The Supply Chain Response to Environmental Pressures

by

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Abstract

Understanding and shaping the relationship between supply chain management and the natural environment is critical not only to human health and the environment, but to the future success of business. While the cumulative environmental impacts of industrial production are best addressed at the supply chain level, little research has connected the overall context of supply chain management, including the characteristics of environmental pressures and market drivers, to a general approach for developing operational supply chain processes that may deliver environmental and economic performance improvements.

Findings from a series of semi-structured interviews indicate that there are four sources of environmental pressure currently affecting supply chain management in unique ways. These include regulations, customer demands, resources, and ethical responsibility. Corporations that are better able to identify and understand these impacts will be better positioned to address them strategically.

A framework of supply chain environmental excellence is presented to illustrate how corporations may integrate environmental operating models, operational objectives, and new supply chain processes into a comprehensive corporate strategy.

A case study of the emergence of reverse supply chains within the electronics industry illustrates why supply chain processes should be developed in a context defined by environmental pressures and market drivers. As the electronics industry is faced with environmental pressure from evolving regulatory directives, liability concerns, and social responsibility demands, leading companies are researching and piloting reverse processes to varying extents. Findings from a second series of industry interviews reveal a number of regulatory, behavioral, and economic trends and challenges that collectively shape both strategic considerations for individual corporations and the overall supply chain capabilities of the industry.

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Overview

This thesis draws from supply chain and environmental management literature and industry case studies to 1) characterize the current state of supply chain environmental activity, and 2) identify pressing challenges for supply chain management at the intersection of these topics. Supply chain management as an integrating philosophy and practice has characterized the growth of multi-national corporations over the past two decades. As supply chains continue to mature into sophisticated networks of material and information flow, so does the ability to carefully trace the environmental impacts of individual products and activities along the supply chain and address these impacts proactively.

When I started this thesis, I was primarily interested in how companies are addressing the regulatory requirements associated with extended producer responsibility legislation. Often referred to as "take-back" laws, extended producer responsibility is an environmental initiative to create incentive for manufacturers to design products for reuse, remanufacture, and recycling by requiring them to be financially responsible for products at the end of their useful life.

However, after speaking with industry representatives, I realized that this focus was too limited to capture the changes effecting supply-chains today. Not only do supply-chain regulatory concerns go beyond take-back laws, but environmental concerns and their implications for supply chain management go far beyond regulations. In fact, supply chain professionals are facing a wide range of environmental challenges. Relevant environmental regulations are diverse globally and include material bans, product certification programs, fuel taxes, solid waste fees, and liability considerations. At the same time, consumers increasingly demand products and services with improved environmental attributes, produced by companies that demonstrate social responsibility through innovative environmental initiatives. Finally, many global corporations are acting to address issues of environmental variability and climate change and to protect natural resources that serve as critical feed-stocks for their supply base, such as fresh water, fish, and forest products. In short, the environmental challenge to the supply chain is much larger than regulatory compliance. The full range of environmental pressures is diverse, dynamic, and demands new levels of accountability, financial commitment, and supply chain capabilities. To the supply chain professional, such changes raise many questions: What happens when environmental performance becomes a supply chain objective? How does this change the way that supply chains are designed and operated? What are best practices? How does environmental performance affect strategy and the competition in the market? In the future, considerable technical and organizational innovation will be needed to develop the supply chain processes, metrics, and relationships to address these questions.

While corporations may be increasingly receptive to the role of environmental steward, this intention may or may not be filtering to the functional levels of supply chain management. A growing body of literature discusses various components of this issue. However, the imprecise understanding of supply chain management as a discipline becomes even more ambiguous when adding an environmental component. In environmental management literature, the term "supply chain" is often used as a proxy for the environmental impacts of a single product throughout its life-cycle. "Green supply chain" may refer to purchasing preferences that include environmental criteria, while "supply chain environmental management" describes the practice of requiring suppliers to meet certain environmental performance standards in their own facilities. Topics further include methods for assessing supply chain environmental impacts, incentives for improving the environmental performance of the supply chain, suggestions for building management capacity for change, and process-specific research addressing reverse logistics or materials tracking. The increasing numbers of case studies and anecdotal data reflect the interest and timeliness of these papers. Nonetheless, what is lacking in this relatively new genre of research is a theoretical framework that describes generally an approach for developing operational business processes that appropriately support environmental objectives and business strategies. Such a framework may be used to bridge the efforts of environmental management and supply chain management in theory and practice, while serving as an anchor for prescriptive advice on how to best respond to environmental pressures.

This thesis lays the foundation for the development of a theoretical framework and future empirical research. It draws from environmental and supply chain management literature as well as industry case studies to characterize the current state of supply chain environmental activity. The challenge in writing this thesis was to tackle two very large issues – environment and supply chain management - in a clear and convincing way that may be relevant to future analysis. This thesis is meant to be very straightforward in both purpose and message. As environmental pressures become more diverse and demanding in the future, the most successful companies will be those who design and operate their supply chains appropriately.

Chapter 1 explores the relationship between supply chain management and the environment. The design and operation of supply chains impacts the natural environment in both direct and indirect ways. While this impact may not be explicitly measured, supply chain processes in general bring great efficiency to a linear production system that is environmentally intense. Current trends in supply chain and environmental management suggest that corporations will increasingly turn to supply chain management to simultaneously mitigate environmental implications and promote business goals. The chapter concludes with a review of existing literature addressing the extent of this relationship and strategies for managing it.

Chapter 2 presents an assessment of the four sources of environmental pressures that impact the supply chain, including: consumers, regulations, resources, and ethical responsibilities. This content is based on findings from an initial round of four in-depth industry interviews, along with supporting research.

Chapter 3 relates a framework of supply chain excellence to supply chain environmental excellence. The chapter examines the MIT Supply Chain 2020 four statement hypothesis defining an "excellent supply chain" with respect to environmental excellence, and introduces some of the many business processes that could yield environmental improvements and business value.

Chapter 4 revisits the issue of extended producer responsibility in the context of environmentally motivated reverse supply chain processes. The chapter begins with a closer look at the operational dimensions of reverse supply chains. It describes the environmental pressure posed by current legislation in Europe and the United States, and outlines what leading electronics companies are doing and learning in direct response. The content of this chapter is based on findings from eight interviews with electronics companies, along with supporting research.

The thesis ends with conclusions that summarize key findings and areas for future research. This work represents just a small piece of the large scope of research that may be done in this emerging area, including future qualitative and quantitative research to present a path towards the proactive development of supply chain processes that enable increased profitability and environmental sustainability.

1. Supply chain management and the environment

The environment is a supply chain management issue.

Understanding and shaping the relationship between supply chain management and the natural environment is critical not only to human health and the environment, but to the future success of business. The cumulative environmental impacts of industrial production are best addressed at the supply chain level. A growing body of literature promotes this end and proposes tools and approaches to do so.[1,2,3] Nonetheless, very little research has connected the overall context of a supply chain, including the characteristics and interplay of environmental pressures and market drivers, to process level changes within the supply chain that can deliver environmental and economic performance improvements. The purpose of this thesis is to examine this connection, considering both the interests of society and supply chain decision-makers. The introduction of environmental concerns may broaden the scope of supply chain management too far, as an already ambiguous area of research and practice. Nonetheless, societal demands and physical limitations increasingly pose challenges for corporations to address the environmental impacts of mass production and consumption. Supply chain management is the operational level at which industrial reform is most appropriate.

Chapter one describes the importance of both supply chain management and the environment to the future success of corporations, and examines the complex relationship between these two areas. The chapter also explores the potential for corporations to leverage supply chains in promoting environmental stewardship and outlines existing literature on this topic. Finally, it explains why supply chain processes should be developed in direct response to specific environmental pressures and market drivers as a preface to the rest of the thesis.

The information presented in this chapter was collected from an extensive literature search that involved both supply chain and environmental management literature.

1.1 The Case for Concern

There are certainly many altruistic reasons for corporations to worry and act on behalf of the environment. However, there are also compelling business reasons. This section draws a connection between supply chain management and the environment and describes how management of this connection is in the best interest of corporations.

1.1.1 Importance of supply chain management

The emergence of supply chain management as an integrating philosophy and practice has been heralded as creating marked growth in corporate production and profitability.[4] Originally coined in 1992, the term supply chain management continues to evolve in definition and scope. In essence, supply chain management is a holistic approach to controlling the transformation and flow of materials from supply to distribution.[5] It merges traditionally supportive business functions including purchasing, inventory management, and logistics into a single set of strategic processes. While there is no explicit and universal definition of supply chain management, common themes are present in a growing body of applied research:[6,7,8]

- *Supply chain management improves operational performance.*

Integration of disparate business functions - planning, product design, sourcing, manufacturing, fabrication, assembly, transportation, warehousing, distribution, and post-delivery customer support – allows system-wide optimization and reduces uncertainty about product volumes and flows. Information technology plays a key role in this development. The supply chain approach allows companies to "meet customer needs more quickly, less expensively, and through more channels."[9]

- *Supply chain management improves financial performance.*

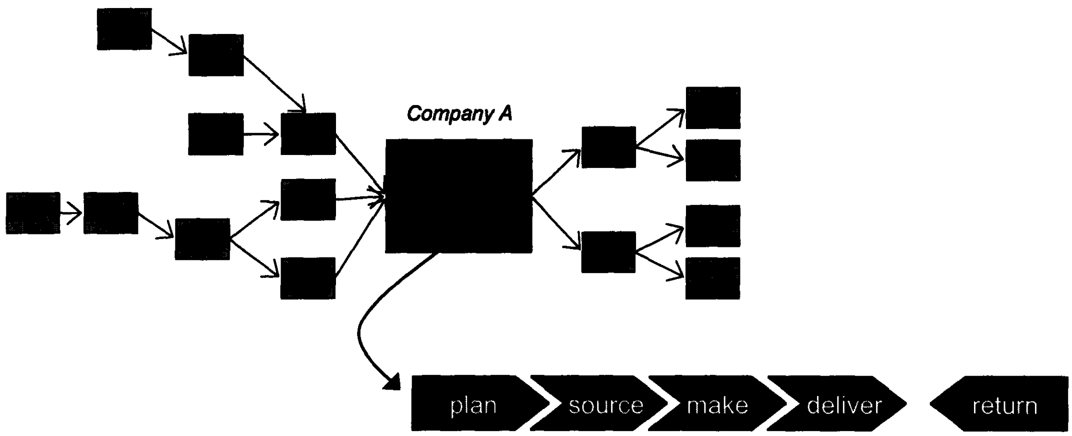
Operational savings and better customer service increases profitability. In 2001, Accenture surveyed one hundred and fifty Fortune 1000 executives about the performance of supply chain initiatives. Eighty percent indicated that supply chain initiatives have helped to "cut costs, improve efficiencies, enhance customer service and revenues, and improve competitiveness."[10]

- *Supply chain management is a source of competitive advantage.*

In a global economy where almost all companies are linked through a sequence of transactions, supplier relationships and operational coordination becomes a quality that is difficult to replicate.[11]

The importance and pervasiveness of supply chain management is further indicated by the growing number of research papers, trade publications, professional organizations, and graduate degrees dedicated to the discipline. This serves as evidence that supply chain management will continue to grow in importance in corporate functioning.

Figure 1.1: Basic supply chain management functions within a network



Basic supply chain management functions of Company A

1.1.2 Importance of environment

In 1991, the World Business Council for Sustainable Development was created in order to involve corporations in the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. Starting as an informal consortium of approximately fifty executives, the Council has since grown to involve 170 multinational companies from more than 20 major industrial sectors with 45 regional organizations.[12] The Council has published several dozen reports with the underlying assumption that "business is good for sustainable development and that sustainable development is good for business." This body of research represents not only a critical agenda for change in corporate practices, but also a new wave of thinking about the direct relationship between environmental and business performance.

In growing recognition of this relationship, many corporations publicize information about their environmental practices. A study completed in 2002 reported that 63% of global Fortune 500 companies included some form of environmental information on their websites.[13] At least 36% of the top 100 companies in the United States publish annual reports that cover issues of social and environmental performance.[14] A survey of 140 companies, many of which are in the Fortune 100, showed that 75% report adopting environmentally-responsible business practices.[15] These types of statistics indicate that at the very least there is the perception among corporate leaders that environmental practices are important and may contribute tangibly to business performance.

Beyond that, a large body of literature outlines many reasons for why the business community should care about the environment.[16] At the heart of this research is the implication that "many of the non-financial concerns associated with sustainability are fundamental drivers of long-term shareholder value.... failure to recognize these strategic issues threatens the very survival of a business enterprise."[17] Therefore, awareness of and strategy for addressing environmental issues is an essential corporate undertaking.

One area that certainly impacts business practices is the availability of natural resources or "goods and services" from the ecosystem necessary for both production and consumption. Protecting these resources is akin to protecting long-term investments to insure future viability. In a report released July 2005, the Millennium Ecosystem Assessment team described ramifications of damage to the ecosystem for business and industry.[18] Several broad conclusions were drawn:

- If current trends continue, ecosystem services that are freely available today will cease to be available or become more costly in the near future. The higher costs that primary users may face will be passed downstream to secondary and tertiary industries and will transform the operating environment of all businesses.
- Loss of ecosystem services will also affect the framework conditions within which businesses operate, influencing customer preferences, stockholder expectations, regulatory regimes, governmental policies, employee well-being, and the availability of finance and insurance.
- New business opportunities will emerge as demand grows for more efficient or different ways to use ecosystem services, mitigate impacts, or to track or trade ecosystem services. Innovation and new technologies can play a key role in the creation of these new business opportunities. Many leading companies are already capitalizing on these needs and trends.

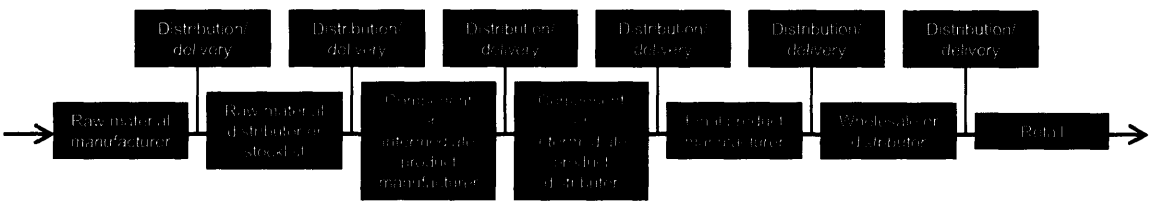
Echoing these conclusions, researcher Steven Hart writes "the basis for gaining competitive advantage in the coming years will be rooted increasingly in a set of emerging capabilities that facilitate environmentally sustainable economic activity."[19] As the reasons and apparent willingness for corporate environmental activity increase, it is not entirely clear what these "capabilities" are and whether or not they currently exist. Nonetheless, it is safe to say that the environment will be an important business issue in the future.

1.1.3 Importance of the relationship between supply chain and environment

Supply chain management is the firm's direct interface with the natural environment. As a mechanism for controlling the physical flow and transformation of materials within and through organizations, corporations directly impact the environment through their supply chains. Some decisions made by corporations bear *indirect* environmental impacts. For instance, the design of a product will define how it impacts the environment during consumer use phase. However, as supply chain management becomes more important to business and the environment becomes a greater concern to business, the more likely the corporations will turn to supply chain management processes to address environmental issues. This section explores the unique overlap between these two areas.

Figure 1.2: Stages of a product supply chain

Each stage of the production system impacts the environment in different ways: emissions, use of resources, toxicity.



The success of supply chain management as a decision-making framework may be attributed to the ability to optimize operations system-wide for a given outcome. An effective supply chain organizes production, both industrial and commercial activities, with awareness of system-level goals – low cost, short time, high reliability, complete use of assets. Altogether, this system meets or even creates demand by exceeding consumer expectations. At the same time, supply chains represent a path along which to trace the cumulative environmental impacts of a linear production system. Each stage of production, from material extraction to final disposal has environmental affects, ranging from air and water emissions to toxicity and waste. While there is some research examining the impact of a single product over its life-cycle or along its supply chain,[20] there is no systematic treatment of the environmental impacts of supply chain management.

Isolating the degree to which supply chain management as an organizing framework impacts the environment may be extremely difficult. However, it is useful to begin by discussing the current environmental effects of generalized supply chain management outcomes. For instance, supply chains that are optimized for cost in an increasingly globalized and technologically advanced economy typically yield three outcomes: 1) more transportation, 2) less environmental governance, and 3) more global consumption.

Transportation

Advancements in transportation technology combined with low-cost labor in less developed countries have allowed supply chains to grow geographically. Over the past seventy-five years transportation innovations have lowered the unit cost of carrying freight by ship at least 70 percent, and the average revenue per mile for air transport has fallen from $0.68 to at least $0.11 during the same time period.[21] Lower transportation costs combined with liberal international trade agreements has altered the outcomes of supply chain management decisions. For those firms operating with a strategy of lowest cost, it has proven to be common to choose suppliers located in regions with low labor rates and overhead expenses, even when the facility is located thousands of miles away. In fact, the late 1980s and 1990s saw an explosion of overseas sourcing. In fact, between 1995 and 1998 alone, the tonnage of goods carried by ship rose more than six-fold to $5.1 billion total.[22] While many consumers will cite the electronics, automobile, and steel industries as ones that take advantage of overseas labor, it appears that other industries are following lower operating costs due to specialization. For instance, "a study by the London-based National Food Alliance found that food consumed in the United Kingdom on average traveled more than 50 percent further over the last two decades. A small jar of strawberry yogurt eaten in Germany has components that travel more than 3,000 kilometers, according to a report by the Wuppertal Institute. Though the milk is available locally, the strawberries are grown in Poland, and the packaging materials come from Austria and Switzerland."[23] Although the decision to transport materials, components, and finished products further offers operational and financial benefits, there are several direct environmental repercussions:

- Emissions from air, sea, road and rail transport impact air and water quality.
- Energy is consumed in fueling transportation, as well as powering offices, warehouses, and other facilities that are dedicated to logistics functions.
- Goods are transported in vehicles that are increasing in size and numbers. Their very existence impacts land use and communities, adding congestion and noise.
- Packaging is produced for the sole purpose of facilitating handling and transportation, and creates waste.
- "Bio-invasion" threatens native plants and species.

There is a significant body of research that examines the negative environmental impacts of transportation and mobility,[24] although it is not made clear that any directly connect transportation decision-making to a supply chain management framework.

Governance

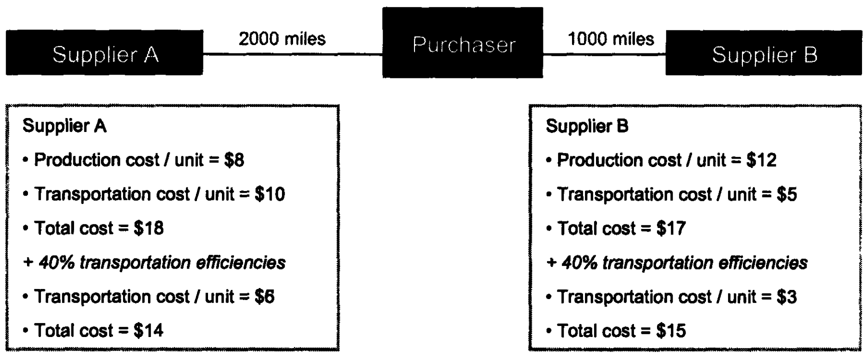
As supply chains grow geographically, national environmental regulations have relatively less influence on corporate functioning. Companies may be operating in several countries at once with regulatory requirements for the environment ranging from extensive to non-existent. Although labor cost may be the most often cited factor in the decision to move manufacturing operations to less developed countries, other operational characteristics such as the absence of stringent environmental regulations may also make these locations attractive. In fact, the most hazardous industries over the past ten years have become "concentrated in the developing world, where safety practices and environmental enforcement and monitoring are often rudimentary at best."[25] In the city of Mexicali, near the California border, there are approximately 3200 manufacturing plants. In a survey conducted in the late 1980s, more than 25% of plant operators cited Mexico's relatively low environmental enforcement as a consideration in their decisions to locate there.[26] There is a significant body of literature that examines the connection between environmental regulations and manufacturing location decisions,[27] although it is not clear to what degree this decision-making is related to the supply chain management framework.

Consumption

If the supply chain is designed and operated to deliver lowest-priced goods, it may be expected that consumption rates increase because of simple relationships between economic supply and demand. In this sense, supply chain management enables a larger population of consumers to have access to a growing number of products. Although outside of the scope of this paper, it may be useful to examine trends related to cost minimization, consumer purchasing, repair rates, global manufacturing, and global markets in order to draw specific conclusions about how supply chain processes increase consumption rates and subsequent environmental implications. In general however, supply chain management brings considerable *efficiency* to a linear production system that encourages higher rates of consumption for better or worse.

Efficiency is not typically something that environmentalists refute. An efficient process generates output with fewer resources and, usually, less impact. Efficient may be considered synonymous with effective, resourceful, or "ecologically-aware." However, the efficiency associated with supply chain management has the potential to lead to environmental degradation, by opening up production conditions with attractive financial but unattractive environmental characteristics. Consider this simple example:

Figure 1.3: An example of supply chain management decision-making



Here, Supplier B manufactures components for $12, ships components for $5, and is located approximately one-thousand miles away. Supplier A manufactures identical components for $8 and ships for $10 since the facility is located two-thousand miles away. Based on lowest cost, the purchaser selects Supplier B – a decision that is also environmentally preferable because it reduces total distance traveled. However, a new innovation in transportation technologies or transportation planning yields fuel savings of 40 percent, lowering shipping costs accordingly. Now, Supplier B can deliver finished components for a total cost of $15. Supplier A can deliver for a total cost of $14, so the purchaser selects Supplier A. As such, the improved efficiency of logistics actually leads to a net increase in the environmental impact of transportation.

While it may be near impossible to measure the impacts that supply chain management as an orientation and practice have had on the environment, it is clear that the outcomes of this orientation promote environmentally-intensive behaviors. While this is certainly the case today, a shift in design criteria, values, or perspective could change supply chain decision outcomes.

1.2 The Case for Action

As a decision-making framework, supply chain management offers sufficient scope and leverage to re-orient corporate behavior towards more environmentally-responsible outcomes. Anthony Nieves, president of the Institute for Supply Management's Commission on Social Responsibility, notes that "supply chain managers are well-positioned to be catalysts for (environmental initiatives) because of their positions in the company. They interact with other functional areas of the organization as well as externally with suppliers and customers. They can have huge influence."[28] This section discusses why the relationship between supply chain management and the environment could be transformed into one that is mutually beneficial.

In a paper titled "Business Decisions and the Environment: Significance, Challenges, and Momentum of an Emerging Research Field," Andrew Hoffman echoes the sentiments of the World Business Council on Sustainable Development in saying that "no solution to the environmental problems society faces will be solved without the involvement of business."[29] He cites four lines of reasoning in support of this statement:

1. *Governments no longer possess the full array of resources and knowledge necessary to dictate environmental solutions to business. Many within policy circles now agree that business must become a participant in the environmental regulatory process if sustainable and economically efficient solutions are to be found.*
2. *The power of business organizations to determine the structures of our social, economic, and political activity has grown to such enormous proportions that industry now possesses the most resources both individually and through markets to create more efficient coordinating mechanisms.*
3. *Industry is in general the sources of technological evolution within society. As such, firms best understand the technical tradeoffs that innovation choices may involve. While environmentalists and others may appreciate the impacts of systemic change, firms understand the underlying technical and economic aspects of innovative activities.*
4. *Business decisions about what inputs to use and how to manage outputs ultimately determine environmental quality. Industry bears the direct cause and effect link to environmental problems, such that it is the most vulnerable institution to social and political challenges for change.*

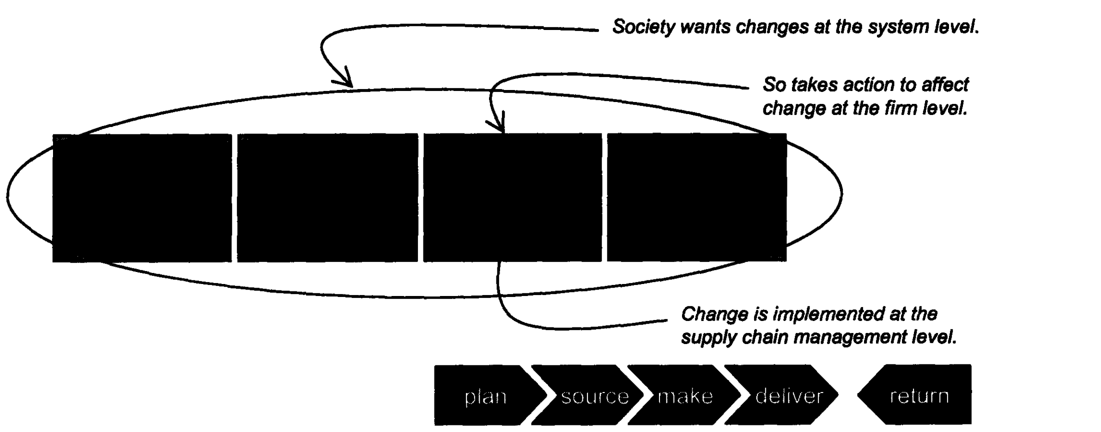
Taken together, this reasoning may very easily apply to a discussion about supply chain management. To begin with, one may write that *no solution to the environmental problems society faces will be solved without the involvement of supply chain management*. As supply chains expand into numerous countries and regulatory structures, the relative influence of national requirements may be weaker. However, if supply chains are designed and operated with explicit environmental goals, then environmentally-preferable activities could ripple through the supply chain defining the behavior of many linked corporations operating in as many countries. Today, regulatory shifts of some countries, including the United States, are predicated on the belief that voluntary partnerships and programs incite corporate innovation that will have more significant environmental benefits than those prescribed by legislation.[30] For instance, the United States EPA enlists voluntary efforts from corporations and local communities in the Resource Conservation Challenge program. The EPA states that "EPA cannot achieve resource conservation goals on its own or regulate them into place. The transformation to a new way of thinking about wastes and materials is a joint effort between EPA, businesses, and communities."[31] Another example is provided by the Suppliers Partnership for the Environment, a collaboration between EPA, National Institute of Standards and Technology, and a consortium of suppliers within the automobile industry. The mission of the Suppliers Partnership is to identify and pursue "opportunities within the automobile supply chain to improve the environment and the bottom lines of our member companies."[32] The combination of governments turning to corporations for voluntary environmental leadership and of corporations leveraging networks of suppliers and customers to meet operating goals, presents considerable prospects for the alignment and expansion of corporate and governmental environmental initiatives on a global scale.

Consider the influence of the largest multi-national corporations. The Fortune 500 is a ranking of the top 500 American-owned corporations as measured by gross revenue. These companies jointly represented over $7.5 trillion in revenue in 2004.[33] Their leverage, both individually and through markets, is enormous. First, large corporations collaborate with numerous supply chain partners. While supply chain management becomes increasingly strategic, relationships with suppliers may become increasingly purposeful and long-term.[34] This business situation enables environmental innovation to be developed between partners and diffused along the lines of supply chains into networks of companies and consumers. Second, large corporations have access to considerable financial resources that are dedicated to research and development of new products and processes to continually serve the marketplace. These offerings may incorporate more environmentally-responsible attributes. Corporations are generally the most aware of the technical and economic tradeoffs of new products, and also how a shift in operational priorities may change the composition and configuration of an entire supply chain. If companies were provided incentives to value environmental performance as much as cost or any other operating objective, then environmental innovation might occur. Third, large corporations manage hundreds of individual decisions about material inputs and outputs at the supply chain level. The cumulative impact of these decisions on the environment makes corporations and their supply chains prime targets for "social and political challenges for change." Concern for the environment translates into regulatory pressures and consumer demands that corporations must address in order to stay viable.

In a recent article, researcher Lutz Preuss asks "what contribution may supply chain management make to environmental protection?"[35] As discussed, supply chain management as an integrated decision-making framework may be applied to attain environmental goals. However, rather than stating "environmental protection" as an operating objective, corporations must identify specific pressures and objectives to define the supply chains response at a functional level. As environmental problems become more diverse, variable, and demanding, corporations will need to make innumerable changes to manage supply chains effectively in response. Today, the appropriate question is not asking whether supply chain management can contribute to environmental protection, but rather how supply chain resources should be targeted. What environmental issues are most relevant? What supply chain decision outcomes need to change? What is the best strategy for change? On which supply chain processes should corporations focus their efforts?

The complexity of challenges posed by both supply chain management and the environment suggests that the answer to these questions is not universal. Rather, environmental supply chain management will involve complex, tailored responses which may vary considerably by context. Today, there is a growing body of research literature and industry case studies that attempt to answer the many questions posed by supply chain environmental management.

Figure 1.4: Environmental concerns prompt changes to supply chain management



1.3 Existing Literature

Considerable progress is needed to understand fully the relationship between supply chain management and the environment. A review of over 40 articles written between 1990 and 2005 reveals that there are many exploratory papers, as well as qualitative and quantitative case studies. What is lacking, however, in this relatively new genre of research is a theoretical framework that describes generally an approach for developing operational business processes that appropriately support environmental and business strategies.

To begin with, the imprecise definition of supply chain management becomes further complicated by the introduction of environmental criteria. In environmental management literature, the term "supply chain" is often used as a proxy for the environmental impacts of a single product throughout its life-cycle. "Greening the supply chain" may also refer to purchasing preferences that include environmental criteria, while "supply chain environmental management" describes the practice of requiring suppliers to meet certain environmental performance standards in their own facilities.[36] Q. Zhu defines "greening the supply chain" as intentionally creating networks of suppliers to purchase environmentally superior products and to pursue common approaches to waste reduction and operational efficiencies.[37] Stefan Seuring has proposed "integrated chain management" as a term that encompasses many of the concepts conveyed in "green or environmental supply chain management."[38] Joseph Sarkis explains that "lack of consensus in practice and definition of green supply chain, is not surprising since its foundational elements of corporate environmental management and supply chain management are both relatively new areas of study and practice. If the practice of green supply chains is novel, the theory is even more so, if true theory even exists."[39] This sentiment is echoed by Remko van Hoek in identifying areas for future applied research in order to set forth "a grounded theory for supply chain environmental improvements."[40] Altogether, this lack of clarity makes it difficult to prescribe a generalized approach for supply chain improvements.

Despite the apparent lack of definition and theory, there are several papers that address how to assess the environmental impact of a product supply chain. This represents a very important area of research, thematically consistent with life cycle analysis and sustainability metrics. Paul Kleindorfer writes: "Careful tracking of environmental information, including cost, value, and performance, is essential in understanding, managing, and legitimizing investments in product (environmental) stewardship activities in the supply chain."[41] In a case study of Xerox, Ltd., Kirsten McIntyre proposes a single metric that may be used to indicate the environmental performance of an entire product supply chain as well as each element of the supply chain. She asserts that: "Until the environmental becomes represented by an easily understood, top-level metric, it will be difficult to achieve the level of environmental integration which will be required to make the leap into long-term environmental sustainability."[42] Roland Clift developed case studies of several industries to demonstrate how to account for environmental impacts along the supply chain,[43,44] an approach that is also espoused in a industry report published by the US Environmental Protection Agency.[45] In many cases, the motivation for tracking environmental indicators is to select appropriate suppliers. M.H. Nagel and A.C. Brent propose an environmental performance metric for assessing a supplier's production facility. Adam Faruk et al describes an approach for "analyzing, mapping, and managing environmental impacts along supply chains" for the purpose of reducing environmental stress.[46]

There is also a growing body of literature that relates to specific supply chain management processes. Nagel focuses on procurement functions,[47] Handfield discusses commodity strategies,[48] and Hall focuses on the exchange of environmental information and practices between customer and supplier.[49] (there was a paper about transportation optimization?) Greener Management International explored several of these processes in a special issue.[50] Considerable attention has also been devoted to understanding reverse supply chain processes, including reverse logistics and remanufacturing. California Management Review recently dedicated entire issues to this topic.[51]

Several researchers have addressed management approaches for implementing environmentally improved supply chain processes. Key to this area is basic decision-making. Joseph Sarkis presents how an analysis of supply chain management elements may serve as a foundation for a multi-attribute strategic decision framework.[52] T. Kuo has developed a similar method for decision making including both environmental and economic factors.[53] Fiksel proposes that decisions may be shaped by a controlled, six-step protocol that encourages explicit consideration of the environment in product, network, or system design.[54] Many further question whether or not there is a certain management capacity that must be demonstrated prior to engaging in environmental supply chain activities, such as successful implementation of environmental management systems. Curkovic empirically shows a strong relationship between "total quality management" capabilities and the ability to implement environmentally responsible manufacturing systems related to supply chain management.[55] Bowen examines supply chain management performance as a pre-requisite to "green supply."[56]

Finally, there are a significant number of papers that describe technical and organizational challenges to supply chain environmental activities. These include:

- *Inadequate tools.*

It may be extremely difficult for supply chain professionals to integrate environmental information into a design process. Handfield et al demonstrates through a study of ten environmentally-oriented firms that "a large gap exists between the environmentally responsible (process) supporters and users of environmentally responsible (process) tools in terms of expectations, perceptions and orientations."[57]

- *Inappropriate incentives.*

Internal incentive structures are critical to the success of all new initiatives, particularly environmental activities which alter supply chain management decision outcomes. Handfield explains that "as environmental strategies filter to the functional and commodity level strategy development process, managers must consider how this will affect the performance metrics used to evaluate the supply chain management groups."[58]

- *Displaced efforts.*

Given the broad scope of environmental activities, it may be challenging to focus efforts appropriately on a process, or to execute that process in the best manner. Swarr explains that managers should focus on high risk processes and suppliers. Burdensome administrative requirements are frequently placed on suppliers "regardless of the risk posed to the original equipment manufacturer…A risk assessment methodology is needed to...focus effort and resource by identifying the industry sectors or commodity groups within the supply line that present the greatest environmental risk to the business."[59]

- *Structural barriers.*

Corporate management structure impacts the ability to implement supply chain environmental activities. Preuss points out that "the marginal contribution of supply chain management to environmental protection initiatives contrasts both with the function's increasing economic role and with the general tenor of environmental policy documents."[60] This disconnect may be attributed to the role of supply chain within companies. In the future, supply chain managers should participate in cross-functional teams and management boards. They should be further encouraged to develop long-term relationships with innovative suppliers.[61]

- *Learning curve.*

The Global Environmental Management Initiative reports that leading companies are just beginning to understand the value that environmental activity brings to supply chain management. "The barriers that can prevent environmental, health, and safety activities from adding value (to supply chain management) are similar to those that have impeded past efforts at supply chain innovation – namely resources limitations, resistance to change, lack of adequate models, and lack of champions for integrated thinking."

Altogether, the growing body of literature indicates that there is interest in and incentive to account for and mitigate the environmental impacts of supply chain processes. What is lacking, however, in this relatively new genre of research is a theoretical framework that describes generally an approach for developing operational processes that appropriately support both environmental and business strategies. Essentially, this means that certain environmental standards, for lack of a better word, need to be specified as criteria in supply chain decision-making. These standards may serve as operating objectives for the management of supply chain processes that are developed in a context defined by specific environmental pressures and market drivers.

While existing research contributes significantly to a general framework, it falls short in three primary ways:

1. Existing research is not specific in identifying various sources of environmental pressure on the supply chain. Many papers group several environmental challenges together as a single motivation for supply chain improvement. However, such simplification cannot guide the development of supply chain processes. For instance, an appropriate response to new environmental regulations may be quite different from an appropriate response to market demands for products with environmental attributes. Regulations and consumer demands represent two different sources of environmental pressure on the supply chain, and likely entail different time frames, technologies, and levels of competition between corporations. A clear understanding of the various sources of environmental pressures may allow supply chain professionals to develop the most appropriate processes for environmental and economic improvement.
2. Existing research is not specific in proposing environmental objectives for supply chain management. Many papers cite "environmental improvement" as a broad operating goal. However, supply chains are best designed to meet specific and measurable operational objectives. These objectives must be aligned with overall corporate strategy and operating model. In addition, while metrics applied to an entire product supply chain may be useful for industry-level research, they do little to guide process-level decisions and are difficult to balance with conventional supply chain performance metrics. A clear understanding of how environmental processes may be integrated into corporate strategy and indicated by

appropriate performance metrics may allow supply chain professionals to build competitive advantage with environmental supply chain practices.

3. Existing research presents case studies and anecdotal details about specific supply chain processes. However, prescriptive advice that is either too general or too specific without adequately providing context is not generally useful. Supply chain processes, such as reverse logistics and purchasing, are influenced by a wide variety of internal and external market drivers. As environmental pressures become more diverse and demanding, the success of individual processes will depend on political, economic, social, and physical limitations. A clear understanding of market trends and challenges allows supply chain professionals to make strategic considerations in the development of appropriate processes.

These areas will be explored further in the next three chapters.

1.4 Summary

Supply chain management and the environment represent two areas that are increasing important to the business community. As environmental concerns become more diverse and demanding, leading corporations may leverage supply chain processes to advance environmental and business goals. A growing body of literature addresses the complex relationship between these two areas, however, there is no theoretical framework that describes generally an approach for developing operational business processes. There is likely no universal prescription. Rather, appropriate supply chain processes will be developed in response to specific environmental pressures, within a framework of corporate strategy, informed by a context of market drivers.

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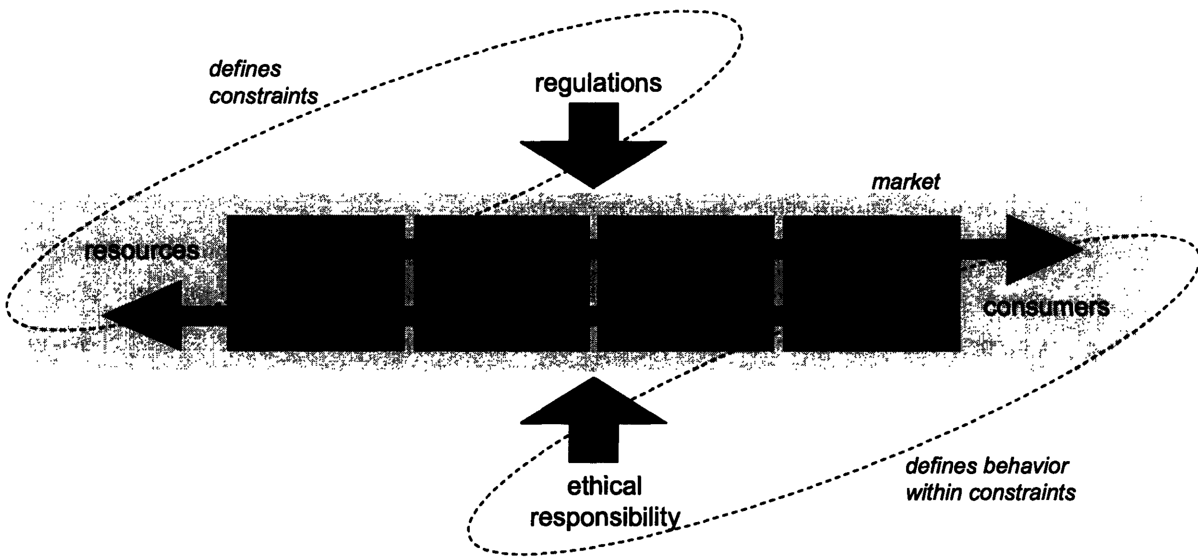
2. Environmental Pressures

Supply chains must respond to four sources of environmental pressures.

Supply chain processes directly and indirectly impact the natural environment. As environmental impacts grow, so do public concerns for protecting the environment and human health. Concerns are most visibly translated into environmental regulations that shape the behavior and economics of industry. However, regulations represent just one source of environmentally-motivated pressure which affects supply chain decision-making. Though significant, this narrow frame of reference may be expanded to include three additional sources: resource availability, ethical responsibility of corporations, and consumer demands for environmentally-advanced products and services. It is critical that corporations understand the specific nature and extent of environmental pressures on the supply chain, in order to respond appropriately with innovative processes that may address environmental concerns while supporting business goals.

Chapter two describes four sources of environmental pressure that affect supply chain management uniquely. In addition to a literature review, the information presented in this chapter was collected from four in-depth interviews with industry representatives. Companies were selected from industries that have been affected by environmental regulations that significantly impact supply chain management. These include: consumer packaged goods, fashion retail, and electronics industries. The companies were also selected because of their involvement with the Supply Chain 2020 research initiative. Each representative was approached and provided a questionnaire in advance involving a series of questions about corporate environmental concerns and activities. Informal transcripts were shared after the interview to allow for clarifying comments.

Figure 2.1: Sources of environmental pressures affecting the supply chain



2.1 Regulations

Governments use a variety of regulatory instruments to address the environmental and health externalities associated with industrial and commercial activities. These instruments include environmental directives, taxes and fees, and liability. All three affect the pricing and availability of products and services, and warrant consideration at the supply chain level. This section will describe the changing nature of environmental regulatory instruments as they may be applied to supply chain management.

2.1.1 Directives

The most commonly recognized examples of environmental regulation come in the form of directives, such as pollution limits, material bans, and fuel-economy standards. Regulatory directives set requirements for industry practices and performance. In the United States, more than a dozen statutes form the primary legal basis for federal environmental regulations, including[1,2]:

- Clean Air Act (1967, 1970, 1977, 1990, 1999) requiring development of National Ambient Air Quality Standards, Hazardous Air Pollution Standards, Motor Vehicle Emissions Standards, Fuel and Fuel Additive Standards, Aircraft Emission Standards, and authorizing provisions for ozone protection

- Clean Water Act (1972, 1988, 1981, 1987) authorizing regulation of wastewater facilities and non-point discharges and provisions for federal funding of municipal sewage treatment systems.
- Resource Conservation and Recovery Act (1976, 1984, 1986) authorizing regulation and banning of the generation, storage, transport, treatment, and disposal of hazardous waste, as well as management of non-hazardous wastes.
- Toxics Substance and Control Act (1976) authorizing regulation and banning of industrial chemicals that pose "unreasonable risk" to human health or the environment.
- Comprehensive Environmental Response, Compensation and Liability Act (1980) allowing federal funding to remediate sites contaminated from prior unregulated disposal.
- Superfund Amendments and Reauthorization Act (1986) authorizing the development of clean-up standards and provisions for increased public participation.
- Emergency Planning & Community Right-To-Know Act (1986) authorizing the EPA to publicly report the release and storage of specified chemicals, and requiring emergency planning at the state level.
- Pollution Prevention Act (1990) allowing provisions for agencies to support "cost effective" changes in production, operation, and raw material use through technical assistance and voluntary partnerships.

Though this list comprises only a few of the more influential statutes from the supply chain perspective, it represents a discernible shift in the federal government's regulatory approach. Stringent "command and control" regulation of industrial point-source releases has given way to agency support for continuous environmental improvement and community risk management. While this shift has moved targets from "end-of-pipe" pollution control to process pollution prevention, current environmental regulations within the United States focus primarily on the *facility*. Facility personnel are responsible for implementing environmental health and safety activities, efficiency measures, and emergency planning. No formal mandate requires that environmental management processes and improvements extend beyond this domain. Further, while facility-focused regulations impact the cost of operations which may very well change the decisions of supply chain managers, they do not require that any factor beyond cost be explicitly considered.

Environmental regulations are increasingly focused on *consumer products*. Products embody the cumulative environmental impacts from production, use, and disposal. Therefore, regulatory directives aimed at improving the environmental attributes of individual products effectively impact industry as a whole. In fact, product-focused regulation is ostensibly *supply chain* regulation, because changes to products drive changes to the design and operation of supply chains. Whereas regulations targeting manufacturing and transport activities at the facility level largely encourage either compliance or relocation of facilities (both of which are reflected in operation costs), regulations at the product level require new business processes both within the facilities that make up the supply chain and between them.

Today, there are at least three categories of regulatory directives that are focused on consumer products:

- *Performance requirements.*

Standards that address the environmental impact of products during their "use" phase are relatively established regulatory instruments, including product fuel economy, energy efficiency, and emissions standards. In the United States, sequential acts for National Energy Policy (1975, 1978, 1992) authorize the Department of Energy to regulate energy (and to a lesser extent) water efficiency in end-use equipment, appliances, and building systems, notably including Corporate Average Fuel Economy (CAFÉ) standards for passenger cars and light trucks. Use of such standards is increasing across the globe. The European Union recently passed the Directive on the "eco-design" of Energy Using Products[3] which will harmonize and advance the already strict energy and water efficiency standards across the EU. It is likely that performance targets, as well as labeling and reporting requirements, will grow more stringent with time. These requirements place significant demands on product designers and also affect architectural, material, and process choices. Although it may appear that a change in product attributes has limited impact on the design and operation of the supply chain, a large body of research suggests that end-product design alterations affect the entire production system.[4] Therefore, product innovation to meet mounting performance standards will affect fundamental supply chain functions – planning, sourcing, manufacturing, and marketing.

- *Material mandates.*

Research increasingly correlates damage to the environment and human health to the use of toxic and hazardous materials. Accordingly, mandates in the United States have moved beyond manufacturing emissions controls to regulate the use of select materials in consumer products. In concept, material mandates are nothing new. The Food and Drug Administration has been regulating the materials of food, drugs, cosmetics, medical devices, and radiation-emitting electronics for over a century, representing a large portion of products that consumers purchase[5]. The Consumer Product Safety Commission sets guidelines for material use in consumer goods such as appliances, toys, clothing, and paint. Past mandates have focused on materials that may directly harm human health due to direct exposure, and include a variety of state and federal-level restrictions on products containing asbestos, lead, and mercury.[6] Today, material mandates are being applied to a broader range of materials, products, and industries with arguably less direct health impacts. For instance, the European Union's Restriction on Hazardous Substances (RoHS) Directive is one of the more aggressive bans of materials in history.[7] The directive specifically targets the electronics industry and requires the phase out of lead, mercury, cadmium, hexavalent chromium and two groups of flame retardants in all products by 2008. This type of material mandate not only challenges the technical capabilities of product designers, but also the organizational capabilities across the electronics industry. Although materials for electronics are often selected far up the supply chain for commodity components, RoHS places responsibility for a complete bill of materials and certification on the final producers, requiring a level of information exchange and data management unprecedented in the electronics industry. Supply chain managers will be called upon to manage data, monitor supplier activity, and provide quality control while coordinating material transitions in existing product lines.

- *Extended producer responsibility legislation.*

In an effort to reduce material waste, conserve resources, and prevent hazardous disposal, several countries have enacted the principle of extended producer responsibility (EPR) within statutory frameworks. EPR directives place financial responsibility for the collection and disposal of products at the end of their useful life on manufacturers, thereby aiming to create incentive to redesign products for reuse and recycling. EPR legislation, also referred to as "take-back," is attractive to policy-makers not only because it is a market-oriented instrument for environmental improvement, but also because it reduces the burden of waste disposal from individual municipalities.[8] While deposit schemes for the recovery of aluminum cans and car batteries represent variations of "take-back" directives, EPR as discussed here has approximately a fifteen-year history beginning with packaging initiatives in Europe. The early efforts of several European countries were formalized in 1994 by the European Union's Packaging and Packaging Waste Directive that stipulates national collection systems and recycling quotas.[9] A variety of public and private systems have developed in response, including Germany's Dual System which collects waste and coordinates recycling at a profit for producers who pay an upfront fee to display the "green dot" logo on their packaging.[10] EPR directives have since targeted more complex products, including automobiles, appliances, and electronics. The more aggressive legislative efforts are coming out of East Asia and Europe, and include Japan's End-of-Life Vehicle

Recycling Initiative (1996) and Home Appliance Recycling Law (2001), and the EU's Directive on End-of-Life Vehicles (2000) and Directive on Waste Electrical and Electronic Equipment (2002). Regulations have also been adopted or proposed in Korea, China, India, Brazil, Venezuela, Chile, and some states within the United States. In order to comply with EPR requirements, companies must design, implement, and possibly operate comprehensive reverse supply chains.[11] Representing no small endeavor, reverse supply chains may involve collection facilities, reverse logistics, partnerships with disassembly and recycling providers, integrated remanufacturing and reuse plans, and marketing initiatives to encourage consumer participation. Altogether, "take back" requires considerable organizational, technical, and financial commitment from industry.

Figure 2.2: Industry snapshot – Texas Instrument

Texas Instrument, Educational and Productivity Solutions

• Lead conversion activities are being managed consistently with competitors. Lead conversion represents a reliability and environmental issue that has been researched for a number of years.

• TI is well positioned to meet the deadline of RoHS, and plans to use Certificates of Compliance for the majority of components in addition to Certificates of Analysis on high risk components

• Decisions regarding environmental activity is primarily compliance driven, but also in response to market demand. The Eco-calculator (TI-30EcoRS) is an example of an environmentally-sensitive product offering.

• Demanufacturing facilities are operated for product returns, but third-party collection and disposal will be contracted to comply with the WEEE Directive.

• TI selects suppliers according to weighted performance criteria that measures reliability, product development expertise, and environmental programs, among other factors.

This discussion of product-focused directives is in no way exhaustive, rather providing a broad overview of present and future regulatory directions. Altogether, several broad conclusions may be drawn:

First, the global nature of today's markets and supply chains complicates regulatory compliance efforts. The broad and sometimes conflicting requirements of various regulatory bodies must be managed effectively, presenting an additional element of complexity to supply chain management. As such, there is considerable incentive to standardize environmental processes across the supply chain when possible. In the past decade, the United States has taken a much different approach to regulating industry than other nations – favoring environmental improvement through voluntary partnerships with corporations over more adversarial and legislative measures.

While this shift may be preferable for supporting a market-oriented environmental response, it is likely that the more stringent regulations coming out of Europe and East Asia will set the standard for performance in all countries for better or worse.

Second, product-focused regulatory directives raise the stakes for industry because they assign chief responsibility for environmental improvement to the most visible players in the production chain – the final manufacturers. A requirement that the product embody certain environmental attributes ensures that some level of improved environmental coordination occurred along the supply chain, regardless of whether or not the product was imported from a country with little to no environmental regulations. While regulations that required facility improvements affect operation costs along the supply chain, product-focused directives change the entire decision framework of the supply chain, influencing cost and adding environmental criteria to fundamental processes in sourcing, manufacturing, operations, distribution, and data management.

Third, the optimal supply chain response to product-focused directives will be difficult to determine in the near future. Not only are global production systems increasingly complex, but such regulatory frameworks are relatively new, still evolving, and seemingly unclear about ultimate environmental goals. For instance, it is unclear whether EPR legislation is intended primarily to minimize waste, reduce the toxic constituents of waste, encourage alternative waste disposal methods, or achieve a combination of these things. Evidence from past governmental initiatives suggests that it is difficult to achieve multiple goals with one policy instrument (Walls, 2003). For this reason, it may be presumed that future regulations will require multiple activities as an integrated response to multiple policy goals.

2.1.2 Taxes and fees

Environmental taxes either "impose a tax cost on a product or activity that is environmentally damaging or they give a tax benefit to some product or activity that is environmentally beneficial."[12] For example, in the United States, the federal government imposes an excise tax on ozone-depleting chemicals and offers a tax credit to people who buy electric vehicles. In this sense, environmental taxes do not replace regulatory directives, but rather help regulate the use of resources by visibly changing the purchase price. Environmental taxes, if applied aggressively and globally, may transform the way supply chains are designed and operated. For instance, suppose the United States levied a substantially higher gasoline tax. Logistics systems might change dramatically in light of escalating transportation costs. This response could either foster regional supply chains and economic development or irreparably damage international markets. Environmental fees create the same affect, increasing the cost of select activities to environmentally-preferable ends. Fees may be applied to landfill, hazardous waste, or raw material extraction, with ramifications that ripple along the supply chain.

While a large body of literature discusses the use of taxation to shape consumer behavior and raise government revenue[13], the direct impact of various taxation schemes on the management of global supply chains is not addressed. Environmental taxes and fees may be effective instruments for environmental progress, though arguably less effective for *supply chain* progress. In changing the visible price of a product or activity, supply chain decision outcomes may be drastically different, but the decision framework and business processes in place will likely stay the same.

2.1.3 Liability

Liability for environmental damage serves as pressure for performance improvements. Under United States tort law and environmental statutes such as the Resource Conservation and Recovery Act, "strict liability places the full burden of environmental costs on the pollution generator, independent of the safety or precaution taken by the defendant."[14] This liability extends along the supply chain, creating situations where organizations may be held liable for environmental damage even when that damage is not a direct consequence of their actions. In the case that larger companies are conducting business with supply chain partners who have limited assets, it is in the best interest of those large companies to put into place technical support systems that assure compliance in the use of their products.[15] In fact, companies that have "relative advantages in certain risk reduction factors should implement these to reduce the liability of the entire supply chain."[16] Risk reduction activities may include training initiatives, product redesign, management of end-of-life products, and service offerings. For example, Greentech Assets, Inc. in Rhode Island offers recycling services specifically targeted at corporations aiming to limit the environmental and privacy risks associated with retired electronics.[17] Ashland Chemical reduced their own liability and that of their customers by offering chemical services rather than sales[18] - on a "turn-key basis, taking on all the responsibilities of providing and disposing chemicals."[19]

In this sense, liability becomes an extremely effective regulatory instrument for several reasons. One, assigning liability to the most influential player creates incentive for the adoption and diffusion of environmental practices. Two, liability also invites pressure for environmental practices from insurance providers who underwrite industrial activities. Third and perhaps most importantly to supply chain processes, liability creates business opportunities to those companies who have invested in environmental literacy and services because they are able to reduce the risks associated with the activities of their customers' and the supply chain as a whole.[20]

2.2 Consumers and Ethical Responsibility

Markets create powerful venues for change since a savvy consumer base continually demands more value from products, services, and the organizations that offer them. In this sense, end consumers drive fundamental characteristics of the supply chain, including environmental performance. This type of pressure for environmental attributes and responsibility creates distinct market opportunities for supply chains that can deliver the "right product at the right time." This section will describe how consumer product demands and the ethical responsibilities of corporations are realized through supply chain level environmental performance.

2.2.1 Quality

Consumers demand quality products. As environmental awareness and expectations increase, so do demands for products with improved environmental qualities, including energy-efficient appliances, organic food and fabrics, recycled paper goods, and non-toxic cleaners. Past studies have shown that pinning down the exact status of environmental consumerism is challenging and subject to debate. Even as "79% of Americans consider themselves environmentalists and 67% state they would be willing to pay 5-10% more for environmentally compatible goods,"[21] actual buying practices have *not* supported opinion polls. Consumers rarely accept environmentally-preferred products with inferior performance, and very few are willing to pay a price premium for environmental attributes.[22] While environmental expectations may be high all around, many companies still view the green consumer as a niche market.

Regardless, the niche market has demonstrated consistent growth in recent years and currently comprises more products with improved environmental attributes than ever before. Sales in select product categories demonstrate this phenomenon:

- *Organic.*

While the conventional food industry is generating a steady 2-3% per year growth, the organic industry has grown at rates between 17-20% annually for the past several years.[23]

- *Energy-efficient.*

Energy Star, a labeling program administered by the United States EPA since 1992 to reward the most energy-efficient products, has expanded to include 11,000 different models within 40 product categories, ranging from washing machines to light bulbs.[24]

- *Non-toxic.*

Natural household cleaners, including laundry and dishwashing detergents, have risen in sales from $140 million in 2000 to $290 million in 2004.[25]

Industrial sales mirror these trends. Purchasing Magazine reported in 2002 that "the most significant factor affecting supply, demand, pricing, and availability of solvents is the environmental issue." While demand for conventional solvents will be essentially flat at 0.2% per year growth, green solvents will post robust gains averaging 5.7% per year through 2005.[26]

The issue of branding adds another element to managing consumer pressures for environmental performance. Research suggests that environmental expectations are higher when products are marketed with a strong brand. Since branding efforts essentially encourage consumers to develop an emotional attachment to a company's image and reputation, consumers in turn expect a relatively higher level of social and environmental performance. In fact, one of the most comprehensive surveys conducted in this area, covering 25,000 individuals in 26 countries, found that "more consumers base their impression of a company on its corporate social responsibility than do on (product) reputation or financial factors."[27]

A positive "reputation is a valuable corporate asset, hard to build, yet easy to diminish."[28] The higher the profile of the brand, the more responsibility that that company must take for environmental activities along its supply chain. Environmental activities, however, represent just one aspect of the broader corporate social responsibility (CSR) agenda which has gained wide appeal in the past fifteen years. Also referred to as corporate citizenship, CSR involves the ethical treatment of employees, resources, the natural environment, communities and nations in which companies operate. Non-profit advocacy organizations have evoked the concept of CSR to raise awareness and build pressure for more ethical corporate behavior. For example, Global Exchange launched an infamous campaign against Nike, Inc. for sub-contracting to "sweatshops" throughout South East Asia that employed children, required long hours, and maintained no environmental health and safety policies.[29] The Silicon Valley Toxics Coalition condemns brand name electronics manufacturers for toxic components and hazardous waste as a result of irresponsible disposal. Their seminal publication, "Exporting Harm: The High Tech Trashing of

Asia," drew public attention to the practice of exporting electronic waste to be processed in parts of Asia.[30]

On the other hand, some companies such as Stoneyfield Farm and Aveda have built a name for themselves on a basis of CSR. The efforts of these companies may drive both consumer demand for environmentally advanced products and competitive pressure for more responsible behavior in general. In a time when marketing, media, and public relations define success for many high profile companies, pressure to project an image of corporate ethical responsibility is very high. While it may be relatively easy to pay tribute to CSR in annual reports, it appears considerably more challenging to implement and enforce practices along the supply chain that yield measurable environmental benefits.

Figure 2.3: Industry snapshot – Limited Brands

Limited Brands, Inc.

- The issues faced by Limited are very different from organizations that are vertically integrated and highly regulated.
- Limited's supply base and operations will be affected by environmental issues, regulations, and energy production in China and developing countries.
- Limited is currently involved in several product stewardship initiatives.
- Environmental initiatives must be balanced with business strategy and support Limited's branding efforts.
- Vendors in China and developing countries that partner with Limited typically maintain internal codes of practices and are audited for environmental performance.

Altogether, consumer demands create serious challenges for supply chain management because while environmental expectations are high and extend beyond final manufacturers to include multi-tiered suppliers, consumers are unwilling to sacrifice product performance or price. Improved environmental performance, whether necessitated by regulatory directives or consumer demand, require product design changes which ultimately affect supply chain functions in planning, sourcing, manufacturing, and marketing. In the case of directives, often regulatory agencies provide technical assistance and facilitate compliance activities to a degree. However, the onus of meeting consumer pressures for environmental improvement in a time of greater corporate ethical responsibility is on those who sell the products.

2.2.2 Cost

Consumers also demand competitively-priced products. In order to offer the "right price" and maintain profitability, production system costs must be carefully balanced with performance along the supply chain.

Ample anecdotal and empirical evidence suggests that environmental waste equals financial waste in production systems.[31] High utilities, fuel costs, and waste disposal fees provide incentive for the adoption of environmental management systems that streamline production and yield greater efficiencies along the supply chain. An oft-cited paper by Michael Porter and Claas van der Linde published in 1995 presents basic reasoning for environmental improvements as investments that yield both product and process benefits and possibly create major competitive advantages in innovation and operations.[32] These mechanisms for efficiency include:

- *Process.*
  - substitution, reuse, or recycling of production inputs;
  - less downtime through more careful monitoring and maintenance;
  - better utilization of by-products by conversion of waste into valuable forms;
  - lower energy consumption during the production process;
  - reduced material storage and handling costs;
  - savings from safer workplace conditions; and
  - elimination or reduction of the cost of activities involved in discharges or waste disposal
- *Product.*
  - higher quality, more consistent, safer products;
  - lower product costs;
  - lower packaging costs;
  - lower net costs of product disposal to customers; and
  - higher product resale and scrap value

This concept of keeping operation costs low through environmental improvements has been plugged by business environmentalists for years as the illustrious "win-win" situation. As such, there are abundant anecdotal case studies that endorse the use of environmental management systems and processes both within individual facilities and as collaborative efforts between supply chain partners.[33] In a document published in 2000, the EPA reported that[34]:

- GM reduced disposal costs by $12 million between 1987 and 1997 by establishing a reusable container program with its suppliers. Additionally, reusable containers can reduced solid waste, product damage during shipping, and worker safety problems that come with slicing open boxes.

- Andersen Corporation developed a composite material from wood wastes generated during its manufacturing process. This innovation yielded internal rates of return exceeding 50% and enabled Andersen to decrease solid lumber purchases by 750,000 board-feet.
- Public Service Electric and Gas Company saved more than $2 million in 1997 in storage and product disposal fees by requiring maintenance and operating material suppliers to adhere to stringent return policies. These costs had previously been hidden in overhead accounts.

Examples like these may be found in many publications, old and new, along with a wide range of process tools for organizations to identify and implement tailored environmental strategies. Notably, a tool called GreenSCOR[35] has been developed to merge environmental management with supply chain management in order to integrate environmental considerations into the entire supply chain process. An offshoot of the Supply Chain Council's original Supply Chain Operation Reference model (SCOR), benefits to GreenSCOR include the ability to reduce environmental impacts and related costs system-wide while supporting traditional supply chain objectives. The approach also raises the visibility of the financial and operational benefits of environmental supply chain practices.

While the desire to keep operating costs low is good reason to pursue environmental performance improvements along the supply chain, this desire does not represent a unique *environmental pressure* within this framework. It is perhaps more accurate to group the "win-win" situations described here as either 1) operational improvements motivated by economic pressures that happen to demonstrate environmental benefits, or 2) environmental improvements motivated by regulatory, consumer, or ethical responsibility pressures that happen to yield cost-savings. In the future, environmental pressures will require significant and pervasive changes in supply chain design and operations, changes that will not likely be motivated by incremental cost-savings.

Figure 2.4: Industry snapshot – Interbrew

InBev! / Interbrew

- Interbrew's supply chain is influenced on an implementation level, rather than strategic level, by environmental legislation and corporate responsibility activities.
- Interbrew's supply chain is well poised to react to new regulation because of a diverse supply base and local presence.
- Suppliers agree to Interbrew's corporate responsibility statement.
- Environmental metrics are collected and shared with facility managers to provide benchmarks for environmental performance.
- In the future, supply chain professionals are going to need more diverse skills including an understanding of environmental and social concerns and how they relate to delivering products to customers.

2.4 Resources

Escalating global population and affluence create demand for more and more products. The corresponding rates of production inevitably place strains on the natural environment's ability to supply resources and absorb wastes. Traditional supply chains "are based on a linear production paradigm which relies on constant input of virgin natural resources and unlimited environmental capacity for assimilation of wastes and emissions."[36] Despite considerable progress in resource conservation and process efficiency measures, this paradigm is still pervasive. The secure supply of critical feed-stocks will remain a supply chain challenge into the future.

An examination of the global supply and demand for fish illustrates this point well. The World Resource Institute reports that consumption of fish and fishing products has doubled in the past thirty years and has increased five-fold since 1950.[37] "Fish supply has become one of the major natural resource concerns, as seventy-five percent of commercially important marine and most inland water fish stocks are either currently being over-fished, or are being fished at their biological limit."[38] This situation bodes poorly for those in the fish business, including global corporations such as Unilever that sells fish and uses fish products as raw materials. Unilever is one of the world's leading suppliers of food, home care, and personal care consumer goods. In the mid-1990s, Unilever launched a comprehensive effort to secure a sustainable supply of fish. First, they provided seed money to the World Wildlife Foundation to research the situation and establish the Marine Stewardship Council as an independent organization to certify sustainable fish supplies. Then, they initiated discussion with competitors and national regulatory bodies in support of the Council's standards. Finally, Unilever publicly endorsed the work of the Stewardship Council and committed to purchasing only certified fish.[39]

The availability of energy and water resources for manufacturing also presents a challenge to supply chain management. Water shortages are increasing world-wide as demand for drinking and irrigation grows. The United Nations Environmental Program reports that one third of the world's population lives in countries where consumption exceeds 10% of total supply and more than 2.7 billion people will face severe water shortages by the year 2025.[40] Supply chain managers must consider resource constraints when locating facilities and planning operations, since energy and water shortages may dramatically affect business. For example, both Pepsi and Coca-Cola lost their license to use local groundwater at bottling plants in Kerala, India following a local drought.[41]

While it may be easy to take for granted the availability of natural resources to support industrial activities, resource constraints represent a systemic environmental pressure. The most successful companies will recognize natural limitations, in time to plan for conservation, substitution, or production of their own feed-stocks. Such a response will require a broader perspective on the role of companies in providing goods, services, as well as stewardship of the resources that enable economic success.

Figure 2.5: Industry snapshot - Unilever

Unilever

- Unilever's core environmental activities relate to sustainable fisheries, agriculture, and water conservation.
- Environmental costs represent a relatively small part of overall lifecycle costs, and less than 10% of manufacturing costs. Many cost saving activities translate to environmental savings and vice versa.
- Suppliers are managed with regard to environmental risk and performance under a code of business principles.
- It is critical to express a particular set of values at the corporate level, environmental or otherwise, in order to operate outside a cost-driven framework.
- It is important to identify the best areas in which to be proactive. This decision often comes down to sustainable *business* decisions.

2.5 Summary

Altogether, supply chains must respond to environmental pressures from four sources. Resource availability and regulatory pressures place physical, legal, and economic constraints on supply chain management, while consumer demands and the ethical responsibilities of corporations define desirable behavior in the market and within those constraints. As supply chains mature and environmental pressures increase, technical and organizational innovation to support supply chain processes developed in response to specific pressures.

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3. Supply Chain Environmental Excellence

An excellent supply chain response to environmental pressures involves a distinct operating model, objective, and processes.

In order to characterize how industry may best respond to environmental pressures through their supply chains, it is important to understand the role supply chain management plays in supporting business strategy. Given that "ample evidence exists to support the premise that supply chain management processes have a significant impact on the operational and financial performance of companies," it is appropriate to ask what constitutes a supply chain that successfully brings value to a company.[1] In a working paper that forms the basis for the Supply Chain 2020 research initiative at Massachusetts Institute of Technology, a four statement hypothesis defining an "excellent supply chain" is proposed. "An excellent supply chain:

- enhances and is an integral part of a corporation's business strategy;
- leverages a distinctive operating model to gain competitive advantage;
- executes well against a balanced set of operational objectives or metrics; and
- focuses on a small number of best business processes that are aligned with objectives."

Chapter three further examines this hypothesis with respect to environmental excellence. It introduces a number of processes within each basic function of supply chain management that improve environmental performance and concludes with a discussion of how corporations may begin to develop processes within a context of environmental pressures and market drivers. The supporting content for this chapter was drawn primary from environmental management literature.

3.1 Integral part of strategy

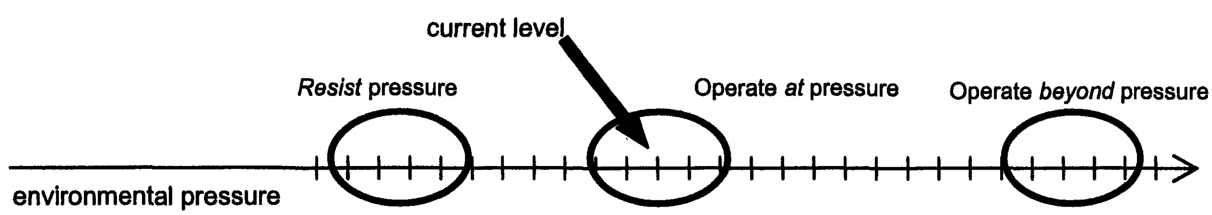
First, if an excellent supply chain is considered an integral part of a corporation's business strategy, then it should also be integral to a corporation's environmental strategy. Supply chains operationalize the existing linear cycles of industrial production, and represent the cumulative environmental impacts of a product from extraction to final delivery. It is reasonable to believe that if a company has an environmental strategy, then that strategy would be implemented through activities at the supply chain level. Many companies have exhibited a commitment to the natural environment through corporate responsibility statements in marketing publications and on the internet. One may evaluate whether or not these companies' supply chains are enhancing or undermining their stated environmental positions.

3.2 Distinct operating model

Second, an excellent supply chain should leverage a distinctive operating model to gain competitive advantage. An operating model defines an organization's overall strategy for business, and may be reduced commonly to simple statements like "to offer the lowest priced products" or "to provide the largest selection of products." Supply chains either support the designated operating model, effectively coordinating supply channels and production activities, or they do not.

A supply chain may also leverage a distinctive operating model with respect to environmental pressures. Although environmental activities are typically regarded as ancillary to business operations, under ideal circumstances, these activities are aligned with and augment the core operating model. Regardless of whether or not this alignment exists, as environmental pressures increase and require action at the supply chain level, a company must choose 1) to operate beyond environmental pressures, 2) to operate at environmental pressures, or 3) to resist environmental pressures.

Figure 3.1: Environmental operating models



This categorization of environmental operating models is not a new concept. Several researchers have described various corporate environmental orientations in a similar way. R. Kopicki presents three approaches in environmental management: the reactive, proactive, or value-seeking.[2,3] Steve Walton offers a comparable model in characterizing the purpose of environmental activity as either "comply with the letter of the law," "clean up," or "be proactive."[4] Robert Klassen describes the continuum of behavior from reactive to proactive orientations in several publications.[5] Ad de Ron designates environmental strategy as following, market-oriented, or sustainability-oriented.[6] Finally, Paul Murphy introduced a survey tool that classifies companies across industries as environmental progressives, moderates, or conservatives.[7] It is important to note, however, that these categorizations of corporate environmental orientation focus primarily on behavior *within the facility,* as opposed to articulating a product-focused supply chain response. Also, they do not explicitly identify the different sources of environmental pressure - regulations, consumers, and resources – in recognition of the fact that it may be advantageous to operate *beyond* pressure for one and *at* pressure for others. Despite this more limited view and slight difference in descriptive terms, it is generally agreed that environmental and core business activities are best when mutually supportive. Accordingly, an excellent supply chain should leverage a distinct operating model that is *informed by environmental pressures* to gain competitive advantage.

3.3 Balanced operational objectives

Third, an excellent supply chain executes well against a balanced set of operational objectives or metrics. Classic supply chain objectives are described by the Supply Chain Council to include reliability, responsiveness, flexibility, cost, and asset utilization.[8] A "balanced set" may include only one or two of these operational objectives depending on the designated operating model. For instance, a corporation may focus on supply chain efficiency and may employ metrics such as line-items-picked-per-hour or cash-to-cash-cycle-time to indicate performance. With regard to the environment, operational objectives may be developed for each environmental *operating model* in response to each type of environmental *pressure* as follows:

Figure 3.2: Environmental operational objectives

environmental operating models	environmental pressures: *Resources*	*Regulations*	*Markets*
Operate beyond pressure	Substitute Expand	Obviate the need for Exceed	Drive Create
Operate at pressure	Conserve Secure	Comply	Meet Satisfy
Resist pressure	-	Breach Relocate	Exit Ignore

Suppose a corporation elects to operate *at* regulatory pressure. This corporation's operating objective, therefore, is to comply with all regulatory directives that affect its activities with the least disruption to other business processes. Metrics such as number-of-non-compliance-incidents, or fines-for-non-compliance may be selected to indicate direct environmental performance. Metrics such as cost-to-compliance and time-to-compliance may be used to indicate efficiency and environmental performance. A large body of research discusses the application of metrics to indicate direct environmental performance, such as energy use or total waste generated.[9] An interesting extension of this research involves the development of metrics to indicate environmental performance of an entire supply chain.[10]

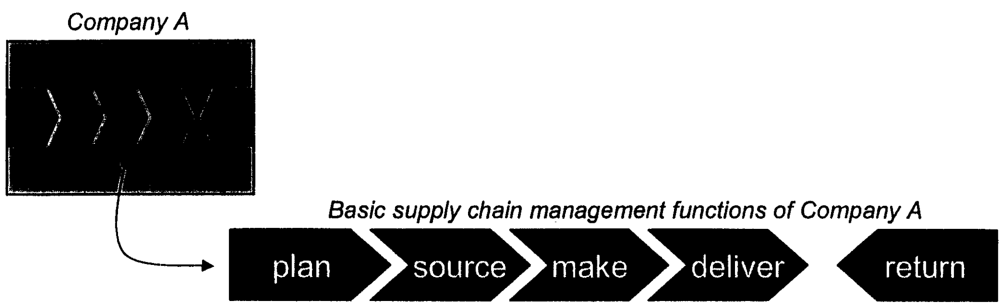
Figure 3.2 presents a useful framework for examining industry environmental activity at large. Proponents of corporate environmental initiatives may argue that a proactive orientation "operating beyond environmental pressures" is the best way to protect the natural environment and sustain long-term value and profitability. However this framework suggests that environmentally-aware supply chain excellence may be achieved within *each* operating model. In this sense, excellence may perhaps rely on three conditions: 1) environmental pressure is effectively signaled to the company, 2) there is sufficient time to respond to the pressure, and 3) the company has adequate management and technological capability to implement a response at the supply chain level. A company that is reactive, flexible, and efficient in execution may operate extremely well *at* environmental pressure, while a company that is proactive, innovative, and differentiated from competition may best place themselves beyond pressure. The operating model decision may be further determined by market conditions and product attributes.

3.4 Best business processes

Fourth, an excellent supply chain focuses on a small number of best business processes that are aligned with operational objectives. While comprehensive supply chain management may require hundreds of processes to be performed in a structured manner, the greatest operational and financial benefits result from concentrated efforts on a relatively small number of unique business processes. The same may be said about environmental benefits: an excellent supply chain with respect to environmental performance focuses on a small number of processes that are aligned with environmental operating objectives.

During the past decade, best business processes have typically included cross-functional processes, extended or inter-enterprise processes, the use of formal optimized decision-making, the use of stochastic decision-making, and the use of risk management.[11] Interestingly, the vast body of environmental management literature echoes these themes, encouraging many of the same approaches in developing processes to improve environmental performance. Accordingly, concepts proposed by environmental management literature may be understood and effectively applied to the context of supply chain management.

Figure 3.3: Basic supply chain management functions



Consider environmental processes arranged by the most basic functions of supply chain management as defined by the SCOR model:

3.1.1 Plan

The chief variables that influence the environmental performance of a product or system are determined during the planning phase. A number of processes may be used to aid environmental decision-making while planning the supply chain.

- *Environmental cost accounting.*[12]

Environmental cost accounting is a technique to identify and assign discrete costs to environmentally harmful activities within a broader system. The term "cost" as used implies two meanings. The first is the monetary cost that an individual company might incur from a specific activity, such as the fees associated with hazardous waste disposal. The second is the cost of damage to human health or the natural environment that may be directly attributed to a corporate activity. Companies motivated to reduce operating costs or to demonstrate an environmental commitment use environmentally accounting techniques to capture environmental costs not typically captured through conventional accounting methods. The US EPA commissioned a comprehensive study of the use of environmental accounting in hospital purchasing and waste management in the year 2000, which serves as an excellent reference about accounting techniques.[13]

- *Environmental life cycle analysis.*

Environmental life cycle analysis is a method used to identify and evaluate the environmental impacts associated with a product or service throughout its entire life from material extraction to eventual disposal and assimilation into the environment. As opposed to environmental cost accounting, life cycle analysis implies non-monetary environmental assessment and is used as a product or system design tool. A number of life cycle analysis methodology books and software programs are available,[14] although not specifically geared to supply chain managers.

- *Design for environment*

Design for environment is an approach to reduce the environmental impacts of a product by introducing specific design criteria during the product development phase, such as "design for recyclability" or "design for energy efficiency." Once the environmental impacts of a particular product characteristic or life-cycle phase are identified through a formal or informal analysis, design for environment may be used as an organizing design principle to ameliorate those impacts. Many industries have successfully implemented a design for environment approach in product development. For instance, appliances that have been awarded Energy Star rating by the US EPA are designed to meet specific energy efficiency criteria,[15] and Kodak "Fun Saver" one-use-cameras are designed to be disassembled and remanufactured into new cameras.[16]

3.1.2 Source

Sourcing professionals may consider the environmental attributes of materials, components, and products, as well as the environmental performance of the suppliers' direct activities using the following processes.

- *Environmental auditing.*

Environmental auditing is a procedure to verify the environmental performance of a material, component, product, or facility. Auditing may be conducted by a third-party organization or the buyer in accordance with previously established environmental guidelines. Many multi-national companies, including Limited Brands, Inc., Texas Instruments, and General Motors have designated standards and routinely audit suppliers for environmental performance.[17] Internal auditing is also widely promoted as part of the ISO 14000[18] environmental management standards.

- *Environmental certification.*

Environmental certification is a guarantee that a product or facility meets environmental standards defined by a third party. Certification typically involves product labeling for consumer marketing in response to regulatory pressures or consumer demands for products with improved environmental attributes. Examples of prevalent certification programs include Green Seal[19], Germany's Blue Angel[20], Certified Organic,[21] and the building industry's Leadership in Energy and Environmental Design certification[22]. Companies may undergo environmental certification for their own products or seek to purchase certified products.

3.1.3 Make

As discussed earlier, the manufacturing response to facility-focused regulatory directives has evolved from end-of-pipe pollution control to the implementation of environmental management systems. It may be expected that this evolution will continue domestically and extend to facilities in regions with weaker regulatory regimes, involving the following processes:

- *Pollution prevention.*

Pollution prevention is an approach to preemptively identify and alter activities that create waste. Prevention techniques including substitution, product modification, improved maintenance, and recycling have been successfully applied at several facilities following the Pollution Prevention Act of 1990 and several state-level regulatory directives. The Journal for Cleaner Production[23] and the Pollution Prevention Resource Exchange[24] serve as excellent references on this topic.

- *Environmental management systems.*

Environmental management systems are sets of processes that enable an organization to identify, monitor, and address the environmental impacts of its activities. Systems typically include guidance for employees in environmental health and safety procedures and facilitation tools for continual improvement of environmental performance. While developing an environmental management system does not guarantee better environmental performance, it generally helps companies comply with regulations and manage risk more consistently and effectively. While ISO 14000 serves as the international standard for environmental management, the US EPA also provides several good references to develop a system independently.[25]

3.1.4 Deliver

The environmental implications from transportation are growing, as materials, components, and finished products travel longer distances through production and distribution cycles. The total impact of delivery functions correlates to two variables that logistics professionals manage directly: transportation distance and mode.

- *"Green" logistics.*

Green logistics is an approach that considers the environmental impacts of procurement, transport, inventory control, and distribution activities along with other considerations in order to minimize environmental costs. For example, in addition to considering monetary cost, time, and reliability of freight service, one may also consider the volume carbon dioxide emissions. There are several interesting studies that compare the environmental impacts of various product distribution systems, including online retail models.[26]

3.1.5 Return

Return processes are gaining in strategic importance as companies compete further to better serve customers, recover assets, minimize liability, and meet extended producer responsibility regulatory requirements.

- *Reverse logistics.*

Reverse logistics is a set of activities to collect, transport, and manage products and materials after sale and delivery to the customer. Reverse logistics has been typically used to facilitate unsold product and warrantee returns, and it is being further developed to address "take back" regulatory obligations and to pioneer concepts of closed-loop supply chains. This subject represents an important area of emerging research within supply chain management.[27]

- *Remanufacturing.*

Remanufacturing is a process to clean, repair, and restore used durable products to good condition for resale. Remanufacturing is typically integrated with reverse logistics processes because valuable products and components must be appropriately transferred from the consumer to the manufacturer. In addition to logistical challenges, remanufacturing involves serious technical, planning, and inventory management challenges, areas which are increasingly explored in practice and research literature.[28]

- *Recycling*

Recycling is a procedure to reuse materials, which may otherwise be considered waste, in a form other than primary use. Recycling is facilitated by return processes in part because existence of a secondary market depends on the quality of recycled materials. Whether recycling recovered materials or using purchased recycled content in production, processes require additional planning due to fluctuations in material timing and availability.

This list is by no means exhaustive or prescriptive. Rather, it provides an overview of the many business processes that could yield significant environmental improvements while being conscious of the impact on corporate strategy. While comprehensive supply chain management may require hundreds of processes to be performed in a structured manner, the greatest operational and financial benefits may result from concentrated efforts on a relatively small number of business processes. Although many would argue that true environmental excellence is a product of the holistic integration of many processes, the previous statement likely holds true for environmental performance as well. Concentrated efforts on even one of the processes described above may yield significant environmental benefits for the company. The focused innovation applied on one process may also yield environmental benefits and behaviors that ripple through the supply chain.

3.5 Summary

Environmental pressures add a new element of complexity to supply chain management, requiring a comprehensive response involving environmental operating models, operational objectives, and new supply chain processes. In order to develop processes that both advance environmental goals and support corporate strategy, a framework for supply chain environmental excellence should be used. This framework allows corporations to use environmental activities to position themselves strategically and consider how best to develop supply chain processes that may confer competitive advantage.

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4. Reverse Supply Chain and the Environment

Processes must be developed within a context.

While comprehensive supply chain management requires hundreds of processes to be performed in a structured manner, the greatest operational, financial, and environmental benefits may result from concentrated efforts on a relatively small number of unique business processes. In order to confer competitive advantage, companies should focus on developing processes within areas of core competencies and within the context of environmental pressures and market drivers. For example, return processes serve as the functional building blocks of reverse supply chains, which many consider to be the "final frontiers of supply chain management."[1] Distinct return processes may be leveraged by companies to better serve customers, recover valuable material assets, minimize liability, and meet evolving environmental requirements. However, these processes will contribute to both corporate profitability and environmental protection only when managed appropriately for the context within which a firm operates.

This chapter explores the importance of *context* by examining the emergence of reverse supply chains in direct response to environmental pressures within the electronics industry. The chapter is organized into two sections. The first section introduces various types and operational dimensions of reverse supply chains. The second section focuses on the electronics industry. It describes the unique environmental pressure posed by evolving "take-back" laws in Europe and the United States, which require that manufacturers assume responsibility for products at the end of their useful lives for recycling and disposal. It compares the activities of leading electronics companies, and outlines the trends, challenges, and strategic considerations that define the industry response. In this case, processes are shaped by a broad context of regulatory, behavioral, and economic market drivers.

As noted in the corresponding citations, the information presented in this chapter was collected from research literature and direct semi-structured interviews with representatives from eight global consumer electronics companies. The companies include Hewlett Packard, Motorola, Dell, Philips, and leading television and computer equipment manufacturers. These companies were selected because of their involvement with the MIT Supply Chain 2020 research initiative and participation in national electronics meetings hosted by the US Environmental Protection Agency in order to examine the emerging issues of end-of-life electronics. Each representative was provided with a questionnaire in advance involving a series of questions about reverse supply chain processes and motivations. This questionnaire is shown in Appendix B. Specifically, company representatives were asked questions about:

- System financing
- Collection mechanisms and incentives
- Transportation
- Partnerships
- Management structures

As electronics end-of-life issues are currently managed by individuals with various professional backgrounds and scopes of work, the interviews were conducted in a semi-structured manner to focus on each representative's primary area of knowledge. Informal transcripts were shared after the interview to allow for clarifying comments.

4.1 Understanding reverse supply chains

The Reverse Logistics Executive Council defines reverse supply chain management as "planning, implementing, and controlling the efficient, cost effective flow of raw materials, inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal."[2] Building on this definition, reverse supply chain management is an integrative approach to recovering a product from a consumer for resale, reuse, recycling, or disposal.

4.1.1 Reverse supply chain and the environment

Reverse supply chains are heralded by environmentalists as key elements of sustainable production. In changing the end-point of a company's supply chain from the consumer to the product's end-of-life or to possibly even the start of a new production cycle, reverse supply chains present opportunity to extend the use of products, conserve resources, prevent waste, and create secondary markets and jobs in remanufacturing and recycling. For instance, reverse supply chains facilitate the collection and recycling of aluminum cans, steel, newspaper, plastics, and glass – all of which provide material feed-stocks that are produced at 40-95% less energy than those produced from raw materials and provide approximately 1.1 million jobs in the United States.[3] Reverse supply chains support the sales of remanufactured products such as re-treaded tires, which require 70% less oil for production and cost 30-70% less money.[4] Beyond this, reverse supply chains of the future may operationalize entirely closed-loop industrial cycles, a notion popularized by industrial ecology research literature[5] and popular books such as William McDonough and Michael Braungart's *Cradle to cradle: remaking the way we make things*.[6] The design and operation of reverse supply chains clearly suggests many environmental benefits. However, to frame the development of reverse supply chains as motivated strictly by environment pressures, detracts from the broad implications of reverse processes and the compelling business case for further development of supporting capabilities.

4.1.2 Types of reverse supply chains

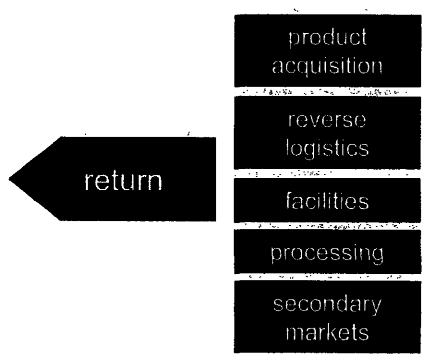
In a 2001 study evaluating reverse supply chain activity in the United States, researchers found that reverse supply chains are an "important and often strategic part of the business mission with an increasingly large bottom-line impact." This statement is particularly accurate when considering that companies must accommodate up to four types of product returns supported by markedly different reverse supply chains:[7]

- *Commercial returns* are products that are linked to the sales process. In the United States, the value of commercial returns is estimated at $100 billion annually.[8] In fact, products returned directly from the consumer have increased in volume up to 25% of turnover in some industries because of the growth of online and catalog sales. Also included in this group are overstock products, recalled products, and products that are returned because they are broken and under warranty. Commercial returns have various handling mechanisms depending on the industry and product. The trend in retail is certainly to allow more and more returns as a guarantee of product quality and enhanced customer service.
- *End-of-use returns* include products taken back after some period of operations due to the end of the lease, trade-in, or product replacement. Common examples of these types of returns include leased automobiles, carpets, computers, and copy machines. Products with significant end-of-use returns are generally characterized by high economic value. These products are less expensive to refurbish than replace and resale to secondary markets typically creates additional profit for the company's original investment.
- *Packaging returns* include a broad range of reusable items that are not part of the consumable product itself. Such returns include products that are related to the consumption, use, or distribution of the main product, including containers and pallets, refillable cartridges, and bottles. There are several motivations to collect packaging returns. In some cases, manufacturers are motivated to recover and reuse packaging in order to save on disposal fees or the manufacture of new packaging. In other cases, consumers are motivated by a deposit scheme to return packaging to a redemption center which is supported by a secondary market. State bottle bills placing deposits on aluminum cans are good examples of how to create consumer motivation.
- *End-of-life returns* include products with high material value such as automobiles and appliances, or those taken back from the market at the end of useful life because of some sort of negative environmental externality. The latter situation is typically driven by regulatory directives, including products such as car batteries, X-ray film, and a wide-range of electronic products that are being collected under extended producer responsibility legislation.

4.1.3 Reverse processes

Each type of return requires a unique reverse supply chain with as many considerations as the forward supply chain. In fact, reverse supply chains require not just one, but a number of functional processes that are developed specifically to accommodate returns. These processes are complex, costly, and should be aligned with overall corporate strategy, operating model, and operational objectives. Altogether, the design and operation of the reverse supply chain is considered to be more challenging than the forward supply chain because of the wider range of products, variable conditions, and networks of users.[9,10] Moreover, current legislation is causing the scope of reverse supply chain management to increase. For instance, the WEEE Directive in Europe is requiring that almost *all* electronic products be returned to the manufacturer – a situation that may require careful process controls to effectively address the inherent range of products, variable conditions, and networks of users.

Figure 4.1: Return processes



The design and operation of reverse supply chains of all types involve the following processes:

- *Product acquisition*

Product acquisition poses the most critical questions in designing the reverse supply chain: Which products to collect? Where to collect them from? When can they be collected? Considered the "foundation for operational planning and control activities,"[11] product acquisition varies according to product, market, and type of reverse supply chain. There are a number of different ways that product may be acquired from the consumer. A familiar venue such as customer service desk may be most appropriate for commercial returns, while a municipality waste location or redemption center may best accommodate end-of-life returns. In the case of commercial returns and end-of-use returns, literature suggests that information technology, including RFID and sensors, is beneficial for controlling the quality and rate of product returns.[12] In fact, the more uncertainty is eliminated in the return process, the more a company can plan and implement efficient strategies. Van Nuunen cites companies such as Oce, Bosch, and Heineken as leaders in using technology to eliminate uncertainty and control the return process to the firm's benefit. Product acquisition also defines who the players in the reverse supply chain may be, including third party logistics providers, retailers, municipalities, or even recycling partners.

- *Reverse logistics*

Reverse logistics is frequently used synonymously with reverse supply chain, but here the term encompasses the transportation, handling, and facility location processes of reverse supply chain management. Reverse logistics may be highly complex and costly. A study in 2000 estimated that reverse logistics for commercial returns accounts for approximately 4% of total logistics costs. Logistics costs account for approximately 9.9% of the United States economy, so applied to the GDP, reverse logistics costs for commercial returns amounted to approximately $37 billion in 1999.[13] The natural inclination to combine forward and reverse logistics systems may seem "appealing, but forward distribution rarely fits reverse logistics needs."[14] This is because forward distribution is designed to handle large volumes of the same product from the manufacturer to customer locations. Return processes typically yield various products, at numerous locations, and often in low volumes. Final destinations are rarely the original manufacturing site.[15] Moreover, depending on the nature of the returns, handling may be more complicated. Products will likely be in odd-shaped packaging, if packaged at all. In this sense, they are more "fragile" and need to be carefully handled. There may be limitations on who is able or licensed to handle them. In the case of end-of-life returns, regulatory restriction may require special licensing for various classes of waste. Facilities may be similarly restricted, and there may not be local destinations for some products. Other products may need to travel long distances to a central processing facilities.

- *Facilities*

Facility processes require another level of consideration and management. Is it worth operating your own facilities or does it make sense to partner or outsource? Should the facility be co-located with retailers or manufacturing facilities? A 2004 study evaluated a variety of collection scenarios for end-of-life electronic products, including a "hypothetical single, large drop-off facility placed in the center of the service area to a highly distributed set of micro-collection facilities co-located at existing retailers, charities, and municipal facilities."[16] Results demonstrated that multiple, convenient collection options faired well because they minimized consumer waiting time and carbon dioxide emissions from gasoline consumption. Beyond the citing of the facility, decisions about inspection and sorting activities will be shaped by the final destination of returned products. What sort of labor or technology is best to separate products and materials for different purposes? Will these products and materials be distributed for further processing?

- *Processing*

Processing involves various levels of remanufacturing, refurbishment, repackaging, or separating the most valuable components and materials for resale or recycle. Processing decisions for returned products may depend on a number of external factors. Is there a secondary market for reconditioned products? Do reconditioned products, components, or materials create the most revenue? What technology is needed to process returned products? Thierry et al describe the benefits and challenges of "several types of processes or operations that characterize product recovery, such as refurbishing, re-use, and cannibalization."[17] Gungor and Gupta propose a categorization of these processes into two main groups of product recovery practice: recycling and remanufacturing. Recycling returns materials to a commodity state, where their identity is lost, and involves operations that might include collecting, sorting, processing, decontaminating, and disassembly of the materials. In contrast, remanufacturing preserves the basic identity of the original product, bringing back its functionality to an acceptable level of quality or performance.[18]

- *Secondary markets*

Secondary markets largely define what is economically feasible for the reverse supply chain. The sale of a reconditioned product, component, or material may or may not finance the other return processes. High-quality recycled materials may be profitably processed and sold as a commodity in existing markets. Reconditioned products such as automobiles and mobile phones may also be sold to meet the demands of consumers who may not be able to afford newly manufactured products. Currently, 70% of recovered mobile phones are reconditioned and resold to secondary markets in Africa, Latin America, India, China, and the United States.[19] While the absence of a robust secondary market removes incentive to develop reverse supply chain processes, innovative planning and marketing approaches could potentially create demand. Further, it is interesting to consider how volume affects the viability of secondary markets.

- *Organizational considerations*

Organizational considerations include strategy development, management structure, learning, and performance metrics. Initially, companies must decide to what extent return processes are going to enhance or support overall strategy. Will managing returned products involve dedicated staff and objectives? Is it a side activity? Who should manage reverse supply chain processes? Structured learning about the products that are being returned may not only improve the return processes, but may inform the design, marketing, and distribution of new products. Consideration must also be given to performance metrics applied to return processes and reverse supply chain managers. Performance may be tied to cost of returns, time for processing, or volumes of waste. A set of environmental metrics may be applied very appropriately here.

Collectively, the processes of reverse supply chain management involve many challenges and demand technical and organizational innovation to design and operate. These processes present clear opportunity for leading companies to gain competitive advantage in the return function.

4.1.4 Operating objectives

As described earlier, the operating objective of reverse supply chains should be in line with the overall operating model and objectives of the business. This statement is complicated by the fact that a single company may manage several reverse supply chains to accommodate several types of returns. Nonetheless, if reverse supply chain processes do not support the overall operating objectives of the organization, then they will not create value. For example, consider a company whose operating model is simply "to offer the lowest priced products". In such a case, the reverse supply chains should be designed for cost minimization. The proper approach to minimizing costs depends entirely on the type of product and the type of return. With commercial returns, a central facility and standard operating procedure may minimize costs for one line of products, while a decentralized approach for quick turn around of time-sensitive products may minimize costs for others.[20] With end-of-life returns, a third-party service provider may be able to manage returns at a far lower cost than internal processes. In all cases, realizing return services at lowest cost supports the overall operating objectives of the organization, and, thereby, creates value.

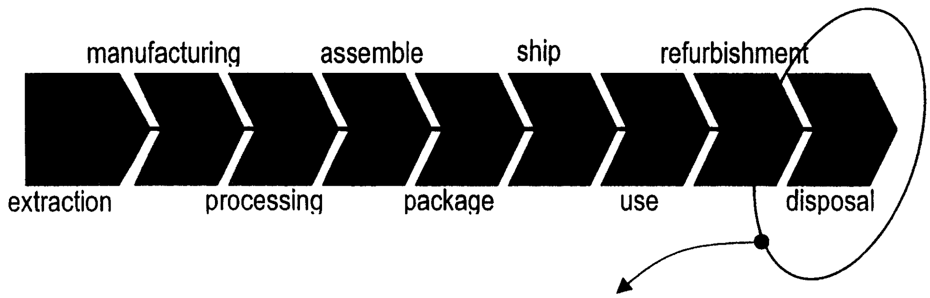
4.2 Reverse supply chain response to environmental pressures

Companies that successfully manage reverse supply chains may benefit not only from increased profitability and customer value, but also from increased capacity to respond to environmental pressures as they evolve. The following section describes the reverse supply chain response to environmental pressures within the electronics industry. Though parallel developments have occurred in other industries, including packaging, construction, and automobiles, electronics offers a dynamic and timely case study. The industry is characterized by competition and rapid change, and has benefited broadly from supply chain management innovation.

4.2.1 Attention to end-of-life

As described in Chapter 2, there are four sources of environmental pressures that affect the supply chain, including consumers, resources, ethical responsibility, and regulations. The electronics industry, which is among the largest manufacturing industries in the United States, is generally regarded as relatively clean.[21] Nonetheless, because of "the growing importance of the industry to national economic competitiveness and the increasing recognition that many processes used to produce electronic systems do have environmental consequences,"[22] the industry has proactively addressed a number of environmental issues. In fact, leading companies have set the standard for other industries in launching extensive environmental programs which address issues across the product life-cycle.[23] These issues include workplace health and safety, material selection, pollution prevention, and perhaps most prominently, product end-of-life. The intent in this chapter is to explore the processes under development to address product end-of-life because of the obvious and direct supply chain management implications.

Figure 4.2: Product life cycles



Product end-of-life phase impacts the environment.

4.2.2 Concern about end-of-life

Many environmental, trade, and government organizations have published notable reports detailing the fate and environmental impact of electronics at the end of their useful lives. These include reports by the Basel Action Network,[24] the Silicon Valley Toxics Coalition,[25] National Safety Council,[26] the US Environmental Protection Agency,[27] and several state-level agencies.[28] This body of research indicates that there are three primary factors that prompt concern over end-of-life electronic products.

- *Production/Obsolescence rate.*

At the current rate of technology introduction, new models of personal electronic products are developed and introduced into the market place every 18 to 24 months.[29] This rate of innovation drives high rates of obsolescence. Today for instance, nearly 500 million personal computers in the United States are considered to be obsolete.[30] These and other obsolete electronics will eventually find their way into disposal systems. Ultimately, this makes electronics the fastest growing segment of waste.

- *Disposal practices.*

In the United States, an estimated 5-15% of computer and electronic equipment is recycled for material, component, or energy recovery. Between 5-20% is disposed of in landfills, incinerated, or illegally dumped in the natural environment. The remaining 75% of personal computer and electronic equipment is currently stored in private attics, garages, office closets, and warehouses.[31]

- *Toxicity.*

Personal electronics contain various levels of lead, mercury, cadmium, and poly-brominated flame retardants which are known health hazards. As of 2002, electronic waste accounted for 40% of lead and 70% of mercury and cadmium found within landfills.[32] As landfills settle, chemical and metal leaching into groundwater is common. The incineration of flame retardants in the presence of copper emits toxic dioxins and furans into the atmosphere. Municipal incineration is the largest point source of dioxins and heavy metal contamination in the United States.[33] Together, these characteristics mean that there is real potential for adverse health effects when electronics are disposed of through conventional means.

4.2.3 Issues with end-of-life

Collectively, these factors create an environmental imperative in need of comprehensive reverse supply chain processes to remove end-of-life electronics from conventional waste streams. While remanufacturing and resale may be attractive options for high value equipment, the short-run economics of a high-technology firm leave little motivation to design and recover most personal electronics products for future reuse. In this sense, electronic waste represents a serious environmental externality because the cost of safe and efficient waste management is not internalized into the price of the product.

Policy-makers, waste management professionals, and electronic manufacturers generally agree that electronics *recycling* is the best way to manage existing waste streams. However, the recovery and recycling of electronic products is no easy task. In fact, there are significant barriers to the development of wide-scale electronics recycling:

- *Unwillingness to pay.*

The general public is either unaware of electronic waste disposal options or unwilling to pay for appropriate waste management. A recent study from the State of Florida indicates that 81% of consumers are not even aware you can recycle computers. Further, 64% of those that do know about recycling options are *not willing to pay* to have their computer properly recycled.[34]

- *Market.*

Recycling is a time, labor, and technology intensive process. The cost of recycling a computer in the United States was reportedly $0.38 per pound in 1999.[35] Added to this cost is the necessary and highly variable costs of transportation and handling at central redemption centers. Moreover, the market demand for recycled electronic materials within the United States is inconsistent at best. Most dramatically, the price for recovered microchips has declined from a height of between $8 and $14 in 1991 to $0.50 in 1999.[36]

- *Lacking infrastructure.*

The increasing volumes of electronic waste may overwhelm existing bulk transport, storage, processing, and recovery infrastructure. Without a reliable demand for scrap materials, there is little incentive for private organizations to engage in a lengthy RCRA permitting process for hazardous waste recycling as described above. Without adequate means to handle electronic waste, the likelihood of this waste being land-filled, incinerated, or exported to less developed countries increases.

4.2.4 Regulatory Action

Governments generally turn to regulatory instruments to address the environmental and health externalities associated with industrial and commercial activities. In the case of end-of-life electronics, companies have developed a nominal level of recycling services in response to a combination of liability concerns and economic motivations. Nonetheless, these efforts do not address the full need. Governments around the globe are calling on the electronics industry to further address deeper structural, technical, and economic barriers that impede electronics recycling. The most influential legislative framework is based on the principle of extended producer responsibility.

Often referred to as "take-back," extended producer responsibility legislation is used to create incentive for "design for environment" processes that may reduce toxicity and increase recyclability of electronic products. While this incentive may be the ultimate goal, in practice today, take-back laws are serving as a regulatory mechanism that forces manufacturers to develop reverse supply chain processes to reduce the environmental impact and financial burden of waste management on individual municipalities. In this sense, extended producer responsibility is in every way a supply chain regulatory directive that requires the development of new processes such as reverse logistics.

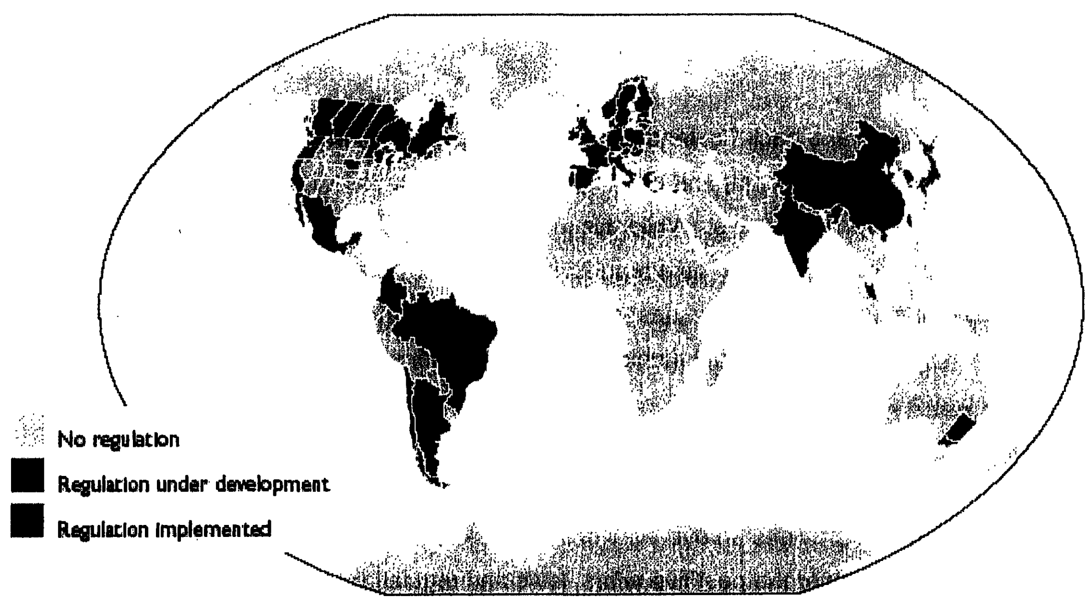
The following section provides an overview of take-back laws both generally and specifically. It is important to note that over the past five years, laws and regulations around the world are being proposed, adopted, and evolving at a rapid pace. In order to stay updated on legislative updates, companies and researchers pay for subscription services such as those maintained by the Electronics Industries Alliance and Raymond Communications, Inc.[37] In fact, trade journals and reports seem to be the best sources of current information and industrial case studies.

In general, extended producer responsibility may take many regulatory forms. Researcher Michael Toffel explains that legally imposed producer responsibilities vary according to the following elements[38]:

- Type of responsibility: economic, physical, informational, or liability;

- Product recovery stage: economic or physical responsibility may occur at various stages of end-of-life. For instance, do manufacturers take responsibility as the product leaves the household or once the product is collected and returned to a central location?
- Recovery or recycling targets: targets may designate recycling or recovery according to % mass, % revenue, market share, among others;
- Historic waste: legislation may also assign responsibility for historic waste which could be products produced before regulations take affect or products produced by companies that are no longer in business;
- Individual or collective responsibility: system may designate manufacturers responsible for only their own products or a portion of all products collectively.

Figure 4.3: Global take-back legislation in 2005



Credit: Philips Consumer Electronics, 2005

While a number of variables influence the viability of reverse supply chain processes, the nature and extent of regulatory requirements is a key factor. Government decisions about recovery targets and historic waste for instance may dictate whether or not return processes are profitable. To this end, it is critical for leading companies to stay aware of change and actively involved to the extent that they can be with developing legislation.

4.2.5 Focus on Europe

The European Union's Directive on Waste of Electrical and Electronic Equipment (WEEE)[39] is the most prominent and extensive "take back" legislation enacted to date. The directive essentially provides a uniform framework for the development of national regulatory requirements within each of the European members states. WEEE "defines, prescribes actions, and sets regulatory milestones for the collection, treatment, recovery, and financing for electrical and electronic equipment."[40]

WEEE originally covered ten product categories, including large household appliances, small household appliances, information and telecommunications equipment, consumer electronics, lighting, electronic tools, toys and sports equipment, medical devices, monitoring instruments and automatic dispensers. As national regulations are developed, the requirements continue to evolve. For instance, medical devices are now exempt from requirements. New products must be marked with "do not trash" symbols and information on product disassembly must be provided. Manufacturers and importers of these products may address their financial responsibilities for recycling and disposal either individually or collectively based on market share. The costs associated with the processing of "orphaned waste" or products that reach market before the August 13, 2005 program commencement will be shared by all manufacturers at the time those costs are incurred. Products put to market after commencement may not include a visible fee to fund recycling efforts. The Directive also designates specific recovery and recycling targets ranging from 50-80 percent for each product category. Initial recovery targets must be met by December 31, 2006.[41]

Although some member states are delaying implementation of national regulations, WEEE has by now sparked an abundance of activity among manufacturers, consultants, and third party logistics and processing service providers. Researcher Alan Scroope describes the supply chain response to WEEE as a network management problem. "Ensuring WEEE compliance entails managing the collection of products via licensed carriers, and the coordination of sorting and disposing of products within authorized facilities. It also includes managing the resale of products to ensure the highest recovery rate and tracking treatment through certified recyclers."[42]

This statement hits on one of the biggest points of contention in the EU, relating to the issue of operational choice. National WEEE requirements vary according to country and industrial sector. Some countries, including Sweden, Norway, Belgium, and Switzerland require all manufacturers to use a national take-back scheme with little operational flexibility. While some electronics manufacturers openly support such national schemes because it nominally lowers administrative costs, others see them as a barrier to free-market competition and the development of cost-effective services. In fact, some companies have partnered to form a consortium to establish branded take-back schemes using privately-contracted third-party logistics and processing services. A prominent consortium is the European Recycling Platform, co-founded by Braun, Electrolux, Hewlett Packard, and Sony. The following section details findings from case interviews regarding how different European companies see this issue and how it effects their reverse supply chain processes.

Case study on practices in Europe

An assessment of implementation strategies in Europe illustrates the complexity and learning involved with developing reverse supply chains under regulatory environmental pressure. Leading companies may generally be divided into two groups – namely those advocating independent action and those who prefer a government-endorsed collective. Even companies that have demonstrated significant environmental leadership disagree on the most basic approach to compliance. Two firms, Philips and Hewlett Packard, which were both interviewed, expressed particular preferences regarding this issue and are representative of the two perspectives.

Table 4.1: A summary of opposing approaches to compliance in Europe

	Philips[43]	**HP Europe**[44]
Motivation	Compliance, environmental leadership, brand value	Compliance, environmental leadership, brand value
Cited challenges	Compliance with national requirements, cost	Compliance with national requirements, cost
Leadership	Active in working with European Parliament to develop amendments through commenting and committee work	Driving service competition and compliance uniformity through the co-founding of the European Recycling Platform
Product Acquisition	Municipalities	Municipalities
Reverse logistics	Uses local, price-competitive logistics providers	Contracts to 2 centralized logistics providers through ERP
Processing	Uses local, price-competitive processing services	Logistics providers manage processing
Financing	Favors the visible fee and collective responsibility for historic and orphaned waste	Opposes visible fee and collective responsibility for orphaned waste. Supports individual insurance and financial guarantees
Partners	Joins competitors in collective national systems	Joins non-competitors in the ERP

It is worth understanding why Hewlett Packard strongly and publicly supports the European Recycling Platform. Launched at the end of 2002, the mission of the ERP is "to ensure the cost effective implementation of the WEEE Directive for the benefit of participating companies and their clients."[45] This launch was motivated by two primary concerns: 1) the desire to increase competition, and 2) the desire to encourage uniformity.

HP aims to promote a competitive market for collection and recycling services in all European countries. Based on their direct experiences with the Green Dot system in Germany, HP asserts that competition will keep costs low: "In 1995, when there was one solution, we were paying approximately $350E/ton. Now there are six competitors to the Green Dot system and we pay $70E/ton." Competition will also improve the availability and quality of services: "When we first formed the European Recycling Platform, we had trouble finding service providers who could address the requirements of WEEE in all member states for us. We are driving the market in this area. Our vision for 2012 is that there will be four or five European Consortium systems competing in all 25 countries."

National WEEE requirements vary according to country and industrial sector. Tracking and managing the operational requirements of 25 national systems is costly. HP feels that the consortium offers uniformity in the ability to administer on a "pan-European" basis: "We commissioned a study in 2004 to investigate whether or not this solution would be the most cost-effective. Findings indicated that if a single consortium could provide compliance services across Europe, participating members would save 70-80% overhead costs." Uniformity also allows savings in other ways: "The larger geographic expanse would also allow greater economies of scale resulting in reduced operating costs of 30% and the system would increase competitive pressure to all compliance national schemes.[46]"

On the other hand, Philips supports national collective systems and pursues local, price-competitive services in each country. Although Philips was not asked specifically about the ERP or their views about "pan-European" approaches during the interview, it may be concluded that Philips is a company that draws value from maintaining a strong local presence. Philips has been very active in working with European Parliament through commenting and committee work since the onset of discussion about how to apply extended producer responsibility in Europe. No doubt their efforts in this work reflect a corporate level strategic approach.

4.2.6 Focus on the United States

Consumers in the United States dispose of 2 million tons of electronic waste each year, including 50 million computers and 130 million cell phones. The International Association of Electronics Recyclers has predicted that by 2010, Americans will be disposing 400 million electronic products annually.[47] As such, end-of-life electronics present a concern as significant for the United States as elsewhere. Today, there is a functioning albeit small recovery system in the United States, which is driven by corporate social responsibility efforts, liability concerns, and to a lesser degree, profit.

Cellular phones provide a good example of profit-motivated reverse supply chains. Approximately 70% of cellular phones that are collected from consumers are refurbished and resold in international and domestic secondary markets. The total costs of refurbishing cell phones ranges from $15-30 per phone, while the resale price reaches $40-50 per phone.[48] The revenue from these sales covers the costs of recycling phones that cannot be refurbished and results in net profit. Although the existence of the secondary market makes these return processes attractive to manufacturers and third party recyclers, less than 5 million cell phones are collected from consumers from a total stock of approximately 130 million each year.[49] Collection is both the most expensive and the most challenging aspect of the cellular phone reverse supply chain in the United States.

Table 4.2: Cost comparison for recovery of cellular phones and personal computers[50]

Cost (USD)	Cellular phone	Personal computer
Collection	6.00	23.50
Transportation	0.35	0.43
Sorting	-	3.50
Dismantling	0.03	2.75
Refining	0.32	7.87
Non-hazardous waste disposal	0.01	0.83
Hazardous waste disposal	0.03	5.00

Leading manufacturing companies and cellular service providers are highly motivated to collect phones from customers. Given that cellular phone recovery is currently a net positive or neutral endeavor, companies can leverage collection initiatives in a number of ways. Initiatives may serve as a foundation for corporate social responsibility programs. Collection demonstrates environmental leadership. Refurbishment and resale of cellular phones provide revenue and product that may be donated to charity. Potential revenue may also support other in-house environmental programs or recycling of other types of equipment. As one manufacturing company explained, "The primary motive for recycling and collection lies in our overall philosophy of being a leading environmental company. Part of our logistics chain involves take back of not only phones, but networking equipment, accessories and batteries."[51] Initiatives also present opportunities to reduce liability concerns, market directly to customers looking for new phones, conduct product research, and participate in conversations with legislators about future regulatory approaches.

Table 4.3: A comparison of leading cellular phone manufacturer activity in the United States

	Motorola[52]	**"Leading cell phone manufacturer"**
Motivation	compliance, environmental responsibility, customer support, asset recovery	compliance, environmental responsibility, customer support, asset recovery
Cited challenges	collection, shipping costs	collection, shipping costs
Most promising initiative	"Race to Recycle" incentive program that offers schools $4 per phone	potential partnership with US Postal Service for collection – solves "first mile" problem
Consumer collection	E-bay Rethink, free mailers, incentive programs, collection events	E-bay Rethink, free mailers, collection events, collection at service and "experience" centers
Transportation	primarily individual shipments to Dexter, MI, encourages larger shipments of 100 phones	primarily individual shipments to Fort Worth, TX, encourages larger shipments
Processing	relationships with vendors in several locations, competitively bid each year	Long term relationship in TX
Management	environmental research and supply chain operations	Materials disposition
Magnitude	goal for "race to recycle" is 3m lbs in 2005	<$1m lbs per year
Goal	corporate social responsibility	corporate social responsibility

While such pre-existing systems in the United States are not designed or equipped to address the scale of recovery that is necessary, the regulatory landscape in the United States is very different from Europe. Despite precedent set by other countries, the United States has not passed legislation to address electronic waste at the national level. There have been a number of exploratory activities, however. To start, the EPA funded and participated in a stakeholder dialogue called the National Electronics Product Stewardship Initiative (NEPSI), which took place from June 2001 until February 2004. The NEPSI group's main goal for the dialogue, agreed to at its June 22 meeting in San Francisco, was "the development of a system, which includes a viable financing mechanism, to maximize the collection, reuse, and recycling of used electronics, while considering appropriate incentives to design products that facilitate source reduction, reuse and recycling; reduce toxicity; and increase recycled content." Participating in this dialogue were several state environmental agencies, recycling organizations, and a number of manufacturers, including: Panasonic, Hewlett Packard, CompTIA, Philips, Sony, Canon, JVC, Epson, Microsoft, Nokia, Thomson, Dell, Sharp, Compaq, Solectron, among others.

One of the informal outcomes of the NEPSI dialogue was the establishment of the "Manufacturer's Coalition for Responsible Recycling," a group of thirteen electronics companies that have joined together in support of applying an advanced recovery fee (ARF) to the sale of new electronic products. The group includes IBM, Sony, Sharp, Panasonic, JVC, and Samsung. They believe an ARF approach is the best way to viably finance waste management at both the state and national levels. The group has published many white papers detailing the benefits of the ARF approach:[53]

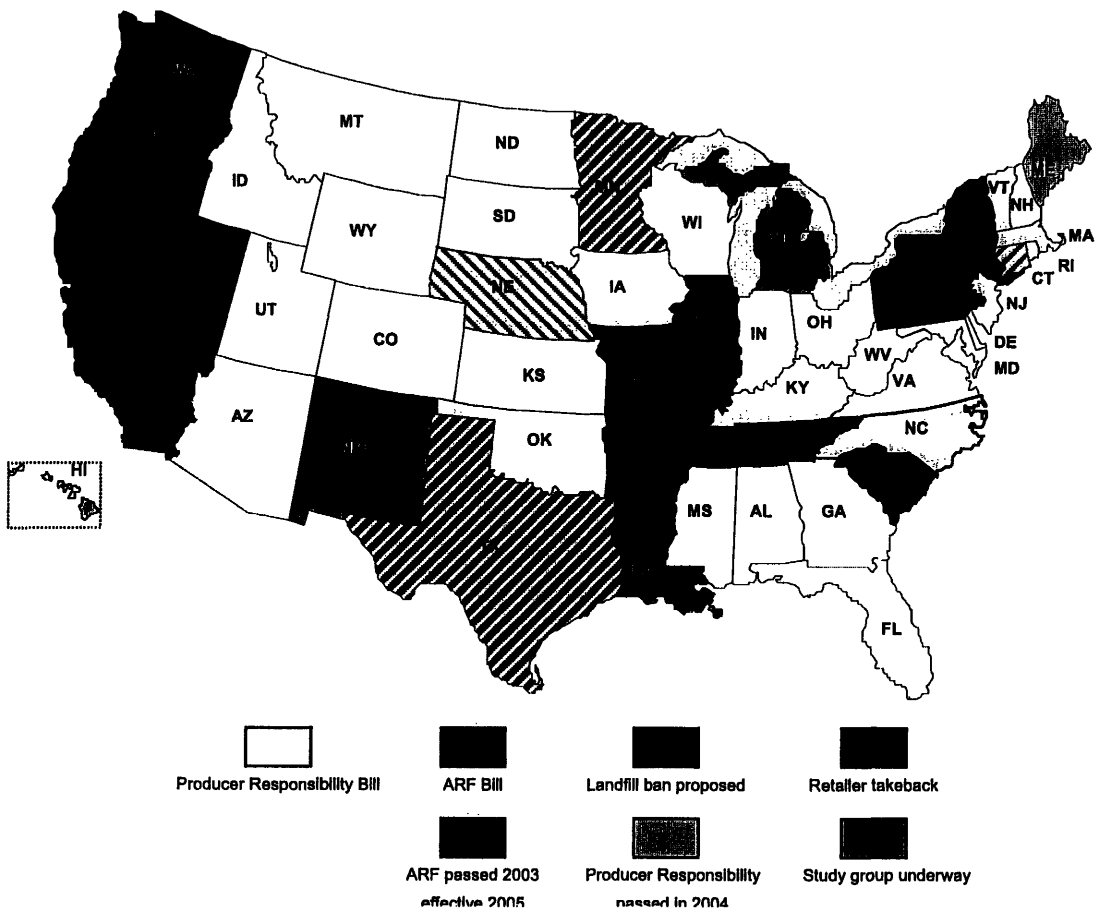
- The ARF is a visible to the consumer so delivers an educational message that consumption implies environmental and economic impacts at end-of-life, and that old products should be returned for reuse and recycling
- The ARF system will not burden local governments with the costs of collecting and transporting products, since those costs are covered
- The ARF provides a consistent and adequate source of funds for recycling of historic and orphaned products.
- The system will build efficiencies and economies of scale in the infrastructure through competitive contracting while maximizing local resources
- The ARF maintains a level playing field in the market because it is equitable for all products and sellers, and it offers the least opportunities for manufacturers and others to escape their responsibilities.
- When implemented at a state level, the ARF-based system will most readily transfer to a national system when it emerges based on the NEPSI model.

Critics of the ARF approach believe that a flat fee on all products lacks any direct incentive for individual manufacturers to improve environmental design. In addition, it detracts from the investments that many manufacturers have already made to develop independent reverse supply chain processes. While stakeholders will be involved in the design and management of the system initially, the ARF approach ostensibly removes learning feedback and the incentive for developing reverse supply chains internally – for either environmental or economic benefit.

Interestingly, this debate may be played out pragmatically because of two bills as will be described in the section below on state activity.

In the absence of federal government leadership, the states are leading the way in proposing legislation and regulations, funding pilot programs and infrastructure research, and adjusting existing laws to accommodate the development of more recycling services. While the pace of change has been very fast, several organizations track the activity of individual states, including the National Caucus of Environmental Legislators and the Northwest Product Stewardship Council among others.

Figure 4.4: State recycling legislation 2005



Courtesy of Thompson Electronics, Inc.

In September 2003, California adopted bill SB20, the Electronic Waste Recycling Act of 2003 which was the first comprehensive electronics recycling policy in the United States. The act requires retailers to collect a waste recycling fee, and the manufacturer to provide information to consumers that describes where and how to return, recycle, and dispose of electronic products. The bill also requires an Electronic Waste Recovery and Recycling Account to be established within the Integrated Waste Management Fund in the State Treasury for collection of recycling fees and distribution of payments to electronic waste recycling facilities. Retailers began collecting fees in January 2005. This law is in line with those who support advanced recovery fee as an approach to funding recycling.

In April 2004, Maine passed the first electronics producer responsibility bill, LD1892. The bill establishes a statewide recycling system for computer monitors and televisions that is fully financed by manufacturers.[54] This law is different from the act passed in California, because it does not involve an advanced recycling fee. Rather, it places the financial and physical responsibility of recycling directly on the manufacturers. Supporters believe that "the law gives manufacturers the flexibility to design and implement collection and recycling systems that best suit their individual business model, and permits two or more manufacturers to join together to accomplish the requirements of the bill."[55] HP is among the public proponents of this approach.

Moving forward, both sides may learn from the experiences in Europe with regard to high-volume, collective national schemes verses membership based, competitive consortium. The real challenge is to devise a system that accommodates both the interests of manufacturers who support collective infrastructure and the interests of those who see benefit in independent systems.[56]

Case study on practices in the United States

Hewlett Packard and Dell are leaders in both market share and environmental commitment in the United States. They jointly represented over 40% of personal computer market share in 2004,[57] and were recognized by the Computer Take-back Campaign (CTBC) as the industry's "environmental leaders" the same year.[58] This recognition is based in part because of their support for the *Statement of Principles on Producer Responsibility for Electronic Waste* authored by CTBC and refined in conjunction with HP and Dell. This statement encourages the goals of extended producer responsibility in a system where manufacturers partner with consumers and state and local government agencies to recover electronic waste. In a press release, the CTBC state: "HP and Dell's support for the Principles represents a significant break from many other companies in the electronics industry, which are backing a more narrow solution that leaves taxpayers bearing a significant share of recycling costs.... The Principles frame a crucial distinction between the type of advanced (recovery) fee adopted by California, which CTBC, Dell and HP do not advocate, and a system wherein manufacturers internalize costs associated with collection and recycling of discarded products."[59]

Given this leadership and the fact that neither HP nor Dell supports the development of a collective system financed by advanced recovery fees, it is particularly important that they develop recovery systems that promote both business and environmental goals.

Table 4.4: A comparison of leading computer manufacturer activity in the United States

	Dell[60]	HP[61]
Motivation	compliance, customer support, environmental leadership, risk mitigation	compliance, customer support, environmental leadership, risk mitigation
Cited challenges	collection, transportation costs	collection, transportation costs, processing costs
Most promising initiative	Asset Recovery Services for corporate clients showing 500% increase in collection volume in one year	Office Depot partnership pilot yielding 10.5m lbs in 7 weeks Planet Partners program set goal of 1 billion cumulative lbs collected from 1987-2007
Consumer collection	special events, pre-paid and free mailers, E-bay Rethink, potential partnership with Goodwill	special events, pre-paid and free mailers, E-bay Rethink, Office Depot partnership
Transportation	goal of full trucks to central processing in Austin, TX, may expand to OH and west coast locations	goal of full trucks to Roseville, CA or Nashville, TN
Processing	long term partnership, manages 1st and 2nd tier, completes third party audits downstream waste	long term partnership, maintains employees onsite
Management	Deployment Services	supply chain branch of Imaging and Printing Group
Magnitude	52.8m lbs/year in North America	48m lbs/year in North America
Goal	break even, charity support	lowest cost, charity support

While there are a number of factors that influence the viability of reverse supply chain processes, the nature and extent of regulatory requirements is a key factor. Ideally, regulatory mechanisms would simultaneously promote environmental goals and business objectives. Clearly, such details influence the management of reverse supply chains for compliance and whether or not companies are able to create business value with prescribed approaches. Regulations must carefully balance the need to address environmental externalities with the need to support market-driven solutions that may be more efficient and sustainable economically.

4.3 Lessons learned about developing processes

The preceding sections introduced a number of issues associated with reverse supply chain management. While all supply chain processes must be developed within a context of market drivers, this is especially true in the case of the electronics industry. Reverse processes represent a new area for innovation in a highly competitive industry, and regulatory pressures ubiquitously raise the stakes for supply chain performance. As illustrated by cases in both the United States and Europe, environmental expectations about the recovery of end-of-life electronics conflict with behavioral and economic realities. Regulations intended to align these drivers create opportunity for some companies and further obstacles for others. The following section outlines current trends, challenges, and strategic considerations that define the electronics industry response to date. These lists are not entirely inclusive, but provide a snapshot of current contextual drivers and lessons learned.

4.3.1 Trends

Several trends are shaping the nature and extent of both regulatory pressure and electronics industry response to pressure. These trends include:

- *Increasing attention to the issue.*

As public awareness of the environmental impact of electronic waste continues to increase, industry and regulatory bodies have reacted with reports, special collection events, online information, and pilot programs. Attention to the issue of electronic waste will continue to grow as the international community passes legislation to address the issue and as obsolete product continues to accumulate in homes. The growing number of investigative reports in state agencies (at least 3 states are launching studies this year to add to the existing 28) and the emergence of E-bay's RETHINK initiative in 2005 are indicative of this growth.

- *Dynamic rules.*

Regulatory requirements continue to evolve in Europe and to be adopted in the United States. Companies that follow legislative activity closely assume that deadlines, exemptions, and targets are dynamic as this relatively new and ambitious regulatory approach progresses. For example, medical devices were initially regulated under WEEE, and are now considered exempt. The enactment date for all national regulations was originally August 13, 2005 under WEEE, and now is rolled back in countries that were unable to draft guidelines in time.

- *Increasing volumes.*

Numerous studies indicate that the volume of electronic waste will continue to grow as production, obsolescence, and disposal rates increase. Consumers Union, publisher of Consumer Reports, recently estimated that the average American household could expect to discard approximately 68 electronic items over the next 20 years, including 20 cellular phones, 10 personal computers, 7 televisions, 7 VCRs or DVD players, as well as answering machines, printers, and CD players.[62] Studies conducted in Europe estimate that the quantity of electronic waste is increasing by 3-5% per year, nearly three times faster than the municipal waste stream.[63]

- *Net negative revenues.*

Overall, the value of recovered parts and materials from electronic equipment is less than the cost to collect, transport, and process this equipment. In fact, the material value of a $2000 computer at the end of its useful life is approximately $1.50-2.00,[64] whereas it costs upwards of $50 per computer.[65] Nearly 80% of this cost is in the actual logistics processes.[66] Although costs may clearly be reduced as logistics and processing services become more advanced and competitive, processing costs are also increasing as products become more compact, and therefore, more difficult to dismantle. Markets for commodities would need to expand dramatically to raise the value of recovered materials. At present, with the exception of cellular phone manufacturers, no companies view collection of personal electronics from consumers as a value-added proposition.

- *Emergence of 3rd party service providers.*

The market for third party reverse logistics and service providers continues to grow in the United States and Europe. This growth is indicated to some degree by the increase in research and development of professional organizations such as the Reverse Logistics Executive Council and Reverse Logistics Association. As one electronics representative described, "Logistics and processing will grow just by the nature and magnitude of take-back that's going to be required. My view is that this industry will grow like the waste industry. First small mom & pop shops will offer services, then it will consolidate into a larger industry, and finally someone will buy it up and become the low cost provider in a particular service. It's just a matter of time." With growth comes the emergence of better and more competitive services, which will change the competitive landscape. In Europe, select manufacturers themselves played a role in instigating this growth in order to secure low cost, high quality services for their own compliance efforts.

4.3.2 Major challenges

In developing reverse processes, the electronics industry is facing major challenges that will require both technical and organizational innovation to overcome. These include:

- *Operating costs.*

Transportation costs are widely cited and clearly demonstrated to be a significant barrier to further development of recycling networks. The net costs of transportation are closely linked to several factors, including volume, distance, and mode. Manufacturers are making efforts to build volume through special electronics collection events and partnerships with organizations that can store larger volumes of equipment on-site prior to shipping. Currently, most processing occurs at one or two centralized locations. Central processing may build economies of scale, but when the primary cost is transportation, a decentralized approach may work best. Existing RCRA regulations in the United States inadvertently serve to limit the availability of electronic waste recycling services by designating volumes above a certain threshold as hazardous. However, for the past three years, EPA has been in the process of streamlining requirements to reduce costs for processing facilities.[67] In the meantime, some states are addressing this issue by handling retired electronic equipment as "universal waste" and thereby reducing the management requirements. A significant reduction in the costs associated with transportation and processing could change the economics and viability of the entire reverse supply chain, and perhaps serve to overcome the current trend of net-negative revenues.

- *Non-uniform rules.*

In Europe, and increasingly in the United States, the varying nature of local regulations presents a serious challenge to administration and operation of reverse processes. This non-uniformity requires that each company stay informed of and develop processes to comply with several independent regulatory systems. One manufacturer explained, "In Austria, waste is separated into five categories: lamps, televisions and monitors, refrigerators, above 50 cm, and below 50 cm. In Germany, waste is separated into cooling, other large domestic appliances, consumer electronics, small household goods, and power tools. In United Kingdom, there is no separation. This difference in procedure is one of the biggest challenges for all companies."[68] Companies in the United States may soon be dealing with similar challenges as states and municipalities adopt independent regulations without a cohesive national framework. Costs include administration, local lobbying, training, and loss of economies of scale.

- *Consumer participation.*

Consumer participation is a challenge in the United States in many respects. The majority of interviewed companies cited consumer awareness, participation, and lack of incentives as a key challenge to generating the high volumes of product that they need to develop effective reverse processes. One manufacturer described, "The real issue is driving consumer participation. We've tried a number of incentive programs. We've seen better recovery rates on printers than personal computers, but it's still very small."[69] On the other hand, some companies are not inclined to promote increased participation, because as one described, "Our research shows that most people don't care about end-of-life offerings. There is no clear advantage to us to increase our return rate. As a business, why would we provide incentives to do so? We've provided an easy program – what more can we do?"[70] It is likely that this attitude is prevalent among companies that were not involved in this or other academic and governmental studies. It raises an interesting point. The US EPA continues to advocate voluntary initiatives as a means towards environmental progress, including the development of electronics recycling infrastructure. However, it is questionable whether or not voluntary approaches can replace regulatory directives in generating adequate incentive for both consumer and manufacturer participation.

- *Material markets.*

Recovered material prices are volatile due to fluctuations in the availability of or demand for commodity materials like aluminum, steel, copper, and plastics. This volatility makes it difficult for recyclers and reverse supply managers to plan cost-effective processes because there are no steady revenue streams. As a result, existing recyclers are turning to "fee-for-recycling" service models, which may or may not provide incentive for design changes related to material choice.[71] In charging a flat fee or per pound rate, some of the financial uncertainty is removed from the operation.

4.3.4 Strategic considerations

Current trends and challenges surrounding the issue of electronic take-back define the strategic considerations of individual electronics companies. Decisions made in these areas may determine whether or not reverse supply chains contribute to environmental and economic success system-wide. These considerations include:

- *System financing.*

Manufacturers disagree on fundamental system financing in both Europe and the United States. Representative positions are influenced by many factors, including product type, marketing, sales, management capabilities, and strategic positioning. Many companies in the United States support the advanced recovery fee approach because "it will be the least expensive overall, easiest to implement, and most appropriate to transfer from a state level to a national system."[72] While this may be largely true, there are leading companies who would choose to administer independent systems if participation is voluntary. This would remove a large percentage of revenue and volume from the collective system, making its operation less viable. In Europe, the debates about financial guarantees, advanced disposal fees, and collective systems mirror the United States. It is critical to finance the system in a way that provides incentives to consumers, manufacturers, and recyclers alike. While this may be challenging, companies need to determine their position on various scenarios and how that may affect their position in the market.

- *System design.*

While regulatory structure is still under development in the United States and to a lesser degree in Europe, manufacturers have the prerogative to design a reverse supply chain that may benefit their competitive position. Collection and reverse logistics processes are widely cited as key challenges; manufacturers may pilot systems to provide incentives and opportunities for collection and develop relationships with processing services and recyclers as they see fit. It is clear that there will not be a standard solution that suits all stakeholders.

- *Use of 3rd party operators.*

While nearly all companies manage some sort of reverse supply chain to handle product returns, only one electronics manufacturer reported using these existing processes to handle end-of-life product returns. In this case, the manufacturer was collecting very small volumes of end-of-life product. The majority of electronics manufacturers in the United States and Europe are turning to third-party logistics and processing service providers because this area is outside of their core competency. This decision is pushing a relatively unsophisticated cottage industry into one with an increasing array of technology and services. Nevertheless, the decision to outsource logistics or recycling processes is an important one and may influence future ability to develop in-house reuse or remanufacturing models or to enable recycling processes to inform design for environment efforts. This decision also relates to conventional issues of supplier management and the nature of relationships, either "arm's length" or actively cooperative, with suppliers and service providers.[73]

- *Legislative involvement.*

With changing regulation and a steep learning curve, leading companies are actively involved in providing feedback to legislators. In the United States, over 15 manufacturers participated in National Electronics Product Stewardship Initiative, a national stakeholder dialogue about infrastructure for collecting, reusing and recycling electronics. Active involvement in rule-making and voluntary initiatives may alter the time frame of alternative regulatory approaches.

- *Consumer outreach.*

In the United States, leading companies are exploring ways to leverage product take-back efforts to build brand reputation or to directly encourage additional sales. This is an approach to building value through what might have been regarded simply as compliance requirements. Companies are reaching out to consumers through collection events, by placing collection bins in public places, by offering discounts for new products, and through charity fund-raising events like Motorola's "Race to Recycle." Since consumer participation in recycling programs is a major challenge that each of the companies interviewed identified, this represents an opportunity for competitive advantage.

Altogether, there are no easy solutions for the electronics industry in developing reverse processes. It is clear that leading companies are addressing this issue within operational and supply chain management groups. They are investing in research, outreach, and advocacy to the public and government, building capacity for reverse processes through operations or relationships or both, and adapting existing systems to accept the reverse flow. There are no agreed "best practices" in this arena, because the both the regulatory bodies and the electronics industry are certainly still in the learning phase. As trends and challenges change and continue to shape strategic considerations, "best practices" have more to with how companies are learning and positioning themselves with customers, governments, and partners for the future.

4.4 Summary

There are at least four types of product returns that must be supported by reverse supply chains, including commercial returns, end-of-use returns, packaging returns, and end-of-life returns. The management of these reverse supply chains involves several unique and complex processes, which must be developed within a context of environmental pressures and market drivers. This point is particularly true when considering the emergence of reverse supply chains within the electronics industry.

Today, there is considerable environmental pressure in the form of regulatory directives, liability concerns, and social responsibility motivations that are prompting the development of processes for wide-scale electronics take-back. What is the reverse supply chain response? While the environmental imperative for action is very high, there are no easy answers to this question for either legislators drafting requirements or supply chain professionals aiming to build value in compliance. On one hand, the issues surrounding product take back relate to waste management and building infrastructure for future environmental progress. On the other hand, the issues relate to the supply chain capabilities of the electronics industry in developing distinct processes that support corporate objectives and strategies.

Leading electronics companies are investing in research, advocacy and outreach. As trends and challenges within the electronics industry change and continue to shape strategic considerations, industry "best practices" are defined by how individual companies are learning, adapting, and positioning themselves with customers, governmental bodies, and partners for the future. This represents a challenging and important role for supply chain management professionals.

Altogether, activity within the electronics industry illustrates the fact that supply chain processes are important and should be developed with awareness of context. Companies that focus on figuring out how a small number of distinct processes may address environmental pressure, take advantage of market drivers, and support corporate objectives and strategy will be most successful in the future.

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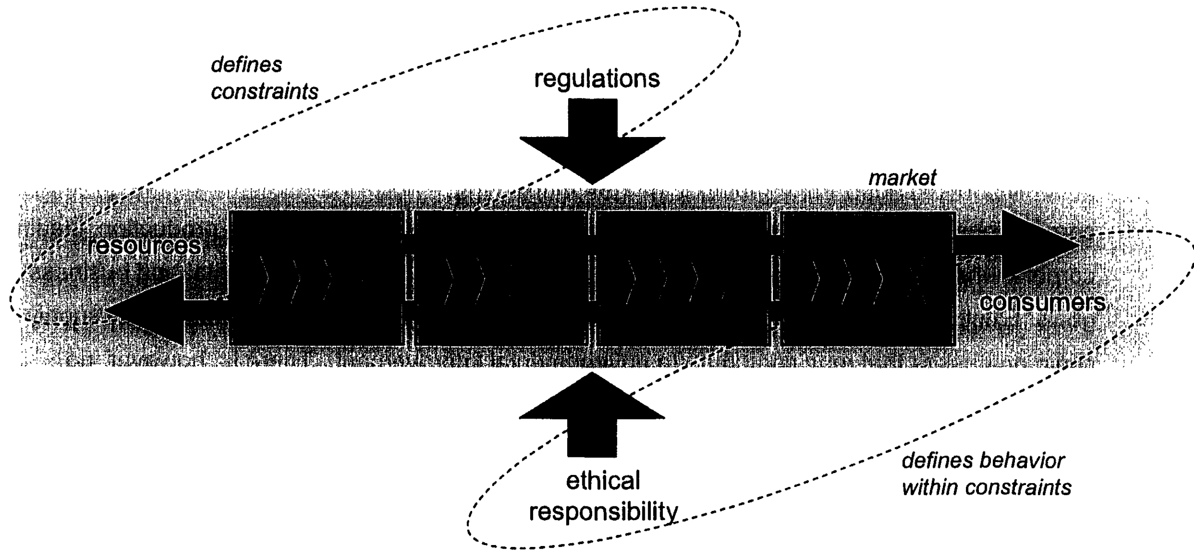
Conclusion

The complex relationship between supply chain management and the natural environment impacts human health, environment, and the long term viability of business. This relationship is becoming increasingly important to corporate functioning. As environmental concerns prompt corporations to address the environmental implications associated with mass production, leading corporations will turn to supply chain management to pursue both environmental and business goals. Existing literature and industry accounts make it clear that there are innumerable supply chain processes that may contribute to environmental improvement. There is, however, no universal approach. The most appropriate supply chain response will vary considerably by a context defined by the nature and extent of environmental pressures and market drivers.

Today, there is no theoretical framework that describes generally an approach for developing operational business processes that appropriately support environmental objectives and business strategies. Such a framework may be used to bridge the efforts of environmental management and supply chain management in theory and practice, while serving as an anchor for prescriptive advice on how to best respond to environmental pressures. A growing body of literature deals with dimensions of this issue, but falls short in some ways. This thesis has directly addressed three of these shortfalls:

1. There are four sources of environmental pressures: regulations, customer demands, resources, and ethical responsibility. Although these pressures are generally grouped together in existing literature, they actually impact the supply chain in very different ways. Conversations with individual firms across four industries indicated that each of these pressures affect the current supply chain decisions of at least one firm interviewed. It may be assumed that as environmental pressures increase, companies that are better able to identify and understand them will be better positioned to address these pressures strategically.

Figure 2.1: Sources of environmental pressures affecting the supply chain



2. A framework for supply chain excellence applies to supply chain *environmental* excellence as well. In direct response to environmental pressures, companies should develop a supply chain operating model that is supported by operational objectives and processes. This framework does not suggest that there is a universal approach to environmental issues. In fact, there are situations where being less proactive environmentally may be more advantageous than not. In addition, there are innumerable processes that may generate environmental and economic value for each basic function of the supply chain. While the greatest operational and financial benefits come from focusing on one or two distinct processes, this is also true of environmental benefits because concentrated efforts may yield effects that will ripple through the supply chain.

3. Supply chain processes should be developed in a context defined by environmental pressures and market drivers. Environmental pressures come from four sources. Market drivers are the result of regulatory, behavioral, and economic trends and challenges. The collective impact of these things shape a number of strategic considerations for individual firms and the overall supply chain capabilities of an industry.

A close look at the emergence of reverse supply chains within the electronics industry illustrates each of these findings. The electronics industry is faced with environmental pressure from evolving regulatory directives, liability concerns, and social responsibility demands. While leading companies are researching and piloting reverse processes to varying extents, a number of trends, challenges, and strategic considerations have been identified:

- *Trends.*
  - increasing attention to the issue of end-of-life electronics;
  - increasing volumes of end-of-life electronics;
  - dynamic regulations;
  - net negative revenues; and
  - emergence of 3rd party service providers.
- *Challenges.*
  - operating costs;
  - non-uniform regulations;
  - consumer participation; and
  - dynamic material markets.
- *Strategic Considerations.*
  - system financing;
  - system design;
  - use of 3rd party operators;
  - legislative involvement; and
  - consumer outreach.

One conclusion that may be drawn from the industry case study is that there is no universal solution or established "best practices" in the realm of supply chain management and the environment. Rather, the supply chain response to environmental pressures is characterized by the manner in which individual firms learn, adapt, and position themselves with customers, governmental bodies, and partners for the future. As environmental pressures grow more demanding and diverse, supply chain professionals maintain a challenging and important role across industries.

Moving forward, this research represents an early examination of one industry's supply chain response to a particular set of environmental pressures. The response involves the development of reverse processes, which include only a small number of all supply chain processes. This type of targeted research may easily be expanded in many ways. First, the development and contextual drivers of other processes may be assessed, including processes to support supplier relationships, design for environment efforts, and purchasing programs. More focused interviews may be conducted to relate process development to the overall framework for supply chain environmental excellence. In this way, new environmental activities may be compared for relevance to and impact on a company's supply chain operating model, objectives, and processes. Processes may be further evaluated for environmental performance using appropriate metrics. Finally, the environmental and financial performance of electronics companies who focused efforts on one or two processes may be compared against those who implement several across the supply chain. This research may be repeated to examine and compare many other industry sectors.

The ideas presented in earlier chapters prompt further research as well. Understanding the fundamental relationship between supply chain management and the environment is a complicated and challenging endeavor. To begin with, the direct and indirect environmental impacts of supply chain management as a global practice may be isolated and quantified. Particular outcomes of supply chain decision-making may be identified as "environmental culprits" in order to better understand the global factors driving these outcomes. Next, various supply chain models may be compared for environmental impact, including models based on just-in-time, lean, and asset utilization principles. In a separate but related study, environmental pressures represent a large area for research. Pressures affecting individual industry sectors may be systematically addressed, including a more comprehensive effort to catalogue global regulations. The relative pressure coming from each source may be quantified by identifying appropriate indicators and assessing whether or not environmental pressure is adequately signaled to companies. Altogether, further research may clearly establish a relationship between environmental pressures, supply chain management strategy, and emerging processes in a context of economic, behavioral, and political drivers. Ideally, these efforts will ultimately present a path towards to the development of supply chains that enable increased profitability and environmental sustainability.

Supply chains today represent the strategic integration of hundreds of decisions, each with economic and increasingly significant environmental implications. As supply chains continue to mature into sophisticated networks of material and information flow, so may the ability to trace the environmental impacts of individual products and activities along the supply chain and address these impacts proactively. However, this ability will not develop spontaneously, but rather in awareness of and in response to environmental pressures.

Appendix A

Sample questions for semi-structured industry interviews

Introduction

I am interested in learning about how your supply chain responds to environmental regulations and pressures. I will ask about three primary areas during this interview: 1) current supply chain practices that relate to the environment, 2) practices under evaluation, and 3) decision-making - how you evaluate future practices

Orientation questions

1. What is your job?
2. How does your work fit into the company structure?
3. What led you to this current position?

Supply chain questions

1. What is the basic structure (operating model) of your supply chain?
    - What are the top considerations in supply chain decision making?
    - What do you think your company does particularly well?
    - Where do you think improvements could be made?
    - Do you have supply chain performance improvement goals?
2. What are your biggest environmental regulatory concerns?
    - How do your competitors address issues related to the environment?
    - What do you consider best practice?
    - Who makes decisions related to compliance activities?
    - What is the most costly compliance activity in terms of time and money?
3. How do you think changes in the environmental concerns may affect your industry?
    - Do you consider new environmental concerns to be threats or opportunities?
    - How closely do your supply chain managers follow these changes?
4. Do you think your customers care about the environment?
    - What do you think your competitors will do to address those concerns?
    - What do you think the most proactive companies in your industry are doing?
5. When selecting suppliers, how would you rank the following performance areas?
    - Brand reputation
    - Cost
    - Environment
    - Reliability
    - Speed

Meeting Minutes

Participants: Julie Paquette, MIT; Roy Wiley and Henry King of Safety and Environmental Assurance Centre, Unilever
Date: December 6, 2004

Roy, Henry, and I discussed their perspectives on the supply chain response to environmental pressures and legislation. Both are employed within Unilever's independent Safety and Environmental Assurance Centre. Roy focuses on factory based initiatives; Henry on strategic supply chain initiatives.

Both answered a set of informal questions, as follows:

Q: What is the history of SEAC?

SEAC is the corporate group to assure safety for Unilever – not only environmental safety, but also food safety, product safety, etc.

After a safety incident in the early to mid-1960s, Unilever established an independent organization within the corporation to assure safety. The agenda expanded to the environment came into it in the 1970s, and then towards sustainability as a whole. Our initial environmental report in the early 1990s established fisheries, water, and agriculture as Unilever's primary environmental concerns.

Q: How do these concerns relate to supply chain?

Our fisheries initiative is specifically aimed at supply chain management. We couldn't imagine a sustainable business model without a sustainable (adequate and affordable) supply of fish. However, this is not something we could do unilaterally – we needed to move our initiative into the market place. But how do you communicate this type initiative to suppliers and customers?

Q: How did Unilever do it? Within industry?

With fisheries, we initiated discussions with competitors, etc. Our basis was that Unilever provide seed money and endorsement with the WWF to establish the Marine Stewardship Council as an independent organization for certification. Our commitment was to use certified fish only. Several governments also wanted their own certification scheme.....so our internal target changed from "MSC certified" to "MSC or equivalent."

Agriculture started as an internal exercise to establish best environmental practice for our contract farming organizations – we started with our largest areas that we have influence – tea, tomatoes, etc. – we weren't looking at an independent certification scheme, although in establishing the metrics for what may constitute sustainable practices, we involved outside experts.

Q: What about packaging ordinances in Europe?

The Essential Requirements has only been adopted in three countries, most countries are not in compliance. Much of the debate surrounding packaging is about adopting environmental indicators for the best packaging. But implementing the Essential Requirements should be a first step.

Q: In terms of decision-making – are environmental impacts driving the decisions being made or are they just one consideration in supply chain?

You have every end of the scale. With the fisheries, you might argue that environment is a critical factor. On average, across the business, at the end of the day many of the decisions are about cost. Environmental issues that translate into cost are considered, but these would not be labeled environment – they're called transport costs, or utilities, or a legislated tax. Environmental costs, however, are still a small part of overall lifecycle costs.

Q: Do you have a sense of how much costs savings actions are actually helping the environment?

No. Though, I think that many cost savings do help the environment. In our own manufacturing activities, we've gone through rigorous environmental reporting – and we could perhaps tell you how much money we have saved from this reporting (if we've published it.)

There is also the issue of segmented management – logistics managers, factory managers, buyers manage suppliers – often you get individual management across the product value chain. It is all optimized for cost.

Q: What is Roy's responsibility on the facility side?

My role is factory based – Unilever factories. As a group, we look at geographical regions, consider the highest environmental impacts, and then try to drive them down. The vast proportion of our production is internal, and this is the data we report. When we started environmental reporting, 90% of our production was internal – and it has gradually changed to approximately 70%.

Q: Does outsourcing concern you from an environmental point of view?

It depends on what way you look at it. There is some activity underway looking at those types of issues. We have a code of business principles, of which environmental risk and performance are included with a supplier assurance process.

We recognize that we run risks in our supply chain whether it is contract manufacturing or raw material suppliers that we need to manage – environmental, social, quality, whatever.

We recognize that the risks are increasing and we have a more rigorous process of managing supplier assurance, but I am convinced that it will not be in the same way that we manage our own factories. We cannot and we shouldn't take that level of responsibility.

Q: What is the Unilever's vision for the future for the larger industry in terms of sustainability?

Whatever organization you are in, unless someone expresses a particular set of values, it is very difficult to operate outside a cost driven framework.

Environment is not a huge cost from a business perspective, compared to labor, capital, or raw materials. This could change in the future – taxation schemes could be environmentally based rather than labor based. Currently, environmental compliance represents less than 10% of manufacturing costs.

Everything we do in supply chain ultimately relates to selling a product to a consumer. So there are a number of management issues that may be raised in the future – environmental issues, labor issues, etc. It would be great if good management of these types of issues could translate into consumer sales. 1-2% of all investments now are held in "socially responsible" investment funds. So although not mainstream, if you are spending lots of time and building a reputation on the Dow Jones Sustainability Index, etc – this may pan out into the future. But it is very difficult to go into a meeting today and explain this approach.

It's a matter of identifying in which issues we need to be proactive. This decision often comes down to sustainable *business* decisions. In many areas it takes the whole of industry to change. There are things we could do – or our competitors could do – but there are many stakeholders at play.

Meeting Minutes

Participants: Julie Paquette, MIT; Rick Vanlandingham, Manager of Quality and Reliability Assurance, Texas Instrument
Date: December 7, 2004

Rick Vanlandingham and I discussed his perspective on the supply chain response to environmental pressures and legislation. Rick has been employed by Texas Instrument in various capacities for approximately thirty years.

Rick answered a set of informal questions, as follows:

Q: What do you do at TI?

I am the quality and reliability assurance manager. I work with development and manufacturing teams help deliver customer's requirements – both voiced and unvoiced requirements – including environmental and reliability issues along the entire supply chain.

Q: What are examples of the environmental and reliability issues?

A good example of reliability and environmental overlap is in lead solder connections between one circuit to another. Over the next nine months all of our suppliers will begin shipping to us products that are free of lead solder by July 2005. The main incentive for us to do this is the laws in Europe as well as those promulgating around the US and world.

Changing a well proven technology with a lot of forgiving characteristics to a less forgiving technology is a big deal. We've been working on this for approximately 10 years.

Q: How do you feel TI is handling this issue compared to competitors?

Compared to competitors, TI is handling this conversion consistently. We've benchmarked and looked at what others are doing. Industry has been active on this in Washington and elsewhere for a number of years.

We've been talking about the conversion of lead. When you discuss the RoHS directive in total – there are a wide range of approaches. Some are just reactive "give me the recipe and we'll deal with it when problems show up." Others are groundbreaking and require investment in R&D. TI approaches are somewhere in between.

Given that we handle $500 million a year in the calculator business – we don't have the financial resources that some of the other organizations have. We've followed the lead of others, we've reviewed best practices, developed our own process qualification on joints and reliability testing, and have begun to implement that in product usage.

Q: How will the actual conversion take place? How will your suppliers be managed?

We meet monthly with our suppliers and talk about their progress and their schedules for switchover. We define how they will verify how things will perform, look at laboratories in their own facilities. We review action plans, we help manage stocks as they switch over. We will put out mixed technologies for a period of time during the transition. And then we'll know when we've switched strictly to non-lead. It is an extensive process, but most of our work is monitoring and reviewing.

So to implement RoHS, we will follow a similar path. We will use certificates of compliance and analysis on high risk components. Although we will have a complete bill of materials, we're not going to have everything analyzed. Since we deal with highly reputable and established suppliers, to take the time to review their laboratory analyses is not necessarily value added work. None of our direct suppliers are the sort that you may characterize as unreliable, short term, or fast transition organizations with less than 6 months of operation.

We believe we are well positioned to meet the deadline of RoHS, and ship compliant products before July 2006 deadline.

Q: Do you anticipate offering different products for Europe and the US based on RoHS?

By and large, our products for Europe and the US will not be different. However, some of our markets are different. Some of the business calculators in the US are not popular in Europe. Adaptors are different for the US and Europe. Not all US products will comply with RoHS at the same time as Europe.

Q: What is your experience with the packaging directives?

You gather your information, find a good service provider, like Green DOT, pay your fees and minimize your costs.

Rarely do you see this type of initiative bring value to most industries. A presentation at an IEEE conference showed that customers showed that only 1-2% pay any attention whatsoever to environmental impacts of products – of those, only 1/10 would pay more money for environmental products.

Q: Since it is not creating value for the customer or TI, how do you make decisions about what is worth pursuing or not?

We do make decisions based on market demand. Our educational customers, for instance, do tend to fall more into the 1/10 of 1% that value reduced environmental impacts. We built an Eco-calculator for Europe - recycled papers, soy inks, the calculator is solar powered, no battery at all in it, case plastics are 100% post consumer, blue angel solar power. We sell enough of these to continue to manage and build – but it is not a high runner by any means. We try to address certain segments of the market that have concerns.

And we address regulations, of course.

Q: How do you plan on complying with WEEE?

Through 3rd party collection and disposal groups. Our calculators need to be big enough to use, which changes constantly. But smaller is better, more power efficient, and it needs to last a long time.

The environmental ideal of easy disassembly needs to be balanced with these needs.

We have disassembly of our own in the returns products. We sell obsolete products on home shopping networks, magazines, etc. If we can't put it to use, we disassemble and demanufacture. There is not a lot of reuse – we separate into plastics, circuit board, and things that are safe for municipal waste or incineration. We sell the plastic to people making outdoor furniture and posts.

But most of our plastic since it does not contain a lot of high energy circuits, does not contain flame retardants so it is an excellent candidate for those types of secondary products.

In our own demanufacturing operations, we are ISO14000 certified. We do audit where the product goes – we have certificates of disposal – and audit where the trails of operations go. In other cases where we are contracting with large industry consortiums, we work with top notch ones.

Q: In the future, what constraints do you see becoming the most relevant and how do you see supply chain responding to them?

Energy consumption will become one of the most important issues – across the life cycle – in production, manufacturing, and in use – computers, monitors, printers use phase is really HIGH. It dwarfs the use in production – reducing that portion is the next big customer concern.

Q: Is industry positioned to address this issue?

There are a lot of very creative scientists and engineers world wide. Most of the time, it is the lack of resources to be able to focus the talent on the right things. Need to prioritize – what is the most important in front of us today will be changing tomorrow. I believe that when industry focuses, then solutions are found.

Overall, regulations provide a level playing field to everyone. Leading companies are already performing beyond regulations.

Q: When working with suppliers, how do you consider: brand reputation, cost, environment, reliability, speed

No priority – all our suppliers must achieve at a certain level of performance before we talk. All must have ISO 14000, since 2000 transition. They also need ISO 9000.

Our measurement criteria for all the suppliers, includes reliability, ability to develop the products we need, their product development expertise and execution, delivery or operational execution, and environmental programs. Each gets a different total number of points - - but shouldn't be considered a priority, we wouldn't be talking to a supplier who scores below a 70 on our overall scale. Above the 70, score system grades.

Meeting Minutes

Participants: Julie Paquette, MIT; Koen Goosens, Interbrew
Date: December 8, 2004

Koen Goessens and I discussed his perspective on the supply chain response to environmental pressures and legislation as a logistics professional. Koen has been employed by Inbev!, the world's leading beer brewer with more than 200 brands, for approximately four months.

Koen answered a set of informal questions, as follows:

Q: How is you supply chain structured?

Since the merger, supply chain more important. We are decreasing the number of breweries and therefore increasing the number of imports. The overall supply chain structure is varied. In some countries we are completely vertical and other not. It depends on the culture and local habits. In Belgium, we are fully vertically integrated. In Germany, we are not. Europe is diverse from a market point of view. So the supply chain responds to this.

Q: From a SCM point of view, what are your top environmental concerns?

From the corporate level, much of corporate responsibility has to do with alcohol consumption and the quality of the environment because we are a food industry.

Supply chain is influenced by these things as well as anything effecting bottling. Bottling issues affect us more on an implementation level though rather than strategic level.

Q: What is the difference between operational and strategic?

For instance, decisions about bottling materials effect weight etc, so when governments make changes in bottling requirements, such as glass bottles vs. plastic, we adjust transportation and distribution to minimize weight and costs.

Q: Would you say that Interbrew is compliance driven?

Yes. We obey local regulations around the globe.

Q: It seems like the packaging costs in beverage industry must be a high percentage of costs, and being able to reduce these costs would be advantageous.

Yes. But the cost of the packaging affects transport costs. Returnable crates, etc, also drive up our transportation costs. In Europe especially, this is an important consideration.

Q: In terms of new environmental regulations, do you feel that your supply chain is well poised to react?
Yes. We have a diverse market that can handle a diverse number of issues. We also have good local presence.

Q: What do you think are the top concerns going into the future that you will need to deal with?

Consolidation is one of our main supply chain strategies right now. I view environmental concerns as something coming from governments that we need to be able to react to. We need to have transport and distribution networks that are capable of changes in oil prices, etc. It is all on the operational level.

Resiliency in our case is a product of diversity and local presence. We can react to changes quickly, so changes in environmental laws or costs associated with environmental concerned may be handled.

Q: How do you manage suppliers?

Our direct suppliers agree with our corporate responsibility statements. We also work directly with raw material suppliers for quality assurance.

Q: How do you select suppliers – what are the top considerations? Based on the five given?

5. Reputation
2. Cost
3. Environmental performance
1. Reliability
4. Turn around/speed

Interbrew reputation stands on its own, if everything else is in place, we don't care about reputation.

Q: How are compliance activities handled within your company?

We have someone in our corporate office that looks at all of this.

Q: Do you know if there are environmental metrics that they track? (I suggested some: carbon emissions, waste generation, etc.)

Yes, they use all of those. And as a supply chain person I have access to that information, and I use it to know who is performing well and make decisions – but mostly for target setting. The information is shared with facility managers and it has been very effective in improving environmental performance. They provide benchmarks.

Some of the measures that are used include: energy consumption by unit, waste water by unit, etc. We track approximately 10-15 metrics.

Q: In your opinion and experience, do you think environmental concerns will play a larger role in supply chain management in the future?

They are increasingly important because they affect the world wide global network. But it also depends on the industry and the extent to which you operate globally. Supply chain professionals in the future are going to need more diverse skills, understanding finance, environmental and social concerns, and how everything relates to delivering products to customers.

Meeting Minutes

Participants: Julie Paquette, MIT; Dr. Tom Hellman, Executive Vice President, Compliance Services, Limited Brands, Inc.

Date: March 23, 2005

Tom Hellman and I discussed his perspective on the supply chain response to environmental pressures. Tom has a broad background in environmental health, safety, and strategy. He currently serves as executive vice president in compliance services, and has been employed by Limited Brands, Inc. since 2001.

Tom addressed an informal set of questions. His responses are paraphrased below.

The issues that the retail companies face are quite different from other organizations in my experience. With companies such as Bristol Myers Squib and General Electric, which are vertically integrated and highly regulated, products are regulated from inception to end-of-life. This structure does not exist in the same way for retail. Limited Brands supports six brands: Victoria's Secret, The Limited, Express, Henri Bendel, White Barn Candle Co., and Bath & Body Works. These brands may be organized into three business areas, including personal care products, intimate apparel, and clothing and accessories. We deal with a wide range of compliance issues which is complicated by the fast pace of change and demand for new products.

We are very concerned with global climate change and the environmental issues in China. Air and water pollution are very serious issues. I travel to China approximately twice per year, and have noticed increasing levels of air pollution. Though they are trying to address these issues, it is extremely challenging and will likely take the form of command and control regulations in the next 15 years. Energy shortages are a serious concern. The country experiences a sort of "rolling brown out" with planned shut downs at manufacturing facilities weekly. The public in China, and other developing countries, will deal with these environmental problems and demand a governmental and industrial response. Neighboring countries are also affected by this – Hong Kong is the recipient of much of China's air pollution, pollution levels recorded recently in Hong Kong were highest in history.

Since much of our apparel products come from China, environmental regulations – and other types of regulations like labor laws - will impact our supply chain. Across the industry, the supply base will change since some vendors may go out of business or operate differently.

The majority of personal care products are manufactured in US and Europe, with well developed regulations. In the future, it is plausible that more of this work will move to China. China is playing an increasingly important role across the industry, so China's need for reliable, clean energy, changing manufacturing regulations, and transportation issues are critical factors to future plans.

The key question is - how do these concerns for the future translate into activities for today? Limited is currently involved in several product stewardship initiatives, including SC Johnson's Greenlist™ system, which classifies product ingredients according to their impact on the environment and human health. Limited also supports energy efficiency programs for retail locations, and sustainable packaging initiatives with Environmental Defense and Pew Charitable Trust. A lot of this work is information building that we integrate into new products and higher-end products.

A key challenge is balancing environmental sustainability with business goals, of course. For instance, we work with logistics providers who are trying to "green the supply chain" by using more ocean than air transport. Ocean is less expensive and more efficient – but poses a big challenge to fast paced businesses like Express that depend on trendy products with fast turn-around. The business model sometimes makes it difficult to do simple things. Also, in my experience working in other companies – although consumers say they want "environmentally friendly," what they mean is environmentally friendly at the same price and performance. That's the fundamental challenge. Our customers have not demanded an environmentally superior product.

At the same time, Limited cares very much about protecting the brand. In the end, our customers are interested in the product style and function, and there is an emotional attachment to the brand. Environmental expectations and the enforcement of responsible behavior will continue to increase the same way labor expectations have increased. Companies from the US and Europe have forced more responsible practices (as defined by US and EU standards) on their primary vendors because they don't want to risk hurting the brand. Vendors in China and other developing countries who want to sell to the US and Europe typically maintain internal codes of practice and are audited by customers as often as 5-6 times per month.

Appendix B

Questionnaire for semi-structured interviews with electronics industry

The following questionnaire was distributed to electronics industry representatives when first approached for an interview. It was sent again as a reminder and to serve as a general guide during semi-structured interviews.

Supply Chain 2020

This questionnaire was developed as part of the Supply Chain 2020 research initiative exploring critical factors and technologies that will shape supply chains of the future. It is intended to facilitate discussion about the development of reverse supply chains for compliance with the WEEE Directive. Participation in this survey is entirely voluntary.

1. Introductory	a. Does your company have a reverse supply chain for any of the following?	☐ EoL products ☐ unsold products ☐ product returns
	b. With EoL products, what are your reverse supply chain goals? (Choose all that apply.)	☐ WEEE compliance ☐ better customer service ☐ customer loyalty ☐ IP protection ☐ cost savings ☐ new revenue ☐ learning about products ☐ other types of learning
2. Management	a. Where in your company is the EoL reverse supply chain managed? b. How many people are involved in EoL reverse supply chain activity? c. What are the management goals and indicators of success for the reverse supply chain?	
3. Cost	a. What are key cost issues associated with your EoL activities?	
4. Collection	a. How will you collect product from the customer? b. How many collection facilities will be available to your customers? c. Will you engage in partnerships with other organizations, such as retailers, municipalities, or third-party service providers?	
5. Quality	a. What types of products are you accepting? b. How will you handle other manufacturers' EoL products? c. Will you differentiate your collection strategy by product age? d. How will product be sorted at collection facilities?	
6. Quantity	a. How much EoL product are you collecting? b. What is your collection goal? products/month – pounds/year – etc. c. What is your capacity to handle EoL product? In house? Third party?	
7. Timing	a. How frequently will you collect products from customers?	
8. Customer incentives	a. Are there incentives for customers to return products to you? b. What other options are available to them as you see it?	
9. Transportation	a. How will the end-of-life products be transported from collection? b. How far will the EoL products be transported?	

10. Processing

a. Where are your processing facilities located?
b. How many employees will your process require at each facility?
c. What are the processes? Inspection? Sorting? Disassembly? Recycling?
d. What sort of guidelines will be in place to support inspection and sorting?

11. Markets & revenues

a. What material streams are generated from your processes?
b. What is the destination of these material streams?
c. Is there revenue/cost associated with these streams?
d. What are the factors that may affect your ability to create new revenue from EoL product?
   - ☐ future product design
   - ☐ regulations
   - ☐ demand for materials
e. What are the major revenue sources for funding these efforts?
   - ☐ remanufactured product sales
   - ☐ part sales
   - ☐ material sales
   - ☐ fees
   - ☐ other company funds

Thank you for you participation!

Please note: Participating firm names will be withheld from the report unless approved in advance.

Discussion Notes

Participants: Julie Paquette, Jeremy Gregory, MIT; Steve Rockhold, Hewlett Packard

Date: April 25, 2005

Q: Does your company have a reverse supply chain for any of the following?

HP has all three reverse supply chains: EoL products, unsold, and product returns. My area is within EoL.

Q: With EoL products, what are your reverse supply chain goals? (Choose all that apply.)

☑ WEEE compliance: Yes, and other legislative requirements around the world
☑ better customer service: To some degree
☑ increased customer loyalty: There is certainly an element of that
☐ IP protection: No, not as a primary driver
☑ cost savings: Cost avoidance because it may cost us more to have someone else do it for us
☐ new revenue: No – well if we really pushed ourselves perhaps
☐ learning about product use: No
☑ other types of learning: We do learn a bit about how long our products last, we've done some samples in a few situations to approximate any financial accrual. We know PC products coming back are about 7-8 years old.

Q: Is there interaction between those handling the reverse supply chains for returned or unsold product and those working in EoL?

No, not currently - I've worked in those areas previously, and they each require dedicated efforts. For instance, inventory devaluation is a critical concern with forward supply chains and these other types of reverse supply chains. With EoL, it is not a concern at all.

Q: Where in your company is the EoL reverse supply chain being managed?

Imaging and Printing Group for the entire company.

Q: How many people are involved in EoL reverse supply chain management?

There are two people who work with me centrally, and approximately 60 in the group working on take-back, all within the supply chain organization of IPG. The take-back efforts are viewed as an operational liability, so they are managed as an operation. In other companies, take-back and recycling initiatives often fall under EH&S functions. Here, we handle it as an operation with some EH&S overlap. I think this alone demonstrates a higher level of commitment from our business management teams.

Q: What are the management goals and indicators of success for the reverse supply chain?

This is a constant balancing act between operating at the lowest possible cost and effectively mitigating risk. In addition to cost, we focus on risk mitigation and responsible management for public relations and brand protection.

Q: What are key cost issues associated with your EoL reverse supply chain?

Collection, transportation, and processing. The more plastic the more expensive it is. Leaded glass monitors also pose a cost problem.

Q: How will you collect product from the customer?

The collection differs by region and channel.

In North America, we use a combination of pre-paid mailers, home pick-up by UPS and Fed Ex (which the customer pays for), and retail partners like Office Depot.

The Office Depot collection events were great because we can leverage their reverse logistics network and aggregation points. This is also the lowest cost because we're dealing with full truckloads.

In Europe, we collect from municipalities local recycling points. We are required to recycle, some fraction of the dumpsters. Sometimes there are vacuum cleaners, microwave ovens, all sorts of products mixed in the dumpster. There is no sorting by brand or product – so there is no design motivation.

HP has joined with Sony Europe, Braun, and Electrolux to form the European Recycling Platform. The objective of the platform is to cooperate in evaluation, planning, and operation of WEEE compliance activities in the most efficient way. The ERP recently selected a single contractor to facilitate WEEE compliance. ERP supports market-based incentives the need for competition and market-based structures that reward "design for recycling."

With collection, in general, we need partners to share the cost and provide pick-up points in the network. HP is committed to financing the processing, but collection costs should definitely be shared.

Q: How much EoL product are you collecting?

Worldwide we are collecting approximately 120 million pounds of hardware and supplies per year. The break down is about 50% Europe, 40% North America, and 10% Asia.

Q: What is your collection goal? products/month – pounds/year – etc.

Our collection volume is increasing each year and our goal is 1 billion pounds cumulatively from 1987-2007. HP started recycling hardware in 1987.

The recycling initiative is handled under the "Planet Partners" program. Planet Partners was established in 1991 to handle HP LaserJet print cartridges recycling. It expanded to include HP inkjet print cartridges in 1997, and hardware was folded into the Planet Partners program in 1997 after 10 years.

Q: Are there incentives for customers to return products to you?

A mail-back envelope is provided with printer cartridges. Cartridge recycling in the US is about 4 times higher than in Europe – perhaps because of the ease and uniformity of the mailing service.

Q: Where are your processing facilities located?

Roseville, CA
Nashville, TN

Q: How many employees will your process require at each facility?

There are no HP employees at the Nashville facility. The facility is operated by Noranda. We employ 15 on-site HP employees at Roseville, who manage suppliers and oversee operations. We are operating below capacity at both facilities.

Additional comments

The whole industry is immature, run by companies in other businesses such as waste management. WEEE seems misguided, almost like trading one problem for another. Right now, we see limited opportunities in dealing with WEEE.

The Office Depot program was pretty effective, and this sort of partnership preempts legislations. The challenges we are facing now include 1) the CEO of Office Depot is no longer there, so the partnership is in limbo, 2) we are not able to demonstrate that collection events bring store traffic.

There are regulator barriers that prevent the development of better and more competitive services. We are also following what is happening in China pretty closely. China is trying to create their own version of WEEE and RoHS. I think China should capitalize on their industrial infrastructure and look to create a clean recycling industry.

Discussion Notes

Participants: Julie Paquette, MIT; Thomas Marinelli, Philips

Date: May 10, 2005

Q: Does your company have a reverse supply chain?

As a company, Philips is responsible for following legislation. We have representatives in every country to see what the position will be there. In response to the EU's WEEE Directive, we need to build a take-back system in each country according to national requirements. The EU started this directive ten years ago - in 2002 the legislation was final. It was given to all the 25 member states to transpose into their national legislation. There are 2 articles that provide reference for the directive, meaning the member states can have slight adjustments – stricter or not.

Generally, you can use existing companies to meet the requirements in each country. Philips wants to participate in a collective system CRO (collective recycling organization) with competitors. This is important, because Philips is not itself building a reverse supply chain, but participating in a collective recycling system with partners.

Q: With EoL products, what are your reverse supply chain goals? (Choose all that apply.)

☑ WEEE compliance: Yes, this is a primary concern.
☐ better customer service
☐ increased customer loyalty
☐ IP protection
☑ cost savings: This is certainly a goal.
☐ new revenue
☐ learning about product use
☑ other types of learning: Yes, we hope to learn about how well we recycle and recover materials, particularly precious metals.

We also consider what is important for the environment and finances.

Q: Where in your company is the EoL reverse supply chain being managed?

At the moment, we have medical, lighting, consumer electronics, appliances - since the impact is broad, we have different teams working on it. For lighting, there is a central team working on this since the impacts are the biggest. We have representatives in each country, directly or indirectly working with the national governments and building our CRO. I have regular phone conferences with all of them.

Q: How many people are involved in EoL reverse supply chain management?

In consumer electronics, no one is doing this full time. All together, there are between 20 and 30 people involved in this work. In lighting, there are more than 50.

Q: What are the management goals and indicators of success for the reverse supply chain?

We have been active, not only in knowing what government is doing, but also in working with European Parliament to develop amendments through commenting, committee participation, etc. This involvement on a country level is a big impact. So how do we know we are doing a good job in this area? In certain countries we are more effective lobbyist than in others. We are certainly very effective in monitoring.

We are VERY strongly supporting the visible fee. Historical waste can be paid by the visible fee. The mindset in Europe is that the consumers are aware that we need to do more for the environment – so the visible fee is a reminder that the consumer must return the product to a collection point and companies will take it from there. Moreover, the money is needed. Industry cannot afford it without the fee because products are extremely price sensitive. We need a visible fee in consumer electronics especially, because our products are worth so little.

Another factor that is very important is how future waste will be paid. One suggestion is to establish a bank account to recover the costs that will be accrued in future years. However, we don't want to put money actively into such account or pay for insurance. Collective systems address this issue. If someone goes bankrupt, then the other collective participants have committed to take responsibility for their market share. This eliminates the necessity to put money aside or add insurance, although some may want insurance in addition.

Each country differs on this point. France wants insurance for one year - millions of Euro. Although for participants in the collective system - 3 months is required. Germany requires a small percentage as insurance, but only because the collective system is standing behind it. Nonetheless, there are companies that are using an individual approach to the ERP as opposed to the collective system. They are convinced that they can do it cheaper.

All that said, two primary management goals are: 1) to operate in a collective system, and 2) to minimize investment. I'll add one more: to deliver the same set of data to each country. For this we are pushing legislators for harmonization across the EU.

Q: What are key cost issues associated with your EoL reverse supply chain?

The cost depends of course on how well the system will be arranged in the future. Generally we spend 0.5E/kg which includes 30% logistics, 20% processing. Administrative costs are and will be very high.

Q: How will you collect product from the customer?

This varies by country. We generally use municipality facilities.

Q: How much EoL product are you collecting?

In the Netherlands, the legal requirement is 5 kg/inhabitant/year. We are well above that at about 6 kilos. In some countries such as Poland, you will never get 4 kilos back per inhabitant each year because of geographic constraints or welfare. In Poland, this would require 95% collection.

In terms of processing capacity – countries such as Germany, France, and the Netherlands have many facilities. Others like in the UK are building up. I'm sure that the Baltic States are going to build facilities.

There are several entrepreneurs who are joining this industry and this is just the beginning. The industry will build up as the Directive evolves. The way it's running in Belgium and the Netherlands is great.

Philips does not link to one company or logistics provider – we go with what is available. The company who is complying with all the rules and offers the best price gets our business. There is a WEEE forum to help industry – there is support and visits to existing sites. I have no doubt we will be successful in the end, but how quickly is the question.

Q: What are the major revenue sources for funding these efforts?

☐ remanufactured product sales
☐ part sales
☐ material sales
☐ fees
☑ other company funds: Yes, the producer has to pay.

With consumer electronics, we are not seeing end value. The collection processes and recycling will not be compensated. In fact, there are only a couple of products which have a positive end value, including mobile phones. The fee on lamps is nearly half of the cost of the product.

So in the end, it will be company funds that cover these efforts. As a representative of Philips, this may be difficult. But as a citizen, I'm asking for an environment that is good for my kids, and I expect to make this contribution.

Discussion Notes

Participants: Julie Paquette, MIT; Bill Olson, Motorola

Date: April 25, 2005

Q: Does your company have a reverse supply chains?

Yes, we have processes in place for EoL products, unsold products, and product returns. Depending on the type of return, we have preferred vendors who do recycling and various mechanisms for getting them back. We use envelopes and collection bins, programs – such as the race to recycle program where schools can earn $3 per phone up to $2100 per school, similar programs in China the green van program, and in Europe we are leveraging the country take-back programs.

Q: With EoL products, what are your reverse supply chain goals?

☑ WEEE compliance: This is our #1 concern as we have to comply and provide take-back mechanisms.
☑ Better customer service: I would rank this concern #2, certainly in terms of the warranty repair service.
☑ Increased customer loyalty: I consider this our #3 concern in these efforts.
☐ IP protection: I feel that this goal is dubious at best even with PC take-back efforts.
☐ Cost savings
☐ New revenue: This is not my primary goal.
☑ Learning about product use: Yes, this is a concern certainly on products being returned, but not with the EoL.
☐ Other types of learning

Q: Where in your company is the EoL reverse supply chain being managed?

We treat the EoL reverse supply chain as a business function. At Motorola, all the supply chain functions from each business area were just organized into one function. Previously, each business area was separate and each had unique reverse supply chain needs. For instance, base station and cell phone reverse supply chain didn't involve the same people. Base stations are almost like an appliance business - you may need to remove the station and this requires more customer interaction. This is very different than coordinating cell phone take-back.
By combining all the supply chain management functions, we are hoping to have consistent management processes and goals across procurement.

Q: How many people are involved in EoL reverse supply chain management?

This is a hard question to answer – I don't know off-hand. We may partner with 3 recyclers in one country and 2 in another. In Germany, we are paying the government's country systems and we pay by our market share. Our efforts vary so much, I couldn't say how many people in Motorola are working full time on reverse logistics.

Q: What are the management goals and indicators of success for the reverse supply chain?

Good question. You need to have a process in place. You have a cost associated with the process and then you have the refurbishment and resale. Out-of-date products are one thing – a

judgment call has to be made. How you make that judgment is mainly an economic decision. When you test a phone, you may be willing to invest a certain amount of money to refurbish. Motorola has established guidelines for decision-making here.
So mainly, economic metrics are used.

Q: What are key cost issues associated with your EoL reverse supply chain?

Shipping is the big cost issue. Labor isn't all that much in the relative scheme of things. Materials to repair and inventory are also a concern.

Shipping and providing financial incentives for collection from customers are big concerns. If you are buying phones from people, paying for shipping, and repairing, those are all significant key costs.

Q: How will you collect product from the customer?

Right now we are testing a pre-paid product return envelope in a couple of places through Europe, including Germany. It is hard to say whether or not this method is the cheapest or most effective. Compare it to the Club Nokia approach. Nokia is using the "club" for purchasing – they are also leveraging it for take-back. I would say that the envelope approach is an effective one that facilitates a more direct relationship with customer. We know it works – it may not be the only way – but it works. The envelope approach also might seem expensive because of shipping, but if you are building an organization to comply with law, investors appreciate an approach that is proven.

Also, we have warranty repair processes that we've been doing for years. If anything, we are augmenting those processes with take-back efforts.

Q: Will you engage in partnerships with other organizations, such as retailers, municipalities, or third-party service providers?

We partner with other organizations and we will continue to do so. This varies considerably by country. In some cases, the government requires partnership. For instance, Motorola sells "x" amount, the government calculates what we are responsible for, they provide the take back system, and they expect Motorola to pay for it. In other countries, we may say that we are going to contract with Company "x" and we pay them to handle take-back. In the countries where we have envelopes – we handle take-back ourselves.

I equate this situation to a visit to the hospital. If you went into a hospital with several health problems, you would not have a cure all. Maybe Club Nokia works well for Nokia in some cases. For us, we are doing a number of different initiatives in the market which vary according to country restrictions.

Q: What types of products are you accepting?

We take it all. We take any manufacturer's phone.

Q: How much EoL product are you collecting?

This is a difficult question to answer, because for example, we have no idea how much is going into the German system. I know specific customer information – but I can't release that because it's sensitive.

Q: What is your collection goal?

Goal for the school program in the US is 3 million pounds in 2005 - -but this is a drop in the bucket compared to the entire cell phone market.

Through this program, Motorola is helping to develop relationships with future purchasers and we could potentially refurbish and resell the products we are collecting. So there is opportunity and also a lot of goodwill in this program. There is some amount of money that is being lost through this effort. But overall, this program is win-win.

In comparison, in England or Germany, they were buying phones fro 10 Euros a piece. I can't believe they were making money on that.

Q: Where are your processing facilities located?

We have relationships with trusted vendors in several locations. We don't process the product ourselves. We have trusted relationships, but no public partners "officially certified by Motorola," it is all competitively bid annually.

My feeling is that processing is a competitive industry, and it's going to grow just by the nature and magnitude of take-back that's going to be required. Processing is well developed in some countries, like Japan. There, the system works and they make money because take-back and processing is typically operated by the company itself like in white-wares. I think we'll see more – there's tons of recyclers in Europe. Some people have their own processes, non-toxic etc. But energy into a process makes it uneconomic, and disposing some inert material may be better than processing. There's trade-offs between everything.

Ultimately, my view is that this industry will grow like waste industry. First small "mom & pop" shops will offer services, then it will consolidate into a larger industry, and finally someone will buy it up and become the low cost provider in a particular service. It's just a matter of time.

When you collect 3 million phones, there's going to be a sorting process that occurs. You look for products that can be resold or donated. Although, the bulk of it is not something that someone is going to buy again. Right now, warranty repair centers are centralized and handle much of the take-back in the US. But at 100,000 million phones a year this approach would be phased out.

Q: What material streams are generated from your processes? What is the relative magnitude of material streams?

When we refurbish and resell – we see revenue from that.
When we donate – we get tax credit from charity.
When we have e-waste disposed of – we get some material revenue.

There are revenue streams and material streams. A certain percentage of our plastic is reused. At the end of the day, when something is broken, its scrap and frankly it is not worth much.

When you are at a level of collecting 100,000 million lbs/year, you're expected to be profitable enough to afford the efforts. This is all about lifecycle product and price management – we'll have to plan take-back efforts into the product cycle. These plans are already underway to an extent, the problem comes in with a warranty repair problems – say we were using a Microsoft operating system and we would have to reload – you can't really plan for those things. But for EoL, absolutely you can plan.

In the future, I think that recovery fees will either be built into the price of the phone or added as a fee. I don't think that the provisioning models that work for the automotive industry will work for the cell phone industry, because our products don't last as long, the investment in components isn't as high, and sometimes it's cheaper to get a completely new product rather than repair an older model. Remanufactured auto parts represent a huge industry – but a completely different industry model.

But could this change? Perhaps.

Q: What is the ideal outcome of all of these efforts in your opinion?

I think that ideally, it's a system by which products have value at their end-of-life, sufficient enough to provide the customer incentives for recycling and so that these older products serve as a resource for companies in making new products.

Ideal would be a microprocessor that gets used for its intended lifetime, rather than just once and then ground up and smelted for a fraction of its value.

Where will we end up ultimately? I'm not sure. If you look at the computer industry, you see more resale and remanufacture than consumer hand-held electronic units. But the more valuable the product, the more such a model may apply. In China, consumers don't throw these products away – they give them to others, adding millions to the network. They have much longer lives. If we start looking at tangible assets as having longer lives – we could extend them by design.

Discussion Notes

Participants: Julie Paquette, MIT; Representative from major printer manufacturer

Date: July 7, 2005

Q: Does your company have a reverse supply chain for any of the following?

Yes, we have a reverse supply chain in place to handle products returned on warranty, obsolete and broken products, and end-of-life products returned from customers.

Our end-of-life program as described on the website was started 2 years ago at the request of our parent company. Our parent company feels that environmental activities are very important and is very active in this area. They have a 5-year environmental plan, a 7-year environmental plan, etc. There are many components to these plans, and one of which is to provide this return service to our customers.

We base our end-of-life offering on what our competitors do. It is a very expensive undertaking, so we chose a "vanilla" approach. We take only our stuff (as opposed to our competitors.) We charge customers $10 and offer them a $5 coupon for future purchase. Customers receive a pre-paid mailer to send their equipment directly to our processor. This is a break-even, non-profit approach – the $10 covers all of our expenses.

We currently receive a very small number of printers per month. We don't track demographics of the people who return their products. We presume that they return the product to us because there are no resources available in their communities. Sometimes, there are corporate or institutional customers who return products to us. Perhaps it is easier for them to do this than find another alternative.

Q: How much EoL product are you collecting?

Total processing is approximately 2 million pounds per year, consisting of equipment from product returns, obsolete product and broken products.

Q: Where are your processing facilities located?

Currently we have 2 processors across the country. Our original partnership was with an organization in the mid-west. We have also been working with a company here in Los Angeles for the past year and a half. They have a process in place that has been recognized by many, including the state of California and NGOS, to result in 100% materials recycling, with no land-fill, no incineration, and no pollution. We started with them on ink cartridges, at 100,000 lbs per month. We made the decision to move the bulk of waste out of a processing from the Midwest to LA. The environmental benefit was so great --- the shipping and processing is about double in cost - - We are transitioning from one to the another

Q: What are key cost issues associated with your reverse supply chain?

Transportation and processing fees.

Q: Where in your company is the reverse supply chain being managed?

Our reverse supply chain for broken and obsolete products is managed out of the main distribution center in Indianapolis. They have a warehouse that manages inflow and outflow.

There is limited space, so they know everything that goes in and out. They ship full trucks each week with full containers. This takes a lot of planning.

Several of us are involved in monitoring different parts of these activities. The warranty group monitors the defective product and sends a new product. So there's a lot of management of reverse supply chain functionality in Indiana.

There are only a couple of us who look at environmental issues – one in Indianapolis and my self. I have a lot of contact with our parent company because I am involved in all the legislative issues. In the US, there are 9 states that have requirements relating to mercury labeling. The laws are very complicated and nothing is manufactured here, so we have to interpret this legislation for Japan. You need to label this product in this place, etc. - all those requirements need to be communicated clearly.

We do have a very large global environmental policy division in Japan.

Q: What are the management goals and indicators of success for the reverse supply chain?

There are many goals. For one thing, we'd like to get fewer items back. Selling a product that is more durable and easier to use is a goal.

Indicators of success? Right now, it's cost reduction. Our switch to the processor in Los Angeles doubled the cost of processing. It is very difficult to make a case for this – it was a battle that took months and months.

Q: Are there incentives for customers to return products to you?

Our research shows that most people don't care about end-of-life offerings. We are a sales and marketing organization – so to take on more voluntary programs wouldn't make sense. If legislation required it, of course we would make efforts to provide incentives and offer services.

I struggle with this question a little bit, because people own their stuff. Is Epson in the position to tell them what they should do with it? There is no clear advantage for us to increase that return rate. As a business, why would we provide incentives for customers to do so? We've provided an easy program – what more can we do?

Q: What are the major revenue sources for funding these efforts?

There are a couple of revenue sources. They're kind of small. If there was a return on our activities in this area, we would have found it. For example, if you can get ink cartridges back, you keep them out of the hands of the refillers. We don't have an ink cartridge collection program. Also, by taking other company's products, you might persuade the customer to buy your product. But I feel this benefit is negligible. Doing the "right thing" doesn't seem to have much return. This issue is a real challenge.

Discussion Notes

Participants: Julie Paquette, MIT; Ken Hashman, Dell

Date: May 10, 2005

Q: Does your company have a reverse supply chain for any of the following?

We have processes in place for all three: EoL products, unsold products, and product returns.

Within EoL, we are most active in 2 areas. First, we have a process to supply our service parts. Any part, however, that is we end up with at the end of that process, we send into a secondary channel. If you search "Dell spare parts" on google, you will see all these parts in the secondary market. If they're old – we might recycle them.

The more interesting area for us is our Asset Recovery Services, where we take back old units from customers when deploying new systems. We've offered this service for a long time for end of lease customers, but it's something that has really caught on in the last 2-3 years because of increased concerns of data privacy, increased awareness of the environmental impact of improper disposal, and liability concerns. We've focused on corporate clients – we see it as a profit opportunity. Basically, when we sell to corporations, we go and take their computers, wipe their hard-drives, give them certificates of assurance, and recycling certificates. We resell those models that have value and give the client the money.

Asset Recovery has been most successful for us within education. For instance, with Chicago public schools, we were able to offer a "clean the closet" service. If you're buying 100,000 Dell computers, we'll come and take your 100,000 electronic devices that have been sitting in storage. It's been good on the corporate side because in addition to Asset Recovery, we've done a lot of community based "take-back events" with large customers.

Consumer side recovery is a bigger challenge. We've tried a number of incentive programs - free recycling of your old computer when you buy a new, $10 recycling, $0.99 recycling – all with limited success. Currently, when you buy a new printer, you get a free mailing label for the old printer. We've seen better recovery rates on printers than PCs, but still very small.

So right now, Dell is pursuing a two-fold approach. First, we are hosting collection events. We've done a number of events in Austin, Denver, Portland, Atlanta, and others. We'll do a recycling event with a community with a bunch of trucks. We'll also partner with local communities in conjunction with large corporations – like Ford and Dell host a big event together to generate good will for both companies. Second, we are working on a partnership with Good Will to collect electronic waste – we know this model works well with consumers.

In Austin, the Good Will is going to have a computer works location, where they de-manufacture computers and send them out for recycling. The goal is to break even. It's a nice model. It provides jobs and it solves the collection issue in part. In Austin, we lent our expertise to Good Will in building partnerships, "these are the companies we use.....glass, cable, etc...." and we lent them our name for PR.

San Francisco is our second test case. Good Will provides collection point, and we'll send a truck and pick the equipment up. It's a very cost effective way for us to do this. Pre-printed mailers are very expensive.

Q: Where in your company is the EoL reverse supply chain being managed?

I sit in the deployment services group, which is a profit center. While we are not making money on the consumer programs, we are making money on the commercial side.

It is our people who are removing the old computers to put into our reverse logistics network. We partner with organizations that sort equipment and wipe data. They determine what good equipment can be sold and help us sell for value. They either recycle the rest of the equipment themselves or send it to a second tier recycler.

We manage both Tier 1 and Tier 2, and we contract a third party to audit the downstream waste. We meet with them to ask specific questions like, "where do send the cable?" We manage all of this because we don't want to expose ourselves to the liability and the public relations risks of an irresponsible partner.

It's interesting because recycling and recovery is definitely a cottage industry. Competition is with small firms – local unsophisticated shops. But we've seen increased interest in venture capital to go and buy out these small firms because they see the potential in this whole industry. In fact, I've met with 3 VC firms who are thinking about it. Personally, I think there's money to be made if you do it right – the key is a building a firm that can provide good value for new as well as recycle the old.

Q: How much EoL product are you collecting?

We publish an environmental report that describes all our collection volumes. It is available online.

Q: How does your collection system differ in Europe?

Europe is interesting - I can refer you to the person who runs the recovery business in Europe. Customers still need to get their assets to a collection point, so they still want the services that we are offering here. In some ways, I think the new legislation in Europe helps us because it builds awareness. There are different legislative models emerging everywhere, which we track. Personally, I don't think the California advanced recovery fee will work, because it's still up to the consumer or the end user to take their computer back to collection points. It's hard to see how they'll do that...which is really where our Good Will partnerships may play a role.

Q: Where are your processing facilities located?

We have one central facility that everything from around the country comes back to and then a handful of processing partners in a few states. We are looking to migrate from the one central point to regional – maybe 3 locations altogether. Any more than three would be too hard to manage, particularly with the data destruction process. We'd rather err on the side of control. Right now, the one facility is in Dallas – we may move to one in Ohio and one on the west coast.

Q: What are the major revenue sources for funding these efforts?

The residual value you receive from the second tier recyclers is very small. So our goal really is to break even. The national Goodwill model should get us there, and we're playing with a lot of models right now to see what works.

The real issue is driving customer participation. I don't think legislation is necessarily the answer – you need the private sector to solve the problem. However, if government were to get more involved in the US, I think curbside collection would be the easiest answer. Recycling on the curb – you could see that evolve successfully like existing recycling and trash collection.

Discussion Notes

Participants: Julie Paquette, MIT; Representative from major television manufacturing company that is undergoing transition.

Date: July 19th, 2005

Q: How do your ownerships changes affect your interest in electronics end-of-life?

Prior to the sale of our television business, we were very active in NEPSI and the Electronic Manufacturer's Coalition for Responsible Recycling. We are strong advocates of the Advanced Recycling Fee (ARF) as the best approach to financing management of end-of-life electronics at the state and national levels.

I've sent you a number of materials that outline the reasons for our support of the ARF approach. In short, we believe it will be the least expensive overall, easiest to implement, and most appropriate to transfer from a state-level to a national system.

Since the sale, we are relatively less active in this area of advocacy. However, we still support the ARF approach and remain active in other areas of environmental activity.

Discussion Notes

Participants: Julie Paquette, MIT; Klaus Hieronymi, HP

Date: August 2, 2005

The European Recycling Platform (ERP) is a collective system, in that it represents many manufacturers coming together to fulfill their obligation on take-back jointly. ERP is different, however, than collective systems where all manufacturers are forced to work together. For instance, in Belgium there is no choice in operation. Manufacturers are forced to use a single system. All the European member states are different in this respect. Austria is a good example for us to discuss because it is a small country with very well-developed legislation. Many countries have delayed implementation until the first quarter of 2006, but Austria will be implementing on August 13th.

Q: Why did HP co-found this initiative?

This decision was based primarily on our experience with packaging laws. In Germany when packaging laws were established in 1991, there were only two compliance solutions. Manufacturers could take back their own packaging or they could join a collective system called the Green Dot. In 1995, I began managing environmental programs in Germany. I realized that a large percentage of my budget was being spent on the Green Dot system. I tried to meet with them and it took 9 months for a meeting. After this point, the government tried to assist the situation by setting up 6 competitors to the Green Dot system. We were paying $350E/ton then, but today in 2005, it is $70 per ton. This competition drives down cost and increases service.

I should mention that we are still a member of Green Dot for a small percentage of our work, but we do not wait 9 months for a meeting now.

To draw comparisons, the cost of WEEE will be significantly higher than packaging compliance. We don't know how much more expensive exactly, because it is still under development - - but we assume 10 times higher. This prompts two primary concerns. We want a choice in systems, and we do not want to comply with 25 separate national systems. Choice and competition drives down costs. Uniformity drives down costs. With separate systems, we would need 25 highly-educated people protecting our interests in each country.

Hewlett Packard's vision for 2012 is that there will be four or five European Consortium systems competing in all 25 countries. Promoting such a competitive system has been our strategic approach for the past two years.

Q: Why did these five particular companies come together?

These five companies all support the principle of individual producer responsibility. Electrolux, for instance, ran a campaign a couple of years ago showing a neighbor's trash in a yard, writing "why should I care about my neighbors waste?" It is agreement that you will only achieve better product if you make the individual manufacturer responsible. The time for socialist/communal systems has passed.

When we began looking to buy take-back services, we didn't find service providers with a "European" view. Many of the industries in Europe are not organized on a European-wide basis, rather, they are still nationalistic. HP is very European and our main decisions are made on a European level. The cost of take-back is managed on a European level, in fact. I own the budget for the entire continent. I can optimize on a pan-European basis. I think HP has a very innovative approach in centralizing as much as we can. We couldn't find service providers – we had to create the market. So we started the ERP in November 2004. We needed external expertise so solicited a study from Accenture, which projected a 30% savings. We should keep in mind that for HP this is just an interim solution. Hopefully, eventually – ERP will be independent. We would like to see 3-5 systems competing for our business. We will consider competition from other consortia to be one of the first signs of success.

In Austria, we have seen that 4 consortia have applied for a permit. Why is this good? Because every manufacturer will have this choice in Austria. There are 5 waste categories. ERP is not participating in fluorescent lamps because none of our founding members have an obligation for this. We are offering all other services.

In addition, we have seen prices in the last two weeks in Austria. Prices from ERP are the lowest in the market because we do not have to establish a specific overhead for Austria. We have European overhead. We learned that European overhead equates to the same as overhead for two or three individual countries.

Across Europe, we see that systems in Spain and Ireland are offering prices that are much lower than those from countries with a single monopolistic system. Sweden, Norway, Belgium, and Switzerland all went for a local monopolistic solution.

ERP uses competition internally and externally. We use two general contractors. CCR is a waste management company based in Germany, and they will be handling take-back in Italy, Austria, Germany, and Poland. Geodis is a large French logistics company with about 45,000 employees who will be handling Ireland, UK, Portugal, and Spain. We chose these two contractors out of 15-16 applicants. We chose two so that one could cover the other if necessary.

Q: How will the actual take-back happen in most countries?

Europe is not Europe. Europe is a bunch of countries that do whatever they like and do not care about their neighbors. Each country is different. In Austria, they collect waste in their municipalities in five separate categories: lamps, televisions and monitors, refrigerators, above 50 cm, and below 50 cm. In Germany, waste is separated into cooling, other large domestic appliances, consumer electronics including television and information technology, small household goods, and power tools. In UK, there is no separation. This difference in procedure is one of the biggest challenges for all companies.

Q: What about insurance?

This is another area where countries do not follow the WEEE Directive explicitly. WEEE requires that you assume responsibility for the products that you put onto the market after August 2005. All of industry is jointly responsible for products put out before that date. This means that HP and other manufacturers are responsible for brands from companies that are no longer in existence. These are called orphaned products. Moving forward, the legislation requires all companies to put a "guarantee" which insures that if you leave the market, there are funds available for recycling. One way to cover that guarantee is to cooperate with a bank or insurance company. To make a long story short - - only Germany is following this part of the directive.

In Germany, they differentiate between financial and operational responsibilities. ERP members will pay either based on market share or only for their product. At the end of the day they need someone who goes out and picks up their products for recycling. HP will register ERP with the government body. If HP is selling 25% of the market, then the agency will know that every fourth container will go to ERP. In other countries around the world, like Korea, they organize geographically. These volumes, while varying, are very predictable. There are some peaks seasonally.

Q: How do you feel enforcement will work on this?

Enforcement is critical, and we would like governments to try hard to do this. But we are not sure they will do so. They feel that industry should regulate itself. Different countries have different approaches. All countries will require companies to register themselves with a number which you will put on every invoice. This will help. The other way is to publish the brand names participating and reward companies that have done well. Relying on the government may not be the right strategy. HP and others actually end up paying for companies that are cheating the system.

Big names will not purposefully work around the system because there is too much to risk in a brand name. But small importers will try to avoid the system for $500. You shouldn't do that in Denmark, because the penalties include imprisonment of the CEO for two years.

Discussion Notes

Participants: Julie Paquette, MIT; Representative from major cellular phone manufacturer

Date: August 3, 2005

Q: Does your company have reverse supply chains for product returns, obsolete product, and end-of-life?

Yes, we have these three product return mechanisms. Warrantees are handled through our customer care group. Obsolete and EoL are handled differently, and this really depends on the customer. It is also worth noting that Nokia's programs are area specific. What we do in APEC and China are completely different than what happens elsewhere. I manage and will be speaking about the American Time Zone.

Q: Where in your company is the EoL reverse supply chain being managed?

I handle EoL for the ATZ, and we have several material flows. With regard to EoL phones from consumers, we have a few different approaches. We have our own website which provides return directions and free mailing. These phones come directly to Forth Worth. We are also supporting the E-bay RETHINK initiative, which is an information clearinghouse with many manufacturers partnering.

We do not separate these EoL phones. We typically receive products that are 24 months or older, because anything else would be sent to warranty repair. The recycling facility may make some determinations about the phones: Can anything else be used again? Can parts be used in other applications? However, we do segregate into three groups – handsets, accessories, and batteries. Lithium-ion batteries are sent straight to cobalt processors. Cobalt is recovered from the batteries and sent back to our manufacturers. The accessories themselves are sent to copper smelters. Main circuit boards go to precious metal recovery. LEDs also go to precious metal for gold and palladium.

Q: How will you collect product from the customer?

We are hoping to develop a partnership with the US Postal Service to provide collection bins at the post office. There are 38,000 post offices in the US. Collection there would solve the "first mile" problem. If people bring them to the post office, we can take back larger volumes at one time, rather than one at a time. We are also investigating including free mailers with new phones.

We have a variety of collection initiatives right now. We operate 300 service centers with collection bins. We collect phones at all of our factories and offices. We're also launching "experience centers" in malls and shopping centers which show Nokia products. We'll place collection bins there. We sponsor various functions during the year, including the Sugar Bowl. So we set up demonstrations of products and collect phones.

These collection points are helpful, but they don't reach out as much as the internet or post office. On our own website, we have 11 million subscribers to our newsletter and we send out communication all the time. But it is hard to provide incentives for customers to return phones. I read in a recent EPA report that 78% of cell phones are sitting around people's homes. When consumers choose to upgrade their phones, it is very easy to just throw your old phone in a drawer. They are not intrusive.

There are several alliances in the US to address this. A Senate panel held a hearing about it last week.

Q: How much EoL product are you collecting?

The only way that I can really answer that is we have 5 main flows.

1. In the ATZ, we have 3 production factories located in Brazil, Texas, and Mexico. They produce paper products, plastics, cardboard, and electronics.

2. We have flow from our repair centers. This may include spare parts, plastic frames, or LEDs for instance.

3. We have flow from our R&D facilities. This material is very critical for EoL.

4. We have flow from our take-back, which includes phones from consumers and also networking equipment which is an entirely different challenge.

5. Office products – we have computers and monitors etc, like everyone else.

I think centrally managing all of these flows makes a lot of sense, because there is an expertise here. Looking at this holistically gives us a pretty good feel for what is happening across the board. We realize early on that if we were going to take advantage of the best EoL options – we really needed volume. By combining all of these material flows, we get better volume.

Cell phones operate through network bay stations which are located about every 10 miles. With the merger of Cingular and AT&T wireless, there were two network bay stations located in many areas when you only need one. Right now, we are responsible for removing unnecessary networking equipment. From a logistics standpoint, this is a huge challenge. We are averaging 100,000 lbs per day.

With phone take-back, typically we see about 300-500 phones per month. Since the partnership with E-bay began, we see about 3,000 phones per month. We anticipate that this number will increase when we tie-in purchase of a new product with return of old product.

Do we have goals? No. We just want as many phones back as we can get.

Another key challenge in all of this is that we "compete" with the retailers for take-back. The retailers and service providers have 2,700 locations between them where people go to buy new phones and naturally, return their old phones. Retailers are just a lot more visible.

Q: Can you tell me a bit about your professional background?

I worked for a precious metal refining company for 18 years. I set up collection facilities throughout the world, handling reverse logistics and segregation.

I think there is a lot of room for improvement in this industry. Right now, there's incredible growth, and companies that research this will find some companies with very impressive processing capabilities. The really good ones can do a lot – they can take products from mainframe computers all the way down to phones, put them into shredders that separate all the various components into almost usable material.

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