The Green Supply Chain: Integrating Suppliers into Environmental Management Processes

BY

Steve V. Walton, Robert B. Handfield, and Steven A. Melnyk

Steve V. Walton *is Assistant Professor of Decision and Information Analysis at the Goizueta Business School at Emory University. He earned his Ph.D. degree in Operations Management from the University of North Carolina at Chapel Hill. His research focuses on supply chain management (SCM), including issues such as the role of electronic commerce in SCM and environmental implications of SCM.*

Robert B. Handfield *is Associate Professor of Purchasing and Operations Management at Michigan State University. He earned his Ph.D. degree in Operations Management from the University of North Carolina at Chapel Hill. His research combines qualitative and structural modeling approaches to the study of time-based competition, quality management, and strategic sourcing.*

Steven A. Melnyk *is Professor of Operations Management at Michigan State University. He earned his Ph.D. degree from the University of Western Ontario. His research interests include MRP II, tool management and control, shop floor control, Time-Based Competition (TBC), and Environmentally Responsible Manufacturing (ERM).*

International Journal of Purchasing and Materials Management

IN BRIEF

In business today, companies cannot ignore environmental issues. Increasing government regulation and stronger public mandates for environmental accountability have brought these issues into the executive suite, and onto strategic planning agendas. At the same time, companies are integrating their supply chain processes to lower costs and better serve customers. These two trends are not independent; companies must involve suppliers and purchasers to meet and even exceed the environmental expectations of their customers and their governments. Based on case studies of five companies in the furniture industry, a number of supply chain environmentally-friendly practices (EFP) are identified. Using accepted qualitative research methods for case-based research, several primary areas for change to increase purchasing's impact on environmental results are identified:

1. **Materials used in product design for the environment**
2. **Product design processes**
3. **Supplier process improvement**
4. **Supplier evaluation**
5. **Inbound logistics processes**

The experiences of these companies illustrate the types of environmentally-friendly practices used in each of these five areas, and "rules of thumb" which purchasing and supply chain managers can apply. Two additional themes which emerge from this research are the importance of management's commitment to supply chain EFP, and the need to move beyond environmental compliance to achieve a proactive environmentally-friendly supply chain.

INTRODUCTION

The environment has become a critical issue in business today. In the 1960s and 1970s businesses typically considered environmental compliance to be a "fringe" issue which elicited little discussion at executive levels. Since then, several highly visible environmental disasters (e.g., Love Canal, Three Mile Island, Exxon Valdez) have demonstrated the importance of having a comprehensive environmental strategy in place. As is true of Total Quality Management (TQM), environmental strategies must be conceived and supported by top management, but

deployed in every functional area of an organization to be meaningful. Previous research showed how cross-functional "buy-in" is necessary to integrate environmental strategies with supply chain management.[1] This study extends the findings of that research by focusing on the role of purchasing and supply chain management in improving the environmental performance of an organization. The next section discusses the growing importance of environmental management to business. Case studies are discussed and a set of generic guidelines regarding the role of purchasing and supply chain management in environmental management is presented. The final section summarizes the conclusions and insights from the study.

APPROACHES TO ENVIRONMENTAL MANAGEMENT

The traditional view of environmental management in business has been either "we need only comply to the letter of the law," or worse yet, "ignore it and it might go away." These attitudes grew out of the perception that any actions which improved the environment were detrimental to interests of business. Such perceptions were often fueled by the news media (e.g., the ongoing dispute concerning the logging industry and the spotted owl in the Pacific Northwest). Traditional "anti-business" environmental perceptions also led to instances where companies decided it was in their best interest to pollute and pay a small fine, instead of finding ways to prevent or eliminate the waste. Penalties associated with polluting escalated with the passage of the Superfund in the 1970s, SERA in the 1980s, and other legislation in the 1990s, and businesses began to realize that some level of compliance would be necessary. The typical response of companies was to comply with the legislation, but to rarely integrate these policies across the company. This type of response to environmental issues can be termed "resistant adaptation."[2]

A slightly more developed environmental management approach accepts the goal of minimizing waste, without trying to eliminate the source of the waste. Companies pursuing this approach often try to find ways to "clean up" or store the waste once it is created. Companies that install smokestack devices to reduce the level of pollutants *emitted* into the air, without trying to reduce the level of pollutants *produced,* are "embracing without innovating." This reactive approach to environmental issues is characterized by "end-of-the-pipe" solutions.[3] While embracing environmental issues without changing current processes provides the company with a sense of social legitimacy,[4] it usually leads to narrow, incremental solutions.[5] As such, companies are not realizing the competitive implications of environmentally-friendly supply chain practices; they merely experience penalty avoidance.

Companies are now starting to recognize the possible competitive advantages associated with environmental awareness.[6] However, as environmental management makes its way into corporate strategic planning, it must also be integrated with the day-to-day processes of the organization. Companies which make minimal changes to optimize their current processes can be called "receptive" to environmental issues. Companies which look beyond their current processes to find and eliminate sources of waste are more "constructive" in their response. Constructive responses to environmental issues focus on the value embodied in the product and process by integrating product planning and changes into environmental planning and response. Constructive responses also rely on companies adopting a resource-productivity framework to maximize benefits attained from environmental initiatives.[7]

Companies wanting to reap the greatest benefits from their environmental management processes* must *integrate other members of the supply chain into these processes.

The weakness with these modes of environmental management response is that each focuses only on the internal functions of an organization. One environmental expert suggests that a "proactive" company will "thrive only when it acts as a whole system that includes not just executives and workers, but customers, suppliers, and neighbors," and by integrating total quality environmental management (TQEM) into its planning and operations processes.[8] This paradigm implies that companies wanting to reap the greatest benefits from their environmental management processes *must* integrate other members of the supply chain into these processes. Companies are compelled to include suppliers if they want truly environmentally-friendly practices (EFP) for purchasing and materials management, which is tantamount to "greening the supply chain".

The notion of a green supply chain is related to the broader concept of a "sustainable economy."[9] This view extends the idea of TQEM beyond the boundaries of organizations and beyond the current generation of products and services. Fundamental to developing a sustainable economy is the recognition that environmental initiatives may start as operational initiatives to reduce waste and emissions, but these initiatives must grow to a point where the strategy and the vision of the company incorporates environmental issues.

In this study, the experiences of managers collected from case studies in five furniture manufactures are applied to illustrate current practices in environmentally-friendly supply chain management. The research examines how these managers were able to drive environmentally-friendly practices within their own supply base. In the next section, the

nature of the companies included in the study, and the environmental practices of suppliers in their supply chains are described. Based on the practices described by these managers, a number of suggestions are offered for other purchasing and supply managers to consider in attempting to integrate their suppliers into their environmental management initiatives.

THE COMPANIES STUDIED

Because of the paucity of research on issues concerning the role of suppliers in environmental management, a case-based approach was adopted to initially identify key trends and practices currently employed in industry. The first step in this case-based method involved a review of the literature to identify existing practices and to integrate these practices into an interview protocol prior to conducting the case studies. Because of the cross-functional nature of the questions, a review of environmental issues in a number of areas was conducted, including general management, purchasing, operations, and distribution and logistics. The model of the role of purchasing and suppliers in environmental management, which emerged from this portion of the study (see Table I), was used as the basis for developing a semi-structured interview protocol.[10] The interview protocol is included in Appendix II on page 11.

Table I shows how the focus, responsibility for actions, and goals differed in the sample, according to the sophistication of each company's environmental response. Advanced companies moved beyond practices emphasizing the avoidance of environmental fines through end-of-pipe, cleanup-oriented solutions. These proactive companies recognized that processes and products must be redesigned to achieve the higher environmental goals associated with leveraging environmental management for competitive advantage. Companies that achieve these higher levels of environmental response accept their responsibility to society as a whole. Based on these possible responses, an interview protocol was developed which asked managers to discuss the role of supplier evaluation, supplier selection, supplier management, new product design, purchasing processes, and inbound logistics in supply chain EFP.

When conducting case-based research it is important to remember that "[s]ampling involves not only decisions about which *people* to observe or interview, but also about *settings, events,* and *social processes*."[11] With this in mind, a group of organizations was selected that were at different stages of implementing EFP in their supply chains. Five major firms in the furniture industry agreed to participate in the study. A single industry was used to control for differences in processes and materials which might confound the results of a cross-industry study. A major challenge in selecting firms to participate in this type of study is the need to strike a balance between similarities and differences. Companies included in the study had to be similar enough to allow for comparison, but at the same time diverse enough to permit some generalizability.

Based on these criteria and a number of other considerations, companies in the furniture industry were selected. First, key members of the furniture industry were readily accessible to the research team. Second, the industry is fairly concentrated,[12] and a significant segment of the industry could be included using as few as five case studies. Third, several of the key processes in the furniture industry that have significant environmental implications are common to many manufacturing industries (e.g., coating processes using solvent-based paints, solid waste management, zinc plating, paper packaging). Fourth, the furniture industry faces primarily the same legislative initiatives as many other manufacturing organizations, such as the Clear Air Act Amendments of 1990. These amendments call for warning labels to be placed on products manufactured using ozone depleting substances (ODS) and volatile organic compounds (VOC). In the past these substances were produced in large quantities in furniture manufacturing. Hence, results concerning the role of purchasing in EFP can be generalized to a large number of manufacturing industries. The furniture industry was chosen also because of its recent high visibility in the public arena. Specifically, furniture companies have come under fire for using tropical woods in their products, which encourages harvesting endangered tropical forests. Focusing only on these unique environmental issues may limit the

TABLE I

STRATEGIES FOR DEALING WITH ENVIRONMENTAL ISSUES

Strategy	Location of Action	Responsible Party	Goal of Activity
1. Resistant adaptation	End-of-pipe	External consultants	Minimize exposure
2. Embracing without innovating	End-of-pipe	External consultants and internal specialists	Minimize exposure
3. Reactive	End-of-pipe	Internal specialists	Minimize exposure
4. Receptive	Process change	Managers	Optimize process
5. Constructive	Product change	Industry	Quantum leap
6. Proactive	Needs assessment	Society	Create a new vision

generalizability of the study to other industries, but doing so may allow for a richer discussion of how public awareness influences corporate behavior. Finally, several companies in the industry are generally acknowledged as "leading edge" in terms of their environmental initiatives, with a long history of environmental responsibility. These companies' environmental activities date back to 1969 (before the first Earth Day), when many began hiring environmental engineers. Several of the furniture companies included in our case study were also highlighted in the press for their environmentally-responsible practices. Thus, the furniture industry appeared to have a number of suitable cross-industry benchmarking firms as candidates for case studies.

The companies were initially screened in a telephone pre-interview with the environmental manager at the divisional office. The screening questions included the following:

- Do you have an environmental management program?
- If so, how successful has this program been and how do you measure its success?
- What are the primary components of your program?
- Are suppliers included in the program?

During the initial screening the willingness of the company to participate in the study was assessed. All the firms contacted were willing to be a part of the study, and site visits were scheduled. Table II presents an overview of the five companies which participated in the research.

The interviews were conducted with several managers responsible for different components of the company's overall environmental strategy at each site using the interview protocol. Respondent job titles included director of facilities, general manager of safety and environmental compliance, environmental manager, and waste reduction coordinator. The interviews lasted between two and four hours and were conducted at the company's site. The interview protocol focused the process of the interview on the company's environmental objectives and the impact of environmental issues on procurement, design, packaging, and logistics activities.[13] Detailed notes were taken during the interviews.

The field notes were transcribed and a "meta-matrix" display was constructed to assist with data coding and analysis.[14] The meta-matrix summarized each of the major environmental practices directed at materials management and purchasing processes at each of the sites. Appendix I (see page 10) describes the procedures used to code the data and ensure the reliability of the data coding process.

The coded data from the meta-matrix were used to identify the types of supply-based practices in the environmental management processes of purchasing companies. One of the most important issues faced by purchasing is whether to integrate a particular supplier into the internal environmental management processes of the company. Figure 1 (see page 6) depicts the types of processes used by companies in the sample for driving environmental improvements in the supply base.

To further understand the processes by which purchasing managers could drive environmental improvements within their supply base, a series of averages was calculated from the coded data which provided environmental "scores" for each of the five companies. All five companies were involved in similar types of environmental practices with their suppliers, consistent with the supplier evaluation and selection criteria depicted in Figure 1.

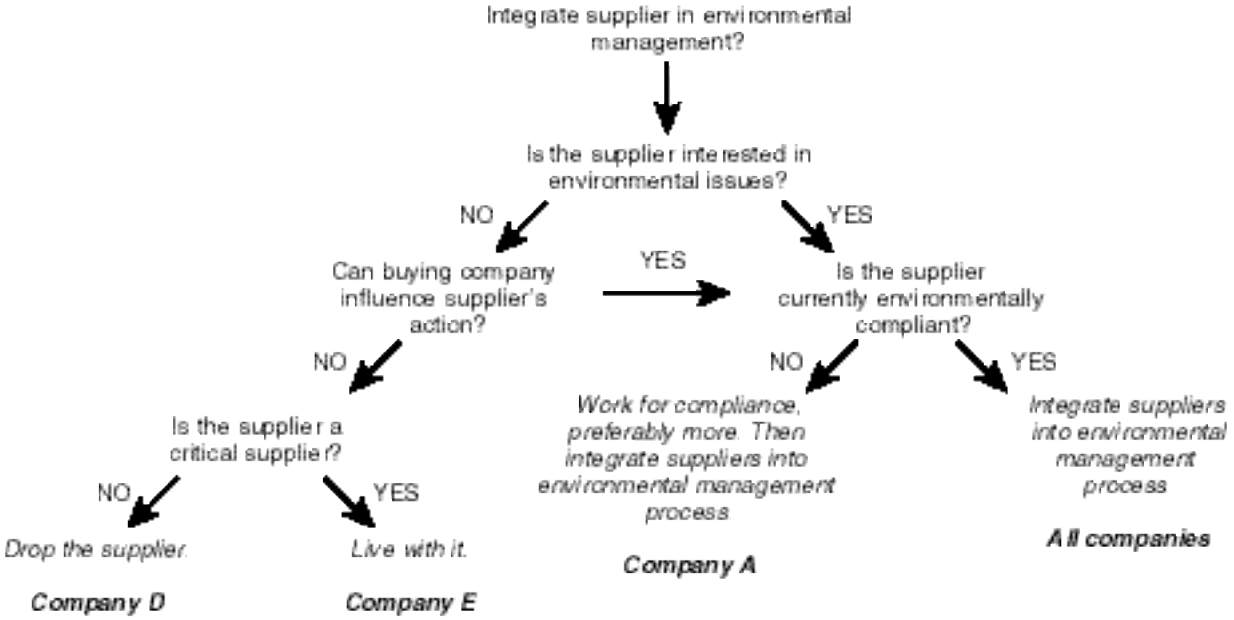
TABLE II

OVERVIEW OF COMPANIES INCLUDED IN THE RESEARCH

Company	Annual Sales (fiscal 1996)	Main Product Line	Comments
Company A	$1.3 billion	High-end office furniture. Most of the product is wood construction.	Has implemented a system of evaluating suppliers on environmental impact attributed. Has begun ISO 14000 supplier certification.
Company B	$2.6 billion	High-end office furniture. Most of the product is wood construction.	Has a long history of strategic sourcing and cooperative supplier relationships for key suppliers.
Company C	$1.2 billion	High-end office furniture. Most of the product is wood construction.	Works with product designers and suppliers to reduce and eliminate product off-gassing (i.e., product emitting formaldehyde).
Company D	$22.3 million	High-end office furniture, particularly executive desks. Most of the product is wood construction.	Has a long history of developing suppliers for strategic initiatives, for example sending systems analysts to the supplier to implement EDI purchasing.
Company E	$1.7 billion	High-end consumer furniture. Most of the product is wood construction.	Has had limited success in supplier development with the bulk of the success coming from a few large suppliers.

FIGURE 1

DECIDING TO INTEGRATE SUPPLIERS IN ENVIRONMENTAL MANAGEMENT



Within the five companies, the responsibilities of purchasing and inbound logistics included, to some extent, facilitating product design, determining appropriate methods and criteria for supplier evaluation and selection, and making changes to purchasing processes and purchased materials delivery across the supply chain. This studyfocuses on these main tasks as areas where purchasing could influence EFP in the supply chain. Hence, the environmental management activities of the five companies were classified into five major supply chain-oriented categories:

1. Materials used in product design for the environment
2. Product design processes
3. Supplier process improvement
4. Supplier evaluation
5. Inbound logistics processes

All of the companies pursued activities aimed at improving environmental performance in each of these supply chain categories, but experienced very different performance outcomes. In understanding the role of suppliers in environmental management, a number of differences in the implementation of the strategies in the five companies were identified. By highlighting and comparing these differences, a number of key insights and strategies were derived which were aimed at integrating suppliers into environmental management initiatives. These insights are presented as general guidelines that purchasing and supply chain managers can apply in managing environmental issues within their own supply base. The next section discusses these observations and recommendations based on the company environmental scores and the associated practices.

EFP IN PRODUCT DESIGN AND PURCHASED MATERIALS

"Design for the Environment" (DFE) initiatives in product design and development processes include activities initiated both by the buying company alone as well as joint initiatives with suppliers. The buying company's DFE activities are relevant to the role of suppliers in environmental management processes because they set a stage for integrating suppliers into the DFE process. Primarily, DFE activities follow one of two directions: product materials and design processes.

Company A focused heavily on product materials in their DFE initiatives. As an example of change made in a product's materials in the design stage, Company A has started using materials with lower formaldehyde off-gas potential. As of 1993, any product which releases ozone-depleting substances (ODS) or which uses ODS in its manufacturing process must be labeled. Company A met the Environmental Protection Agency's (EPA) deadline for removing ODS from products sold in the United States. More importantly, Company A strictly adheres to or exceeds the formaldehyde standards set by the EPA. Company A is also attempting to reduce the formaldehyde content of the particle board it uses because the chemical is released when the board is incinerated.

Company A is also working to reduce the number of different materials used in their products. In the past, the product might have several components made from different materials. This made the product, as a whole, more difficult to recycle.

Company C is also active in product materials DFE practices. They encourage their designers to consider alternative woods in their designs and to consider the tradeoffs associated with using veneers rather than solid wood. Company C has also reduced the aluminum content of its furniture to the lowest possible level without sacrificing the product's strength.

None of the other three companies reported any product materials DFE practices. Companies D and E were the most deficient in this area. Company D is a make-to-order company, hence their materials selections are usually driven by customer preferences. Similarly, Company E views their business as a "fashion industry" and are more concerned with consumer preferences than with innovating the materials used in the product to reduce environmental impact. In general, the more advanced companies in this study were seeking environmental improvements in product design by proactively involving members of their supply base in design activities.

Guideline: Product design and purchasing personnel should work together to influence environmental improvements in their own and their supplier's products. This can be achieved by substituting or changing material specifications for purchased products, and avoiding the use of hazardous or EPA-regulated materials where possible, to reflect the environmental agenda of the company.

EFP IN PRODUCT DESIGN PROCESSES

One way to influence material specifications is by promoting an improved dialogue between purchasers and designers. Companies A and B are active in reengineering their design processes to implement DFE. Company A uses "product design teams" to discuss the environmental issues and concerns related to the new product being designed. These design teams use life cycle analysis as a focal point for their discussions. Life cycle analysis involves studying all of the inflows and outflows of materials within the product's bill of materials, the by-products from the processes used to produce them, and the potential for recycling or re-using the product once it has reached the end of its useful life. Company B empowers its engineers to employ DFE practices by delegating ownership of product quality, environmental quality, and manufacturing process design. Company B also uses life cycle analysis, as well as Quality Functions Deployment (QFD) techniques to support DFE strategies aimed at producing "greener" products and services.

Companies C, D, and E are not involved with integrating DFE into their design and development processes. None of these companies considers life cycle issues in their design processes and none has integrated cross-functional efforts into their design processes.

Guideline: Product design processes must consider the lifecycle of all materials used in the product, including "cradle to grave" considerations. This can be accomplished by promoting a dialogue between designers and materials experts, and the use of tools such as life cycle analysis, QFD, and DFE by cross-functional design teams.

EFP IN SUPPLIER PROCESS IMPROVEMENTS

All five companies have recognized the role that purchasing plays in EFP. Actively developing suppliers' focus on environmental process improvements within their facilities is one high-leverage area where purchasing can significantly influence EFP in the supply chain. Each of the companies studied was pursuing some sort of initiative to influence or improve their primary supplier's processes. In some instances, the companies pursued nearly identical initiatives to achieve EFP purchasing. For example, all of the companies purchase wood from suppliers that practice sustainable forestry, and all of the companies either use no or very little tropical wood from endangered species (e.g., mahogany). In addition to wood, other material suppliers were being asked by purchasing managers to implement different types of process improvements to reduce waste, with the added benefit of lowering landfill tonnage. For example, Company B is working with a key fabric supplier to reduce the length of the bolts of cloth they buy, in order to reduce the quantity of remnants from the cutting process. At Company C, mangers were centralizing their cloth cutting operations and working with key fabric suppliers to *increase* the length of the bolts of cloth, again to reduce waste.

Actively developing suppliers' focus on environmental process improvements within their facilities is one high-leverage area where purchasing can significantly influence EFP in the supply chain.

All five companies work with their suppliers to reduce waste and emissions in the suppliers' process. A manager at Company A recognized that both his company and his suppliers were facing the same types of regulations. If Company A could reduce the environmental impact of incoming materials to its processes, then the negative environmental impact of its own products could also be reduced. Company A also views this on-going dialogue with suppliers regarding the environment as

an opportunity to learn and thereby improve its own processes. Company B is working with a major paint supplier to reduce VOCs in their paints. Company C works with its suppliers to help them meet environmental regulations by helping the suppliers identify their waste streams. Company C also monitors their suppliers' environmental processes within their certification system. Company D sends its vice president responsible for environmental management to suppliers to "pitch" environmental programs and send the message that green products are a priority if the supplier wishes to become a long-term partner with the company. Company D also includes in its operating budget money to send information technology specialists to the suppliers to help them with systems issues, such as EDI implementation and data integrity, which results in reductions in paper usage. Company E has worked with several of its larger suppliers to reduce some emissions and solid waste.

Guideline: Purchasing managers must proactively influence suppliers' processes, since liability for non-compliance to environmental regulations extends to all supply chain members. This can be accomplished by understanding core supplier processes and materials, and the environmental regulations associated with these processes and materials. High-level support of these activities is critical for success.

EFP IN SUPPLIER EVALUATION METHODS

To truly integrate suppliers into EFP, a close relationship is required between the trading partners. As Figure 1 suggests, the supplier must either be willing or coerced to work on the EFP initiatives. If the supplier is coerced, the company should be prepared to experience resistance from the supplier, and have a backup plan. The five companies have had limited success in convincing suppliers, particularly smaller suppliers, to take part in EFP initiatives. Company E has implemented several EFP projects with its larger suppliers, but the more numerous small suppliers have expressed little interest in working on environmentally-oriented initiatives. In many cases, this is due to the supplier's lack of internal resources. A notable example of the problem of convincing suppliers of the benefits of EFP is illustrated by the experience of Company D with one of its foam suppliers. Company D accounted for nearly 80 percent of the supplier's business and was located less than five miles from the supplier. Company D approached the supplier and inquired about the possibility of using reusable packaging to deliver the foam to Company D. Despite the apparent leverage Company D enjoyed with this supplier, they refused. Company D dropped the supplier and began fabricating the foam internally (an interesting twist on the insourcing/outsourcing decision).

The development of supplier evaluation systems that place significant weight on objective environmental criteria can play a major role in influencing supplier behavior. This problem becomes especially challenging when companies have a very large supply base. Company B's supply base is so diverse, for example, that they have not been able to finalize a set of supplier evaluation and selection criteria. Company A has partly addressed this problem by centralizing the evaluation and selection of some suppliers (particularly waste disposal service providers).

Of all the companies studied, only Company A has successfully completed a set of guidelines for supplier evaluation and selection based on environmental issues, the first step of which is achieving compliance to current environmental regulations. Company A wants suppliers to go beyond strict compliance, but this is a minimum requirement. However, they will not implement such criteria as rigid standards which must be met by their suppliers. Company A's goal is to develop environmental partnerships with its suppliers, without having to regulate and audit them.

The results of a recent focus group of ten materials managers (unrelated to this study's furniture companies) emphasizes the importance of carefully developed supplier evaluation criteria.[15] These managers were presented with a list of 30 environmental criteria mentioned as important in the literature, and were asked to rate the importance of the criteria in evaluating suppliers. Table III (see page 9) summarizes the top 10 criteria rated by managers in the focus group. Note that many of the criteria are still reactive in nature, (e.g., VOC content of the purchased product, recycled content of the purchased product, and whether the supplier has been assessed a fine by the government for environmental non-compliance). These results lend credence to the earlier statement regarding the difficulties associated with improving suppliers' environmental processes. If a supplier is willing to voluntarily improve environmental performance, either through their own insight or through the exercise of their customer's leverage, the diversity of possible approaches can be bewildering. Furthermore, the environmental outcomes represented by alternative process technologies are also often unknown. The fact that a number of proactive environmental measures are conspicuously absent in Table III suggests that this area of EFP in supply chain management is indeed in its earliest stages of development.

Guideline: The methods used and the criteria emphasized for supplier evaluation must reflect the strategic direction of the buying company's environmental initiatives. This is accomplished by first selecting criteria which focus on meeting government regulations, followed by proactive criteria focused on process improvements.

EFP IN INBOUND LOGISTICS PROCESS

Changes in inbound logistics processes can significantly reduce waste and cost. Not surprisingly, the companies in this study focused attention on achieving improvements in this area. Company B has worked to sensitize its employees concerning the environmental implications of purchasing, particularly packaging and inbound logistics. Company C trained their buyers in the environmental implications of the fallacy of purchasing strictly based on unit price and the importance of considering other issues such as disposal and obsolescence.

Companies A, C, and D have begun receiving shipments in reusable packaging from certain suppliers. Company A receives caster assemblies in reusable plastic trays, instead of the plastic bags and cardboard cartons previously used. Not only did this change reduce packaging material, it made it easier for the workers to assemble the product by improving the assembler's access to the assemblies. Similarly, Company C's change to plastic trays made of 100 percent recycled content reduced the handling time for its chair bases by 40 percent. Company D replaced palletized corrugated packaging with metal trays. This change saved the company $12,000 in the first three years after the change and dramatically reduced the amount of corrugated cardboard to be disposed.

Guideline: Suppliers must help buying companies change inbound logistics processes to reduce waste (e.g, packaging), which in turn can yield an operational advantage (e.g., cost and ease of assembly). This is accomplished by initiatives such as reusable containers for material delivery.

Not all of the companies were effectively managing supplier environmental performance. For instance, Company E focused much of its attention on the emerging laws of environmental compliance, and has been active at all levels of government, from local to national, in trying to shape the progress of the laws. Because Company E's environmental programs are significantly understaffed (two people for the entire organization), the focus on legislation comes at the expense of a focus on operational or strategic implications of environmental issues. Company E has no projects in place to reduce packaging of incoming materials through reusable containers. The company has also failed to develop guidelines for supplier evaluation and selection based on the supplier's environmental performance, and has made no effort to change the purchasing process to include environmental issues.

CONCLUSIONS

Purchasing and supply chain managers are in a critical position to influence the size of the overall environmental footprint of a company. Their influence on activities such as supplier selection and evaluation, supplier development, and purchasing processes means they can have a major impact on the ability of a company to establish and maintain a competitive advantage through EFP. The experiences of these five companies in the furniture industry demonstrate the need for purchasing and supply chain managers to integrate suppliers into environmental management initiatives.

TABLE III

TOP TEN ENVIRONMENTAL SUPPLIER EVALUATION CRITERIA

1. Public disclosure of environmental record
2. Second-tier supplier EFP evaluation
3. Hazardous waste management
4. Toxic waste pollution management
5. On EPA 17 hazardous material list for product labeling
6. ISO 14000 certified
7. Reverse logistics program
8. EFP in product packaging
9. ODS management
10. Hazardous air emission management

However, meeting this need will not be easy. Companies will face many challenges when trying to make suppliers an integral part of their environmental programs, including supplier resistance and constantly changing government regulations. Despite the difficulties, companies must commit themselves to improving the environmental performance of their supply chains. Only through a commitment of resources to environmental concerns can a company hope to achieve a competitive advantage through EFP. More important, as business is further pressed by customers and governments to achieve sustainability, minimal environmental compliance will not effectively position the company to maintain its market position. Therefore, a final guideline is:

Guideline: Companies must proactively manage supply chain environmental initiatives and seek higher benchmarks rather than simple compliance with government regulations. Proactive strategies must be supported with adequate resources and cannot just be given "lip service". A number of cross-functional and inter-organizational processes must be addressed, including product design, suppliers' processes, supplier evaluation systems, and inbound logistics. Proactive environmental strategies also have another benefit: cost and waste-reduction objectives can frequently be achieved.

REFERENCES

1. R.B. Handfield, S.V. Walton, S.A. Melnyk, and L. Seegers, "Green Supply Chain Practices in the Furniture Industry," *Journal of Operations Management,* forthcoming, 1997.
2. Handfield, et. al., op. cit., 1997; P. Winsemius and U. Guntram, "Responding to the Environmental Challenge," *Business Horizons,* vol. 35, no. 2 (1992), pp. 12-20.
3. Winsemius and Guntram, op. cit., 1992; M. Porter and C. van der Linde, "Green and Competitive," *Harvard Business Review,* vol. 73, no. 5 (1995), pp. 120-134.

4. C.J. Corbett and L.N. Van Wassenhove, "The Green Fee: Internalizing and Operationalizing Environmental Issues," *California Management Review,* vol. 36, no. 1 (1993), pp. 116-135; D.J. Wood, "Corporate Social Performance Revisited," *Academy of Management Review,* vol. 16, no. 4 (1991), pp. 691-718.
5. Porter and van der Linde, op. cit., 1995.
6. See B.C. Bonifant, M.B. Arnold, and F.J. Long, "Gaining Competitive Advantage through Environmental Investments," *Business Horizons,* vol. 38, no. 4 (1995), pp. 37-47; M.C. Gupta "Environmental Management and Its Impact on the Operations Function," *International Journal of Operations and Production Management,* vol. 15, no. 8 (1995), pp. 34-51; Porter and van der Linde, op. cit., 1995; J. Sarkis and A. Rasheed, "Greening the Manufacturing Function," *Business Horizons,* vol. 38, no. 5 (1995), pp. 17-27, for a more detailed description of how companies might leverage environmental policy for competitive advantage.
7. Porter and van der Linde, op. cit., 1995; N. Walley and B. Whitehead, "It's Not Easy Being Green," *Harvard Business Review*, vol. 72, no. 3 (1994), pp. 46-52. Briefly stated, a resource-productivity framework labels *anything* that does not add value as a waste to be eliminated. In this framework, pollutants are simply another example of waste to be eliminated; they do not represent a special class of problem.
8. J. Makower, *Beyond the Bottom Line* (New York: Simon & Schuster, 1994).
9. S.L. Hart "Beyond Greening: Strategies for a Sustainable World," *Harvard Business Review,* vol. 75, no. 1 (1997), pp. 66-76.
10. The stages presented in Table I draw on the works of P. Winsemius and U. Guntram, 1992; R.B. Handfield, S.V. Walton, S.A. Melnyk, and L. Seegers, 1997; and the experience of the authors.
11. M.B. Miles and A.M. Huberman, *Qualitative Data Analysis: A Sourcebook of New Methods* (Newbury Park, CA: Sage Publications, 1994, p. 37).
12. R.D. Klassen and C.P. McLaughlin, "The Impact of Environmental Management on Firm Performance," *Management Science,* vol. 42, no. 8 (1996), pp. 1199-1214.
13. The interview protocol is available from Steve Walton upon request, preferably by e-mail, to steve_walton @bus.emory.edu.
14. Miles and Huberman, 1994, p. 178, define a meta-matrix as a "master chart assembling descriptive data from each of several cases in a standard format." A meta-matrix is one first step for analyzing and displaying qualitative data.
15. Industry Executive Advisory Team, December 3-4, 1996, Michigan State University Environmentally-Responsible Manufacturing Research Team, NSF Study #DMI-9528759. These managers represented firms in the automotive, computer, electronic, and consumer goods industries.
16. Miles and Huberman, op. cit., 1994, p. 56.
17. Miles and Huberman, op. cit., 1994.

APPENDIX I

DATA CODING AND RELIABILITY ANALYSIS

Unlike large sample size statistical analysis, qualitative data analysis is iterative; refining, reconstructing, and refocusing successive displays drawn from the meta-matrix at each iteration until the final display incorporates as much of the qualitative data as is appropriate. For this reason, data reduction is an integral part of the data analysis process. In the areas of product design, supplier evaluation, purchasing process and logistics, the objective was to determine the best environmental supply chain practices. Using the processes described in this appendix, the events and responses from each site were classified into the conceptual structure presented in Table I, which could then be used to describe a taxonomy of EFP best practices in purchasing and materials management.

The data were coded by applying abbreviations or symbols to sentences and/or paragraphs in the transcribed field notes to classify the sentences/paragraphs.[16] The transcribed field notes were reviewed several times to code the activities into the appropriate environmental response categories presented in Table I and to compare field notes taken during the interviews. In so doing, the activities and processes observed at each site could be further classified as design and development, purchasing process, and inbound logistics. Four coders — the authors and another expert in supply chain management — independently coded the data. The classification and coding was refined iteratively between the four codes until all activities were classified to the satisfaction of all coders.

Each activity was coded independently and assigned a position on the relative scale suggested in Table I (i.e., scores ranging from 1 to 6, with 1 = resistant, 2 = embracing, 3 = reactive, 4 = receptive, 5 = constructive, and 6 = proactive). The scores assigned to each of the practices were then averaged, resulting in an environmental "score" for each activity for each company. All of the scores were rounded to the nearest integer. This method enabled a check on the reliability of the coding using the following formula:[17]

$$\text{Reliability} = \frac{\text{Number of agreements}}{\text{Total number of items}}$$

Miles and Huberman advocate a 70 percent intercoder reliability as appropriate when using multiple raters to code field notes. Using the method described above, each rounded average score for each activity was used to calculate the intercoder reliability. Each reliability was found to be 0.70 or higher.

APPENDIX II

INTERVIEW PROTOCOL FOR EFP IN THE FURNITURE INDUSTRY

Objectives

1. To understand which environmental issues concern furniture companies.
2. To understand how concern for environmental issues translates into action within materials and logistics management responsibilities.
3. To share best practices regarding waste prevention, reduction, and management within the furniture industry.

General issues

1. What is your role in environmental issues?
2. How long has your company been concerned about environmental issues? What has been the primary driver for action?
3. Why is your company involved in environmental issues? Overall, what are the tangible and intangible benefits?
4. What departments in the company are concerned/involved with environmental issues?
5. How does handling of environmental issues fit within the organization (i.e., who is responsible for these issues)? If you are responsible, where do you fit in the organization chart?
6. What is your impact on materials and logistics management issues?
7. Are the environmental efforts publicized/marketed? In what way?
8. What are the company's overall objectives in environmental affairs?
9. How do you and your firm identify and prioritize environmental issues? Does the consumer affect priority and resolution of issues? How do you guard against short-term decisions?
10. What is (are) your source(s) of environmental information? Consultants, internal experts, local action groups, regulatory agencies?
11. Which community action groups do you have relationships with?

Manufacturing

1. What is the impact of environmental issues on manufacturing?
2. What waste streams are generated that your firm tries to control/regulate?
3. Have any processes been redesigned to reduce waste?
4. How is the product designed? Is the life cycle of the product considered?
5. Discuss the remanufacturing trend in the furniture industry. What part of your business is this? Why does the customer want remanufactured furniture?
6. How is solid waste handled? Who has primary responsibility for disposition of scrap and waste?

Purchasing

1. How do environmental issues impact purchasing?
2. Are environmental criteria used to evaluate potential suppliers (e.g., supplier's manufacturing process, use of materials, source of materials)?
3. What is the interest level of your suppliers? Have any suppliers actively participated in environmental efforts?
4. Do you have any specific projects in this area? Examples include dyes, "good wood," and supplier qualification.

Marketing

1. Do your customers request environmentally-responsible products?
2. What is the potential for growth in this area?

Packaging

1. How are your products packaged?
2. What are your company's environmental efforts in this area?

Logistics

1. Does your company manage any reverse logistics flows? Describe.
2. How do environmental issues impact transportation selection and/or distribution methods?

General environmental initiatives

1. Describe any other major environmental initiatives.
2. How do you measure the benefits of environmental initiatives in terms of cost?

Future trends

1. What are future environmental trends in the furniture industry?
2. Do you see your environmental initiatives fitting in with your long-term business strategy?