Supply Chain Decarbonisation: Drivers, Barriers and Strategies.

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Abstract:

The management of Greenhouse Gases (GHG) in organisations' supply chains is increasingly recognised as an avenue through which to pursue climate change mitigation and wider corporate responsibility goals. This presents both opportunities and challenges. The literature and practice of environmental or green supply chain management is well developed, but less so when applied specifically to GHGs.

This paper aims to develop a deeper understanding of the current state of supply chain decarbonisation in the UK by identifying leading organisations, the strategies used and the factors driving and hindering such efforts. An exploratory interview survey of eleven experts from academia, think tanks, business support and consultancy organisations was conducted in order to provide an 'insiders' perspective and supplement what is an underdeveloped area of the supply chain management literature.

It is found that large corporate brand firms with high supply chain control and high levels of supply chain GHG emissions are leading current efforts, driven by factors such as competitive advantage, reputation and risk management. Supply chain leading organisations utilise many strategies, including encouraging disclosure and reporting of emissions, the use of GHG supplier selection criteria and collaborative reduction initiatives. A prominent role is also found for the third sector, particularly in the scrutiny of disclosed and reported emissions data. The research suggests that current factors driving engagement rely on characteristics and capabilities not present within in all organisations, meaning further engagement will rely on broadening the impact of driving factors and enhancing low carbon supply chain management capabilities.

Introduction:

The increased importance and efficacy of corporate responsibility (CR) has seen organisations attempting to ensure that their activities and conduct exceeds that as required by law. As environmental problems, and more specifically anthropogenic climate change, have increased in severity, CR is now seen to include the environmental impacts, including those occurring in supply chains (Kovács, 2008). Consequently, the management of Greenhouse Gases (GHG) in organisations' supply chains is increasingly recognised as an area that organisations must engage in order to pursue climate change mitigation and wider CR goals (Brickman & Ungerman, 2008; Carter, 2004; Carter & Jenning, 2002).

The supply chains of consumer goods makers, manufacturers and high tech firms can contain 40-60% of their GHG footprint, whilst for retailers the figure can be over 80% (Brickman & Ungerman, 2008; Oracle, 2008). Such high instances of emissions within the supply chain pose a CR and potential future regulatory risk; however less than a quarter of top executives surveyed by Brickman and Ungerman (2008) are found to have acted in their supply chains, even though three quarters noted it as a priority.

The management of supply chains, both for more orthodox operational objectives and more recently for environmental and wider sustainability goals is well-established in the academic literature (Gold *et al*., 2010). However, there is little empirical or theoretical literature concerning supply chain decarbonisation, as literature concerning sustainable 'supply chain management' (SCM) has generally failed to cover energy consumption or gaseous emissions (Seuring & Müller, 2008).

The UK is seen as a leader in terms of climate change policy, with the passing of the Climate Change Act in 2008, however there is no legislation or regulation directed at supply chain emissions. There is nevertheless evidence that organisations are managing and reducing their supply chain emissions in the absence of legislation, through programs such as Carbon Disclosure Program (CDP) Supply Chain (CDP, 2010, 2011). Which organisations are leading such efforts, how and why are all important questions.

The importance of supply chains to organisations' prosperity and success is un-doubtable with the expansion of CR to include activities occurring upstream in the supply chain. In order for the possible negative impacts of such activities to be minimised, and for the opportunities presented to be seized upon, it is critical that greater understanding is gained. Knowledge is required on the factors driving this process, the aspects that act as barriers, as well as the strategies being used by those organisations that have moved early and begun to manage and reduce supply chain GHG emissions.

This paper seeks to contribute to GHG SCM literature by identifying current leading organisations in the UK with regards to supply chain decarbonisation and the strategies they are using, including the factors that are driving or hindering engagement. The fulfilment of these aims will allow the formation of a knowledge base from which further research into this important topic can be launched.

The Supply Chain & CR

Ideas regarding the spread of corporate responsibility beyond the traditional boundaries of organisations, and specifically in supply chains, are well addressed by Kovács (2008), who attributes such shifts to increasing recognition by organisations of the importance of stakeholders.

A well-defined set of literature concerning CR issues within the supply chain centres on labour standards, where early efforts concentrated non-governmental sources of regulation to control activities upstream in the supply chain (Weil & Mallo, 2007). This literature has concerned itself with ethical procurement initiatives, which have experienced mixed success (Roberts, 2003), and represents a widening of areas where firms were felt to have to act responsibly (Welford & Frost, 2006).

Although literature in this area offers a precedent, it is concerned with more social aspects of SCM, but does demonstrate how practices occurring up stream in the supply chain have impacted supply chain leading organisations and led them to engage and increase control over their supply chain for CR purposes.

Environmental or Sustainable SCM

Much work has been conducted on SCM and its integration with concepts and objectives of sustainability. One issue with such literature is its wide ranging focus, for examples from logistics (e.g. Carter & Rogers, 2008) to aspects of product design (e.g. Baumann *et al.*, 2002). Several authors have attempted to review the literature, each developing their own classifications in an attempt to encompass what is a substantial and ill-defined body of work.

Handfield *et al*. (2005) classify the literature depending upon topic, covering areas such as environmental risk management, environmental purchasing or product and process design. Srivstava (2007) categorise on problem context, covering green design versus green operation, with the later including green manufacturing and remanufacturing, reverse logistics and waste management. Both these reviews demonstrate the breadth of literature and its wide focus.

Other areas linked to sustainable SCM include environmental purchasing (Zsidisin & Siferd, 2001) and environmental performance as an operations directive with supply chain issue subordinate (De Burgos & Lorente, 2001). Walker *et al*. (2008), through an interview survey of seven public and private organisations notes that environmental supply chain initiatives can range from reducing packaging and waste, to vendor environmental assessments, to eco-friendly product design. Such efforts share benefits however, including reduced costs, improved organisational performance and enhanced reputation.

No one theory has been established that covers environmental or sustainable SCM fully (Seuring & Müller, 2008; Halldorson, *et al.*, 2007). Various theories have been applied to SCM, including the Resource-based View (RBV), transaction cost approach and the network perspective, each offering contributions via different perspectives to SCM efforts (Skjott-Larsen, 1999; Hobbs, 1996).

Walker *et al*. (2008) also offer the most comprehensive review of the factors that can drive or hinder sustainable SCM efforts. Categorisation is based on their internal or external operation, with internal drivers including pressure to reduce costs from investors and managers, as a risk management function, or due to owners/founders values. External drivers are noted as including regulation, customers, competition, society and suppliers.

There is general agreement regarding these drivers, with Croom *et al*. (2009) noting the primacy of regulatory drivers, Kovács (2008) focussing on stakeholders and Florida (1996) and Green *et al*. (1994) highlighting the role of consumers.

Lee (2011) and Seuring and Müller (2008) are in agreement that few efforts to date have attempted to incorporate the management of carbon emissions, or indeed energy, into SCM science. This gap is fundamental to supply chain decarbonisation, as within the narrower field of climate change, rather than sustainable development, little theoretical or empirical evidence is available as to how to manage and reduce GHG emissions within supply chains.

All such literature do however share a common goal, that being, enabling a focal firm or supply chain leading organisation to improve its own environmental performance, and enhance sustainability competitiveness, by improving the environmental performance of its suppliers (Lee, 2011).

Although the above noted work is no doubt useful and relevant for efforts towards the management and reduction of GHGs in supply chains, its lack of specificity in this regard means it is unable to provide anything other than points of inference for the questions posed in this research.

The Management and Reduction of Carbon in the Supply Chain

Lee (2011) provides a case study of an attempt to integrate GHG emissions into the SCM efforts of Hyundai Motor Company, highlighting the importance of boundary setting and measurement as well as the mapping of carbon emissions across a manufacturing supply chain. The study concedes that the contextual environment and operational specifics of the organisation in question will greatly impact on supply chain decarbonisation efforts and strategies. It also fails to note how suppliers were engaged and incorporated into the process.

Chaabane *et al*. (2010) develop a framework to allow trade-off decisions to be made regarding an organisation's participation in an emissions trading scheme, including gaseous emissions, as well as solid and liquid wastes. Although novel and concerned with the management of GHG in a supply chain, this paper takes a waste focussed approach and within an industrial setting, whereas many supply chain emissions will be emitted from non-industrial suppliers and processes.

Although little work has been conducted within the academic literature, much grey literature exists on supply chain decarbonisation. Capgemini (2008) in a report on 'future supply chains', focuses on physical supply chain innovation, highlighting in-store logistics, collaborative physical logistics (i.e. shared transport), reverse logistics and demand management fluctuation; all methods well documented in the academic literature concerning

general SCM. They do however mention the importance of information sharing, an area central to working with supply chain partners.

Other grey literature is light on substance and novelty, such as Kane (2008) noting that reduced material flows result in reduced carbon emissions. BSR (2009) offer a more comprehensive, if generic, guide, taking a logistics centred approach specific to carbon, but again fail to highlight supplier engagement strategies and methods concerning design or manufacturing.

The CDP (2011), through their yearly reports, offer a roadmap for their voluntary member companies to engage with supply chain decarbonisation. Strategic awareness, carbon reduction ambition, reporting capabilities and final implementation are covered, with each area consisting of three levels of competence. Based primarily on the 'reporting' of emissions, the approach has allowed many firms to reduce emissions with little or no direct costs.

In earlier reports and one of the few contributions regarding strategy, the CDP highlights the different levers available for reducing supply chain emissions, including the simple reduction of demand, to sustainability criteria for supplier selection and collaborating with suppliers (CDP, 2010).

UK Government Policy & Supply Chain Decarbonisation

An important contextual factor for supply chain decarbonisation, as noted earlier when discussing driving factors, is the impact of legislation. The UK Government committed itself to the reduction of GHGs with the introduction of the 2008 Climate Change Act, with overall mitigation policy aimed at creating a long term, stable and pragmatic approach, intending to prepare the economy to ensure its continued competitiveness (HMG, 2009:6).

A noted driver of wider sustainable SCM initiatives, legislation is identified by some authors (e.g. Green *et al*., 1994) as the most influential given its legal nature. There is currently no legislation aimed at supply chain emissions; however the Climate Change Act does require the government to introducing mandatory GHG reporting. A consultation has been launched, outlining several options, including the addition of scope 3, which include supply chain emissions (Defra, 2011).

Comment [ST1]: Provide reference for this

It is evident from the above sections that CR concerns in the supply chain are not a new phenomenon and was initially concerned with labour standards; equally the management of the environmental performance of supply chains is well documented. However, these literatures fail to adequately inform the questions posed by this research - those being: who is leading current supply chain decarbonisation efforts, how are such efforts being pursued, what factors are responsible and what challenges are being presented? - as only a handful of articles and grey literature specifically tackle carbon management or supply chain decarbonisation; this further demonstrates the need for an exploration of current state of supply chain decarbonisation in the UK.

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Methods & Analysis:

Although much literature exists on SCM it was felt that none offered a framework able to offer a satisfactorily holistic view of the phenomenon under study. Consequently, with a wish to ensure that all relevant information was gathered, a qualitative and exploratory approach was adopted.

An interview survey, based on eleven interviews with identified experts in the field, was conducted to identify organisations engaged with supply chain decarbonisation and explore the factors driving or hindering this, as well as the strategies enacted.

Respondents were chosen due to their context specific knowledge and experience, established through a criterion (Bognor, *et al.*, 2009); they were considered experts if they had three or more years' experience in a relevant position, or had been published on the topic.

Comment [ST3]: Did you specify the number of publications? Again how did you decide to set this criterion? Based on literature or something else , need to state it here.

Through academic and grey literature searches, internet searches, and co-nomination more than 70 individuals or organisations were identified as holding the relevant knowledge and experience to be considered eligible for recruitment; of these, eleven agreed to be interviewed and are shown in table 1. Data collection was stopped once data saturation was reached, that being when no new information was being obtained and was felt to be in line with non-probabilistic and purposive sampling in relation to homogenous groups.

Interview Number:	Respondents Position:	Organisation Type:
1	Senior Policy Advisor	Business Representation Org.
2	Head of Corporate Relations	Business Support & Representation Org.
3	Operations Director	Low Carbon Business Support Org.
4	Senior Account Management	Low Carbon Solution Based NGO
5	Program Manager	Regional Intelligence Network
6	Research Fellow	Think Tank
7	Environmental Campaign Organiser	Business Support Org.
8	Corporate Strategy Consultant	Global Management Consultancy
9	Post-Doctoral Researcher	Academia
10	Senior Strategy Manager	Low Carbon Business Support Org.
11	Senior Sustainability Manager	Think Tank

Table 1. Interview Respondents

Comment [ST4]: Title of the table??

Respondents were interviewed under anonymity, in order to encourage openness. Interviews were conducted face-to-face or via the telephone depending upon the preference of the respondent, and lasted between 45 minutes to 1 1/2 hours.

A semi-structured and in-depth interview approach was adopted in line with exploratory and explanatory research questions, such as the ones posed here (Creswell, 1998). The interview included introductory comments, and prompts to ensure respondents were 'warmed up' and did not stray away from the questions asked.

An interview protocol was develop on the basis of the literature review and covered the following areas:

- Respondent's position and experience,
- Best way of dealing with the issue of supply chains decarbonisation,
- Current leading organisations with regards to supply chain decarbonisation,
    - Factors driving their engagement,
    - Factors acting as barriers,
    - Strategies being used.

All interviews were recorded and transcribed in order to aid in the analysis of the data. Once finalised, the transcripts were sent to the respondents to be check for accuracy and once completed, were coded through a process of abstraction and generalisation.

In line with exploratory research methodology, topics or themes that seemed significant during the interviews were noted and aided in the coding process. Any information that was deemed crucial to the answering of the research question was also coded. Through several iterations, the coding was checked and refined to ensure accuracy.

Results:

This section presents and discusses the findings of the interview survey. Their wider implications and how they relate to the literature summarised previously are discussed in the next section.

Organisations Leading Current Efforts

Several characteristics were identified with regards to organisations that were leading current supply chain decarbonisation efforts, including a private stance (i.e. not government or the public sector), high supply chain GHG emissions instances, high public profile, high brand value and size. Specifically, these characteristics were felt to describe a situation where large corporations had taken the lead, with regulatory bodies and government following, as was noted by one of the respondents:

> "But the crucial thing is that governments are following the lead of the corporations."

Organisations noted included large retailers such as Tesco's and Wal-Mart as well as consumer goods firms such as Unilever and PepsiCo. It should be noted however that it was felt that such corporations formed a minority within the business sector and that many such organisations were not engaging and waiting for regulation.

It was also noted that 3rd sector organisations, such as campaign and solution driven non-governmental organisations (NGO's), representative bodies and academia could be considered to be leading decarbonisation efforts also, through a range of activities including scrutiny, issue raising, highlighting best practices and facilitation, including collaboration facilitation.

Decarbonisation Strategies

With regards to how organisations were leading supply chain decarbonisation efforts, respondents outlined a variety of supply chain management strategies.

These strategies can be split into several categories including those aimed at understanding and scoping emissions in the supply chain versus strategies aimed at reductions. Within the second 'reduction' category a further distinction can be made between those that involved collaboration with supply chain partners and those that were 'hands-off' or mandatory; table 2 outlines the strategies identified.

Scoping/Informing Strategies:	**Involves:**
Internal Management Capabilities	Development of internal working practices and skills.
Supplier Engagement	Initial engagement to raise issues.
Supplier Disclosure & Reporting	Asking Suppliers to Disclose and Report emissions.
Supply Chain Mapping	Mapping of emissions instances and points of influence.
Product Level Data	Per product GHG data.
Reduction Strategies:	**Involve:**
Supply Network Optimization and Logistics Choices	Changes to transportation modes, tracking technologies and routes.
Contractualised Reductions	Suppliers contacted to reduce their GHG over life of contract.
Supplier Selection Criteria	Suppliers partly selected on bases of GHG performance.
Supply Chain Collaboration	Collaborating with supply chain to achieve reductions.

Table 2.

Informing & Scoping Strategies

The initial informing and scoping strategies were seen as prerequisites for further action and included the development of internal management capabilities. As the capabilities required for supply chain decarbonisation overlapped between different departments within an organisations it was seen as important to ensure that they were able to work effectively together; departments such as environmental management, SCM and purchasing were all felt to be relevant. Ensuring personnel within these departments had the correct skills and knowledge to implement supply chain decarbonisation initiatives was also highlighted.

Engagement with suppliers in the first instance was noted as an important initial step. Although not critical, these initial approaches to inform suppliers that GHG emissions were to become an important concern were felt to improve the chances of further requests or demands being received positively; it was noted however that some suppliers would not be receptive.

Asking suppliers to disclose and report their emissions was highlighted and following the adage, 'to measure is to manage', such requests allow several other avenues to be followed,

such as supply chain mapping and instigating competition between suppliers based on GHG emissions performance. Supply chain mapping allows priorities and points of influence to be highlighted and involves charting the emissions instances at each stage of the supply chain.

A further level of data gathering involves establishing a per product emissions rating; respondents noted that this was often an end point for some organisations who had led early engagement efforts, as it allowed them to label products and inform consumers. Difficulties do exist however, specifically with regards to the number of products some organisations provide.

Reduction Strategies

The second category of strategies identified can be split further; those being collaboratory versus mandatory or 'hands-off' strategies. Mandatory strategies identified include supply network optimization and logistics choices, such as route, transport mode and the type of technology used to track and monitor products and materials within the supply network.

Respondents also identified the use of GHG supplier selection criteria; although it was noted that currently a maximum of around 6% of supplier selection criteria would focus upon GHG emissions, it was felt that this would be sufficient for suppliers to win or lose business based upon their GHG performance. A subsequent aspect of this involved the writing into contracts of agreed reductions from suppliers over time, with penalties for failures. Both these strategies place an emphasis on suppliers to compete for business based on their GHG performance.

A very different strategy identified sought collaboration with suppliers rather than mandating or demanding that they manage or reduce their emissions. Such efforts were felt to be used where long term trading relationships exist or where the supplier in question is critical to the supply chain. The supply chain leading organisation would use its own resources and expertise to enact reductions within a supplier to the benefit of both, often through 'gain share' initiatives.

Several of the respondents noted that the degree of supply chain power that the supply chain leading organisation held was likely to impact upon its choice of engagement strategy. With high levels of supply chain power, a supply chain leading organisation could choose to either collaborate or encourage suppliers to compete through selection criteria or contractualised reductions. Where low power was found it was expected that a collaboratory approach would have to be adopted to prevent suppliers from ending the trading relationship in protest.

Driving factors

Respondents were asked about the factors responsible for driving organisations to manage and reduce their supply chain emissions; the results are presented in table 3.

The first noted driving factor concerned CR or Public Relations issues, with engagement as a method of ensuring that they were seen to be doing the 'right thing' with regards to their supply chain to minimise potential bad publicity or damage to their reputation.

Driving Factors	Respondents Noting
CR/Public Relations	6
Savings, Efficiency & Cost Cutting	6
Competitive Advantage & Market Positioning/Differentiation	5
Consensus & Demonstration of Best Practice	3
Risk	4
Legislative or Policy	2
Investment & Supply Chain Finance	1
Stakeholder Demand	5

Table 3.

A desire to increase efficiency and reduce costs was also cited. It was noted that within the current economic climate all organisations were attempting to minimise costs, and reductions to GHG emissions offered a potential route. Future increases in the costs of key commodities including medium to long term fossil fuel prices was highlighted as a factor likely to operate through this driver in the future.

Engagement as a way to gain competitive advantage and differentiate the organisation within the market place was also highlighted, especially for organisations, such as retailers, who were consumer facing and competed to some extent on their environmental image and performance.

The emergence of a consensus for action and the publicising of successful initiatives aimed at reducing supply chain emissions were also highlighted as a driver. As organisations engaged, it was felt that competing or comparable organisations would take notice and start to engage also.

Risk was a noted driver in two ways, both in terms of supply risk and brand or image risk. High instances of GHG supply chain emissions, if publicised could pose a risk to the organisations brand or image, with future legislative options forming a second risk function.

Legislation and regulation, although not directed specifically at supply chains was noted as a driving factor. It was felt that legislation such as fuel taxes and schemes such as the EU-ETS and the CRC Energy Efficiency scheme could have indirect effects on purchasing and SCM; for example, an organisation within the CRC Energy Efficiency scheme may change its buying behaviour, purchasing products that were more efficient, emitting fewer emissions, as a result of its participation.

Supply chain investment and finance initiatives, due to the current economic down turn were also noted. Seeking increased efficiency and reduced costs, organisations were acting voluntarily and investing in their supply chains. It was noted that such action in the supply chain was part of a wider cost rationalisation and service level enhancement process that had existed for a number of years in large organisations.

Finally, stakeholder pressure operating through consumers as well as investors or shareholders was noted. Both these groups of stakeholders were felt to be increasingly aware of climate change issues leading them to either demand low carbon products or seek

assurances that organisations that held their capital were managing the risks and taking the appropriate courses of action.

In summary, although all the factors mentioned drove supply chain leading organisation to engage with the management and reduction of emissions, they often operate indirectly as the result of reducing exposure to fossil fuel prices or efforts to increase overall efficiency.

Barriers

Respondents were also asked to comment on the challenges or barriers that they felt existed; these are shown in table 4.

Identified Barriers	**Respondents Noting**
Finance Issues & Cost	4
Data Reliability, Scales & Methodologies	4
Lack of Policy or Support and Uncertainty	4
Lack of Understanding or Belief	4
Cooperation Requirements	2
Low Stakeholder Pressures	2

Table 4.

Financial and cost issues were highlighted as hindering engagement; poor access to finance, investment payback periods, and also the existence of several carbon markets and prices complicating decisions, were all cited in this regard.

Issues were also raised with regards to data reliability and the methodologies used. One respondent noted that for primary data from suppliers, the highest levels of verification would be around 30%, meaning that 70% of data received would be estimated, reducing confidence in the data and hence decisions made using it. Further, the existence of countless methodologies made comparisons across different schemes difficult, further complicating engagement.

With no direct supply chain legislation driving engagement it was noted that organisations had to act voluntarily and that engagement relied upon drivers present within the wider operating environment; this was felt to limit the breadth of current engagement levels.

Linked to low levels of support provision, poor understanding and awareness was highlighted; where organisations did want to act, levels of information and practical support were felt to be too low, constraining wider engagement. Further, it was felt that a “hearts and mind job” was still required to persuade the majority of organisations that this was an issue.

The need for cooperation with supply chain partners was another cited challenge; as supply chains contain many different organisations, no one organisation can tackle supply chain decarbonisation alone.

Several cited barriers seem to contradict noted drivers. For example stakeholder pressure was noted as both a driver when high and a barrier when low; such cross-over demonstrates the differing situations, characteristics and contexts of relevant organisations.

Discussion:

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The development and analysis of this topic has demonstrated that engagement with supply chain decarbonisation is occurring in the absence of legislative drivers due to factors present within society and the market such as cost, competitiveness and CR pressures.

Large, high profile, private sector corporations with high supply chain emissions and brand value were reported to be leading current efforts due to their exposure to specific driving factors such as stakeholder pressure, competitive pressures, their resources and capabilities and supply chain power. Such organisations have overcome barriers identified through the interviews, utilising a range of strategies to manage and reduce their supply chain emissions.

Where mandatory strategies are being used, a concern exists regarding the impact these have on certain businesses within the supply chain, specifically SME suppliers, who have a poor history with regards to engagement with environmental initiatives and are unlikely to possess the required capabilities to deal with them effectively (Vickers *et al.*, 2009:5).

That it has been found that supply chain leading organisations are acting to reduce their supply chain emissions raises the possibility of using supply chain as 'conduits of decarbonisation', where the many organisations and businesses that make up a supply chain can be impacted or targeted as a single entity. Consequently, if climate change mitigation efforts are concentrated on organisations that lead and control supply chains, within the context that they are responsible for their supply chain emissions, then a plethora of organisations will start to manage and reduce their own emissions, reducing the resources needed compared to a situation where each organisation and business within that supply chain were targeted alone.

Perceived lack of action by government both with regards to policy and levels of support and advice, mean this role is currently being played by 3rd sector actors, such as solution driven NGOs. If engagement increases in the future, this source of support may be inadequate. The 3rd sectors broader role is seen as significant, especially with regards to the scrutiny and pressure they provide, and also in the demonstration and publicising of positive results and best practice examples.

Wider engagement with supply chain decarbonisation will require current driving factors to broaden. This is expected to occur to some degree naturally over time as current trends are amplified through factors such as cost pressures and greater stakeholder demand. Although some drivers may be reduced, such as those created due to the current financial situation and associated amalgamated issues, others are expected to increase, with the overall balance of these changes only known over time.

Legislation would result in wider and more even levels of engagement. Such legislation would not necessarily mandate reduction, but would require the disclosing and reporting of

supply chain emissions and operate through drivers such as competitive pressures, CR/PR and stakeholder demand.

The global nature of modern supply chains has an impact on the options available for increasing engagement however. Any measures taken by government would have to be considered in terms of the UKs continued international competitiveness; as a result such measures may be better served at the supranational level.

Further, sectoral differences are expected; for instance brand and image are not significant in all industries negating several driving forces. Further, different sectors and indeed different organisations will have different supply chain contexts with some able to exert more power over their supply chain partners than others. This will affect how supply chain decarbonisation is approached and the impacts it will have on supply chain members.

Contribution

Many of the drivers identified for supply chain decarbonisation are also identified by Walker *et al*. (2008), including cost pressures, stakeholder demand (both internal and external), and competitive advantage. Further, several barriers identified by Walker *et al*. (2008) were also confirmed to exist, such as cost and financial issues, lack of support and information and the need for collaboration. As such, the findings regarding drivers and barriers can be seen to suggest that supply chain decarbonisation shares many characteristics with wider environmental or sustainable SCM.

The study also tentatively confirms CR in the supply chain includes GHG emissions, as noted by Kovács (2008), demonstrated by the identification of CR/PR drivers and a concern by leading organisations to be seen to be doing the 'right thing'.

The results of this research do not seem to contradict previous research on CR in the supply chain or with regards to SCM literature; rather they add a new facet of knowledge to what was an under researched area. Indeed, the results indicate that existing literature on the wider topic of sustainable SCM as synergise with supply chain decarbonisation. For example, walker et al. (2008 notes the use of vendor assessments, which hold similarities with supplier disclosure and reporting requirements. Further synergies are found in the CDP's (2011) report, which highlighted the use of selection criteria and collaborative working to reduce emissions.

This research has also provided a base from which to launch further enquiries due to the under developed or all together absent literature concerning supply chain decarbonisation efforts within UK. It has demonstrated that engagement is occurring in the absence of policy, driven by factors within the wider operating environment.

Limitations and Assumptions

Although much light has been shed by these finding on what was a previously under researched topic, this study has several limitations which potentially impact its relevance and validity.

Although over 70 potential respondents were identified, only eleven submitted to be interviewed. While this was felt to be a poor response rate, respondent recruitment and data collection was stopped once data saturation was felt to have been reached in line with Strauss and Corbin's (1998) views. Secondly, although all effort was taken to minimise the possibility of respondent or researcher bias through the interviews the possibility of it occurring is always present.

Further, the type of respondent interviewed could have impacted the results, as attempts to recruit respondents from organisations potentially engaged in supply chain decarbonisation failed. Although this is a deficiency, several of the respondents had worked with organisations identified as leading current efforts as consultants. Further, all respondents passed the selection criteria established.

The aims of this study were to explore what was an underdeveloped area of research, and with limiting factors considered, the author feels that the research has still been able to contribute by providing an initial assessment of the current state of supply chain decarbonisation within the UK.

Conclusions:

By successfully identifying those organisations seen to be leading current supply chain decarbonisation efforts in the UK, this research has contributed in several ways.

Firstly, it has demonstrated that many of the barriers and driving factors identified for supply chain decarbonisation are similar to those operating within environmental or sustainable SCM. Such synergies allow this body of literature to be used with more confidence for the study of supply chain decarbonisation.

Secondly, it also demonstrated that CR is a key driving force, confirming that CR in the supply chain also encompasses GHG emissions. Finally, this research has been able to establish a knowledge base from which further research on supply chain decarbonisation efforts can be launched.

There are many avenues for future research in this area. Key barriers, such as the need for collaboration, should be explored and solutions found; a smoothing of supply chain wide initiatives would greatly enhance current efforts.

Worries with regards to the impact of decarbonisation strategies on SME suppliers also deserve greater consideration, especially given the unique nature and importance of SME suppliers to both supply chains and the wider economy. Such research could investigate what support and capabilities SMEs may require in order to participate in initiatives, as well as methods for minimising negative impacts.

Those organisations felt to be leading supply chain decarbonisations, the strategies they use and the factors driving and hindering such engagement have been identified. A narrow set of

characteristics were felt to define those organisations seen as leading current engagement efforts. Several different strategies were noted, each suited to differing supply chain situations. Finally, those factors seen to be driving or hindering engagement were explored and although some cross-over between these factors was noted, this was due to the differing situations and characteristics of relevant organisations.

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