Green Supply Chain Management; Critical Research and Practices

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Abstract

The waste and emissions caused by the supply chain have become the main sources of serious environmental problems including global warming and acid rain. Green supply chain policies are desirable since reactive regulatory, to proactive strategic and competitive advantages. The novelty of this topic makes it difficult to truly determine contradictory and conflicting issues that could be considered true "debates". We will present some of the debates that do occur, but this paper appraisal of investigation, practice and evaluation of green supply chain management.

Keywords
Green supply chain management, green purchasing, in-bound logistics, out-bound logistics, reverse logistics.

1. Introduction
In early environmental management frameworks, operating managers were involved only at arm's length. Separate organizational units had responsibility for ensuring environmental excellence in product development, process design, operations, logistics, marketing, regulatory compliance and waste management. Today, this has changed. As in the quality revolution of the 1980s and supply chain revolution of the 1990s, it has become clear that the best practices call for integration of environmental management with ongoing operations. Green supply chain management (GSCM) is gaining increasing interest among researchers and practioners of operations and supply chain management. The growing importance of GSCM is driven mainly by the escalating deterioration of environment, e.g. diminishing raw material resources, overflowing waste sites and increasing level of pollution. However, it is not just about being environment friendly; it is about good business sense and higher profit. The supply chain "system" includes Purchasing and In-bound Logistics, Production, Distribution (Outbound Logistics & Marketing), and Reverse Logistics. The first three categories are part of the well-known value chain concept espoused by strategic thinkers [22]. The last functional element, Reverse Logistics, is one of the more recent areas of focus by supply chain researchers. Figure 1 brings these factors together and exactly, what is the green supply chain? After a brief discussion concerning the definition of green supply chains, the discussion and presentation of issues turns to our four defined areas. Some practices, research, and evolving issues are discussed for each of them. Then, an integrative look at the whole system and common issues will be presented.

1.1 Green Supply Chain Management – What is it?
"Green supply refers to the way in which innovations in supply chain management and industrial purchasing may be considered in the context of the environment" [7]. "Environmental supply chain management consists of the purchasing function's involvement in activities that include reduction, recycling, reuse and the substitution of materials." [18]. "The practice of monitoring and improving environmental performance in the supply chain…" [06]. "Integrating environmental thinking into a supply chain management, including product design, material resourcing and selection, manufacturing processes, delivery of the final product to the consumer as well as end-of-life management of the product after its useful life" [25]. From these four definitions we see that there is a range of author focus and purpose on green supply chains and their management. Research or practitioner field (i.e. purchasing, operations, marketing or logistics) also influences the definition. The definition of the purpose of green supply chains, which range from reactive monitoring of general environmental management programs to more

proactive practices such as the R's of environmental management and incorporating "innovations", also seem to differ. This lack of consensus in practice and definition of green supply chain is not surprising, since its foundational elements of corporate environmental management and supply chain management are both relatively new areas of study and practice. If the practice of green supply chains is novel, the theory is even more so, if true theory even exists.

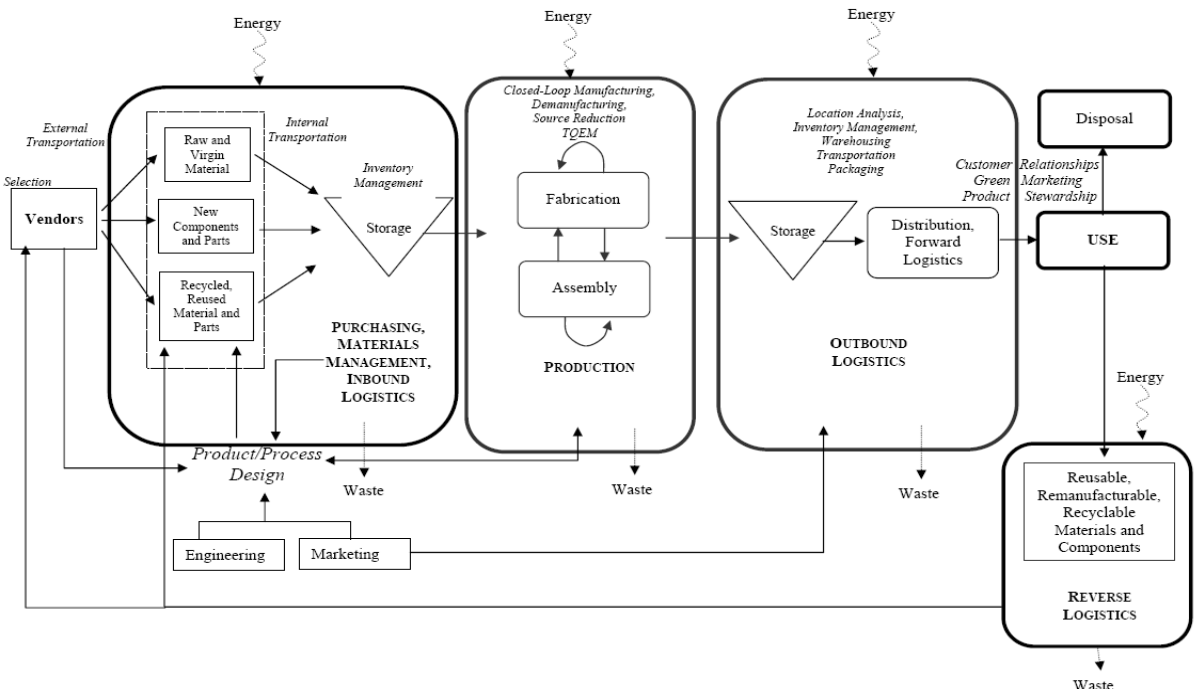

Figure 1: Operational functions and environmental practices within the supply green supply chain

2. Purchasing and In-Bound Logistics

The purchasing function involves the acquisition of materials from suppliers to meet the needs of producing the organizational product or service. Purchasing includes duties such as vendor selection, material selection, outsourcing, negotiation, buying, delivery scheduling, inventory and materials management, and to some extent, involvement in design. We shall initially take an overall look at some of the issues relevant to general green purchasing.

2.1 General Green Purchasing Practice

Green purchasing has a number of environmentally based initiatives that may be incorporated into the purchasing function; these are summarized as follow [12, 13]. Supplier Environmental Questionnaires; Supplier Environmental Audits and Assessments; Environmental Criteria on Approved Supplier List; Require Suppliers to undertake independent Environmental Certification; Jointly Develop Cleaner Technology/Processes with Supplier(s); Engage Suppliers in Design for Environment product/process innovation; Reduce packaging waste at the customer/supplier interface ; Reuse/Recycling of materials requiring co-operation with supplier; Reuse initiatives (including buy-backs and leasing); Conduct LCA with cooperation from suppliers; Seek to influence legislation in cooperation with suppliers; Create supply "club" to collaborate on environmental issues ; Coordinate minimization of environmental impact over full supply chain ; Build environmental criteria into supplier contract conditions; Audit Supplier Environmental Performance. Exemplary Industrial Practices for the Green Purchasing Function as follows.

Fiat Auto – A document called "Guidelines for Cooperation," signed in February 2004, requires that partners accept the increasing environmental compatibility of their products and manufacturing processes as a priority, while respecting the economic and competitive balance. A survey of 360 suppliers was conducted in 2004 to monitor their management of environmental resources (energy, water, air, and so on). A packaging waste control program is under way with 70 suppliers, monitoring incoming and outgoing materials. (Company Report, 2006)

General Motors formed a Supplier Environmental Advisory (SEA) Team to explore ways that GM can work effectively with suppliers to integrate environmental concerns into the design, sourcing, and manufacturing processes. The SEA Team has identified near-term and longer-term opportunities for collaboration among GM and its suppliers on environmental management systems (EMS), design for environment, and environmental metrics

throughout the supply chain. Working with the SEA Team, GM developed a policy statement on "Environmental Performance Management in GM's Value Chain." (Company Report, 2005)

2.2 In-bound Logistics

One of the issues in delivery (and production) is the use of just-in-time (JIT) practice. This practice is meant to reduce inventory, thus eliminating costs and waste. For example, less storage and warehouse space is needed. This practice reduces the necessary overhead and resource consumption needed to manage this inventory. Thus, JIT seems to be an environmentally sound practice, yet when considered on the whole, the environmental savings can be deceptive. For example, the major method to lessen the amount of inventory is to deliver and produce in small batches. These smaller batches mean more deliveries, thus raising fuel consumption and traffic congestion [16, 19, 21, and 27]. Investigations of this tradeoff's are necessary. But some of these issues are mitigated with such practices as on-site suppliers or those that are in close proximity for JIT reasons. Another factor related to JIT and supplier management is that fewer suppliers are usually used in a JIT environment. This means better forecasting and fuller loads could be planned. Of course this delivery approach will be dependent on demand levels and characteristics.

Wu & Dunn have also identified a number of other "tradeoffs" and issues facing in-bound logistics (and out-bound, as well) [27] . One is freight consolidation. Waiting for freight to become a full load may lead to longer lead times but may yield savings and be environmentally preferable. Another issue is mode selection. Some transport modes like rail and barge use less energy or use energy more efficiently than other modes like road haulage and air cargo. In this case, flexibility, timing and speed are tradeoffs to cost and environmental factors. The transport mode decision determines which transport option to use and often affects traffic congestion and air pollution both directly and indirectly. Carrier selection, a part of supplier selection, is an important in-bound logistics decision. Transportation is important to all industries. As an example, the Chemical Manufacturers Association cited Roadway Express, a major carrier, as a responsive care partner in hauling chemicals.

The major question in these examples is whether companies are capable and willing to make the tradeoffs. An issue that arises relates to any major environmental issue: when does the environment play a large enough role to overcome other performance metrics? As well, the addition of a third party (third-party carriers and logistics managers are quite popular) into the decision process makes it more difficult for the vendor-customer relationship. Who makes the decision on mode and freight consolidation, especially when organizations may have differing environmental strategies?

3. Production

The manufacturing and production function's role in corporate environmental has been well addressed in the literature. The internal supply chain's performance can best be managed within this function. Since a number of reviews on environmentally conscious manufacturing have been completed [5, 8, 9, 11, 20]. We shall only focus on a few of the major principles in this function.

A principle topic that has evolved within this area is total quality environmental management (TQEM). But, similar to the concept of total quality management, it is hard to get a concrete definition and practice of TQEM. It is a managerial philosophy, rather than a hard technology or program, with a number of tenets (some of which are also espoused above in dealing with suppliers as well). Some of the tenets of TQEM include empowerment of employees, continuous improvement, team efforts, inter functional collaboration, and leadership elements. There are issues in each of these areas, one of the most important of these areas, from a managerial perspective, is empowerment and employee involvement.

Closed-loop manufacturing is one of the internal measures that can be used to improve the environmental performance of the internal supply chain. The philosophy of zero-emissions (similar to zero-defects of many TQM programs) is what drives closed-loop manufacturing practice. Closed-loop manufacturing is a process of producing products with no negative environmental impact [10]. Currently, much of the emphasis on closed-loop manufacturing is on development of supporting technology. This internal loop helps to lessen some waste streams that flow from the production function, but may require additional energy and resources to function and maintain. As part of the source-reduction philosophy closed-loop manufacturing, a related issue to the zero-emissions philosophy is substitutability, which has become much more popular with design for the environment linkages. For example, substitutes for environmentally toxic materials such as solvents with aqueous solution for processes and powders paint for liquid paint are examples of using substitutes to reduce and eliminate emissions [26]. The determination of life cycle impacts of these substitutes is still a problematic proposition. The investigation of managing in this environment seems to be almost non-existent. From a research perspective this is one of the more technology and tool driven functions of the green supply chain.

Exemplary state-of-the-art green practices in the production function are as follows.

Compaq (formerly Digital Equipment Corporation) has a recovery facility for electronics parts where purchasing agents also serve as marketers and salesmen. They have developed relationships with a number of organizations that send their electronics components and products there for demanufacturing and organizations (such as Envirocycle) that use their outputs as inputs for their products [22].

Disney built an on-site material recovery facility (MRF), which began handling recyclables from the Walt Disney World Resort. The MRF handles more than 45 tons of paper, plastic, glass, steel, aluminum, and cardboard, daily, representing an average recycling rate of more than 30% of these materials. Other used equipment and excess items are sold to Cast Members or auctioned to the public. (Corporate Environmental Report, 2004)

4. Distribution and Out-Bound Logistics

Whereas, purchasing and in-bound logistics focuses on managing the vendor-organization relationships of the supply chain, the distribution and out-bound logistics function is meant to address the organization-customer relationship issues. We shall begin with a discussion on some of the issues in a general category of "customer" relationships which includes some developments in green marketing. A brief discussion on out-bound logistics completes this section.

4.1 Customer Relationships

Customer relationships are greatly influenced by green marketing policies. Some studies have found that ultimate individual consumer interest in the environment and environmentally sound products is quite substantial, even though there has been a slight decline [24]. This interest along with government regulations, are two external pressures that flow throughout the supply chain. Studies have shown that many companies are putting pressure on their suppliers and suppliers are listening to corporate customers, as well as the end-user [12]. One of the controversies in green marketing and customer relationships is whether customer interest in environmentally sound products relates to actual purchase. Various studies have shown that interest is usually higher than actual purchase. This argument can be made for either individual consumers or corporate and industrial buyers. Even though this issue has been shown to be an individual consumer phenomena [15, 23], the extension to corporate buyers needs a more complete evaluation.

4.2 Outbound Logistics

One of the reviews of the literature found a number of areas within standard practice of outbound logistics that have implications for greening the logistics function [27]. The design of a logistics network and its planning are two of the more strategic issues facing logistics managers in this function. Many trade-off decisions need to be made with regard to the firm's market, customer, product and logistical resources. Examples of typical logistics decisions include options such as direct shipping or hub-and-spoke, central warehouse or distributed network, intermodal or single mode, and third party services or private fleet. Some of the design and management criteria that support environmental planning in this area include fewer shipments, less handling, shorter movements, more direct routes, and better space utilization. But, each of these issues includes tradeoffs among delivery time, responsiveness, quality and cost, as well as environmental performance. Warehousing and delivery packaging design are two important issues in outbound (and inbound) logistics and distribution. Wu and Dunn argue that warehousing, other than land use requirements, also generates much of the packaging waste in the supply chain [27]. Standardized reusable containers, good warehouse layouts, easy information access all cut storage and retrieval movements and save on operating costs and are environmentally sounder. Freight consolidation functions and "breakbulk" operations carried out in warehouses also have the potential of utilizing transport capacity more efficiently, thus minimizing the environmental impact of the out bound transport system. Following example shows some exemplary practices that have impact on the greening of distribution, out-bound logistics and marketing. Bristol Myer's Squibb has a customer related environmental program that educates customers, typically health care management institutions to aid in environmental practices (Corporate Environmental Report, 2005). DuPont has developed a partnership with Ford Motor in which DuPont's payments are based on the number of cars that are painted. This creates an incentive for the two companies to use paint as efficiently as possible [4].

5. Reverse Logistics

Reverse logistics incorporates the return of materials, components and products back into the "forward logistics" chain. Carter and Ellram, have further defined reverse logistics as an environmentally conscious approach by incorporating reverse distribution and resource reduction [2]. Their complete definition for reverse logistics is the return, upstream movement or a good or material resulting from reuse, recycling, or disposal with the minimization of waste which results in more efficient forward and reverse distribution processes. Reverse logistics operations include the following major steps: collection, separation, densification or disassembly, transitional processing, delivery and integration. The operational emphasis is dependent on the type of material or component that flows in

the reverse logistics channel. For example, disassembly will be required for copy machines, whereas plastic bottles would require densification. Practical examples of issues that have been addressed in the reverse logistics function are as follows. Siemens Nixdorf Informations system AG has a recovery plant located in Paderborn, Germany. The recovery plant reconditions and recycles used computers. The customer bears the burden of some of the disposal costs. It charges customers on a sliding scale based on the product type and disassembly and recycling costs. [1]. Rank Xerox, with a history of leasing copier equipment, has implemented programs to increase the leasing option to help in recovery of parts and equipment. These programs have increased the rate of return for purposes of asset recovery. Decreasing the costs of fully warranted equipment at reduced prices. Marketing programs have been developed strictly for promoting these "green" products [1].

5.1 System and Emerging Issues

A number of issues that encompass the green supply chain or that are common across the supply chain are now presented. Within these issues are a set of emerging organizational topics and fields that may have direct impact on the green supply chain.

5.2 Small Companies and the Green Supply Chain

One of the more difficult, and probably most important, groups to incorporate into the supply chain are the small companies. In an academic survey of 135 companies found smaller companies attached less importance to management of environmental issues when compared to larger firms (greater than $1 billion) [17]. It have been found in a study of manufacturers that convincing small companies to become involved in green purchasing was a major barrier for these manufacturers. In a more general study of corporate performance and environmental consciousness, found that larger companies are more inclined to be environmentally conscious [20]. In a regional survey of small manufacturer practices found a large number of them were interested or practicing environmental practices (especially recycling initiatives) in their organizations. Almost a third of these companies also monitor their suppliers [5]. In an investigation of industrial co-location and inter-firm networking's influence on economies in environmental management finds that these strategies can help small organizations gain environmental savings [11]. Such savings manifest themselves in the form of less expensive environmental management infrastructure and services; accelerated and less expensive information flows; decreased incidence and intensity of land-use conflicts; and an enhanced ability on the part of the public sector to enforce environmental regulations. Thus, close and inter-firm networks could be a way to help small organizations become more effective environmental partners. The use of eco-industrial parks and government sponsored waste exchange programs as techniques to aid the linkage between small and large companies [14]. Another approach is to aid small companies is through mentoring programs from large companies as evidenced by a study in Guadalajara, knowing that there is a difference between large and small companies in their involvement and acceptance of green supply chain principles is one issue for investigation [3]. Another, more important issue is determining requirements and practices that would help small manufacturers become more involved in this process.

6. Summary and Conclusion

We have reviewed a number of issues related to green supply chains and their management. The structure of the presentation was based on four major functions that could be considered as drivers within the green supply chain. These functions included purchasing and in-bound logistics, production, distribution and out-bound logistics, and reverse logistics. A number of integrative issues potentially effecting each of these functional areas were then presented. Even in this relatively new field of green supply chain management a number of debates have emerged, within and between functions. It has been found that most of the literature on green supply chain management has been descriptive, anecdotal, and/or prescriptive. As, well much of the literature has investigated small portions of the whole supply chain. Academic journals have only begun to address issues that have been appearing in the trade journals since the early 1990's. With only a few empirical studies, which have been exploratory, the amount of generalizable knowledge and theory development in this area is almost non-existent. To truly address these emerging debates and issues, effective research agendas and methodologies will be required. Even then, the debates may never truly be answered. As in all environmentally based research arenas tools, techniques and theory from a number of disciplines will be required for a truly complete study of this area. We feel that as in future, this topic and field and its debates will keep a number of researchers busy.

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References

1. Ayres, R.U., G. Ferrer, and T. Van Lyenseele. 1997. “Eco-efficiency, asset recovery and remanufacturing.” Working paper 97/35/EPS/TM, INSEAD, Centre for Management of Environmental Resources, Fontainebleu, France.
2. Carter, C.R., and L.M. Ellram. 1998. “Reverse logistics: A review of the literature and framework for future investigation.” Journal of Business Logistics. 19(1): 85-102.
3. Champion, D. 1998. “Briefings from the Editor: Environmental Management – Spreading the Green.” Harvard Business Review. 76(6): 16-27.
4. Denton, T. 1998. “Sustainable development at the next level.” *Chemical Market Reporter*. 253 (7): 3-5.
5. Florida, R. 1996. “Lean and green: the move to environmentally conscious manufacturing.” California Management Review. 39(1): 80-105.
6. Godfrey, R. 1998. “Ethical purchasing: Developing the supply chain beyond the environment.” in *Greener Purchasing: Opportunities and Innovations*, edited by T. Russel, Sheffield, England: Greenleaf Publishing: 244-251.
7. Green, K., B. Morton, and S. New. 1998. “Green purchasing and supply policies: Do they improve companies’ environmental performance?” *Supply Chain Management*. 3(2): 89-95.
8. Gupta, M., 1995. “Environmental management and its impact on the operations function”, *International Journal of Operations and Production Management*, 15(8): 34-51.
9. Hanna, M.D, and W.R. Newman. 1995. “Operations and the environment: An expanded focus for TQM”, *International Journal of Quality and Reliability Management*, 12(6), 38-53.
10. Hasek, G. 1997. “Closing the loop: Companies use innovative methods to reduce waste”, *Industry Week*. 246(8): 13-16.
11. Klassen, R. and C. McClaughlin 1996. “The impact of environmental management on firm performance.” *Management Science*. 42(8): 1199-1214.
12. Lamming, R., and J. Hampson. 1996. “The environment as a supply chain management issue.” *British Journal of Management.* 7(S): 45-62.
13. Lloyd, M. 1994. “How green are my suppliers? – Buying environmental risk*.” Purchasing and Supply Management*. October: 36-39.
14. Lowe, E. 1997. “Creating by-product resource exchanges: strategies for eco-industrial parks.” *Journal of Cleaner Production.* 5(1-2): 57-65.
15. Mandese, J. 1991. “New study finds green confusion.” *Advertising Age***,** 62(45): 1-2.
16. McIntyre, K., H.A. Smith, A. Henham, and J. Pretlove. 1998. “Logistics performance measurement and greening supply chains: Diverging mindsets.” *The International Journal of Logistics Management*, 9(1): 57-67.
17. Murphy, P.R., R.F. Poist, and C.D. Braunschweig. 1996. “Green logistics: Comparative views of environmental progressives, moderates, and conservatives.” *Journal of Business Logistics*. 17 (1): 191-211
18. Narasimhan, R., and J.R. Carter. 1998. *Environmental Supply Chain Management. The Center for Advanced Purchasing Studies*. Arizona State University, Tempe, AZ.
19. Penman, I. 1994. “Environmental Concern: Implications for supply chain management.” in *Logistics and Distribution Planning – Strategies for Management*, 2nd Edition, edited by J. Cooper, London: Kogan Page Ltd.: 270-292.
20. Sarkis, J. 1995a. “Manufacturing strategy and environmental consciousness”, *Technovation*, 15(2): 79 -97.
21. Sarkis, J. 1995b. “Supply chain management and environmentally conscious design and manufacturing.” *International Journal of Environmentally Conscious Design and Manufacturing.* 4(2): 43-52.
22. Sarkis, J. 1999. “Manufacturing’s role in corporate environmental sustainability: Concerns for the new millennium.” *International Journal of Operations and Production Management*, forthcoming.
23. Schlossberg, H. 1990. “Canadians are serious about their environment and ours, too.” *Marketing News*, March 19: 16.
24. Speer, T.L. 1997. “Growing in the green market.” *American Demographics*. 19(8): 45-49.
25. Srivastava, S.K. 2007. “Green supply chain management: A state of the art literature review”,International journal of management reviews, 9(1):53-80.
26. Vasilash, G.S. 1997. “USCAR pushing painting technology to the next level.” *Automotive Manufacturing & Production*. 109(2): 52-56.
27. Wu, H.J., and S.C. Dunn. 1995. “Environmentally responsible logistics systems.” *International Journal of Physical Distribution & Logistics Management.* 25(2): 20-38.