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Integrating Environmental Management and Supply Chain Strategies

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ABSTRACT
The decisions related to managing the supply chain and supply chain strategy are already considered important in many organizations. As more executives adopt environmental practices, supply chain strategies will only increase in importance. In this paper, we review how companies develop environmental supply chain strategies. Our interviews with companies from The United States, The United Kingdom, Japan and Korea, along with prior research, are used to develop a framework for environmental supply chain strategy decision-making. We then use this framework to suggest guidelines for how companies might change their current supply chain practices to successfully integrate environmental issues into their supply chain strategy. Copyright © 2005 John Wiley & Sons, Ltd and ERP Environment.

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Forces Driving Proactive Integration of Environmental Practices with Supply Chain Management

STRATEGIC SUPPLY CHAIN MANAGEMENT HAS GAINED STATURE IN THE STRATEGIC PLANNING PROCESS in organizations. Considerable research has shown that companies increasingly rely on their suppliers for competitive success (Hahn *et al.*, 1990). As companies focus more tightly on their core competencies, they will rely more heavily on their suppliers for non-core activities such as new product development through early design and concurrent engineering (Prahalad and Hamel, 1990). With the added responsibilities being placed on the supply chain, businesses also find environmental risks can be passed on through suppliers. This additional risk brings about an opportunity for environmentally conscious supply chain management to impact both environmental and financial performance.

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With companies increasingly relying on their supplier's environmental performance (Narasimhan and Carter, 1998), managers are coming to understand that environmental compliance is not sufficient; governments and consumers require better environmental stewardship. Environmental performance and the move to lean manufacturing, with its incumbent focus on cost effectiveness, exert greater pressure on materials departments to seek cost reductions in all materials-oriented processes, including disposal (Womack *et al.*, 1990).

Discussions of environmental performance have usually focused on industries such as chemicals, petrochemicals, mining and semiconductors. Recently, though, managers have come to realize that a large and increasing amount of environmental risk can be found in nearly every company's supply chain. This realization highlights the fact that decisions in this area are increasing in importance. So, two apparently divergent business trends meet: the acceptance of supply chain strategy for competitive advantage and the role of environmental performance in competitive advantage. In addition to traditional performance dimensions of cost, quality, delivery and technology, managers must also consider the impact of their decisions on the environment. These forces together make it difficult for a company to manage suppliers based on strict compliance; they require a more proactive or strategic approach.

The increasing interest in integrating environmental practices and business finds researchers considering 'ecological sustainability' as a framework for studying management practices (Sarkis and Rasheed, 1995; Klassen, 1993; Klassen and McLaughlin, 1993; Wood, 1991). 'Environmentally conscious business' now influences product design (Allenby, 1993; Sroufe *et al.*, 2000), process design (Porter and van der Linde, 1995a, 1995b), manufacturing practices (Gupta, 1995; Klassen and McLaughlin, 1996; Thierry *et al.*, 1995; Winsemius and Guntram, 1992) and more recently purchasing. In this paper, we draw on more than 34 interviews with purchasing managers from 17 global organizations in the US, Japan, the UK and Korea with the purpose of defining environmental supply chain management and presenting a framework that describes how strategic goals can be linked to materials strategy and specific commodity strategies. This is accomplished by examining the traditional 'commodity strategy development process', and identifying how the process is modified when considering the effect of environmental issues. The resulting framework provides some important guidelines for managers to follow in managing their supply chain relationships. Next, we discuss and describe commodity and environmental strategy development. We then discuss the methods used to obtain environmental supply chain information from several multinational companies and then review environmental supply chain management, and the steps used by firms to develop a green commodity strategy.

Linking Business, Commodity and Environmental Strategies

With the competitive landscape companies currently operate in changing so quickly, the activities of every function in an organization must be proactive if they are to continually enhance market position and competitive strength. These activities include better management of resources by focusing on minimizing environmental impact (Anderson and Bateman, 2000). This new focus for purchasing practitioners requires the sourcing function to develop strategies more comprehensive than 'deliver maximum efficiency' or 'achieve lowest materials cost'. For the purpose of this study an environmental sourcing strategy formally integrates environmental issues with supply base and purchasing process activities. An effective environmental sourcing strategy must fit with the needs and goals of the company; strategic consistency is paramount. Unfortunately, one cannot assume that supply chain executives can easily claim their position in the business-level strategy development and planning process (Anderson and Bateman, 2000). Only when purchasing and logistics adopt a strategic orientation can they readily be

included in business-level strategy, and inclusion is the only way to ensure integration of purchasing with business strategy.

Integration of environmental performance with business and functional strategies is a dynamic, two-way process that relies on a number of information sources, including corporate objectives, business unit and functional capabilities, market objectives, competitive pressures and customer requirements. The direct environmental input provided by functional and business-level executives to the business strategy development process drives strategic integration. In the end, a top-down communication structure cannot result in an integrated business and functional strategy. Linking environmental business strategy to each functional strategy has the added advantage of linking all the functional strategies to one another, which helps to remove many of the barriers to environmental integration.

The process of linking purchasing and business strategy results in clear functional objectives that drive the formulation of specific environmental strategies for purchased materials, or commodities. However, supply chain strategies are never truly 'implemented' until they are integrated at the commodity or product family level.

What is a Commodity Strategy?

Figure 1 shows that strategic consistency causes business-level strategy to drive functional-level strategies. Similarly, an environmental sourcing strategy becomes a driver for a series of lower-level tactical and operational decisions, including the use of an environmental commodity strategy. The term 'commodity' is used in supply chain management to refer to a general class of purchased items, so a commodity strategy is the specific decisions concerning sources of supply, number of suppliers, number of stocking points and relationship with suppliers that a company makes concerning any single commodity, while staying within the boundaries defined by the purchasing strategy. What has been overlooked in the literature to date is the integration of environmental concerns such as redesign, substitutes, reduction, extension of the product life cycle and support for environmentally conscious suppliers into supply chain management via the primary vehicle for deployment: the commodity strategy.

The Role of the Environment in Supply Chain Strategy Development

When a company makes supply chain decisions such as which supplier to buy from, whether to implement vendor managed inventory or what method of distribution to use, the company implicitly accepts the waste stream generated because of the decision. For example, in selecting a supplier the company 'buys' the item desired, the waste created during the production of the good or service purchased and the waste associated with the disposal of the product at the end of its useful life. Some companies worry about assuming legal liability for their suppliers' environmental problems and would rather not know about problems with their supplier. These firms create barriers to environmental supply chain management and overlook the importance of documentation and strong relationships with proactive environmentally conscious suppliers. International certification programs such as ISO 14001 recognize this issue and place a high priority on documentation of processes (Tibor and Feldman, 1996; Cascio, 1996).

Top management at the companies we visited recognized the importance of environmental issues in the supply chain. For example, furniture manufacturer Herman Miller goes beyond a myopic focus on financial returns because the company philosophy developed by its founder embraces 'being a steward for the environment'. This strategy has driven many of their green supply chain efforts. Similarly, at Ford Motor Company, Jacques Nassar emphasized the importance of the environment in his weekly 'memos' to employees, and highlighted actions occurring within product design or supplier management that resulted in a cleaner environment. In some cases, top executive support was partly a result of

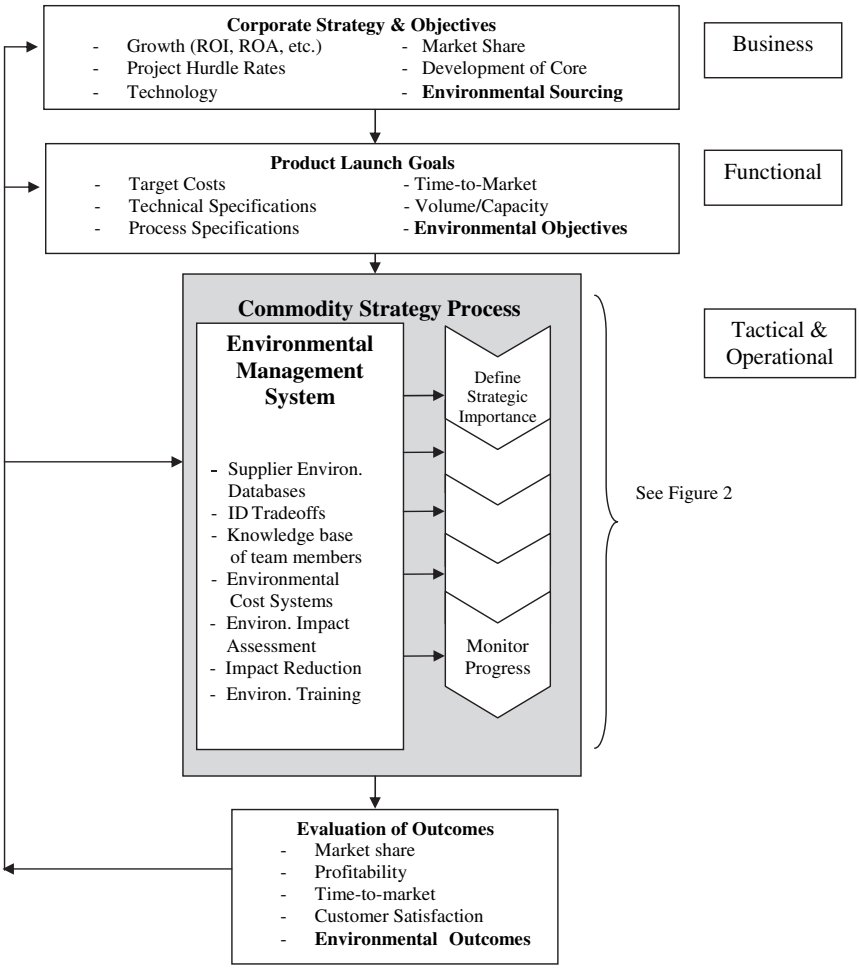

Figure 1. Conceptual model of environmental role in supply chain decisions

a major environmental crisis. At Dow Chemical, their strategy for re-designing their supply chain logistics channels came about after a major chemical spill on a rail line that resulted in huge clean-up costs. In another case, the Korean conglomerate Doosan's environmental policy was driven by an event in 1993, when one of the company's facilities accidentally discharged polluted water into a river for 30 days. This affected the local town's water supplies and the smell from the water in the river became a public embarrassment. The clean-up, using charcoal filtering, cost $30 M. This provided the impetus for Doosan to adopt strict self-regulation. In an interview with the researchers, the company's chairman offered the opinion that if Doosan had experienced one more similar incident, the public and the government would have driven them out of business. As such, they aim to limit their waste streams to levels that are *50% lower than the government's environmental standards*. The chairman also noted that environmental commitments such as Doosan's can be difficult for companies operating in smaller countries where environmental regulations are not as tightly enforced. For example, many small Korean companies still simply discharge their untreated effluent.

Executive leadership recognizing their role in supply chain environmental performance is an important beginning, but the difficulty in implementing this type of strategy becomes apparent at the busi-

ness unit and functional level (Corbett and Van Wassenhove, 1993). The obvious first steps to implement an environmental supply chain strategy are to reduce the likelihood of environmental catastrophes, and to capture the 'low-hanging fruit' such as recycling cardboard, paper and glass. After these steps are taken, however, the going gets tougher. In particular, managers suddenly encounter perceived trade-offs between increased environmental responsibility (i.e. 'doing the right thing') and performance results that affect metrics used to evaluate managers – cost, leadtime, quality and flexibility (i.e. 'what I'm rewarded for') (Handfield *et al.*, 1997). Much the same as the trade-off often cited between quality and costs, improved environmental performance and costs are often seen only as in dichotomous, and not symbiotic relationship. This rarely occurs at the corporate-level strategy development process, as 'doing the right thing' or being environmentally friendly is very easy to put forward as a broad goal that everyone agrees on. However, when environmental strategies filter down to the functional and commodity-level strategy development process (see Figure 1), managers must consider how buying more responsibly will affect the performance metrics used to evaluate the supply chain management groups. For example, should environmental assessments be made at the product or corporate level? Commodity teams often struggle with having to choose between materials that are environmentally friendly, versus materials that meet traditional cost or quality objectives. For example, vehicles last longer today than they ever have before. However, the technology is changing so quickly that cars quickly become obsolete – the useful life of vehicles far outlasts their actual life. At Ford, remanufacturing is used, but the company is forbidden to use old parts in new vehicles. Government transportation laws make reusing illegal, and there are large product liability risks. Given these dual constraints, engineers at Ford are struggling with how to make recycling a practical reality.

One challenge that affects the companies' ability to make these decisions is the lack of appropriate analytic tools and procedures to address issues such as the apparent trade-off between environmental responsibility and the company's competitive posture. As one manager at IBM asked, 'If you can't objectively define and measure environmental criteria, how do you expect me to improve it?'.

Data Collection

Because so little research examines the role of purchasers and material managers in integrating environmental concerns into commodity strategy and supply chain management, we chose a case-based approach using field studies to identify key trends and practices employed in industry. Prior to conducting the field studies, we developed an interview protocol by integrating our experiences with current practices described in the literature. The interview protocol asked managers to discuss the role of the environment in commodity strategies, supplier evaluation, supplier selection, supplier management, purchasing processes and inbound logistics. The interview protocol was pretested by several academic faculty and managers to help ensure the face validity of the protocol.

Selecting an appropriate sample is critically important when conducting field study research. Sampling decisions involve people, settings and social processes (Miles and Huberman, 1994). With this in mind, we set out to find a group of organizations that have integrated environmental practices into supply chain management. Further, we targeted a handful of manufacturing industries in particular. The automotive, chemical, computer and electronics, and office furniture industries were targeted for this study because they are highly competitive, experience high rates of technological change, which shorten product life cycles, and have large global firms that produce and sell their products in more than one country. Each of these characteristics contributes to the need for world-class suppliers and forces participant firms to continuously improve product quality and reduce product costs (Hahn *et al.*, 1990). These case studies focused on organizations in four countries, the United States, the United Kingdom,

Firm	Industry	Country	Interviewed	Environment criteria included?
Doosan	Chemicals and consumer products	Korea	CEO, VP of purchasing	Y
Dow Chemical	Chemical	United States	VP of logistics, VP of purchasing	Y
IBM	Computer/electronics	United States	Director of purchasing, VP of global sourcing, commodity managers	N
NEC	Computer/electronics	United States	Director of purchasing, commodity managers	Y
NCR	Computer/electronics	United States	Director of materials, commodity managers	Y
Sony	Electronics	Japan	Director of purchasing, commodity managers	Y
Intel	Semiconductors	United States	Director of purchasing, commodity manager	N
Samsung	Semiconductors	Korea	VP of purchasing, commodity managers	Y
Haworth	Furniture	United States	VP of purchasing, commodity managers	Y
Steelcase	Furniture	United States	VP of purchasing, commodity managers	Y
Herman Miller	Furniture	United States	VP of materials mgmt, commodity manager	Y
Rover	Automotive	United Kingdom	VP of purchasing, commodity manager	N
Unipart	Automotive	United Kingdom	Director of purchasing, commodity manager	Y
Honda	Automotive	Japan/US	VP of purchasing, commodity manager	Y
BMW	Automotive	United States	VP of purchasing, commodity manger	Y
Ford Motor Co	Automotive	United States	Director of purchasing, commodity manager	N
Hyundai	Automotive	Korea	VP of purchasing, commodity manager	N

Table 1. Companies in this study

Japan and South Korea, and took place in 1998–1999. The companies interviewed are shown in Table 1.

We sought to interview at least two companies in each of these industries to obtain parallel yet differentiated insights into strategic processes used to select suppliers, and the importance of environmental performance in making this selection. In each company we interviewed a minimum of two people from the purchasing function (typically a commodity manager in charge of a single purchase family), but also from a senior level (at least at the director level) in order to understand the importance of environmental management in the firm's overall strategy. The individuals interviewed at each location are also shown in Table 1, along with an indication of whether environmental criteria formed an important part of the supplier selection process. When possible, we conducted additional interviews with

environmental managers and operations managers. This particular approach was adopted to facilitate comparison of supplier management practices in companies in the same industries, but located in different countries. Regional experts familiar with local business practices provided case study contacts in each region.

Interview Procedures

Each site visit lasted one to two days. We began each visit with a meeting with the senior executive in charge of purchasing, in order to identify the critical elements of the company's strategy, its market environment, challenges and future plans. We also indirectly ascertained the relative importance of environmental criteria in the firm's overall strategy, as well as its purchasing strategy. In many cases, the interviews extended to include a tour of the plant and discussions with other functional employees. To further enhance the validity of the data we collected, documentation of purchasing policies, organizational charts, product descriptions and marketing reports were obtained at each site when possible. Because of the diverse organizational configurations found within the sample, the management level of the individual responsible for a green commodity strategy development at each site was often different. In most cases, it was a commodity manager responsible for managing a particular product family. We interviewed this individual and identified some of the specific criteria used to evaluate performance and select suppliers within that product family. Interviews with the commodity manager occurred separately from the executive to avoid bias.

Data Analysis

Following each interview, the field notes were written up in typeface. The transcribed field notes were reviewed several times by the authors in order to code the events into appropriate categories, and to compare field notes taken during the same interview. The coded data were then used to generate various visual representations (i.e. tree diagrams) to identify the central themes and linkages in the data. The conceptual linkages were then refined into the process model described below.

Environmental Supply Chain Management

Environmental supply chain management (ESCM) involves introducing and integrating environmental issues and concerns into supply chain management processes by auditing and assessing suppliers on environmental performance metrics. Our ESCM framework provides a structured approach for integrating environmental issues into supply chain management. We define ESCM as

> The formal system that integrates strategic, functional and operational procedures and processes for employee training and for monitoring, summarizing and reporting environmental supply chain management information to stakeholders of the firm. The documentation of this environmental information is primarily focused on supplier performance, audits, design, waste minimization, training, reporting to top management and goal setting.

The 'green supply chain' (Handfield *et al.*, 1997), is an integral component of the environmentally conscious enterprise (ECE), which also includes industrial ecology (Arthur D. Little, 1989) and environmentally conscious manufacturing (Sarkis and Rasheed, 1995). ECE integrates environmental issues into all parts of corporate life, including accounting for the environment, environmentally responsible product design, production planning and control and even 'responsible chain management' (Bakker and

Nijhof, 2002). By focusing on these and other activities, ESCM identifies costs, benefits and risks associated with environmental performance, identifies opportunities to manage or reduce waste and drives to ultimately eliminate waste from the system through improved resource efficiency. ESCM also takes a systems perspective of the integration of environmental issues with supply chain management. This perspective highlights the importance of environmental management systems (EMSs) and how firms integrate environmental issues within the firm and then extend this integration to the supply base (an EMS consists of the knowledge base of the organization concerning environmental issues, including the intellectual assets of personnel, databases and environmental cost tracking and impact assessment systems).

Purchasing Impacts

As shown in Figure 1, ESCM essentially extends conventional supply chain processes to include environmental management at the strategic level, environmental objectives at the functional level and the review of environmental outcomes. This is best accomplished by involving commodity managers in the product design cycle. In 1998 Sony Corporation implemented its 'Green procurement operations' initiative, which provides an excellent example of ESCM at work. Sony seeks suppliers who can help solve environmental problems because suppliers face the same demands and regulations as Sony. Sony uses ESCM to select suppliers that exceed environmental regulatory requirements and who also try to work with an environmentally sound supply base. Environmental performance becomes a relatively new and more critical evaluation dimension. In fact, this dimension is emphasized in the new product development stage with suppliers who are helping to develop new products. Designers from key suppliers working with Sony engineers are made aware of environmental updates and new products/processes that are considered inappropriate due to environmental impacts and end of life disposition. Sony has environmental policies that impact suppliers, but they want to have a partnership relationship with suppliers and not have to audit them. However, Sony spends a great deal of time conducting detailed 'surveys' of its suppliers to understand

- suppliers' stance towards the environment
- volumes of harmful substances in the elements comprising the products
- use of recyclable materials
- frameworks for quality maintenance, packing and distribution
- reuse and recycling of product packing materials and methods of disposing of metal molds and other equipment.

Supplier Impacts

For Sony and other firms such as NEC, Herman Miller and Doosan, a supplier's environmental performance can be an order winner, while cost and quality are typically order qualifiers. ESCM manages supply chain activities and their environmental impact to enhance the firm's strategic position. Generally, supply chain processes consist of operational and strategic components. Operational components include needs recognition and description, supplier selection and evaluation, and production planning and control. Embedded in these operational components are strategic components such as whether to make or buy the item, size of the supply base (Leenders and Feeron, 1993), degree of closeness in the supplier relationships (Landeros and Monczka, 1989), level of supplier integration (Rajagopal and Bernard, 1993), amount of information sharing, setting and administering performance measures and supplier certification/quality assurance activities (Burt, 1989; Garvin, 1983). ESCM incorporates

Commodity goals
• Reduce cost of purchased commodity by 10% in 2 years
• Reduce defects of purchased commodity from 10 000 ppm to 1000 ppm in 1 year
• Improve on-time delivery of purchased commodity to 99% with a 1 day window over the next 3 years
• Integrate state-of-the-art components within the next 6 months
• Align our company with the leading edge supplier over the next year
• Get supplier *X* to work with our engineers in new product development
• Have suppliers communicate directly with our customers regarding specifications
Environmental goals
• Reduce content of harmful substance to zero in all products within six months
• Dollar savings goal of *x* for disposal of old parts
• Have 10% of the supply base ISO 14001 compliant
• Ensure that no new parts contain the 57 hazardous substances documented in our policies, and that volumes for existing parts be reduced to *x* ppm
• Ensure that all new product packing materials comply with recycling goals
• Ensure that all suppliers are disposing of metal molds for mass production in an environmentally appropriate manner

Table 2. Examples of goals for commodity strategies

environmental considerations into both the operational and strategic components of supply chain management.

Not surprisingly, the success of ESCM hinges on top management support. Whether that support is motivated by the executive's desire to improve the company's competitive position through proactive environmental management or by a specific environmental threat the company faces, top management support is a fundamental driver for ESCM. Sony again provides an excellent example. In addition to the 'Green procurement operations' effort, Sony is implementing a company-wide environmental policy called 'care for the environment' (Sony, 1997), which promotes reduced materials use, energy savings, shorter product disassembly times, increased recyclability of products and reduced use of harmful substances. Doosan provides another example. After surviving a $30 million non-compliance fine stemming from an environmental infraction, the company implemented an environmental program that included a set of quantitative, broad-based and specific goals for improvement. The company's chairman personally visited each facility to make sure that progress was being made on this front.

Importance of Environmental Metrics

Firms using, or developing, ESCM typically set specific environmental goals, develop action plans to achieve these goals and devise appropriate measures to monitor progress in achieving these goals. Here we find firms such as Sony and Herman Miller working with suppliers to set goals and develop strategies such as those found in Table 2. These goals include not only cost, quality and delivery goals, but also environmental goals that are specific and measurable. In order to truly integrate corporate environmental objectives, each commodity will have its own set of environmental goals, depending on the criticality of the product in terms of its potential environmental impact. The most environmentally successful companies we interviewed had translated commodity environmental goals into detailed quantitative assessments. This was achieved with the help of an environmental management system (EMS), which supports all supply chain environmental decisions. For instance, the EMS at Herman Miller is designed to reflect the direct impact the commodity strategy has on the environment. Some of the critical performance measures include gallons of oil used, number of trees cut and cubic yards of landfill

space saved. A monthly report tracks waste of fabric, foam, leather, paper and polyvinyl film. The report also includes dollar savings of disposal cost. More general goals might include satisfying laws and regulations, meeting standards on environmental labels, eliminating harmful substances and developing substitute materials. Similarly, at Sony, survey results from suppliers are integrated in part databases to understand the net environmental impact of final products based on component selection early in the design stage.

Intimately linked to goal setting and action plan generation is appropriate environmental measure development within the EMS. Companies find it difficult to develop good measures of environmental performance. Even when they can devise good measures, companies often struggle to prioritize the performance criteria. To develop environmental performance measures, Sony collects information on the environmental attributes of all materials used in all of their products worldwide, and houses this information in a centrally maintained EMS database. They use the database to determine which environmentally sensitive materials should be closely managed. They then survey their businesses and divisions to determine how widely used these substances are, so specific rules can be derived on how to effectively manage them. These rules reflect the performance measures Sony emphasizes, and the information generated through these rules is used to quantitatively evaluate Sony's 'burden' on the environment.

Achieving executive support, setting goals, finalizing action plans and developing performance measures represent establishing the infrastructure for ESCM. An important first step in actually implementing ESCM is integrating environmental issues with commodity strategies. Not all commodities are environmentally equal, though. Low environmental impact commodities, such as computer chips, which are fabricated in a class 1 clean room, have minimum potential for pollutants. Even these commodities, though, involve waste streams that require managing.

Figure 2 shows the different steps associated with developing a commodity strategy. In the next section, we discuss how environmental performance criteria can be integrated into this decision process.

How to Develop a Green Commodity Strategy

Step 1 – Define the Strategic and Environmental Importance of the Commodity

The key to this first step is recognizing that you can not attack all the areas of ESCM at once – so you begin by selecting those commodities with the highest priority, and go from there. The first step of developing a commodity strategy is to initially classify the importance of the commodity, which can range widely in value and environmental importance (see Figure 2). A computer manufacturer would not want to spend a great deal of effort managing fasteners as a commodity class when microprocessor sources require attention. Two dimensions that can be used to initially classify commodities are the supply risk associated with buying the commodity and the profit contribution of the commodity. Supply risk includes issues such as the number of alternate sources of supply and the volatility of the commodity's price, and availability. Profit contribution includes the average price of the commodity and the relationship between this price and the final cost of the end-item. These two dimensions combine to yield four major types of commodity, each of which will require a unique commodity strategy. Figure 3 summarizes four commodity types, including examples of each type.

To go beyond these four commodity types, procurement managers need more information. When supplier assessment information includes environmental data, then there is a new third dimension to help classify a commodity: environmental risk. While this third dimension adds to the complexity of the commodity assessment process, the environmental information provides procurement specialists with a richer set of decision criteria. Including this third criterion causes firms to confront trade-offs between

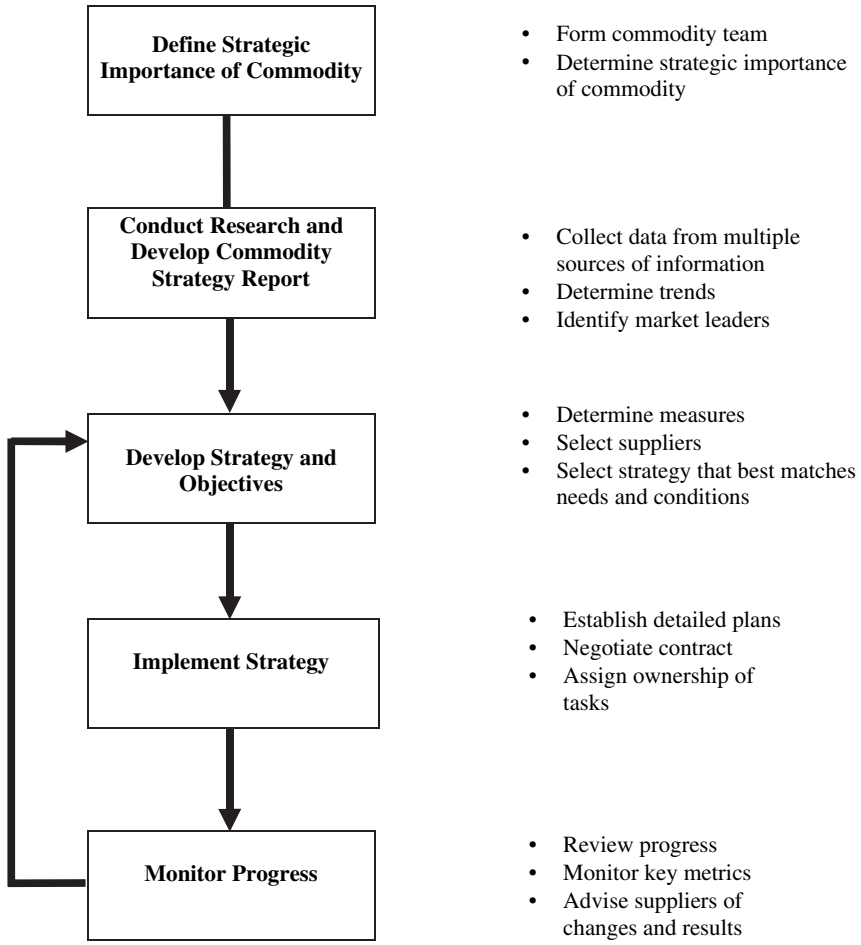

Figure 2. Commodity strategy development process

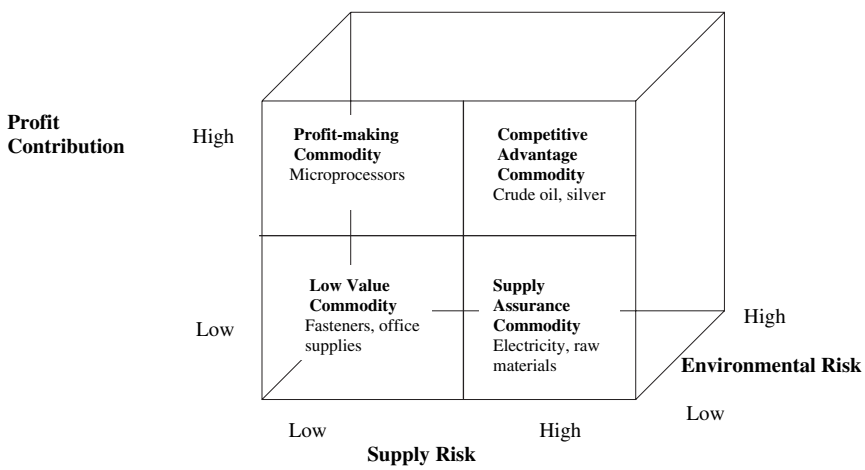

Figure 3. Four commodity types and environmental risk

- *Redesign* the product or process to reduce environmental waste.
- *Substitute* less polluting materials or processes, including increasing use of recycled inputs.
- *Reduce* the number and amount used of materials that contribute to waste streams.
- *Recycle* the product at the end of its useful life.
- *Remanufacture* items returned from customers.
- *Extend* the products' life cycle by selecting materials with longer useful lives.
- *Support* suppliers with established environmentally responsible reputations.
- *Life cycle assessment* to better understand total costs, and cradle to grave processes.

Table 3. Strategies for environmental impact reduction*
*Adopted from NSF ORD#64852, *Environmentally Conscious Manufacturing: Integrating Environmental Issues into Product Design, Planning and Manufacturing*. Principal Investigators: R. Lal Tummala, Steve Melnyk, Roger Calantone, Robert Handfield, Erik Goodman and Keith Helferich.

environmental costs and price of the commodity. Low-environmental-risk commodities do not require the same attention of management as do high-risk commodities.

Classifying the commodities is the responsibility of the commodity team formed to develop the commodity strategy. Commodity teams should be cross-functional and include members from manufacturing, product design, process engineering, marketing, finance and purchasing, depending on the commodity. Commodities classified as profit contribution or competitive advantage commodities generally require more cross-functional teams, and more detailed commodity strategies, than low-value or supply assurance commodities. The steps the commodity team will follow are shown in Figure 2.

Commodities with high environmental impact require a more detailed environmental commodity strategy, one designed for 'environmentally critical commodities'. A commodity can be classified as environmentally critical if either the commodity itself is environmentally dangerous or if the process used to make the product employs significant environmentally dangerous materials. This comprises an additional set of criteria that may have a profound impact on the commodity strategy. Hazardous commodities or commodities with high disposal costs must be managed to minimize the company's exposure to environmental risk. The company can choose to outsource the commodity, as did an electronics company buying bareboards, which require significant hazardous materials for production, or Doosan outsourcing its dirty environmental jobs. Outsourcing, though, fails to recognize the responsibility of each member of the supply chain in environmental performance. Instead, environmentally critical commodities must be targeted for source reduction or elimination. Specific strategies for reduction and elimination are shown in Table 3.

For nearly all of these environmentally critical commodities, the logistics of delivery, use and disposal could also earn them entry into the 'environmentally critical' class. Regardless of the reason for being classified as environmentally critical, when purchasing these commodities, detailed information is needed concerning the environmental impact of both the purchased product and the supplier's process for manufacturing the product. The EPA's list of 17 hazardous materials identifies a set of these commodities. As important for the ESCM commodity strategy are the process wastes associated with the purchased item, such as toxic emissions of titanium dioxide, air emissions of ozone depleting substances and water emissions of volatile organic compounds, and the risks associated with transporting hazardous materials.

Although many companies use a commodity strategy development process, few have a truly 'green' commodity strategy process in place. For example, at Sony, commodity teams tasked with a re-design will begin defining their product and environmental requirements through involvement in the new product development team. The environmental criteria for the components comprising the product are

specified immediately following the concept stage. For existing products, environmental information is available in the engineering parts database, and the engineering team will avoid 'designing-in' parts that do not meet the requirements. For new products, environmental specifications must be broadcast to all potential new suppliers. Examples of such specifications are shown at the bottom of Table 1. Because the company has surveyed its supply base and integrated this information into a database, the search for potential suppliers who will source these new components will be limited only to those suppliers who can successfully meet all of the requirements (including environmental ones). If a supplier is capable but has problems meeting emissions or hazardous material requirements, Sony may send a team of engineers to the suppliers' location to help them address this problem. All of this occurs early in the new product development cycle, *before* the sourcing decisions have been made. Suppliers also have a strong motivation for cleaning up their hazardous manufacturing processes: new business!

Step 2 – Conduct Research

After the commodity team classifies the commodities it is responsible for, this same team gathers information needed to develop a commodity status report. For example, a major manufacturer of electronics has a purchasing team responsible for working with suppliers on environmental requirements, qualifying the supplier's processes and recording information. This team is also responsible for developing procurement specifications, risk analysis using financial ratios and performing a technical analysis of the supplier. This commodity status report contains information required to make sound procurement decisions, and to present management with information about future supply, price and profit contribution for the commodity. Sources of information that can be used to develop commodity status reports include Internet searches, mailings, government reports, trade magazines, the Thomas Register and other database searches. More customized data is gathered by interviewing suppliers and customers to benchmark the commodity strategy.

Linking environmental and commodity strategies causes supply chain processes to become more complicated because more supplier and product attributes must be considered; each supplier and product must be evaluated on cost, quality, lead time, flexibility and environmental impact. In the research stage of the commodity strategy decision process, the environmental management system is an invaluable resource in developing objectives and seeking information on supplier capabilities and processes. While information technology solutions such as integrated databases can help manage available environmental data, they cannot address the design question of what metrics to collect and evaluate. For example, while Hyundai, Intel, Ford and IBM all maintain databases on 'green' performance measures for their major suppliers, none of these companies have successfully developed a systematic method to integrate these measures into supply chain decisions such as supplier selection and evaluation. Why has this happened? Basically, environmental issues have developed slowly from ad hoc processes, and have not been 'systematically' integrated. As noted earlier, the environment may be on an executive team's radar screen immediately after an environmental crisis; however, after countermeasures have been taken and the 'low-hanging fruit' picked, the environment tends to become part of a 'checklist' that may or may not be systematically used in decision-making. However, by linking specific environmental metrics into the decision-making framework of commodity teams, the team is *forced* to focus on materials, process and logistics that reduce the environmental impact of various commodities. In doing so, buying companies can then certify suppliers' processes to better understand their impact on the environment.

Process certification involves assessing whether the supplier can capably provide the items and services the buyer requires. This usually entails conducting surveys and assessments of the supplier's operations to determine whether they can consistently deliver the needed quality level. These surveys and assessments also provide insight into how environmentally related materials impact procurement. Sup-

plier certification is one method that companies such as Sony, NCR, Herman Miller and Dow are using to drive environmental initiatives throughout the supply chain. Pre-qualification can also be used to reduce the time required to accomplish this.

At National Cash Register (NCR), a central purchasing group known as the Computer Engineering Technology Center is responsible for working with suppliers on environmental requirements. The group is also responsible for qualifying suppliers' processes and recording information into a centralized database that is made available to all purchasing groups at the different divisions. This group develops procurement specification, and also performs risk analyses on different suppliers. For instance, they have the capability to conduct an analysis of the supplier's financial ratios, as well as a technical analysis, and provide a 'quick and dirty' assessment on any given suppliers within a 24 hour period. The analysis might also include an assessment of any customers the supplier is affiliated with or is serving that might be considered a possible risk. This group also performed fabrication/quality audits at all DRAM suppliers, and could provide a capability and roadmap analysis on the supplier. Finally, they were also knowledgeable in the area of environmental performance, and were able to audit suppliers' processes to determine whether they were CFC free. All of the engineers at the center were capable of talking to suppliers on a technical basis, and 'spoke the same language'. Monitoring the supplier's process control data helps maintain ongoing adherence to quality standards. Performance summary data and suppliers certification measurements targeted at the objectives of the supplier assessment will help in this effort. The creation of systems is important to capture and understand the data derived from the surveys and assessments. It is also here that supplier development programs can target potential waste areas of the supplier and work with the supplier to move toward a low-waste, mutually beneficial long-term relationship.

For environmentally critical products or services, commodity team members will need to work closely with engineering, environmental specialists and quality management specialists to certify the supplier's processes. Ideally, this process should take place in the product design cycle, at the time that the product and process specifications are being set.

For example, the technical center group at NCR started off as a component-testing lab, but emerged as a component engineering technical center responsible for qualifying all suppliers used by the company. In the electronics markets, conformance quality is an order qualifier, but a key order winner is the ability to develop technologies and bring them to market. The tech group evolved from that standpoint: it developed a patented supplier qualification process that was used by all of the different manufacturing divisions. For any supplier qualified by that process, every purchasing manager and product designer accepted the rating de facto. Because all suppliers are qualified by *process*, any parts produced by suppliers' qualified process were also by definition qualified. This is much more cost efficient than qualifying by part number, which might involve the same process for a whole family of parts.

Step 3 – Develop a Strategy

Internal Assessment

The commodity status report is used as a primary input to developing specific strategies and objectives for each commodity. The characteristics of each commodity class suggest specific strategies. Low-value commodities require little attention and might even be completely outsourced. Use of web-based technologies can reduce transaction costs for these commodities without exposing the company to significant supply risk. However, if something were to go wrong at a supplier's facility, this commodity may be more important due to environmental risks and a firm could find itself in trouble because of the performance of an upstream supplier. As is true with any type of commodity, decisions should not be made until the environmental dimension has been assessed.

Supply assurance commodities need more detailed strategies aimed at ensuring availability. These strategies might focus on improving total cost of acquisition through detailed cost analysis. Additional information on environmental performance of the supplier can provide a better understanding of the commodity's profit contribution and provide opportunities to work with suppliers to reduce costs, disruptions in the supply system and reduce environmental risk.

Profit contribution commodities might leverage multiple sourcing to maintain competitive pressure on suppliers for improved price and delivery performance. Competitive advantage commodities require constant monitoring and likely the bulk of commodity strategy planning effort. These commodities might use strategic alliances with key suppliers, electronic commerce systems to improve communication with suppliers or joint problem-solving sessions with the supplier. Reducing environmental risk from these suppliers may involve audits of the supplier and even a supplier certification program for selected suppliers that includes multiple dimensions of environmental performance.

For commodities classified as environmentally critical because of the materials themselves (e.g. EPA Hazardous 17 substances), the commodity strategy must strike a balance between meeting current materials needs and seeking substitute materials. This generally requires working closely with the supplier of the commodity. The commodity strategy for these materials will be based on a relatively limited number of suppliers and long-term, cooperative relationships. Information sharing and collaboration are both critical to the success of sourcing decisions that have a reduced impact on the environment.

Haworth, a manufacturer of high-end office furniture, provides an example of this type of commodity strategy. Haworth was sourcing solvent-based paint from a major American supplier. Because solvent-based paints require solvents for clean-up, the team wanted to phase this type of paint out of their product. They worked closely with the paint manufacturer to devise different painting techniques including water-based and powder-based coatings, neither of which requires solvents for clean-up. In the end, Haworth was able to eliminate solvents and solvent-based paints from the commodities it sourced.

Some commodities are not environmentally sensitive when sold, but embody significant environmental risk in their manufacture, such as bareboards for computers. Commodities made using environmentally critical processes require a strategy based on cross-organizational source reduction. As was the case for environmentally critical materials decisions, the commodity strategy for these commodities must rely on close relationships between the trading partners.

External Assessment

Another set of environmentally critical commodity decisions involves transportation and logistics of the purchased item. While not often considered a commodity, transportation of purchased materials represents a significant cost and opportunity for environmental problems. Strategies for environmentally critical logistics decisions must proceed on two fronts. First, the commodity strategy should focus on reducing the need to transport hazardous materials. In the case of the furniture manufacturer, reducing the need for solvents to clean painting equipment directly reduced the need to transport hazardous solvents. Second, because transportation is frequently outsourced to a third party, the commodity strategy must also focus on third party education and assurance while source reductions are undertaken.

For example, a major portion of accidents and environmental hazards at Dow Corporation occur not in manufacture or disposal, but in transportation of environmentally critical materials. Hence, Dow directs much of its environmental effort at logistics, including educating carriers. Dow has spent over $800 million educating transportation-related stakeholders about hazardous materials distribution. Dow has trained truckers, rail carriers and fire chiefs how to handle chemical emergencies. Dow works closely with the railroads to ensure that they adhere to a special maintenance program (e.g., when train wheels get too hot they need to be replaced). In addition, Dow only uses those carriers that can meet stringent standards for environmentally critical logistics. One manager claimed he could save 15% in distribution

costs by using carriers who do not meet Dow's standards, but because the environmental, legal and clean-up cost risks are so high they clearly overshadow these potential savings.

Integration

With the strategy in place, the team determines whether the appropriate goals have been met, and develops a detailed action plan for achieving new goals. Table 1 presents examples of both qualitative and quantitative goals for the commodity strategy. Whether these goals are external measures of supplier performance, internal measures of process integration or internal performance measures, they must be based on a detailed competitive analysis, an understanding of market leaders and an understanding of future trends in the marketplace.

Action plans might specify the number of suppliers to do business with, or the percentage of dollar volume allocated to each supplier. The action plan should also specify the type of contract to be used for the commodity, whether an alliance or partnership will be pursued or whether further supplier training or development is needed. The action plans must also include an assessment of possible risks and rewards associated with each action plan.

With the detailed commodity strategy in place, the commodity team must implement the strategy. The team will generate a detailed list of tasks to be accomplished and a timeline for completion that will be passed on to the individual or team assigned to carrying out the strategy. Often the commodity team that creates the strategy implements it. The organization must also make adequate resources available to the implementing team for the commodity strategy. At this point, the team will proceed with systems development and contract negotiations, develop communications plans and begin sourcing the commodity.

Step 4 – Monitor Results

Once sourcing begins, the commodity team must monitor the progress of the strategy execution at the firm, functional and tactical levels. Annual reviews can be used to determine the success of the strategy and to modify the strategy as needed. These reviews can include meeting with key suppliers to understand their perspective on the commodity strategy. The result of the annual review, as well as future strategic expectations, should be communicated to all relevant suppliers. This task often falls to purchasing personnel since they are usually the primary contacts for the supplier, and are often responsible for measuring the supplier's performance.

In monitoring results, ESCM oriented corporations evaluate their *supply base* on the environmental criteria embedded in their supplier evaluation systems. One such evaluation system is the EMS and formal certification of these systems using International Organization for Standardization (ISO) 14001. This environmental standard goes beyond the ISO 9000 series of standards and involves having an EMS in place to track, report and reduce waste. The standard was released in the Fall of 1996. It appears the best candidates for ISO 14001 certification are firms already ISO 9000 certified (Burkey, 1996). Additionally, if ISO 14001 becomes as prevalent as ISO 9000, or QS 9000, not only will companies with certification have a competitive advantage, but they should also have more efficient processes through understanding the conversion of raw materials into finished goods.

Doosan is ISO 14001 registered. The company now requires its entire supply base to be ISO 14001 compliant as well. Many companies such as Ford and Honda have announced the planned certification of their manufacturing facilities and the need for supply chain members to also pursue certification (Anonymous, 1999). Thus, an EMS becomes very important for capturing and disseminating environmental information and performance. Similarly, at Unipart, a manufacturer of automotive parts in the United Kingdom, environmental performance is deemed a core part of their supplier evaluation framework. Suppliers are evaluated on a one to ten scale concerning

- quality (zero defects and failures)
- value (zero waste, lowest cost base in market)
- range (zero range gaps in achievement of product goals)
- availability (zero availability loss in replenishment and stock turn)
- delivery (zero order to delivery lead time)
- transactions (zero transaction costs in the form of errors, etc.)
- service quality (zero service defects)
- responsiveness (zero response time)
- relationship (zero relationship gaps)
- environment (zero environmental harm).

The one to ten scale used to evaluate suppliers in this last category is defined as follows:

10. Supplier has not demonstrated compliance with all environmental legislation relevant to its business.
9. Supplier recognizes the need to consider environmental issues within its business. Supplier complies with all environmental legislation relevant to its business.
8. A full environmental review has been conducted identifying all environmental impacts and risks.
7. The company has a relevant environmental policy and an environmental management plan, which has the active commitment of senior management.
6. Procedures exist covering all compliance and risk issues.
5. Procedures related to environmental management and environmental performance are regularly audited, and records are maintained.
4. All personnel are fully trained in the environmental issues that are relevant to their role in the company.
3. Quantifiable progress has been made in reducing environmental impact, and cost savings are included and identified in company accounts.
2. Environmental performance is included in the assessment and selection of suppliers and contractors.
1. Supplier is working with Unipart to reduce life-cycle impacts of their products.
0. Certification to a recognized environmental standard has been attained (BS7750/ISO14001/EMAS).

Although not all suppliers are a '10', Unipart works with suppliers on an on-going basis to ensure that continuous improvement is being made. In cases where a supplier is experiencing problems meeting environmental goals, Unipart will work with the supplier to improve this capability, often in a 'hands-on' manner through an engineering team. Although the type of supplier evaluation and monitoring system will vary by industry, or firm, it is important to link these results back to the original corporate and purchasing strategies (see Figure 1). By combining results from multiple commodity strategies into aggregated results, purchasing executives will be better positioned to demonstrate their successes to executive boards, and ask for additional resources to carry on further supply chain strategies that will improve not only corporate environmental performance, but also the bottom line.

Conclusions

This research demonstrates how companies can begin to integrate environmental and supply chain decisions. By integrating these decisions the company is able to move past the ill founded belief that there

is an inherent trade-off between being environmentally friendly and being profitable. We have shown that companies can extend their commodity strategy process to incorporate environmental criteria, thus achieving environmental supply chain management or ESCM. We would offer several final thoughts from our work.

Intense global competition among businesses leads companies to search for innovative ways to reduce waste and its associated cost, while maintaining a flexible corporate strategy, and improving market position. The companies we interviewed have demonstrated that the trade-off mentality concerning environmental issues becomes less relevant as companies pursue best-in-class materials management practices that reduce cost by reducing waste. These supply chain management practices are actually environmental initiatives, which can spur new ways of thinking and acting on total quality and continuous improvement (Baker, 1996).

To best integrate environmental issues into supply chain management, companies should begin by evaluating the role of environmental issues in commodity strategies and develop an EMS to better measure, monitor and manage environmental issues. ESCM identifies, quantifies, assesses and manages the flow of environmentally critical materials through the value chain with the goal of reducing waste and maximizing resource efficiency. Achieving these goals will only enhance the strategic contribution of supply chain managers to the company's overall strategic objectives.

As ESCM takes hold in companies, these organizations will encourage or force their suppliers to adopt ESCM. Sony through its new product design process, Doosan through its insistence on ISO 14001 certification and others have actively promoted ESCM into their first-tier suppliers. Given the interconnected nature of supply chains, it is quite likely that these first-tier suppliers will in turn force or encourage ESCM in their suppliers, further accelerating the rate at which ESCM becomes mainstream. Again, this only increases the strategic importance of supply chain managers in corporate strategic processes, a result we believe it is inevitable and desirable.

However, there is still work to do. For example, more analytic tools are needed to help companies evaluate ESCM. Several companies have made real strides toward this end. Sony's procurement policy promotes QCDS + E (quality, cost, delivery, service and the environment) in the relationships with business partners. Other companies, such as Intel, are beginning to detail 'total cost' models that consider not only the price paid, but the impact of disposition of a supplier's product. Not surprisingly, in some cases the lowest 'total cost' supplier is not the one with the lowest price!

While more work is needed, our research suggests a new and different image of 'green' purchasing emerges from the ESCM perspective – one that is cost and strategy driven, economically justified, and integrated with the corporate and product/process decisions. Our case research suggests that the biggest disconnect occurs in aligning corporate environmental strategy with specific environmental performance criteria at the commodity level (see Figure 1). In the end, managing environmentally critical materials, processes and logistics improves the value the company can deliver to its customers.

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