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# Green supply Chain: An Introduction and review to critically evaluate its impact and measures for improving the effectiveness

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***Abstract*—**This paper aims at applying the concept of supply chain to make an eco-friendly environment by arresting the factors responsible for enhancing the pollution and others environmental related problems. The green supply chain has come up an effective tool for caring the environment related issues and particularly in the field of packaging. An effort has been initiated in the regard to identify recognize the upcoming issues and critically evaluate to bring about improvement out of this. The paper shall lead systematically to define the green supply chain, its comparison with the conventional supply chain, the critical review and benefits. It shall also discuss some of the practices adopted and its intervention in manufacturing. A due consideration as a prime objective shall be on the packaging area.

***Keyword:*—**Green supply chain, environment, manufacturing, packaging

## 1 Introduction:

**1.1 Supply chain:** In today's dynamic and highly technologically sensitive industrial scenario supply chain management is getting prime importance so as to have a competitive advantage. As a preliminary definition supply chain involves flow of Material, Money and Information. Infrastructure for flow of money and material is always in place so the most risk prone area is the flow of information. It's tempting to mention that in the webbed world, there is no risk that an enterprise can't avoid or mitigate if it's armed with the right information. Obviously, it is said, information has to be accurate, of value, complete and germane to a specific risk or problem in sourcing, production, inventory, transportation etc. With costs continually rising and supply chains ever stretching, manufacturers, retailers and others feel that they are managing more risk than ever before. Advanced supply chain modeling, transportation management systems, multiple sourcing and inventory optimization are among the strategies that some companies are implementing to help control risk. Of course, information has to be reliable for any one of these strategies to be successful.

One of the big challenges in supply chain is getting information, the right information, complete and in time. There may be a risk of not getting the right combination of products to a customer sales point and missing out on a very expensive promotion, to miss out revenue. Also there is risk of getting inferior product or incomplete

product to market on time, and not include everything.

The point is that any risk, poses an economic threat to a company's health. That's especially true if one's brand is put at risk. Product recalls, for instance, can be very costly and embarrassing, but it's potentially far more damaging to a company if the equity in its brand is eroded because of some event that was neither planned for nor handled efficiently and quickly as it unfolded. The benefits are in seeing, managing and controlling all aspects of your supply chain. Information systems can help companies identify and monitor in real time the exact location and whereabouts of every single item moving in their supply chain and then make moves to divert or remove items. Those companies that collect detailed performance data on their suppliers and logistics providers are well positioned to see such warning signs.

In assessing the viability of a supply chain, companies often undervalue the element and complexity of risk. Supply chain disruptions can arise from external sources such as a natural disaster or internal sources like failure to integrate all functions in a supply chain. Disruptions can also result from attempts to create a more efficient, cost conscious supply chain environment.

### *1.2 Features:*

A supply chain must be fully integrated to operate at maximum efficiency. Failing to understand the potential vulnerabilities can compromise the supply chain's ability to handle unexpected and sudden shocks. By understanding risk within and external to the supply chain, an organization can more clearly identify its options for optimizing the supply chain to ensure viability and strength.

Optimized financial performance demands an ongoing analysis of the key risks spanning this increasingly complex supply network that connects suppliers, manufacturers, distributors, retailers, and customers. Analyzing supply chains with the perspective of risk results in a better understanding of the potential sources and, most importantly, the potential costs of a disruption.

### *1.3 Risk Analysis*

By adopting a risk-adjusted approach to supply chain management, organizations can more effectively begin to address such questions as:

- What is the risk of potentially moving manufacturing facilities overseas?
- What is the risk of not being able to fulfill a spike in consumer demand for our products?
- What is the risk of not having real -time inventory information from vendors or customers?
- What is the risk of managing every customer as if they were equal?
- What is the risk to your brand if an incident occurs at one of your suppliers or distributors?

## 2. GREEN SUPPLY CHAIN MANAGEMENT (GSCM) :

### *A review*

As defined by Srivastava,(2007), it is an integrating environment thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers, and end-of-life management of the product after its useful life. Green SCM is the process of using environmentally friendly inputs & transforming these inputs into outputs that can be reclaimed & reused at the end of their life cycle thus, creating a sustainable supply chain." GSCM relates to a wide-range of production from product design to recycle or destroy, or from cradle to grave. This principal is similar to

lifecycle of product. Many studies addressed product lifecycle along with supply chain or GSCM, for example, (Stonebraker & Liao, 2006) discussed that the stage of lifecycle variables is associated with the various dimensions of supply chain integration.

Since GSCM normally involved the inverse of the product flow, reverse logistics are automatically included in the study. Sheu, Chou, & Hu, (2005) proposed a linear multi-objective programming model optimizing the operations of both integrated logistics and used product reverse logistics in green supply chain. Results from their study showed that the proposed model improved net profits by 21.1%. Trunick (2006) discussed why the logistics companies should be more concerned on the GSCM. He described some regulations that affects to the logistics. Boks & Stevels, (2007), categorized "green" into 3 types depended on the different perceptions of the environment among different stakeholders involved: scientific green, government green, and customer green. In scientific green, life cycle assessment (LCA) was used to determine the environmental impact of products, processes, and systems. However, it concerned only the emissions, not other aspects. In government green, several factors were involved such as population density, geographical position, and the availability of energy sources. These factors affected the government agenda to maintain or improve quality of life. For customer green, the perceptions of green were strongly linked to emotions that were directly impacted to people, especially health and safety, than resources or emissions.

## 3. BENEFITS OF GREEN SCM (GSCM)

Greening the supply chain, strikes of banning toxic chemical substance usages or reducing emission or waste to the environment. However, it is much more than just mere reducing usage and pollution. The benefits are not limited to only less toxic consuming or less waste but can be applied to all departments in the organization.

Stevels (2002) demonstrated the benefits of GSCM to in terms material, immaterial, and emotion. For material, it lowers environmental load for environment, lower cost prices for supplier, lower cost for producer, lower cost of ownership for customer, and less consumption of resources for society. For immaterial, it helps overcoming prejudice and cynicism for environment, less rejects for supplier, easier to manufacture for producer, convenience and fun for customer, and better compliance for society. For emotion, GSCM helps motivation of stakeholder for environment, better image for supplier and producer, feel good and quality of life for customer, and make industry on the right track for society. He also provided examples of company that were successfully adopted GSCM.

### *3.1 Reasons to adopt supply chain:*

The top ten reasons that the company should adopt the Green SCM concept can be listed as under:

- Target marketing,
- Sustainability of resources,
- Lowered costs/increased efficiency,
- Product differentiation & competitive advantage,
- Competitive and supply chain pressures,
- Adapting to regulation and reducing risk,
- Brand reputation,
- Return on investment,
- Employee morale, and
- The ethical imperative.

## 4. GREEN SUPPLY CHAIN (GSC) PRACTICES

- Align GSC goals with business goals.

- Evaluate the SC as a single life cycle system.
- Use GSC analysis as a catalyst for innovation.
- Focus on source reduction to reduce waste.

Green supply chain provides an opportunity to review processes, materials,& operational concepts. As with continuous improvement programs, green supply chain analysis targets wasted material, wasted energy or effort, under-utilized resources.

GSCM involves traditional supply chain practices to integrate environmental criteria, into organizational purchasing decision & long term relationships with suppliers. A green supply chain aims at confining the wastes within the industrial system to conserve energy and prevent the dissipation of dangerous materials into the environment.

Conventional and green supply chains differ in many ways. Conventional chains often concentrate on economic objectives and values, while green chains give significant consideration to ecological causes and extend the scope not only to human toxicological effects, but also to ecologically negative effects on the natural environment.

In conventional chains, the predominant standard is price. In green chains, the ecological objective is a part of the supplier selection criteria. Putting these ecological criteria into practice requires careful supplier evaluation, based on long-term oriented relationships.

One of the initial perceptions about green products is that they lead to higher cost of manufacturing compared to conventional ones. However recent findings showed that innovations and optimal planning can dramatically reduce the costs in most cases. For the cost challenges to be managed effectively, the efficiency of the entire supply chain must be evaluated. Compared to conventional chains which have a large number of conventional materials and suppliers, green chains are relatively inferior in terms of speed and flexibility.

The table here summarizes the major differences between the conventional & green supply chain management.

Table: 1 Comparison: Conventional Vs Green SCM

| Character-istics | Conventional SCM | Green SCM |
|---|---|---|
| Objectives and Values | Economic | Economic & eco-logical |
| Ecological optimiza-tion | High ecological impacts | Integrated ap-proach. Low eco-logical impacts. |
| Supplier selection criteria | Price switching suppliers Short term relationships. | Ecological aspects (& price) Long - term relationships |
| Cost pres-sure & prices | High cost pressure Low prices | High cost pressure High prices |
| Speed & flexibility | High | Low |

## 5. GREEN SCM MANUFACTURING

A few common methods for making the manufacturing stage "green" could be as Reusing, Remanufacturing & Recycling. The primary difference between these processes is the extent to which the characteristics of the product are changed. While the physical characteristics of a material are maintained in reuse, remanufacturing includes some changing of parts or disassembly. Recycling may change the characteristics of the material completely including physical & chemical traits. An organization has to decide which methods to employ depending on the product characteristics.

The suppliers have a significant influence on the "greening" of the manufacturing stage in a supply chain. Manufacturers are liable for purchasing products and services that violate environmental standards, but they may not be legally responsible for their suppliers' environmental activities.

A recent study found that an informed relationship between supplier & manufacturer can lead to innovative & cost effective end-products. Involvement of suppliers' in manufacturer's plant & manufacturer's in suppliers' plant helps them to communicate better, build trust, plan effectively & concentrate on each individual process & part to achieve a desired environmental rating for a product.

Benefits can be generated for both supplier & manufacturer. Firms can work together to improve product design & product efficiency, which can lead to overall waste reduction. The manufacturing system is where the greatest amount of pollution may be generated by firms & where the highest volume of resources is consumed. This means that the supplier manufacturer relationship has the ability to make significant strides towards a greener leaner supply chain.

A company can employ environmentally beneficial strategies selectively to become more competitive over the long run. Putting these strategies into practice will require fundamental changes in core business processes, including product development, manufacturing & supply chain management.

## 6. GREEN SCM IN PACKAGING

Packaging performs various functions in today's society. It can be seen differently from either the producer or consumer's standpoint. For producers it is a way to promote differentiate products, as well as safely transport finished goods to the market. For consumers, packaging is a way to identify the maker of the product, its usage, & important features. The basic objectives of the packaging process are:

- Physically protect the product from any damage during storage or shipping.
- Agglomeration of products.
- Packaging gives the information for use of product, its disposal and transport..
- Design of the packaging that attracts consumers to buy the product.
- Reduce the theft associated with particular products.

To think of supply chains without thinking of the packaging that goes into the chain would create a "blind spot" in the firm. This blind spot is the lack of vision of adopting "green" packaging materials or creating alliances with suppliers that use "green" packaging materials.

Packaging has a strong relationship with other components of the operational life cycle. Packaging characteristics such as size, shape & materials have an impact on distribution because of their affect on the transport characteristics of the product. Better packaging along with rearranged loading patterns can reduce materials usage, increase space utilization in the warehouse & in the trailer, & reduce the amount of handling required.

Systems that encourage & adopt returnable packaging methods will require a strong customer supplier relationship as well as an effective reverse logistics channel.

The most common form of packaging materials that can be seen daily is the classic peanuts, bubble wrap, Styrofoam, air bladders, & the numerous paperboard formats. The key with respect to greener

supply chain is the implementation of use of green packaging materials.

Green packaging materials are those that are used for making a sustainable packing with least or no impact on environment. Bioplastics that are completely biodegradable in a composting cycle belong to this category. Bioplastics from renewable sources are a new generation of plastics that are being used in specific applications where biodegradability is required. Bioplastics resemble plastics in functionality & are completely degradable in a composting cycle. Various applications where bioplastics are used are composting bags & sacks, fast food service ware, packaging agriculture & hygiene. Bioploastics that are available in market are mainly derived from starch. Polylactic acid (PLA) is obtained from fermentation & polymerization of starch. Bioplastics that are directly derived from starch are used extensively whereas the use of PLA is less due to the high cost in the market. Other bio degradable materials that can be used for packaging applications are bio-nano composites that are prepared with biopolymers, such as starch & protein. Though the usage of nanocomposites at present is low due to the high cost involved in their production, research is underway to produce low cost nano composites that can be used especially in short life time applications where recycling is difficult &/ or not economical.

Although cost is a main consideration, there are many examples of companies that have reduced operating costs by implementing greener packaging products. Before green supply chain management can be successfully adopted, there needs to be co-ordination between all involved members of the chain in addition to industry leaders, governments, & consumers.

## 7. CONCLUSION

The research work signifies various aspects of supply chain and green supply chain are discussed and their relative characteristics are compared. The factors responsible are studied at length and their impacts and effects are given due consideration. As a case study the GSCM is being applied for the packaging concerns a wide discussion is carried out to conclude that a comprehensive data collection and analysis shall result in defining a bettered system which shall mitigate the effects of supply chain on environment making it ecological more balance and in turn making it more effective, economical and flexible to adapt changes.

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