An Agenda for Sustainable Operations and Supply Chain Management Research

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ABSTRACT

The purpose of this paper is to review some of the key challenges to sustainable operations and supply chain management and provide future research directions. While sustainability and sustainable development is defined in many ways, the principles of integrating economic, environmental and social imperatives are well understood. Despite an expanding understanding of the implications of sustainability, research to date, as well as practical implementation, reveals many areas for further development. Sustainability is a particularly difficult subject to research which raises many trade-off situations. As examples, there are conflicts between different environmental factors (energy and waste) when taking a life cycle perspective and burgeoning institutional constraints limit the economic degrees of freedom (limiting opportunities for closed loop solutions). Drawing on past experiences, recent research and current practices, this article provides a framework for future research in sustainable operations and supply chain management.

Keywords: Sustainability, operations management, supply chain management

INTRODUCTION

Sustainable supply chains has been variously described as " *the strategic, transparent integration and achievement of an organization's social, systemic coordination of key interorganizational business processes for improving the environmental, and economic goals in the long-term economic performance of the individual company and its supply chains*." (Carter and Rogers,

2008) or "'*supplier selection including environmental and social criteria, 'auditing and monitoring of suppliers & certification of suppliers according to environmental and social standards*" (Seuring and Mueller, 2008). Overall the integration of the three pillars of sustainability – environmental, social and economic - into company operations and supply chains is the main route to sustainability. For the purposes of this paper the majority of the discussion will focus on environmental sustainability, but many of the challenges presented here are equally relevant to social and economic sustainability.

There are many drivers of sustainability in operations and supply chains but these can be broadly grouped into three main areas. These are compliance, risks and opportunities. On the compliance side there have been many developments in legislation over recent years particularly in Europe. These regulations have variously driven responsibility for the design and manufacturing of products which have lower impacts on the environment, especially in the area of waste generation. Compliance however is not only a legislative issue but is also driven through standards and codes of practice. More and more companies are imposing standards and codes on their own suppliers in order to drive them to meet new levels of performance related to environmental management and social issues (Preuss, 2009). A typical approach is for customers to impose suppliers to adopt ISO14001 for example, but of course this only ensures a base level of performance, in a sense leveling the playing field, albeit to a 'higher' common level. The second main driver relates to risks due to not effectively managing operations and supply chains in a responsible manner. On the one hand companies face additional unforeseen costs due to their suppliers not meeting regulations or as a result of accidental pollution or spillages of harmful chemical (clean-up costs or loss of operating licences). On the other hand, and potentially more significant is the damage to reputation if a company is seen as not managing its environmental impacts effectively or allowing product safety to be compromised. In such cases the loss of reputation can immediately affect the bottom line through lost sales as was the case for Gap and Nike in the 1990s due to the use of child labour, and more recently Nestle through the use of palm oil from non-sustainable sources. The last driver is that of opportunity to lower costs or to raise sales income. If companies can avoid waste disposal for example through process redesign, this can avoid disposal charges which in some countries is very significant. On the other hand, products which are seen as green might even command a premium in some customer segments, so that revenues can be increased by demonstrating the product contains recycled materials or avoids hazardous contents harmful to the environment (such as green cleaning products produced and marketed by both Unilever and Procter & Gamble). The combination of drivers tends to depend on the sector and the type of customer and products, but there can be no doubt that the importance of these drivers for sustainable oprations and supply chains is only increasing at present.

KEY CHALLENGES TO SUSTAINABLE OPERATIONS AND SUPPLY CHAINS

While the drivers for sustainability are quite well understood, the way that companies implement responsible operations is less well defined. In particular the specific challenges that companies face are wide and varied and the links between them relatively unexplored. For the purposes of this paper a number of challenges (not all) are discussed with the intention to provide some direction for future research in this field. The following diagram (Figure 1) encapsulates the challenges discussed here. The idea that operations are part of supply chains is shown by including ‘produce’ as one of the supply chain processes. This framework is loosely based on the SCOR model which has been widely adopted by industry in the last decade or so.

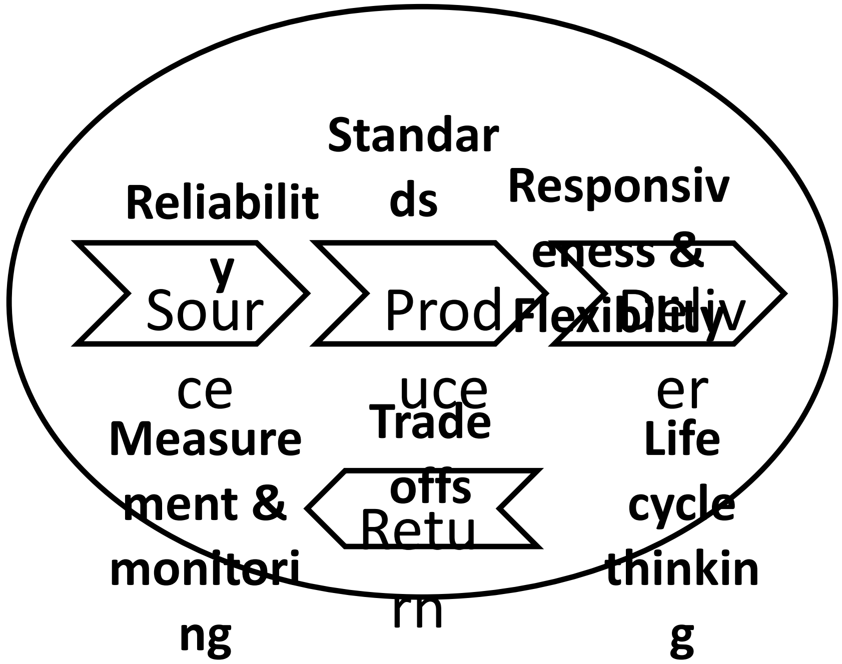

Figure 1: A framework for sustainable operations and supply chain challenges.

The paper will make reference to these challenges with relation to different processes of the supply chain. It is not possible here to provide detail on each of the processes, instead the paper aims to provide some examples of how the challenges can manifest in different parts of the supply chain. The paper takes each of the four supply chain elements in turn (source, produce, deliver and return) in the following sections.

SOURCING

One of the key issues in sustainable sourcing is the use and imposition of standards whether they be based on legal frameworks or voluntary agreements. In developing countries, this is especially difficult to manage as often the standards vary widely and are difficult to control. One approach that many companies have adopted is this use of codes of conduct for suppliers. Here suppliers are requested to sign the code and demonstrate to the customer how the elements of the code are met. There are two issues related to this. The first is that compliance is often self reported by the supplier. In some cases the customer will audit a selection of suppliers and even more rarely customers use third parties to verify the supplier compliance to the code. This leads to a great deal of variability in the application of the codes. A second issue is the actual composition of the code. Recent research has shown that while most codes of conduct request compliance to local laws and environmental protection, it is rare to find codes that consider other elements including life cycle thinking and the protection of biodiversity (Preuss, 2009).

Another key challenge is the requirement of responsiveness and flexibility in logistics from suppliers. In some industries just in time deliveries are important to responding to customer demand and also the reduction of working capital in the form of inventory. Hence this has driven the need for smaller and smaller delivery lot sizes. As part of a study in the automotive sector we found that there are often missed opportunities to consolidate or pool logistics across suppliers and customers in order to both reduce costs of flexible logistics but also to reduce fuel consumption and carbon emissions. In this case we found in one logistics provider three automotive factories shared 11% of their suppliers and at least two factories had many more suppliers in common, but collections from these suppliers was not shared and coordinated. These kinds of actions have the potential to reduce road transport impacts significantly.

A final issue relating to the sourcing part of the supply chain is the question of what to measure. Recent research has shown that in the majority of cases the literature focuses on internal processes and how they are organised, and the issues of material, wastes and recycling (Miemczyk et al., 2012). Far less research is focused on the issues of life cycle analysis, risks and other elements of sustainability. Related to this challenge is ‘where’ to measure and again here the majority of research measures the extent of sustainability in internal processes and direct relationships with direct suppliers. The challenge on the sourcing side of the supply chain is the identification of risks all the way back to raw materials and also consideration of the influence of stakeholders outside of the traditional supply chains such as NGOs. Most research does not take this level of analysis as a basis for studies.

PRODUCTION

Sustainability in operations and production has been a focus of operations management research for a number of years (Corbett et al., 2009; Kleindorfer et al., 2005). Research has covered a number of issues from the links between environmental management and production and quality management (Hart, 1997; Theyel, 2000). Bringing together advanced production systems and sustainability however has been less studied. One focus of this work has been the link between green and lean, with most work showing there to be a positive relationship (Florida, 1996; Mollenkopf et al., 2010; Rothenberg et al., 2001). However as mentioned in the previous section there is not always a positive relationship between lean and green, or in the previous case JIT and green. Other work in the automotive sector also shows that we should be cautious about stating this link.

One area identified as problematic in the lean and green link is the car painting process. Indeed this is viewed as the most environmentally harmful single process element of making cars. Our hypothesis was that if manufacturing was to be truly flexible to respond to actual customer demand then the painting process would need to operate on minimum batch sizes – even a batch size of one – hence some of the data collected in the study of the paint process included emissions and waste data in order to estimate this impact. At the time most of the car plants in the study still operated solvent based paint applications. With potentially smaller batch sizes in manufacturing, the changeover frequency would increase and consequently the amount of pollution and waste from the purging process would increase as well (shown in Figure 2). This was published alongside other issues of painting flexibility in 2004 (Howard et al., 2004). Of course, lean is about eliminating waste, so in theory at least lean companies would strive to reduce changeover waste not just relating to time and effort but also environmental pollution. After discussions with industry in an industry conference workshop we proposed a significant painted body store to decouple this process from the end demand and maintain larger batch sizes, in a sense this is a contribution to the decoupling literature providing 'environmental' arguments for where to locate a decoupling point. More general findings based on environmental impacts in the automotive supply chain were published in a book chapter (Miemczyk, 2004).

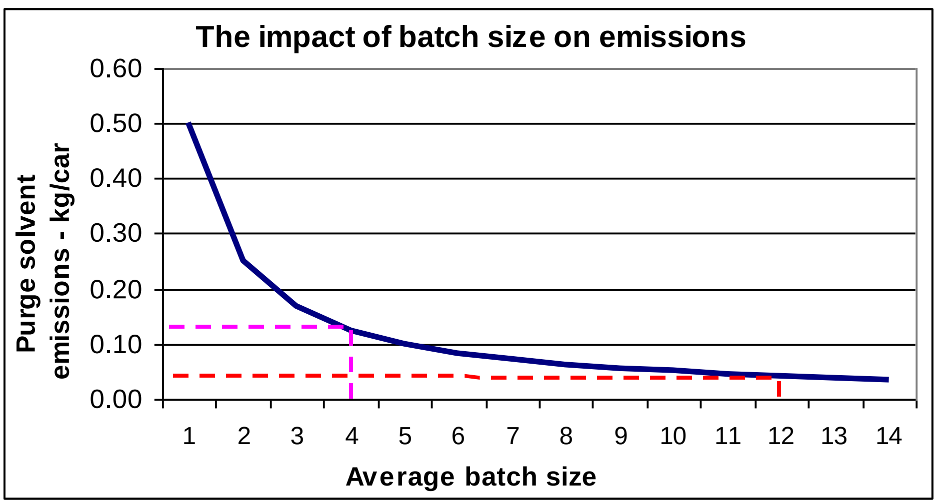

Figure 2: Relationship between batch size and environmental impact (based on Howard et al., 2004).

Another issue that was identified in the car manufacturing process was that of unreliability. Here we found that it is not uncommon, especially in the painting process, for cars to require rework either by using offline mini spray booths or for cars to go through the process of painting twice. It is clear that this rework also has implications for pollution and waste which is increased due to quality problems and process unreliability. Hence if we can improve reliability in processes that pollute the environment, we can decrease the associated impacts – again this is an area which is under-researched.

This section on operations and production has focused on two issues flexibility and reliability which are key operations priorities in many industries today. Where there are processes that led to environmental harm these priorities can potentially increase this impact unless they are purposively designed to avoid such effects. One approach could be to re-examine the set-up/die exchange procedure to make sure that increasing changeovers does not increase impacts. The following section examines challenges to the outbound logistics process from manufacturers and distributors towards the end customers.

DELIVERY

Sustainable distribution and delivery has been a focus of research in the logistics field for a number of years now (Browne et al., 2006; Christensen, 2002; de Brito et al., 2008; Wu and Dunn, 1995). We examined the impact of the short delivery time on cost and the environment as part of automotive logistics case studies (Holweg and Miemczyk, 2002). We found that cost and carbon emissions increased by about 30% overall due to the increased dispersion of delivery points to justify full truck delivery each day, compared with grouping orders to together and delivering when a dealer has 3-4 cars due for delivery to customers. We also found that this varied according to geographic area, being of greater importance when delivery was closer to the point of distribution, as the line haul part of the delivery was a lower proportion of the whole distribution chain. Therefore this is an example of how more responsive delivery (from 3-4 days to 1 day) can lead to greater impacts, especially when undertaking local distribution (Figure 3).

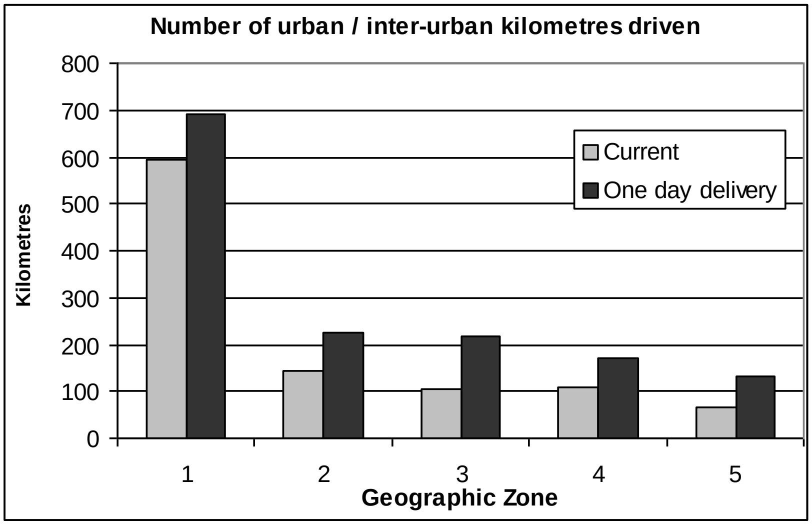

Figure 3: The impact of one day delivery on kilometres driven to deliver new cars (Holweg & Miemczyk 2002).

We also considered ways of mitigating this effect by changing the typical method of delivery such as by using smaller trucks or sharing (mutualising) the delivery stream from more than one vehicle brand.

Another trend in distribution is to use alternative channels to market such as the internet. Instead of having products collected by customers from retail outlets this approach means that customers have their products delivered by truck or van owned by the retailer (or subcontracted by them). In theory at least this can reduce overall impacts because customers orders can be collected together and delivered in one delivery loop thus saving vehicle kilometres per customer and so reducing carbon emissions. However, linking to the challenge of reliability, if the truck fails to deliver because the customer is absent the resulting impacts of returning to do the delivery again or even the customer driving to the retailer to collect the items, the overall impact can be much greater than for the traditional shopping trip by car.

Another significant issue in delivery is that the majority of logistics operations are carried out by third party logistics providers, who in many cases subcontract part of their transport to other sub-contracted transport companies. This means that measuring and monitoring and imposing standards to reduce the environmental impact of transport is increasingly difficult. One example is DHL, the largest logistics contractor (express delivery and also industrial logistics solutions) in the world today. The majority of the carbon emissions related to this company come under what is known as scope 3 (the United Nations definition of external emissions from suppliers). This is because most of the actual transport service is done by DHL's sub-contractors. These are often small family owned businesses who operate on low margins, such that investment in clean engine technology and innovative logistics practices to reduce emissions are often out of reach.

RETURNS

This fourth area of sustainable supply chains has developed significantly in Europe due to new legislation developed in the last 10 years based on the principle of producer responsibility (Walther and Spengler, 2005). In this context, companies have had to develop strategies for bringing back products at the end of their life at no cost to the end user (Guide Jr. and Van Wassenhove, 2002). This is particularly challenging because revenue from the reuse and recycling of components and materials is uncertain. Furthermore the cost of doing this whilst taking into account stringent environmental standards (dealing with hazardous waste such as oil and acid from car batteries) can be elevated. Hence it is within this context that companies in Europe have developed new processes and structures to meet newly mandated recycling levels (Cairncross, 1992).

However this is not to say that reverse logistics and product take back systems did not exist before these regulations. In fact companies have been engaged in this area for decades, but with the principle goal of obtaining or recovering value (Roy and Whelan, 1992). One case exemplar is Xerox who has been involved in take back and recycling of their photocopiers for many years (Maslennikova and Foley, 2000; McIntyre et al., 1998). In fact this example is one of closed-loop supply chains where recycling materials are reused as raw material for new or at least remanufactured machines. The objective of reusing parts and recycling parts is made easier because not only is the product designed with this in mind but in addition the whole business model based on leasing machines and providing a service is more aligned to achieving product recovery. As the end user often does not own the copier but instead leases the product, Xerox is able to retain ownership and has control over the 'retirement' process, deciding when it is economically viable to return the product to the remanufacturing site (based on balancing revenue and maintenance cost which rise as the life extends). The process of recovery then follows a number of predefined steps in sorting according to quality then either repairing, refurbishing/reconditioning, remanufacturing (as new) or recycling the constituent parts and materials. Xerox are actually able to save money with this process by having cheaper raw materials and remanufacturing copiers to lease into the market 'as new'.

The following chart (Figure 4) highlights some of the key issues related to the reverse or return supply chain. The first observation to make is that typically there is a complex network of relationships, quite often not formalized, using spot market type transactions for transport and sales of recycled materials. This means that taking a long term, partnership perspective where risks and rewards are shared is difficult to implement. A second major challenge is the problem of both supply and demand uncertainty which means that both flexibility and responsiveness are crucial, but can lead to high cost in an environment where the margins are often quite low. A third difficulty is the lack of standards in the returns process environment. This is driven partly by the high variability in the quality of returned products and also the wide variety of product acquisition routes (from final customers, local authorities and other organizations).

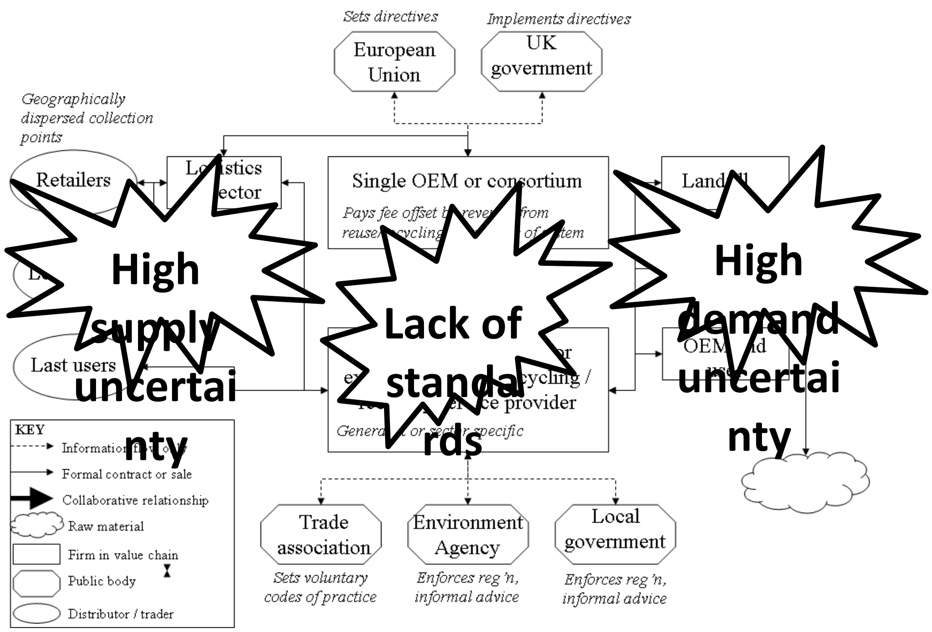

Figure 4: Relationship map of end of life product take back systems (Based on (Miemczyk, 2008)

CONCLUSIONS

There are many challenges, this paper has only mentioned some of these. Yet alongside these challenges come many opportunities for research that fills gaps in theory but also provides impact to companies.

AN AGENDA FOR FUTURE RESEARCH

The field of sustainable operations and SCM is still in a developing phase and therefore there are many opportunities for new research. The following non-exhaustive list provides some insights for potential research in this area and is based on the general discussion given in this paper.

- *Standards, measurement and monitoring*

Both from a research and practice perspective there are many limitations in the measures that are used. In particular research could focus on how companies adopted approaches related to risks, life cycle management and how energy and carbon are managed in supply chains. Another major opportunity is to look at how companies are measuring and monitoring the sustainability performance of their suppliers further up their supply chains past the first tier of supply. This is particularly relevant to identifying and controlling risks but also essential if a life cycle approach is to be taken where often the majority of carbon emissions can be traced back to raw materials.

- *Responsiveness and flexibility*

A key trend in supply chains is the need for responsiveness and the required flexibility to achieve this. In sectors where there is more and more product proliferation such as in the automotive sector (Stäblein et al., 2011), being able to respond to end customer demand is essential. However despite research and advanced practices, there is very little research in this area. Although research has explored to limited extent the link between lean and green, supply strategies such as agile and leagility warrant further examination in the context of sustainability. In addition, the huge challenges of product take back are further hindered by product proliferation and therefore research can also look to address how design and manufacturing techniques such as modularity can help this process of material and component recovery.

- *Reliability*

Rework, expediting, non-productive actions are all defined as wastes in the lean production paradigm. Equally this activities can cause environmental pollution and wastes over and above that which is ‘planned’ within production processes. Furthermore, logistics systems which fail to deliver as planned also require ‘rework’ and are non-valued added. Hence there is a need to assess the total costs of failure including the costs to society due to the release of harmful chemicals or the generation of excessive wastes, providing further arguments for prevention actions and right first time.

- *Life cycle thinking*

The final opportunity suggested in this paper is the adoption of life cycle thinking in the delivery of products and services. As in the adoption of total cost thinking, life cycle thinking aims at drawing a picture of the total impacts of products from the extraction of raw materials to the disposal and return of the end of life products. Life cycle management will never be achievable without effective supply chains, so a possible research question could be are well organized and integrated supply chains more able to adopt life cycle management, than disparate, uncoordinated supply chains.

One other promising area is the development of product service systems - service dominant logic – whereby instead on a focus on manufactured product companies concentrate on the solving the customers problems and needs (Vargo and Lusch, 2004). Such an approach moves companies away from simply managing products to providing innovative solutions which no longer requires buying and selling physical objects. This approach is providing new ways of thinking about the customer offer which could lead to more leasing type models such as in the Xerox case example.

This view could provide further drivers to maximize asset utilization and extension of product life times and hence reduce waste from product disposal.

A final comment to these conclusions reflects on the relevance of these challenges to sustainable operations and supply chains in Brazil. If we consider how companies and organizations respond to stakeholders, a useful concept is that of stakeholder salience (Mitchell et al., 1997). According to this theory, organizations view stakeholders (and their associated issues) as salient when there is power, legitimacy and urgency. There can be no doubt that stakeholders in the domain of sustainability are becoming more powerful, public bodies more legitimate and the sense of urgency is growing in a world of constrained resources and an environment under pressure. Before legislators create constraining rules and additional costs, now is the time to act and develop innovative solutions which reduce risks and provide opportunities for sustainable operations and supply chains.

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