Green Supply Chain Management: A Literature Review

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Birds flap their wings in oil-infested coastal waters, unable to take off. Trees in a coniferous forest have lost all but a handful of their needles. An empty landscape is scarred by open-cast mining. These are just some of the images that have brought home the enormous costs to the natural environmental of industrial development Preuss (2005, p. 1).

Abstract
Sustainable development has made remarkable progress in establishing environmental and social sustainability towards operations management and the supply chain. Manufacturers in the late 1980’s went beyond what was required in the legislation and went for a greener approach in their operations systems. The purpose of this paper is to briefly review the literature of the green supply chain management (GrSCM) over the last twenty years. The key themes that came out of the literature are: green operations, green design, green manufacturing, reverse logistics and waste management. This paper will briefly discuss these issues. This paper will also mention the reasons why organisations would opt for a green supply chain. This essay will then conclude that there is a gap in the literature in terms of the stakeholder views towards green supply chain management. Knowing the different stakeholders’ views to greening initiatives requires qualitative study such as interviews – to portray the different views about the concept and how this would implicate management decisions.

Key words: Green supply chain management (GrSCM), literature review, green design, green operations and reverse logistics.

Introduction
Supply chain management has traditionally been viewed as a process wherein raw materials are converted into final products, then delivered to the end-consumer (Beamon, 1999). This process involves extraction and exploitation of the natural resources (Srivastava, 2007). It is important to note however that we live in a decade where environmental sustainability has been an important issue to business practice. Since the early 1990’s, manufacturers have been faced with pressure to address Environmental Management (EM) in their supply chains (Wu & Dann, 1995). This is not an easy task to do however. Adding the ‘green’ concept to the ‘supply chain’ concept adds a new paradigm where the supply chain will have a direct relation to the environment. This is interesting because, in history, these two paradigms were once in head-on collision with each other (Srivastava, 2007).
Supply chains, in an operational sense, are about extracting and exploiting raw materials from the natural environment.

This paper will provide an overview of the Green Supply Chain Management (GrSCM) literature. Knowing the wider perspective of the Green supply chain is an important step in knowing the branch of environmental sustainability. There are large amounts of literatures that surround GrSCM, especially from 1989 to the present. But the key themes that came out of the GrSCM literature over the last twenty years are the concepts of green design, green operations, reverse logistics, waste management and green manufacturing (Guide & Srivastava, 1998; Srivastava, 2007). The purpose of this paper, however, is to discuss some of these issues and provide an overview of the academic perspective of the GrSCM literature. This paper will provide a brief introduction to traditional supply chain management and the chronology of GrSCM. This paper will then discuss the concepts of Green Design and Green Operations. At the end, this paper will briefly mention why organisations opt for a Green supply chain. This paper will mention some of the key academics in the field and their arguments around green operations.

Supply Chain Management: Back to the Basics
The term ‘supply chain’ was coined in the mid 70’s. Banbury (1975) used ‘supply chain’ as a term of passing on electricity towards the ultimate consumer. It was not until the 1980’s, however, that the term ‘supply chain management’ came into context. Oliver and Webber (1982) discussed the potential benefits of integrating internal business functions of purchasing, manufacturing, sales and distribution into one cohesive framework. Stevens (1989) has defined supply chain management as the integration of business functions involving the flow of materials and information from inbound to outbound ends of the business. Dyadic or party relationships between suppliers are becoming part of the supply chain process (Harland, 1996). Here we see the formulation of a supply chain framework in terms of establishing contracts between firms. Organisations have been given the opportunity to either vertically integrate or market their products in connection with other partners (Stevens, 1989).

Supply Chain Integration
In the early 1990’s, supply chain management evolved dramatically with the increasing importance of the relationship with other suppliers (Harland, 1996). Slack (1991) and Christopher (1992) explain that the reason for this was the emergence of a globalised marketplace. Wood (1997) argues that firms need to become more integrative amongst other firms to reduce the vulnerability of the supply chain. There are various case studies where firms are becoming more integrative to their supply chain partners. Lamming (1993) and Womack, Jones and Roos (1990) mention the Japanese automotive industry and the Italian craft-based industry as basic examples. Lean and Just-In-Time (JIT) Management have added factors that helped enhanced the operational processes of the supply chain (Wood, 1997; Power, 2005). The requirement for organisations to become actively responsive to the needs of customers has increasingly been important (Christopher, 2000). Power (2005) observes that speed (delivering customer demand quickly),
agility (responsiveness to customer demand) and leanness (doing more with less) are the contributing factors that would make firms more competitive.

The Chronology of Green Supply Chain Management (GrSCM)

Green supply chain management (GrSCM) is an emerging field that stands out of the traditional supply chain perspective. The “quality revolution in the late 1980’s and the supply chain revolution in the early 1990’s” have sparked businesses to become environmentally conscious (Srivastava, 2007, p. 53). GrSCM has gained popularity with both academics and practitioners to aim in reducing waste and preserving the quality of product-life and the natural resources. Eco-efficiency and remanufacturing processes are now important assets to achieve best practice (Ashley, 1993; Srivastava, 2007). Global market demands and governmental pressures are pushing businesses to become more sustainable (Guide & Srivastava, 1998; Gungor & Gupta, 1999). Walton, Handfield and Melynyk (1998, p. 2) even claim that “increasing government regulation and stronger public mandates for environmental accountability have brought these issues into the executive suites, and onto strategic planning agendas.”

The key themes that came out in the literature over the last twenty years are the concepts of: green design, green operations, reverse logistics, waste management and green manufacturing (Guide & Srivastava, 1998; Srivastava, 2007). The very first green supply chain came into context in 1989. Kelle and Silver’s (1989) article was the first of this literature that developed an optimal forecasting system for organisations to use to forecast products that can be potentially be reused. This forecasting system, however, was highly contentious because returning individual containers is not usually known with certainty, so therefore, their findings may somewhat be incoherent.

The first green design literature came into context in 1991. Navin-Chandra’s (1991) article was the first of the literature to consider the need for a green design to reduce the impact of product waste. Works of Ashley (1993); Allenby and Richards (1994) and Zhang, Kuo, Lu and Huang (1997) came into context and expanded the framework of green design. Life-cycle analysis was an example of a framework that came out of green design. Works of Arena, Mastellone and Perugini (2003), Beamon (1999) and De Ron Penev (1995) all discussed life-cycle analysis as a framework.

Green Operations in terms of reverse logistics was an important concept that came out of the GrSCM literature. Apart from Kelle and Silver’s (1989) article, works of Pohlen and Farris (1992); Stock (1998) and Tibben and Limbke (2002) all provided case studies on reverse logistics. The use of plastics and bottle recycling are mentioned in some of these articles. Carter and Ellram, (1998); Srivastava and Srivastava, (2005); Shih, (2001); Nagorney and Toyasaki, (2005) and Min, Ko and Ko, (2006) are all academic perspectives of reverse logistics.

Waste management is another topic that came out of the GrSCM literature. This came into prominence with the work of Roy and Whelan (1992). This article created a standardised model for reducing electronic waste without harming the environment. After this article, different waste management issues came into context particularly around recycling and

Green Manufacturing, on the other hand, was not conceptualised until 1993 in the work of Crainic, Gendreau and Dejax (1993). This article established a comprehensive green supply chain model in terms of transporting containers from land to sea and vice-versa. Ideas of green manufacturing were then developed further by Van Der Laan and Salomon (1997); Guide and Srivastava (1998) and White, Masanet, Rosen and Beckman (2003).

There are other comprehensive reviews around GrSCM, particularly in the late 1990’s where issues such as green production and planning and manufacturing (Bras & McIntosh, 1999; Sarkis & Cordeiro, 2001; Van der Laan, Salomon & Dekker, 1996) and product recovery (Gungor & Gupta, 1999; Van Der Laan et al., 1996) are discussed. Barros, Dekker, and Scholten (1998) discuss recycling in the supply chain and Darnall, Jolley, Jason and Harnfield (2008) critique GrSCM by saying that Environmental Management Systems (EMS) are making less progress in reducing environmental harms. Some studies, however, are of limited focus. Van Der Laan et al. (1996) only discussed product remanufacturing and disposal, and Zhang et al. (1997) only discussed environmental technologies and design. Journals that are useful to GrSCM are Organisations and the Natural Environment, Business Strategy and Environment and Journal of Operations Management. Some key authors of the field are Srivastava (2006; 2007), Gupta (1999) and Guide (1998; 2003). Some of the famous books of GrSCM are from Allenby and Richard’s (1994) ‘The Greening of Industrial Eco-system’ and Preuss’s (2005) ‘The Green Multiplier: A Study of Environmental Protection and the Supply Chain’ and Sarkis’s (2006) ‘Greening the Supply Chain’.

**Green Design**

Green design is an important sub-topic to Green supply chain management. It is about designing a product or a service that encourages environmental awareness. Fiksel (1996) argues that organisations have definite potential to become eco-friendly towards product re-manufacturing. Heavy industries that have complex supply chains should take into consideration the benefits of reverse logistics (RL). Beamon (1999) acknowledged the development of ISO14000. This was introduced as a result of the Rio Summit on the Environment in 1992. There are growing pressure groups that calls for firms to encourage ‘greening’ in the supply chain.

There are several literatures that relate to Green Design. Barros et al. (1998) proposed a two-level location model on product recovery with the support of the Dutch government. Johnson (1998) examined the role of purchasing in reverse logistics system and design. In this study, twelve American manufacturing plants participated and it appears that all of them were in favour of reverse logistics without government legislation having been imposed. Taleb and Gupta (1997) created applied algorithms to design a product recovery system. This study shows that ‘core algorithms’ and ‘allocation algorithms’ are the scheduling systems that would help reduce waste.
**Life-cycle Analysis**

Life-cycle analysis is an important sub-concept to Green Design. Life-cycle analysis was introduced to measure environmental and resource related products to the production process (Srivastava, 2007). This measurement involves in stages from extraction of raw materials, production, distribution, and remanufacturing, recycling and final disposal. Gungor and Gupta (1999, p. 818) comments that life cycle analysis “examines and quantifies the energy and materials used and wasted and assesses the impact of the product on the environment.” Government regulations are also an added factor for organisations to work towards life-cycle analysis. Works of Arena et al. (2003), Beamon (1999) and De Ron Penev (1995) all discussed life-cycle analysis as a framework.

**Green Operations**

**Reverse logistics**

Reverse Logistics (RL) is the opposite of traditional or forward logistics (Beamon, 1999). Dowlatshahi (2000) and Carter and Ellram (1998) define reverse logistics as a process where a manufacturer accepts previously shipped products from the point for consumption for possible recycling and re-manufacturing. Beamon (1999) illustrates the fundamentals of reverse logistics (See Figure 1). The diagram shows the works around RL involving managing the flow of materials towards remanufacturing and recycling, which in this sense reduces the costs of making new products (Dowlatshahi, 2000). Thierry, Wassenhove, Van Nunen and Salomon (1995) reports that reverse logistics have been widely used in automobile industries such as BMW and General Motors. Other companies such as Hewlett Packard, Storage Tek and TRW are also using reverse logistics as a supply chain process. Doing this would eventually help firms become more competitive in their own industry (Srivastava, 2007).

Collection is the first stage in the recovery process. Products are selected, collected and transported to facilities for remanufacturing (Srivastava, 2007). Used products came from different sources and should be brought to product recovery facility to begin the converging process (Thierry et al., 1995). Sorting and Recycling are also an important mechanism when sorting reusable products. Cairncross (1992) and Srivastava (2007) suggest that collection schemes should be classified according to materials whether separated by the consumer (separation at source) or centralised (mixed waste). The goal is to sort products that can be reused to reduce costs of making new products.
Dowlatshahi (2000) claims that Reverse Logistics (RL) is mainly a practitioner based view. But there are comprehensive academic journals, particularly quantitative studies, that shows and supports reverse logistics. Umeda, Tsakagushi and Li (2003) established a mathematical reverse logistics model in electrical appliances in Japan. The reason for this implementation was a result of governmental regulations been made. Ravi, Ravi and Tiwari (2005) add Analytical Network Process (ANP) based decision model to enhance reverse logistics for EOL Computers. This study used a balance scorecard approach that has four different dimensions (customer, internal business, innovation and learning and finance) to enhance the validity of the model. Nagorney and Toyasaki (2005) developed an integrated framework to reduce electronic waste. In this study, multi-tiered e-cycling network equilibrium model was used to enhance the reverse supply chain. This model can be applied to a variety of recycling issues and policies in Japan and the European Union.

There are also qualitative studies done on Reverse Logistics, mainly in the forms of surveys and semi-structured interviews. Guide and Srivastava (1998) have based their methodology on using semi-structured interviews and surveys to managers in remanufacturing facilities. In this study, managers used inventory buffers (delay buffers) to aid coordination and control in the flow parts of remanufacturing and reassembly stages of the

The Case of Kodak: Green Technological Advancement
Since the early 1990’s, the need for technological advancement to Green Operations is becoming more popular. Wu and Dunn (1995) claim that the ‘new economy’ has encouraged firms to be more environmentally sustainable and eco-efficient. Kodak is an example of a company that has a remanufacturing line to the supply chain (See Figure 2). It is reported that 310 million single-use cameras have been returned since 1990 (Kodak, 1999; Guide, Jayaraman & Linton, 2003). Although the timing of returns of single-use cameras is unknown, Kodak has managed to allocate 310 million single-use cameras back into their production line. The reason for this success came from its own product design (Guide et al., 2003). Kodak’s single-use cameras are simple, reusable and easy to recycle, and because of this, Kodak has managed to reuse their products and save costs.

Guide et al. (2003) also used Xerox Europe, US Naval Aviation and Kodak as case studies to Green Operations. Due to various legislation, companies are encouraged to have Green Logistics (Guide et al., 2003). Producer responsibility has been, and still is, a growing issue. This issue is important because organisations are now starting to become sensible to preserving the natural resources and the environment (Guide et al., 2003; Umeda et al., 2003, Srivastava, 2007).

Why Change to Green Supply Chain Management?
There are different motivators for companies to switch to ‘green’ in their supply chain. Although some of the motivators are quite unclear, Wu and Dunn (1995) suggests that some organisations are simply doing this because it is the right thing to do for the environment. Perhaps some are more radical to environmental change, but others may not (Wu & Dunn, 1995). Studies, however, have shown that profitability and cost reduction are some of the main motivators for businesses to become ‘green’ in the supply chain (Srivastava & Srivastava, 2006; Srivastava, 2007; Darnall et al., 2008). Johnson (1998) argues that reverse logistics were motivated primarily by economic factors and not concerns about protecting the eco-system. Tibben-Lembke (2002) and Van Hock and Erasmus (2000) suggest that reverse logistics can only bring about profitability, reduction of waste and, advertising. Zhu and Sarkis (2004) took this idea further and argued that most of the 186 participants in their study all agreed that GrSCM practices are only about ‘win-win relationships on environmental and economic performance’.
Figure 2: Kodak’s Green Remanufacturing Line

Raw Material Supplier

Kodak Manufacturing Facility

Sub-assembly enter

Subcontractor
- Remove packaging
- Clean
- Remove batteries

Collection Facility
- Sort by manufacturer

Retail Outlets

Customers

Photofinishing

Forward flow

Reverse flow

Source: Guide et al. (2003)
Companies, however, need to acknowledge that there are hidden values to reverse logistics (Mollenkopf & Closs, 2005). Jayaraman and Luo (2007) claims that customers, on average, return about 6% of the products they buy. These products can be from plastic bottles to boxes. Organisations are able to cost-save if they can capture this 6% return from the consumers. Doing this, however, still remains in question. Srivastava and Srivastava (2006) suggested a model to manage product returns. The study utilised average-life cycle of product data, past sales forecast demands to support their analysis. Semi-structured interviews to 84 stakeholders were used to triangulate the findings of the model. The findings shows that reverse logistics can cost-save only if done correctly. Saying this means that organisations must have a core vision to encourage Environmental Management before going any further to green logistics.

Conclusion
The purpose of this paper is to briefly provide an overview of the Green supply chain literature. This paper has argued that GrSCM has helped reduce the ecological impacts of industrial activity. Key academics have argued different angles to GrSCM. Works such as Carter and Ellram (1998); Srivastava and Srivastava (2005); Shih (2001); Nagorney and Toyasaki,(2005); and Min et al. (2006) discussed reverse logistics, whereas Arena et al. (2003) and Beamon (1999) discussed life-cycle analysis. But the key themes that came out of the GrSCM literature over the last twenty years are the concepts of green design, green operations, reverse logistics, waste management and green manufacturing (Guide & Srivastava, 1998; Srivastava, 2007). This paper, however, briefly discussed some of these issues and provided, first of all, a brief introduction to traditional supply chain management, then a discussion to the chronology of GrSCM and green supply chain as a discipline. This followed by brief discussions of green design and green operations. The last part of this paper briefly touched on the motives for organisations to go towards green operations.

Although GrSCM has been comprehensively reviewed, there are areas around Green supply chain that still require further study. One is a gap in the literature in terms of the stakeholder’s views towards green supply chain. Stakeholders would definitely have different views about this and can sometimes be conflicting from the company’s point of view. Normally, when the word ‘natural environment’ and ‘sustainability’ comes into the picture, most operation managers and stakeholders would see this as a constraint to the organisation’s generation of profits (Srivastava, 2007). Some stakeholders would go against green supply chain management and some would not. This paper recommends that researchers should focus more towards qualitative study such as interviews in understanding the different stakeholder views towards green supply chain management to portray the different views about the concept and how this, in the end, implicates management decisions.

References


