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Successful enviornmental supply chain management in an electronics firm

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SUCCESSFUL ENVIRONMENTAL
SUPPLY CHAIN MANAGEMENT
IN
AN ELECTRONICS FIRM

A Thesis

Presented to

The Faculty of the Department of Environmental Studies

San Jose State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science

Linden Skjeie

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ABSTRACT

SUCCESSFUL ENVIRONMENTAL SUPPLY CHAIN MANAGEMENT IN AN ELECTRONICS FIRM

By Linden Skjeie

This thesis examines the factors that contribute to successful environmental supply chain management in one representative company in the electronics industry. Specifically, case studies of five supply chains in the firm identify characteristics of the external environment, internal organizational structure and processes, and the customer supplier relationships that tend to be associated with reduced environmental impacts of supplier-manufactured components. The study concludes with a set of recommendations for businesses, regulators, and policy makers interested in reducing environmental impacts in industries that use significant amounts of vendor-supplied components.

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Lastly, the late Roger Harm, who taught environmental biology at Foothill College, was an eloquent and inspiring teacher who's values, humanity, and passion touched me and whom I will never forget. It is to his memory and to the life of my daughter, Alison Victoria White, that I dedicate this thesis, for Roger helped make it possible for me to do environmental work while Alison provides its purpose.

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CHAPTER 1

INTRODUCTION

The Environmental Impact of Production and Consumption

Environmental supply chain management (ESCM) refers to how a company works to reduce the environmental impacts of its suppliers' operations and the materials and components they supply. This thesis examines how one electronics company implemented ESCM with five of its suppliers to help ensure the achievement of its product environmental goals such as eco-label qualification, recyclability, and end of life management. Because of the horizontal nature of the electronics industry, a company that wants to reduce the environmental impact of its products will need to engage its suppliers in the process. Using case study research methods, the main finding of the research is that all companies involved in this particular supply chain were motivated to improve product environmental quality by business customers and would not work to improve environmental product quality without a market driver. It also found that end-consumers (as opposed to business consumers) were weak drivers of environmental product innovation and that they could exercise considerably greater influence in motivating companies to improve product environmental quality. This chapter introduces the business and environmental contexts within which environmental supply chain management originated and the thesis research is described briefly.

Environmental and Business Contexts

At the turn of the century, humanity finds itself facing several paradoxical situations. On the one hand, food production, medical care and improvements in living conditions are making it possible for more and more of us to survive childhood and live

to an old age. On the other hand, economic realities, religious and cultural traditions make it difficult to temper population growth with the wide application of family planning services and education.

Economic development is making it possible for more and more people today to enjoy a standard of living unparalleled in human history. But the ways we develop and deliver this standard of living are taxing the natural systems that make it possible in equally unparalleled ways. Biologists such as Paul Ehrlich and Barry Commoner recognized this in the 1960s when they developed their $EB = P \times A \times T$ equation in which environmental burden (EB) is a function of 1) the size of the human population (P), 2) the affluence that population enjoys (A), and 3) the technology utilized to create the affluence (T) (Hart 1997).

Addressing these three factors poses many challenges. Ninety percent of the world's population growth over the next fifty years is expected to be in the southern hemisphere, where economic growth is expected to be double that of the developed world (Hart 1995). It is estimated that providing people in developing countries just with basic amenities would necessitate increasing economic activity five to tenfold (McNeil 1989; Ruckelshaus 1989).

Satisfying this increase in demand for goods has the potential to further devastate already stressed ecosystems. For instance, it is estimated that the world's virgin forests will be gone in 50 years, resulting in a loss of half the world's species. Additionally, the 18 primary fisheries of the world have now reached or exceeded their levels of maximum sustained yield (Brown, Kane, and Roodman 1994). Both facts illustrate the non-sustainable nature of humanity's current relationship with the natural systems that support the species. In the electronics arena, over 300 million computers are expected to become obsolete within the next several years with few precious metals to recycle, yet they contain several toxic substances to dispose of such as lead, chromium and mercury.

These require special landfilling and have been banned from landfills in states such as Massachusetts. Companies such as Hewlett Packard and IBM have developed voluntary takeback programs for such equipment (Hopewell 2001).

With population growth and development seemingly inevitable, reducing the environmental impact of development is perhaps the most feasible course to sustainable development and the one that can be implemented most quickly (Graedel and Allenby 1995). And with resource scarcity becoming more common, it is also the most imperative.

The Impact on Business

Sustainable Development is defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (Lesh and Lowrie, 1990, 13). Because current systems lack environmental sustainability, Hart predicts a paradigm shift in our industrial and economic systems towards sustainable development. He believes that companies that succeed in the long run will develop proficiency in waste minimization, green product design and technology cooperation, rooting themselves in sustainable economic activity (Hart 1995).

Within this context, industry has been undergoing its own transformations in recent years. Significantly, many industries, including the focus of this thesis -- the electronics industry -- have transitioned from a vertically integrated to a horizontally integrated model of business. This means that the majority of the materials and components that make up a "design" company's products (a design company being the one to conceive of and design a product but not to manufacture all its components) comes from other companies or suppliers. They are not necessarily generated by the company whose name ultimately appears on the product. For instance, a company making a computer typically buys power supplies, plastics, metals, printed-circuit

boards (PCBs), monitors, and keyboards from other companies, assembles them, and sells them as their own products. Beckman, Worhach and Sheng stated that only 10-15% of a typical electronics product might be produced internally (Beckman, Worhach and Sheng 1995). Therefore, a company moving towards sustainable economic activity needs to do so within the context of its supply web.

Three areas germane to this thesis were the evolving environmental regulatory climate in which electronics companies produced products and conducted business, the growing trend towards industrial ecology, and a growing market preference for environmental quality that influenced how companies produced products. These three areas are addressed below.

Because the goods of suppliers make up such a large portion of so many finished products, any effort that a design company makes to reduce product environmental impact needs to include suppliers in its efforts. Otherwise, product environmental quality will hardly be impacted. This thesis will help show how this was addressed by Hewlett Packard.

Drivers of Product Environmental Quality

At the time of this research, the two major drivers for improving product environmental quality in the electronics industry were market forces and regulations. At the turn of the century, both showed signs of growing influence in motivating companies to reduce their environmental product impacts.

Market Forces Affecting Environmental Product Quality

The markets for electronic equipment can be broadly divided into end-consumers, and business or institutional customers. A U.S. survey of 1,000 consumers found that more than 90 percent of adults were "concerned" about the environment, with

half saying they were "very concerned" (Environmental Research Associates 1996). When asked who was responsible for environmental problems, a 1996 survey by the Roper organization found people identifying themselves. The same Roper poll found that the initial market for "green" products was not lucrative but afforded early producers "competitive preemption," meaning they gained access to resources or established rules favorable to the firm's capabilities. At the same time, respondents expressed an unwillingness to pay more for environmental product quality, saying that it should be part of the product's overall quality (The Green Business Letter 1996). The 1999 NEETF/Roper Poll found the American public lacking in basic environmental knowledge about contemporary environmental challenges but still interested in reducing individual environmental impacts (National Environmental Education & Training Foundation 2000).

The market for environmentally sound products is growing. In research done in 1998, over 70 percent of teens and 60 percent of "baby boomers" (people fifty and over) agreed that business and governments were not concerned about the environment and expressed willingness to pay financially for greater environmental quality in products and physical environments (Environmental News Network 1998). However, when companies surveyed customers, the only ones that consistently demanded environmental product quality were businesses who demanded it of each other, government institutions, and institutions of higher learning. Geographically, the majority of these business, government agencies and institutions of higher learning were located in Europe (Mulder 1998).

With their superior access to environmental information, institutional buyers were in a better position to influence each other's environmental activities, for the most part, than were end-consumers. Corporations sell more to each other than they do to end-consumers and are afforded more opportunities and information for influencing

each other's environmental product quality. For instance, Green et al. noted that in 1993, consumer spending in the UK was 400 billion pounds while UK corporations large enough to have purchasing departments spent 750 billion pounds (Green, Morton and New 1996). Mulder further noted that large private companies developed most private green purchasing guidelines. Many of these guidelines applied worldwide while some even tailored their guidelines to fit the particular environmental needs of the country in which the purchase was made (Mulder 1998).

In any case, if customer environmental preferences from any market continue to grow, market forces will grow in their ability to drive improved product environmental quality. Additionally, the environmental preferences of end-consumers have the potential to affect corporate environmentalism all the way up the supply chain.

This creates a good deal of uncertainty for companies who want to know if improving product environmental quality will actually translate into increased sales. Sharfman et al. noted that uncertainty may or may not influence companies to improve product environmental quality (Sharfman, Ellington, Meo, and Shaft 1997). Many companies do proceed with product environmental improvements in hope of gaining the competitive preemption noted by Roper. Others start demanding environmental quality as part of their own "good corporate citizenship." Or, they demand environmental quality from suppliers to ensure their own products meet environmental quality goals.

One tool customers (especially corporate and institutional customers) use to gauge a product's environmental quality is eco-labels. An eco-label is a seal of approval available to a class of products that certifies that a particular model meets the environmental criteria developed for that class of products. Governmental or quasi-governmental bodies such as the TCO trade union in Sweden generally develop them. The labels most common to the electronics industry are the US Environmental Protection Agency's Energy Star, the German Blue Angel and the Swedish TCO labels.

Criteria include design for disassembly, material specifications, and energy specifications. Many companies are qualifying their products for eco-labels in hope of assuring themselves access to eco-sensitive customers (United States Environmental Protection Agency Web page 1998). Thus, eco-labels have become a market driver for product environmental quality.

Environmental Regulations Affecting Product Environmental Quality

While environmental regulations of the past have focused on a company's operations, environmental regulations are now addressing product issues. For instance, the European packaging and battery take-back regulations enacted in the early 1990s are being followed by product take-back regulations which require companies to take back products for reuse and recycling once the consumer is done with them. The European Commission issued a draft product take back directive for electronic products in October 1997, which they based upon an earlier vehicle take-back ordinance (Hunter 1997). The directive would mandate a percentage of recycled content in products, ban certain heavy metals, and require producers to deal with the end-of-life management of their products (European Union 2001). Countries such as the Netherlands, Denmark, Italy and Australia are in the process of enacting take-back laws (Business and the Environment 2000). This affects numerous American electronics companies who sell into European countries. Hewlett Packard called this "perhaps the most significant development that has awakened industry leaders to think about their products in life-cycle management terms" (Bast and Korpalski 1996, 200).

The possibility exists for analogous laws to be enacted in the United States in the form of "extended producer responsibility" and battery take-back laws (Green Business Letter 1996). Extended producer responsibility refers to holding a company responsible for a product that it manufactures once the customer it sold the product to is done with

it. This would mean the company is responsible for its "end of life management." End of life management refers to minimizing the waste generated by a product at end of life as well as its toxicity through recycling and reuse. Managing product take back efficiently will require the participation of suppliers both in the product development and disposal stages.

How this Affects Corporations

All these factors compound the complexities of the business environment. Post and Altman state, "Industry now faces an agenda of ecological and natural resource issues that is large, complex, and momentous in terms of global life support systems" (Post and Altman 1992, 4). The growth of eco-sensitive markets creates more complexity and risk. The regulatory trend may expand corporate responsibility and thus the liability a company has for its products. And with potential resource constraints, producers may need to learn to make more with less.

Business is moving from an adversarial relationship with environmental regulators to a cooperative relationship with them. Dechant and Altman describe this as "a continuum of adjustment, adaptation and finally, innovation" (Dechant and Altman 1994, 7). According to Lloyd, 45 percent of all companies implementing environmental programs were motivated by compliance and the remaining 55 percent by cost reductions and increased profitability (Lloyd 1994). In any case, Hart believes that successfully competing for the eco-sensitive customers of the future may depend upon a firm's ability to envision sustainable technologies and products that do not yet exist and to stake them out ahead of the competition (Hart 1995).

Industrial Ecology as a Solution

Creating technologies that are attractive to eco-sensitive customers, meet regulatory requirements, and reduce resource requirements means modifying product development processes to account for environmental impacts throughout product life cycles. Two strategies for doing this include "Product Stewardship" or "Design for Environment," and "Industrial Ecology."

Product stewardship, in which products are designed, built, maintained, reused, and recycled in ways that pose minimal environmental impact, is perhaps industry's most potent weapon in reducing the environmental impact of the goods it produces. First coined in the early 1990s, product stewardship is being championed by forward-thinking companies that recognize its potential for competitive advantage, cost savings, and reduced liability in product end-of-life management. The term is synonymous with Design for Environment. Two of the industries championing product stewardship include the automotive industry, especially in Europe, and the electronics industry.

Like overall corporate environmental management, product stewardship needs to be incorporated into the company's existing product delivery process, making it seamless, minimizing costs, and supporting the integration of environmental management into the business.

Industrial Ecology is defined as "a systems view in which one seeks to optimize the total materials cycle from virgin material, to finished materials, to component, to product, to obsolete product and to ultimate disposal. Factors to be optimized include resources, energy, and capital" (Graedel and Allenby 1995, 9).

An industrial ecology system mimics a biological system by rejecting the notion of waste. Instead, materials and products that have reached the end of their initial life cycles can be considered residues. Our current industrial processes have not yet evolved

to a point where these residues can be efficiently used for further production (Graedel and Allenby 1995). But coupling the pressures of regulations, resource constraints, and eco-sensitive markets with product stewardship and industrial ecology would effectively move us towards optimizing the use of product residues.

The Role of the Supplier

As stated earlier, a company's products often contain components and materials from dozens to thousands of suppliers, depending on the size of the company and the scope of its products. In fact, some products are merely a competitor's product with the customer logo on it, sent directly from the supplier to distribution points.

While the role of the supplier in producing a company's products has grown inversely to the role of labor, the purchasing function of most companies still suffers from neglect in comparison. According to Bhote, "direct labor, today, has shrunk to an inconsequential 5 percent of sales and less, while purchased material has grown to a hefty 50 percent of sales and more" (Bhote 1989, 33).

Additionally, suppliers themselves may use numerous sub-contractors, both domestically and internationally, that operate under inadequate environmental standards and with great potential for adverse health and environmental effects. As evidenced by the recent experience of the garment industry, companies that do not adequately evaluate suppliers can find themselves in a public relations nightmare when those suppliers are found to exploit their workers, resources, or the environment (Nation Magazine 1996).

While many electronics companies have moved beyond regulatory compliance to developing environmental management systems that address company functions, few have moved beyond their internal operations to address the impacts of the goods coming from their suppliers or the impacts created in their production (Beckman, Worhach and Sheng 1995).

Companies that have made such efforts initially focused on the realm of office supplies and equipment purchases. According to a 1995 survey done by Purchasing magazine, 80 percent of respondents had begun to buy green office equipment and supplies, up from 40 percent two years previous. Of importance to the electronics industry, 71 percent of respondents said they bought equipment such as copiers, fax machines, printers and lighting designed to conserve energy (Avery 1995).

But if companies are going to develop resource-conserving products, appeal to eco-sensitive markets, and minimize the burden of product take-back laws, they need to give suppliers a bigger role in addressing product environmental quality. Without such partnerships, any attempts to reduce environmental impact will fall woefully short of their potential. Additionally, it will slow progress towards industrial ecology and sustainable development, where economic development happens in a more ecologically efficient manner.

With continued globalization of commerce and the trend towards out-sourcing, the role of the supplier will only grow in importance. Bhote predicted "in the factory of the future the direct labor contribution to goods produced will shrink even further, approaching zero, while purchased material will increase to 60 percent of sales" (Bhote 1989, 33). Additionally, Sarkis noted that in the future, customer-buyer relationships will evolve from being commodity-based to the creation of an agile web in which ad-hoc enterprises form to manufacture products in "virtual relationships" -- transient business arrangements that last only long enough to address a particular market condition. Within these virtual enterprises, effective supply chain management will be of paramount importance and effective environmental management even more of a challenge unless it is made a priority (Sarkis 1995).

Therefore, any attempt by a company to reduce the environmental impact of its products and prepare them for end-of-life management needs to include the suppliers who contributed to them.

Problem Statement -- Importance

While many companies are establishing or refining environmental management systems and adopting product stewardship, few have moved beyond addressing their internal operations to address the environmental impacts of their suppliers (Beckman, Worhach, and Sheng 1995). In the case of the electronics industry, supplier components can comprise up to 80 percent of a typical electronics product, thus profoundly impacting its environmental quality (Bhote 1989). Unless design companies work with their suppliers to reduce the environmental impact of supplier products and operations, they will fail to minimize the environmental impact of their products or contribute to an industrial ecology model of commerce (Hart 1995; Sarkis 1995).

Theoretical Framework

Current understanding of Environmental Supply Chain Management comes from the areas of industrial ecology and supplier management.

One goal of industrial ecology is for the flow of commerce to be cyclical or circular rather than linear (where obsolete goods become waste and exits the system) (Graedel and Allenby 1995).

According to Smart, “the environmental impact of a product is the sum of the impact of each input that goes into its making, use and disposal. Thus it is logical for the proactive company to look not only at its own processes but up and down the chain of materials, distribution and use - a concept known as product stewardship” (Smart 1992, 170).

Lamming and Hampson hypothesized that “diffusing environmental management techniques backwards and forwards through the supply chain might be a very effective way of developing the general environmental performance of an industry” (Lamming and Hampson 1996, S46).

Several recent papers theorize about the factors that facilitate effective environmental management of suppliers. First of all, it is theorized that companies where the purchasing function has evolved from a clerical function to a strategic function will be more effective at ESCM (Pearson, Ellram and Carter 1996). Secondly, companies that maintain collaborative, long-term supplier relationships with a strong element of trust and commitment, rather than adversarial relationships, will be more effective at ESCM (Sharfman, Ellington, Meo and Shaft 1997). Additionally, companies that perceive a competitive advantage, either because of market or competitive forces will be more likely to engage in environmental supply chain management (Drumwright 1994).

Sharfman et al. theorized about the antecedents to customer/supplier cooperation on environmental issues. For instance, they theorized that if a supplier had few customers for its good, it was more likely to be motivated to comply with a customer’s environmental requirements and therefore more successful at collaborating on environmental issues. They additionally theorized that companies that were experiencing a high degree of regulatory pressure would engage suppliers in environmental issues (Sharfman, Ellington, Meo and Shaft 1997).

Sarkis theorized that a considerable amount of information exchange between the customer company and its suppliers would be present in successful ESCM. Moreover, suppliers would be involved with their customers in a cross-functional effort beginning at the research and design stage of the product delivery process (Sarkis 1995).

It was theorized that companies that wanted to evaluate supplier environmental performance would use supplier evaluations that ranked suppliers on the environmental quality of their operations and products (Lamming and Hampson 1996). Additionally, Drumwright theorized that there would be a "policy entrepreneur" who champions environmental supplier management (Drumwright 1994). A policy entrepreneur is someone who enters the purchasing department from elsewhere in the organization to influence it to develop an environmental supply chain management process.

At this stage in environmental supply chain management, it was theorized that little effort would have been made towards measuring actual environmental improvements and that what measurements did exist would reflect the original motivating factors. For instance, if a company were motivated to achieve eco-labels, then they would measure progress in the number of products that qualify for targeted eco-labels.

The Focus of this Research

This research builds on the work of other theorists by pursuing the following research questions and hypotheses:

Question 1. *What characterizes companies that initiate environmental supply chain management programs and what motivates them to do so?*

Hypothesis 1. *Companies at the forefront of environmental supplier management will share the following characteristics:*

- a. They will have established environmental leadership programs early on (circa 1990-1992), compared to other members of their industry;
- b. They will have "total quality" programs;
- c. There may be one environmental champion who spearheads the

integration of environmental considerations into the supplier management process;

- d. Their products will contain a majority of parts and materials from outside vendors;
- e. They will be multinational companies;
- f. The purchasing function will be a strategic element of the company.

Hypothesis 2. *Companies will be motivated by:*

- a. Market forces such as competitor activities, customer requirements, and eco-labels;
- b. Regulation;
- c. Internal company environmental policy;
- d. Anticipated cost savings such as reduced compliance costs and insurance premiums;

Question 2. *What types of customer/supplier relationships are most likely to succeed in improving the environmental performance of supply chains?*

Hypothesis 1:

- a. Non-adversarial customer/supplier relationships characterized by collaborative partnerships and trust are most likely to succeed;
- b. Customer/supplier relationships in which goods are not easily transferable to other customers, in which the design company has a large percentage of the supplier's market share and few alternative suppliers exist, will be most likely to succeed;
- c. Customer supplier relationships in which suppliers have access to adequate product information and are made part of cross-functional teams are most likely to succeed.

Question 3. *How do companies identify and reduce environmental impacts associated with their supply chains?*

Hypothesis 1:

- a. Companies will include eco-label criteria in product specifications;
- b. They will use expanded supplier questionnaires, standards, audits and product specifications to evaluate suppliers and identify areas requiring change;
- c. Companies may consider ISO 14000 certification as sufficient evidence of the environmental quality of supplier operations.

Question 4. *What challenges have companies found in engaging their suppliers in improving environmental management and products?*

Hypothesis 1: Challenges will include:

- a. Achieving actual and measurable environmental improvements;
- b. Motivating suppliers who do not perceive sufficient economic incentive;
- c. Cost containment;
- d. Dealing with challenges from purchasing itself and middle management;
- e. Effective information exchange; and
- f. Product lead times.

Question 5. *How do companies measure success in improving the environmental performance of a supply chain? Can actual environmental improvements be quantified?*

Hypothesis 1: Companies will measure success in:

- a. The number of suppliers who qualify under environmental criteria;

- b. The number of environmental goals the company meets that are supplier-dependent such as eco-label qualification;
- c. Measurements that reflect the original motivating factors that lead to their programs.

Hypothesis 2: Measurement will be less well developed than other aspects of supplier management programs. Product measurements may include parameters such as:

- a. Product energy savings;
- b. Percentage of parts and components utilizing recycled materials;
- c. Number of parts labeled with material content;
- d. Reductions in the use of hazardous materials;
- e. The number of products achieving eco-labels.

CHAPTER 2

RELATED RESEARCH

This chapter reviews the literature on ESCM. It examines research on general supply chain management, theories around why companies collaborate on ESCM, and the experiences of industry practitioners in operationalizing the concept in their companies. Several articles about HP's experience are discussed as well.

A complex web of customers and suppliers characterizes today's electronics industry. As mentioned in Chapter I, any company supplying end-users (individuals or corporations) with electronic equipment most likely uses numerous suppliers. Therefore, suppliers contribute greatly not only to overall product quality, but to the product's environmental impact as well. Research on how design companies work with suppliers to reduce these environmental impacts is the subject of this literature review.

Recent studies in the general supplier management literature describe a discipline in transition from what was initially a clerical function to a more strategic one. This parallels a similar transition in the environment, health and safety function of many companies. Today, environment, health and safety issues are being incorporated into the overall business functions in which EH&S impacts occur, such as product development and manufacturing. In this way, they are treated more strategically than in the past and their costs are tied to the products and processes with which they are associated (Cascio, Woodside and Mitchell 1996).

Research on the greening of supply chains is sparse and recent, focusing primarily upon theory building. Only very recently have academic studies of ESCM begun to emerge. One academic study addressed how the environment, as a non-

economic buying criterion, affects the buying policies and processes of companies. Its primary aim is to help companies determine how to market green goods to companies, not to describe the environmental supply chain management process. Additionally, some case study research has been done on environmental initiatives within the furniture manufacturing industry, including ESCM.

Beyond theory-building articles and the above-mentioned studies, several electronics industry practitioners have presented their own experiences in greening their company's supply chains at industry environmental symposia. Several publications related to purchasing have identified the opportunity company purchasing departments have to reduce the environmental impact of their businesses by favoring "green" purchases. Additionally, some literature exists on greening the supply chain within other industries.

What follows is a summation and critique of this literature as it pertains to the current state of purchasing and how supply chains can be improved environmentally within this context.

General Supplier Management Literature

Supplier management has come under the same pressure to cut costs as other business functions. According to Bordenaro, this is especially important today. Efficiencies have already been achieved in other parts of the business, out-sourcing creates numerous new purchasing tasks, product cycles are decreasing, commerce is global, and business expansion is much more rapid than previously possible (Bordenaro 1996).

In this increasingly complex business environment, professional purchasers with related graduate degrees are replacing the earlier generation of purchasing staff. With

the help of advanced information management systems, today's purchasers are reducing procurement costs by changing the definition of what they buy (e.g., buying a service rather than the material used to perform the service). They are negotiating for fixed prices and results and making suppliers responsible for bad work. Additionally, they are including performance parameters in contracts, and forcing inventory control on suppliers. So far, these trends appear to be saving business money (New York Times 1996).

To deal with these changes in supplier management, Williams suggests a "learning-based supply management organization" in which employees anticipate change, share a vision of how the supply management function supports business goals, and demonstrate a willingness to take risks to achieve those goals (Williams 1995).

Spekman thinks that traditional approaches to vendor analysis and management may not work in today's fast-paced global environment. He recommends a long list of considerations beyond cost, quality, and delivery when evaluating potential strategic partners. Among them are technological leadership capabilities, joint problem-solving capabilities, and a willingness to share information. His strategy also dovetails well with environmental product improvements as advocated by the theorists and practitioners discussed below (Spekman 1988).

This evolution in the purchasing function is particularly pronounced in the electronics industry. Pearson, Ellram and Carter's 1996 study of 210 electronics companies shows a purchasing function in transition from clerical to strategic, but still lacking the status and recognition of other functions. This reduces the firm's ability to fully benefit from purchasing's strategic potential. The researchers feel that a more cross-functional approach that includes purchasing will increase its status, access to

information and its ability to contribute to business goals (Pearson, Ellram and Carter 1996).

More strategic use of the purchasing function is especially important considering the vertical disintegration that has occurred in the electronics industry since the mid 1980s (Beckman, Worhach and Sheng 1995). In their view, "The supply chain can be conceptually viewed as a network of firms among which information (in the form of product specifications, performance metrics, prices, etc.), products and/or services flow" (Beckman, Worhach and Sheng 1995, 235). When first and second tier suppliers are considered, such an arrangement reduces a design firm's control over the environmental quality of the components and materials it buys as well as the environmental impact of the processes used to make them. Initially, companies in this model have focused on managing suppliers against cost, quality, and timeliness. Environmental management of suppliers has traditionally been relegated to regulatory management.

Theory Building

Recently published theoretical works on environmental supply chain management include studies in the fields of industrial ecology, "environmentally-conscious design and manufacturing," and "life-cycle oriented environmental management."

Life-cycle Oriented Environmental Management and Interfirm Cooperation.

Sharfman et al. (1997) have developed a model of interfirm cooperation, which they hypothesize influences the greening of the supply chain. They characterize greening of the supply chain as a component of "life-cycle oriented environmental management," an approach they believe can improve product environmental impacts at every stage of

product life cycles. They identify the primary drivers of such initiatives as product take-back regulations, competitive pressures, and ISO 14000 environmental management standards. They do not discuss the influence eco-labels have in improving product designs in the electronics industry, nor does their research test their hypotheses.

Rather than build their framework around one customer and its suppliers, the researchers utilize a political economy approach in which the entire supply chain is a social system composed of "interacting sets of major economic and sociopolitical forces which affect collective behavior" (Sharfman et al. 1997, 4). They hypothesize about three variables: 1) the power relationship between customers and suppliers; 2) the level of governmental intervention and regulation experienced by the firm, and 3) the barriers to cooperation arising from anti trust considerations.

The researchers hypothesize that the firms which are more likely to cooperate on greening supply chains will be heavily dependent upon each other, either because of the volume of goods exchanged, or the lack of transferability of goods, or the lack of additional suppliers. Additionally, firms with a heavy regulatory burden (present or anticipated) are likely to collaborate on such initiatives. Uncertainty about environmental issues may or may not lead to cooperation, they hypothesize, depending upon the potential financial risks and benefits. And lastly, Sharfman et al. hypothesize that high levels of knowledge transfer and trust between customers and suppliers will be associated with increased collaboration (Sharfman, Ellington, Meo and Shaft 1997).

All of these theories directly apply to greening electronic supply chains. The electronics industry is among the initial targets of many new product-oriented environmental regulations and standards. These include standards such as the ISO 14000 environmental management standards and various take-back ordinances, such as the European Union's take-back directive on waste electrical and electronic equipment.

Most electronics firms are horizontally integrated. Therefore, the industry is able to lend itself easily to testing hypotheses about the roles of dependence, volume, and transferability in the greening of supply chains as well as the roles of trust and collaboration.

Environmentally-conscious design and manufacturing. While Sharfman et al. couch environmental supply chain management as part of life-cycle oriented environmental management, Sarkis calls it environmentally conscious design and manufacturing (ECDM). He notes that much of the attention paid to ECDM has focused on internal organizational functions. Like Smart, Sarkis believes that by ignoring what goes on up and down the supply chain, companies miss an opportunity to move industries towards closed-loop industrial ecosystems (Sarkis 1995).

Sarkis briefly discusses examples of industrial eco-systems that include supply chain management and declares, "managing supplier (and customer) relationships from a strategic ecological viewpoint is becoming significant and needs to be addressed" (Sarkis 1995, 45). He likens the impact of Total Quality Management on supply chain management to the impact of Total Quality Environmental Management (TQEM) on the development of industrial ecology.

Like Sharfman et al., Sarkis believes that trust and collaboration play important roles in creating effective environmental management in the customer/supplier relationship. However, he goes far beyond the sociopolitical and economic constructs they discuss.

Sarkis delineates numerous supplier, customer and organizational supply chain management strategies, which may be expanded to address environmental management. For instance, among ten supplier strategies, Sarkis notes that integrated quality control

in supplier relationships can be expanded to include environmental quality considerations, much like the approach taken by Quantum Corporation (discussed below). Customer strategies include green marketing to industrial customers and end-users. Organizational strategies include expanding supplier evaluation criteria to include environmental performance and TQM's continuous improvement strategy. Hewlett Packard Corporation has employed both of these strategies in its expanded supplier evaluation criteria.

In the future, Sarkis believes that virtual and agile enterprises will form among companies to take advantage of a market trend or opportunity. Quick formation and dissolution of companies that bring together a variety of core competencies for a specific manufacturing goal have the potential to create related environmental problems, requiring a corresponding sophistication in environmental supply chain management.

Partnerships versus adversaries. Like Sarkis and Sharfman et al., Green, Morton and New identify "the interorganisational network" as the key unit of analysis in investigating environmental supply chain management, acknowledging the significance of supplier relationships in today's era of horizontal integration and out-sourcing of non-core activities (Green, Morton and New 1996). They note the replacement of the former adversarial relationship between suppliers and customers with long-term partnerships in which both parties strive for continuous improvement and mutually benefit from the rewards. While facilitating other aspects of production, such as just-in-time delivery, Green, Morton and New believe that collaboration facilitates environmental improvements along the supply chain as well. They also note the lack of a clear theoretical framework, which would explain "the commercial and industrial logic of

'green supply' and which allow varying strategies to be compared and empirical information on what companies are actually doing" (Green, Morton, and New 1996, 7).

Green, Morton and New identify the end-consumer as one of the drivers of corporate greening, joining legislation and stakeholders as motivational forces. But they agree with Sarkis who considers end-consumers to be weak agents of change because they lack the knowledge to distinguish between cosmetic and true environmental improvements. Green et al. identify the complex "web of selling" created by business-to-business commerce as a more effective way to reduce environmental impacts. Corporations sell more to each other than they do to end-consumers and are afforded more opportunities and information for influencing each other's environmental product quality than end-consumers are. They believe that the methods firms adopt to influence each other's behavior, to influence the appropriate government policies, and to improve environmental product quality must be further studied.

The mechanisms Green, Morton and New identify to make supply chains more environmentally-sound include developing corporate environmental policies; involving the supplier in the design and specification process (like Spekman); including environmental criteria in the supplier qualification procedures (like Sarkis and Hewlett Packard); environmental cost accounting; and logistics. Spekman, Sarkis and Hewlett Packard support these mechanisms. Additionally, the researchers think that suppliers must also engage their customers in the greening process (like Sarkis, and the Quantum example below).

Tying ESCM to business goals. After discussing legislation, market trends, and the different elements of environmental management systems, Lamming and Hampson correlate these phenomena to the greening of supply chains through the activities of five

UK-based companies. While Lamming and Hampson (1996) come up with some good information, their methodology is unclear. Source information comes from a literature search of other academic writing, company literature, and papers given by companies at symposia.

Lamming and Hampson find two different methodologies companies use to assess their suppliers: "interventionist" where suppliers are evaluated through questionnaires and environmental audits, and, a "cascade" strategy where companies include their suppliers' attainment of environmental management standards as part of the supplier evaluation process. These seem somewhat redundant.

While these two strategies are not well defined or delineated, Lamming and Hampson are the only "theory builders" to tie supply chain greening to business goals. They find that "the extent to which SMEs [small and medium-sized enterprises] respond to this issue will be dictated by the strength of the business case, in terms of commercial benefit" (Lamming and Hampson, 1996, S51). They identify the two biggest factors influencing the environmental activities of industry as environmental legislation and bottom line impacts.

ESCM in Other Industries

Case study research has been done to identify "environmentally-friendly practices" for supply chain management within the furniture manufacturing industry. The industry has several key processes common to most members with significant environmental implications, legislative considerations, and public scrutiny. The industry is fairly concentrated among a few companies. Walton, Handfield, and Melnyk identify five areas where procurement can improve environmental product quality: 1) materials used in product design for the environment; 2) product design processes; 3)

supplier process improvement; 4) supplier evaluation; and 5) inbound logistics processes, noting that environmental management must be integrated with the day-to-day processes of the organization (Walton, Handfield, and Melnyk 1998). They say that “proactive companies wanting to reap the greatest benefits from their environmental management processes must integrate other members of the supply chain into these processes” (Walton, Handfield, and Melnyk 1998, 3).

The study makes several recommendations: First of all, the authors recommend that product design and purchasing personnel work together to address environmental quality in supplier and end products with materials substitutions where appropriate. Additionally, the authors recommend that product designers apply lifecycle analysis to products and have procurement staff work with product designers to do this.

The authors make several additional recommendations regarding regulatory compliance: First, they recommend that customer companies work with suppliers to ensure regulatory compliance, thus reducing the risk of business interruption. This also avoids non-compliance with environmental regulations by the customer company since liability extends to all supply chain members. Second, criteria used to evaluate suppliers must reflect the environmental goals of the customer company. Third, in-bound logistics represent a good opportunity to reduce environmental impacts and should be addressed. All of these require that supplier management initiatives addressing environmental impact should go beyond compliance and be supported with adequate resources to ensure success (Walton, Handfield, Melnyk 1998).

The authors also found that close working relationships are most conducive to improving product environmental quality and that the smaller the supplier, the less interested they were in addressing environmental issues. The authors identified regulatory compliance as the primary driver and paid little attention to market forces in

inspiring these furniture manufacturers to improve environmental quality. However, they do state that minimal regulatory compliance will not be enough for these companies to maintain market share (Walton, Handfield, Melnyk 1998).

Environmental Concern as a Non-economic Buying Criterion

Drumwright's research on environmental concern as a non-economic buying criterion is the only study actually to test theory on environmental supplier management. Drumwright states that previous research on non-economic buying criteria is scant. She uses case study research methods to examine the process by which corporations integrate non-economic buying criteria, such as environmental criteria, into traditional considerations such as cost, quality and reliability (Drumwright 1994).

With in-depth study of 35 buying processes in ten organizations, Drumwright identifies two key factors critical to the successful integration of environmental criteria in supplier evaluation. One is the patronage of an adept "policy entrepreneur" for whom the issue has a moral element. A policy entrepreneur comes from outside the purchasing function to champion the integration of environmental considerations into how the company works with its suppliers. The second factor is the context within which this entrepreneur operates (Drumwright 1994). None of the researchers discussed so far have identified these two factors as necessary to the process. One encouraging finding of Drumwright's is that "socially-responsible buying 'took', in that initial resisters became converts and no one reverted," which "suggests a growth opportunity rather than a fad" (Drumwright 1994, 16).

Drumwright found two different categories of organizations were represented by her sample: one in which socially responsible buying was part of a deliberate corporate strategy and another in which it was not. Within these two categories were four types of

companies. In the Type I companies, socially responsible behavior was an extension of the values of the company founder and company products were designed to appeal to socially conscious consumers. In this type of company, purchasing managers were afforded a higher status and were often involved with products central to the business' profitability. The function was becoming strategic and less clerical.

In Type II companies, the impetus for socially conscious buying was management's recognition that socially conscious behavior through purchasing made good business sense. These companies were made up primarily of heavily regulated companies who traditionally suffered intense public scrutiny.

Type III companies were inspired to do socially-conscious buying because they felt it would give them a competitive advantage; it was not done as a matter of course. "Socially responsible meant whatever their customers perceived it to mean, which generally involved the product's composition" (Drumwright 1994, 10).

Type IV companies had a much broader view of socially conscious buying, including "whence and from whom [the product] came," costing the companies appreciably more than the Type I - III companies (Drumwright 1994, 11). They didn't necessarily have a deliberate buying strategy, but they would use their efforts in this arena for public relations benefits.

From this research, Drumwright found the success of socially-conscious buying to be context-dependent, greatly influenced by the effectiveness of the policy entrepreneur and whatever team he or she would form to develop the process. Successful efforts resulted in a conversion to "a mind-set and behavior pattern of social responsibility" (Drumwright 1994, 13).

Drumwright also found that the company's purchasing professionals who resist the initiatives of others could thwart success. Pearson, Ellram and Carter found this as

well in their survey of purchasing professionals in the electronics industry (Pearson, Ellram and Carter 1996). Therefore, purchasing professionals need to be included in any cross-functional groups that address these issues. Beyond reluctant purchasing professionals, the success of socially conscious buying initiatives can be reduced by the middle managers most affected by the initiative. Additionally, covert support from top management was helpful if it was within "a climate conducive to risk taking and persistent problem solving" (Drumwright 1994, 14).

Unlike the previously discussed research, Drumwright does not consider supplier, customer, or organizational strategies along the lines of Sarkis, nor the roles of trust, collaboration, or transferability discussed by Sharfman et al. Drumwright does not examine the criteria companies use to evaluate their suppliers nor the processes by which companies operationalize these criteria. Rather than focusing on supply chain greening, Drumwright's research is done for vendors who want to have better market access to eco-sensitive customers.

Electronics Industry Practitioners

The IEEE Symposium on Electronics and the Environment has provided a forum for environmental supplier management progress in the electronics industry. The Symposia presentations are informative of the practices of early adopters and support the theories put forth above to a certain extent. They support the supply chain as the unit of analysis, and the idea that business-to-business commerce is an effective agent of change.

How the electronics Industry is developing ESCM. Mulder (1998) states that theoretically, " 'green' customer demand forms a major driver for companies to offer and market greener products" but that it is unclear just how effective green purchasing

initiatives have been in terms of gaining better environmental performance from electronic equipment such as computers (Mulder 1998, 123). Mulder notes that in customer survey work done by Digital Equipment Corporation in 1995, 60 percent of Digital's European customers identified environmental and ergonomic features as factoring into purchasing decisions. The major market drivers originate primarily in Europe, especially Scandinavia, Germany, Switzerland, and The Netherlands. Other areas beginning to evaluate information technology (IT) equipment on environmental criteria are Canada, Japan, and to a lesser extent, the United States.

Mulder notes considerable variance and inconsistency in how purchasing bodies evaluate and rate environmental performance of IT equipment. Criteria can range from general environmental performance such as the endorsement of an environmental policy and regulatory compliance, to specific product requirements such as eco-label qualification or end-of-life product potential. However, the research notes the difficulty in ascertaining how much weight is attributed to product environmental performance and very little feedback is offered to IT bidders on how they rate or how the environmental information is used.

She notes that the German Blue Angel forms the basis for numerous green purchasing guidelines. Suppliers are asked to provide environmental information through environmental questionnaires, presentations, and tender documents, which contain lists of green requirements or specifications. Some appear as requirements, others as preferences. However, few of these guidelines are the product of joint efforts between the IT industry and government (Mulder 1998). The great disparity among green purchasing guidelines reduces the effectiveness green purchasing could have on improving the environmental quality of IT equipment and harmonization would improve

this. Mulder believes that purchasing bodies should work with the IT industry to create this.

Mulder notes that most evaluating entities have developed their own guidelines for evaluating and comparing environmental bid information. They include 1) ad hoc evaluations based primarily on impressions; 2) scoring; 3) life cycle costing which bases decisions on total cost of ownership; 4) eco-labels and environmental management standards; and 4) general evaluation guidance. All of these factors work in concert to reduce the potential for purchasing practices to effectively influence supplier environmental improvements.

Individual Company Programs

Chambers and Cox describe environmental supply chain management in Quantum Corporation's Environmental Product Design (EPD) Program. Quantum is an American manufacturer of disk drives. EPD works to ensure the fulfillment of customer environmental goals by working more closely with suppliers on materials selection. The program began in response to customer environmental inquiries that in turn required Quantum to make its own inquiries of its suppliers.

To begin addressing customer environmental requirements, Quantum developed a DFE process that included suppliers and representatives of other functional groups such as marketing, finance and product design. This supports Sarkis and Spekman's theory that suppliers need to be involved early on in order to achieve product goals. Supplier input was included when the company amended the supplier evaluation process to include environmental considerations, much like Lamming and Hampson's cascade strategy. Ultimately, Quantum incorporated these environmental criteria into their ISO 9000 procurement quality procedures (Chambers and Cox 1996).

Hewlett Packard research. A slightly different situation is described in Hsia Choong's IEEE paper on Hewlett Packard's approach. Hewlett Packard makes computers for business and consumer end-users, some of whom are demanding better environmental performance from both HP products and company operations. The company's efforts to integrate environmental considerations into supplier management followed an earlier initiative to make supply chain management more strategic (Davis 1993). In order to evaluate their suppliers' environmental performance, HP added an "E" for environment to their five point evaluation criteria -- "TQRDC-E," as suggested by Sarkis, Lamming and Hampson. The other points represent technology, quality, responsiveness, delivery, and cost. Environmental criteria include global and commodity specific criteria.

Global criteria include supplier environmental improvement policy, implementation plan with metrics, and elimination of ozone-depleting substances. The purpose of these criteria is to facilitate the development of environmentally responsible materials and processes for specific commodities. Beyond this, commodity-specific criteria are developed for those commodities that have been identified as offering favorable opportunities for environmental improvement (Choong 1996).

Then, to help its suppliers qualify under the new environmental requirements, Hewlett Packard began a Procurement of Environmentally Responsible Material (PERM) program with the aim of having 100 percent of company suppliers worldwide qualify by the end of 1996. The environmental criteria are commodity-specific as well as global in nature, addressing the suppliers' management processes and policies.

The process was instrumental in the successful incorporation of recycled plastics into HP printers (Ross and Choong 1996). Without these criteria, HP would be unable

to qualify its products for the eco-labels the company identifies as potential market requirements nor meet internal environmental product goals.

Eddie Maxie's IEEE Symposia paper, "Supplier Performance and the Environment" supports Lamming's hypothesis that companies will be motivated to better environmental performance by bottom line advantages. Maxie says that while his employer, Hewlett Packard, will not dictate the environmental management of its suppliers, "Hewlett-Packard procurement will favor, whenever possible, new business awards to those suppliers demonstrating the best technology, quality, responsiveness, delivery, cost and environmental (TQRDC-E) metrics" (Maxie 1994, 324).

Other ESCM Innovations

The industry practitioner articles above discuss integrating environmental considerations into traditional supplier relationships and flows of goods. Johnson, White and Hearne present an approach that replaces buying goods, which perform services, such as cleaning or painting, to just buying the services. Ownership of the goods stays with the company that produced them, as well as responsibility for their management and disposal.

This gives an incentive to, say, a chemical company, to reduce the amount of chemicals used by a car manufacturer to clean engine parts, both because it reduces the costs of providing the service and the cost of dealing with the hazardous material and waste generated (Johnson, White and Hearne 1997). This supports Lamming and Hampson's contention that environmental improvements and programs succeed better when tied to business goals.

This model changes the traditional contract incentives from volume sold to service delivered and can have a positive environmental effect. Several automakers are

implementing this new type of supplier relationship (Johnson, White and Hearne 1997). For instance, Volvo is shifting its business model from one of supplying vehicles to supplying solutions in the way of transport systems. This is in response to the need for transportation that doesn't add to resource consumption, pollution and solid waste.

The company is working with its suppliers to transition away from various chemicals and materials it plans to no longer use. Volvo requires suppliers to have an environmental management system and goals for reducing environmental impact, optimization of waste management, design for recyclability and increased use of recycled materials. Additionally, Volvo cooperates with their suppliers on life cycle analysis and requires open data sharing (Friend 1998).

In the agile and virtual enterprises that Sarkis envisions for the future, such arrangements will be more commonplace and may help alleviate some of the environmental risks that could accompany such enterprises.

Summary

While limited, the supplier management literature related to environmental management does present some solid theory and anecdotal evidence. Each theorist places the unit of analysis at the supply chain as opposed to individual companies. Drumwright's unit of analysis is a company's buying processes, as is the case with each industry practitioner.

One area not well researched to date is the role eco-labels play in spurring electronic companies to improve environmental product quality. The US EPA notes that companies are using eco-labels to lend credibility to their environmental claims (United States Environmental Protection Agency 1999). Additionally, Mulder notes that companies will use eco-label qualification or criteria to evaluate products they buy

(Mulder 1998). Using case study research methods, this thesis will examine their role and test the theories and issues put forth to date.

While there is not much information on greening supply chains, there is research on supply chains in general and on the theory behind ESCM. ESCM theory hypothesizes that ESCM occurs as part of product stewardship and is driven by market and regulatory forces. Companies may develop both global criteria, such as a supplier having an environmental policy and commodity specific environmental criteria. Most of the conditions hypothesized to be necessary for ESCM, such as horizontal integration, are present in the electronics industry. While market forces are identified as drivers of ESCM, they are hypothesized to be weak ones unless applied to business-to-business commerce. Companies are attempting to qualify for eco-labels but it is unclear whether or not environmental product improvements actually result in increased sales. In the future, ESCM may encompass redefining the "supply" bought to be just the service the product performs such as cleaning. Environmental benefits may be derived from having the supplier maintain responsibility for the product.

Research to date indicates that there is a real need to test the theories put forth in the Literature Review and determine how effective initial industry practices are in influencing the environmental practices of suppliers. By examining five supply chains at one company, this thesis research will test the hypotheses.

The five supply chains include materials, components, peripherals and services suppliers. Hewlett Packard, the company to whom they all supply is an American multinational electronics company with considerable business in Europe. It established its environmental programs early on and is at the forefront of integrating environmental considerations into its supply chain management.

CHAPTER 3

METHODS

Introduction to Case Study Research Design

The lack of academic research on environmental supply chain management makes case study research methods an appropriate choice for this thesis. Case studies are common to theory development in organizational and management studies. According to Robert K. Yin, case study research allows one's research to retain the holistic and meaningful characteristics of contemporary real-life phenomena when the investigator has little control over events, and when data collection and analysis can be guided by theoretical propositions that have already been put forth (Yin 1994).

Case studies are good for research questions that are too complex for survey or experimental research and for exploring situations in which the intervention being evaluated has no clear single set of outcomes. Case study methods can be applied to single- or multiple-case studies. A single case study is adequate "when it represents the critical case in testing a well-formulated theory" (Yin 1994, 38), or when it represents an extreme or revelatory case. Analysis techniques include pattern matching and explanation building.

This thesis consists of a single case study of how an electronics company integrated environmental considerations into its supplier management processes. By looking at five of the company's supply chains, this thesis identifies what aspects of ESCM have and have not worked. The supply chains include materials, components, peripherals, and parts suppliers. It relies primarily on qualitative information. When available, quantitative information is used as well.

Components of Research

Location of study site. The electronics industry was especially appropriate for a study of ESCM for several reasons. First, the product cycles for many electronics companies were relatively short, e.g. 12 - 18 months to build a computer printer. This made it possible for electronics firms to implement product and process improvements quickly, including modifications to supplier relationships. Second, most design companies assembled their products from components and parts made by other companies. Therefore, they were heavily dependent upon suppliers (Beckman, Worhach, and Sheng 1995). The materials and components supplied by these companies could have a profound effect on the end product's environmental quality and end-of-life potential. Additionally, they affected the company's ability to qualify products for eco-labels such as the German Blue Angel and the US EPA's Energy Star.

Rapid product evolution in the electronics industry generated tremendous waste which, given its global nature, was distributed worldwide. As discussed earlier, this drove the development of international product take-back laws, creating additional pressure on companies to create environmentally sound products.

Firms in Santa Clara County, California, the particular site of this research had been particularly innovative. Home to the nation's largest concentration of high technology companies, Santa Clara County had proven to be an innovator in terms of managing its environmental problems as well as in developing new technologies. Several factors had contributed to the former. First of all, the county was home to the nation's highest concentration of Superfund sites. Discovery of more than 130 contaminated sites in the early 1980s created a crisis for the county with environmental, political, and public relations ramifications. In response, local governments, industry and non-government organizations collaborated on the development of a preventive

model "Hazardous Materials Storage Permit Ordinance" (Logsdon 1992). This would be the first of many environmental innovations credited to local industry. Lawrence and Morell note that such "critical events" often motivate companies to re-examine their materials and improve their environmental management systems to ensure against future spills or disasters (Lawrence and Morell 1995).

Lawrence and Morell also noted the concentration of various non-governmental organizations and industry groups within Santa Clara County that addressed the environmental issues of local electronics companies. The Business Environmental Network, the Santa Clara Valley Manufacturing Group, and the Pacific Industrial Business Association all held monthly business meetings on environmental topics ranging from new state regulations to ISO 14000 certification. The Silicon Valley Toxics Coalition and other Bay Area environmental groups such as Citizens for a Better Environment addressed environmental problems specific to the electronics industry and the health of San Francisco Bay (Lawrence and Morell 1995). All of these have contributed to creating an environment in which innovations in supplier management can occur.

One such innovation was the Supplier Management Questionnaire developed by local electronics companies to address supplier environmental performance. Under the auspices of the Pacific Industrial Business Association (PIBA) the group's supplier questionnaire became the basis for the Computer Industry Quality Conference's Standard 0014, called the "Supplier Environmental Performance Review Questionnaire" (Pacific Industrial Business Association 1996). Companies now use it worldwide to manage suppliers on environmental performance. The questionnaire covers issues such as whether or not the supplier has an environmental policy, a management system, staff

members with line-item environmental responsibility, and a commitment to continuous improvement in environmental performance.

Sample Selection

Why the company studied is appropriate for this research. Hewlett Packard was appropriate because it meets several relevant criteria. Following the initiation of formal HP quality systems in 1987, HP established an Environmental Management Steering Committee in 1993, ahead of most of its fellow electronics companies (Bast 1994). Around the same time, the company began treating procurement as a strategic element of the business. Thus, it has a solid program in which to integrate the environmental management of supply chains (Davis 1993). The company's position as a leader in integrating environmental quality into procurement was confirmed in the 1997 BSR/GM benchmark study (Business for Social Responsibility Education Fund, 1997) as well as by one of its suppliers that reported that other customers frequently ask the supplier about HP's supplier environmental management activities.

Secondly, Hewlett Packard was multi-national and encountered more environmental pressure from international standards, market, eco-labels and regulations than companies with just a domestic focus. They catered primarily to business customers (worldwide) as opposed to end consumers. Therefore, the company experienced more market pressure than a consumer electronics company such as Sony would.

HP's Environmental Management Steering Committee established "Product Stewards" in each business unit to address environmental product quality. Product Stewards were recruited from related disciplines such as product quality, R & D, manufacturing and marketing. Their job was to assess environmental market forces,

create environmental product roadmaps and work within their business units to ensure the realization of environmental product goals (Bast 1994).

The result has been the qualification of numerous scanner, plotter, printer and personal computer products for the US EPA's Energy Star (United States Environmental Protection Agency 1998) as well as for the Swiss Energie 2000 eco-label and Sweden's NUTEK label. Numerous HP computers qualified for the German Blue Angel, one of Europe's most stringent eco-labels (Hewlett Packard 1998). Additionally, the company had incorporated recycled plastic into printer and personal computer products.

Like most of the electronics industry, HP was not vertically integrated; most of its product components come from suppliers. This has forced the company to work with suppliers to qualify for these labels. And ever-shortening product life cycles afforded HP repeated opportunities to refine both its products and its supplier management programs.

When HP began to formally integrate environmental considerations into how they manage suppliers in 1993, it was well ahead of its fellow electronics companies and included the elements noted on the CIQC questionnaire (Maxie 1994). In fact, HP was instrumental in the development of that standard. Both of these company initiatives -- HP's product stewardship and environmental supplier management -- represent a significant opportunity to test the theories put forth in the literature on environmental supply chain management.

The Choice of Suppliers for this Research

There was little opportunity to choose the suppliers who participated in the research. HP gave little assistance in identifying appropriate suppliers or putting the researcher in touch with them. Of the suppliers the researcher was referred to by HP,

only one was willing to participate in the research. Otherwise, it was up to the researcher to identify which companies might be suppliers to HP and contact them independently. This afforded little opportunity to ensure variation among the suppliers or their experience working with HP on environmental issues. Ultimately, five suppliers consented to participate so long as they remained anonymous. Data was gathered from a sixth as well, but their legal department declined to give permission to use the data. Fortunately there is variation among the types of products each supply to HP. Of those who did participate:

- One supplies memory devices to HP's computer products division,
- One makes materials used in HP products such as printers,
- One produces cables,
- One produces hard drives, and
- One is a contract manufacturer that HP has used to manufacture its products.

The materials supplier was chosen in part because of its involvement in developing recycled materials for use in HP's printers. The other companies were chosen primarily because they were willing to discuss their experience addressing HP's supplier environmental criteria. In the case of the contract manufacturer, its data is especially helpful from the standpoint that, with the industry trend towards contract manufacturing, there will be increasingly more need to work with such service providers to ensure product and operational environmental quality. The variety among the participants helped identify how effective the supplier environmental criteria were among different types of suppliers and what challenges may have existed with different types of suppliers.

Data Gathering: Hewlett Packard

Once the objectives, research questions and hypotheses were developed, corresponding research questions were written. Initial data gathering was conducted from documentary evidence provided by HP. This evidence included journal and symposia articles written by HP practitioners, the company's Web site, annual reports, and environmental reports over a period of 4 years. Additionally, HP developed a supplier brochure entitled "Procuring Environmentally Responsible Material" designed to educate suppliers about HP's environmental expectations and requirements (Hewlett Packard 1995). To as great an extent as possible, the research questions were answered from these sources initially. For the most part, this information is publicly available. Some information on HP's European product plans is not publicly available.

Interviews were conducted with two members of HP product stewardship and supplier staff. Interview respondents were chosen based upon their roles in developing or administering the environmental elements of HP's procurement process or addressing them within supplier companies. Additionally, the product steward for HP's printer division was interviewed. Initially the two interviews with the printer representative focused on HP's initiative to utilize 25 percent recycled material in the production of its printers.

Since it was not practical to ask each respondent all the questions, the questions asked were based upon the amount of time available and the person's role in the program. Time within the interview was allowed for impromptu discussion as well.

HP interviews were conducted face-to-face and via telephone over a four month period in the late winter and early spring of 1998. They were conducted during business hours. Face to face interviews were conducted on-site at HP and off-site.

Interviews lasted between 1 and 3 hours. Data was collected using a portable computer and responses were recorded as close to verbatim as possible while the interview was conducted.

Supplier interviews were conducted in the late summer and early fall of 1998. Suppliers were identified primarily through the researcher's network within the high tech industry. In some cases, respondents were identified either through this network or by "cold calling" the company to identify the appropriate individual. All six companies contacted were initially amenable to participating. As stated earlier, only when the legal department of one supplier was asked for permission did that company decline to participate.

For companies located in Santa Clara Valley, interviews were held face to face while those in other parts of the country were conducted by telephone. Each respondent was given a list of research questions prior to the interview.

Data Analysis

Pattern matching on the data was conducted by creating a data table. The vertical axis included the hypotheses and research questions put forth at the end of the literature review. The horizontal axis included the data collected from each supplier company. Only research questions germane to the suppliers were included. Several different patterns emerged from this exercise. They are described in chapter 5. The data table itself is included in Appendix 1.

In general, a number of common categories emerged from each case study. These were very similar to the categories built around the original set of detailed questions. The patterns were also similar across the cases, but no effort was made to

generalize these patterns within the case studies. Each study was written by itself, with whatever wording or patterns that came through in its own analysis and presentation.

CHAPTER 4

HEWLETT PACKARD'S ENVIRONMENTAL SUPPLY CHAIN MANAGEMENT PRACTICES

Overview of Hewlett Packard

With an initial investment of \$538, Hewlett Packard was founded in 1938 in a Palo Alto garage. Since 1940, when the company's three employees made \$34,000 in net revenue from its eight products, HP's product line has grown from microwave and signal generators to today's line of personal computers, printers, scanners, plotters, and scientific instrumentation (Hewlett Packard 1998).

Today Hewlett Packard is number 13 on the Fortune 500 list, with almost 50 billion in sales in 2000 (Hewlett Packard 2001). They employ approximately 88,500 people, manufacture on 4 continents and sell products and services in more than 120 countries" (Hewlett Packard 2001).

Hewlett Packard and the environment. Like many electronics companies, HP's sales growth has been accompanied by environmental challenges. In 1981, two HP sites in the San Francisco Bay Area and one in Colorado, were named Superfund sites (Silicon Valley Toxics Coalition 1998; US EPA Site 1998). The company remediated the contamination at these four sites. It simultaneously launched pollution prevention initiatives designed to reduce or eliminate the need for various chemicals in manufacturing processes. "From 1990 to 1995, HP posted a cumulative reduction in hazardous waste of 23 percent, or approximately 2.2 million pounds (1 million kilograms). For 1997, HP manufacturing sites worldwide reported a decrease from 1996

totals of 17 percent in chemical releases or transfers." (Hewlett Packard 1998). HP's production of hazardous wastes increases as its production does. In 1997, the company generated 9.1 million pounds of hazardous waste, landfilling 11 percent of it (up from 9 percent in 1996) (Hewlett Packard 2000).

In the late 1980s, HP adopted an environmental management system based on the principles of Total Quality Management. It was consistent with regional and global environmental management standards such as ISO 14000 to emerge in the mid 1990s.

In addition to addressing the environmental impact of company operations, these environmental management systems were applied to reducing the environmental impact of HP products. In 1992, the company initiated a Product Stewardship Program within its Computer Products Organization (CPO) which was responsible for the company's computer and printer products. This program tracked applicable regulatory and market trends, developed environmental product strategy, and worked with other product development functions to improve product environmental quality (Bast 1994). Quite often, these improvements were chosen because they allowed the products to qualify for eco-labels such as the German Blue Angel, something identified as potentially improving market access for products. HP was positioning itself as an early adopter of product environmental improvements, in part, in anticipation of regulatory requirements to come.

In a September 1998 address to the International Data Corporation's European Information Technology Forum in Paris, HP CEO Lew Platt stated that with the cooling US market and the faltering Asian market, his hopes were on Europe. He stated "The best news comes right now from Europe. Europe is the growth leader for our company and we hope that continues to be the case for the next couple of years until we can get things straight in Asia" (San Jose Mercury News [San Jose], 8 September 1998). Because of this, it would be fair to speculate that such European phenomena as product

take back regulations, and eco-labels such as the German Blue Angel and the Swedish TCO99 will grow in importance to HP and other members of the electronics industry.

Purchasing history of the company. According to Beckman, Worhach and Sheng, HP joined other industry giants in "vertical disintegration" in the late 1980s to early 1990s in which the company spun off such manufacturing activities as plastic injection molding, sheet metal fabrication and printed circuit board assembly (Beckman, Worhach and Sheng 1995). This resulted in greater complexity in the management of its supply chains. Increasing the number of players involved in the realization of finished product increased HP's business uncertainty accordingly (Davis 1993). One way to deal with this was to increase inventories as insurance against any business interruptions. But doing so was at odds with the competing goal of cost containment.

To deal with the problems of vertical disintegration, HP pursued the following goals:

- Establish and maintain long-term supplier commitments.
- Promote effective communications with suppliers.
- Obtain mutual agreement w/ suppliers on expectations and goals.
- Recognize the supplier's process as an extension of Hewlett-Packard's processes.
- Utilize a team approach (proactive/cooperative) to achieve performance improvements (Maxie 1994).

To address this, HP researched their supply chain management processes and discovered that with better management, their supply chains could reduce supplier inventories by 25 – 50 percent. With this information, HP developed a generic

framework which described their supply chains and modeled uncertainty within them (Davis 1993).

In the process, HP moved beyond choosing suppliers based solely on competitive price quotes to choosing them based on their ability to meet overall performance expectations. The criteria included technology specifications, quality, responsiveness, delivery, and cost (TQRDC). The company's objective in establishing these criteria was to maximize customer satisfaction and profitability for each member of the supply chain, allow for responsiveness to changes in the marketplace, and facilitate communications among members of the supply chain. Success was shared up and down the supply chain and successful supplier performance against the supplier criteria "will always have rewards of repeat business, increased sales, and profitable growth" (Maxie 1994, 324).

It was within this context that HP began to address the environmental impacts of its supply chains.

How Hewlett Packard Integrated ESCM into Its Procurement Processes. HP's efforts to integrate environmental considerations into supply chain management began in 1993 with the establishment of the Environmental Management Steering Committee (Bast 1994). The committee was multi-functional, including representatives from Procurement.

Maxie stated that "Our suppliers are considered an integral part of the environmental improvement effort; therefore, suppliers are expected to conduct their operations in an environmentally-responsible manner" (Maxie 1994, 324).

Initially, HP addressed supplier environmental performance by querying suppliers about their use of ozone depleting substances (ODSs). This was meant to prevent HP from having to label products as containing ODSs as required by the US EPA.

From there, the Procurement Council initiated the "HP Procurement of Environmentally Responsible Material (PERM) Program" which developed supplier environmental expectations and measurement criteria with the goal of providing products that would be environmentally-sound throughout their life cycles (Choong 1996). They based the expectations and criteria on the following policy:

It is Hewlett Packard's procurement policy to work with its suppliers to identify, develop, and maintain products and processes that are environmentally sound (Hewlett Packard 1995, 6).

According to HP's supplier brochure entitled "Procuring Environmentally Responsible Material," HP stated:

We want our suppliers to make their own commitments and to develop their own plans for being environmentally responsible. The relationships we seek with our suppliers include their having an environmental policy, an implementation plan, metrics, and a willingness to share them with us as we work together in this important area (Hewlett Packard 1995, 6).

Rather than applying the most stringent country requirements uniformly to all suppliers worldwide, HP decided to require suppliers to develop environmental improvement plans based on appropriate issues in the country where they operate. This prevented HP from having to establish environmental requirements that applied to every country in which it did business (Maxie 1994). It is also prevented them from inadvertently increasing the price of supplies from countries with less stringent environmental requirements (Maxie 1994).

The TQRDC criteria noted above were expanded to include an "E" for environment. To evaluate supplier environmental performance, HP began to include basic environmental questions in their supplier questionnaires. The questions were:

- "1. Does the company/facility have a written environmental policy statement?
2. Does the facility have written environmental performance

objectives/targets and implementation plans to reduce costs or risks?
Please describe three significant environmental performance
objectives/targets, performance plans and measures for the next twelve
months.

3. Is a management representative assigned responsibility for facilitating compliance with environmental regulations? If "yes," please give name and title.
4. Does the facility have a system to track environmental laws and regulations that apply to the operations of the facility? If "yes," is there a system for communicating this information and training the appropriate personnel?
5. Are periodic environmental regulatory compliance audits of the facility's operations conducted?" (Maxie, 1994, 327).

HP also suggested improvement areas that might be addressed in the supplier's improvement plan. These areas included manufacturing processes, materials and labels, resource conservation and waste management, packaging and recycling. Before implementing these environmental criteria, HP reviewed them with suppliers (Maxie 1994).

These basic environmental questions reflected global environmental criteria which applied to all suppliers. Where necessary, Hewlett Packard also developed commodity-specific criteria. An example of commodity-specific criteria could apply to energy conservation. For instance, components which drew power would need to meet criteria which would allow the product to qualify for the US EPA's Energy Star eco-label. The global criteria were administered by the Procurement Council while the commodity-specific criteria were administered by a Procurement Strategy Board and Product Line Procurement (Choong 1996). HP re-evaluated supplier environmental performance on an annual basis and wanted to see the results of the plan's implementation periodically.

Whatever the supplier decided to include, it was HP's desire that the supplier's policy and the implementation plan be realistic and measurable, and the performance

should always go beyond product specifications or regulatory compliance since those were a given.

To rank suppliers on each of the TQRDC-E criteria, Hewlett Packard established a four-point scale and ranked suppliers relative to other suppliers of the same commodity. Each of the six criteria had certain parameters upon which the supplier was ranked. In the case of "E," the supplier was ranked upon performance and replies to the questions listed above.

Hewlett Packard's Suppliers

In this section, the suppliers will be described, their relationship with HP will be characterized, and how they worked together to implement ESCM will be discussed in terms of the hypotheses put forth in Chapter Two.

TABLE I
HEWLETT PACKARD'S SUPPLIERS

Supplier	Main Product	Employees	Revenue
1	Material Supplier	340,000 (parent company)	\$116B - 1999
2	Disc Drives	6,200	\$5.8B - 1998
3	Contract Manufacturing	46,000	\$12B annually
4	Chips	13,000	\$28.6B - 1999
5	Cables	40,000	\$5.5B - 1998

Supplier 1: Material Supplier

Company background. The material supplier interviewed for this research was a subsidiary of a large American multinational corporation. The multinational and subsidiary were headquartered on the east coast. The subsidiary supplied a particular type of material to the electronics, office equipment, automotive, and building and construction industries. Manufacturing occurred in 250 manufacturing plants in 26 different nations and the parent company employed over 340,000 people.

The parent company of this supplier did not appear to have an environmental policy or publish an environmental report. It had recently initiated a quality program called "Six Sigma" which originated at Motorola. This program required all employees to be trained in "critical to quality characteristics" for their work. So as the supplier collaborated with HP, this quality process helped them identify at the outset what was critical to HP. The respondent did not know the company's position on ISO 14000.

The company had been a supplier to HP for decades and anticipated a business relationship for decades to come. The company respondent characterized the relationship between the supplier and HP as "complex," saying they deal with each other worldwide. He said that HP represented a "very important chunk" of the company's business. By the same token, the company had numerous other customers to whom they could transfer the materials they make if HP were no longer a customer.

While neither the parent company nor the subsidiary had put one person in the role of policy entrepreneur, there were several product stewards who oversaw environmental initiatives in different divisions of the subsidiary.

Collaborating on environmental improvements. HP first approached the company in 1992-93 with a specific requirement to supply 25 percent post-consumer recycled content material to the printer division for use in a new product introduced in 1995. The supplier had been aware of customer environmental preferences as a factor in the marketplace for some time, since other companies (although not an overwhelming number) had approached them with similar environmental inquiries. The respondent stated that global customers, especially those serving markets in the European Union, were interested in environmental quality. Such inquiries had generated a lot of dialogue within the supplier company, mainly geared at the implications of take-back laws. Companies were concerned that, under such take-back requirements, their products would constitute a considerable disposal burden at end of life without appropriate design and material modifications.

Environmental issues such as takeback laws did not create resistance to innovation within the company so long as employees perceived a business case for environmental initiatives and improvements. The respondent stated that because of uncertain demand for environmentally-superior products, the high technology industry feared putting resources into something that would not ultimately perform in the marketplace. The supplier saw the HP recycled materials initiative as an opportunity to establish a competitive advantage over other materials suppliers in a realm in which they anticipated potential growth.

The respondent stated that his company trusted HP and would not do business with a company they did not trust.

In response to HP's recycled materials request, the company did some in-house research to determine if they could accomplish the production of recycled material to HP's specifications. As they made progress, they held follow-up meetings with HP.

Once enough research had been conducted, they determined a time frame, price, and other elements and presented them to HP. They decided to go ahead with the initiative because they felt they had the technical capabilities to do so and that it would represent a good return on investment. They anticipated that Hewlett Packard would be the start of a trend towards recycled materials.

Supplier 2: Component Supplier

Supplier 2 is a multinational manufacturer of storage components. The company employed 6,200 people in at least 14 countries and achieved \$5.8 billion in sales in FY1998. Customers included Compaq Computer, Dell Computer, Data General, Hewlett-Packard, IBM, Packard Bell, Sun Microsystems, Apple Computer, and Acer (Company web site 1998). The company's manufacturing partner in Asia manufactured all but one of the company's products. The respondent said that HP represented "a good chunk" of their business, saying their top five Original Equipment Manufacturer customers (of which HP is one) represented about half their business. They had supplied to HP since 1983 and anticipated having HP as a customer for a long time to come. The components they supplied to HP were readily transferable to other customers.

The supplier was among the first of HP's suppliers to receive and complete its questionnaire on environmental considerations in 1992. The initial inquiry was directed to the company's account managers and reflected the Montreal Protocol's mandate to phase out the use of CFCs from industrial processes. The questionnaire quickly made its way to the Environmental Health and Safety department. This questionnaire, as well as those from other customers, were in part the impetus behind initiating Design for Environment activities in 1995. To address these environmental issues, the company hired an EHS manager and charged him with this task. HP also requested that the

company mark its plastic packaging in reference to an ISO standard. The ISO standard was characterized by the chasing arrows triangle that enclosed a number which denoted the type of plastic from which the part was made. This aided in materials recycling at end of life. Because the company was in the midst of redesigning this packaging, it was an easy change to make.

The supplier reported that 14 out of its top 20 customers had made environmental inquiries. Inquiries ranged from simple ones such as the use of CFCs to more in-depth inquiries aimed at eco-label qualification (primarily the German Blue Angel). In this respect, customers were interested in the use of brominated-flame retardant plastics, product disassembly, parts marking, and the use of restricted substances.

The respondent stated that other customers considered HP's environmental supply chain management process to be an industry benchmark; they had been known to ask Supplier 2 for information about it. The supplier stated that, at some point, HP had reduced the weight of the environmental factor in purchasing relative to the TQRDC criteria. This was a disappointment to this supplier's EHS staff who found that having an influential customer such as HP have such a requirement was helpful in advocating for their own environmental improvements. This is further proof of the power of the customer in inspiring a company to reduce the environmental impacts of its products. (HP denied reducing environmental relative to other criteria. The supplier said that their inability at times to answer customer environmental inquiries (because they had not yet made the inquiries of their own suppliers) had not resulted in lost business. Cost containment had not been a big factor in addressing customer environmental preferences and requirements.

Supplier 2 introduced its own environmental policy in 1995 in which it committed to pollution prevention, working with suppliers to improve environmental performance, and measuring performance against the policy.

To ensure fulfillment of the policy, the company stated that they had developed and implemented an environmental management system consisting of a formalized network of people and procedures to manage and reduce the environmental impacts of the organization's operations. The company became certified to ISO 9000 around 1993. The company's manufacturing site in Northern Europe achieved ISO 14000 certification by a third-party auditor. All of the sites belonging to the company's manufacturing partner were ISO 14000 certified.

The EHS manager hired to phase-out ozone-depleting substances from manufacturing processes went on to champion the company's other environmental initiatives addressing product environmental quality and supplier management. Product environmental initiatives began around 1995, the year the environmental policy was first published.

Purchasing was considered a strategic part of the company's business.

The supplier's EHS group had not experienced appreciable resistance from other parts of the company in dealing with environmental considerations because they had addressed them on their own. Potential product environmental improvements were weighed against other product goals and were not adopted if they conflicted with them.

At the point the data was gathered, the company's environmental programs had had negligible impact on company finances or the costs of producing products. The respondent felt that this could easily change with an economic downturn.

The respondent stated fairly simply that customers motivated them to make product environmental improvements and they kept their focus on activities they believed

would maintain or increase market share. Unless the company anticipated a loss of business from a customer over product environmental quality, or making an environmental improvement required negligible costs, they would not do it. To ensure that environmental improvements made sense within the overall business context, other parts of the company made the final decisions as to which environmental improvements and initiatives to implement.

The supplier stated that HP has asked for several non-environmental product changes that it has declined to supply. Examples included reducing noise generated by the component and guaranteeing that the component the supplier furnished would meet certain failure standards. The decision as to whether or not to grant HP's request balanced the costs and benefits to the supplier. The supplier stated that for the most part, non-environmental product attributes were more important to HP than environmental improvements and had more impact on the business relationship between the two. The supplier also stated that at times, customers had played suppliers off each other in hopes of getting concessions from them.

The company did not believe product take-back laws would impact them directly, saying that such laws had a greater impact on their customers. Their components were already fairly modular and easy to disassemble. The materials and sub-components were high value. So they felt they would pose minimal liability at end of life.

As for eco-labels, the major elements of the most popular eco-labels -- the German Blue Angel and the EPA's Energy Star -- that affected the supplier were acoustic and energy conservation requirements. Having already been incorporated into the company's product roadmap, these were both being addressed through the mainstream product development process.

How the supplier works with HP. The supplier said they trusted HP. In fact, they were more familiar with HP than with some other customers and this bred more trust. As far as working together with HP to address product environmental quality, the supplier said that no collaboration occurred, although the two companies did work together on other aspects of products. When asked to describe the company's relationship with HP, the respondent said that it was not collaborative, stating that "it is very hard to have a good relationship with them". So while the supplier trusted HP, they found them difficult to deal with.

Like other suppliers, the company stated that they could use more information from HP. A European division of HP sent the supplier a list of "Musts" and "Wants" for their products. This particular division was described by the supplier as having perhaps the most advanced product stewardship program in the industry. They were the first, the supplier said, to add the "E" for environment to the TQRDC-E HP scorecard. The "musts" reflected regulatory requirements and company commitments. The "wants" reflected eco-label criteria although which eco-labels were not specified.

The supplier felt that the list was "ill-defined" and failed to reflect the global context within which the supplier would be trying to comply with the criteria. For instance, the division stated that HP wanted packaging with 50 percent recycled content. However, worldwide, the quality of 50 percent recycled content packaging varied significantly. Such packaging from Japan would be too flimsy for that particular packaging application while 50 percent recycled content packaging from the US would work because the fibers of the US version would be longer and therefore stronger. The supplier stated that knowing the analysis HP used and the basis for the list would have been helpful in complying with it.

Challenges. The biggest challenge the supplier faced in addressing environmental product issues was in the costs to track substances. For instance, this same European HP division stated that they did not want their suppliers to use glycol ethers (a must) without giving an explanation of why ethers were of concern. Initially, this supplier was not tracking glycol ethers in its supply chain. They stated that evaluating the supply chain for it would take at least a year. If they were to find the chemical in its supply chain, they would inform HP about its use and when they expected it to be phased out. None of these customer environmental preferences/requirements or other environmental issues affected product lead times; the company said they would not let this happen.

The company had not yet developed a formal environmental performance measurement system. At the time, they tracked environmental improvements in packaging, and restricted substance use through a restricted substances database. They were working to identify additional measures. Their manufacturing partner in Asia queried all its suppliers on their use of 180 chemicals. This influenced some of them to phase some chemicals out of use. The manufacturing partner also had plans to require suppliers to take back packaging as part of their ISO 14000-compliant environmental management system. The company anticipated packaging take-back laws, the European Union's Waste Electronic and Electrical Equipment directive, and further substance restrictions would affect them in the future.

Supplier 3: Service Manufacturer

Supplier 3 differed from the other supply chains in that it furnished a service -- namely "electronic manufacturing services" -- rather than a product or material. The industries served by this company included the computer, telecommunications, computer peripherals, networking, semiconductor, and medical electronics industries.

The company was incorporated in the late 1970s and since 1992 had averaged 55 percent annual sales growth. It employed over 46,000 people at over 25 sites around the world (21 of which were manufacturing sites). The company's customers included Sun Microsystems, Hewlett Packard, and IBM. Because this supplier concentrated on manufacturing, they were able to reduce customer costs both by leveraging their own manufacturing expertise across numerous customers and by reducing the customer needs for in-house manufacturing expertise and resources. In addition to manufacturing, the company's web site stated that their services included "end-of-life services", meaning that they could process a company's products once customers were done with them. This could become an increasingly attractive service in light of looming take-back regulations.

One of the company's European sites had become ISO 14000 certified. Other sites were either in the certification process or evaluating its feasibility and business case. The decision was based upon market requirements. Environmental regulations were complied with as standard procedure. Additionally, the company had been doing pollution prevention for quite some time; their policy was to not use Volatile Organic Compounds (VOCs) within their manufacturing processes. They were also working to minimize their waste to landfill. The respondent said that the company was motivated to make environmental improvements in the way they do things "because it is the right thing to do." As far as an environmental champion was concerned, the respondent said that there was one within the California facility who was championing pollution prevention.

The respondent said that in HP's case, they did not believe that environmental improvements would garner them more business from HP. They characterized HP as being more interested in quality and on-time delivery; environmental qualities were "nice to have" but not required. Complying with HP's environmental requests had not cost the company anything financially.

Supplier 3's manufacturing engineers worked with their customer's product design engineers to help determine if a product the customer wanted to develop could be manufactured economically.

The respondent for Supplier 3 said that they had worked with HP on and off. At the time, they did not do a substantial amount of business with HP although they would have welcomed more. Business from other companies represented a much higher dollar value for them. Because they had a substantial customer base across different elements of the electronics industry, their services were easily transferable from HP to other companies. Supplier 3 echoed other suppliers in saying that they trust HP and would not do business with a company they did not trust.

HP first approached this supplier in the early 1990s with a written questionnaire about the company's environmental policy, management systems, and use of ODSs. Such questionnaires were not unusual to the company; they had received such inquiries from customers for years. The questionnaire was completed by the Environmental Health and Safety department. HP had done a general audit of the supplier but had not done one specific to EHS considerations. The questionnaire (and its analogs from other companies) helped the company determine where they stood in terms of compliance issues and customer environmental priorities. In the case of HP, this was the only environmental communication to come from the customer. The respondent for the supplier said that they could have used more information from HP. Beyond this, the company did not experience any problems in complying with HP's environmental information requests.

In response to customer inquiries, the company decided to "beef up" its own supplier questionnaire to include more environmental considerations. In the future, the environmental health and safety staff was planning to work more closely with the

company's purchasing department to address materials and components. While their initial attempts at collaborating with other functions within the company on environmental initiatives had met with initial resistance, effective environmental education and communication had helped garner support from non-EHS people and functions. They stated that a strong business case must exist for this to happen. But the respondent stated that complying with customer environmental preferences and requirements did not facilitate their regulatory compliance.

The supplier stated that its relationship with HP was collaborative to a point. This collaboration was coordinated through the company's marketing department, not the EHS function (nor had Supplier 3's EHS department collaborated with its own suppliers). Some of the company's engineers work on-site at a customer's facility to ensure the manufacturability of the customer's product at the desired price point. Beyond that, the relationship could be described more as customer/supplier with HP being more in command. Whatever product the supplier contracted to manufacture had a "Bill of Materials" associated with it as well as any additional required specifications (such as whether or not it should be made without the use of VOCs).

In evaluating potential environmental improvements (customer-driven or not), the company weighed three elements: the costs involved, the benefits to be reaped, and the impact on manufacturing. Unless the picture were favorable from a financial standpoint, they would not proceed with such a change. Some environmental initiatives, such as removing lead from facilities, were taken on "because it is the right thing to do."

In terms of measuring progress on environmental improvements, the company tracked reductions in waste to landfill and how much their waste cost them (beyond just disposal costs).

The company did not anticipate product take-back laws affecting them. Nor did eco-labels affect them. However, they had begun to offer reverse logistics/engineering processes for customers who did need to take back their customers' products. They anticipated this becoming a bigger part of their business. At the time, they were evaluating components for end-of-life potential, recycling, and refurbishing where possible.

Supplier 4: Chip Supplier

Established in the 1960s, Supplier 4 produced microprocessors and related components that were used in telecommunications and networking applications. It employed around 13,000 people and operated semiconductor fabrication plants in California, Texas, Thailand, Malaysia, Singapore and Japan. New manufacturing facilities were under construction in China and Europe.

The company established an environmental policy in the early 1990s which committed it to protecting the environment, the health of its employees, and the communities in which it did business. To operationalize this, the company established analogous EHS standards that applied to all sites and operations. It was up to each site to assess the local environment and culture and establish appropriate measures and programs intended to ensure the sites' compliance with the corporate environmental policy. Environmental management systems had been established for all manufacturing sites and each went through an annual corporate audit to ensure its adherence to the policy and standards. While not actively pursuing ISO 14000 certification, all sites were working to make sure that their EMSs would qualify. The company has participated in SEMATECH, a semiconductor industry consortia designed in part to improve the EHS performance of the industry. The company was also part of the Center for

Environmentally Benign Semiconductor Manufacturing which researched pollution prevention opportunities and ways to reduce water and energy consumption in semiconductor manufacturing.

Supplier 4 had pushed environmental criteria down their supply chain as well. Rather than create a new mechanism to track environmental quality, they incorporated environmental criteria into their "Semiconductor Supplier Quality Audit Process" and applied it to key suppliers such as hazardous waste disposal companies and chemical suppliers. The company had received many awards that recognized their environmental efforts including an Energy Star Award from the EPA that was given to them and HP for their efforts to improve energy conservation.

The company had been approached by other customers with similar environmental inquiries as those from HP and they describe HP's as relatively typical. The respondent stated that HP gave them two environmental questionnaires in 1996, none in 1997 and two in 1998. The questionnaires evolved over time to reflect the changing nature of the environmental marketplace and regulatory requirements. The supplier did have one policy entrepreneur in the form of the EHS manager for US operations. However, people in sales, marketing, quality, and field service were very supportive of product environmental initiatives as they saw them as a way for them to add customer value. The respondents reported very little, if any resistance to addressing environmental quality issues within the company.

In answering customer inquiries, the supplier tried to go beyond the information the customer asked for to demonstrate their proactivity. Customer inquiries inspired the company to begin publishing annual environmental reports in the early 1990s.

The respondents characterized their relationship with HP as "really good." HP was very important to their business, enough so that HP could possibly have spurred the

company to make an environmental innovation without the input of other customers. Hewlett Packard had collaborated with the supplier on environmental innovations having to do with energy conservation. But otherwise, the supplier said that HP called the shots. They said they trusted HP and in fact, that because HP set ethical standards for the electronics industry many years ago, they were even more likely to believe them. The supplier got enough information from HP to address their environmental concerns and stated that HP's questionnaires always stated the availability of additional information if it was needed. The supplier's biggest challenge in responding to these inquiries was receiving input from various parts of the company in time to complete them before HP's deadline. Their relationship with HP went back many years and they anticipated it being long-term. The components they supplied to HP would be easily transferred to another customer if one existed. But these environmental initiatives had not affected their product lead times nor did they create a big financial burden. However, they were working to improve how they responded to these requirements and minimize the staff resources required.

This supplier's environmental initiatives were motivated by customers first and foremost, noting that customers constituted a new motivator for environmental improvements. The supplier said that if a customer wanted an environmental innovation that did not have the potential to increase market share in the short run, they would do it if a customer would commit to buy products long-term over several product generations. The supplier stated that their environmental initiatives might help them secure more sales with HP, and given HP's importance to them, they were willing to do this.

Take back regulations affected the supplier only to the extent that they affected their customers, whose inquiries reflected their own compliance issues. However, the supplier recognized that customer environmental inquiries might reflect future

regulations. The supplier had been affected by Energy Star requirements since before 1992. They were starting to address Blue Angel criteria and future Energy Star criteria (which were in the process of being revised). The company had no formal measurement process for tracking progress on environmental product initiatives. They anticipated future challenges in addressing international regulations, voluntary standards, substance restrictions such as on lead, and streamlining their response to the myriad customer inquiries.

Supplier 5: Cable Supplier

This multinational east-coast company supplied cables to the high technology and automotive industries. In response to customer and regulatory pressures, they began expanding their environmental programs in the mid 1990s. They had had an environmental policy in place since the early 90's and they published an annual environmental report. At the time, their plans to become ISO 14000 certified were contingent upon the outcome of a hostile takeover bid.

Many other customers besides Hewlett Packard had approached the company about their environmental activities, and they characterized HP's requests as being fairly typical. In response, they appointed the respondent (the Environment, Health and Safety Manager) to address product environmental issues in 1991. He in turn began the company's design-for-environment activities. Purchasing was considered to be a strategic part of the business. However, at that point, the company had not approached their own suppliers with the same kinds of inquiries they got from their customers.

The company had been a supplier to Hewlett Packard for between 10 and 15 years and anticipated working with them in the long run. HP represented such a large chunk of the company's business that HP alone could drive environmental initiatives.

HP first approached the company regarding environmental issues around 1992 when they inquired about the supplier's use of CFCs. After that, HP's environmental supplier questionnaires were sent regularly. In response to customer inquiries, the company began their own internal design-for-environment activities to address the concerns of their customers. While there had been some costs involved in implementing Design for Environment, many of the costs had been offset by cost savings from things like dematerialization and discontinuing the use of certain substances.

The respondent stated that resistance to environmental initiatives was felt from the upper reaches of management, especially within the customer service function, but not within engineering teams charged with realizing environmental improvements. Marketing, Sales, and Product Management had all been supportive since they were responsible for product features and received the pressure from customers -- both for environmental and technical innovation.

As with other respondents, the supplier was motivated to improve product environmental quality by its customers. In comparison, regulations played a minor role. With HP, the supplier believed that its environmental initiatives would not get it more business with HP on their own. But if they were competitive on price, quality and delivery, their environmental programs could affect sales at the margin with most customers. Their environmental programs fortified their image as a world class quality supplier. The respondent stated that he knew of no instance where his or any other company got extra business for their environmental programs. If the supplier did not think they would make money from their environmental programs, they would not implement them.

Take-back regulations and eco-labels only affected the supplier from the standpoint that they affected their customers. So if a customer needed to avoid lead in its

products to comply with the upcoming EU's take-back directive on Waste Electrical and Electronic Equipment, then the supplier needed to avoid lead in its components. The only laws the company's environmental initiatives had helped it comply with were those dealing with restricted substances.

The supplier said that they collaborated with HP to a considerable degree but could not clarify this. They trusted HP very much and felt that HP gave them adequate information with which to address their environmental requirements. At the time, they had no system in place to measure their progress in improving product environmental quality, nor had they imposed analogous requirements on their own suppliers. Their future challenges included educating senior management and frontline sales people about environmental drivers in their business and applying their environmental solutions to their business globally.

Table 2 lists the different questions and hypotheses of the research and the responses from each participating supplier.

TABLE 2

SUPPLIER DATA

Question/ Hypotheses	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
Question 1: What characteristics are shared by companies at the forefront of environmental supplier management?					
One environmental champion	Yes	Yes - EHS manager	Yes - the president of the local division	Yes - head of EHS	Yes - Global EHS manager
Multi-national	Yes	Yes	Yes	Yes	Yes
Purchasing is a strategic part of company	Yes	Yes	Yes	Yes	Yes
Total Quality Management	Yes	Yes	Yes	Yes	Yes

TABLE 2 (continued)

Question/ Hypotheses	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
Motivational Factors					
1. Competitor activities	1. Yes	1. No	1. No	1. No	1. No
2. Customer requirements	2. Yes	2. Yes	2. Yes	2. Yes	2. Yes
3. Eco-labels	3. Yes, if they motivated customers.	3. Yes	3. Yes, if they motivated customers.	3. Yes, if they motivated their customers.	3. Yes, if they motivated their customers.
4. Regulations	4. No	4. No	4. No	4. No	4. Minor role
5. Internal company environmental policy	5. No	5. Yes	5. Yes	5. Yes	5. Yes
6. Anticipated cost-savings	6. No	6. Yes	6. Yes	6. Yes	6. No. Some costs involved in doing DFE which were offset by dematerialization savings.

TABLE 2 (continued)

Question/ Hypotheses	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
Question 2: Successful customer/supplier relationships will be characterized by:					
1. Being non-adversarial.	Relationship with HP has been a little contentious. HP did not always get what they want.	Relationship with HP has been somewhat contentious. HP did not always get what they want.	Non-adversarial.	Had a good relationship with HP, even won an environmental award from the EPA with them.	Described the relationship as a partnership.
2. A lack of additional customers to whom the supplier could sell their products.	Not the case with them, they sold to the entire electronics industry. They did the HP project to gain a competitive advantage. But HP was big enough to them that they wanted to fill their need regardless of other customer drivers.	Had lots of other customers so did not have to have HP's business, but HP did represent a large percentage of their business.	Supplier had many companies to whom they could sell their services. They cooperated because their customer wanted ESCM from them.	The company had many other customers. However, HP was big enough to be able to get them to do an environmental innovation all on their own, in part because of HP's size and because this would denote a trend to prepare for.	They had lots of customers for their products. However, HP was big enough to be able to get them to innovate all on their own, in part because of the size of HP and because this would denote a trend to prepare for.

TABLE 2 (continued)

Question/ Hypotheses	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
3. Where suppliers have adequate information access.	Stated that they could always use more information and they would like to have gotten a better mutual understanding with HP up front.	Felt they could use more information; wanted to understand the rationale behind HP's requests.	Company felt that they had adequate access to information from HP.	Felt they got enough information and said that HP's questionnaires stated that additional information was available.	Felt that HP gave them adequate information with which to fulfill their environmental requirements.

TABLE 2 (continued)

Question/ Hypotheses	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
Question 3. How do companies identify and reduce environmental impacts associated with their supply chains?					
Companies will include eco-label criteria in product specifications.	No (no applicable eco-label for supplies).	Yes	No - not as a service provider.	No (no applicable eco-label for supplies).	No (no applicable eco-label for supplies).
Companies will use expanded supplier questionnaires, standards, audits and product specifications to evaluate suppliers.	Environmental issues arose in the course of normal business dealings	Yes – supplier received HP's ESCM questionnaires.	No - not as a service provider.	Yes	Yes
ISO 14000 qualification.	No	No	No	No	No

TABLE 2 (continued)

Question/ Hypotheses	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
Question 4: What challenges have companies found in engaging suppliers in ESCM?					
Achieving actual and measurable environmental improvements.	In this case, they did achieve an actual environmental improvement that was measurable, in the way of recycled material.	Had made some improvements, such as banning CFCs. Working on DFE measurements.	They had not really done anything to try to measure environmental product progress.	Did not know.	Had not begun to measure for environmental improvements.
Cost containment.	This was a problem especially with the price of virgin material going down.	Not an issue except during industry downturn.	This did not seem to be an issue for them. The environmental measures often saved money.	Environmental product initiatives had not created a financial burden.	Was not a problem.
Dealing with challenges from Purchasing itself.	Not when Purchasing was educated about there being an actual market to which they were responding. They were only a problem if they thought the environmental initiative was fluff.	Did not have challenges from Purchasing.	This did not seem to be a problem for them.	Not a problem from any part of the company.	Not addressed.

TABLE 2 (continued)

Question/ Hypotheses	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5
Effective information exchange.	Yes, this was a challenge for them.	Felt it could be better with HP, wanted to understand the rationale behind their requests.	This did not seem to be a problem for them.	Got enough information and said that HP stated that additional information was available if required.	Felt they get enough information from HP to do their job.
Product lead times.	Not a problem. The environmental initiative was factored into the product timeline.	Environmental considerations did not hold up product lead times. Environmental product innovations were not adopted if they conflicted with other product goals. Environmental considerations were second to more central product features.	This was not a problem for them. HP would have built in the appropriate lead time to accommodate whatever environmental requirements they had.	Did not affect product lead times. The environment was not key enough to the product that it would hold up a product timeline.	Did not affect product lead times. The environment was not key enough to the product that it would hold up a product timeline.

CHAPTER 5

FINDINGS

The purpose of this research was to identify the factors associated with successful environmental supply chain management: the characteristics of a company initiating ESCM, the motivators, the characteristics of successful relationships, how environmental impacts are identified and reduced, and how performance is measured. This was done by examining the experience of one electronics company at the forefront of integrating environmental considerations into how it worked with suppliers, as well as the experience of its suppliers in addressing the company's environmental criteria.

The findings are organized into five sections that correspond to the five major research questions put forth starting on page 15. The first characterizes Hewlett Packard, the company that initiated environmental supply chain management. The other four characterize the relationships with suppliers, the challenges, whether or not actual environmental improvements occur, and how such improvements are measured.

The Characteristics of Hewlett Packard

It was hypothesized that a company with a well-developed environmental supply chain management program would have begun to move beyond the traditional environment, health and safety programs that typified the 1980s to a more comprehensive program in the early 1990s with an emphasis on products. These programs -- known as "Environmental Leadership," "Product Stewardship," or more broadly, "Environmental Management" -- were inspired by Earth Day 1990 when forward-thinking industry members realized that environmental concerns might translate into market drivers.

By starting its Product Stewardship Program in 1992, Hewlett Packard could be considered an early adopter of such programs. The company's Total Quality Program was initiated in the late 1980s as well. Together, they formed a foundation from which to drive environmental considerations through the supply chain. And when Hewlett Packard transitioned from a vertical to a horizontal business model where the majority of product parts were secured from other companies, they had the incentive to do this. Reflecting this business model, Procurement at HP became a strategic part of the business.

One person within HP's Corporate Procurement department championed this initiative, supporting Drumwright's assertion that a policy entrepreneur is instrumental in developing and driving such a program. This person took responsibility for developing the global supplier environmental questionnaire, disseminating it within HP and working with industry consortia to have it adopted widely. Its wide use streamlined the process for industry and helped suppliers avoid the possibility of having numerous different environmental supplier questionnaires to complete.

Additionally, HP is multi-national. With the importance the company put on its European sales, HP was more at risk from environmental factors than it would have been with a purely domestic focus. Europe was out-pacing the United States on eco-labels and take-back laws, so HP needed to act accordingly to avoid losing sales to its eco-sensitive customers. While the US market lagged behind Europe at this time, Europe represented a large enough portion of business to drive product environmental improvements. At the time, HP would make only one version of a product (say a particular printer) for all its markets, so that one printer needed to have all the environmental features required by its most stringent market. This is how European market drivers, though small in numbers, could influence the environmental quality of all the products put out by a company.

Motivational Factors

Very little variation was found regarding motivational factors either for HP or for its suppliers. By far, the biggest motivator for improving environmental product quality for both was pressure from *customers*. Without market pressure, HP and its suppliers were hard pressed to come up with a motivator for improving product environmental quality. All of the suppliers except the service provider (Supplier 3) said that HP represented a large enough portion of their business to motivate them to improve product environmental quality without other customers driving it as well.

Other than HP, none of the companies studied identified their competitors' environmental initiatives as influencing their own. However, Supplier 1 did state that they felt that HP's requirement for recycled material might indicate a market trend, that they were in a good position to fill the need, and that, as an early adopter, this would give them an advantage over their competitors.

None of the suppliers identified regulations as motivators. However, some suppliers reacted to product take back directives and initiated some programs in anticipation of taking responsibility for end-of-life management. Regulations seemed to have a greater effect on HP, which would be responsible for take back, than on the suppliers, that would not be responsible for take back.

Eco-labels provided a driver for HP. This was because the German Blue Angel had criteria for products made by HP and the label enjoyed considerable support in Europe. Suppliers stated that while eco-labels did not exist at the time for their products or materials, they still drove their product decisions because their customers had products they wanted to qualify.

Several suppliers stated that while they were motivated by customers to make environmental improvements, they said that non-environmental criteria for judging

supplier performance were more important to HP than environmental criteria. Supplier 3 stated that HP cared more about the supplier making products that work and were delivered on time than in environmental innovation -- a sentiment that was echoed by other respondents. For instance, Supplier 5 stated that environmental initiatives only helped suppliers secure business at the margins. When all else was equal, environmental programs may have made the difference in being awarded contracts. But on their own, environmental initiatives were not enough to guarantee the award of a contract.

This seemed to be an important point. Rather than close collaboration and focus on environmental product improvements, environmental considerations were incorporated into the overall product delivery and supplier management processes with no more or less focus than any other product considerations. This may be in part why it succeeded; if incorporating environmental considerations into product delivery had required considerable time and resources, there is a good chance that it would not have been integrated as the fledgling state of the eco-sensitive market would not have been worth it. Like Supplier 1, HP seemed to think that, while small, the market for product environmental quality would grow and that proactivity would put them in a good position to take advantage of it.

Each of the companies had an environmental policy, five of which included language about product environmental quality. Two also included language about working with suppliers to reduce environmental impacts.

Cost savings were not listed as a motivational factor for any of these companies. While initiating product environmental and supplier management programs have cost the companies money, the costs have been negligible, especially in strong economic times. However, one supplier's environmental budget began to receive more scrutiny during the economic slowdown of 1998. Their activities were curtailed accordingly. Without a

strong market driver, environmental considerations are still vulnerable during economic slowdowns.

Only supplier 5 reported that product environmental improvements had saved them money because of the dematerialization involved. Dematerialization refers to attempting to reduce the amount of material required to produce a product, especially virgin material. None of the companies interviewed knew whether their product environmental programs had reduced insurance or compliance costs, but thought they had not.

Qualifying for eco-labels did not concern suppliers whose products lack eco-labels, but it did concern Hewlett Packard, which saw eco-label qualification as a market-driven phenomenon. Additionally, HP recognized that ecolabel criteria might be an indicator of coming regulatory requirements. This had been the case in Germany with voluntary battery requirements which later became regulations. Therefore qualifying for eco-labels was seen as a way to get a head start on complying with future regulations. While HP's "global" environmental requirements for suppliers reflected operational considerations, their commodity-specific requirements often reflected eco-label criteria. The requirements primarily covered energy consumption, acoustics, the use of brominated-flame retardants, and design criteria. All suppliers reported receiving inquiries that reflected eco-label criteria from HP. Additionally, the list of "musts" and "wants" put out by HP Grenoble reflected the Blue Angel eco-label criteria. Eco-label qualification was seen as a way to legitimize a company's environmental product improvements and assist customers in identifying environmentally superior products.

Successful Customer/Supplier Relationships in terms of ESCM

Adversarial vs. non-adversarial relationships. The literature hypothesized that non-adversarial relationships characterized by trust and collaboration would be more successful at environmental supply chain management. The five researched supply chains bear this out. For the most part, HP and its suppliers reported harmonious relationships. Universally, all the companies reported that they would not work with a company they did not trust. For the most part, the companies collaborated with each other in addressing both general product and environmental product innovations. However, the collaboration could not be characterized as "close." This is because HP wanted to only give its suppliers as much information as required for them to be able to do their jobs. By limiting the information, the company felt it could better protect its proprietary information.

Of the five, two reported difficulties working with HP to a certain extent. One characterized the relationship as "complex", the other saying that HP did not collaborate and was very difficult to work with. Both declined to elaborate. However, both were the only suppliers to state that HP did not always get what they wanted in terms of environmental concessions from them. In the case of the material supplier, the environmental innovations they collaborated on with HP constituted a learning experience. They stated that in the future, they would spell expectations out more clearly with a customer so that the economics of the collaboration would work out more favorably for them.

Transferability of goods and market share. It was hypothesized that customers and suppliers who have little transferability of goods would be more likely to collaborate.

This means that a company has either few customers to sell their goods to or that they have few if any companies from which to buy their supplies. Hewlett Packard reported that they would not let themselves get into a situation where they only had one supplier for a required component. In the case of one material commodity, HP had four suppliers to approach for the development of recycled materials. In all cases, the suppliers responded that they had other customers for their goods. However, they all stated that Hewlett Packard represented a significant portion of their revenue. In two cases (suppliers 4 and 5), HP was identified as having enough clout to change the way the supplier did things environmentally without other customers' influence as well. And, in fact they did change the materials utilized in their production. A representative of HP stated that long-term partnering with their suppliers to their mutual benefit was very important to HP.

Supplier information access. It was hypothesized that suppliers who received adequate access to information and were made part of cross-functional teams would be more likely to succeed in creating environmental innovations. This proved to be true in the research. However, there seemed to be some tension between Hewlett Packard as the customer trying to protect its trade secrets and its suppliers trying to understand the reasoning behind some of their requirements. All but one said they could use more information. In the case of the one who felt they had enough, it was the contract manufacturing company, not a supplier of a component or material. The types of information suppliers wanted included information about the laws and eco-labels HP was reacting to as well as information on how they came to some of their requirements such as requiring a certain percentage of recycled material in packaging.

What This Says about Theory

For the most part, these theories have been supported by the data. The only one to be a moot point is the one involving trust, since all the companies involved stated that they would not conduct business with a company they did not trust. While some found HP difficult to work with, none felt that the company was un-trustworthy. Trust seemed to be a black and white issue. Either a company trusted its business partners or it did not. If it did not, it did not do business with them.

Identifying and Reducing Environmental Impacts

Hewlett Packard used three different tools for identifying and reducing environmental impacts. They were 1) the Global Environmental Questionnaire, 2) the Commodity-specific Questionnaire, and 3) the Supplier Quality Assessment, which was expanded to include environmental considerations. While the global questionnaire covered policy and operations, the commodity-specific questionnaires covered requirements that helped HP products meet environmental goals such as qualifying for eco-labels. Often, the commodity-specific criteria included eco-label criteria such as acoustic requirements, energy consumption, and the avoidance of certain hazardous materials such as brominated flame-retardants common to certain plastics. Additionally, the list of "Wants" put out by HP Grenoble reflected eco-label criteria. The Supplier Quality Audit gave HP the opportunity to evaluate supplier operations themselves.

Initially, HP did not plan to certify manufacturing sites to the ISO 14000 Environmental Management Standard or require its suppliers to be certified. According to correspondence with a UK-based HP employee, HP made the decision to get ISO 14000 certification at 5 sites. The decision was based on potential lost orders with

customers who were just beginning to use ISO 14000 certification as an order qualifier, just as the ISO 9000 series of quality standards was used (Rush 1999).

While in themselves these questionnaires may not have created environmental improvements, they did signal suppliers about HP's preference to work with environmentally sound companies. And as we have seen, the companies responded.

Challenges

Measurement. While achieving actual and measurable environmental improvements was certainly possible, HP had not given measurement the kind of attention other elements of the supplier management program had to date. Measurement will be addressed more with time. At the time, things like the amount of recycled material used in a product line, how many suppliers qualify under TQRDC-E, how many products qualify for various eco-labels, etcetera were used to measure success.

Economic incentive. Motivating suppliers who did not perceive sufficient economic incentive had certainly been borne out by the data, especially in the case of Supplier 1. Two out of four suppliers of this particular commodity decided that it was worth their while to develop the capability to produce recycled materials for HP. For the two who did not, they did not perceive this opportunity as being advantageous to them given their circumstances at the time, compared to other opportunities/risks.

Cost containment. Cost containment did not seem to be an issue for HP with respect to the management of suppliers. But it did when considering which environmental improvements to make vis-à-vis other product goals and considerations. For instance, if one of HP's environmental goals was to increase the cost to such an extent that the product could not be offered at its price point (and the lost business from a higher priced product would not be compensated for by additional eco-sensitive sales), the

environmental feature could be left out. HP suppliers stated that other product goals were more important to HP than environmental goals.

Internal resistance. The HP policy entrepreneur stated that dealing with challenges from Purchasing and middle management was not an issue because the program was so well implemented that Purchasing did not present a lot of challenges. Resistance surfaced within Purchasing not around whether or not to address environmental impacts, but how to address them. They were concerned that environmental evaluation not get out of hand and that whatever information was gathered from suppliers be succinct and usable. HP suppliers reported little internal resistance to environmental initiatives so long as they were backed up by sound business reasons. This pointed out the ultimate business drivers of environmental product improvements, there had to be a market for the product feature or it would not be incorporated into the product.

Information exchange. Information exchange was an issue from the standpoint that HP needed to inform suppliers of what the company wanted in the way of environmental management and product environmental improvements, why they wanted it, and what was in it for the supplier to comply as well. They worked with suppliers to ensure that they understood these things and helped them get there. HP included suppliers in cross-functional teams to the extent that the suppliers needed to have information, and not beyond. Beyond that would mean incurring more competitive risk than considered necessary.

Product lead times. Product lead times did not seem to be an issue for HP. Apparently no product introductions had been postponed in favor of incorporating an environmental feature into a product. This held true for suppliers as well.

Quantifying Success

HP used the number of suppliers who qualified under environmental criteria as a measurement. Other measurements included the number of environmental goals the company met that were supplier-dependent such as eco-label qualification, and the performance of environmentally superior products within the marketplace. Measurement was less well developed than other aspects of supplier management programs. HP product measurements included such parameters as product energy savings, the percentage of parts and components utilizing recycled materials, and reductions in the use of hazardous materials.

The number of products to qualify for eco-labels was probably the most significant measurement of product environmental quality for HP. They seemed to think that achieving a multi-criteria eco-label such as the Blue Angel was more effective at getting them to improve their own environmental performance as a company than ISO 14000 certification. By qualifying for the Blue Angel, they have to reduce the use of hazardous materials, etcetera, whereas implementing an EMS only meant that they had a system but not necessarily specific goals within it.

CHAPTER 6

RECOMMENDATIONS

Overview

This research began with the objective of identifying how companies successfully worked with suppliers to improve product environmental quality. This is important because of the need to reduce the environmental impact of commerce in an industrial model where numerous players contribute to finished products. Additionally, the findings of this research could help move industry towards industrial ecology as a way of creating products and managing them from "cradle to cradle," where each product component or material has a new application at the end of its old application.

Good environmental supply chain management has these goals:

1. To allow the customer company to meet its product environmental goals.
2. To inform the supplier about the environmental requirements of the customer company and about how complying with product environmental requirements will benefit the supplier.
3. To allow for accurate and meaningful measurement of product environmental improvements all along the supply chain.
4. To reduce the environmental impacts of products and all of their components and materials throughout the product life cycle.

The data showed these major barriers to achieving these goals:

1. A lack of strong market drivers in the U. S. market.

2. Lack of standardization of environmental requirements among industry members, which made it difficult for individual suppliers to comply with the myriad environmental requirements they faced from different customers.
3. Lack of accurate measurement of product environmental improvements or market success.

Major Finding

The major finding of this thesis was that the market played a profound role in determining whether or not any member of a supply chain, be it an end customer such as HP or its suppliers, would work to improve a product's environmental quality. Market drivers were much more potent in driving environmental improvements than regulations or competitor activities.

The Role of the Customer. Over and over, surveys have shown that the public is concerned about environmental problems and hungry for ways to reduce their environmental impacts. But few U. S. market segments had begun to use their purchasing power to do this. Given the fact that all the companies participating in this research stated that customers drive these innovations, there is tremendous room for more leverage of environmental preferences.

At this point, the primary markets that drive product environmental innovation in the high technology industry are the large institutional buyers from corporations, universities and governments in certain European countries. This was happening to a lesser extent in the United States and other parts of the globe. As a group, private end-consumers were not demanding environmental quality. Very little preference for product environmental quality existed among any consumers in the United States, the biggest

electronics market in the world. So the most effective motivator for reducing the environmental impact of commerce remained largely untouched. The European drivers were enough to make companies incorporate environmental improvements in their products as well as anticipation of environmental preferences becoming mandatory. Additionally, companies such as Hewlett Packard do not make multiple product versions for different markets. For instance, in designing and manufacturing a printer, they did not make an iteration of the printer for the German market, a different iteration of it for the American and Japanese markets. They made one model. Therefore, it had to meet the most stringent standards internationally.

These standards were in the form of product environmental labels such as the German Blue Angel, the TCO labels, and, to a lesser extent, the United States EPA's Energy Star label (which only covers the amount of energy the product uses). These labels make it easier for consumers to identify environmentally-sound products. They have the potential to especially help end-consumers, who have few resources (time or information) with which to identify them on their own.

The Role of Environmental Education. To remedy this, environmental education that includes curricula on how to be an effective consumer from an environmental standpoint would help consumers become aware of this avenue for helping the environment and make them more effective at using it. Such education should teach consumers how to determine the environmental impacts of a product and what to look for and demand from producers. Again, eco-labels can be very helpful in this regard. While not directly related to how to improve environmental supply chain management, this would be the single most potent motivator for encouraging companies to improve their products, at any rung of the supply chain. In addition to customers, everyone involved in

the product delivery process at every rung in the supply chain needs to be educated on the environmental aspects of their products and the marketplace so that environmental initiatives have the buy-in necessary for them to succeed.

The lack of environmentally-savvy customers slows progress in reducing the environmental impact of commerce. For instance, when Hewlett Packard attempted to utilize recycled plastic in its printers, they specified the use of post-consumer plastic as opposed to pre-consumer plastic because of customer preferences. HP's representative stated that limiting themselves to post-consumer plastic reduced the feedstream of materials to such an extent as to make its use unviable. Had the public been more open to pre-consumer plastic, this environmental improvement would have succeeded. Additionally, much pre-consumer waste plastic, such as tailings from the manufacture of automotive dash boards ended up in landfill anyway. Therefore, the public needs to be much more sophisticated in how it evaluates environmental quality.

In doing this, customers need to have their environmental requirements well thought out and provide their suppliers with adequate information about them, including the drivers and rationale behind them. Suppliers 1 and 2 both stated that this would have helped them determine better how to meet HP's environmental requirements.

This was especially true given that suppliers reported that they did not receive internal resistance to environmental innovation so long as the innovation made good business sense. Therefore, it is important to have internal support from management, sales and marketing. Without the support of sales and marketing, those in charge of product development would not proceed with innovations of any sort for fear that no market would exist for them. Support from sales and marketing would not be forthcoming without strong market preferences.

Additionally, suppliers need to educate their customers about what they are doing to reduce environmental impacts. Since this is a market differentiator, it could make the difference in a sale in some instances. Companies whose product innovations represent true environmental improvements should be rewarded for them with increased business. Having educated customers who demanded environmentally-superior products would create the strong business case for them.

Customers such as HP need to make sure that their suppliers receive the information they need to meet their environmental requirements. A fuller understanding of the drivers behind a customer's environmental requirements would help the supplier meet them more effectively. Standardizing requirements across companies as much as possible will help suppliers avoid myriad disparate requirements to fulfill. The creation of the Computer Industry Quality Conference's Supplier Environmental Performance Review Questionnaire is a good initial step in this direction.

The Role of Measurement. To date, the companies in this research have not created very sophisticated ways of measuring progress in terms of reducing product environmental impacts. Nor have they determined whether or not -- or to what extent -- environmentally-superior products perform better in the marketplace than their less environmental counterparts. Doing so would make it easier to make a business case for such products and help prove to eco-sensitive customers which products are truly greener. Product environmental measurements could include:

1. The number of products to qualify for targeted eco-labels,
2. The number of products to utilize post-consumer materials,
3. The number to have reduced the amount of hazardous materials utilized,
4. Dematerialization statistics,

5. A measurement of end of life impacts such as the amount of waste generated versus that which can be recycled,
6. Energy consumption information,
7. Dollars saved in waste disposal/landfill costs to society.

The Role of Regulation. Given the fact that the marketplace is still fairly immature in terms of demanding environmental quality, there is a big role to be played by regulation or voluntary standards such as eco-labels. Until the marketplace becomes more adept at creating environmental improvements, laws such as the European Directive on Waste Electronic and Electrical Equipment, concepts such as extended producer responsibility and eco-labels such as the United States Environmental Protection Agency's Energy Star, can effectively reduce environmental impacts by mandating or encouraging them beyond the marketplace's current ability. An environmentally-educated market would create more demand for both eco-labels and the products they qualify.

Future Research

In researching collaboration between companies on environmental initiatives, future researchers need to have better access to a more diverse pool of suppliers. In the course of this study, there was no access to suppliers for whom HP's environmental questionnaires and requirements were problematic or access to companies with whom implementing the programs did not go well. This would have been more helpful in identifying how to improve the process.

Since customers are identified universally as driving product environmental innovations, some suppliers mentioned an interest in researching whether or not product

environmental innovations really do result in increased sales. As already mentioned, little if any research has been done to date on this topic.

In their 1997 environmental report, Swedish appliance manufacturer AB Electrolux offered some statistics on how their green products fared in the marketplace. Their environmentally-superior white goods such as refrigerators, freezers, washing machines and dishwashers all enjoyed marked increases in sales from the first to the second half of 1997 with profitability at least as high as that for less green products (Cutter Information Corporation 1998). Research needs to be done within the electronics industry to identify any analogous trends.

And finally, research that helps companies quantify their environmental improvements in a non-resource intensive way (meaning without requiring a sizable commitment of staff and time) would both help legitimize the products in the marketplace and secure their acceptance by all relevant members of the supply chain.

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APPENDIX 1

Human Subjects Materials

San José State
UNIVERSITY

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Vice President**

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Graduate Studies and Research**

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TO: Linden Skjeie
2051 Valparaiso Ave.
Menlo Park, CA 94025

FROM: Nabil Ibrahim,
Acting AVP, Graduate Studies & Research

DATE: October 26, 1998

The Human Subjects-Institutional Review Board has approved your request to use human subjects in the study entitled:

**"Successful Environmental Supply Chain
Management in an Electronics Firm"**

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The Board's approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Nabil Ibrahim, Ph.D., immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at
(408) 924-2480.

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