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Chapter

Green Supply Chain Management: A Precursor to Green Purchasing

Kenneth Mathu

Abstract

The chapter's focus is on an enterprise collaboration with the members of the value chain and the use of technology to enhance integration. These factors are attributes of supply chain management (SCM). When emphasis is placed on lean and agile supply chains, closed-loop supply chains, reverse logistics, and the practice of just in time (JIT), the operation is transformed to green supply chain management (GSCM). JIT reduces outsourcing of resources, has controlled production and transportation, and uses distribution centers to expedite the distribution process. The utilization of the returned products in reverse logistics for reuse, recycle, and remanufacturing reduces dumping and environmental degradation. The returned materials become additional resource which is value-added to the enterprise. Ultimately, this is a cost saving and a contribution to the enterprise's bottom line and sustainability.

Keywords: collaboration and integration, environment, green supply chain management, lean and agile, reverse logistics

1. Introduction

The green supply chain management (GSCM) emerged from the conventional supply chain management (SCM) in the last two decades or so, and supply chain itself is just over a generation old. Supply chain evolved from discussions initiated by a group of professional consultants in the early 1980s [1]. The deliberations reached a peak with the publication of Michael Porter's book, *The Competitive Advantage: Creating and Sustaining Superior Performance* [2]. In the book, Porter emphasized that industries could perform various primary and support activities that could add value to the products/services that in turn could add value for customers. The linkages of these activities that added value to the products/services that an organization produces was Porter's description of "value chain." Porter described the support services as inbound logistics, operations, outbound logistics, marketing, sales, and services. Inbound logistics is the supply chain process of supplying raw materials to the focal manufacturer. The transformation of raw materials by the focal manufacturer into finished products or work in progress is referred to as operations. The distribution of the manufactured goods to fulfill customer orders is outbound logistics. The marketing process establishes the demand of products/services by customers. On understanding the customer needs, the sales process is pursued to take the customer orders. Subsequently, service provisions ensue in fulfilling customer's product/service orders.

The global supply chain forum of 1999 defined supply chain as "an integration of procedures from suppliers to consumers to provide products/services and information in order to add the values of the customers and the related roles" ([3], pp. 194-205).

Supply chain management covers industry planning and control of activity that relate to trade, exchange and logistics management, and collaboration among suppliers, agents, and new customers. With increased customer awareness and more stringent regulations, industries have started to integrate environmental factors in all sectors of the organization. The industries have started integrating green technologies in product designs, production, and distribution which is a gradual trend of shifting toward environmentally friendly supply chain (SC). These efforts and the desire to incorporate "extended production responsibility" (EPR) as pertains to environmental impacts are the precursors to the evolution of "green supply chain management" (GSCM) ([4], p. 4).

The theory of GSCM was developed in the 1990s, but emphasis on green production by most industries commenced from around 2000. With the growing consciousness about the environment, SC complexity and the scale of GSCM technologies also increased. GSCM is defined as "a supply chain that considers environmental impacts on its operations and takes action along the supply chain to comply with environmental safety regulations and communicates this to customers and partners" ([5], p. 73). GSCM integrates all the aspects of environmental management which includes reverse logistics. Reverse logistics entails "a supply chain dedicated to reverse flow of products and materials for the purpose of returns, repair, remanufacture, and/or recycling." The organizations that proactively manage reverse logistics have added financial benefits to their bottom line ([6], p. 619).

2. Green supply chain management (GSCM)

Green supply chain management extends across the organization, its trading partners, and processes involved in purchasing, manufacturing, materials management, distribution, and reverse logistics. The GSCM ensures that there is sharing of environmental responsibility in supply chain at every stage and process to ensure that the adverse impact on the environment is minimized ([7], p. 508).

The American leading global retailer Walmart, provide green materials. Its goals among others include being supplied 100% by renewable energy, to produce zero waste and to sell products that sustain people's health and environment. The retailer has integrated a supplier sustainability index into its business to measure the vendor product offerings [8].

3. Impact of GSCM on industry

Industry evaluation is done through product/service analysis called "life cycle assessment" (LCA). LCA helps designers at the beginning of product design to identify techniques that ensure that the product components and designs are to the environmental standards. Standards are the set of the amount of energy and natural resources utilized, the amount of emissions caused by air and water pollution, and the waste products resulting from the consumption of the product output ([5], p. 93).

Industries strive through GSCM system to evaluate the green performance of suppliers, assess the quality of green product, and direct overall management of suppliers. Information technology (IT) is used to sort out the green supply chain

(GSC) issues between the organization and the value chain partners. The process involves gathering all existing material systems, information management systems, and process operation systems and integrating all the green requirements into tasks and procedures to achieve greening. The last step is to ensure that the overall SC conforms to the standard of GSCM through management systems, production processes, technique standards, verification of work, and analysis of product components [9].

A 2017 empirical study in the developing countries focusing on Pakistan's manufacturing firms using exploratory factor and simultaneous analysis on five independent variables of GSCM practices established that four of them were statistically significant in predicting the organizational performance. The four predictable variables were ecological product designs, green manufacturing, green information systems, and cooperation with customers, and the variable that failed the test was green purchasing [10]. Another research in Pakistan's manufacturing firms investigated their economic and environmental performance and established that green practices such as ecological design of products, green transport, and distribution positively impacted on the environmental performance [11]. These distinctive examples illustrate how GSCM implementation would drive sustainability in enterprises and become a conduit for the unfolding Fourth Industrial Revolution (4IR).

4. Benefits of GSCM

The benefits of GSCM encompass green initiatives such as green materials, green production, reverse logistics, closed-loop supply chains, sustainability and green initiatives, and green procurement to ensure sustainability for the present and future generation. Wang and Gupta ([4] p. 8) described six benefits of GSCM in client/supplier relationship as follows:

1. *Increased interaction between client and supplier*: the process of understanding the client's needs and wants, providing opportunity for future product development and encouraging suppliers to continuously improve on their products/services.

2. *Collaboration between the company (client) and the supplier to create innovative product design*: innovation through identifying substitute materials, creating energy-saving design, and upgrading infrastructure to increase efficiency.

3. Requirement for supplier to provide environmental information: to ensure product conformance with environmental standards, identification of hazardous component in the product, mode of transportation, and weight of products, among others.

4. *Client and supplier collaboration in creating green product design*: collaboration development of product design and the client to provide the supplier with product requirements that would meet environmental standards.

5. *Auditing the supplier's green performance*: the client prepares a checklist of green management requirements or environmental audit management system to ensure the supplier satisfies the product requirements that help the client achieve the corporate social responsibility (CSR) goals.

6. *Supplier initiative in standardization process*: taking initiative to install own testing equipment to ensure meeting the standard of green purchasing.

5. Environmental design

Environmental design involves designing a product in a way that the environmental impact is minimized throughout the product life cycle. Such product is a "green product," and it is produced through a "green manufacturing" process. Green product is a good or service that minimizes external costs and pollution, and green manufacturing is a process of producing a good or service that minimizes external cost and pollution. The process includes design for reuse, disassembly, and remanufacture [5].

In pursuit of green manufacturing, governments, corporations, and societies must commit to rethink, reduce, reuse, recycle, and redesign products to achieve reduction of waste and pollution and sustainable quality of life. Hence, environmental concern is about taking cognizance of green products related to environment protection.

Presently, two techniques are used to analyze and improve the design of products for making them environmentally friendly. The first involves analyzing the effects of design efficiency of a product on the environment through its end of life (EOL), disassembly, and disposal. The second involves inserting sensors into products during their production phase to provide information on the condition and version of the main components before disassembling them at the end of life ([4], p. 37).

Environmental protection has continued to grow as a major global concern with more organizations paying more attention in ensuring that green standards are adhered to at all levels of the value chain. This entails involvement of suppliers of raw materials, manufacturers, distribution process, and social welfare that is referred to as "green value chain." The green value chain framework is built based on future trends and environmental requirements for sustainable design ([12], p. 431).

6. Green materials

Green materials are used in green engineering, whereby products are designed and produced using minimum amount of resources, and the process that is used to produce them has a minimum impact on the environment. Thus, green materials refer to the minimum resources used to make a product/service. They comprise utilization of minimum raw materials and renewable energy that has minimal carbon emissions. The green materials emanate from the minimization of material's content and types, energy consumption during usage, scraps during production, disposal at products' end of life, packaging materials, and energy consumption during product development and production stages ([12], p. 301).

The planet earth has different types of materials used for various applications. They comprise metals (steel, aluminum, titanium), ceramics (porcelain, mineral glass, and metallic oxides), polymer thermoplastics (acrylic and polypropylene), polymer thermosets (epoxy and polyurethane), elastomers (isoprene, neoprene, and styrene butadiene rubber), natural organic materials (wood, bamboo, and cotton), and composites (graphite epoxy, polyester, and fiberglass) [13].

7. Green production

Green production is a method of producing a good or service that minimizes external costs and pollution. The process involves design for reuse, design for disassembly, and design for remanufacture. Green productivity focuses on enhancing productivity and environmental performance for sustainable development in the industry to achieve competitive advantage. The industry has not only increase product value; it also needs to use the value chain. Thus, the critical point is to decrease the environmental impact throughout the value chain, from raw material supply to the final product. The environmental impact emanates from energy use, consumption of natural resources, and pollution-related problems [14].

The environment is damaged by the exploitation of the global natural resources for economic development. The process causes pollution that spread to the entire world via wind and water. As a result, many countries under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC) have sought to combat carbon emissions which have been proven by scientists as a contributor to the global phenomenon of climate change or global warming [15].

Since the advent of green manufacturing, manufacturers are required to be responsible for the logistics process from production planning to product recovery and greenhouse gas emissions, that is, being responsible for the entire life cycle of products/services. That includes responsibility over the returned products' repair, refurbishing, remanufacturing, cannibalization, recycling, and disposal ([16], p. 130).

8. Sustainable development

Sustainable development is defined as "development that meets the needs of the present without compromising the ability of the future generations to meet their own needs" [17]. This definition was initiated during the United Nations "World Commission on Environmental and Development" (WCED) summit in 1987.

Sustainable development is characterized by energy consumption and production, greenhouse gas (GHG) emissions, and climate change. As these issues are interrelated, they are better considered in an integrated manner and linked to economic, social, and environmental implications. Scientists have proven that the increased consumption of fossil fuels (oil, coal, and gas) as energy source for development adversely affects the global climate. The ensuing severe climatic conditions lead to global warming and heavy rain with devastating floods and melting of ice in the polar region raising the seal level. As the price of oil rises with increasing demand, the cost of production of goods and services increases, affecting the supply chain costs. In view of these increasing costs, solutions in the form of resource efficiency and technology innovation emerge as opportunities for reducing costs and increasing competitiveness and employment which are critical factors to managing an effective supply chain ([7], p. 402).

9. Sustainability and green initiatives

Sustainability and green initiatives focus on dematerialization, detoxification, and decarbonization processes that culminate into 4Rs (reduction, redesign, reuse, and remanufacture) ([16], pp. 83-84).

Dematerialization: it refers to industries' attempt to reduce materials or time needed to produce and deliver products/services required by the customers.

Detoxification: it is the reduction of poisonous and hazardous materials contained in industrial waste during processing of natural raw materials in industries to produce products/services. The poisonous materials which are in the form of industrial waste and pollution contaminate in the environment. The degradation of the environment threatens the living condition of the organisms in the ecosystem.

Decarbonization (de-energization): it is the reduction of greenhouse gas (GHG) emissions in the atmosphere that occur when burning fossil fuels for electricity generation. The most abundant GHG is carbon dioxide that has been proven by environmental scientists to be a contributor to the global phenomenon of climate or global warming.

To achieve sustainable goals or greening the environment, redesigning of products is crucial, reducing energy consumption (use of renewable energy), reusing the returned products, and remanufacturing the damaged products ([18], pp. 64-66).

10. Supply chain operations reference (SCOR) model

Supply chain operations reference (SCOR) model is a diagnostic benchmarking and improvement process for supply chain operations. The SCOR model was established in 1996 as a tool for manufacturing and service organizations. It is managed by Supply Chain Council (SCC) that among other roles educates the supply council members on its application ([19], pp. 322-344).

The SCOR model integrates the supply chain members by linking the delivery operations of the seller to the sourcing operations of the buyer. This is done in six categories: plan, source, make, deliver, return, and enable:

Plan: this involves planning all the activities involved in demand and supply of products/services (resources, communication, performance, inventory, capital/assets, transportation, and others).

Source: this comprises sourcing of stocks, make to order, engineer to order, scheduling deliveries, selecting suppliers, and managing incoming inventories.

Make: the production process: make to stock, make to order, engineer to order, and other production networks.

Deliver: it involves order preparation, warehouse, transportation, and distribution of products.

Return: return of purchased materials to suppliers and finished goods from customers and managing the return process.

Enable: the process of establishing, maintaining, and monitoring information, relationships, resources, assets, design, planning, and execution of supply chain.

The SCOR model is for all types of supply chains, but its application identifies more with the characteristics of GSCM.

11. Supply chain collaboration (SCC)

Advancing GSCM requires a high level of supplier-customer information-sharing relationship in a form of collaboration and integration. "Collaboration in supply chain is a process through which trading partners can jointly plan key supply chain activities from the delivery of raw materials, through production and delivery of finished products to the end customers. The process encompasses business

planning, sales forecasting and all operations required to replenish raw materials and finished products" ([5], p. 28).

Supply chain collaboration (SCC) is a relationship between supply chain partners developed over some time. Collaboration commences with open-market negotiations, whereby fewer suppliers cooperate to supply a common customer. Cooperation entails organizations working jointly toward the same goal as in ensuring customer satisfaction. The relationship moves to the next level of coordination through information linkages as in the use of electronic data interchange (EDI). Coordination entails the ability of different organizations sorting out their complexities in a working-together relationship, as supply chain partners do to deliver value to customer. Subsequently, collaboration is achieved when organizations start joint planning and technology sharing (supply chain integration). This indicates that supply chain integration is an enabler of collaboration ([19], pp. 322–344).

Supply chain collaboration is experienced in two types: vertical collaboration and horizontal collaboration ([20], p. 50).

Vertical collaboration is the relationship between suppliers (external), focal organization (internal), and customers (external).

Horizontal collaboration is experienced when the focal organization (internal) collaborates with other organizations and the third-party logistics (3PL) companies (external) for joint transportation.

12. Supply chain integration (SCI)

Supply chain integration (SCI) is the alignment and interlinking of business processes. The alignment and interlinkage of the focal organization with the first-tier suppliers and first-tier customers allow the organization to focus its time and resources on managing important process links with other trading partners. These are partners' upstream (suppliers) and downstream (customers) that allow larger and complex supply chain to perform better ([20], p. 48).

13. Lean and agile supply chain

The conventional way for the focal organizations or manufacturers is to hold a high level of inbound, internal, and outbound inventories to cover for incidental or unplanned orders. The inbound inventory comprises raw materials from the first-tier suppliers to the manufacturer, internal inventories are the manufactured products and work-in-progress products (unfinished products) at the manufacturer's warehouse, and when the finished products are being shipped to end users (customers), they are inbound inventories ([21], p. 150). These are non-value-added activities which are avoided in GSCM.

Lean supply chain requires the suppliers to deliver smaller quantities of raw materials more frequently to the manufacturer. As frequent smaller inbound transportation and outbound transportation of finished products add costs, suppliers usually locate warehouses near the manufacturing facilities. In this era of shopping malls, the leading retail chain stores of fast-moving consumer goods (FMCGs) own distribution centers (DCs) at convenient locations to receive supplies from different suppliers to ease distribution to their retail outlets. The DCs are built on national and regional formations depending on the retail outlets' distribution network. Usually, third-party logistics (3PL) companies provide the transportation, although in some isolated situations, retailers substitute 3PL with their own transport. This

type of logistics arrangement focuses on timeous delivery, to the right location, in right quantities and qualities. Ultimately, this lowers the inventory levels and reduces holding costs ([7], p. 330).

In GSCM, the manufacturers focus on a limited number of suppliers and customers to collaborate in identifying customer requirements. The collaboration process aims to remove waste, reduce costs, and improve quality and customer service. The process renders supply chain "lean" by utilizing limited materials to produce limited inventories and "agile" by responding quickly to unpredictable changes in customer needs. The two terms are coined together to make an emerging word "leagile," a characteristic that distinguishes GSCM with the conventional SCM ([21], p. 329).

14. Just in time (JIT)

Just in time (JIT) originated from the Toyota company, Japan, in the 1940s. The Toyota managers such as Taiichi Ohno pursued "Kanban" that involved continuous problem-solving aimed at eliminating waste. However, lean management is more practiced outside Japan as both have similar objectives. JIT enhances supply chain process when suppliers and manufacturers work together or collaborate to enable them to respond more quickly to customer needs. This is done through information-sharing via Internet connectivity, resulting in improved customer service, less inventory holding, and reduced waste. As the supply chain becomes more streamlined and focused in speedy turnaround of smaller quantities, it assumes the characteristics of GSCM. Hence, JIT is crucial for a supply chain to achieve its primary objectives of low cost, high quality, and fast response ([7], p. 249).

15. Reverse logistics

Reverse logistics is the process of moving or transporting goods from their final forward destination back to the manufacturer and suppliers for the purpose of creating value or for proper disposal. It involves the processes of sending new or used products "back upstream" for repair, reuse, refurbishing, resale, recycling, scrap, or salvage. In reverse logistics system, items are usually returned to a central location for processing. The processing involves transporting, receiving, testing, inspecting, and sorting for appropriate actions such as repair, refurbish, or resale. Where the product has no value, it is disposed in landfill or other environmentally acceptable processes. The facility and related processes are provided either by the original manufacturer or a third-party logistics (3PL) company. The characteristics of reverse logistics that involves preparing returned products for reuse, recycling, remanufacturing, and proper disposal are identified with GSCM ([6], p. 614).

In reverse logistics, items may be collected from diverse geographical locations, and some of them could be hazardous materials. The hazardous materials would require special handling and disposal. Usually, items collected in reverse logistics go through a tedious process of testing, sorting, grading, and inspecting. Other complexities and challenges experienced are in remanufacturing, reconditioning, and reselling that could be problematic depending on the type of items involved. Thus, green logistics is executed through five stages comprising of suppliers, manufacturers, distribution centers (DCs), customers, and dismantlers or recyclers ([21], p. 47).

However, despite of all these challenges, reverse logistics add value to the triple bottom line of the organization involved. That entails adding value to an

organization's economic, social, and environmental attributes. This summarizes the three major drivers of reverse logistics as customer service, environmental issues, and economic benefits. The effective role of reverse logistics is demonstrated by the collaboration of the leading retailers of fast-moving consumer goods (FMCGs) and their suppliers as they proactively pursue reverse flows to capture value [22].

16. Closed-loop supply chains

The closed-loop supply chains are designed and managed to explicitly consider both forward and reverse flow activities in a supply chain. The combined roles of forward and backward flow of goods in closed-loop supply chains essentially aim at reducing cost and capturing value. Consequently, closed-loop logistics is a crucial component to supply-demand chain management in closed-loop supply chains. The focal organization or manufacturer proactively utilizes them as they add value to the organization ([6], p. 614).

17. Green purchasing

The increasing consciousness in recent times about environmental protection has triggered more interest in green supply chain, sustainability, and green initiatives as they are interrelated. Green purchasing is concerned with the purchase of products that emanate from energy efficiency, bio-based and recycled content, non-ozone-depleting substances, green power, and other environmentally friendly products. Green power refers to electricity generated from sources that have limited greenhouse gas emissions such as renewable sources comprising of hydro, solar, and wind, among others ([16], pp. 35–36).

The Institute of Supply Management defined green purchasing as "making environmentally conscious decisions throughout the purchasing process, beginning with product and process design and through product disposal" ([5], p. 74). Green purchasing in supply chain is supposed to address some of the pressing environmental issues such as ozone layer depletion, global warming, and hazardous waste ([12], p. 324).

The selection of green suppliers is guided by global regulations for environmental protection. The rules and regulations address pertinent issues for environmental management from production of products/services to consumption. Wang and Gupta [4] summarized some of the crucial laws and regulations observed by several countries as follows:

1. Waste Electrical and Electronic Equipment (WEEE) Directive of 2003

2. Restriction of Hazardous Substances (ROHS) Directive of 2010

3. Energy-Using Products (EuP) Directive of 2010

4. End-of-Life Vehicle (ELV) Directive

5. Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)

The conventional SCM focuses on information flows from vendors to the customers, whereas GSCM must, in addition to this, fulfill the four Rs (4Rs) of green

factor regulations: reduction, redesign, remanufacturing, and reuse. Industries are increasingly creating environmentally friendly products (green products) to satisfy the customer demand. The green products are made with reduced raw materials, using renewable energy and recycling of old products. The reduction of primary resource use, pollution prevention, waste management, and policies governing sustainable products have become the focus of modern industrial societies and environmental guidance. This distinguishes green supply chain management from the traditional supply chain management as it encompasses environmental impacts and material utilization factors in the selection of suppliers ([6], p. 619).

In pursuit of environmental sustainability in logistics, organizations strive to change the transportation modes of their products to overcome the growing pressure and to improve environmental performance. The rail mode of transportation where feasible is preferred over road use, especially in the haulage of heavy loads as organizations strive to reduce carbon footprint of their products.

18. Conclusion

The history of supply chain and the crucial role played by Michael Porter in coining in the application of value chain from his book on competitive advantage in 1985 provided the initial building blocks of supply chain management. The GSCM was defined and elaborated to distinguish it from the conventional SCM. Its impacts and implications to environmental management and benefits to organizations and to product/service end users were exhausted. The global concerns of the greenhouse gas emissions leading to the phenomenon of climate change or global warming and that GSCM drives sustainability goal were discussed in detail. The United Nations watchdog body for global climate change and emissions, the UNFCCC, was also expressed. The narrative included the definition and elaboration of sustainable development.

The pursuance of GSCM by the industry utilizing green materials and green production processes and applying green purchasing which are environmentally friendly was stipulated. The drivers of GSCM such as closed-loop supply chains; lean and agile supply chains; functions such as SCC, SCI, and JIT; and SCOR application were examined.

Subsequently, successful implementation of GSCM was found in Pakistan from an empirical study on GSC practices conducted in the manufacturing firms where four variables of GSCM, namely, ecological design of products, green manufacturing, green information systems, and cooperation with customers, were found to significantly improve organizational performance. Another research in the same country on the impact of GSC on manufacturing firms' economic and environmental performance established that green practices impacted on the environmental performance. These examples demonstrate the role of GSCM as an infrastructure that would drive the unfolding 4IR and business sustainability.

DOI: http://dx.doi.org/10.5772/intechopen.87158

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Author details

Kenneth Mathu
North West University, South Africa

*Address all correspondence to: kenmathu@yahoo.com

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