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Green Supply Chain Management

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Abstract

There is a need to consolidate environmental issues and try to find solutions to the problems that are detrimental to the environment. Researches show that the idea of green supply-chain is not fully developed. There is a need to understand green supply-chain management from a different perspective. Green supply chain helps in utilizing all the available productive resources effectively. By implementing green supply chain management principles in the business decision making process, organization can purchase green resources that will help in providing environmental friendly products and achieve greater desired results. The growing importance of supply chain is driven mainly by worsening of the environment. The waste and emission caused by supply chains have become one of major concerns of serious environmental problems which include acid rains and global warming. One of the vital facet of green supply chain is to improve both environmental and economic performance simultaneously. This paper mainly focuses on optimization and implementation of Green supply chain operations to reduce environmental problems.

Keywords: Green supply chain management, Environmental impact, Reverse Logistics, Green Design, Environmental Management, Manufacturing, Sustainability, pollution.

Introduction

The Council of Logistics Management (CLM) defines supply chain management as "The Strategic coordination of the core functions and tactics across these functions within a specific organization and across its partners within the supply chain for the purpose of improving the long-term performance of the individual organizations and the supply chain as a whole". Supply chain management is involved in wide range of functional areas. Supply chain management emerged as an independent topic from marketing and strategic management.

Supply chain management was long-established as a process where raw materials are made into fine products and delivered to the consumer. According to Srivastava (2006), the process involves extraction and exploitation of the natural resources. It is important to realize that even though we live in a world where technology grows at a rapid pace, we must consider environmental sustainability as a significant issue to business practice. The emissions and wastes created by supply chain have become a serious problem which could be detrimental to the future generations. Green supply chain policies are desirable since they are reactive regulatory, to proactive strategic and competitive advantages. The growing importance of green supply chain grabbed the attention of many researchers, environmental scientists and supply chain analysts. Green supply chain is not just about being environmental friendly but also about good business sense and higher profit. Green supply chain has its roots in both supply chain management and environmental literature.

The boundary of green supply chain depends on the goal of the investigator. According to Zhu and Sarkis (2004), the definition and scope green supply chain management in literature has

ranged from green purchasing to integrated green supply chains flowing from supplier to manufacturer to customer and even Reverse Logistics.

Supply chain includes various operations such as purchasing and In-bound Logistics (materials management), production, outbound logistics (physical distribution and marketing) and Reverse Logistics. The main goal of green supply chain is to balance marketing performance with environmental issues. Many organizations started implementing the green supply chain in order to meet challenges such as pollution abatement and energy conservation, this creates network of suppliers to purchase environmentally superior products and to develop a similar approaches to operational efficiencies and waste reduction. Green supply chain has become a great concern for many organizations. One major concern is bringing organizational environmental awareness and putting environmental activities into practice in the logistic activities of their supply chains. According to Wilkerson (2005), green supply chain is a business value driver and not a cost center. Green supply chain is driven by regulatory requirements and consumer pressures.

Environmentally conscious business practices have been receiving increasing scrutiny from both researchers and practitioners. Interdisciplinary research has integrated the efforts of management, engineering, physical and social sciences to investigate the issues relevant to this topic. Similarly, multifunctional groups within organizations and external stakeholders have a role in decisions related to organizations and the natural environment. When organizational environmental decisions are to be made they will necessarily be strategic and usually more complex for this reason. These decisions will have internal and external implications for the management of an organization. Green supply chain decisions are one of the latest issues facing organizations with strong internal and external linkages. One approach to model the dynamic

nature of business and its relationship to the natural environment into a decision framework is a technique that is capable of considering the multidimensional qualitative and strategic characteristics.

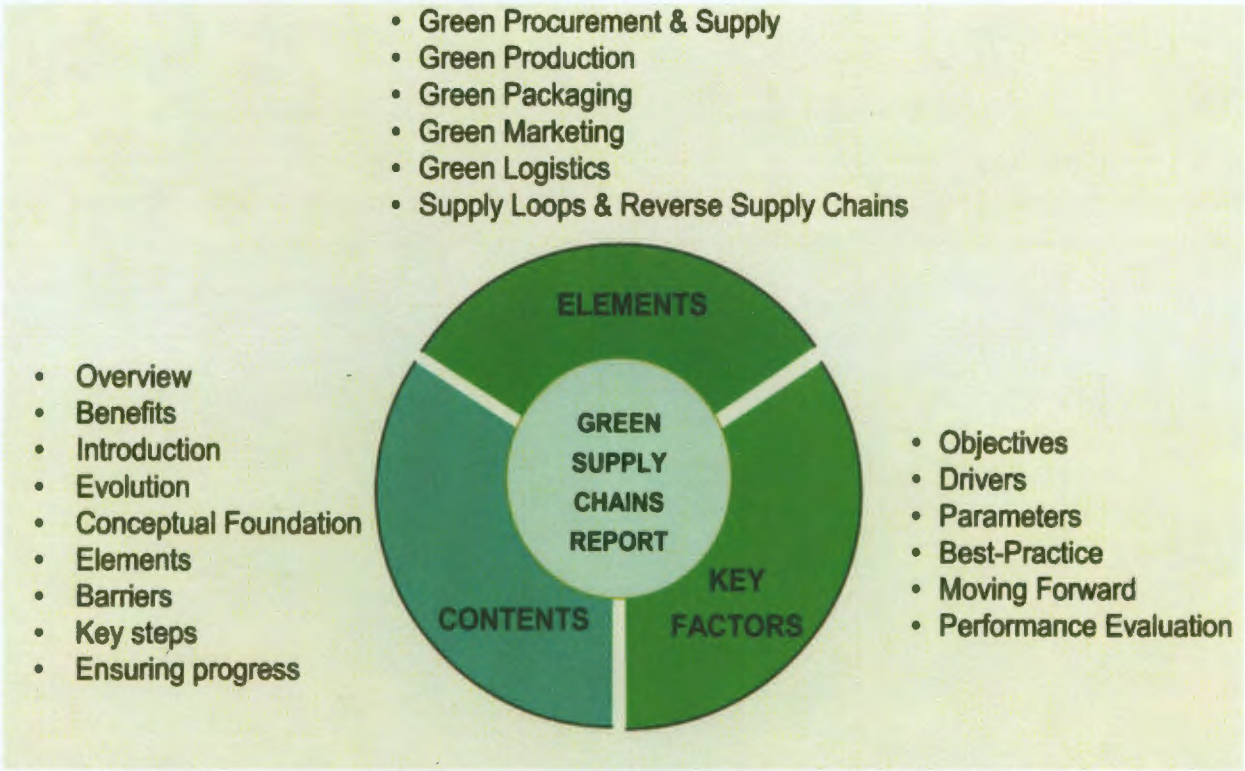

Figure 1. Green supply chain Report. Description of contents, elements and key factors. Retrieved from http://globalscgroup.com/offers/green-supply-chain-management-diagnostic/ 03/06/2016.

Green supply chain is defined as incorporating environmental thinking into supply chain management which includes product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life.

Green design has been widely used to represent designing products with certain environmental specifications. Fiksel (1996) says that green design is the systematic consideration

of design issues linked with environmental safety and health over the full product life cycle during production and also during the development of a product. Its scope surrounds many disciplines, including environmental risk management, product safety, pollution safety, occupational health and safety, pollution prevention, resource conservation and waste management.

Lund (1984), thinks that the operations of green supply chain Management relate to product manufacture/remanufacture, usage, handling, logistics and waste management. The goal of Green manufacturing is to reduce the ecological burden by using suitable material and technologies, while remanufacturing is an industrial process in which damaged products are repaired.

The inbound and outbound logistic activities are potential polluters to the environment. Organizational and operational learning can be inferred from the firm's experience with the implementation of the programs such as Total Quality Management and various environmental management systems.

Research Methodology

The objective of this research paper is to emphasize the significance of green supply chain and its impact on environment and to identify gaps, problems and scope of further study. A literature review is a necessary step in shaping a research field and forming an integral part of any research conducted (Easterby-Smith et al. 2002).

Searcy and Mentzer (2003) suggest that Research methodology may be categorized as an archival research method in the framework for conducting and evaluating research. The process

of analysis is comprised of defining unit of analysis, classification context, and material evaluation

Defining unit of analysis

This unit of analysis is classified as a single research paper explain the importance of green supply chain management and its impact on environment. Unit of analysis mainly deals with implementation of green supply chain management in order to achieve desired results.

Classification context

Selecting and defining the classification context that needs to be applied in the literature review to build and categorize the material. The classification context is of two types:

- Problem context.
- Methodology/approach context.

Material evaluation

The material is broken down and arranged according to the classification context. This helps in identifying the relevant issues and interpretation of results.

Collecting publications and delimiting the area of research: The literature review focuses on books and past journals only.

Classification based on Problem context

The existing green supply chain Management is categorized into three groups based on problem context in supply chain design:

- Literature highlighting the importance of green supply chain management
- Literature on green design
- Literature on green operations

Green design mainly focuses on environment conscious design while taking considering life-cycle assessment of the product/process into account. Similarly, green operations entail all operational facets related reverse logistics and network design, green manufacturing and remanufacturing which includes reduction, recycling, production planning and scheduling; inventory management and waste management. This research focuses more on reverse logistics as the implementation of effective and efficient reverse logistics networks is prerequisite for efficient and profitable recycling and remanufacturing.

This classification is done for easier understanding of different problem contexts of green supply chain management, their interactions and relationships to present a concise picture for further study and research.

The study of green supply chain is not rigid, according to Srivastava (2007) there may be many overlaps. When the wastage is reduced, it gets the attention of organizations not only in green manufacturing and remanufacturing but also in reverse logistics and waste management.

The *figure 2* present a view of the operations in green supply chain management. It mainly shows the model and steps that are being followed in green supply chain management. The figure shows the procedures that are carried out in green operations and the steps that are

involved in green manufacturing and remanufacturing, reverse logistics and network design, Waste Management.

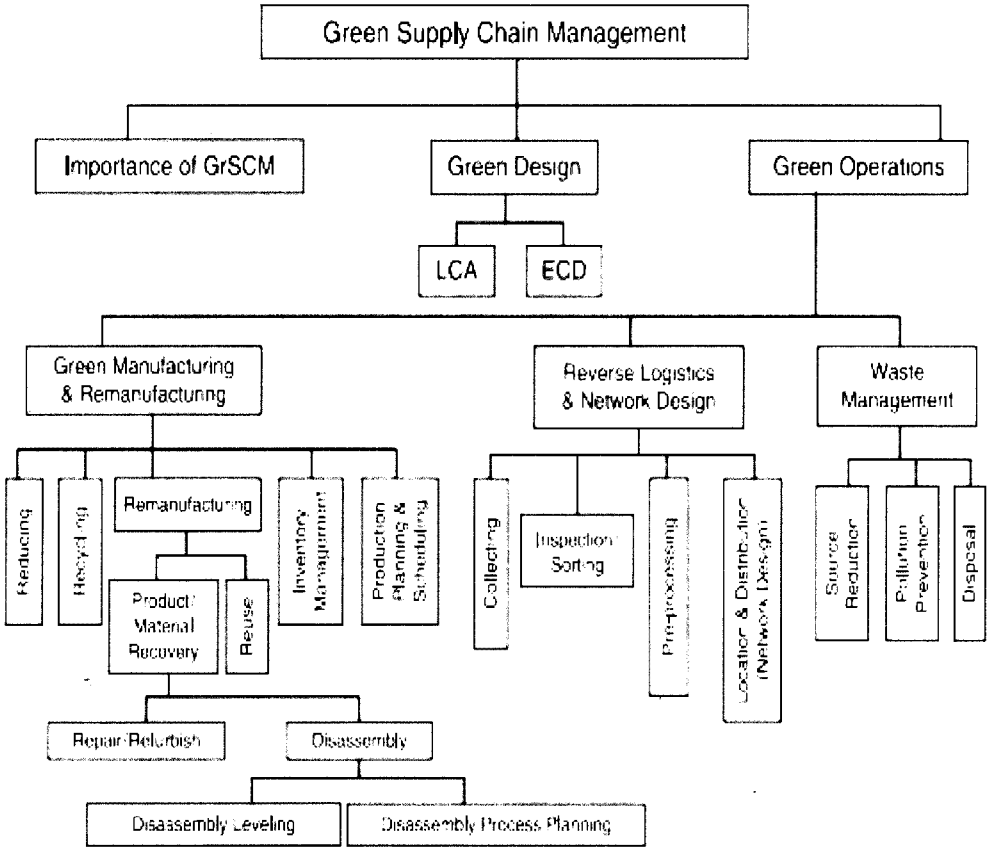

Figure 2. Classification based on problem context in supply design. Retrieved from http://iic.wiki.fgv.br/file/view/Green%20supply-chain%20management.A%20state-of-the-art%20literaturereview.2007.Srivastava..pdf/ 03/06/2016

Importance of Green supply chain Management

In any developing research area, the early literature focuses on the need and significance of green supply chain management. It defines the meaning and scope of various terms and propose advancements to explore the field further. Porter and van der Linde (2005) demonstrated the fundamentals of greening as a competitive initiative. Their argument ws that investments in greening can be resource saving, waste eliminating and productivity improving. Kopicki (1993) and van Hoek (1999) suggested three approaches in green supply chain management:

- Reactive approach
- Proactive approach
- Value-seeking approach

In reactive approach, companies provide minimal resources to environmental management, recyclable products are labelled and use 'end of pipeline' initiatives to lower the environmental impact of production. In the proactive approach, they start pre-emptive new environmental laws by engaging in a modest resource commitment to initiate the recycling of products and by designing green products. In the value-seeking approach, companies consolidate environmental activities such green purchasing and ISO implementation as strategic initiative into their business strategy. Guide and Wassenhove (2002) discussed the role of environmental manager at its changes. Gungor and Gupta (1998) described that interactions among various stakeholders on integrated Green supply chain Management and advantages that may occur to them.

In a study related to green supply chain management elements and performance measurement, Beamon (1999) argues for the establishment and implementation of new performance measurement systems. He proposes that the traditional performance measurement structure of the supply chain must be extended to include mechanisms for product recovery.

Empirical findings on relations between performance and operational practices among early adopters of Green supply chain were described by Zhu and Saris (2004). This includes the range of supply chain to include to re-use and recycling throughout the life cycle of product and services. Problems related to the integration of reverse logistics activities within a supply chain information system was put forth by Chouinard et al. (2005).

Green Design

The literature emphasizes both environmentally conscious design (ECD) and life-cycle assessment and analysis (LCA) of the product. A common method is to replace a potential hazardous material or process with one that is less problematic. This approach may sometimes results in the rapid depletion of a potentially scarce resource or increased extraction of the other environmentally problematic materials. Graedel (2002) made several examples of such equivocal proposals.

According to Srivastava (2007), Life-cycle assessment/analysis is described as a process for assessing and evaluating the environmental, resource-related consequences of a product through all phases of its life, occupational health. The scope of Life-cycle assessment involves tracking all material and energy flows of a product from the retrieval of its raw materials out of the environment to the disposal of the product back into environment. Sanchez et al (2004) thinks that attempts were made to develop operational models to help companies understand, monitor and assess life-cycle management.

Green Operations

Ferrer and Whybark (2001), argue that some of the vital challenges of green supply chain management such as integrating remanufacturing with internal operations.

Green manufacturing and remanufacturing: This is a significant field within green operations. Linnhoff (2003), thinks that the techniques for minimum energy and resource consumption for flow systems in order to reduce the use of new materials are based on three fields of study:

- Industrial Energy.
- Pinch analysis.
- Energy and life-cycle analysis.

Recycling is mainly driven by economic and regulatory factors. Recycling is performed to retrieve the material content of used and non-functioning products. Stock (2002) believes that Logistics represent up to 95% of total costs in recycling. Hoshino et al (2005) defined remanufacturing as recycling-integrate manufacturing. Industries that apply remanufacturing include automobiles, electronics. Product recovery refers to the broad group of activities designed to reclaim value from a product at the end of its useful life.

Ashayeri et al (1996) says that Automobiles, electronic and paper recycling are the most common examples of product recovery. The purpose of repair is to return used products to 'working order'. The quality of repaired products is generally lower than the quality of new products. The purpose of refurbishing is to bring used products up to a specified quality. Amini et al. (2005) proposed that reverse logistics operations and the supply chains they support are significantly more complex than traditional manufacturing supply chains.

According to Taleb and Gupta (2007), disassembly is a systematic method of separating a product into its constituent parts, components, subassemblies or other groupings. It may involve

dismantling or demolition or reprocessing or all of the processes. An important aspect of disassembly is to find an efficient disassembly process scheduling (Dowie 2004). Traditional production planning and scheduling methods have limited applicability to remanufacturing systems. Most inventory models consider three types of stocked items:

- Non-serviceable items.
- Deterministic models.
- Stochastic models.

Reverse logistics and network design

Carter and Ellram (2008) proposed that reverse logistics activities differ from those of traditional logistics. Blumberg (2009, pg.no 141-159) says "Reverse logistics networks have some generic characteristics related to the coordination requirement of two markets, supply uncertainty, returns disposition decisions, postponement and speculation." As a result, they affect network design considerably.

Collection of data is the first stage in the recovery process in which product types are selected and products are located, collected and transported to facilities for remanufacturing. Ferrer and Whybark (2000) postulated that inspection/sorting illustrates the need for skill in the sorting of used products. Wu and Dunn (2005) highlights the need for environmentally responsible logistics systems. Stock (2002) points out the importance of reverse logistics programs and the process of their development and implementation. Fleischmann (2001) says that the physical location of facilities and transportation links need to be chosen to convey used products from their former users to a producer and to future markets again.

Mollenkopf and Closs (2005) believe that companies need to realize the hidden value in Reverse Logistics and start to focus in this field. They must understand the financial impact of Reverse Logistics strategies. Srivastava and Srivastava (2005) developed a hierarchical decision-making framework to find the feasibility of profit-driven reverse logistics networks. They found Reverse Logistics activities profitable for their select category of products. In this modern age information and communication technologies play key role in the co-ordination and integration of green supply chain activities.

Shih (2001) discussed the reverse logistics system planning for recycling electrical appliances and computers. The author presented application cases to demonstrate the feasibility of the approach. Listes and Dekker (2005) presented a stochastic programming-based approach by which a deterministic location model for product recovery network design may be extended to account clearly for uncertainties.

Mostard and Teunter (2006) carried out a case study to derive a simple closed-form equation. They determined the optimal order quantity with the demand distribution given, the probability that a sold product is returned and all relevant revenues and cost for a single period model.

Classification Based on Methodology

The literature on green supply chain management may be classified on the basis of methodology and approach used. The study is conducted through papers and perspectives; frameworks and approaches. This helps us to understand green supply chain management from a different perspective from the problem context described earlier.

Several empirical studies in the area of green supply chain management deal with green design (product and logistics) and green operations (remanufacturing, recycling, Reverse Logistics). A large number of articles using survey-based empirical methods have also been published in the field of Green supply chain Management.

Mathematical Model

Many tools and techniques have been used to find out the root cause of the problems. According to Srivastava and Srivastava (2005), linear programming is the most common technique used for analysis of the problem. The next step is dynamic programming. Sometimes non-linear programming was also used according to the requirement. Mostard and Teunter (2006) derived an equation that gives the value of optimal order quantity, where the values of demand distribution is known.

Simulation is widely used for the generation of scenario and analysis (Ashayeri *et al.* 1996). System dynamics simulation technique was used by Srivastava and Srivastava (2006) to estimate end-of-life returns. A variety of tools and techniques were used to analyze the problems associated with Mathematical modelling.

Ferrer and Whybark (2001) state that green manufacturing and remanufacturing have used mathematical models, tools and techniques to a greater extent. In production planning and control, a common approach is to work out problems using priority rules followed by simulation for generating descriptive statistics for analysis. In inventory management economic order quantity formulas are used frequently.

Reverse logistics models focus on network design problems and depend on traditional location and layout models. Computer programming and many software tools are being increasingly used.

Wu and Dunn (2005) argue that very few models have been used for integrated green supply chain. AHP/ANP, Regression, DEA and descriptive statistics (based on surveys/interviews) have been tried. Linear programming, non-linear programming (NLP) and MILP have also been suggested in books but have not been used to a great extent. Green design has seen very little application in terms of mathematical tools, techniques and methodologies. Lately, LP, MILP formulations and software packages and spreadsheets for solution have been used (Mollenkopf and Closs 2005).

Green manufacturing and remanufacturing have used mathematical models, tools and techniques to a much larger extent. MILP, simulation, computer programming, software packages, spreadsheets and dynamic programming have been used extensively. Fleischmann (2001) believes that other traditional tools and techniques such as simulation, Markov chains, algebraic equations, ANOVA, heuristics, meta-heuristics and regression have also been used. Fuzzy reasoning, neuro-fuzzy and game theory too have been tried.

Conclusion

Green supply chain management can reduce the ecological impact of industrial activity without the omission quality, cost, reliability, performance or energy utilization efficiency. Green supply chain management has various challenges. Many specific empirical studies and remanufacturing procedures have been carried out. In recent years, other categories such as

reverse logistics have gained importance. This research gives more scope for future studies in the field of green supply chain management.

Many researchers are interested and focusing more on integrated green supply chain Management from wider perspective. The main area focused are quality, operations strategy, supply-chain management, product and process technologies, which are collectively are contributing to a more systematic knowledge base.

One of the biggest challenges facing the field of green supply chain is managing operations. Many applications have been focused on operations from external influences, which include natural environment. Natural environment is recognized as external constraint which requires operations to work within the specified limits.

An effective approach for the sharing of data is being developed. Researchers are taking the advantage of information and technology for effective collaboration and corporation. In the recent years Artificial intelligence techniques, including knowledge-based systems, fuzzy systems and neural networks have played an important role in the research and development in the field of green supply chain management.

In order to understand the green supply chain, researches have to focus more on reverse logistics and its connection to the product life. A particular theory and model need to be developed to build a relationship between new product sales and return sales. Research must be done on how companies should process, store and dispose of returned goods.

The present trend of development in green supply chain management is welcoming but it is being conducted in groups (mainly North America and Europe). It is necessary to encourage

the study globally. More research needs to be done on how companies select the products for the outlet of maximum profits.

Green supply chain management is a vast and promising subject for trying new techniques and operations for its design. One main problem is that this field is complex and challenging because of the very large parameters, decision variables and constraints that are involved. It also has large number of estimation requirements such as expected demands and returns associated with each decision. Many changes in concepts, technologies and players can be expected in the years ahead. We can expect a steady growth in the area of recovery/re-use/remanufacture of items and a quantum leap in the area of Reverse Logistics.

A steady growth in the area of recovery items, remanufacturing and reverse logistics can be expected. Green supply chain principles can be effectively implemented for a better tomorrow.

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