the responsibility of separate and sometimes adversarial entities. Their research found support for the concept of how employee involvement in the form of environmental improvement teams could positively result in both operational and environmental performance through the integration of pollution prevention initiatives and process improvement techniques.

Angell (2001) also explored the impact of teams and other factors on implementing successful change for both environmental and quality initiatives. She concluded that employees from different functional areas and levels of management were essential to successful implementation. Also comparing cultural components to both quality and environmental elements, Kitazawa and Sarkis (2000) studied cultural changes that supported the reduction of environmental impacts primarily based in the context of TQM (see Table 3.11). They concluded that although the ISO 14001 EMS standard does not focus on cultural change, an organization must instill the cultural elements of TQM in order to see the benefits of source reduction.

This above research supports the thesis that management practices are complementary assets with regard to moderating the impact of environmental practices on performance. Our position is that firms that tend to have higher levels of management practices in their resource bases will affect the firm's ability to produce higher levels of operational and environmental performance from the implementation of environmental practices.

3.2.2.1.4 Quality Information

The quality practices construct is built from existing research which itemizes quality practices employed by firms pursuing popular initiative such as total quality management (TQM) and ISO 9001. Table 2.12 highlights a steady research stream that suggests that quality management may be indicative of an organization's ability to successfully implement environmental management.

The evolution of environmental management can be similarly compared to the evolution of quality management in the 1970's and 1980's. In this era where customers and organizations are becoming aware of and concerned with environmental initiatives; attention to the environment can easily be considered as another means to achieving customer satisfaction as was the case during the quality revolution. Organizations like

Nissan, Intercontinental Hotels, and Northern Telecom, have begun to realize that environmental waste reduction, much like improved quality, cannot be achieved effectively at the end of the process but instead must be built into every stage of the development (McInerney & White, 1995).

Hart (1995) conceptualized that firms with a demonstrated capability in TQM will be better able to accumulate resources necessary for the prevention of pollution than those firms that do not. Klassen and Vachon (2008) agreed that the linkage between quality and environmental management has been established in the literature as shown in Table 2.12. These authors state, however, that little research has been conducted on a potential link between environmental activities in the supply chain and internal quality management practices. This construct will study quality practices such as benchmarking, statistical process control (SPC) and process improvement as a moderator of the relationship between environmental practices and firm performance.

Table 3.11: Environmental Research Involving Quality Information

Author(s)	Sample / Methodology	Findings
Curkovic et al. (2000)	Confirmatory factor analysis, SEM	The ability to reframe learnings from TQM is crucial to environmentally responsible manufacturing (ERM). Findings support that there is a relationship between TQM and ERM based systems, and that the presence of a TQM based system encourages the emergence and acceptance of an ERM based system.
Klassen & McLaughlin (1993)	conceptual	Suggested the need for an empirical investigation which examines whether firms which have advanced TQM programs in place also have advanced EM programs in place relative to firms just initiating TQM.
Pil & Rothenberg (2003)	correlation	Study of how superior environmental performance is associated with superior quality. Interviews revealed a reciprocal relationship between quality and the environment. As discussed earlier, the more commonly discussed relationship is that quality influences environmental performance. First, the practices associated with increased quality also improve environmental performance.
King & Lenox (2001)	Probit model	9001 adoption predicts future 14001 (environmental management) adoption.
Klassen (2000)	regression model	As investment in quality-related organizational systems increases, investment in environmental technologies is increasingly allocated toward pollution prevention and management systems and away from pollution control.

The presence of a quality program and quality practices as factors in environmental excellence has been discussed at length by various authors (Table 3.11).

King and Lennox (2001a) found that in the presence of existing TQM practices, workers had an easier time understanding the tools necessary for environmental improvements. Klassen and Angell (1998) declared that "future research needs to explore whether other operational capabilities, such as quality, also support environmental management across international contexts." In addition, over a decade ago, Klassen & McLaughlin (1993) questioned if firms which have advanced TQM programs in place also have more advanced environmental management programs relative to firms just initiating TQM. They commented that an obvious extension of the TQM principle of waste elimination is eliminating the source of unproductive waste entering the environment. They referenced a large electronics firm that adopted the position that emissions and waste should be characterized as quality defects, thus treating them as an extension of quality procedures. Additionally, Hart (1997) noted that TQM predisposed firms "to accumulate the resources necessary for pollution prevention more quickly than firms without such prior capability."

Curkovic et al. (2000) investigated this relationship between TQM and ERM, and concluded that firms that have developed capabilities in TQM will be more likely to develop capabilities necessary for being environmentally responsible. We hope in this research to see the effect on performance for those companies that have implemented not only TQM but other quality practices such as competitive benchmarking and six-sigma. To further explain the close parallel between the environment and quality, the term Total

Quality Environmental Management (TQEM) is now used (Welford, 1992). TQEM is a philosophy similar to TQM that is focused on integrating environmental thinking into an organizational-wide motivation involving all aspects of the enterprise, and not just regulation alone. There are many similarities between the two programs as companies are beginning to appreciate the value of environmentally sound practices as means to cost savings and innovation.

Experts in quality such as Edwards Deming taught the concepts of detection versus prevention, and that improving quality was inherently a path to cost reduction and competiveness. Similarly environmental management has evolved from a government regulations and legal requirements arena (sometimes referred to as "end-of-pipe") to a preventive approach of removing pollution at the source, thus avoiding the downstream responsibilities of treating pollution after it has been created. As the researchers in Table 3.10 agree, the quality philosophy of "do it right the first time" is a premise applicable to environmental management as well.

This research intends to test the concept that the existence of quality management practices can enhance environmental performance and serve as "a ready bridge to environmental excellence" (Klassen and McLaughlin, 1993). As a moderating lever, we propose that integrating environmental management can be more successful if the firm has resources such as quality practices in place.

3.3.2.2 Just-In-Time Management Practices

This construct, perhaps the most controversial (Hanna et al., 2000), will capture the practices that a firm may employ to reduce waste in its operations as part of a lean manufacturing program. Lean manufacturing is a multi-dimensional philosophy and approach that encompasses a wide variety of management practices, such as just-in-time (JIT), work teams, cellular manufacturing and supplier management in an integrated system. The essence of lean production is that these practices can work synergistically to create a streamlined, high quality system that produces finished products at the pace of customer demand with little or no waste (Shah and Ward, 2003). We will utilize constructs of just-in-time (JIT) practices as a means to understanding how lean manufacturing complements the base relationship of environmental practices and performance.

Lean manufacturing concepts in environmental practice initiatives are controversial due to the understanding that reduction of waste will always have some environmental benefit, albeit not typically captured by the organization's cost accounting methods, as well as, simply unrecognized as in the case of Boeing (EPA, 2000a). This study of Boeing documented by the EPA states that "improved environmental performance can ride the coattails of lean culture change and equal a win for business and win for environmental improvement."

Recognizing the importance of the involvement of manufacturing in waste reduction and environmental protection, the government has joined forces with industry to provide oversight and support to improvement programs. In 2003, an innovative and collaborative model was established between the government (Environmental Protection Agency (EPA) and industry was established called the Green Suppliers Network. This association is aimed at enhancing the competitiveness of U.S. manufacturers in the global market, while improving their material and resource efficiency. By combining lean manufacturing and pollution prevention (P2) techniques, the Green Suppliers Network focuses on improving supplier productivity, capacity building, efficiency, and environmental performance. Through on-site Green Supplier reviews, suppliers continuously learn ways to increase energy efficiency, identify cost-saving opportunities, and optimize resources and technologies to eliminate waste.

Research conducted by King and Lenox (2001) established a connection between lean production and environmental performance. The measures of lean performance as established in this work were a) ISO-9001 adoption, and 2) low chemical inventories. This dissertation will build upon this research by suggesting and using other measures of lean production that seem more congruent and aligned to a body of work concerning just-in-time (JIT) manufacturing techniques (Shah and Ward, 2003, 2007). We will make use of just-in-time (JIT) manufacturing practice constructs as developed in previous research (Mehra and Inman, 1992; Sakakibara et al., 1993; Sakakibara et al., 1997).

Recent research has begun to investigate the synergistic effects of exploring lean production systems and the environment as complementary (Table 3.12). We have already established that just-in-time manufacturing is a core thrust of the philosophy of lean manufacturing (Shah and Ward, 2003). Corbett and Klassen (2006) suggested that the reason environmental research has struggled to enter mainstream operations management is due to a paradox of “law of the expected unexpected side benefits” and that benefits from adopting an environmental perspective “usually materializes in unexpected forms and hence are usually greater after the fact than can be predicted in advance.” Larson and Greenwood (2004) suggested that potential synergies between lean production and eco-sustainability exist when integrating these two parallel universes. Rothenberg et al. (2001) studied how environmental initiatives can become a strong driver of quality performance. Although the results were not definitive or statistically significant, the survey suggested that lean systems may marginally reduce the cost of environmental projects. Similarly King and Lenox (2001a) found that lean production as measured by ISO 9001 adoption and maximum inventories is complementary to environmental performance, and can be a component that can lead to lower emissions. This dissertation will utilize more practical constructs to measure lean manufacturing.

A practitioner organization heavily involved in this arena, the SCMEP in Columbia, South Carolina (www.scmep.org) stated that "small and mid-sized manufacturers (SMMs) produce over half of the country's manufacturing output, and unfortunately, SMMs also produce over half of the environmental impact attributable to manufacturing. Clean Manufacturing will improve products and processes, increase productivity, and lessen environmental impact, while providing solutions that are consistent with your company's lean manufacturing goals." The SCMEP agents who consult with manufacturers have found that an operational system that is efficient is also less environmentally harmful, thus becoming more financially successful. Fundamentally expanding the facility's improvement scope from quality, lean concepts and supply chain improvement activities to include an environmental perspective can improve the productivity of the original and entire system.

Table 3.12: Environmental Research Involving JIT and Lean Practices

Author(s)	Sample / Methodology	Findings
Rothenberg et al. (2001)	correlation	▪ Different aspects of lean manufacturing-buffer minimization, work systems and human resource practices, contribute to improved resource efficiency. ▪ Plants that operate according to a lean philosophy will be more likely to have higher volatile organic compound emissions (paint operations). ▪ The presence of lean reduces the marginal implementation cost of superior environmental practices.

King & Lenox (2001a)	Probit model	▪ Lean production will lead to implementation of a formal EMS, less waste generation at the source, less end-of-pipe treatment, lower emissions. ▪ Lean production as measured by ISO 9001 adoption and maximum inventories is complementary to environmental performance. Adopting lean production may lower the marginal cost of pollution reduction. ▪ Lean production is associated with lower emissions.
Klassen (2000)	regression	Explored the relationship between investment in JIT and environmental initiatives and their outputs, delivery performance and environmental performance. Authors found that increased investment in JIT systems lowered releases and transfers of toxic chemicals

On the other hand, there are results and discussions also contradicting the effects of lean manufacturing on the environment. The study by Rothenberg et al. (2001) in the automotive industry found that some lean facilities are willing to trade-off lean practices in order to improve environmental impact and meet regulatory emission requirements, thus finding a negative association between lean practices and environmental performance in paint operations. They also cite a study in which lean practices such as just-in-time delivery may be conducive to congested roads and pollution in Japan.

The relationship between lean manufacturing and environmental consequences is not always considered to be positive. Thornton (2000) discussed the incompatibility of lean manufacturing and environmental results, believing that since lean manufacturing is designed to meet rapid increases in demand, the corresponding actions may "stretch or break environmental controls or safeguards." Both of the above situations are relevant to circumstances that may indeed provide insight as to why lean and green are not necessarily well-suited (i.e. paint operations, transportation industries). Our study intends to further investigate this phenomenon in a hope to understand more of these relationships as controlled by industry.

As a moderating lever, we propose that environmental management practices can be more successful if the firm has lean practices such as JIT in place and thereby propose the following hypotheses.

3.3.2.3 Flexibility

The topic of organizational flexibility and its relationship to environmental management was first researched by Klassen and Angell (1998). They concluded that manufacturing flexibility as measured by 1) to change product, 2) to change output volume, and 3) product ramp up and introduction supported an increased level of environmental ambition for environmental initiatives in the U.S. The potential competitive impact of flexibility is well recognized (Koste et al., 2004) and will provide a contribution to this dissertation in understanding the moderating effects of flexibility on the relationship between environmental practices and performance. This dissertation will build on Klassen and Angel's research (1998). We will use measures of flexibility that investigate worker and mix flexibility, in addition to volume flexibility using more detailed and comprehensive scales designed by Jack & Raturi (2002) and Zhang et al. (2003). These dimensions were selected to understand how a firm's abilities to have flexibility with mix, volume, and worker tasks might moderate the relationship between environmental practices and performance.

Klassen and Angell (1998) are the only researchers' to-date to study the topic of manufacturing flexibility and its association to organizational environmental management. Manufacturing flexibility has many diverse dimensions and certain flexibilities are essential to meet the challenges imposed by today's ever-demanding marketplaces (Koste and Malhotra, 1999). Swink and Hegarty (1998) defined volume flexibility as "the ability to efficiently produce wide ranges in demanded volumes of products" and mix flexibility as "the ability to manufacture a variety of products over a short time span, without modifying facilities."

This dissertation will propose that volume, mix and worker flexibility will support and facilitate environmental initiatives. Manufacturing flexibility can provide significant knowledge and capabilities necessary to innovate and evolve into the environmental arena as new processes and new markets are established for environmentally-based products. For example, often design changes can eliminate the need for processing steps with harmful environmental impacts or the need for packaging altogether. Additionally, new and innovative product markets such as "erasable and reusable paper" are in development by companies such as Xerox in order to favorably impact the usage of precious resources.

Worker flexibility becomes relevant because analogous to quality management systems, employees must be involved in EMS practices. For example, ISO 14001 requires employees to be aware of environmental aspects that are considered significant. They must be able to perform the operations in compliance with the operating criteria established for the significant impact, and understand how to handle and dispose of a variety of production wastes. Additionally workers must be capable of understanding and performing tasks relative to emergency preparedness and response procedures.

Klassen and Angel (1998) discussed linkages between environmental management and manufacturing flexibility. They theorized that maintaining reduced inventory levels through volume flexibility allowed firms to create less waste and obsolescence, thereby consuming fewer resources. They also commented that firms with low mix and low new product flexibility are more likely to resist regulatory environmental changes and abide by end-of-pipe controls rather than focus on pollution prevention. Alternatively, organizations with high flexibility are more aligned to new markets and have the capability to modify and change product design to reduce environmental consequences of selected materials and processes. Companies that are flexible are also likely to utilize more recycled materials (Klassen and Angel, 1998).

Over the years, many authors have developed the concepts of flexibility in the manufacturing arena (Malhotra and Ritzman, 1990; Koste and Malhotra, 1999; Jack and Raturi, 2002) among others. This dissertation hopes to contribute to this research as well as branch off from the premise researched by Klassen and Angell (1998), and investigate the effect of volume, mix and labor flexibility on the relationship between environmental practices and performance proposing the following hypotheses.

Table 3.13: Flexibility and Environment Management Research

Author(s)	Sample / Methodology	Findings
Klassen & Angell (1998)	Factor analysis	Explored the link between manufacturing flexibility and environmental management. In the US environmental management initiative was supported by manufacturing flexibility.
Koste & Malhotra (1999)	Conceptual	Analyzed and mapped 10 dimension of manufacturing flexibility: machine, labor, material handling, routing, operation, expansion, volume, mix, new product & modification.
Jack & Raturi (2002)	Regression, anova, SEM	Found that volume flexibility has a positive impact on performance.
Zhang et al. (2003)	SEM	Volume flexibility and mix flexibility have positive relationships with customer satisfaction.

3.3.3 Measures of Environmental Effectiveness

The literature review discussed studies conducted on the impact of the environment on operational (Melnyk, 1999; Sroufe, 2003, Melnyk et al, 2003, Montabon, 2000), financial (Sarkis, 2005) and environmental performance (King and Lenox, 2001). Various authors have made the claim that "green" is profitable to the manufacturer

(Porter and Van der Linde, 1995; Kleiner, 1991) while others sought to discover the interaction of supply chain activities and performance (Klassen and Vachon, 2003; Zhu et al., 2006). In this dissertation, we will test measures of both operational and environmental performance as moderated by complementary capabilities.

3.3.3.1 Operational Performance

Empirical research demonstrates that environmental management systems have a positive effect on operational performance (Sroufe 2003, Melnyk et al., 2003a). Capturing the performance affect of environmental practices and activities on operational performance has been diverse. Many researchers have based performance measures on perceptions ranging from improved lead times to enhanced reputation (Melnyk, 1999; Sroufe, 2003; Melnyk et al, 2003; Montabon, 2000). Alberti (2000) divided performance into "economic benefits" such as energy and raw material savings, and "non-economic benefits" such as relationships, image and reduction of human risk. As evidence of advancement in the call for environmental measures, Sarkis (2005) discussed performance metrics for green supply chains measures based on the balanced score card approach (see Fig. 3.5). Some of these measures will be used in the environmental and operational scales utilized in this dissertation.

Financial

Percentage of proactive vs reactive expenditures
$ Capital investments
$ Operating expenditures
Disposal costs
Recycling revenues
Revenues from "green" products
$ Fines and penalties
Cost avoidance from environmental actions

Internal Process

Percentage of production and office materials recycled
#Certified suppliers
#Accidents and spills
Internal audit scores
Energy consumption
Percentage of facilities certified
Percentage of product remanufactured
Energy use
Greenhouse gas emissions
Hazardous material output

Customer	Learning and growth
# Green products	Percentage of Employees trained
Product safety	# Community complaints
# Recals	Percentage of renewable resource use
Customer returns	#Violations reported by employees
Unfavorable press Coverage	# Employees with incentives related to environmental goals
Percentage of products reclaimed after use	#Functions with environmental responsibilities
Functional product eco-efficiency	Emergence response programs

Fig. 3.5 Balanced Scorecard Approach to Environmental Metrics. Source Sarkis (2005)

3.3.3.2 Environmental Performance

Previous studies have measured environmental performance as a degree of toxic pollution emissions (Hart and Ahuja, 1996). As a way to help control for differences in production activities across industries and various sized plants, King and Lenox (2001) measure environmental performance in terms of total pollution at the facility level. Klassen and Whybark (1999) use the public Toxics Release Inventory (TRI) release and transfer (lb./emp.) database to examine the two-year changes in TRI releases and transfers. The TRI is a publicly available EPA database that contains information on toxic chemical releases and other waste management activities reported annually by certain industry groups as well as federal facilities (http://www.epa.gov/tri/). Under TRI, an individual facility reports to EPA if it meets the following criteria:

- It employs the equivalent of at least 10 full-time workers; and
- It "manufactures" or "processes" at least 25,000 pounds of a listed chemical or it "otherwise uses" at least 10,000 pounds of a listed chemical

Our study will not use the TRI database as a quantifiable measure of environmental emissions. Rather, this study will utilize scales created by Zhu et al. (2008) to evaluate environmental "emissions" performance.

3.3.3.3 Organizational Performance

The last motivation of this dissertation is to understand how both environmental and operational performance impact organizational performance. Many researchers have called for the need to investigate competitive advantage and improved performance from the best practices of environmental management (Reinhardt, 1998; Klassen and Angell, 1998; Melnyk et al., 1999; Christmann, 2000; King & Lenox, 2001b; Aragon-Correa and Sharma, 2003; Vachon and Klassen, 2008). We will also investigate this relationship using a scale that reflects overall sales and performance of an organization,

3.4 Research Model and Hypotheses

This section discusses the specific hypotheses proposed in this dissertation. The model in Figure 3.6 shows the base relationship between environmental practices and operational and environmental performance. The moderating impact of three complementary assets or resources is shown to impact the base performance relationship. Our research hopes to analyze and determine what assets and resources distinctly give emphasis to enhancing operational and environmental performance through the use of specific environmental practices. The hypotheses of this dissertation are as follows:

Hypothesis 1: *There is a positive relationship between* ***environmental management system practices*** *and performance.*

Hypothesis 2: *There is a positive relationship between* ***environmental supply chain practices*** *and performance.*

Hypothesis 3(a): *The relationship between* ***environmental management system practices*** *and performance will be strengthened by higher levels of* ***quality management practices****.*

Hypothesis 4(a): *The relationship between* ***environmental supply chain practices*** *and performance will be strengthened by higher levels of* ***quality management practices****.*

Hypothesis 3(b): *The relationship between **environmental management system practices** and performance will be strengthened by higher levels of **just-in-time practices**.*

Hypothesis 4(b): *The relationship between **environmental supply chain practices** and performance will be strengthened by higher levels of **just-in-time practices.***

Hypothesis 3(c): *The relationship between **environmental management system practices** and performance will be strengthened by higher levels of **flexibility**.*

Hypothesis 4(c): *The relationship between **environmental supply chain practices** and performance will be strengthened by higher levels of **flexibility**.*

Hypothesis 5: *Environmental and operational performance will be positively associated with organizational performance.*

3.5 Summary

This chapter formally set up the research model, elaborated on the constructs, and proposed the hypotheses (Fig. 3.9). Earlier in the discussion about complementary capabilities, King and Lenox (2001b) observed that environmental management and other capabilities may prove to be complementarities and that different bundles of capabilities may be important. They concluded that additional research is needed to explore how underlying firm characteristics affect the relationship between environmental management and relative firm performance.

The research model builds upon the literature developed in Chapter 2 and is founded on the themes discovered in the extant research. This methodology facilitates a discussion of environmental practices and complementary assets that will impact firm performance. Chapter 4 will discuss these issues in greater detail.

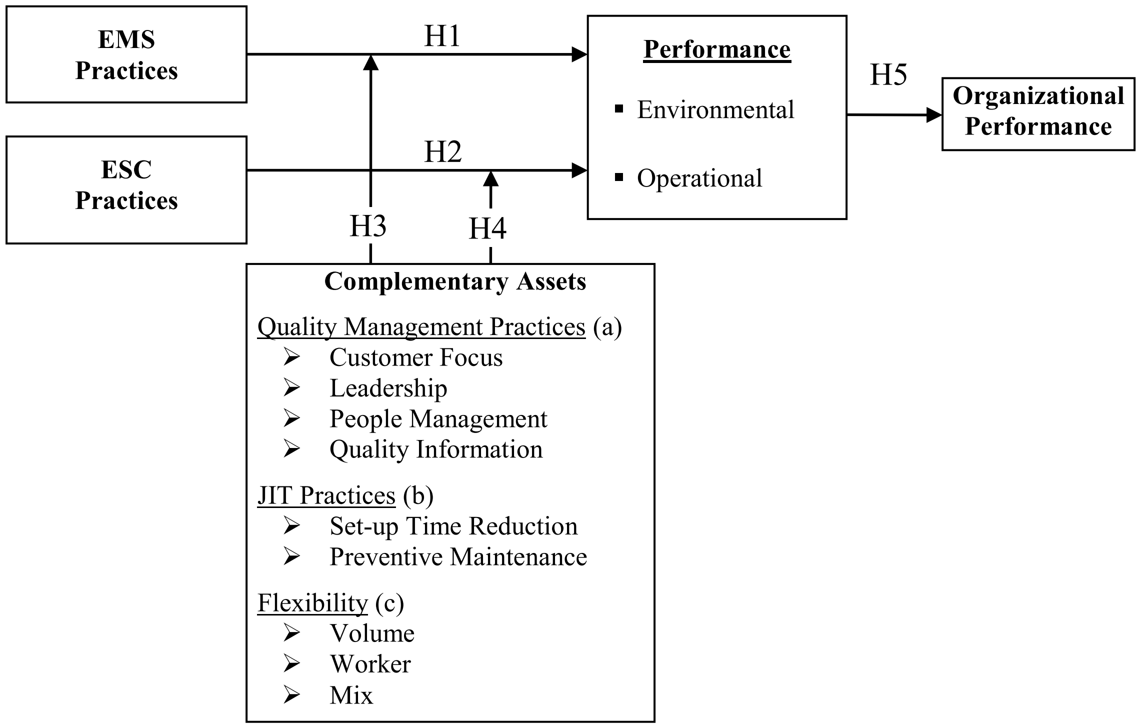


Fig. 3.6 Hypotheses of the Environmental Performance Model

3.6 Conclusion

This chapter formally introduced the research model, developed the constructs and proposed the hypotheses. The research model is based on research primarily in the environmental domain. This investigation includes a diverse set of variables that provide insights into the relationships of interest not addressed in previous research. The next chapter discusses the operationalization of the model and data collection procedures to test the proposed research model.

CHAPTER FOUR

Research Design

4.0 Introduction

The intent of this chapter is to introduce the operationalization of the research model. The objective of the research design is to assure that the study has good validity and reliability. First, the definition of the moderating model will be presented and explained followed by the presentation of the items and the procedure for measure development that is recommended by Churchill (1979).

4.1 The Moderating Model

The moderating research model shown in Figure 3.8 is a moderating model that proposes an organization's complementary assets will moderate the base relationship between environmental practices and firm performance. In this research the moderators include (1) quality practices, (2) just-in-time practices, and (3) flexibility.

Regression will be the main methodology used. Hair et al. (1998) state the objective of multiple regression methodology is "to predict a single dependent variable from the knowledge of one or more independent variables." Further, multiple regression provides an objective means of assessing the predictive power of a set of independent variables. In a moderating model, a base relationship exists between two variables which are moderated by a third variable (Sharma, 1996). In this case, the model proposes that complementary assets moderate the base relationship between environmental practices and firm performance. The base relationship between environmental practices and performance has been previously established in extant research (Melnyk, 2002; Sroufe, 2003). As a result of the presence of the moderating variable, organizational performance can become stronger or weaker. It is the intent of this chapter to define how this analysis will be conducted.

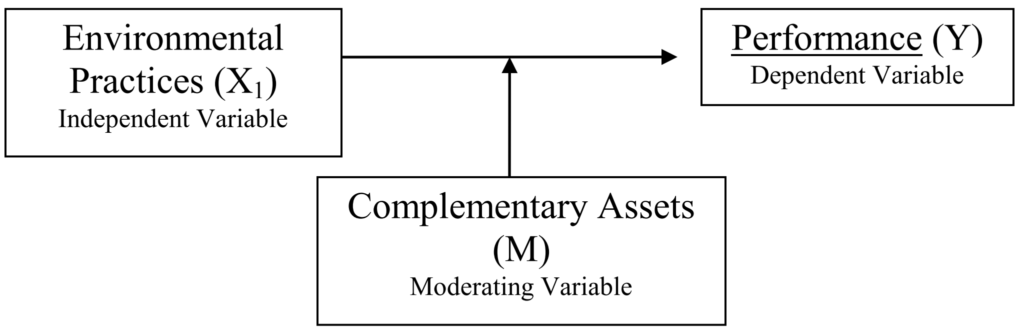


Fig. 4.1: Moderated Regression Analysis

Sharma et al. (1981) defined a moderator as "one which systematically modifies either the form or strength of the relationship between a predictor and criterion variable." In Figure 4.1, "environmental practices" are the predictor variables, the complementary assets are the moderator, and the firm performance is the dependent variable. Hair et al. (1998) similarly described the moderator effect as one in which a third independent variable (the moderator variable) causes the relationship between a dependent/independent variable pair to change, depending on the value of the moderator variable. It is also known as a "moderator effect." As stated before, equations will be used to fit the data and test the hypotheses. The moderated relationship is represented by:

$$Y = a + b_1X + b_2M + b_3XM$$

where:

Y = Dependant Var. (performance)

X = Independent Var. (environmental or supply chain practices)
M = Moderating Var.
a = intercept
b_1 = the effect of X when M is zero
b_2 = the effect of M when X is zero
b_3 = how the effect of X varies as M varies

To determine whether the moderator effect is significant, the original (or un-moderated) equation is estimated. If the change in R-square (R^2) is statistically significant between the original and moderated relationship a significant moderator effect is present.

4.2 Construct Development

The first step was to undertake an extensive review of the extant literature in order to understand content domain. Secondly, this research selected constructs that have been previously examined by researchers. These existing scales were modified slightly to add clarity to the items and the overall construct as advised by content experts during preliminary reviews.

Table 4.1: Construct Definitions

Construct Name	Definition	Author
Environmental Management System Practices	A formal system and database which integrates processes for the training of personnel, monitoring, summarizing and reporting of environmental performance.	Sroufe (2003)
Environmental Supply Chain Management	Environmental collaboration focusing on inter-organizational interactions between supply chain members, including such aspects as joint environmental goal setting, shared environmental planning and working together to reduce pollution or other environmental impacts.	Vachon & Klassen (2008)
Quality Management Practices	A way of achieving high manufacturing quality. Efficient process management, open communication and systematic identification, and removal of defects and their causes.	Ahire & Dreyfus (2000)
Just-in-time (JIT) Practices	Eliminating waste through the simplification of manufacturing processes. Simplification includes the elimination of excess inventories and overly large lot sizes which cause unnecessarily long customer cycle times.	Flynn et al. (1995)
Flexibility	The ability to change or react with little penalty in time, effort, cost or performance.''	Upton (1994)

4.2.1 Content of the Constructs

A widespread review of the extant research was conducted to cover the environmental practice and complementary asset domain. The literature review in Chapter 2 extracted research themes that have been looked at by pertinent authors in this field of research. Chapter 3 introduced the constructs based on the review and relevancy of supporting literature. This chapter will discuss the content of each construct. Table 4.1 provides the definition of each construct.

4.2.1.1 Environmental System Practices

Environmental practices for this study were selected based on research that showed these practices have an effect on performance. Environmental management system practices have been studied by various researchers (Klassen & McLaughlin, 1996; Melnyk et al., 1999; Melnyk et al., 2002; Melnyk et al, 2003a; Sroufe, 2003; Klassen & Vachon, 2003; Montabon et al., 2007). The construct selected for this research was adopted from research conducted by Sroufe (2003).

Another construct selected for this study was from the environmental supply chain arena. In recent years, environmental management has evolved to include boundary-spanning activities such as green purchasing (Min and Galle, 2001) and supply chain life cycles (Hagelaar, van der Vorst and Marcelis, 2004). Other researchers have investigated effects of the "green supply chain" on some aspect of performance (Melnyk et al., 1999; Rao, 2002; Klassen & Vachon, 2003; Zhu and Sarkis, 2004; Rao & Holt, 2005; Zhu et al., 2005; Vachon & Klassen, 2008). The construct selected for this research came from research conducted by Vachon and Klassen (2008). These authors comment that although the environmental management within the supply chain has been developing, it is still, for the most part, still sparse.

4.2.1.2 Complementary Assets

The moderating constructs were chosen as a result of the literature review and the linkages established in extent research. This dissertation recognizes that the constructs and combinations of the constructs are multidimensional. Practices can be combined, and there is synergy associated with these possible combinations (Shah and Ward, 2003). Management or "infrastructural" practices have been studied by authors examining similar research pertinent to relevant literature such as Just-in-Time (JIT) and Total Quality Management (Flynn et al., 1995). In this work, Flynn et al. (1995) selected five dimensions of infrastructural practices – information feedback, plant environment, management support, supplier relationship and workforce management stating their mutual support of JIT and TQM initiatives. The basis of this study came from the underlying knowledge that manufacturing competiveness is integrative and overlapping.

Table 4.2 shows the constructs selected for this dissertation. Many of them came from Samson & Terziovsky (1999) in a study of TQM and operational performance (Table 4.2). Management practices in this study are described as necessary for a TQM framework (customer focus, leadership and people management). This linkage between quality management has been established in the environmental management literature (King and Lenox, 2001a; Vachon and Klassen, 2008). However, Vachon and Klassen (2008) state that very little research has been established studying this link between environmental activities in the supply chain and internal quality management practices.

Thus, the management practices selected for this study not only contribute to this body of knowledge, but also serve as suitable complementary assets and moderators.

Table 4.2: Extent Research of Selected Constructs: Complementary Assets	
Construct Name	**Extent Research**
Quality Practices	Customer Focus *Samson & Terziovsky (1999)* Leadership *Samson & Terziovsky (1999)* People Management *Samson & Terziovsky (1999)* Quality Practices *Shah & Ward (2003)*
Just-in Time (JIT) Practices	Set-up Time Reduction *Sakakibara et al. (1993)* Preventive Maintenance *Sakakibara et al. (1993)*
Flexibility	Volume Flexibility *Jack & Raturi (2002)* Mix Flexibility *Zhang et al. (2003)* Worker Flexibility *Zhang et al. (2003)*

The quality practices constructs were taken from Shah and Ward (2003) and Samson and Terziovsky (1999), and consist of practices such as quality management programs, customer focus, and people management. Shah and Ward (2003) considered quality management as a "lean" bundle to investigate their effects on performance. The linkage between environmental and quality management programs has been established in the extant literature as shown in Chapter 2 (Curkovic, 1998; Angell and Klassen, 1999; Corbett & Cutler, 2000; King & Lennox, 2001a; Florida & Davidson, 2001; Angell, 2001; Vachon & Klassen, 2008). The linkage between environmental management and lean practices were established by King and Lenox (2001).

The association and relationships between manufacturing flexibility and environmental management were established and discussed by Klassen and Angel (1998) and Vachon & Klassen (2008). The results of Klassen and Angel (1998) found that manufacturing flexibility supports an increase in environmental ambition among US firms. This dissertation will explore this concept and result in greater depth, and has adopted constructs for flexibility from Jack & Raturi (2002) and Zhang et al. (2003).

4.2.1.3 Performance

The scales for performance were adopted from prior research, which record three types of performance: 1) environmental performance (Zhu et al., 2008), 2) operational performance (Devraj et al.,2007), and 3) organizational performance (Fugate et al., 2009).

4.2.2 Measurement Items

This research intends to identify and utilize measurement items from previously validated scales in extant research. However, items were modified from these validated scales as a result of in-depth survey reviews with three environmental management system consultants and from two firms. The management system consultants contributed their insight to the content and readability of the items. Specifically, they found the original construct by Sroufe (2003) with 19 items to be repetitious and lengthy. As a result, those items were modified and the construct was streamlined to 8 comprehensive items reflecting current activities in environmental management system implementation.

4.2.3 Initial Purification of the Items

During the review with three environmental management system consultants and two in-depth survey field reviews with a printing firm (Plant Manager & Quality Engineer) and a turbine component manufacturer (Design Manager), modifications were made to the initial survey for language, intent, and clarification of ambiguous statements and/or concepts. The respondents were asked to answer the questions verbally with the interviewers. The time involved to conduct these interviews was approximately 2 hours in each case. The printing company employed approximately 100 people, and the turbine component manufacturer employed approximately 150 at the time of the survey review. The respondents were asked to put into words any problems that they encountered with understanding the question, the language or the intent. As a result, ambiguities and problems were discussed and addressed. The modifications are noted in the Tables 4.3 to 4.14. The constructs for operational performance and organizational performance were not modified, but are shown in Tables 4.15 and 4.16 respectively for the sake of completeness.

Table 4.3: Environmental System Practices	
Source: Sroufe (2003)	
Please indicate the extent to which you are implementing the following practices:	
EM 1	New: We formally document and implement environmental management system procedures at our site. Original: EMS procedures are widely available. Reason: problematic: "widely available" was unclear and may have several meanings. Thus these words were replaced with "document" and "implement"
EM 2	New: We include environmental issues and policies in training and communication activities at our site. Original: Environmental issues, policies, and procedures are included in training. Reason: problematic: "training" was found as only one method of communicating issues, policies and procedures. "Communition activities" was added.
EM 3	New: We have formal roles, responsibilities and authority for environmental affairs at our site. Original: Formal department responsible for environmental affairs. Reason: problematic: the word "department" implied more than one person. In small to medium-sized firms, roles, responsibilities and authorities are formal with an official capacity but may not be related to a department.
EM 4	New: We regularly track and monitor environmental information regarding environmental impact at our site. Original: Environmental information is tracked and monitored regularly. Reason: problematic: "environmental information" was seen as too broad. "Impact" was added.
EM 5	New: We formally track and report environmental performance at our site (i.e. goals, programs, objectives & targets). Original: Environmental performance formally tracked and reported. Reason: "performance" was found to be in the form of "goals, programs, objectives & targets" and added to the item.
EM 6	New: We widely distribute and give visibility to environmental performance at our site (i.e. goals, programs, objectives & targets). Original: Environmental performance results widely distributed. Reason: "performance" was found to be in the form of "goals, objectives & targets" and added to the item.
EM 7	New: Top management at our site supports environmental performance and prevention of pollution. Original: Top management support for environmental performance. Reason: "performance" can include reducing the impact of pollution.
EM 8	New: People within our site consider our system to be effective at meeting our goals, objectives and targets. Original: People within firm consider the EMS highly effective. Reason: "highly effective" was found to be in terms of meeting goals, objectives and targets and added to the item.
General Modification Notes: (1) This scale originally contained 19 items. The modifications above when reviewed by the management system consultants concurred that they covered the original intent of the 19 items. Also, companies with conforming or certified EMS's are the target frame of this study. (2) "at this site" wording ws added to clarify plant-level activity and performance.	

Table 4.4: Environmental Supply Chain Management Practices	
Source: Vachon & Klassen (2008)	
During the past three years to what extent did your plant engage in the following control and monitoring activities with your primary suppliers?	
ESC 1	New: We achieve environmental goals collectively with our ***primary suppliers***. Original: Achieving environmental goals collectively.
ESC 2	New: We develop a mutual understanding of responsibilities regarding environmental performance with our ***primary suppliers***. Original: Developing a mutual understanding of responsibilities regarding environmental performance.
ESC 3	New: We work together with our ***primary suppliers*** to reduce environmental impact of our activities. Original: Working together to reduce environmental impact of our activities.
ESC 4	New: We conduct joint planning with our ***primary suppliers*** to anticipate and resolve environmental-related problems. Original: Conducting joint planning to anticipate and resolve environmental-related problems.
ESC 5	New: We make joint decisions with our ***primary suppliers*** about ways to reduce the overall environmental impact of our products. Original: Making joint decisions about ways to reduce overall environmental impact of our products.
General Modification Notes: added the terms "suppliers" and "we" to add strength and emphasis.	

Table 4.5: Customer Focus	
Source: Samson & Terziovsky (1999)	
Please indicate the extent to which you agree or disagree with the following statements.	
CF1	We know our external customers' current and future requirements (both in terms of volume and service characteristics).
CF2	New: The requirements of our customers are effectively disseminated and understood throughout our site and our workforce. Original: These customer requirements are effectively disseminated and understood throughout the workforce.
CF3	New: We use the requirements of customers in designing new products and services at our site. Original: In designing new products and services we use the requirements of domestic customers.
CF4	New: We use customer complaints as a method to initiate improvements in our current processes. Original: Customer complaints are used as a method to initiate improvements in our current processes.
CF5	New: We systematically and regularly measure external customer satisfaction at our site. Original: We systematically and regularly measure external customer satisfaction.
General Modification Notes: "At this site" added to clarify plant-level activity and performance.	

Table 4.6: Leadership	
Source: Samson & Terziovsky (1999)	
Please indicate the extent to which you agree or disagree with the following statements.	
L1	New: Senior Managers at our site actively encourage change and implement a culture of trust, involvement and commitment in moving towards "Best Practice." Original: Senior Mangers actively encourage change and implement a culture of trust, involvement and commitment in moving towards "Best Practice."
L2	There is a high degree of unity of purpose throughout our site, and we have eliminated barriers between individuals and/or departments.
L3	Senior Mangers effectively drive "Best Practices" at this site.
L4	At this site we proactively pursue continuous improvement rather than reacting to crisis' "fire-fighting."
L5	New: Ideas from employees are actively used in assisting management at this site. Original: Ideas from production operators are actively used in assisting management.
L6	Environmental "green" protection issues are proactively managed at this site
General Modification Notes: "At this site" added to clarify plant-level activity and performance.	

Table 4.7: People Management	
Source: Samson & Terziovsky (1999)	
Please indicate the extent to which you agree or disagree with the following statements.	
PM1	The concept of the "internal customer" (i.e. the next person or process down the line and including all employees) is well understood at our site.
PM2	New: We have an organization-wide training and development process, including career path planning, for all our employees at our site. Original: We have an organization-wide training and development process, including career path planning, for all our employees.
PM3	Our site has effective 'top–down' and 'bottom–up' communication processes.
PM4	New: We formally and regularly measure employee satisfaction at our site. Original: Employee satisfaction is formally and regularly measured.
PM5	New: We have excellent Occupational Health and Safety practices at our site. Original: Our Occupational Health and Safety practices are excellent.
PM6	New: Employee flexibility, multi-skilling and training are actively used to support improved performance at our site. Original: Employee flexibility, multi-skilling and training are actively used to support improved performance.
PM7	New: At our site all employees believe that quality is their responsibility. Original: All employees believe that quality is their responsibility.
General Modification Notes: "At this site" added to clarify plant-level activity and performance.	

4.8: Quality Information	
Source: Ahire (1996)	
Please indicate the extent to which you are utilizing the following practices at your site:	
QP1	Scrap rates of our primary product are readily available.
QP2	Rework rates of our primary product are readily available.
QP3	Cost of quality data concerning our primary product is readily available.
QP4	Quality information is displayed at most of the work stations.
QP5	Progress toward quality-related goals is displayed in our site.
QP6	Information about defects is conveyed to the appropriate workstation (source).
General Modification Notes: Construct name changed from "TQM" to "Quality Information"	

Table 4.9: Set-up Reduction Practices	
Source: Sakakibara et al. (1997)	
Please indicate the extent to which you agree or disagree with the following statements.	
SU1	New: We are aggressively working to lower setup times at our site. Original: We are aggressively working to lower setup times at our plant. Reason: Consistency with other items.
SU2	We have converted most of the setup times to external time while the machine is running
SU3	New: We have low setup times of equipment at our site. Original: We have low setup times of equipment in our plant. Reason: Consistency with other items.
SU4	Our crews practice setups to reduce the time required.

Table 4.10: Preventive Maintenance Practices	
Source: Sakakibara et al. (1997)	
Please indicate the extent to which you agree or disagree with the following statements.	
PM1	Our equipment is in a high state of readiness for production at all times.
PM2	We dedicate a portion of everyday to preventive maintenance.
PM3	We emphasize good maintenance as a strategy for achieving quality and schedule compliance.
PM4	We have a separate shift, or part of a shift, reserved each day for maintenance activities.
PM5	New: We have a relatively low rate of downtime for repair, compared with our industry. Original: We have a relatively high rate of downtime for repair, compared with our industry (reverse scaled)

Table 4.11: Volume Flexibility	
Source: Jack & Raturi (2002)	
Please indicate the extent to which you agree or disagree with the following statements.	
VF1	New: Production processes and equipment at our site give us the capability to produce high volume levels. Original: Our production processes and equipment give us the capability to produce high volume levels.
VF2	New: Our site can significantly (≥ +/-25%) increase (or decrease) output levels to support fluctuations in demand. Original: We can significantly (>+/-25%) increase (or decrease) our output levels to support fluctuations in demand.
VF3	New: When we increase (or decrease) our site's volume levels we do not experience more than proportionally higher (or lower) production costs. Original: When we increase (or decrease) our volume levels we do not experience more than proportionally higher (or lower) production costs.
VF4	New: When we increase (or decrease) our site's volume levels we do not experience more than proportionally higher (or lower) product quality problems. Original: When we increase (or decrease) our volume levels we do not experience more than proportionally higher (or lower) product quality problems.
General Modification Notes: "At this site" added to clarify plant-level activity and performance.	

Table 4.12: Mix Flexibility	
Source: Zhang et al. (2003)	
Please indicate the extent to which you agree or disagree with the following statements.	
MF1	New: We can produce a wide variety of products at our site. Original: We can produce a wide variety of products in our plants.
MF2	New: At our site we can produce different product types without major changeover. Original: We can produce different product types without major changeover.
MF3	New: At our site we can build different products at the same time. We can build different products at the same time.
MF4	New: At our site we can produce (simultaneously or periodically), multiple products in a steady-state operating mode. Original: We can produce (simultaneously or periodically), multiple products in a steady-state operating mode.
MF5	New: At our site we can vary product combinations from one period to the next. Original: We can vary product combinations from one period to the next.
MF6	New: At our site we can changeover quickly from one product to another. Original: We can changeover quickly from one product to another.
General Modification Notes: "At this site" added to clarify plant-level activity and performance.	

Table 4.13: Worker Flexibility	
Source: Zhang et al. (2003)	
Please indicate the extent to which you agree or disagree with the following statements.	
WF1	New: At our site, workers can perform many different types of operations effectively. Original: Workers can perform many types of operations effectively.
WF2	New: At our site, a typical worker can use many different tools effectively. Original: A typical worker can use many different tools effectively.
WF3	New: At our site, workers can perform a broad range of tasks effectively. Original: Cross-trained workers can perform a broad range of manufacturing tasks effectively in the organization.
WF4	New: At our site, workers can operate various types of machines and/or equipment. Original: Workers can operate various types of machines.
WF5	New: At our site, workers can be transferred easily between different departments. Original: Workers can be transferred easily between organizational units.
General Modification Notes: "At this site" added to clarify plant-level activity and performance.	

Table 4.14: Environmental Performance	
Source: Zhu et al. (2008)	
Please indicate the extent to which environmental activities have influenced environmental performance at your site.	
EP1	New: Reduced our site's air emissions. Original: Reduction of air emissions.
EP2	New: Reduced our site's waste water. Original: Reduction of solid wastes at our site.
EP3	New: Decreased our site's consumption for hazardous/harmful/toxic materials. Original: Decrease of consumption of hazardous/harmful/toxic materials.
EP4	New: Decreased our site's frequency of environmental accidents. Original: Decrease of frequency for environmental accidents.
EP5	New: Improved our site's overall environmental situation. Original: Improvement of an enterprise's environmental situation.
General Modification Notes: "At this site" added to clarify plant-level activity and performance.	

Table 4.15: Operational Performance	
Source: Devraj et al. (2007).	
Please rate the operational performance of your site along the following dimensions. Not Very Good (1) Average (4) Very Good (7)	
OP1	Percent product returned by the customer
OP2	Percent defects during production
OP3	Delivery speed
OP4	Delivery reliability
OP5	Production costs
OP6	Production lead time
OP7	Inventory turns
OP8	The flexibility of operations to accommodate changes to shipping schedules within the effective lead time of the product without the use of safety Stock.

Table 4.16: Organizational Performance	
Source: Fugate et al. (2009).	
Please rate the operational performance of your site along the following dimensions. Far worse than your competitors (1) About the same as competitors (4) Far better than competitors (7)	
OP1	Overall performance
OP2	Market share growth in our primary market
OP3	Sales growth
OP4	Percentage of new product sales generated by new products.
OP5	Return on sales.
OP6	Return on investments.

4.2.4 Pilot Testing of the Instrument

After the initial purification of the items, a pilot test was conducted by administering the survey in person to 15 firms. This process, in addition to an interview, validated the appropriateness of the model and the constructs. Respondents in these 15 firms represented several functional areas, including an Improvement Facilitator, Quality Management, a Regulatory Compliance Engineer, OH&S Management and Safety Management. Each respondent completed the questionnaire at their convenience, and was then questioned as to the appropriateness and understandability of the information collected. The time taken by the respondents was approximately 45-55 minutes.

One of the primary concerns was that the respondent may not have an ability to answer the moderating items that may not be directly part of the respondent's immediate domain (i.e lean practices, flexibility). In each case, there was no perceived or reported indication that this was a potential problem. The respondents needed to be familiar with environmental issues affecting their site and the effects of the environmental programs, as well as quality, JIT practices and flexibility on performance. In theory, organizational managers would be best able to understand these practices and issues. Based on the feedback provided by the respondents, the survey instrument was found to be acceptable.

4.3 Conclusion

This chapter presented the research methodology implemented for this thesis. The intent was to use moderating regression analysis according to established protocols in order to attain good validity and reliability. The next chapter provides results and analysis of the measurement constructs.

CHAPTER FIVE

Research Methods and Preliminary Analysis

5.0 Introduction

This chapter discusses the data collection process, preliminary results, and the refinement and validation of the measures. It will examine the identification of the selected respondents, analysis of construct reliability and validity, in addition to an evaluation of non-response bias. We will present the measurement properties of the scales and then provide a discussion and analysis of the data.

5.1 Response Profiles

The distribution of the survey instrument was done by U.S. postal mail. The introductory letter included the specifics of the research, the importance of participation, the confidentiality of responses, and a link to the survey on the Qualitrics web-based survey offered through the University of South Carolina. The letter also offered each respondent a copy of the research when completed. Potential respondents were identified through the ISO 14001 Certified Company Directory. The directory included the contact persons for organizations having certified environmental management systems. The target recipient of the letter was not necessarily top management, but a manager who would have a detailed understanding and knowledge of the inner workings of the organization's plan to implement environmental management. This key informant also had day-to-day responsibilities in activities that relate to the organization's business. If the database contained an individual's name and title, it was used in the mailing. Otherwise, the letter was addressed to the Environmental Manager. This position is typically held by ISO Management Representative, which is a term commonly referring to a representative of the management responsible for the firm's environmental activities, and holds one of the following positions: Environmental Manager, Plant Manager, Operations Manager, Quality Manager or any combination of these responsibilities. The unit of analysis for this research is the facility or the manufacturing plant

This sample frame used here is similar to that used by Melnyk et al. (1999), Sroufe (2003) and Vachon and Klasen (2008) in that the respondent group represented a variety of positions and functions within a variety of industries. Empirical results have confirmed that firm performance is mainly determined at the business-unit level (McGahan & Porter, 1997; Rumelt, 1991), and not at the corporate level.

5.2 Sample Frame

The target sample frame of this study was manufacturing organizations in the U.S that were certified to the environmental management system international standard ISO 14001. Predominantly, previous research has focused on manufacturing because this target group is heavily involved in pursuing environmental programs and initiatives. A subscription was purchased to the ISO 14001 Certified Company Directory that lists all companies in the United States that have achieved ISO 14001 registrations. These were the companies that were contacted for this dissertation's data collection.

ISO 14001 and environmental management systems are not specific to any industry, and the requirements can be applied to and addressed by any firm. The questionnaire was developed in the spirit that manufacturing enterprises in 2009 will have environmental, as well as quality and lean initiatives in place. King and Lenox (2001) recognized that industry becomes an important factor in environmental progress, and commented that "greener industries may have higher returns than dirtier industries because of lower compliance and regulatory costs." This study hopes to review several industries to understand the effects of the hypothesized moderating variables.

In total, there were approximately 3900 companies in the database. Societies and service companies were eliminated, and many of the organizations in the database were no longer in business as evidenced by non-deliverable mailings. Several weeks after the first mailing, each respondent was contacted a second time by a follow-up letter in order to encourage their participation.

The first responses were received within five days of the initial mailing. A total of 122 responses were received within the first three months, and 173 responses (total) were received over the next three months. To achieve additional responses, a second round of mailing to the same addresses was conducted, and 73 more responses were collected. The total usable count of 246 firms with completed questionnaires was finally achieved, which represents an 8.2% (246/3013) response rate. A wide range of organizational classifications and sizes are represented in the sample.

5.2.1 Industry

There was strong representation of many industries in the final sample. We did not intend for any single industry to dominate the results so that the sample is representative of organizations using environmental practices nationwide. However, it is evident that forty one percent of the responders were from the automotive industry. This high percentage level can be attributed to the fact that in 2002-2003, Ford and General Motors required all suppliers to be ISO 14001 certified. In turn, many of the first tier suppliers also imposed this requirement on the supply base, thus causing heavy concentration of ISO 14001 implementation in the automotive industry, which would suggest that the final sample may be representative of the population. The breakdown of the industries is shown in Table 5-1.

Table 5.1 Respondent Industry

Industry Classification	Frequency	Percent of Total
Automotive	102	41
Chemical	23	9
Computer/Electronic Equipment	23	9
Fabricated Metal Products	22	9
Other	16	7
Primary Metal Industries	11	4
Industry Machinery & Equipment	7	3
Transportation Equipment	7	3
Paper	6	2
Aerospace	5	2
Plastics	4	2
Energy	4	2
Agricultural/forestry	3	1
Food	3	1
Textiles	3	1
Printing and Publishing	2	1
Laboratory/medical instruments & related	2	1
Construction	2	1
Pharmaceutical	1	0
Total	**246**	**100**

5.2.2 Profiles of the Respondent Job Classifications

The research depended on reaching a respondent in the organization who could respond to questions about both environmental initiatives and manufacturing practices, as well as organizational, operational and environmental performance. As noted above, the target respondent was an individual at the management level who understands the environmental practices and the multiple levels of facility performance. It was determined in the pilot testing that the most appropriate individuals would include environmental managers, plant managers, quality managers or other facility managers. The data used for this analysis was obtained from a single respondent from each firm. When a single respondent is used, the individual should be someone who is sufficiently aware of and involved in the topic under investigation (Huber and Power, 1985). This criterion was met since the majority of respondents were from the management rank. The most common respondent was an environmental manager. Other respondents included plant managers, quality managers, engineers and coordinators (see Table 5.2).

Table 5.2 Respondent Title

Title	Frequency	Percent of Total
Manager-Environmental	97	39
Manager-Quality	14	6
Manager-Plant	12	5
Manager-Operations/Production	9	4
Manager-Other	3	1
VP	4	2
Engineer	31	13
Coordinator	27	11
Director	18	7
Specialist	15	6
Not Reported	13	6
Supervisor	3	1
Total	246	100

5.2.3 Characteristics of the Respondents

We collected both number of employees and annual sales (see Table 5.3), number of years certified to ISO 14001 (Table 5.4), and respondents certified to the international quality management system standard ISO-9001 (Table 5.5). The respective tables reflect the fact that the key respondent firm had an environmental management system in place for a number of years. Except for 27 firms, all the others had been ISO 14001 certified for 4 years or longer. It is not surprising to find that many of these companies (206) also have certified ISO 9001 quality management systems as well.

Table 5.3 Annual Sales and Number of Employees

Annual Sales	Frequency	Percent of Total
Less than 10 M	25	10
10-25 M	62	25
26-50 M	58	24
51-100 M	33	13
101-250 M	38	15
251-500 M	13	5
501 M-1B	10	4
Over 1B	6	3
Total	**246**	**100**

No. of Employees	Frequency	Percent of Total
<100	67	27
101-250	83	34
251-500	60	24
501-750	18	7
751-1000	4	2
1001-1500	7	3
1501-2000	5	2
Over 2000	2	1
Total	**246**	**100**

Table 5.4 Years Certified to ISO 14001

Years Certified to ISO 14001	Frequency	Percent of Total
0	8	3
< 2	5	2
2-3	14	6
4-5	55	22
6-7	79	32
8-9	49	20
> 10	36	15
Total	**246**	**100**

Table 5.5 ISO 9001 Certifications

Companies also certified to ISO 9001	Percent of Total
206	83

5.2.4 Evaluation of Non-Response Bias

In this section, we will analyze the potential effect that non-response bias may have on the results of this study. Non-response bias is a bias that results if non-respondent firms differ significantly from respondents on the issues under investigation. A frequent method for assessing whether non-response issues occurs is to compare early and late responders (Armstrong and Overton, 1977; Narasimhan et al., 2001). It is assumed that respondents that respond late will be more characteristic of non-responders, so a comparison can be made to test the differences between the two groups. To test the potential for this bias, respondents were classified into two groups, early and late. Early respondents were those that completed the survey within the first mailing. Late respondents were defined as those who responded after the follow-up letter. Based on the categorical respondent characteristics (industry and sales), there appears to be no evidence of any differences between early and late respondents based on a chi-square test of differences. Results of the chi-square tests are shown in Table 5.6, which indicates a non-significant difference at the 5% significance level. Additionally, early and late responders were compared in terms of the number of employees and years certified to ISO 14001 via a mean difference t-test. These results are shown in Table 5-7.

Table 5.6 Chi-Square Tests Comparing Early and Late Responders

Category	χ^2	**df**	**p-value**	**Critical** χ^2	**Significant**
Industry	22.182	16	.137	26.30	No
Sales	1.796	7	.970	14.07	No

Critical values were based on a 0.05 significance level; if p<.05 we reject null.

Table 5.7 Comparing Early and Late Responders (t test)

Category	**t-statistic**	**df**	**Two-Tail p-value**	**Critical t-statistic**	**Significant**
Years Certified to ISO 14001	0.245	245	0.807	1.96	No
No. of Employees	.848	245	.398	1.96	No

Critical values were based on a 0.05 significance level; if p<.05 we reject null.

5.3 The Construct Validation Process: Measurement, Refinement and Validation

The next step is to validate the constructs, which is a necessary and major element in the research process (O'Leary and Vokurka, 1998; Netemeyer, Bearden and Sharma, 2003). These authors define construct validity as "representing the correspondence between a construct (conceptual definition of a variable) and the operational procedure to measure or manipulate that construct." There are three steps in the construct validation process (see Fig. 5.1) which include 1) unidimensionality, 2) reliability and, 3) validity. Content validity involves a systematic, theoretically based set of measures to represent a latent construct. Chapter 3 provided the foundation for content validity that led to the items in this research. Construct validity will assess how accurately it measures the construct that it was designed to measure.

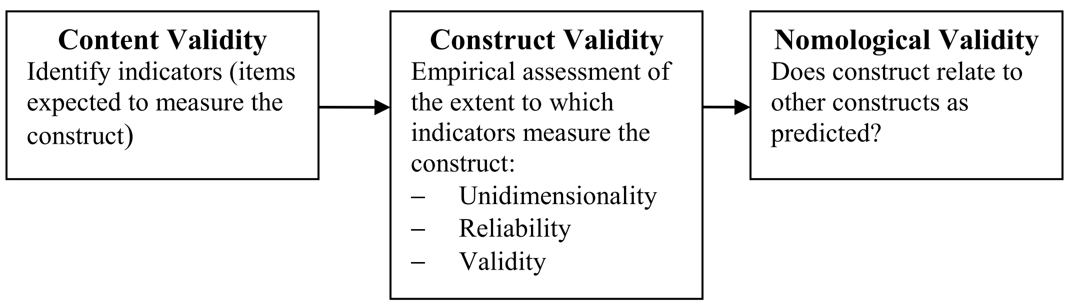


Fig. 5.1 The Content Validation Process. Source: O'Leary-Kelly (1998)

5.3.1 Unidimensionality

Unidimensionality is the existence of one latent construct that underlies a set of measurement items (Hair et al., 1998). Additionally, a set of items can be said to be unidimensional if the correlations among them can be accounted for by a single, common factor (Netemeyer, Bearden, and Sharma, 2003). The initial assessment must address unidimensionality, as further analyses are meaningless without the existence of unidimensional constructs. Gerbing and Anderson (1988) state that "unidimensionality refers to the existence of a single trait or construct underlying a set of measures." To meet the requirements of unidimensionality, a measure must meet two conditions. First, an indicator or an item must be significantly associated with the underlying latent variable and second, it must be associated with only one latent variable. The unidimensionality criteria were examined in this research through confirmatory factor analysis using the SAS PROC CALIS procedure. Confirmatory factor analysis (CFA) assesses whether a pre-determined model effectively fits the data. Goodness of fit indices can be used such as goodness-of-fit index (GFI), root mean square error of approximation (RMSEA), non-normed Fit Indices (NNFI) (Bentler and Bonett 1980) and the Comparative Fit Index (CFI) (Bentler 1990). They are all acceptable approaches to assessing fit (Sharma, 1996).

5.3.2 Reliability

Reliability is the ability of the items to consistently measure the construct. After establishing the unidimensionality of each construct, a reliability assessment is conducted to evaluate the percent of variance in an observed variable that is accounted for by the true scores (i.e., the actual value of the variable of interest). Reliability indicates an instrument, when administered repeatedly to similar groups of respondents, would yield comparable outcomes. The most common aspect of reliability is the internal consistency of the scale, where an internally consistent scale is one in which individual items correlate highly with one another and with the total scale (Hair et al., 1998). Cronbach's (1951) coefficient alpha of .60 (new scales) and .70 (established scales) is recommended (Nunnally, 1994). This indicator ranges from 0 to 1, the higher the index, the higher the reliability. In our case, since the scales were established by previous authors, we will use the rule of thumb of 0.70 or higher for Cronbach's (1951) coefficient alpha.

5.3.3 Convergent and Discriminant Validity

Construct validity focuses on the extent to which a given test is an effective measure of the theoretical construct (Geffen, 2000). Convergent and discriminant validity are two distinct components of construct validity.

Convergent validity is the degree to which varying approaches to construct measurement yield the same results (Campbell and Fiske, 1959). It can be demonstrated when different instruments are used to measure the same construct, and scores from these different items are strongly correlated (Hatch, 1994). Convergent validity can be assessed by evaluating the measurement model for the constructs under consideration. Constructs that theoretically should be related to each other are in fact, observed to be related to each other (DeVellis, 1991). If all factor loadings for the indicators measuring the same construct are statistically significant (greater than twice their standard errors), it is viewed as evidence supporting convergent validity (Anderson and Gerbing, 1988).

In contrast, a scale exhibits discriminant validity if measures of constructs that theoretically should not be related to each other are in fact, observed not to be related to each other (DeVellis, 1991), and which means that dissimilar constructs can be discriminated from one another. In other words, discriminant validity occurs when a scale does not measure the construct it was intended not to measure, and the correlations between the measures of these different constructs are relatively weak. Methods for assessing discriminant validity include the average variance extracted test (Fornell and Larcker, 1981) and the chi-square difference test (Anderson and Gerbing, 1988).

5.3.4 Inter-rater Agreement

After investigating the reliability and convergent validity of the scales, inter-rater agreement was analyzed. A survey was sent to collect a second set of responses from someone equally knowledgeable within the same firm that had previously answered a questionnaire. A total of 41 firms responded, representing nearly 17% (41/246) of the sample. James et al. (1984, 1993) provide a measure for assessing the level of inter-rater agreement using a within-group inter-rater agreement index (r_{wg}). This index will range between 0 and 1 with a suggested cutoff of .71 or higher. Single respondent bias does not appear to exist in our sample, since construct results indicate r_{wg} values ranging from 0.713 to 0.967.

5.4 Assessment of Measurement Properties

This discussion of measurement properties is organized by the following areas; environmental practices, complementary assets, and then the performance of the model in terms of environmental, operational, and organizational metrics. Environmental practices are relative to an organization's implementation of the international standard ISO 14001 and complementary assets include both quality management practices and just-in-time practices. All the scales utilized in this research were created and established by previous authors (Sroufe, 2003; Terziovsky, 1999; Sakakibara, 1993, Zhu et al., 2005; Devraj et al., 2007; Fugate et al., 2009). The descriptive statistics and inter-correlations of the constructs are displayed in Table 5.8.

5.4.1 Analysis of the Environmental Practices and Complementary Asset Constructs

The initial factor analysis of the constructs was generated using eleven factors and sixty-one items (see Table 5.9). The method utilized for this analysis was SPSS, using principle components with Varimax rotation. This analysis resulted in the cross-loading of two factors from the quality practices group – leadership and people management.

Table 5.8 Descriptive Statistics and Inter-correlations with AVE (diagonal)

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
EMS (1)	6.248	.808	.780												
Sup. Chain (2)	3.878	1.709	.392*	.880											
QInfo (3)	6.027	1.103	.333*	.373*	.743										
Cust. Focus (4)	5.983	.876	.342*	.321*	.516*	659									
Leadership (5)	5.284	1.304	.428*	.380*	.539*	.559*	.742								
Prev. Maint.(6)	5.365	1.245	.312*	.299*	.500*	.543*	.611*	.660							
Setup Red.(7)	4.767	1.259	.297*	.416*	.564*	.499*	.555*	.464*	.654						
Vol. Flex.(8)	5.304	1.193	.258*	.341*	.396*	.417*	.448*	.442*	.385*	.677					
Work. Flex.(9)	5.270	1.281	.341*	.374*	.384*	.312*	.583*	.346*	.390*	.554*	.798				
Mix Flex.(10)	5.189	1.394	.151	.199*	.246*	.267*	.310*	.254*	.247*	.504*	.401*	.805			
Ev. Perf.(11)	5.475	.952	.397*	.357*	.325*	.258*	.398*	.333*	.282*	.286*	.398*	.224*	.818		
Op Perf.(12)	5.533	.963	.215*	.234*	.376*	.415*	.544*	.446*	.404*	.485*	.508*	.347*	.342*	.795	
Orgl. Perf. (13)	5.266	.974	.225*	.233*	.385*	.325*	.428*	.433*	.300*	.299*	.358*	.245*	.456*	.544*	

* significant at the .01 level

These two initial scales were established by Samson & Terziovsky (1999), who found these two constructs to be significantly correlated (.69) even though factor analysis had resulted in two distinct scales. As a consequence of this research, some items from both the people and leadership constructs were combined to create a single construct. It was based on our belief that the wording of the scales reflected some redundancy in wording as well as conceptual understanding. This overlap is shown in Table 5.10. The final scales are presented at the end of this chapter (see Table 5.20) and in the appendix.

Table 5.9 CFA Factor Loadings on EMS Practices, Supply Chain Practices and Complementary Asset Constructs (1st Iteration)

Item	CONSTRUCT									
	EMS Practices	Supply Chain Practices	Quality Info	Customer Focus	Leader-ship & People Mgmt.	Preventive Maintenance	Set-up Reduction	Volume Flexibility	Worker Flexibility	Mix Flexibility
EP_1	**.782**	.071	.060	.005	.052	.067	-.004	.112	.102	.006
EP_2	**.833**	.164	.020	.091	.081	.100	.088	.016	.109	.061
EP_3	**.810**	.066	-.012	.150	.174	.084	.008	-.009	.014	-.044
EP_4	**.854**	.095	.052	.017	.189	-.002	.082	-.008	-.011	.052
EP_5	**.830**	.118	.042	.058	.098	.036	.110	.018	.021	-.017
EP_6	**.721**	.240	.038	-.016	.249	.086	.187	.050	.113	.036
EP_7	**.626**	.139	.185	.193	.355	.005	-.182	.001	.080	.150
EP_8	**.709**	.059	.190	.070	.251	-.066	-.043	.103	.161	.033
SCS_1	.178	**.875**	.117	.076	.142	.072	.056	.119	.107	.059
SCS_2	.190	**.876**	.108	.101	.151	.040	.075	.110	.132	.094
SCS_3	.156	**.893**	.096	.083	.149	.028	.081	.076	.155	.014
SCS_4	.166	**.873**	.071	.063	.138	.055	.165	.033	.117	.040
SCS_5	.155	**.872**	.077	.058	.189	.099	.157	.021	.091	.083
QI_1	.047	.034	**.766**	.184	.251	-.053	-.055	.260	-.037	.098
QI_2	.069	.025	**.708**	.163	.311	.029	-.029	.194	.017	.175
QI_3	.110	.122	**.768**	.186	.262	.022	.148	.119	.093	.049
QI_4	.093	.166	**.632**	.052	.183	.255	.307	.010	.084	.028
QI_5	.166	.149	**.642**	.084	.230	.182	.335	.047	.165	.063
QI_6	.040	.117	**.718**	.093	.211	.229	.189	-.121	.184	.102
CF_1	.100	.030	.070	**.643**	.180	.148	.226	.221	-.081	.121
CF_2	.081	.157	.096	**.664**	.259	.061	.204	.103	.113	.074
CF_3	.116	.087	.134	**.765**	.175	.085	.016	.074	.019	.101
CF_4	.065	.053	.280	**.553**	.304	.252	-.044	.054	.134	.032
CF_5	.160	.093	.347	**.556**	.266	.138	.132	-.065	.094	.035
LE_1	.165	.136	.249	.288	**.733**	.161	.051	.045	.055	.072
LE_2	.119	.128	.132	.122	**.801**	.098	.079	.106	.144	.086
LE_3	.164	.179	.221	.132	**.802**	.141	.124	.093	.068	.108
LE_4	.139	.102	.178	.081	**.796**	.158	.038	.197	.104	.124
LE_5	.058	.115	.197	.167	**.737**	.112	.089	.169	.153	.146
LE_6	.319	.233	.067	.151	**.600**	.089	.168	.179	.132	.199
PE_1	.218	.077	.227	.243	**.625**	.062	.074	.045	.201	.126
PE_2	.204	.129	.125	.106	**.678**	.073	.201	-.048	.159	-.032
PE_3	.182	.085	.148	.144	**.791**	.085	.085	.066	.210	.104
PE_4	.056	.082	.090	.262	**.650**	.078	.303	-.107	.159	-.037
PE_5	.144	.016	.142	-.006	**.586**	.202	.135	-.019	.227	.061
PE_6	.131	.113	.040	.036	**.710**	.097	.166	.096	.349	.116
PE_7	.183	.068	.149	.040	**.711**	.115	.083	.132	.264	.159
PM_1	.139	.077	.256	.167	.421	**.376**	-.117	.237	.119	.161
PM_2	.173	.012	.188	.142	.435	**.678**	.057	.192	.007	.026
PM_3	.170	.078	.228	.228	.479	**.608**	.074	.190	.017	.091
PM_4	.035	.149	.041	.105	.212	**.646**	.184	.149	-.055	-.004
PM_5	.020	.075	.153	.253	.276	**.587**	.078	.024	.260	.143
SU_1	.107	.090	.330	.314	.148	-.054	**.548**	.237	.010	-.037
SU_2	.092	.182	.219	.104	.254	.059	**.739**	.087	.101	-.013
SU_3	.030	.144	.138	.029	.307	.140	**.605**	.062	.233	.164
SU_4	.084	.220	.077	.187	.266	.167	**.654**	.032	.040	.121
VF_1	.094	.076	.176	.120	.016	.194	.208	**.689**	.181	.179
VF_2	.055	.064	.189	.119	.153	.136	.025	**.616**	.265	.302
VF_3	.065	.200	.045	.093	.196	.086	.123	**.643**	.279	.158
VF_4	.055	.090	.077	.090	.250	.107	-.033	**.644**	.288	.281
WF_1	.071	.184	.085	.058	.233	.044	.054	.239	**.810**	.175
WF_2	.112	.170	.033	.048	.296	.026	.036	.193	**.832**	.191
WF_3	.143	.093	.045	.106	.335	.029	.093	.196	**.800**	.157
WF_4	.138	.112	.091	.042	.374	.042	.076	.122	**.796**	.124
WF_5	.116	.146	.161	-.017	.284	.029	.119	.115	**.721**	.119
MF_1	.044	.063	.074	.160	-.039	.012	-.012	.081	.263	**.740**
MF_2	.039	.068	.092	.010	.106	.052	.103	.084	.216	**.795**
MF_3	.042	.015	-.024	.027	.167	-.110	.024	.064	-.093	**.839**
MF_4	.062	.039	.092	.005	.214	.009	.057	.168	.010	**.841**
MF_5	-.019	.045	.095	.108	.062	.035	-.042	.179	.100	**.824**
MF_6	.001	.050	.066	.020	.138	.251	.080	.054	.198	**.758**

Table 5.10 Example of Scale Redundancy

Leadership	There is a high degree of unity of purpose throughout our site, and we have eliminated barriers between individuals and/or departments.
People Management	The concept of the "internal customer" (i.e. the next person or process down the line and including all employees) is well understood at our site.

In the second iteration, thirteen items were reduced to nine items and the second iteration of confirmatory factor analysis was conducted which resulted in three scales for quality management practices: quality information, customer focus, and leadership. After combining the cross-loading items into a new scale denoted as LEA (leadership), the factor analysis was conducted and refined again. The final measurement model resulted in all items having significant path loadings and acceptable reliabilities (see Table 5.11). Additionally the fit statistics (CFI, NNFI and RMSEA) calculated in SAS PROC CALIS met suggested minimum values as presented in Table 5.12 (Netemeyer et al., 2003).

The factor analysis indicates that the remaining ten constructs in the research model (the original list had eleven constructs) are unidimensional, which enables subsequent analysis to be performed.

Table 5.11 CFA Factor Loadings on Environmental Practice and Complementary Asset Constructs (2nd iteration)

Item	CONSTRUCT									
	EMS Practices	Supply Chain Practices	Quality Info	Customer Focus	Leader-ship	Preventive Maintenance	Set-up Reduction	Volume Flexibility	Worker Flexibility	Mix Flexibility
EP_1	**.784**	.068	.055	.016	-.009	.048	.005	.130	.107	.016
EP_2	**.837**	.157	.028	.086	.008	.140	.086	.017	.124	.064
EP_3	**.821**	.056	-.036	.159	.121	.124	.032	-.025	.040	-.047
EP_4	**.864**	.072	.060	.024	.159	-.003	.106	-.014	-.004	.042
EP_5	**.831**	.117	.079	.069	.040	.036	.084	.036	.023	-.020
EP_6	**.730**	.239	.075	-.006	.165	.127	.185	.054	.134	.034
EP_7	**.641**	.130	.163	.204	.370	-.012	-.167	.008	.074	.166
EP_8	**.718**	.050	.180	.098	.255	-.119	-.037	.130	.135	.048
SC_1	.189	**.884**	.120	.085	.113	.086	.080	.119	.093	.072
SC_2	.200	**.883**	.122	.108	.127	.047	.092	.118	.118	.107
SC_3	.168	**.898**	.123	.087	.124	.033	.094	.090	.137	.028
SC_4	.182	**.848**	.091	.069	.105	.071	.196	.035	.120	.051
QI_3	.122	.103	**.713**	.236	.231	.028	.128	.150	.094	.071
QI_4	.095	.142	**.742**	.078	.165	.188	.199	.104	.052	.046
QI_5	.168	.129	**.747**	.122	.176	.139	.228	.138	.131	.082
QI_6	.043	.104	**.781**	.150	.184	.145	.109	-.033	.141	.139
CF_1	.114	.012	.015	**.654**	.108	.191	.271	.209	-.065	.111
CF_2	.088	.160	.118	**.678**	.207	.040	.201	.136	.104	.072
CF_3	.121	.082	.085	**.783**	.140	.084	.033	.074	.017	.109
CF_4	.072	.050	.282	**.578**	.272	.236	-.068	.083	.133	.049
CF_5	.165	.093	.372	**.584**	.211	.124	.089	-.024	.099	.050
LEA_2	.158	.113	.137	.148	**.801**	.129	.133	.101	.185	.092
LEA_3	.201	.165	.237	.164	**.783**	.161	.170	.095	.107	.116
LEA_4	.173	.093	.178	.121	**.792**	.176	.083	.194	.132	.131
LEA_5	.086	.114	.197	.207	**.720**	.161	.104	.169	.180	.148
LEA_6	.216	.078	.154	.184	**.736**	.153	.112	.069	.274	.106
LEA_7	.083	.076	.136	.296	**.570**	.133	.320	-.104	.243	-.042
LEA_8	.164	.101	.043	.078	**.636**	.143	.234	.087	.423	.119
PM_2	.189	-.001	.217	.160	.360	**.727**	.048	.191	.050	.041
PM_3	.188	.060	.249	.249	.425	**.623**	.086	.187	.043	.114
PM_4	.041	.143	.097	.105	.143	**.737**	.139	.130	-.027	.000
PM_5	.034	.056	.146	.279	.205	**.543**	.140	.016	.288	.193
SU_1	.114	.068	.361	.318	.103	-.046	**.538**	.258	-.001	-.054
SU_2	.103	.172	.276	.109	.179	.101	**.734**	.088	.115	-.014
SU_3	.048	.113	.166	.045	.251	.103	**.674**	.053	.247	.194
SU_4	.099	.211	.119	.186	.209	.178	**.677**	.035	.034	.134
VF_1	.089	.070	.183	.125	.002	.149	.167	**.739**	.114	.191
VF_2	.057	.076	.157	.138	.137	.120	.003	**.655**	.218	.306
VF_3	.072	.204	.002	.106	.180	.094	.133	**.653**	.262	.161
VF_4	.064	.088	.029	.103	.236	.101	-.018	**.666**	.264	.293
WF_2	.126	.179	.050	.049	.241	.024	.056	.226	**.804**	.231
WF_3	.155	.101	.076	.116	.253	.045	.086	.239	**.811**	.185
WF_4	.153	.113	.112	.058	.279	.067	.089	.151	**.832**	.149
WF_5	.125	.139	.207	.001	.198	.026	.116	.162	**.750**	.130
MF_1	.041	.080	.060	.162	-.073	-.021	-.032	.125	.212	**.757**
MF_2	.049	.057	.056	.012	.109	.032	.124	.094	.175	**.821**
MF_4	-.012	.043	.047	.106	.071	.016	-.034	.200	.047	**.837**
MF_5	.012	.034	.043	.035	.127	.179	.127	.065	.162	**.795**
MF_6	.071	.030	.091	.016	.224	-.006	.050	.197	-.013	**.812**

Table 5.12 Measures of Overall Fit of Complementary Assets

	Chi-Square	df	CFI	RMSEA	NNFI	Constructs Analyzed
Environmental Practices	2617.1	53	.951	.098	.932	▪ EMS Practices ▪ Supply Chain Practices
Quality Practices	250.099	101	.943	.078	.910	▪ Quality Information ▪ Customer Focus ▪ Leadership
JIT Practices	93.283	41	.962	.072	.935	▪ Set-up Reduction ▪ Preventive Maintenance
Flexibility	109.260	62	.979	.056	.952	▪ Volume Flexibility ▪ Worker Flexibility ▪ Mix Flexibility

5.4.1.1 Reliability of the Environmental Practice and Complementary Asset Constructs

Cronbach's coefficient alpha is concerned with the level of interrelatedness among a set of items designed to measure a construct. Similar to coefficient alpha, composite reliability is a measure of the internal consistency of items in a scale. Table 5.13 demonstrates that each of the ten constructs exhibit acceptable levels of both coefficient alpha and composite (or construct) reliability exceeding the suggested 0.70 cutoff value (Cronbach, 1959; Hatcher, 1994). The ten scales in this research range in their alpha values from .747 to .958.

Another internal consistency-based diagnostic is the average variance extracted estimate (AVE). It assesses the amount of variance captured by a set of items in a scale relative to measurement error (Netemeyer et al., 2003). Fornell and Larker (1981) advocate a value of .50 or above, but this test is very conservative and that very often variance extracted estimates will be below .50 even when reliabilities are acceptable. Our AVE values range from .428 to .766.

5.4.1.2 Discriminant Validity of the Environmental Practice and Complementary Asset Constructs

The discriminant validity of the environmental practice and complementary asset constructs is demonstrated when the correlations between the measures of different constructs are relatively weak. Discriminant validity requires that the indicators are unique to the construct and minimal cross loading on other constructs is exhibited and that the constructs are distinct and conceptually unique. Two methods for confirming discriminant validity are 1) the average variance extracted test (AVE) (see Table 5.13), and 2) the chi-square difference test (Hatcher, 1994). Hatcher (1994) recommends that establishing discriminant validity requires that the value for the square root of AVE should exceed the variance shared between the construct and other constructs in the model. Table 5.8 shows that the square root of AVE (in diagonal) is larger than the off diagonal elements in the rows and columns. All constructs were significant at the .001 level when setting exogenous correlation to one. Thus the scales utilized in this research meet both criteria for discriminant validity.

Table 5.13 Reliability of Constructs

Construct and Item	Internal Consistency Reliability		Average Variance Extracted	Composite Reliability	Coefficient Alpha
	Item-to-Total Correlation	Alpha if item deleted			
Environmental Practices			.609	.925	.922
EP_1	.704	.915			
EP_2	.804	.908			
EP_3	.764	.911			
EP_4	.826	.906			
EP_5	.780	.909			
EP_6	.735	.918			
EP_7	.669	.918			
EP_8	.725	.913			
Supply Chain Practices			.766	.929	.957
SC_1	.900	.942			
SC_2	.922	.936			
SC_3	.914	.938			
SC_4	.846	.958			
Quality Information			.552	.831	.870
QI_3	.690	.847			
QI_4	.706	.844			
QI_5	.778	.812			
QI_6	.743	.830			
Customer Focus			.434	.814	.791
CF_1	.567	.789			
CF_2	.650	.763			
CF_3	.623	.772			
CF_4	.588	.784			
CF_5	.603	.777			
Leadership			.550	.935	.939
LEA_2	.844	.919			
LEA_3	.860	.918			
LEA_4	.821	.921			
LEA_5	.786	.926			
LEA_6	.847	.919			
LEA_7	.671	.941			
LEA_8	.756	.927			
Preventive Maintenance			.436	.797	.832
PM_2	.754	.687			
PM_3	.743	.695			
PM_4	.544	.830			
PM_5	.528	.785			
Set-Up Time Reduction			.428	.806	.809
SU_1	.526	.800			
SU_2	.728	.706			
SU_3	.621	.758			
SU_4	.639	.756			

Volume Flexibility			.458	.771	.828
VF_1	.632	.793			
VF_2	.663	.782			
VF_3	.644	.789			
VF_4	.685	.769			
Worker Flexibility			.637	.875	.935
WF_2	.874	.907			
WF_3	.889	.902			
WF_4	.893	.901			
WF_5	.761	.952			
Mix Flexibility			.648	.902	.896
MF_1	.688	.886			
MF_2	.766	.869			
MF_4	.760	.870			
MF_5	.785	.865			
MF_6	.725	.878			

5.4.2 Analysis of the Performance Constructs

The performance constructs consist of three performance scales as listed in Table 5.14. The study proposes that both environmental performance and operational performance will have a positive influence on organizational performance. Two of the scales, environmental performance and operational performance, are reflective and the organizational performance scale is formative. A distinction between formative and reflective measures is important because proper specification of a measurement model is necessary prior to the establishment of assigning meaning to the structural model (Anderson and Gerbing, 1988). Coltman et al. (2008) define a "reflective or effect" model as one where the latent construct exists independent of the measures (i.e. measures of attitudes and personality). Hence, in formative models, a change in the indicators results in a change in the construct under analysis (Coltman et al., 2008). Since the organizational performance scale is formative, partial least squares methodology (PLS) will be used to analyze these relationships.

Table 5.14 Performance Constructs (Type of Scale)

Scale	No. of Items	Type of Scale
Environmental Performance	6	Reflective
Operational Performance	6	Reflective
Organizational Performance	5	Formative

The initial CFA of the two reflective performance constructs was generated using two factors and fourteen items employing SAS PROC FACTOR with principle components and Varimax rotation. The first iteration of the confirmatory factor analysis (Table 5.15) resulted in poor fit statistics (RMEA = .15, CFI = .84, NNFI = .82). The operational performance construct was refined to eliminate two items (OpPerf_2 and OpPerf_3). The final CFA (Table 5.16) indicates that the constructs are unidimensional which enables subsequent analysis to be performed and the acceptable fit statistics are shown in Table 5.17. Convergent validity was demonstrated by the fact that the factor analyses resulted in items that loaded significantly on a single factor.

Table 5.15 CFA Factor Loadings on Performance Constructs, First Iteration)

Item	CONSTRUCT	
	Environmental Performance	Operational Performance
EPerf_1	**0.80238**	0.16164
EPerf_2	**0.79905**	0.06002
EPerf_3	**0.79184**	0.19590
EPerf_4	**0.83118**	0.15135
EPerf_5	**0.81060**	0.14186
EPerf_6	**0.87127**	0.14523
OpPerf_1	0.03768	**0.75264**
OpPerf_2	0.11416	**0.77238**
OpPerf_3	0.12912	**0.85993**
OpPerf_4	0.14126	**0.84695**
OpPerf_5	0.20437	**0.78407**
OpPerf_6	0.18687	**0.80879**
OpPerf_7	0.21973	**0.71276**
OpPerf_8	0.09826	**0.79144**

Table 5.16 CFA Factor Loadings on Performance Constructs (2^{nd} Iteration)

Item	CONSTRUCT	
	Environmental Performance	Operational Performance
EPerf_1	**0.79932**	0.17113
EPerf_2	**0.79986**	0.05869
EPerf_3	**0.79530**	0.18289
EPerf_4	**0.83163**	0.15133
EPerf_5	**0.80958**	0.14909
EPerf_6	**0.87116**	0.14725
OpPerf_1	0.04944	**0.70437**
OpPerf_4	0.14771	**0.81271**
OpPerf_5	0.19578	**0.80816**
OpPerf_6	0.17456	**0.84335**
OpPerf_7	0.20392	**0.76190**
OpPerf_8	0.08538	**0.82947**

Table 5.17 Measures of Overall Fit of Performance Constructs

Chi-Square	df	CFI	RMSEA	NNFI
158.68	53	.94	.09	.91

5.4.2.1 Reliability of the Performance Constructs

Table 5.18 demonstrates acceptable levels for both the coefficient alpha and composite (construct) reliability exceeding the suggested 0.70 cutoff value as assessed by common methods of analysis (Cronbach, 1959; Hatcher, 1994). AVE values exceed 0.6. The performance constructs meet both methods for confirming discriminant validity 1) the variance extracted test, and 2) the chi-square difference test (Hatcher, 1994). Discriminant validity for these constructs is demonstrated in Table 5.8 that shows that the square root of AVE (in diagonal) is larger than the off diagonal elements in the rows and columns.

Table 5.18 Reliability of Dependent Performance Measures

Construct and Item	Internal Consistency Reliability		Average Variance Extracted	Composite Reliability	Coefficient Alpha
	Item-to-Total Correlation	Alpha if item deleted			
Environmental Performance			.632	.911	.910
EPerf_1	.732	.896			
EPerf_2	.706	.900			
EPerf_3	.732	.896			
EPerf_4	.767	.891			
EPerf_5	.738	.896			
EPerf_6	.821	.883			
Operational Performance			.670	.924	.892
OpPerf_1	.588	.892			
OpPerf_4	.737	.870			
OpPerf_5	.741	.870			
OpPerf_6	.782	.862			
OpPerf_7	.689	.877			
OpPerf_8	.739	.870			

5.4.2.2 SmartPLS Modeling

The relationships between the reflective and formative constructs to evaluate the relationships between both operational and environmental performance on organizational performance were evaluated using SmartPLS path modeling software utilizing the technique of partial least squares (PLS). Traditional assessment techniques developed to evaluate convergent and discriminant validity of reflective constructs are generally not applicable to formative constructs. The appropriateness of this technique and the standardization of indicators are described in Chin (2003). PLS is similar to regression, but simultaneously models the structural paths and the theoretical relationship among the latent variables. Again, since the organizational performance scale was formative, PLS was used to model these relationships with environmental practices as the independent variable (Fig. 5.2). The SmartPLS bootstrap technique resulted in the path t-values significant at the 0.01 level (> 2.57), with the exception of the relationship between EMS practices and operational performance (p=.055). Additionally outer loadings were acceptable and above the 0.7 threshold as noted by Hulland (1999) and the reported quality criteria establish an acceptable model fit (see Table 5.19).

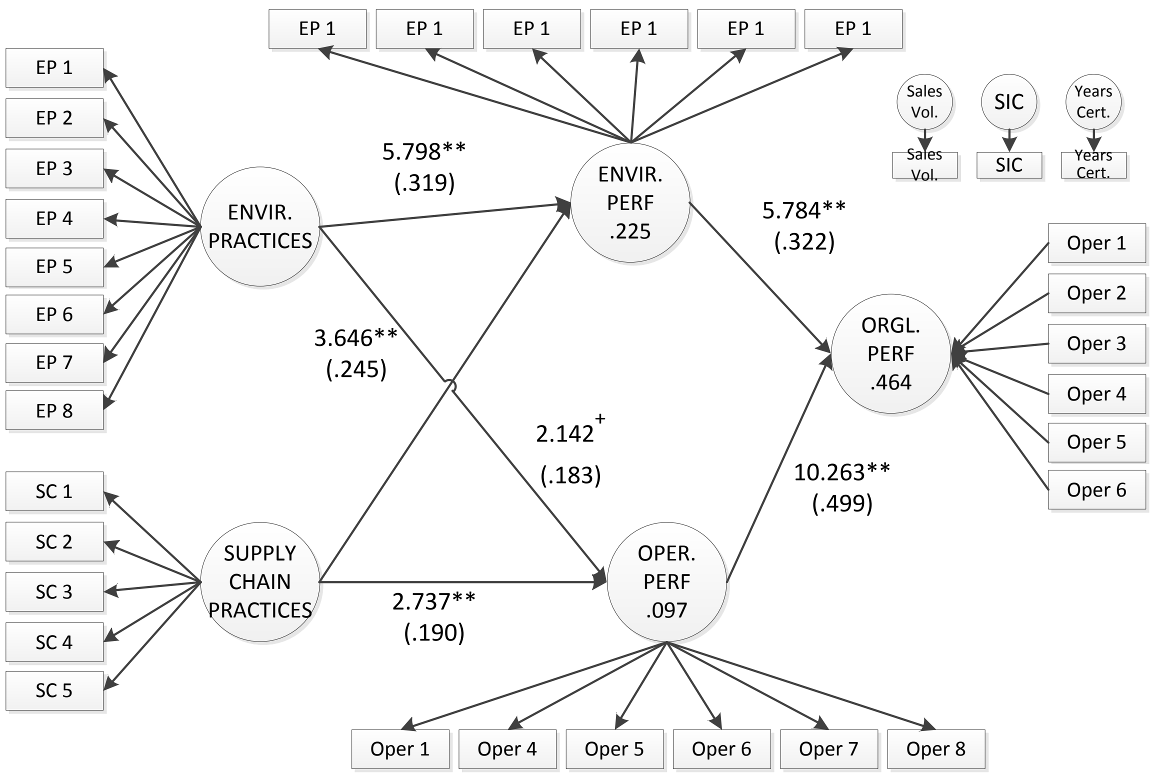


Fig. 5.2: PLS Model

$^{**}p < .01$ $^{+}p = .032$

Controls: Industry sector, sales volume and number of years certified

Table 5.19 PLS Quality Criteria (SmartPLS)

	AVE	Composite Reliability	R-Square	Cronbach's Alpha	Outer/Inner Loadings
EMS Practices	.663	.940	+	.928	.77 - .86
Environmental Performance	.690	.930	.216	.910	.79 - .89
Operational Performance	.647	.936	.078	.922	.70 - .86
Organizational Performance	+	+	.464	+	.65 - .96
Supply Chain Practices	.878	.973	.153	.965	

+ not reported in SmartPLS for "formative" constructs.

5.4.3 Summary of Measurement Refinement and Validation

Table 5.20 Final Scales for Complementary Assets

Quality Information
- Cost of quality data concerning our primary product is readily available (QI3).
- Quality information is displayed at most of the work stations (QI4).
- Progress toward quality-related goals is displayed in our site (QI5).
- Progress toward quality-related goals is displayed in our site (QI6).

Customer Focus
- We know our external customers' current and future requirements (both in terms of volume and service characteristics) (CF1).
- The requirements of our customers are effectively disseminated and understood throughout our site and our workforce (CF2).
- We use the requirements of customers in designing new products and services at our site (CF3).
- We use customer complaints as a method to initiate improvements in our current processes (CF4).
- We systematically and regularly measure external customer satisfaction at our site (CF5).

Leadership
- There is a high degree of unity of purpose throughout our site, and we have eliminated barriers between individuals and/or departments (LEA2)
- Senior Mangers effectively drive "Best Practices" at this site (LEA3)
- At this site we proactively pursue continuous improvement rather than reacting to crisis' "fire-fighting" (LEA4)
- Ideas from employees are actively used in assisting management at this site (LEA5).
- Our site has effective 'top–down' and 'bottom–up' communication processes (LEA6).
- We formally and regularly measure employee satisfaction at our site (LEA7).
- Employee flexibility, multi-skilling and training are actively used to support improved performance at our site (LEA8).

Preventive Maintenance
- We dedicate a portion of everyday to preventive maintenance (PM2).
- We emphasize good maintenance as a strategy for achieving quality and schedule compliance (PM3).
- We have a separate shift, or part of a shift, reserved each day for maintenance activities (PM4).
- We have a relatively low rate of downtime for repair, compared with our industry (PM5).

Set-up Reduction
- We are aggressively working to lower setup times at our site (SU1).
- We have converted most of the setup times to external time while the machine is running (SU2).
- We have low setup times of equipment at our site (SU3).
- Our crews practice setups to reduce the time required (SU4).

Volume Flexibility

- Production processes and equipment at our site give us the capability to produce high volume levels (VF1).
- Our site can significantly (> +/-25%) increase (or decrease) output levels to support fluctuations in demand (VF2).
- When we increase (or decrease) our site's volume levels we do not experience more than proportionally higher (or lower) production costs (VF3).
- When we increase (or decrease) our site's volume levels we do not experience more than proportionally higher (or lower) product quality problems (VF4).

Worker Flexibility

- At our site, workers can perform a broad range of tasks effectively (WF2).
- At our site, a typical worker can use many different tools effectively (WF3).
- At our site, workers can operate various types of machines and/or equipment (WF4).
- At our site, workers can be transferred easily between different departments (WF5).

Mix Flexibility

- We can produce a wide variety of products at our site (MF1).
- At our site we can produce different product types without major changeover (MF2).
- At our site we can produce (simultaneously or periodically), multiple products in a steady-state operating mode (MF4).
- At our site we can vary product combinations from one period to the next (MF5).
- At our site we can changeover quickly from one product to another (MF6).

Table 5.21 Final Scale for Environmental Management and Supply Chain Practices

Environmental Management Practices

- We formally document and implement environmental management system procedures at our site (EP1).
- We include environmental issues and policies in training and communication activities at our site (EP2).
- We have formal roles, responsibilities and authority for environmental affairs at our site (EP3).
- We regularly track and monitor environmental information regarding environmental impact at our site (EP4).
- We formally track and report environmental performance at our site (i.e. goals, programs, objectives & targets) (EP5).
- We widely distribute and give visibility to environmental performance at our site (i.e. goals, programs, objectives & targets) (EP6).
- Top management at our site supports environmental performance and prevention of pollution (EP7).
- People within our site consider our system to be effective at meeting our goals, objectives and targets (EP8).

Supply Chain Practices

- We achieve environmental goals collectively with our primary suppliers (SC1).
- We develop a mutual understanding of responsibilities regarding environmental performance with our primary suppliers (SC2).
- We work together with our primary suppliers to reduce environmental impact of our activities (SC3).
- We conduct joint planning with our primary suppliers to anticipate and resolve environmental-related problems (SC4).

Table 5.22 Final Scales for Performance Constructs

Environmental Performance

- Reduced our site's air emissions (EPerf1).
- Reduced our site's waste water (EPerf2).
- Reduced our site's solid wastes (EPerf3).
- Decreased our site's consumption for hazardous/harmful/toxic materials (EPerf4).
- Decreased our site's frequency of environmental accidents (EPerf5).
- Improved our site's overall environmental situation (EPerf6).

Operational Performance

- Percent product returned by the customer (OpPerf1).
- Delivery reliability (OpPerf4).
- Production costs (OpPerf5).
- Production lead time (OpPerf6).
- Inventory turns (OpPerf7).
- The flexibility of operations to accommodate changes to shipping schedules within the effective lead time of the product without the use of safety tock (OpPerf8).

Organizational Performance

- Overall performance (OrgPerf1).
- Market share growth in our primary market (OrgPerf2).
- Sales growth (OrgPerf3).
- Percentage of new product sales generated by new products (OrgPerf4).
- Return on sales (OrgPerf5).
- Return on investments (OrgPerf6).

5.5 Chapter Summary

This chapter discussed the profiles of respondents, followed by an evaluation of non-response bias. Results from this analysis indicated that non-response bias is not a significant concern, as differences were not noted between early and late responders. Subsequently, the measures for each construct were refined through an analysis of unidimensionality, reliability, and both convergent and discriminant validity. This construct analysis will become the basis for the moderator regression analysis in Chapter 6, which is presented next.

CHAPTER SIX

Examination of the Hypotheses

6.0 Introduction

The psychometric properties of the constructs were examined and assessed in Chapter Five. The intent of this chapter is to test the validity of the hypotheses, and the strength of the complementary assets or moderating variables as interaction effects on the base relationships. The purpose of this chapter is to understand what capabilities are important in moderating the relationship between environmental practices and performance.

6.1 Examination of the Base Relationships

The analysis of the base relationships between environmental practices, and both environmental and operational performance discussed in extant research (Sroufe, 2003; King and Lenox, 2001b) are shown later on in Tables 6.4 and 6.5 when the hypotheses are tested. As expected, the base relationships were supported at the $p < .01$ significance level. The real motivation of this dissertation research is to expand upon this confirmed base relationship in order to understand the impact of moderators or complementary assets in order to understand how environmental practices may be enhanced for better performance by other internally-driven managerial actions and programs. The moderating relationships will be tested by using mean-centered multiple regression.

6.2 Statistical Conclusion Error (Power)

An analysis of statistical power depends on the significance criterion, the sample size and the population effect size (Cohen, 1992). The value of power analysis for our regression analysis is to avoid making a Type I error by mistakenly rejecting H_0 when in fact it is true. In our research, we test the probability that the regression coefficient is not equal to zero and that a relationship exists. The base relationships have been established in existing research, and are also conclusive here. A post-hoc analysis with alpha = .05 was conducted to determine the power of this research (Table 6.1). The power values calculated in Table 6.1 give us confidence that our sample size of 246 respondents has adequate statistical power.

Table 6.1 Power Analysis of the Base Relationships

EMS Practices	**R^2**	**Power**
E Perf	.164	.99
E Perf	.136	.99
Oper. Perf.	.055	.97

6.3 Tests for Multicolinearity

In order to interpret the regression variable, the impact of multicolinearity must be examined (Hair et al., 1998). The variance inflation factors (VIF) are presented in Table 6.6. Large VIF values indicate a high degree of collinearity or multicolinearity among the independent variables. An analysis of the variance inflation factors revealed no serious multicolinearity issues in any of the regression models.

6.4 Testing the Moderators (Complementary Assets)

Hypotheses 1 and 2 posit that operational and environmental performance will be moderated by complementary assets in a positive manner. Regression analysis is used to test these hypotheses in Figure 3.6.

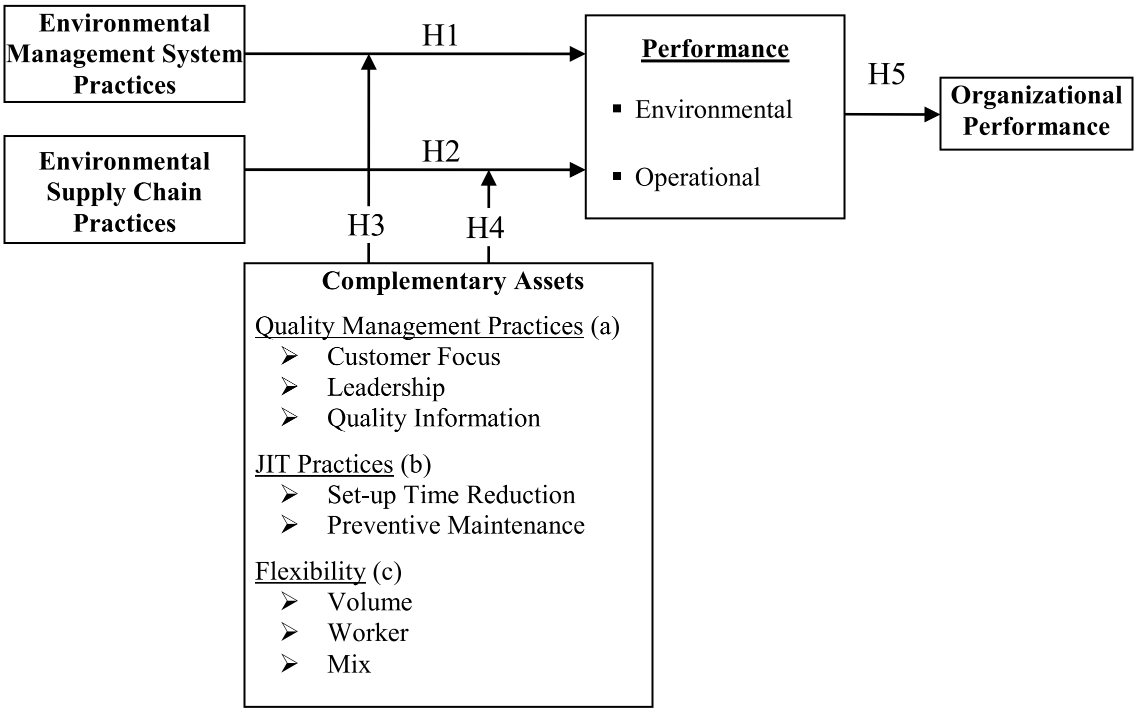


Fig. 3.6 Hypotheses of the Environmental Performance Model

6.4.1 Testing of the Moderator Variables

This research will discuss two types of moderation – pure and quasi (Fig. 6.2) as discussed by Sharma et al. (1981). Identifying the type of moderator variable is important to the research in terms of drawing conclusions and implications from the research. A ***pure moderator*** contains a significant interaction between the predictor (x) and the moderator; while a significant relationship between the moderator and the dependent variable does not exist (Table 6.3).

Table 6.2 Categorization of Moderated Regression Analysis

Predictor (base relationship)	$b_2 \neq 0$	$b_3 = 0$
Pure moderator	$b_2 = 0$	$b_3 \neq 0$
Quasi-moderator	$b_2 \neq 0$	$b_3 \neq 0$

A pure moderator "enters into the interaction with predictor variables, while having a negligible correlation with the criterion itself." If a significant relationship between the moderator and dependent variable exists, the interaction term is determined to be a ***quasi moderator***. The quasi moderator not only interacts with the predictor variable but is also a predictor variable. In this case, the moderator variable can be justified on theoretical grounds to modify the primary relationship (Sharma et al., 1981).

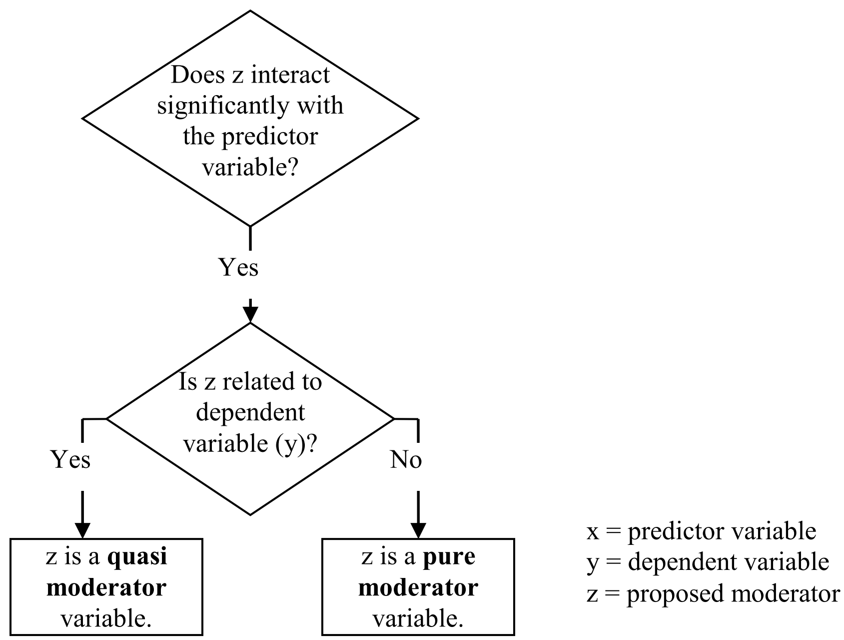


Fig. 6.1 Framework for Identifying Moderator Variables (Sharma et al. (1981)

In order to mitigate any potential effects of multicollinearity, we employed "centering" as recommended by Neter et al. (1985). Multicolinearity can be a significant problem leading to inflated standard errors and misinterpretation of the statistical significance of the regression results (Jaccard et al., 1990). Multicolinearity can cause very low overall p values, yet have high individual p values. This may occur when two predictor (x) variables are highly correlated. One way multicolinearity can be reduced is by "centering" the variables if an interaction term is included. The independent variables were centered to reduce the effects of multicolinearity.

Tables 6.4 and 6.5 present the summary and depict the interaction effects of the moderating relationships tested based on the strength of the relationships. The results of the regression analysis show that there are no pure moderating relationships, yet "quasi-moderators" are present.

Table 6.3 Regression Analysis: Predictor = Environmental Management System Practices (EMS)

Dependent Var.	Model 1		Complementary Asset (Moderator)	Model 2			Model 3				Graph
	B_1	R^2		B_1	B_2	R^2	B_1	B_2	B_3	R^2	
Environmental Performance	.405***	.164	Quality Information	.379***	.203***	.214	.357***	.266***	.187**	.248	1
			Customer Focus	.404***	.163+	.184	.387***	.201**	.096	.191	
			Leadership	.332***	.206***	.228	.328***	.249***	.106**	.250	6
			Preventive Maintenance	.384***	.176***	.212	.390***	.211***	.131**	.236	8
			Set-up Time Reduction	.404***	.143**	.197	.392***	.149***	.051	.201	
			Volume Flexibility	.400***	.158**	.201	.382***	.180***	.112+	.218	10
			Worker Flexibility	.344***	.218***	.240	.162	.229***	.065	.246	
			Mix Flexibility	.432***	.110**	.189	.418***	.107**	.062	.195	
Operational Performance	.246***	.061	Quality Information	.155+	.334***	.186	.143	.370***	.106	.196	
			Customer Focus	.130	.443***	.196	.121	.462***	.048	.198	
			Leadership	.012	.439***	.330	.011	.458***	.046	.334	
			Preventive Maintenance	.145	.327***	.213	.146	.331***	.015	.213	
			Set-up Time Reduction	.164+	.309***	.201	.169+	.305***	-.026	.202	
			Volume Flexibility	.139	.380***	.256	.148+	.369***	-.057	.261	
			Worker Flexibility	.085	.381***	.276	.117	.379***	-.012	.277	
			Mix Flexibility	.226**	.231***	.162	.253***	.236***	-.127	.185	

***$p < .001$ **$p < .010$ +$p < .050$
Model 1: $y = int + B_1X$ Model 2: $y = int + B_1X + B_2Z$ Model 3: $y = int + B_1X + B_2Z + B_3XZ$
Controls: Industry sector, sales volume and number of years certified

Table 6.4 Regression Analysis: Predictor = Environmental Supply Chain Practices (SC)

Dependent Var.	Model 1		Complementary Asset (Moderator)	Model 2			Model 3				Graph
	B_1	R^2		B_1	B_2	R^2	B_1	B_2	B_3	R^2	
Environmental Performance	.331***	.110	Quality Information	.148***	.221***	.167	.125**	.352***	.140***	.221	2
			Customer Focus	.167***	.201**	.140	.147***	.273***	.142**	.172	4
			Leadership	.136***	.239***	.201	.123**	.272***	.082**	.228	7
			Preventive Maintenance	.164***	.203**	.175	.155***	.258***	.113***	.217	9
			Set-up Time Reduction	.158***	.144**	.139	.152***	.161**	.051	.150	
			Volume Flexibility	.162***	.171***	.151	.153***	.193***	.101**	.188	11
			Worker Flexibility	.132**	.241***	.202	-.079	.261***	.074**	.224	12
			Mix Flexibility	.186***	.118**	.138	.184***	.120**	.058+	.154	13
Operational Performance	.219**	.048	Quality Information	.055	.344***	.177	.040	.427***	.089+	.198	3
			Customer Focus	.056	.453***	.193	.043	.501***	.092+	.205	5
			Leadership	.017	.436***	.331	.013	.447***	.026	.333	
			Preventive Maintenance	.076	.333***	.212	.073	.351***	.037	.216	
			Set-up Time Reduction	.036	.321***	.188	.037	.319***	-.007	.184	
			Volume Flexibility	.043	.390***	.248	.040	.397***	.033	.252	
			Worker Flexibility	.025	.390***	.274	-0.033	.395***	.020	.275	
			Mix Flexibility	.104+	.234***	.152	.104+	.234***	-.004	.152	

***$p < .001$ **$p < .010$ +$p < .05$
Model 1: $y = int + B_1X$ Model 2: $y = int + B_1X + B_2Z$ Model 3: $y = int + B_1X + B_2Z + B_3XZ$
Controls: Industry sector, sales volume and number of years certified

Table 6.3 VIF Values

Dependent Variable	Complementary Asset (Moderator)	Model 2	Model 3	
		VIF	VIF_1	VIF_2
Environmental Performance	Quality Information	1.114	1.276	1.146
	Customer Focus	1.132	1.308	1.155
	Leadership	1.225	1.381	1.150
	Preventive Maintenance	1.108	1.194	1.097
	Set-up Time Reduction	1.097	1.116	1.026
	Volume Flexibility	1.071	1.109	1.039
	Worker Flexibility	1.131	1.168	1.032
	Mix Flexibility	1.023	1.025	1.025
Operational Performance	Quality Information	1.180	1.128	1.149
	Customer Focus	1.147	1.329	1.178
	Leadership	1.256	1.412	1.152
	Preventive Maintenance	1.121	1.207	1.101
	Set-up Time Reduction	1.110	1.127	1.030
	Volume Flexibility	1.087	1.128	1.046
	Worker Flexibility	1.144	1.181	1.424
	Mix Flexibility	1.049	1.051	1.029

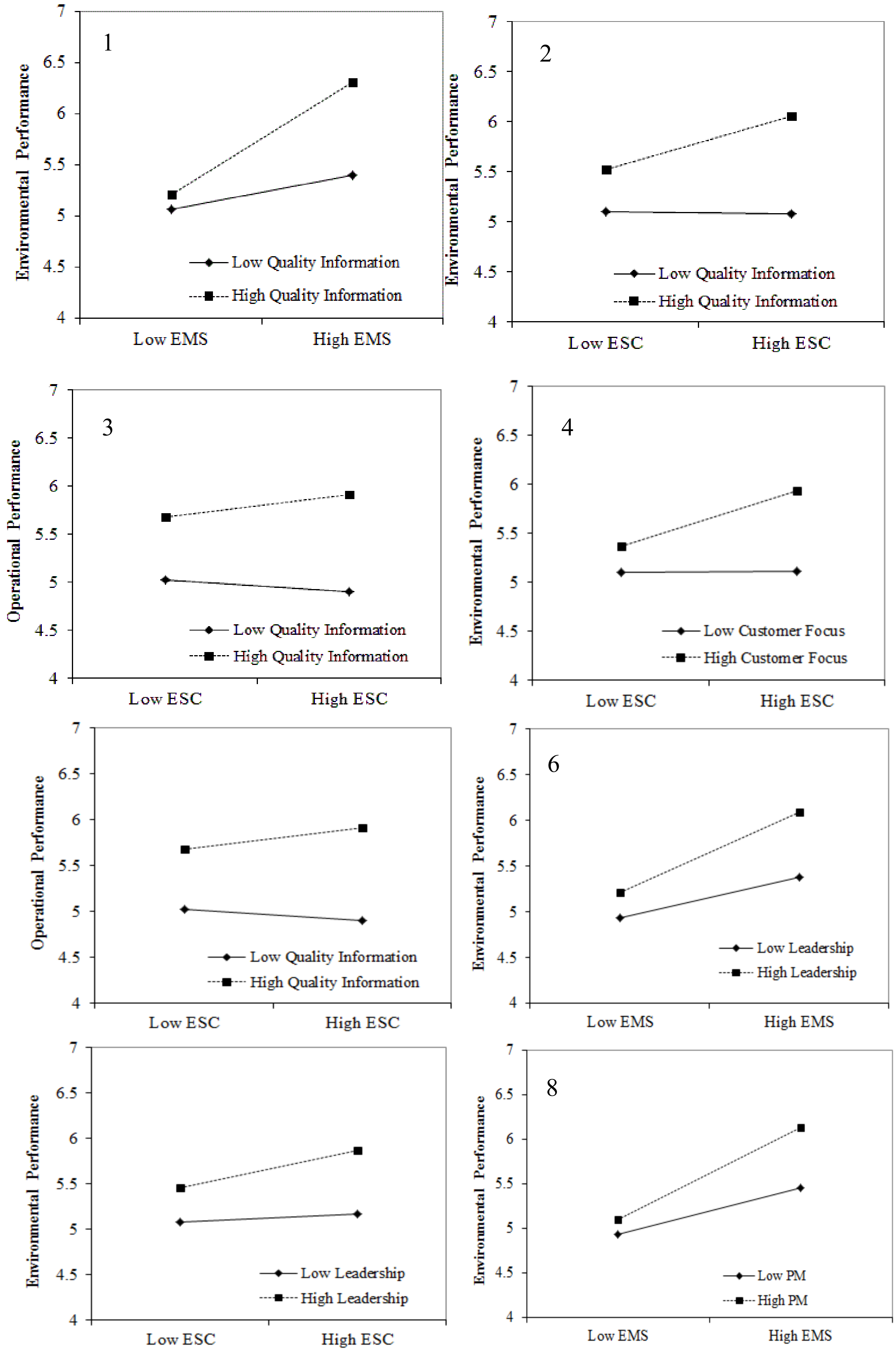
Dependent Variable	Complementary Asset (Moderator)	Model 2	Model 3	
		VIF	VIF_1	VIF_2
Environmental Performance	Quality Information	1.158	1.627	1.407
	Customer Focus	1.115	1.268	1.137
	Leadership	1.168	1.272	1.09
	Preventive Maintenance	1.098	1.237	1.127
	Set-up Time Reduction	1.210	1.281	1.060
	Kanban	1.046	1.054	1.009
	Volume Flexibility	1.132	1.177	1.040
	Worker Flexibility	1.163	1.199	1.033
	Mix Flexibility	1.041	1.042	1.001
Operational Performance	Quality Information	1.158	1.627	1.407
	Customer Focus	1.115	1.268	1.137
	Leadership	1.168	1.272	1.090
	Preventive Maintenance	1.098	1.237	1.127
	Set-up Time Reduction	1.210	1.281	1.060
	Kanban	1.046	1.054	1.009
	Volume Flexibility	1.132	1.177	1.040
	Worker Flexibility	1.163	1.199	1.033
	Mix Flexibility	1.041	1.042	1.001

6.4.2 Moderating Relationships Results

Hypotheses H3 and H4 posit that quality practices, JIT practices, and flexibility practices moderate the relationships between the two predictor variables, 1) environmental management practices, and 2) environmental supply chain practices with performance. Regression analysis was used to test these hypotheses using mean-centered variables and the framework of pure and quasi moderators established by Sharma et al. (1981). Table 6.7 summarizes the regression results.

Table 6.6 Moderator Summary

QUALITY PRACTICES		
Predictor	**Dep. Variable**	**Interaction**
Quality Information (Moderator)		
EMS (1)	Environmental Performance	Quasi
ESC (2)	Environmental Performance	Quasi
ESC (3)	Operational Performance	Quasi
Customer Focus (Moderator)		
ESC (4)	Environmental Performance	Quasi
ESC (5)	Operational Performance	Quasi
Leadership (Moderator)		
EMS (6)	Environmental Performance	Quasi
ESC (7)	Environmental Performance	Quasi
JIT PRACTICES		
Predictor	**Dep. Variable**	**Interaction**
Preventive Maintenance (Moderator)		
EMS (8)	Environmental Performance	Quasi
ESC (9)	Environmental Performance	Quasi
FLEXIBILITY		
Predictor	**Dep. Variable**	**Interaction**
Volume Flexibility (Moderator)		
EMS (10)	Environmental Performance	Quasi
ESC (11)	Environmental Performance	Quasi
Mix Flexibility (Moderator)		
EMS (12)	Operational Performance	Quasi
ESC (14)	Environmental Performance	Quasi
Worker Flexibility (Moderator)		
ESC (13)	Environmental Performance	Quasi


1
Environmental Performance
Low EMS
High EMS
Low Quality Information
High Quality Information
2
Environmental Performance
Low ESC
High ESC
Low Quality Information
High Quality Information
3
Operational Performance
Low ESC
High ESC
Low Quality Information
High Quality Information
4
Environmental Performance
Low ESC
High ESC
Low Customer Focus
High Customer Focus
Operational Performance
Low ESC
High ESC
Low Quality Information
High Quality Information
6
Environmental Performance
Low EMS
High EMS
Low Leadership
High Leadership
Environmental Performance
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Low Leadership
High Leadership
8
Environmental Performance
Low EMS
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Low PM
High PM

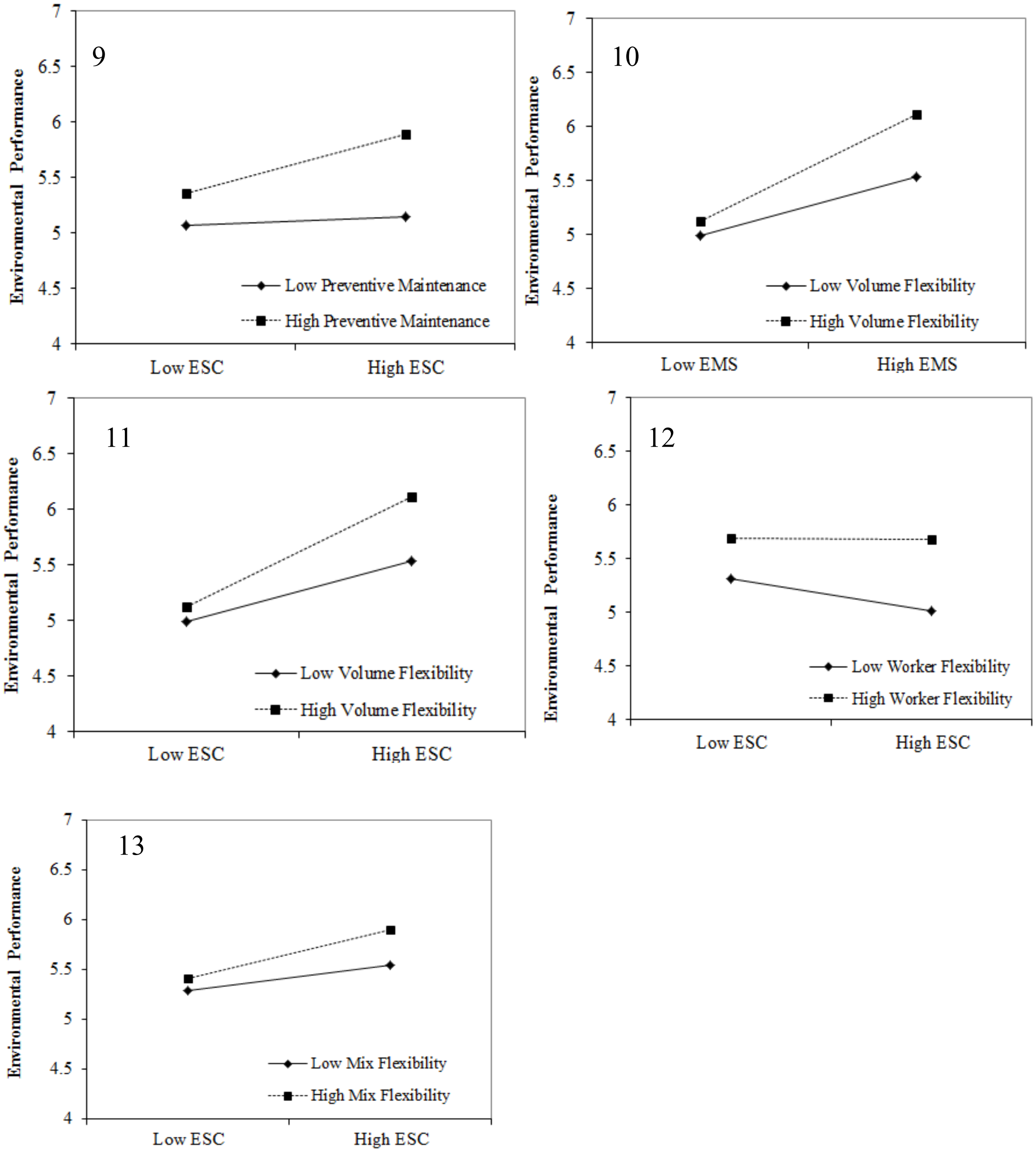

Fig. 6.2 Significant Interactions

Figure 6.2 displays the two-way interaction between the independent and dependent variables as moderated by a third variable (moderator), using procedures by Aiken and West (1991). The plots represent the lines as they are predicted as one standard deviation above and below the mean of the moderator. An ordinal interaction effect is indicated by nonparallel lines that do not intersect (Jaccard and Turrisi, 2003).

6.5 Results of the Structural Model

The structural model to examine the relationships between environmental performance and operational performance was conducted using SmartPLS given that the operational performance construct was formative (Chin, 2003). The objective of the SmartPLS modeling technique is to understand and conclude as to whether firms with higher environmental and operational performance influenced and supported firms' organizational performance. The model confirmed and suported Hypothesis 5 that both enviromental performance and operational performance support organizational performance (Fig. 5.2). The results are shown below in Table 6.8.

Table 6.7 Results of Hypotheses

Hypotheses					
1	There is a positive relationship between **environmental management system practices** and **performance.**				**Supported**
2	There is a positive relationship between **environmental management system practices** and **performance.**				**Supported**
		EMS Practices (Predictor)		**SC Practices (Predictor)**	
		Environmental	**Operational**	**Environmental**	**Operational**
3(a) 4(a)	**Quality Practices**				
	Quality Information	***Moderator***	Not supported	***Moderator***	***Moderator***
	Customer Focus	Not supported	Not supported	***Moderator***	***Moderator***
	Leadership	***Moderator***	Not supported	***Moderator***	Not supported
3(b) 4(b)	**JIT Practices**				
	Preventive Maintenance	***Moderator***	Not supported	***Moderator***	Not supported
	Set-up Reduction	Not supported	Not supported	Not supported	Not supported
3(c) 4(c)	**Flexibility**				
	Volume	***Moderator***	Not supported	***Moderator***	Not supported
	Worker	Not supported	Not supported	***Moderator***	Not supported
	Mix	Not supported	Not supported	***Moderator***	Not supported
5	Environmental and operational performance will be positively associated with organizational performance.				**Supported**
6	Environmental management system practices will be positively associated with Environmental supply chain practices.				**Supported**

6.6 Discussion of Hypotheses

6.6.1 Quality Practices (H3a and H4a)

Quality management practices such as quality information, customer focus and leadership moderate all quality practice to performance relationships. Popular initiatives such as total quality management have an extant research base that suggests that quality techniques can enhance and complement environmental management. Although the drivers for quality and environmental programs are different (Angell; 2001), organizations with quality programs such as TQM or ISO 9001 have developed many of the features in common with environmental programs. These common topics in ISO 14001 and ISO 9001 include management commitment, internal auditing, document and record management, and operational control.

Quality coordination and reduction of waste activities became initiatives in the 1980's to improve quality prior to the recent shift towards a more prevalent environmental movement (Christmann; 2000). It is no surprise that ISO 14001 certified organizations are aligning their environmental programs with well-established quality programs that make the most of factual data and information to monitor progress towards both quality and environmental initiatives. The resourceful use of information and the communication of that information are pertinent to any organization involved in strategic environmental management.

The moderating effect of leadership provides evidence that the effective deployment of "best practices" to all departments and levels of the enterprise contributes to environmental performance. A culture of leadership, trust and involvement supports the people closest to day-to-day operations and with the greatest knowledge of how the organization interacts with the environment. Historically, environmental initiatives have been viewed as "isolated" programs from primary and core business issues and seen strictly as a regulatory function (Melnyk; 2002). Today, however, leaders are considering the strategic aspects of environmental management as part of an overall plan to innovate, compete, and productively utilize firm resources and minimize wastes (Sroufe; 2003). An EMS requires the involvement and commitment of top management, as well as the deployment of responsibilities and activities to all employees. Strong leadership, proactive management and clearly allocated responsibilities will assist EMS efforts, consequently improving environmental performance measures.

6.6.2 JIT Practices (H3b and H4b)

Preventive maintenance was the single complementary asset moderating the relationship between EMS and supply chain practices and environmental performance. Sakakibara et al. (1993) discuss a total of 16 dimensions of JIT practices important to manufacturing activities. In this paper, we chose two of these dimensions to study, and only preventive maintenance resulted as a performance moderator (see Table 6.5).

The notion of preventive maintenance integration as an established manufacturing practice, but also complementary to environmental programs, makes sense for the organization. Measuring reportable emissions and monitoring key environmental process criteria important to environmental performance depends on a strong preventive maintenance strategy. Planned maintenance activity will reduce and eliminate breakdowns and failures contributing to unwanted emissions and effluents detrimental to the environment. Programs and targets common to EMS programs rely on properly maintained, and in many circumstances, technological upgrade to meet existing and ever-improving compliance requirements. Additionally, collecting and recording accurate environmental performance data relies on an organization's ability to calibrate, as well as maintain and repair monitoring devices and equipment that is instrumental to compliance and EMS activities.

The existence of the set-up reduction moderators did not moderate any of the tested practice-performance relationships. The main effects of regression model two in Tables 6.4 and 6.5 does result in a significant result for set up reduction when it is independent of both environmental management and supply chain practices. Therefore the effect of the independent variables on performance does not weaken or improve depending on the setup reduction moderator. An increase in performance attributable to setup reduction does not vary as a result of an organization possessing environmental or supply chain practices.

6.6.3 Flexibility (H3c and H4c)

Volume, worker and mix flexibility were all found to moderate the relationship between EMS and supply chain practices and environmental performance. Klassen and Angell (1998) found that an increased level of environmental ambition for environmental initiatives in the U.S. was supported by manufacturing flexibility. The results of this dissertation finds that an organization's ability to increase and decrease volumes without significantly affecting quality or costs, also strengthens the environmental practice-performance relationship.

We might understand this relationship simply as one of efficiency. The ability to respond to volume and mix changes allow firms to create less waste and obsolescence (Klassen and Angel, 1998). Overproduction and pollution are inefficient, so an organization's ability to respond competently to volume changes will reduce the potential negative environmental effect to its waste streams.

Alternatively, organizations with high flexibility are more aligned to new markets and have the capability to modify and transform product design to reduce environmental consequences of selected materials and processes. Organizations that are flexible are also likely to utilize more recycled materials (Klassen and Angel, 1998). Manufacturing flexibility has many diverse dimensions and certain flexibilities are essential to meet the challenges imposed by ever-demanding marketplaces (Koste and Malhotra, 1999).

Worker flexibility, also a moderator, becomes relevant because analogous to quality management systems, employees must be involved in EMS practices. For example, ISO 14001 requires employees to be aware of environmental aspects that are considered significant. They must be able to perform the operations in regards to the operating criteria established for the significant impact, and understand how to handle and dispose of a variety of production wastes. Additionally, workers must be capable of understanding and performing tasks relative to emergency preparedness and response procedures.

Not unlike setup reduction above, the flexibility practices resulted in significant results when independent of environmental and supply chain practice variables. However, as moderators, there is no strengthening effect on performance.

6.6.4 Organizational Performance

The SmartPLS model confirmed that environmental performance and operational performance have a positive relationship on organizational performance (see Fig. 5.2). These results confirm the findings of other authors such as Sakakibara et al. (1997) and Sroufe (2003).

6.7 Discussion of Results

The direct relationships between environmental practices and environmental performance were no surprise as these results have been concluded by previous research (Melnyk, 1999; Sroufe, 2003, Melnyk et al, 2003, Montabon, 2000). Supply chain practices also reflected positive and significant impacts on both environmental and operational performance supporting prior research (Zhu and Sarkis; 2004).

Additionally, this study also found a significant relationship between environmental practices and operational performance that have been concluded by other authors (Sroufe 2003, Melnyk et al., 2003a) although the operational performance scales were different. For example, the operational performance scale used by Sroufe (2003), included less production-oriented measures, some dealing with reputation and marketplace position. The scale used in this dissertation contained specific measures of operational performance such as delivery speed, delivery reliability and inventory turns.

6.7.1 Interaction Effects

The results presented suggest that at some level, quality practices, JIT practices and flexibility have moderating effects on environmental performance. Quality management programs, as we expected, can be used to further enhance the implementation of environmental activities and resulting performance outcomes. This moderation effect from quality practices is true for both environmental and supply chain activities. Since 206 (83%) of the organizations surveyed are certified to ISO 9001, the results reinforce how environmental and quality management systems are typically integrated and are complementary and influential to organizational performance.

JIT and flexibility moderators show mixed results (Tables 6.3 and 6.4). The main effects of the Model 2 analysis resulted in significant relationships when the regression was controlled for the predictor variable in all cases. However, existence of a moderating effect varied depending on the predictor and type of performance. This would seem to make sense when understanding that quality practices undertook a moderating role as evidenced by the number of facilities already certified to the quality management system standard. Organizations in these instances could build upon the skills gained from inclusion of a quality management system that are comparable to developed practices established for both EMS and environmental supply chains. These companies will have greater knowledge and experience in quality management practices and concepts.

Other internal management practices such as setup reduction and mix flexibility did not behave as moderators in this study, indicating that they may not necessarily build on, or complement environmental practices in industries represented in this study. The preventive maintenance construct included language emphasizing quality, supporting our argument about ISO 9001 certification above. The setup reduction and flexibility constructs may be more indicative of complex or certain industries that rely on lean manufacturing techniques or incorporate environments conducive to flexibility practices. Clearly, additional research is needed to understand the benefit of complementary practices found in many industries, since this study did not focus on specific industries.

6.8 Chapter Summary

In this chapter we discussed hypotheses testing. Next we will discuss the results, contributions of this work to research and practices, limitations of the study, future research and conclusions.

CHAPTER SEVEN

Contributions, Recommendations for Future Research and Conclusions

7.0 Introduction

This chapter covers the discussion of the study's results and expands on the contribution to research and practice. We then present opportunities for future research and present our conclusions.

7.1 Discussion

This dissertation research endeavors to understand some of the important elements of how environmental practices interact with existing organizational practices in order to contribute to both operational and environmental performance. Previous research in this area is lacking and mostly anecdotal, and prior studies do not fully develop constructs that are useful for future researchers or provide an understanding of these relationships (Reinhardt, 1998; Klassen & Angell, 1998; Melnyk et al. 1999; Christmann, 2000). There is still much to be learned about environmental best practices. The two main research questions for this study were:

1) What combinations of programs, activities and practices are being employed by organizations?
2) How do environmentally-related and other assets or capabilities interact with these programs and practices in order to positively impact specifically operational and environmental performance?

The results discussed in Chapter 6 show that there are interactions or complementary assets at work that underlie the organizational benefits of employing environmental practices. We summarize the relationships examined in Table 7.1, which to some extent fulfills the call from several researchers to examine the effect of complementary assets and capabilities on the effect of environmental practices and performance (King and Lenox, 2001b; Reinhardt, 1998; Klassen & Angell, 1998; Melnyk et al. 1999; Christmann, 2000, Aragon-Correa and Sharma, 2003).

Table 7.1 Complementary Assets

QUALITY PRACTICES	
Predictor	**Dep. Variable**
Quality Information (Moderator)	
EMS (1)	Environmental Performance
ESC (2)	Environmental Performance
ESC (3)	Operational Performance
Customer Focus (Moderator)	
ESC (4)	Environmental Performance
ESC (5)	Operational Performance
Leadership (Moderator)	
EMS (6)	Environmental Performance
ESC (7)	Environmental Performance
JIT PRACTICES	
Predictor	**Dep. Variable**
Preventive Maintenance (Moderator)	
EMS (8)	Environmental Performance
ESC (9)	Environmental Performance

FLEXIBILITY	
Predictor	**Dep. Variable**
Volume Flexibility (Moderator)	
EMS (10)	Environmental Performance
ESC (11)	Environmental Performance
Mix Flexibility (Moderator)	
EMS (12)	Operational Performance
Worker Flexibility (Moderator)	
ESC (13)	Environmental Performance

7.2 Contributions

Our results in Table 7.2 illustrate that quality practices significantly moderate the relationship between environmental management system practices and environmental performance. Clearly, these results support our position that performance can be positively influenced by complementary programs and assets such as strong leadership, customer focus and efficient use and communication of information regarding quality. This study reinforces the notion that environmental practices, when associated with quality management practices such as utilizing quality-based information and continual improvement initiatives will positively affect performance. Organizations today in our global economy must be fiscally accountable to invest resources cautiously and implement those activities and programs that support overall firm objectives. An investment in the quality management system emphasizes quality improvement, the reduction of waste, and formal attention to customers and suppliers. These results suggest that an investment in practices inherent to quality will leverage environmental practices, and positively affect performance, as well as provide a foundation for future initiatives.

Secondly, the results demonstrate that ample opportunity exists for future research to explore and examine how environmental activities will play a role in business sustainability and as a field of study in the Operations Management. We found that customer focus, leadership and use of organizational information enhanced performance, while other complementary resources, such as setup reduction did not. The moderation effect supported by quality practices may be resultant of the fact that 83% of our surveys were completed by organizations already holding ISO 9001 certification, which requires a strong and disciplined system for management practices. These quality practices integrate well with environmental practices, and may represent an inclusion of philosophies regarding system management and adherence to international standards. In addition, these firms surveyed may be early adopters of environmental practices because they are certified to be ISO 14001.

Table 7.2 Contributions of Significant Moderators

Moderating Practice	Result	Academic Contribution	Recommendations for Management
Quality Practices	▪ Quality practices strengthen the ***environmental*** performance (EMS practices) ▪ Quality practices strengthens ***environmental*** and ***operational*** performance (ESC practices)	Conclusively answers and provides evidence to a call by researchers to understand if bundles of quality capabilities and practices enhance performance for organizations employing environmental initiatives (see Table 2.1).	A well implemented quality management system promoting customer focus, communication and leadership principles can provide a beneficial platform for successful subsequent programs and initiatives such as environmental management.

Preventive Maintenance	Preventive maintenance moderates ***environmental*** performance (EMS and ESC practices)	▪ Encourages future research to understand specific motivations and factors to more fully understand this relationship beyond traditional production (e.g. can preventive maintenance extend to facility measures such as boilers, compressors, plumbing, electrical, etc.). ▪ Encourages potential future research for preventive maintenance in service organizations.	Dedication to and emphasis on a strategy for preventive maintenance supports environmental performance.
Volume & Worker Flexibility	▪ Volume flexibility moderated ***environmental*** performance (EMS and ESC practices) ▪ Worker and mix flexibility moderated ***environmental*** performance (ESC practices)	▪ Prior research had demonstrated that flexibility influences operational performance (Koste and Malhotra, 1999). This study conclusively finds that flexibility also moderates and can influence environmental performance. ▪ Encourages future research of traditional manufacturing and other flexibility dimensions such as ***organizational*** flexibility and routines such as telecommuting, work hours, etc. as a moderator of environmental performance	Organizations that can successfully employ the techniques and methods of flexibility can enhance environmental performance and can have a positive impact on the environment.

Volume flexibility moderated both predictors with environmental performance but not operational performance, while worker and mix flexibility had mixed results. Environmental programs are extremely sensitive to the topic of production volumes and the potential impact to permit restrictions and other emission data that is reportable and monitored. Our results find evidence that production sites employing environmental practices that can manage and respond to changes in volume will strengthen environmental performance. This makes sense due to the fact that organizations' emissions and associated waste streams are directly related to the amount of production activity. Klassen and Angell (1998) found that manufacturing flexibility (represented by a single construct capturing volume, mix and new product innovation) supports and facilitates proactive environmental posture. Our results show that volume flexibility enhances environmental performance when both EMS and supply chain environmental practices are employed.

Significant results were not obtained for the three flexibility constructs on operational performance, leading us to propose that more research needs to be conducted to understand why these specific flexibility practices are not moderators to operational performance in the presence of environmental practices. Worker flexibility was found to moderate the relationship between environmental supply chain practices and environmental performance. This dissertation does not imply that manufacturing flexibility is unsupportive of operational performance for a specific or particular firm. Rather, the result may be indicative of a wide range of organizational industries targeted as respondents for this study (see Table 5.1). Additionally, our results raise opportunities to include other types of flexibilities that may be important to the workplace such as telecommuting, work hours, responsiveness to change, and resource allocation with respect to environmental performance.

Preventive maintenance moderated both the EMS and environmental supply chain practices and environmental performance. A readiness of equipment and other resources for production is vital to improving a facility's environmental performance. A reliance on the proper functioning of equipment is directly related to emissions, potential spills, leaks and other incidences that would prove harmful to the environment. For example, damaged and inefficient equipment and facilities can have a direct effect on environmental emissions, as well as an increase in the use of natural resources such as electricity and gas.

7.3 Limitations

The limitations of this research include the use of a survey, self-reporting bias, and potential social bias towards environmental issues and perceptions. Although this survey resulted in only an 8.2% response rate reflecting the difficulty of achieving a high response rate for this 10-page survey (which in our pilot testing had taken between 45 minutes and 55 minutes to complete), it nevertheless offers some relevant theoretical contributions to the field of environmental management. The lower response rate was mitigated by having an adequate sample size that had acceptable power of the test. Additionally, self-response bias involves the perceptive measures of items. While we strived to make the survey straight-forward and unambiguous, there is always the potential for this type of bias.

Across the board, JIT and flexibility practices did not moderate the relationships between the environmental practices and operational performance. Drawing a connection between only two JIT techniques, such as setup reduction and preventive maintenance, may have been too specific for this research. JIT practices are known to motivate continual improvement, efficiency, return on investment and quality; but a construct such as setup reduction may not have provided a true representation of this body of work. Sakakibara et al. (2003) used a wide-range of dimensions such as supplier quality, multifunction workers, training, layout, pull systems and small lot sizes to represent JIT concepts and methods. Our study segregated some of these same dimensions into the quality practices and flexibility constructs, which limited their use as JIT constructs in our survey.

7.4 Recommendations for Future Work

This research is just a starting point for further study regarding complementary assets. Our results indicate that manufacturing flexibility and preventive maintenance, as moderators of environmental practices and performance, require additional investigation. Specifically, what do organizations need to understand about the intersection of environmental practices and flexibility or preventive maintenance techniques to impact performance? For example, what other organizational flexibility measures and capabilities can also contribute to performance (e.g. organizational flexibility such as telecommunication; flexible routines and schedules). Similarly, what preventive maintenance activities and capabilities beyond traditional manufacturing impact performance (e.g. facility maintenance, maintenance roles in service industries)? An examination of additional complementary capabilities essential to environmental and operational performance requires more study (see Table 7.2).

Specifically there are many environmental techniques and programs currently utilized by firms interested in improving their performance and sustaining environmentally-friendly operations. Future work should also look at the moderating effects and benefits supporting programs such as the environmental supply chain, as well as environmental process and product design. Some of these environmental practices might include topics in extent research such as:

a) green purchasing practices (Min and Galle, 2001);

b) supply chain life cycle practices (Hagelaar, van der Vorst and Marcelis, 2004);

c) "green supply chain" practices (Melnyk et al., 1999; Rao, 2002; Klassen & Vachon, 2003; Zhu and Sarkis, 2004; Rao & Holt, 2005; Zhu et al., 2005; Vachon & Klassen, 2008); and

d) Environmental process and product design practices (Zhu et al., 2005) or environmental technology practices (Shrivastava, 1995; Sroufe, 2000; Klassen, 2000; Sroufe, 2003).

To support the above future research streams, one only has to look at what proactive firms are involved in to see how organizations are venturing into these arenas. For example, Pacific Gas and Electric Company launched a project in June 30, 2010 to review and analyze the carbon footprint of its supply chain. The project will include over 50 suppliers with the goal to quantify and reduce greenhouse gases while establishing best practices (ClimateBiz.com). Kaiser, a health insurance provider, has reinforced green purchasing by requiring suppliers to provide environmental data on all purchased medical equipment and products utilizing a sustainability scorecard system. Furthermore, a brief review of practitioner articles written on the internet (GreenerDesign.com) in the past year demonstrates the growing need for "green product design" (see Table 7.1).

Likewise, there are many more complementary assets that could be researched to discover a moderating effect. Companies today need complementary programs to leverage their operational activities with those that can benefit overall performance. Complementary assets like the following are suitable for future research:

a) Knowledge acquisition and information distributions;

b) Design and manufacturing integration activities; and

c) Energy management system practices.

Table 7.3 GreenerDesign.com Articles

- Starbucks: All 3 Billion Coffee Cups to be Recyclable by 2012
- Teijin to Cut Back Plastics Development, Focus on Green Chemistry
- Mars Partners with TerraCycle to Turn Candy Wrappers into new Products
- Sun Chips plans Fully Compostable Chip Bag
- Payless Launches Zoe and Zac Line of Greener Footwear
- Pepsi Tests Efficient, Lowe GHG-Emitting Vending Machines
- Target to Launch Organic Clothing, Greener Gardening Collections
- Old Tires Become Timberland Boot Soles

To expand on this study, future research can also include a longitudinal investigation to extend the knowledge of environmental practices. Additionally, since this study utilized companies from different industries, one might ask whether there are distinct strategies used in specific industries (i.e. services, textiles, paper, etc.) to complement the effects of environmental management. Our results may have dampened the effect of various complementary assets due to the diverse industries in the respondent base. Lastly, respondents with both environmental and operational expertise will provide better insights into how operational performance is influenced by moderating effects in regards to environmental practices.

The results of this study interestingly showed that the use of complementary capabilities as moderators were more significant to environmental performance than operational performance. An explanation of this result may be the fact that 39% of our sample came from Environmental Managers. These managers were appropriately selected for our target respondents due to their probable dual role as representatives of the EMS and knowledge of environmental practices. However, the characteristics of a manager who has responsibility for the environmental program may be less versed in other manufacturing techniques and programs such as setup reduction and preventive maintenance, thus skewing the environmental performance results more favorably. These managers may also be more honed to environmental measures and activities, sometimes in regards to regulatory compliance.

Participation by more plant and/or operational managers may offer more insight to moderators and complementary assets that drive operational performance. It is historically evident that with the surge of activity in environmental consciousness that this field of study has been historically driven more by specialists who have experience and backgrounds in the regulatory and legal compliance arenas, rather than facility-wide adoption. More understanding of the makeup and responsibilities of these managers may provide additional and useful information about complementary assets.

7.5 Conclusions

This dissertation adds to the emerging literature of environmental practices and their signification impact on performance. Sroufe concluded in 2001 that there is a shortage of research that empirically examines relationships among key environmental management system (EMS) constructs. His research discussed how the environmental department within the facility could leverage competitive positions as a "benefit and not a cost" to the organization through performance measures such as quality costs, reducing production waste, and market positioning. Sroufe's research explored the base relationship used in this dissertation.

This dissertation and previous researchers understand that the effect of complementary assets on practice-performance relationships is strategically advantageous. When corporate budgets are reduced, companies must become discriminating as to where and how they will invest their dollars. Our results significantly support that quality practices can affect performance. Thus, understanding which programs interact well with their existing activities and which practices will lead to improved business performance can help in better understanding the value of these initiatives in both protecting the environment as well as leading the firm to prosperity. The implementation of environmental programs and those complementary assets keeps an eye on the environment, while supporting the goals of shareholders.

REFERENCES

Ahire, Sanjay L, Damodar Y. Golhar and Matthew A. Waller (1996), "Development and validation of TQM implementation constructs," Decision Sciences, vol. 27, no. 1, pp. 23-56.

Ahire, Sanjay L. and Paul Dreyfus (2000), "The impact of design management and process management on quality: an empirical investigation," *Journal of Operations Management*, Vol. 18, Issue 5, pp. 549-575.

Ammenberg, Jonas (2007), "Environmental management systems and environmental performance," Strategic Sustainability, pp. 242-257.

Anderson, J.C. and Gerbing, D.W. (1988), "Structural equation modeling in practice: A review and recommended two-step approach." *Psychological Bulletin* vol. 103, no. 3, pp. 411-423.

Angell, Linda C. (2001), "Comparing the environmental and quality initiatives of Baldrige award winners," *Production and Operations Management*, vol. 10, no. 3, pp. 306-326.

Angell, Linda C. and Robert D. Klassen (1999), "Integrating environmental issues into the mainstream: an agenda for research in operations management," *Journal of Operations Management*, vol. 17, pp. 575-598.

ANSI/ISO/ASQ E14001 (2004), "Environmental management systems – requirements with guidance for use,"ASQ.

Aragon-Correa, J. Alberto and Sanjay Sharma (2003), "A contingent resource-based view of proactive corporate environmental strategy," *Academy of Management Review,* vol. 28, no. 1 pp. 71-88.

Armstrong, C.G. and T.S. Overton (1977), "Estimating nonresponse bias in mail surveys," *Journal of Marketing Research,* vol. 14 issue 3, pp. 396-402.

Arnst, Catherine and Stanley Reed (1997), "Green begets green," *Business Week*, issue 3552, pp. 98-101.

Bagozzi, R.P., Yi, Y., and Phillips, L.W. (1991), "Assessing construct validity in organizational research." *Administrative Science Quarterly,* vol. 36, issue 3, pp. 421-458.

Barney, Jay (1991), "Firm resources and sustained competitive advantage," *Journal of Management*, vol. 17, no. 1, pp. 99-120.

Bertehelot, Sylvie and Michel Coulmont (2004), "ISO 14000 – a profitable investment?" *CMA Management*, Nov., pp. 36-39.

Bowen, Frances and Sanjay Sharma (2005), "Resourcing corporate environmental strategy: behavioral and resource-based perspectives." *Academy of Management Best Conference Paper*, pp. 1-6.

Campbell, D.T. and D.W. Fiske, D.W. (1959). "Convergent and discriminant validation by the multitrait-multimethod matrix," *Psychological Bulletin,* vol. 56, pp. 81-105.

Cascio, Joseph (1996), "*The ISO 14000 Handbook*," CEEM Information Services with ASQC Quality Press.

Chandreashekar, Ashok, Thomas Dougless and Gayle C. Avery (1999), "The environment is free: the quality analogy," *Journal of Quality Management*, vol. 4, issue 1. p. 123-144.

Chin, Wynne W., Barbara L. Marcolin and Peter R. Newsted (2003), "Partial least squares latent variable modeling approach for measuring interaction effects: results from a monte carlo simulation study and an electronic-mail emotion/adoption study," *Information Systems Research*, vol. 14, no. 2 pp. 189-217.

Chinander, Karen R. (2001), "Aligning accountability and awareness for environmental performance in operations," *Production and Operations Management*, vol. 10, no. 3, pp. 276-291.

Christmann, Petra (2000), "Effects of "best practices" of environmental management on cost advantage: the role of complementation assets," *Academy of Management Journal*, vol. 43, no. 4, pp. 663-680.

Christmann, Petra and Glen Taylor (2001), "Globalization and the environment: determinants of firm self-regulation in China," *Journal of International Business Studies*, vol. 32, no. 3, pp. 439-458.

Clemens, Bruce (2006), "Economic incentives and small firms: does it pay to be green," *Journal of Business Research*, vol. 59, pp. 492-500.

Clemens, Bruce and Thomas J. Douglas (2006), "Does coercion drive firms to adopt "voluntary" green initiatives? Relationships among coercion, superior firm resources, and voluntary green initiatives," *Journal of Business Research*, vol. 59, pp. 483-491.

Cohen, Jacob (1992), "Statistical Power Analysis," *Current Directions in Psychological Science,* vol. 1, no. 3, pp. 98-101.

Coltman, Tim R., Timothy M Devinney, David F. Midgley and Sunil Venaik (2008). Formative versus Reflective Measurement Models: two applications of erroneous measurement," *Faculty of Informatics*, pp. 1-34.

Corbett, Charles J. and David A. Kirsch (2001), "International diffusion of ISO 14000 certification," *Production and Operations Management*, vol. 10, no. 3, pp. 327-341.

Corbett, Charles J. and Robert D. Klassen (2006), "Extending the horizons: environmental excellence as key to improving operations," *Manufacturing & Service Operations Management*, vol. 8, no. 1, pp. 5-22.

Corbett, Lawrence M. and Denise J. Cutler (2000), "Environmental management systems in the New Zealand plastics industry," *International Journal of Operations & Production Management*, vol. 20, no. 2, pg. 204-224.

Corbett, Charles J. and David A. Kirsch (2001), "International diffusion of ISO 14000 certification," *Production and Operations Management*, vol. 10, no. 3, pp. 327-342.

Cordeiro, James J. and Joseph Sarkis (1997), "Environmental proactivism and firm performance: evidence from security analyst earnings forecasts," *Business Strategy and the Environment*, vol. 6, pp. 104-114.

Cronbach, L.J. (1951), "Coefficient alpha and the internal structure of tests," *Psychometrika*, vol. 16, pp. 297-334.

Crosby, Philip (1979). *Quality is Free*. New York: McGraw-Hill.

Crowe, Deirdre and Louis Brennon (2007), "Environmental considerations within manufacturing strategy: an international study," *Business Strategy and the Environment*, no. 16, pp. 266-289.

Cua, Kristy O., Kathleen E. McKone and Roger G. Schroeder (2001), "Relationships between implementation of TQM, JIT and TQM and manufacturing performance," *Journal of Operations Management*, vol. 19, pp. 675-694.

Curkovic, Sime (1998), *"Investigating the linkage between total quality management and environmentally responsible manufacturing,"* Dissertation. Michigan State University.

Curkovic, Sime, Steven A. Melnyk, Robert B. Handfield and Roger Calantone (2000), "Investigating the linkage between total quality management and environmentally responsible manufacturing," *IEEE Transactions on Engineering Management*, vol. 47, no. 4, pp. 444-464.

Curkovic, Sime (2003), "Environmentally responsible manufacturing: the development and validation of a measurement model," *European Journal of Operational Research*, vol. 146, pp. 130-155.

Curkovic, Sime and Robert P. Sroufe (2007), "Total quality environmental management and total cost assessment: an exploratory study," "*International Journal of production Economics*, vol. 105, pp. 560-579.

Daily, Bonnie F. and Su-chun Huang (2001), "Achieving sustainability through attention to human resource factors in environmental management," *International Journal of Operations and Production Management*, vol. 21, no. 12, pp. 1539-1552.

Delmas, M. (2001), "Stakeholders and competitive advantage: the case of ISO 14001," *Production and Operations Management*, vol. 10, no. 3, pp. 343-358.

Devaraj, Sarv, Lee Krajewski and Jerry C. Wei (2007), "Impact of eBusiness technologies on operational perforamance: the role of production information integration in the supply chain," *Journal of Operations Management*, vol. 25, pp. 1199-1216.

DeVellis, Robert F. (1991), *Scale Development Theory and Applications*, Sage Publications, Inc.

Environmental Protection Agency (1993), "Solicitation notice for fiscal year 1994 environmental education grants program", *Federal Register*, Vol 58, no. 142, pp. 40299-300.

Environmental Protection Agency, (2000a), *"Pursuing Perfection: Case Studies Examining Lean Manufacturing Strategies, Pollution Prevention, and Environmental Regulatory Management Implications,"* U.S. EPA Contract #68-W50012, August.

Environmental Protection Agency (2000b), "*The Lean and Green Supply Chain: A Practical Guide for Materials Managers and Supply Chain Managers to Reduce Costs and Improve Environmental Performance.*" EPA 742-R-00-001, January.

Fatkin, Harry (2001), *"Corporate environmental reporting: value for manufacturing operations*," Greener Manufacturing and Operations, Greenleaf Publishing, Sheffield UK.

Florida, Richard (1995), "Lean and green: the move to environmentally conscious manufacturing," *California Management Review*, vol. 39, no. 1. pp. 80-105.

Florida, Richard and Derek Davidson (2001), "Gaining from green management: environmental management systems inside and outside the factory," *California Management Review*, vol. 43, no. 3, pp. 64-84.

Flynn, Barbara B., Sadao Sakakibara and Roger G. Schroeder (1995), "Relationship between JIT and TQM: practices and performance," *Academy of Management Journal*, vol. 38, no. 5, pp. 1325-1360.

Frosch, Robert A. (1997). "Industrial ecology: closing the loop on waste materials," The Industrial Green Game, National Academy Press, Washington, DC.e" 1997

Fugate, Brian S., Theodore P. Stank and John T. Mentzer (2009), "Linking improved knowledge management to operational and organizational performance," *Journal of Operations Management*, vol. 27, pp. 247-264.

Geffen, Charlette A. and Sandra Rothenberg (2000), "Suppliers and environmental innovation, the automotive paint process," *International Journal of Operations and Production Management*, vol. 20, no. 2, pp. 166-186.

Gerbing, D.W. and Anderson, J.C (1988). "An updated paradigm for scale development incorporating unidimensionality and its assessment," *Journal of Marketing Research,* vol. 25, no. 2, pp. 186-192.

Global Environmental Management Initiative (GEMI), 2004 "Forging new links: Enhancing supply chain value through environmental excellence." June, http://www.gemi.org/supplychain/.

Gonzalez, Santiago Garcia, Ana Gessa Perera and Francisco Aguardo Correa (2003), "A new approach to the valuation of production investments with environmental effects." *International Journal of Production Management*, vol. 23, no. 1, pp. 62-87.

Grant, Robert .M. (1991), "The resource-based theory of competitive advantage: implications for strategy formulation," California Management Review, Spring 1991, vol. 33, issue 3, pp. 114-135.

Guimaraes, Tor and Kevin Liska (1995). "Exploring the business benefits of environmental stewardship," *Business Strategy and the Environment*, vol. 4, pp. 9-22.

Gupta, M. (1994), "Environmental management and its impact on the operations function," *International Journal of Operations and Production Management*, vol. 15, no. 8, pp. 34-51.

Gupta, M. and K. Sharma (1996), "Environmental operations management: An opportunity for improvement," *Production and Inventory Management Journal*, vol. 37, no. 3, pp. 40-46.

Hagelaar, Geoffrey J.L.F., Jack G.A.J. van der Vorst and Willem J. Marcelis (2004), "Organising life-cycles in supply chains," *Greener Management International*, Spring 2004, pp. 27-42.

Hair, Joseph F., Rolph E. Anderson, Ronald L. Tatham, William Black (1998). "Multivariate Data Analysis, Fifth Edition, Pearson Education, Inc.

Hanna, Mark D., W. Rocky Newman and Pamela Johnson (2000), "Linking operational and environmental improvement through employee involvement," *International Journal of Operations & Production Management*, vol. 20, no. 2, pp. 148-165.

Hart, Stuart L. (1995), "A natural-resource-based view of the firm," *Academy of Management Review*, vol. 20, no. 4, pp. 986-1014.

Hart, Stuart L. (1997), "Beyond greening: strategies for a sustainable world," *Harvard Business Review*, vol. 75, no. 1, pp. 66-76.

Hart, Stuart L. and Gautam Ahuja (1994), "Does it pay to be green? An empirical examination of the relationship between pollution prevention and firm performance," Working Paper #9550-09, University of Michigan, 28 pages.

Hatcher, L. (1994), *A Step-by-Step Approach to using the SAS System for Factor Analysis and Structural Equation Modeling*. Cary, NC: SAS Institute.

Heine, Michelle D. (1999). *"An empirical study of technology effectiveness in manufacturing firms,"* Dissertation, University of South Carolina.

Hill, Terry. (1994), *Manufacturing Strategy*, R.D. Irwin Publishing, Burr Ridge, IL.

Huber, George P. and Daniel J. Power (1985). "Retrospective reports of strategic-level managers: guidelines for increasing their accuracy," Strategic Management Journal, Apr-June, vol. 6, issue 2, pp. 171-182.

Hulland, John (1999), "Use of partial least squares (PLS) in strategic management research: a review of four recent studies," *Strategic Management Journal*, 20, pp. 195-204.

Hult, G. Thomas M, David J. Ketchen, Jr. and Stanley F. Slater. (2004), "Information processing, knowledge development, and strategic supply chain performance," *Academy of Management Journal*, vol. 47, no. 2, pp. 241-253.

Jack, Eric P. and Amitabh Raturi (2002), "Sources of volume flexibility and their impact on performance," *Journal of Operations Management*, vol. 20, pp. 519-548.

Jaccard, J., Turrisi, R. and Wan, C. K. (1990), *Interaction effects in multiple regression,* Newbury Park, CA: Sage.

James, L.R., Demaree, R.G. and Wolf, G. (1984), "Estimating within-group reliability with and without response bias*," Journal of Applied Psychology*. Vol. 69 (1), pp. 85–98.

James, L.R., Demaree, R.G. and Wolf, G. (1993). "Estimating within-group inter-rater reliability with and without response bias," *Journal of Applied Psychology* Vol. 78 (2), pp. 306–309.

Jimenez, Jeronimo de Burgos and Jose J. Cespedes Lorente (2001). "Environmental performance as an operations objective," *International Journal of Operations and Production Management*, vol. 21, no. 12, pp. 1553-1572.

King, Andrew A. and Michael J. Lenox (2001a), "Lean and green? An empirical examination of the relationship between lean production and environmental performance," *Production and Operations Management*, vol. 10, no. 3, pp. 244-256.

King, Andrew A. and Michael J. Lenox (2001b), "Does it really pay to be green? An empirical study of firm environmental and financial performance," *Journal of Industrial Ecology*, vol. 5, no. 1, pp. 105-116

King, Andrew A. and Michael J. Lenox (2002), "Exploring the locus of profitable pollution reduction," *Management Science*, vol. 48, no. 2, pp. 289-299.

Kitazawa, Shinichi and Joseph Sarkis (2000), "The relationship between ISO 14001 and continuous source reduction programs," *International Journal of Operations & Production Management*, vol. 20, no. 2, pp. 225-248.

Klassen, Robert D. (2000a), "Just-in-time manufacturing and pollution prevention generate mutual benefits in the furniture industry," *Interfaces*, vol. 30, no. 3, pp. 95-106.

Klassen, Robert D. (2000b), "Exploring the linkage between investment in manufacturing and environmental technologies," *International Journal of Operations and Production Management,* vol. 20, no. 2, pp. 127-147.

Klassen, Robert D. (2001), "Plant level environmental management orientation: the influence of management views and plant characteristics," *Production and Operations Management*, vol. 10, no. 3, pp. 684-698.

Klassen, Robert D. (1993), "The integration of environmental issues into manufacturing: toward an interactive open-systems model, "*Production and Inventory Management Journal*, vol. 34, no.1, pp. 82-88.

Klassen, Robert D. and Stephan Vachon (2003), "Collaboration and evaluation in the supply chain: the impact on plant-level environmental investment," *Production and Operations Management*, vol 12, no. 3, pp. 336-352.

Klassen, Robert D. and Linda C. Angell (1998), "An international comparison of environmental management in operations: the impact of manufacturing flexibility in the U.S. and Germany," *Journal of Operations Management*, vol. 16, pp. 177-194.

Klassen, Robert D. and Curtis P. McLaughlin (1996), "The impact of environmental management on firm performance," Management Science, vol. 42, no. 8, pp. 1199-1214.

Klassen, Robert D. and Curtis P. McLaughlin (1993), "TQM and environmental excellence in manufacturing," *Industrial Management & Data Systems*, vol. 93, no. 6, pp. 14-22.

Klassen, Robert D. and D. Clay Whybark (1999a), "Environmental management in operations: the selection of environmental technologies," *Decision Sciences*, vol. 30, no. 3, pp. 601-631.

Klassen, Robert D. and D. Clay Whybark (1999b), "The impact of environmental technologies on manufacturing performance," Academy of Management Journal, vol. 42, no. 6, pp. 599-615.

Kleiner, Art (1991), "What does it mean to be green," *Harvard Business Review*, July-August, pp. 38-47.

Koste, Lori L, Manoj K. Malhotra (1999), *"A theoretical framework for analyzing the dimensions of manufacturing flexibility,"* *Journal of Operations Management*, vol. 18, pp. 75-93.

Koste, Lori L, Manoj K. Malhotra and Subhash Sharma (2004), "Measuring dimensions of manufacturing flexibility," *Journal of Operations Management*, vol. 22, pp. 171-196.

Larson and Greenwood (EQM 2004)

Linton, Jonathan D., Robert Klassen and Vaidyanathan Jayaraman (2007), "Sustainable Supply Chains: an introduction," *Journal of Operations Management,* vol. 25, pp. 1075-1082.

Lokkegaard, Kristian Eg (1999), "ISO 14031 used as a tool in ISO 14001 or as an alternative for a simple EMS," *Greener Management International*, vol. 29, pp. 79-89.

Madu, Christina N. (2004). *Competing on Quality and the Environment*, CHI Publishers, Fairfield, CT.

McGahan, A.M., & Porter M.E. (1997), "How much does industry matter, really?" *Strategic Management Journal*, vol. 18 (summer special issue), pp. 15-30.

Mehra, Satish and R. Anthony Inman (1992), "Determining the critical elements of just-in-time implementation," *Decision Sciences*, vol. 23, pp. 160-174.

Melnyk, S., R. Calantone, R. Handfield, L. Tummala, G. Vastag, T. Hinds, R. Sroufe, F. Montabon, and S. Curkovic (1999), "*ISO 14000 Assessing Its Impact on Corporate Effectiveness and Efficiency*, Focus Study, Center for Advance Purchasing Studies.

Melnyk, Steven A. and Robert Sroufe (2001), "How does management view environmentally responsible manufacturing," *Production and Inventory Management Journal*, vol. 42, no. 3/4, pp. 55-69.

Melnyk, S. A, R. P. Sroufe, R. L. Calantone and F. L. Montabon (2002), "Assessing the effectiveness of US voluntary environmental programmes: an empirical study," *International Journal of Production Research*, vol. 40, no. 8, pp. 1853-1878.

Melnyk, Steven A., Robert P. Sroufe and Roger Calantone (2003a), "Assessing the impact of environmental management systems on corporate and environmental performance," *Journal of Operations Management*, vol. 21, pp. 329-351.

Melnyk, Steven A., Robert P. Sroufe and Roger J. Calantone (2003b), "A model of site-specific antecedents of ISO 14001 certification," *Production and Operations Management*, vol. 12, no. 3, pp. 369-385.

McInerney, Francis and Sean White (1995), *The Total Quality Corporation*, Penguin Books, USA, New York, NY.

Min, Hokey and William P. Galle (2001), "Green purchasing practices of US firms," *International Journal of Production Management*, vol. 21, issue 9, pp. 1222-1238.

Montabon, Frank Lloyd (2001), "An exploratory study of the capabilities, structures and performance of environmental management systems," Dissertation, Michigan State University.

Montabon, Frank, Robert Sroufe and Ram Narasimhan (2007). "An examination of corporate reporting, environmental management practices and firm performance," *Journal of Operations Management*, vol. 25, pp. 998-1014.

Narasimhan, R., and Jayaram, J. (1998), "Causal linkages in supply chain management: An exploratory study of North American manufacturing firms," *Decision Sciences* vol. 29, pp. 579–605.

Netemeyer, R.G., Bearden, W.O., Sharma, S. (2003), *Scaling Procedures: Issues and Applications*. Thousand Oaks, CA: Sage Publications.

Neter, Wasserman and Kutner (1985), *Applied Linear Statistical Models*, 2nd ed, Irwin.

Newman, W. Rocky and Mark D. Hanna (1996), "An empirical exploration of the relationship between manufacturing strategy and environmental management: two complementary models," *International Journal of Operations and Production Management*, vol. 16, no. 4, pp. 69-87.

Nunnally, Jum C., and Ira H. Bernstein (1994), *Psychometric Theory, Third Edition*, New York, McGraw-Hill.

O'Leary-Kelly, Scott W. and Robert J Vokurka (1998). "The empirical assessment of construct validity," *Journal of Operations Management*, vol. 16, pp. 387-405.

Patton (1990) Chapter 4

Pil, Frits K. and Sandra Rothenberg (2003), "Environmental performance as a driver of superior quality," *Productions and Operations Management*, vol. 12, no. 3, pp. 404-415.

Polonsky, Michael Jay and Jacquelyn Ottman (1998). "Stakeholders' contribution to the green new product development process," *Journal of Marketing Management*, vol. 14, pp. 533-557.

Porter, Michal E. (1991), "America's green strategy," *Scientific American*, April, p. 168.

Porter, Michael E. and Claas van der Linde (1995), "Green and competitive-ending the stalemate," *Harvard Business Review*, Sept.–Oct., pp. 120-134.

Prahalad, C.K. and Gary Hamel (1990). "The core competence of the corporation," Harvard Business Revew, May-June 1990, pp. 79-91.

Pun, Kit Fai (2006), "Determinants of environmentally responsible operations: a review," The *International Journal of Quality and Reliability Management*, vol 23, 2/3, pp. 279-297.

Quazi, Hesan A., Yee-Koon Khoo, Chin-Meng Tan and Poh-Seng Wong (2001),"Motivation for ISO 14000 certification: development of a predictive model," *Omega*, vol 29, pp. 525-542.

Rao, Purba (2002), "Greening the supply chain: a new initiative in south east Asia," *International Journal of Operations and Production Management*, vol. 22, no. 6, pp. 632.655.

Rao, Purba and Diane Holt (2005), "Do green supply chains lead to competitiveness and economic performance," *International Journal of Operations and Production Management*, vol. 25, no. 9, pp. 898-916.

Reinhardt, F. L. (1998), "Environmental product differentiation: Implications for corporate strategy," *California Management Review*, vol. 40, no. 4, pp. 43-73.

Ringle, Christian Marc, Sven Wende and Alexander Will (2005), "SmartPLS," http://www.smartpls.de, Robinson, Carol J. and Manoj K. Malhotra (2005), "Defining the concept of supply chain quality management and its relevance to academic and industrial practice," *International Journal of Production Economics*, Vol. 96, pp. 315-337.

Rothenberg, Sandra, Frits K. Pil and James Maxwell (2001), "Lean, green, and the quest for superior environmental performance," *Production and Operations Management*, vol. 10, no. 3, pp. 228-243.

Russo, Michael V. and Paul A. Fouts (1997), "A resource-based perspective on corporate environmental performance and profitability," *Academy of Management Journal*, vol. 40, no. 3, pp. 534-559.

Russo, Michael V. and Niran S. Harrison (2005), "Organizational design and environmental performance: clues from the electronics industry," *Academy of Management Journal*, vol. 48, no. 4, pp. 582-593.

Sakakibara, Sadao, Barbara B. Flynn and Roger G. Schroeder (2003), "A framework and measurement instrument for just-in-time manufacturing," *Production and Operations Management*, vol. 2, no. 3, pp. 177-194.

Sakakibara, Sadao, Barbara B. Flynn, Roger G. Schroeder and William T. Morris (1997), "The impact of just-in-time manufacturing and its infrastructure on manufacturing performance," *Management Science*, vol. 43, no. 9, pp. 1246-1257.

Samson, Danny and Mile Terziovski (1999), "The relationship between total quality management practices and operational performance," *Journal of Operations Management*, vol. 17, pp. 393-409.

Sarkis, Joseph (2001), "Manufacturing's role in corporate environmental sustainability: Concerns for the new millennium," *International Journal of Operations and Production Management,* vol. 21, no. 5/6, pp. 666-686.

Sarkis, Joseph and Abdul Rasheed (1995) "Greening the manufacturing function," *Business Horizons*, Sept-Oct.

Sarkis, Joseph (1998), "Evaluating environmentally conscious business practices," *European Journal of Operational Research*, vol. 107, pp. 159-174.

Schmidheiny, Stephan (1992). *Changing Course*, MIT Press, fifth printing, Cambridge, MA.

Segars, A.H. (1997). "Assessing the unidimensionality of measurement: A paradigm and illustration within the context of information systems research," *Omega* 25, vol. 1, pp. 107-121.

Shah, Rachna and Peter T. Ward (2003), "Lean manufacturing: context, practice bundles and performance," *Journal of Operations Management*, vol. 21, pp. 129-149.

Shah, Rachna and Peter T. Ward (2007), "Defining and developing measures of lean production," *Journal of Operations Management*, vol. 25, pp. 785-805.

Sharma, Subhash, Richard M. Durand and Oded Gur-Arie (1981), "Identification and Analysis of Moderator Variables," *Journal of Marketing Research*, August, vol. xviii, pp. 291-300.

Sharma, Subhash (1996). Applied Multivariate Techniques, John Wiley & Sons, Inc., New York, NY.

Sheridan, J.H. (1992), "Environmental issues by executives time," *Industry Week*, Vol. 241, March 16 pp. 44048.

Shrivastava, Paul (1995), "Environmental technologies and competitive advantage," *Strategic Management Journal*, vol. 16, pp. 183-200.

Sleeswijk, Anneke Wegener, Reinout Heijungs and Steffen T. Erler (2003), "Risk assessment and life-cycle assessment," *Greener Management International*, vol. 41, pp. 77-87.

Sroufe, Robert P. (2000), "*Environmental management systems: implications for operations management and firm performance,"* Dissertation, Michigan State University.

Sroufe, Robert, Sime Curkovic, Frank Montabon and Steven A. Melnyk (2000), "The new product design process and design for environment," *International Journal of Operations & Production Management*, vol. 20, no. 2, pp. 267-291.

Sroufe, Robert, Frank Montabon, Ram Narasimhan and Xinyan Wang (2002), "Environmental management practices: a framework," *Greener Management International*, vol. 40, pp. 23-44.

Sroufe, Robert and Frank Montabon (2007), "What's on the business horizon for environmental performance," *Decision Line*, January.

Sroufe, Robert and Joseph Sarkis (2007), "*Strategic Sustainability*," Greenleaf Publishing Ltd, Sheffield, UK.

Sroufe, Robert (2003), "Effects of Environmental Management Systems on Environmental Management Practices and Operations," *Production and Operations Management*, vol. 12, no. 3, pp. 416-431.

Swink, Morgan and Anand Nair (2007), "Capturing the competitive advantages of AMT: design-manufacturing integration as a complementary asset," *Journal of Operations Management*, vol. 25, pp. 736-754.

Swink, Morgan and W. Harvey Hegarty (1998), "Core manufacturing capabilities and their links to product differentiation," *International Journal of Operations and Production Management,* vol. 18, no. 4, pp. 374-396.

Tam, C.M., Vivian W.Y. Tam and S.X. Zeng (2002), "Environmental performance evaluation for construction," *Building Research & Information*, vol. 30, no. 5, pp. 349-361.

Teece, D. (1986), "Profiting from technological innovation: Implications for integration, collaboration, licensing, and public policy," *Research Policy*, vol. 15, pp. 295-305.

Theyel, Gregory (2000), "Management practices for environmental innovation and performance," *International Journal of Operations and Production Management,* vol. 20, no. 2, pp. 249-266.

Thornton, Russell V. (2000), "New relationships: ISO 14001, lean manufacturing and transportation," *Environmental Quality Management*, Spring, pp. 105-110.

Upton, D.M. (1994), "The management of manufacturing flexibility."California Management Review, pp. 72–89.

Vachon, Stephan (2007), "Green supply chain practices and the selection of environmental technologies," *International Journal of Production Research*, vol. 45, no. 18-19, pp. 4357-4379.

Vachon, Stepah and Robert D. Klassen (2008), "Environmental management and manufacturing performance: the role of collaboration in the supply chain," *International Journal of Production Economics*, vol. 111, pp. 299-315.

Verschoor, A.H. and L. Reijnders (2000), "The environmental monitoring of large international companies: how and what is monitored and why," *Journal of Cleaner Production*, vol. 9, pp. 43-55.

Wagner, Marcus and Stefen Schaltegger (2001), "The relationship between the environmental and economic performance of firms," *Greener Management International*, vol. 34, pp. 95-108.

Walley, Noah and Bradley Whitehead (1994), "It's not easy being green," *Harvard Business Review*, May-June, pp. 46-52.

Watson, Kevin, Beate Klingenberg, Tony Polito and Tom G. Geurts (2004), "Impact of environmental management system implementation on financial performance," *Management of Environmental Quality*, vol. 15, no. 6, pp. 622-628.

Wellford, Richard (1992), "Linking quality and the environment: a strategy for the implementation of environmental management systems, *Business Strategy and the Environment*, pp. 23-35.

White, Gilbert F. (1958), "The facts about our water supply," *Harvard Business Review*, vol. 36, no. 2, pp. 87-94.

Wilkinson, Adrian, Malcolm Hill and Paul Gollan (2001), "The sustainability debate," *International Journal of Operations and Production Management*, vol. 12, no. 12, pp. 1492-1502.

Wu, Haw Jan and Steven C. Dunn (1995), "Environmentally responsible logistics systems," *International Journal of Physical Distribution & Logistics Management*, vol. 25 no. 2, pp. 20-38.

Wu, Sarah J., Steven A. Melnyk and Roger J. Calantone (2008), "Assessing the core resources in the environmental management system from the resource perspective and the contingency perspective," *IEEE Transactions on Engineering Management*, vol. 55, no. 2, pp. 304-315.

Yang, Chen-Lung, Shu-Ping Lin, Ya-hui Chan and Chwen Shew (2010) "Mediated effect of environmental management on manufacturing competitiveness: an empirical study," *International Journal of Production Economics*, vol. 123, pp. 210-220

Yeung, Andy C.L., T.C. Edwin Cheng and Kee-huang Lai (2006), "An operational and institutional perspective on total quality management," *Production and Operations Management*, vol. 15, no. 1, pp. 156-170.

Zhang, Qingyu, Mark A. Vonderembse and Jeen-Su Lim (2003), "Manufacturing flexibility: defining and analyzing relationships among competence, capability, and customer satisfaction," *Journal of Operations Management,* vol. 21, pp. 173-191.

Zhu, Qinghua, Joseph Sarkis and Yong Geng (2005), "Green supply chain management in China: pressures, practices and performance," *International Journal of Operations and Production Management*, vol. 25, no. 5, pp. 449-468.

Zhu, Qinghua and Joseph Sarkis (2004), "The link between quality management and environmental management in firms of differing size: an analysis of organizations in China", *Environmental Quality Management*, vol. 13, issue 3, pp. 53-64.

Zhu, Qinghua and Joseph Sarkis, (2004), "Relationships between operational practices and performance among early adopters of green supply chain management practices in

Chinese manufacturing enterprises," *Journal of Operations Management,* vol. 22, no. 3, pp. 265–289.

Zhu, Qinghua and Joseph Sarkis, (2007), "The moderating effects of institutional pressures on emergent green supply chain practices and performance," *International Journal of Production Research*, vol. 45, no. 18, pp. 4333-4355.

Zutshi, Ambika and Amrik S. Sohal (2003), "Stakeholder involvement in the EMS adoption process," *Business Process Management Journal*, vol. 9, no. 2, pp. 133-148.

APPENDIX A

QUESTIONNAIRE

Dear Manager:

As you are aware, stakeholders, customers and the general public are now increasingly aware of the impact of our actions on the environment and are searching for ways to make this environmental mindset mainstream. Manufacturing firms and organizations are now proactively learning how to minimize the negative impact of their products and operations on the natural environment by developing innovative new products and incorporating environmentally-conscious processing activities. These companies understand the linkages between environmental activities and the corresponding positive impact on performance.

The actions of these environmentally-conscious firms provide sufficient evidence that understanding environmental operations is both relevant and strategic. As a result, many firms have moved from the perception that environmental management is a cost or regulatory requirement, to a comprehensive point of view where being environmentally competent can result in higher efficiencies and competitiveness Environmental management, once considered as a distinct and separate program, is now known to contribute to the success of the entire enterprise.

However, for this research project to be successful, your help is needed!

Included on the following pages is a questionnaire developed with input from practicing OH&S, Environmental, Plant, Operations or other area managers to assist in the understanding of an organization's environmental systems. The survey is very straightforward and should take ***no more than 15—20 minutes of your time***. At your earliest convenience, please complete the survey return it to us via the attached postage-paid envelope. Alternately, an internet version is available **(http://qualitrics/uscsurvey.com**) if an electronic format is preferred.

It should be noted that your responses will be held in the strictest confidence. Under no circumstances will results specific to your organization be made available to any individual or organization. Again, your participation is critical to the success of the project so it is asked that you be open and honest with your responses. Thanks in advance for your cooperation.

Sincerely,

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Project Description

Purpose of this research: This survey is a study to understand the implementation of environmental practices on plant performance and how other business practices affect and influence these measures.

- ***All individual responses will be kept strictly confidential***.
- There are no right or wrong answers.
- Please read the questions carefully.

The respondent should be someone who is familiar with total site operations such as the Plant Manager, Production Manager, Quality Manager, Environmental Manager, OH&S Manager or other area Manager.

Please answer all questions with respect to your major site or facility.

Section 1: General Information About Your Firm

1. What is the approximate annual sales volume, in dollars, of your site?

☐ less than 10 million ☐ 10-25 million ☐ 26-50 million ☐ 51-100 million
☐ 101-250 million ☐ 251-500 million ☐ 501 million – 1 billion ☐ over 1 billion

2. My organization is certified (or registered) to ISO 14001 ☐ Yes ☐ No

3. If yes, How long? ________

4. ***If not certified (or registered)***, my organization has environmental practices in place or is conforming to an environmental management system such as ISO 14001 ☐ Yes ☐ No

NOTE: If you answered "No" to question 3 you can stop at this point.
THANK YOU FOR YOUR PARTICIPATION!

5. My organization is certified to ISO 9001? (Quality Management System) ☐ Yes ☐ No

6. If yes, How long? ___________

7. Industrial Sector (Select one only):

☐ Automotive
☐ Agricultural/forestry
☐ Chemical
☐ Computer/Electronic Equipment
☐ Fabricated Metal Products
☐ Industry Machinery & Equipment
☐ Printing & Publishing
☐ Primary Metal Industries
☐ Pharmaceutical
☐ Transportation Equipment
☐ Food
☐ Laboratory/medical instruments & related products
☐ Office systems
☐ Other _____________

8. Principle product(s): ____

9. Principle customers(s): ____

10. Is your customer base ☐ National ☐ International ☐ Both

11. Do you have a management system conforming to OHSAS 18001? ☐ Yes ☐ No

12. Total number of employees at this site: _______ **13**. % Salary: ____

14. Please indicate which product description most typifies the primary products manufactured at your site? ***(mark only one)***

☐ Standard product with no options.
☐ Standard product with standard options.
☐ Standard product modified to customer Specifications.
☐ Standard product with options modified to customer specification.
☐ Customized product manufactured to customer specification.

15. Compared to other organizations in your industry how would you characterize product volume per part type? (***mark only one***)

- ☐ Low volume
- ☐ Moderate volume
- ☐ High volume
- ☐ Significantly high volume
- ☐ Very high volume

16. The manufacturing process and equipment can be organized in various ways. Please indicate which category comes closest to characterizing the dominant processes used at this site. (***mark only one***)

- ☐ Products are produced in small batches; similar equipment performing the same functions are grouped together.
- ☐ Products are produced in moderately large batches; similar equipment performing the same functions are grouped together.
- ☐ Products are produced in batches; work centers are laid out in the sequence in which the products are manufactured.
- ☐ Products are produced in large batches or in a continuous flow; work centers are laid out in the sequence in which the products are manufactured.

Section 2: Survey

17. <u>Environmental Management System (EMS) Practices</u> **Sroufe (2003)**

Please indicate the extent to which you are implementing the following practices at your site:

	Not at all (1)			Moderately (4)			Great Extent (7)
We formally document and implement environmental management system procedures at our site.	1	2	3	4	5	6	7
We include environmental issues and policies in training and communication activities at our site.	1	2	3	4	5	6	7
We have formal roles, responsibilities and authority for environmental affairs at our site.	1	2	3	4	5	6	7
We regularly track and monitor environmental information regarding environmental impact at our site.	1	2	3	4	5	6	7
We formally track and report environmental performance at our site (i.e goals, programs, objectives & targets).	1	2	3	4	5	6	7
We widely distribute and give visibility to environmental performance at our site (i.e. goals, programs, objectives & targets).	1	2	3	4	5	6	7
Top management at our site supports environmental performance and prevention of pollution.	1	2	3	4	5	6	7
People within our site consider our system to be effective at meeting our goals, objectives and targets.	1	2	3	4	5	6	7

18. Environmental Supply Chain Management Practices: During the past ***three years*** to what extent did your site engage in the following control and monitoring activities with your ***primary*** suppliers?

Vachon and Klassen (2008)

	Not at all (1)			Moderately (4)			Great Extent (7)
We achieve environmental goals collectively with our primary suppliers.	1	2	3	4	5	6	7
We develop a mutual understanding of responsibilities regarding environmental performance with our primary suppliers.	1	2	3	4	5	6	7
We work together with our primary suppliers to reduce environmental impact of our activities.	1	2	3	4	5	6	7
We conduct joint planning with our primary suppliers to anticipate and resolve environmental-related problems.	1	2	3	4	5	6	7
We make joint decisions with our primary suppliers about ways to reduce the overall environmental impact of our products.	1	2	3	4	5	6	7

19. Preventive Maintenance Practices:
Please indicate the extent to which you agree or disagree with the following statements.

Sakakibara, Flynn and Schroeder (1993)

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Agree or Disagree	Slightly Agree	Moderately Agree	Strongly Agree
Our equipment is in a high state of readiness for production at all times	1	2	3	4	5	6	7
We dedicate a portion of everyday to preventive maintenance.	1	2	3	4	5	6	7
We emphasize good maintenance as a strategy for achieving quality and schedule compliance.	1	2	3	4	5	6	7
We have a separate shift, or part of a shift, reserved each day for maintenance activities.	1	2	3	4	5	6	7
We have a relatively low rate of downtime for repair, compared with our industry.	1	2	3	4	5	6	7

20. Quality Information: Please indicate the extent to which you utilize the following practices at your site:

Ahire, Golhar and Waller (1996)

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Agree or Disagree	Slightly Agree	Moderately Agree	Strongly Agree
Scrap rates of our primary product are readily available,	1	2	3	4	5	6	7
Rework rates of our primary product are readily available.	1	2	3	4	5	6	7
Cost of quality data concerning our primary product is readily available.	1	2	3	4	5	6	7
Quality information is displayed at most of the work stations.	1	2	3	4	5	6	7
Progress toward quality-related goals is displayed in our site.	1	2	3	4	5	6	7
Information about defects is conveyed to the appropriate workstation (source).	1	2	3	4	5	6	7

21. Customer Focus Please indicate the extent to which you agree or disagree with the following statements. **Samson and Terziovski (1999)**

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Agree or Disagree	Slightly Agree	Moderately Agree	Strongly Agree
We know our external customers' current and future requirements (both in terms of volume and product characteristics).	1	2	3	4	5	6	7
The requirements of our customers are effectively disseminated and understood throughout our site and our workforce.	1	2	3	4	5	6	7
We use the requirements of customers in designing new products and services at our site.	1	2	3	4	5	6	7
We use customer complaints as a method to initiate improvements in our current processes.	1	2	3	4	5	6	7
We systematically and regularly measure external customer satisfaction at our site.	1	2	3	4	5	6	7

22. Leadership Please indicate the extent to which you agree or disagree with the following statements. **Samson and Terziovski (1999)**

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Agree or Disagree	Slightly Agree	Moderately Agree	Strongly Agree
Senior Managers at our site actively encourage change and implement a culture of trust, involvement and commitment in moving towards "Best Practice."	1	2	3	4	5	6	7
There is a high degree of unity of purpose throughout our site, and we have eliminated barriers between individuals and/or departments.	1	2	3	4	5	6	7
Senior Managers effectively drive "Best Practices" at this site.	1	2	3	4	5	6	7
At this site we proactively pursue continuous improvement rather than reacting to crisis' "fire-fighting."	1	2	3	4	5	6	7
Ideas from employees are actively used in assisting management at this site.	1	2	3	4	5	6	7
Environmental "green" protection issues are proactively managed at this site	1	2	3	4	5	6	7

23. People Management: Please indicate the extent to which you agree or disagree with the following statements. **Samson and Terziovski (1999)**

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Agree or Disagree	Slightly Agree	Moderately Agree	Strongly Agree
The concept of the "internal customer" (i.e. the next person or process down the line and including all employees) is well understood at our site.	1	2	3	4	5	6	7
We have an organization-wide training and development process, including career path planning, for all our employees at our site.	1	2	3	4	5	6	7
Our site has effective 'top–down' and 'bottom–up' communication processes.	1	2	3	4	5	6	7
We formally and regularly measure employee satisfaction at our site.	1	2	3	4	5	6	7
We have excellent Occupational Health and Safety practices at our site.	1	2	3	4	5	6	7
Employee flexibility, multi-skilling and training are actively used to support improved performance at our site.	1	2	3	4	5	6	7
At our site all employees believe that quality is their responsibility.	1	2	3	4	5	6	7

24. Set-up Reduction Practices: Please indicate the extent to which you agree or disagree with the following statements **Sakakibara, Flynn and Schroeder (1993)**

	Strongly Disagree	Moderately Disagree	Slightly Disagree	Neither Agree or Disagree	Slightly Agree	Moderately Agree	Strongly Agree
We are aggressively working to lower setup times at our site.	1	2	3	4	5	6	7
We have converted most of the setup times to external time while the machine is running	1	2	3	4	5	6	7
We have low setup times of equipment at our site.	1	2	3	4	5	6	7
Our crews practice setups to reduce the time required.	1	2	3	4	5	6	7

25. <u>Volume Flexibility</u>: Please indicate the extent to which you agree or disagree with the following statements. **Jack and Raturi (2002)**

	Not at all (1)			Moderately (4)			Great Extent (7)
Production processes and equipment at our site give us the capability to produce high volume levels.	1	2	3	4	5	6	7
Our site can significantly (> +/-25%) increase (or decrease) output levels to support fluctuations in demand.	1	2	3	4	5	6	7
When we increase (or decrease) our site's volume levels we do not experience more than proportionally higher (or lower) production costs.	1	2	3	4	5	6	7
When we increase (or decrease) our site's volume levels we do not experience more than proportionally higher (or lower) product quality problems.	1	2	3	4	5	6	7

26. <u>Worker Flexibility</u>: Please indicate the extent to which you agree or disagree with the following statements. **Zhang, Vonderembse and Lim (2003)**

	Not at all (1)			Moderately (4)			Great Extent (7)
At our site, workers can perform many different types of operations effectively.	1	2	3	4	5	6	7
At our site, workers can perform a broad range of tasks effectively.	1	2	3	4	5	6	7
At our site, a typical worker can use many different tools effectively.	1	2	3	4	5	6	7
At our site, workers can operate various types of machines and/or equipment.	1	2	3	4	5	6	7
At our site, workers can be transferred easily between different departments.	1	2	3	4	5	6	7

27. <u>Mix Flexibility</u> **Zhang, Vonderembse and Lim (2003)**

Please indicate the extent to which you agree or disagree with the following statements.

	Not at all (1)			Moderately (4)			Great Extent (7)
We can produce a wide variety of products at our site.	1	2	3	4	5	6	7
At our site we can produce different product types without major changeover.	1	2	3	4	5	6	7
At our site we can build different products at the same time.	1	2	3	4	5	6	7
At our site we can produce (simultaneously or periodically), multiple products in a steady-state operating mode.	1	2	3	4	5	6	7
At our site we can vary product combinations from one period to the next.	1	2	3	4	5	6	7
At our site we can changeover quickly from one product to another.	1	2	3	4	5	6	7

28. <u>Environmental Performance</u>: Please indicate the extent to which activities at your site have influenced measures of environmental performance ***relative to your primary competitors***:

Zhu, Sarkis and Geng (2005)

	Far worse than your competitors (1)			**About the same as competitors (4)**			**Far better than your competitors (7)**
Reduced our site's air emissions.	1	2	3	4	5	6	7
Reduced our site's waste water.	1	2	3	4	5	6	7
Reduced our site's solid wastes.	1	2	3	4	5	6	7
Decreased our site's consumption of hazardous/harmful/toxic materials.	1	2	3	4	5	6	7
Decreased our site's frequency of environmental accidents.	1	2	3	4	5	6	7
Improved our site's overall environmental situation	1	2	3	4	5	6	7

29. <u>Operational Performance</u>: **Devaraj, Krajewski and Wei (2007)**

Please rate the operational performance of your site along the following dimensions.

	Not Very Good (1)			**Average (4)**			**Very Good (7)**
Percent product returned by the customer	1	2	3	4	5	6	7
Percent defects during production	1	2	3	4	5	6	7
Delivery speed	1	2	3	4	5	6	7
Delivery reliability	1	2	3	4	5	6	7
Production costs	1	2	3	4	5	6	7
Production lead time	1	2	3	4	5	6	7
Inventory turns	1	2	3	4	5	6	7
The flexibility of operations to accommodate changes to shipping schedules within the effective lead time of the product without the use of safety stock	1	2	3	4	5	6	7

30. <u>Organizational Performance</u>: **Fugate, Stank and Mentzer (2009)**

Please indicate the extent to which activities at your site have influenced the following performance measures ***relative to your primary competitors***.

	Far worse than your competitors (1)			**About the same as competitors (4)**			**Far better than your competitors (7)**
Overall performance	1	2	3	4	5	6	7
Market share growth in our primary market	1	2	3	4	5	6	7
Sales growth	1	2	3	4	5	6	7
Percentage of new product sales generated by new products.	1	2	3	4	5	6	7
Return on sales.	1	2	3	4	5	6	7
Return on investments.	1	2	3	4	5	6	7

Section 3 Background

31. Is your site located in the US? ☐ Yes ☐ No If in the US: City: ___________________ State: _________

32. If not located in the U.S., what Country is your site in? _________________________________

33. What is your job title? ____

34. How many years of experience do you have? __________

35. Company Name: ___________________________________

36 Would you like to receive a report of the results of this study? If yes, please attach a business card or leave your email address.

☐ Yes ☐ No

Email: ____

Thank you for your participation. We hope that what we learn in this research will help firms implement beneficial environmental programs and practices in the future.

APPENDIX B

LEADERSHIP CONSTRUCT

Table 4.10: Leadership	
Source: Samson & Terziovsky (1999)	
Please indicate the extent to which you agree or disagree with the following statements.	
L1	Modification: Senior Managers at our site actively encourage change and implement a culture of trust, involvement and commitment in moving towards "Best Practice." Original: Senior Mangers actively encourage change and implement a culture of trust, involvement and commitment in moving towards "Best Practice."
L2	There is a high degree of unity of purpose throughout our site, and we have eliminated barriers between individuals and/or departments.
L3	Senior Mangers effectively drive "Best Practices" at this site.
L4	At this site we proactively pursue continuous improvement rather than reacting to crisis' "fire-fighting."
L5	Modification: Ideas from employees are actively used in assisting management at this site. Original: Ideas from production operators are actively used in assisting management.
L6*	Environmental "green" protection issues are proactively managed at this site
General Modification Notes: "At this site" added to clarify plant-level activity and performance. *Dropped	

Table 4.11: People Management	
Source: Samson & Terziovsky (1999)	
Please indicate the extent to which you agree or disagree with the following statements.	
PM1*	The concept of the "internal customer" (i.e. the next person or process down the line and including all employees) is well understood at our site.
PM2*	Modification: We have an organization-wide training and development process, including career path planning, for all our employees at our site. Original: We have an organization-wide training and development process, including career path planning, for all our employees.
PM3	Our site has effective 'top–down' and 'bottom–up' communication processes.
PM4	Modification: We formally and regularly measure employee satisfaction at our site. Original: Employee satisfaction is formally and regularly measured.
PM5*	Modification: We have excellent Occupational Health and Safety practices at our site. Original: Our Occupational Health and Safety practices are excellent.
PM6	Modification: Employee flexibility, multi-skilling and training are actively used to support improved performance at our site. Original: Employee flexibility, multi-skilling and training are actively used to support improved performance.
PM7	Modification: At our site all employees believe that quality is their responsibility. Original: All employees believe that quality is their responsibility.
General Modification Notes: "At this site" added to clarify plant-level activity and performance. *Dropped	

Leadership (NEW)	
Source: Samson & Terziovsky (1999)	
Please indicate the extent to which you agree or disagree with the following statements.	
LEA1 (L1)	Modification: Senior Managers at our site actively encourage change and implement a culture of trust, involvement and commitment in moving towards "Best Practice." Original: Senior Mangers actively encourage change and implement a culture of trust, involvement and commitment in moving towards "Best Practice."
LEA2 (L2)	There is a high degree of unity of purpose throughout our site, and we have eliminated barriers between individuals and/or departments.
LEA3 (L3)	Senior Mangers effectively drive "Best Practices" at this site.
LEA4 (L4)	At this site we proactively pursue continuous improvement rather than reacting to crisis' "fire-fighting."
LEA5 (L5)	Modification: Ideas from employees are actively used in assisting management at this site. Original: Ideas from production operators are actively used in assisting management.
LEA6 (PE3)	Our site has effective 'top–down' and 'bottom–up' communication processes.
LEA7 (PE4)	Modification: We formally and regularly measure employee satisfaction at our site. Original: Employee satisfaction is formally and regularly measured.
LEA8 (PE6)	Modification: Employee flexibility, multi-skilling and training are actively used to support improved performance at our site. Original: Employee flexibility, multi-skilling and training are actively used to support improved performance.
LEA9 (PE7)	Modification: At our site all employees believe that quality is their responsibility. Original: All employees believe that quality is their responsibility.
General Modification Notes: "At this site" added to clarify plant-level activity and performance.	