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An empirical study of green supply chain management practices amongst UK manufacturers

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Abstract

Purpose – The purpose of this paper is to examine the extent and nature of greening the supply chain (SC) in the UK manufacturing sector; and the factors that influence the breadth and depth of this activity.

Design/methodology/approach – Based on the findings from a sample of manufacturing organisations drawn from the membership of The Chartered Institute for Purchasing and Supply. Data are collected using a questionnaire, piloted and pre-tested before distribution with responses from 60 manufacturing companies.

Findings – On average manufacturers perceive the greatest pressure to improve environmental performance through legislation and internal drivers (IDs). The least influential pressures are related to societal drivers and SC pressures from individual customers. Green supply chain management (GSCM) practices amongst this "average" group of UK manufacturing organisations are focusing on internal, higher risk, descriptive activities, rather than proactive, external engagement processes. Environmental attitude (EA) is a key predictor of GSCM activity and those organisations that have a progressive attitude are also operationally very active. EA shows some relationship to legislative drivers but other factors are also influential. Operational activity may also be moderated by organisational contingencies such as risk, size, and nationality.

Research limitations/implications – The main limitation to this paper is the relatively small manufacturing sample.

Practical implications – This paper presents a series of constructs that identify GSCM operational activities companies to benchmark themselves against. It suggests which factors are driving these operational changes and how industry contingencies may be influential.

Originality/value – This paper explores what is driving environmental behaviour amongst an "average" sample of manufacturers, what specific management practices take place and the relationships between them.

Keywords Manufacturing industries, Environmental management, Supply chain management, Sustainable development, United Kingdom

Paper type Research paper

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Introduction

Environmental sustainability is one of the defining issues of this, and future decades. The following quote from Gordon Brown clearly demonstrates this point in his speech delivered to the United Nations Ambassadors on April 20, 2006 (Brown, 2006):

> Environmental sustainability is not an option – it is a necessity. For economies to flourish, for global poverty to be banished, for the well-being of the world's people to be enhanced – not just in this generation but in succeeding generations – we have a compelling and ever more urgent duty of stewardship to take care of the natural environment and resources on which our economic activity and social fabric depends.

Corporate environmental management has typically focused on managing internal environmental practices. Attention is increasingly shifting towards the management of an organisation's impacts outside the boundaries of the firm, into the management of upstream and downstream activities. Globalisation fuelled by technological advances is reshaping the competitive landscape. Individual businesses no longer compete as solely autonomous entities, but rather as supply chains (SCs), therefore, the ultimate success of a single business will depend on management's ability to integrate the organisation's intricate network of business relationships (Lambert *et al.*, 1998; Oliver and Webber, 1982).

This paper examines how organisations are responding to calls for improvements in environmental sustainability through the management of their SCs, focusing on a sample of UK manufacturers. The paper considers two key research questions:

RQ1. The extent and nature of greening of the SC in the manufacturing sector.

RQ2. Factors that influence the breadth and depth of greening of the manufacturing SC.

Supply chain management (SCM) displays typical characteristics of a subject at early stages of evolution including definitional diversity and lack of conceptual clarity (Gibson *et al.*, 2005). A number of researchers have attempted to produce a unified definition by systematically examining collection of proposed definitions (Bechtel and Jayaram, 1997; Mentzer *et al.*, 2001). Despite these efforts there is no clear consensus as to the definition of SCM. For the purpose of this study we adopted the following definition presented by Lambert *et al.* (1998, p. 1) defining SCM as "the integration of key business processes from end-user through original suppliers that provide products, services, and information that add value for customers and other stakeholders." This definition has similarities with the definition developed by Gibson *et al.* (2005, p. 22) through a survey of SC practitioners. They defined SCM as "encompassing the planning and management of all activities involved in sourcing and procurement, conversion, demand creation and fulfilment, and all logistic management activities" and they went on to suggest that SCM also includes:

> [...] coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, SCM integrates supply and demand management within and across companies.

The similarities between the two definitions and the method used for their development are a measure of robustness and offers strong justification for adoption of the definition.

The challenge is to operationalise the definition of SCM. To this end Lambert *et al.* (1998) identified three closely interrelated elements to support the definition they proposed and adapted for the purposes of this paper. The three elements are:

(1) *SC business processes*. These are activities that produce a specific output of value to stakeholders.

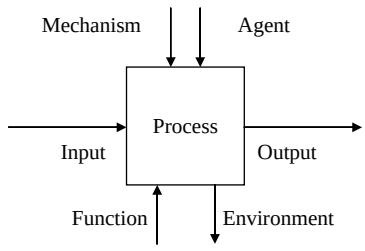
(2) *SCM components*. Managerial variables by which business processes are integrated and managed across the SC.

(3) *SC structure*. This is the network of members of SC.

The SCM concept is underpinned by system theory (Chandra and Tumanyan, 2005), with our chosen definition implicitly predicted on the system theory. The general system components include: input, output, process, mechanism, agent, function, and environment (Figure 1). Systems theory is also a key aspect of the philosophical and conceptual roots of environmental management (after O'Riordan, 1981). Much of the sustainability agenda is driven by the recognition that impacts in one part of a system with have repercussions elsewhere.

Table I examines each of these components in a "green" SC. The elements of the system and the three elements of SCM were combined and used to guide identification of range of managerial practices that might occur in a SC. In addition, the combination of system theory and elements of SCM highlighted the potential influence of internal and external factors upon SCM.

SCM is a relatively new concept and green supply chain management (GSCM) is a newer concept. Little structured literature review exists on GSCM, only recently have review-orientated papers emerged (Carter and Rogers, 2007; Seuring and Muller, 2008; Srivastava, 2007). Seuring and Muller (2008) review the green supply chain literature and note that only eight partial literature review papers have been published over the last 13-year period. However, their review specifically excludes papers primarily focused on reverse logistics and purchasing. The review presented by Srivastava (2007) focuses primarily on reverse logistics, whilst Carter and Rogers (2007) focus on the link to performance. A special edition of the *Journal of Operations Management* considers the role of GSCM within operations management (Linton *et al.*, 2007). As Waller (1999) notes environmental issues potentially affect every aspect of the SC. Yet much of the embryonic GSCM research has tended to focus on upstream activities, conversion processes, or the downstream activities rather than adopting a holistic system approach propagated by SCM. This runs counter to the integrative green SCM research



Source: Chandra and Tunmanyan (2005)

Figure 1.
System components of the supply chain

Components	Properties	Green supply chain in manufacturing
Input	Physical item, information, or service that is necessary to start a process	Reduced volumes and wastage of raw materials. Supplier management
Output	Physical item, information or service that results from, processing an input. The output is related to the total accomplishment of the function	Management of reverse logistics and green outbound logistics
Process	Flows, transformations, conversions, or order of steps, which transforms and input into an output	Internal environmental operations management practices of eco-efficiency
Environment	Physical or sociological factors within which the system elements operate. It relates to resource requirements, both physical and human	Drivers that influence the adoption of green practices from within the organisation and the external environment
Agent	Computational, or human resources for carrying the process. Can be a physical object or a logical object such as a role	Green champions that promote initiatives, influential CEOs, specific job roles to promote environmental behaviour including management of suppliers
Mechanism	Physical or local facilitators in the generation of an output. Planning or workflow activities that are carried out to facilitate the process and organize in a systematic manner	Could include the mapping of waste by-products, supplier assessment questionnaires, accreditation to an environmental management standard
Function	Mission, aim, purpose or primary concern of the system	Overall function is to provide the desired output which has a lower environmental burden/footprint

Source: Chandra and Tumanyan (2005)

Table I.
Systems components of the SC and examples in a "green" SC

philosophy argued by many (Beamon, 1999; van Hoek, 1999; Wu and Dunn, 1995), and systems thinking (Chandra and Tumanyan, 2005; O'Riordan, 1981).

Table II identifies the key empirical GSCM studies that influenced the research reported in this paper. It indicates a clear bias towards an upstream or downstream research focus concentrating on green purchasing or green logistics. However, a trend is emerging of more recent studies that adopt this wider, holistic perspective (Chien and Shih, 2007; Rao, 2002; Zhu and Sarkis, 2004; Zhu *et al.*, 2005, 2007) focusing mostly on ISO14001 certified and/or manufacturing firms in China, Taiwan, and South-East Asia. Many studies (Carter and Carter, 1998; Carter and Ellram, 1998; Zsidisin and Siferd, 2001) suggest that green supply chain research should move away from anecdotal studies and adopt theoretically grounded and empirical research. This trend is also emerging in the more recent studies detailed in Table II amongst the Asian-based studies.

Apart from focusing on a narrower aspect of GSCM (such as purchasing or logistics), the USA has provided the sampling frame for many of the previous empirical studies. Furthermore, few of these studies are cross-sectoral with most focusing on one or two sectors (such as the Zhu *et al.*, Murphy *et al.*, and Carter *et al.* studies) with manufacturing-orientated firms (i.e. the most frequent sectoral choice to study). All these point to a need for studies that are predicated on clear definition and SCM model, adopt an integrated approach to greening of SCM, consider a wide mix of industry

Autry *et al.* (2001)	Retail, electronic goods, USA, reverse logistics)
Baylis *et al.* (1998a, b, c)	Manufacturing and processing, SMEs, South Wales, and green purchasing
Bowen *et al.* (2001a)	Mixed sectors including manufacturing, UK, and SCM capabilities
Carter and Carter (1998)	Consumer products and manufacturing, USA, and green purchasing
Carter and Jenning (2002)	Consumer products and manufacturing, USA, and socially responsibly purchasing
Carter *et al.* (1998)	Consumer products and manufacturing, US Germany, and green purchasing
Carter *et al.* (2000)	Consumer products and manufacturing, USA, environmental purchasing, and firm performance
Chien and Shih (2007)	Electronics manufacturers, Taiwanese, GSCM practices, and performance
Florida (1996)	Manufacturing, US Japanese, and environmentally conscious manufacturing
Hill (1997)	Manufacturing, UK, Yorkshire and Humberside, environmental pressure from SC
Klassen and Whybark (1999)	Furniture manufacturing, USA, and environmental technology investment
Livingstone and Sparks (1994)	Export industries, Scotland, Germany, and environmental legislation/packaging
Min and Galle (1997)	Mixed sectors including manufacturing, USA, and green purchasing/recycled packaging
Murphy and Poist (2000)	Manufacturing and merchandising, Canada, UK, USA, EU, and green logistics
Murphy *et al.* (1994, 1995, 1996)	Manufacturing and merchandising, USA, and green logistics
Prendergast and Pitt (1996)	Mixed including manufacturing, UK, and marketing and environment
Rao (2002)	Mixed sectors including manufacturing, SE Asia, and green supply
Roberts (1996)	Individual consumers, USA, and environmental behaviour
Strong (1995)	Retail, UK, and green purchasing
Theyel (2001)	Chemical, USA, and customer-supplier relationships
Young and Kiekliewiez-Young (2001)	Mixed including manufacturing, USA, EU, and sustainability practices
Ytterhus *et al.* (1996)	Services, Norway, and customer-supplier relationships
Zhu and Sarkis (2004)	Manufacturing, Chinese, GSCM, and performance
Zhu *et al.* (2007)	Manufacturing, Chinese, and GSCM implementation
Zhu *et al.* (2005)	Manufacturing, Chinese, drivers, and GSCM practices and performance
Zsidisin and Hendrick (1998)	Mixed including manufacturing, USA, UK, and environmental purchasing

Table II.
Selected empirical, questionnaire-based research studies on aspects of green supply

types (including "average" rather than best practice examples) and provide a picture from other geographic locations.

The combination of elements of SCM proposed by Lambert *et al.* (1998), the Chandra and Tumanyan (2005) systems-based model of SCM shown in Figure 1, a review of the literature on GSCM (selected examples are in Table II) and examination of a range of published case examples of best-practice GSCM activities led us to develop the model shown in Figure 2. The model simply suggests that depth and breadth of these

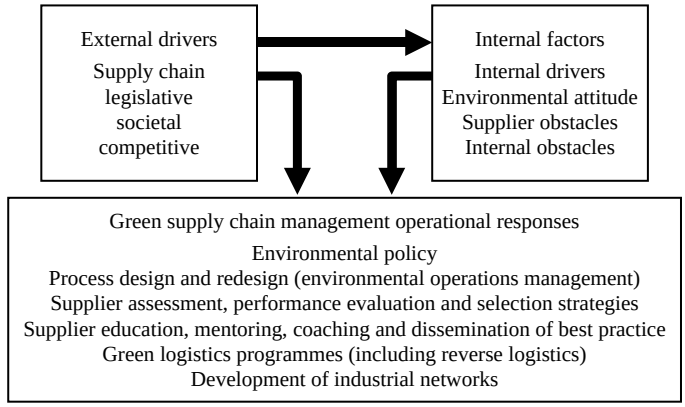


Figure 2.
GSCM pressure/response model

practices (SCM components) adopted are a function of external (open system view of organisation) and internal environment (management component). In another word the totality of inputs to the system (including agent, mechanism, and functions) results in outputs (practices). These outputs are measured by considering GSCM practices from within the whole system (upstream, downstream, and transformation).

The model proposes that the extent and type of these GSCM outputs are influenced by internal and external factors. Little previous empirical research categorises the drivers of upstream or downstream green supply chain operational activity (Carter and Ellram, 1998; Elwood and Case, 2000; Green *et al.*, 1996; Lanoie and Tanguay, 2000). The wider literature on drivers of environmental management in organisations can also be considered (Canning and Hanmer-Lloyd, 2001; Henriques and Sadorsky, 1999; Hall, 2000; IM, 1998). Whilst Bowen *et al.* (2001a) provide a useful summary on the benefits of GSCM practices. The perceived benefits of environmental management are also identified by authors such as Holt (1998) and Rao (2002).

All these previous studies use subtly different constructs to measure or identify the external and internal drivers/benefits of environmental management or some aspects of GSCM. However, all of these constructs can be grouped into four external categories: legislative, competitive, societal, and SC. The literature also suggests that different types of drivers have different relative levels of importance, for instance legislation is most frequently cited as the most influential external driver (ED) (IM, 1998; Murphy *et al.*, 1995; Rao, 2002).

Carter and Ellram (1998) also stress the need to examine internal factors (IF) as well as external environmental factors driving green logistics. Inside an organisation, pressure from employees, leadership from environmentally committed management and perception of possible environmental risk might all contribute to changes in environmental practices in organisations. IDs may be influenced by:

- top/middle management support (Carter *et al.*, 1998; Ghobadian *et al.*, 2001);
- general employee's concern (Baylis *et al.*, 1998a);
- influential individuals such as the chief executive officer (CEO) or "green champions" (Drumwright, 1994; Ogbonna and Harris, 2001; Preston, 2001); and
- an environmentally committed organisational culture (Gavaghan *et al.*, 1998; Green *et al.*, 1998; Lippmann, 1999).

It is sometimes difficult to establish which of this range of "actors" within an organisation influences GSCM initiatives and their relative success. Therefore, a mechanism to benchmark the environmental culture of an organisation might compliment the measure of "IDs". Rather than using a simplistic measure, such as the presence/absence of an environmental policy, a multi-construct measure of "EA" might be developed based on the principles established by Murphy *et al.* (1996) which clusters respondants into categories.

The research reported in this paper attempts to address the shortcomings of previous GSCM research by:

- developing a GSCM model predicted on clear conceptual and theoretical lines;
- empirically testing the efficacy of this model; and
- focusing on the totality of SC system rather than specific elements of it.

This study examined 149 organisations from a cross-sectoral group of UK-based organisations. Within this paper we examine the operational management practices adopted in a selected sample of UK manufacturers and the internal and external pressures leading to changes in operational practices. Fundamentally, this paper examines what management practices are occurring amongst the UK manufacturing group and what drives these activities.

Methodology

Questionnaire design and administration

The sample for this study was drawn randomly from among members of The Chartered Institute of Purchasing and Supply (CIPS). The sampling frame used has advantages and disadvantages. The key advantages are:

- Potential respondents' interest in the subject matter making it less likely for them to ask a junior member of staff with limited knowledge to complete the questionnaire, i.e. a common problem in survey research.
- Knowledge reducing the likelihood of common method variance.

Therefore, it is not surprising to find that a number of previous studies also drew their samples from among the members of a SC-related professional association. For example, Murphy and Poist (2000) and Murphy *et al.* (1994, 1995, 1996) in examining aspects of green logistics practices, drew their sample from among the members of the US-based Council of Logistics, in merchandising and manufacturing firms. Carter *et al.* (1998, 2000), Carter and Jennings (2002), and Carter and Carter (1998) examined aspects of green purchasing using a sample of members of the US-based National Association of Purchasing Managers (NAPM), within the consumer products and manufacturing industries. Min and Galle (1997) also draw upon research from NAPM members, but select those from industrial sectors that are heavy producers of scrap metal and waste. The potential disadvantage is that the members chose to join CIPS and this may infer views that are not widely shared in the population. However, a balanced sample drawn from among interested managers is preferable to a completely random sampling for the reasons stated. Moreover, regardless of these arguments, convenience sampling is considered as an acceptable approach. Convenience sampling is also used in the suite of manufacturing studies in China and Taiwan (Chien and Shih, 2007; Zhu and Sarkis, 2004;

Zhu *et al.*, 2005, 2007) all of whom used access to a group of managers to complete their survey instruments.

Data were collected using a survey instrument designed to identify the GSCM practices in organisations. These organisations deploy upstream, within their transformation process, and downstream to enhance their environmental performance and the internal and external factors that might influence depth and breadth of practices deployed (Figure 2). Several steps were taken to ensure validity. First, wherever possible, research questions from prior studies were used to improve the validity of the research instrument (in particular Carter and Carter, 1998; Carter and Ellram, 1998; Elwood and Case, 2000; Green *et al.*, 1996; Hall, 2000; IM, 1998; Lanoie and Tanguay, 2000; Min and Galle, 1997; Murphy *et al.*, 1995, 1996). Second, the questionnaire was sent to the CIPS environmental panel for perusal and comments. The questionnaire was modified to reflect the feedback received. Third, the modified questionnaire was piloted using a sample of CIPS companies to assess the structure, length, and appropriateness of the questions used (with ten pilot responses received from a range of sectors).

The questionnaire was sent to the CEO or the senior manager of 1,457 organisations drawn randomly from the CIPS database. The sample selected included a broad range of sectors and company sizes. Within this sample there were 461 manufacturing organisations.

There were a total of 60 usable responses from the manufacturing sample comprising a response rate of 13 percent. The remaining 89 respondents in the larger sample were from a range of sectors including utilities and the public sector. *t*-tests of the variables measuring the external pressures, IF and operational practices found no significant differences between the manufacturing group and the non-manufacturing group ($p < 0.01$).

Tabachnick and Fidell (2007, p. 123) discuss the ratio of cases to independent variables and the issues associated with smaller sample sizes. This is a limitation within the study but the total number of respondents was similar to a range of previous studies that used statistical analysis including Klassen and Whybark (1999), Rao (2002), and Zsidisin and Hendrick (1998). Wisner and Tan (2000) surveyed members of the NAPM. In a similar manner to our study and concluded that their response rate of 6.7 percent ($n = 101$) was satisfactory given the complexity and length of the questionnaire. Forza (2002) examines the relationship between sample size, significance level and statistical power stating that relationships with a medium association at a statistical power of 0.8 require a sample of size of 44 ($\alpha < 0.05$) to 62 ($\alpha < 0.01$) and a very strong association requires a smaller sample size than this. Therefore, whilst the manufacturing sample is relative small, it remains a valid size for this exploratory study and has much in common with related studies in the published literature.

Carter *et al.* (1998) note that non-response bias is a potential limitation in survey research, even if there are relatively high response rates. The Armstrong and Overton (1977) protocols were used to test for non-response bias by comparing the responses of early and late respondents. The anonymous nature of the questionnaire and the UK Data Protection Act in place at the CIPS prevented a "slimmed" down version of the questionnaire being mailed to non-respondents (Carter and Jenning, 2002). Therefore, in a similar manner to the study by Autry *et al.* (2001) the final quartile of responses is compared using *t*-tests with the first three-quarters of the sample of respondents order to assess non-response bias. *t*-tests were conducted on 15 scale variables created to capture

the data provided in more than 100 items in the questionnaire. None of these scale variables showed significant differences between the two groups at $p < 0.01$.

Data transformation and analysis

Two forms of data transformation were undertaken to reduce the 17 constructs measuring the EDs to more manageable scale variables. First, a principal components analysis (PCA) was performed for each group of constructs measuring each type of driver (for example the four constructs measuring legislation) to establish how many dimensions these constructs measure. If only one component is extracted this suggests that there is only one dimension captured by each group of constructs and that it is viable to combine them (Blaikie, 2003; Tabachnick and Fidell, 2007). Second, to compensate for any missing values average scores can be calculated for each dimension.

These first two stages result in two types of variables for the competitive, societal, SC and legislative drivers: PCA and average scores. To confirm the accuracy of the average scores for each group of the EDs they can be correlated with the PCA scale developed previously. If the PCA scale and the average scores are highly correlated either scale can be used in later analysis (Blaikie, 2003). The average scores are preferable to the PCA values as the score for each case can be compared with the original Likert scale used in the questionnaire. A Spearman ρ correlation between the PCA and average scales was statistically significant at $p < 0.01$, with ρ values of 0.996 + and therefore average scores were used.

As shown in Figure 2, the IF in this model comprised of measures of IDs, obstacles to green supply and EA. The constructs measuring the IDs were transformed in the same manner as the EDs and comparison of PCA and average scores found no significant differences. Thus, average scores were used.

The possible obstacles to green supply developed using seven constructs, in a similar manner to the development of the internal and external driver scales. A PCA on these seven constructs suggests that there are two dimensions to the data (internally focused obstacles and supplier-orientated obstacles). Each construct loads upon one of these two dimensions and is used to develop average scores for each case.

A score for the "EA" of each case, as a surrogate measure of environmental culture, was developed using scored responses to four indicator questions adapted from Murphy *et al.* (1996) and converted to a percentage scale. These attitudinal scores could then be used to produce a typology that classified each organisation as either a moderate, conservative, or progressive organisation.

Respondents indicated whether each of 32 management practices occurred in their organisations. These responses were scored as "yes", "no", or "intend to in next 12 months" as Bowen *et al.* (2001b) note that including "intend to" as an possible choice decreases the influence of respondents giving socially desirable responses. These data were transformed into three measures of activity:

(1) a percentage score for the total amount of green supply chain activity;

(2) a percentage score for each of the six categories of activity; and

(3) classification of the organisation into an operational typology: proactive, high average, low average, and laggards (Bowen *et al.*, 2001a; Henriques and Sadorsky, 1999; and Murphy *et al.*, 1996).

Research findings

This paper seeks to address two key questions. In the first section of these findings we explore the breadth and depth of the components of the GSCM pressure/response model shown in Figure 2. Second, we provide some initial analysis of the potential relationships between these factors in the model.

Nature and extent of GCSM

External and internal drivers. Table III indicates the rank order for the mean score for various individual constructs used to examine the internal and external drivers of GSCM. Legislative pressures are the highest ranked, followed by IF, competitive, SC, and finally societal.

5 – extremely important, 1 – not important	Mean (man)	SD	Rank
Legislation			
Influence of UK's current environmental legislation	4.20	0.97	1
EU's current environmental legislation	3.93	1.16	2
Forthcoming environmental legislation	3.47	1.09	8
Possible environmental legislation in the future	3.12	1.18	14
Average rank			6.25
Internal drivers			
In order to reduce the health and safety risk associated with our goods, services or operational practices	3.83	1.09	4
In order to reduce the public's perceived risk associated with our company	3.41	1.16	9
Culture of the organisation promotes environmental responsibility	3.32	1.14	10
The CEO (or equivalent) commitment to environmental improvement	3.23	1.29	11
Pressure from employees	2.48	1.02	22
Average rank			11.2
Competitive			
To perform better than our competitors or equivalent institutions	3.65	1.35	5
Provides new market opportunities	3.17	1.38	12
To match the activities of competitors	3.10	1.37	15
Provides operational cost savings	2.95	1.37	17
Average rank			12.25
Supply chain			
Requirements of organisations that you supply to	3.53	1.36	7
Encouragement from organisations that you supply goods and services to	3.13	1.20	13
Pressure from individual consumers/service users	2.71	1.27	19
Influence of your own suppliers that provide goods and services to your organisation	2.60	1.06	21
Average rank			15
Societal			
Maintaining or presenting an environmentally or socially responsible image	3.57	1.13	6
Public opinion/societal expectation	2.77	1.21	18
Pressure from green action groups (such as Greenpeace or Friends of the Earth)	2.18	1.20	23
Pressure from the insurance industry	3.05	1.18	16
Pressure from shareholders or investors (when applicable)	2.68	1.19	20
Average rank			16.6

Table III.
Relative importance of individual items capturing the internal and external drivers of GSCM

The findings suggest that legislative drivers exert the most perceived pressure on manufacturing organisations, which mirrors the findings of similar studies (Baylis *et al.*, 1998a, b; Davies, 1996; Ghobadian *et al.*, 2001; Henriques and Sadorsky, 1996; Lamming and Hampson, 1996; Min and Galle, 1997; Preuss, 2001; Welford and Gouldson, 1993; Zhu and Geng, 2001). Potential risk associated with health and safety is also highly ranked (fourth), which may reflect the extensive legislation associated with these aspects in manufacturers.

Societal pressures are ranked as the least influential factors, apart from the construct of presenting an environmental responsible image (which has some links with the construct measuring risk). But pressures from most societal stakeholders are ranked quite low. The influence of the SC amongst manufacturers is relatively highly ranked (seventh) which perhaps reflects the higher risk aspects of manufacturing and targeting environmental improvements through SC pressure from other companies in the SC. Whereas, influence from individual consumers is amongst the lowest ranked factor (19th) and perhaps reflects the distance manufacturers experience from the end-users as their products are most often passed along the value chain to distributors and retailers.

Table III also indicates that within each category of pressures driving activity there are varying levels of influence. For instance, the role of a "green" CEO (11th) or organisation culture (10th) is much more highly ranked than that of employees as a whole (22nd). This enforces the comments of authors such as Drumwright (1994) and Ogbonna and Harris (2001) that organisational champions are important in driving change and that their managerial position in the organisation is also crucial.

Operational practices. Table IV identifies the percentage of respondents that undertook each of the specific GSCM operational practices. These practices are grouped into sub-categories of activity that recognises that not all organisations undertake the same GSCM practices. Within each category there are also graded activities where some actions such as recycling toner cartridges (ranked first overall) would be more likely than the action of accrediting to an environmental management standard, which requires a greater resource commitment (19th).

Within the categories of activity the internal operational practices were the most common overall for both sets reflecting the concentration on internal practices first, where there are the win-win performance aspects of the triple bottom line approach so prevalent in industry. This suggests that even the most inactive of organisations is addressing these internal operations management actions first. It is questionable however whether such actions are related to GSCM or really just operational efficiencies that make economic sense. Within manufacturing organisations the second most popular group of activities is associated with logistics, which is not unrealistic given the nature of their operations, for instance "Using recyclable pallet systems" is relatively highly ranked (7th).

Supplier assessment and evaluation practices are the third most popular group of activities with informal assessment of suppliers (ranked 9th) much more likely than a formal system (ranked 18th). It should be noted that this was not a sample of leading edge companies (Rao, 2002) but a mixed, more "average" sample and thus perhaps represents a more accurate picture of actual practice than the best of the best scenarios often used in such studies. Informal assessment requires less formalised monitoring and is less resource intensive.

The policy dimension is captured by the fourth aspect, which shows again a clear bias towards the less formal embedding of environmental/social policies into activity

Operational practices – % that undertook that activity	%	Rank
Internal environmental management practices		
We recycle toner cartridges in the offices	88.1	1
We actively manage the disposal of packaging wastes	85.0	2
We actively manage the disposal of all solid wastes in the organisation	84.5	3
Paper recycling in offices is standard practice	82.8	4
We are required by law to control the disposal of some of our wastes (e.g. medical waste)	75.9	5
Energy efficiency measures are adopted for lighting and heating	74.6	6
We have accredited to an environmental management standard such as ISO14001 or EMAS	42.6	16
Average rank		5.3
Logistics		
We ask suppliers to use recyclable pallet system when they deliver supplies to us	62.3	
We have energy efficiency systems in operation in our warehouses	48.0	10
We consider environmental matters generally in our transport decisions	43.6	14
We expect our suppliers to take back their packaging or pallet systems they use to supply goods to us	43.1	15
We plan the routes of our vehicles in order to reduce environmental impacts	31.7	20
We have invested in vehicles that are designed to have reduced environmental impacts	26.2	22
Average rank		14.7
Supplier assessment and evaluation		
We assess the environmental acceptability and performance of our suppliers informally in our assessment criteria	53.7	9
We assess the environmental acceptability and performance of our suppliers in a formal process	37.9	18
We set environmental criteria that suppliers must meet	23.7	25
Average rank		17.3
Green procurement and logistics policy		
We consider ethical and human rights/welfare issues informally in our purchasing decisions	60.7	8
We have a green purchasing or logistics guidelines that recommend the environment is considered	46.4	11
We consider ethical and human rights/welfare issues formally in our purchasing decisions	25.0	23
We have a formal policy on green procurement/purchasing	23.7	24
We are bound by external purchasing directives (e.g. the EC procurement directive or franchise agreements)	22.8	26
We have a formal policy on green logistics/transport	12.5	30
Average rank		20.3
Supplier education, coaching and mentoring		
We have received environmental guidance from our own customers	44.8	12
We communicate to our suppliers our environmental and/or ethical criteria for goods and services we buy	44.1	13
We educate our suppliers through written material	31.0	21
We have been the recipient of educational workshops and visits by our customers to educate us on what environmental improvements can be made	14.3	28

(*continued*)

Table IV.
Operational practices amongst manufacturers in rank order

Operational practices – % that undertook that activity	%	Rank
We (or someone on our behalf) goes into our suppliers' organisations to help them improve environmental performance)	13.6	29
We run workshops/seminars to educate our suppliers	11.9	31
Average rank		22.3
Industrial networks		
The organisation is part of an industry specific partnership that shares good practice/lobbying	39.3	17
The organisation is part of a SC initiative that is involved in active dialogue with suppliers and/or stakeholders	33.3	19
The organisation is part of a general "green" network that shares environmental or ethical good practice or information	20.0	27
The organisation is part of an group that sources products and suppliers (such as the ethical trading initiative)	10.9	32
Average rank		23.75

Table IV.

and a clear difference between the use of a formal purchasing policy (25 percent) and a formal logistics policy (12.5 percent) suggesting that green logistics is less commonly considered as a policy instrument.

The two categories that illustrate the least activity are those associated with outreach activities such as supplier education and mentoring and use of industrial/best practice networks. This again suggests that the "average" group of UK manufacturing organisations is focusing on internal, higher risk, descriptive activities, rather than proactive, external engagement processes. This perhaps again reflects their position in the SC and a compliance orientated approach.

These GSCM activities are also used to cluster respondents into an operational typology, similar to that of Bowen *et al.* (2001a, b) and Henriques and Sadorsky (1999), as illustrated in Table V.

The findings indicate a mixed GSCM response and suggest some contingencies may be influencing operational responses. Over 70 percent of the sample undertakes a high or low average amount of GSCM, with few proactives (6.7 percent) and 20 percent of the sample very inactive. Table VI further explores these groupings and suggests that the laggards are overwhelmingly small and medium-sized firms with lower levels of perceived environmental risk.

Previously, we discussed the idea that IDs/organisational culture might be captured by a variable measuring attitude, with respondents clustered into moderates, progressives, or conservatives. We can compare the attitude variable against that of operational typology as shown in Table VII. This clearly indicates that those with a conservative internal culture are operational "laggards" and those with a progressive

Operational typology	Total score for GSCM activity	Number of respondents	Percentage of sample
Proactive	21-32	4	6.7
High average	14-20	25	41.7
Low average	7-13	19	31.7
Laggards	0-6	12	20

Table V.
Operational typology of manufacturing respondents

attitude are correspondingly more active. This suggests that internal environmental culture (shaped by internal driving forces) may be very influential in promoting GSCM activity.

Table VIII shows the results of some additional question posed only to the manufacturing group in the final section of the cross-sectoral questionnaire. This section reflects the additional demands that are placed on manufacturing organisations

Table VI. Influence of size and risk on GSCM operational practices

	Size groupings			Possible risk group	
	Small/medium	Large	Very large	Lower	Higher
Laggards	11	1	0	10	2
Low average	10	5	4	14	5
High average	6	11	8	14	9
Proactive	1	1	2	1	3
	28	18	14	39	19

Table VII. The relationship between EA and GSCM operational activity

	Laggards	Low average	High average	Proactive	Total
Conservative	8	1	0	0	9
Moderate	3	12	9	0	24
Progressive	1	6	16	4	27
Total	12	19	25	4	60

Table VIII. Additional actions undertaken by manufacturing organisations

Actions undertaken by manufacturing organisations	Num ($n = 60$)
During new product development we involve potential suppliers in the design stage of the process	48
During new product development we involve customers in the design stage of the process	46
We are required to address the recycling of our packaging under the packaging directive	44
Components or materials used in making our products have been substituted for more environmentally friendly alternatives	40
We source at least some of our components so that they come from environmentally or ethically sound sources	37
We use backloads on transports to return materials to us	37
We have had to make changes in our products due to environmental legislation	35
Our original packaging or pallet systems are returned to us from our customers	31
We will not take back goods (unless faulty)	27
At least one life cycle assessment has been undertaken to reduce the environmental burden of our products	27
We are affected by EC directives on end of life products (such as new electronics directive)	26
We undertake some form of environment life cycle assessment during the design stage of new products	25
We recover products and/or components from customers for overhaul and remanufacture	24
We will not take back our packaging/pallets	20
Our products have been designed for dis-assembly	15

in relation to product design. The table suggests a bias towards processes related to design specifications and legislative requirements (such as the packaging directive) but less emphasis on proactive tools such as life cycle assessment or product takeback and recovery. This perhaps then confirms the value of legislation around products that take back such as the waste electrical and electronic equipment directive.

Factors influencing breadth and depth of GSCM

The previous sections have described the findings associated with each of the individual constructs within the model shown in Figure 2. This next section explores the potential relationships between these and various moderating factors to examine the efficacy of the model. The lack of previous empirical work from a total SC perspective with a bias towards homogeneous groupings has represented samples with limited variety in their organisational contingencies and little empirical investigation of the moderating influence of these.

Does nationality affect GSCM practices? Kolk *et al.* (2001) note differences in environmental reporting by the world's top 250 companies, primarily based in the West, based on nationality and sector. Much of the empirical GSCM research is dominated by studies from the West especially the USA (such as Murphy and Carter). The non-Western studies from authors such as Rao, Zhu, Sarkis, and Geng all suggest that there are key differences between organisational responses in different sectors around the world. However, as Zhu *et al.* (2005, 2007) and Chien and Shih (2007) note much of the world's manufacturing base is predicted to move towards the Asian regions. If IDs and environmental culture are very influential, these are surely shaped by cultural norms in the host country or perhaps the parent firm. Therefore, considering nationality as a surrogate measure of this may be a fruitful avenue to explore.

Within the sample 48 firms identified themselves as UK controlled, i.e. based in and controlled by, a UK headquarters or overseas headquarters with devolved policy and strategy making at a local level, whereas 12 firms were controlled by various overseas head offices from seven countries. This data set is not sufficient to statistically test the non-UK group but differences are apparent when the data is explored and may suggest that some aspects of national identity influence the operational practices in a different host country. Therefore, future work should examine the moderating influence of nationality of parent firm and the moderating influence of the in-country location.

Does size affect GSCM? We have already seen in the previous section that most operational laggards are smaller sized organisations. This supports authors such as Baylis *et al.* (1998a, b, c) and Hillary (2000) who suggest size may be a limiting factor to green operational activity and may also be considered a moderating factor with smaller organisations less active.

There were 29 (48.3 percent) small or medium manufacturers (<250 employees), 18 large firms (250-999 employees) and 13 very large firms (1,000 +). The mean rank scores in Table IX suggest that the very large manufacturers (1,000 + employees) experience the greatest amount of external pressure from societal and legislative drivers and as the size of the company increases so do the levels of external pressure from these drivers. EA mimics this pattern with largest manufacturers having the most progressive EA/culture. The total amounts of GSCM operational activity and in each of the sub groupings (except supplier education) are greatest in the largest manufacturers (1,000 +) and least in the small and medium enterprises (SMEs) (<250).

Elements of pressure response model	χ^2	df	Asymp. sig.		Mean rank scores SME	Large	Very large
GSCM operational activity (%)	16.73	2	0.000	*	21.2	37.0	42.3
Supplier education coaching and mentoring (%)	9.36	2	0.009	*	23.3	38.2	33.0
Green procurement and logistics policy (%)	11.21	2	0.004	*	23.1	35.7	39.9
Internal environmental operations management (%)	13.55	2	0.001	*	23.3	32.2	44.2
Green logistics (%)	10.14	2	0.006	*	24.6	30.0	43.0
Industrial networks (%)	6.28	2	0.043	**	24.6	29.6	38.0
Average score for legislation drivers	14.34	2	0.001	*	22.9	32.6	44.5
Average score for societal drivers	10.46	2	0.005	*	23.3	34.8	40.6
Average score IDs	9.97	2	0.007	*	22.8	36.8	37.1
Environmental attitude (%)	15.37	2	0.000	*	21.8	36.0	42.3

Table IX.
Influence of size
(Kruskal Wallis test)

Notes: $^{*}p < 0.01$; $^{**}p < 0.05$

In all cases SMEs undertake the least amount of GSCM operational activity. This mirrors the findings of much of the general environmental management literature that suggests SMEs experience less pressure and adopt less green operational practices.

The role of environmental risk and impact. Of the 26 GSCM empirical studies detailed in Table II, 21 of these specifically investigate one or more manufacturing groups. Often the justification for this sample is that these organisations represent higher levels of risk and impact. However, this thesis may not be accurate for all manufacturing firms and therefore considering risk and environmental impact as moderating factors may be a fruitful aspect to explore. In addition these factors may provide a more useful classification for predicting environmental activity than sector or size as these measures cross "rigid" size and sector classifications. Command and control environmental legislation targets specific high risk/impact processes and products, rather than company size or broad sector.

The level of possible environmental risk and environmental impact of the organisation are "self-perception" measures by each organisation. It could be argued that it is the perception of external and internal pressures by an organisation that governs organisational behaviour. The dirtier, higher risk industries such as the chemical sector would be expected through legislative pressure to be more active in environmental management activities. However, green pressure group lobbying/or criticism on a specific issue aimed at a retail organisation (such as Nike) or light manufacturing company (perhaps associated with a more local concern such as pollution of a local river), might lead to a perception by that organisation of a high level of environmental risk and subsequently influence behaviour – even though their processes are relatively less "damaging" than for instance a chemical company. Therefore, this measure allows potential environmental risk and impact to be included as a relative perception measure by each organisation.

Each respondent was required to self designate the potential level of environmental risk and impact of their organisations. A Mann Whitney U test shows some interesting trends but these are not conclusive due to the lack of comparability between the self-diagnostic classifications. Three elements of the model demonstrate statistically significant differences between negligible/low and moderate/high environmental risk at $p < 0.05$: supplier obstacles (SOs), total green supply operational activity and EA.

Higher risk manufacturers were operationally more active and had a more positive internal EA. SOs were more pronounced in the lower risk group ($p = 0.035$), perhaps due to the lack of a risk imperative in this group leading to resistance and inactivity on the part of suppliers.

Manufacturers with the higher levels of potential environmental impact demonstrate statistically significant differences from the lower impact group in only two elements of the model: IDs ($p = 0.029$) and SC pressure ($p = 0.041$). In both instances higher risk manufacturers experience greater levels of internal and SC pressure. None of the other drivers or the operational responses appears to be affected by the level of potential environmental impact.

Future studies should incorporate this dimension of "risk" but mechanisms need to be developed to provide comparable designations rather than those self selected, or a way to triangulate these self designated measures. This is less problematic in countries where compulsory environmental reporting of some form is available (such as the TRI index in the USA) which can be used for such data triangulation.

What controls GSCM activity?

Attitude, external and internal drivers. Figure 2 shows that GSCM practices are a function of IF and EDs. The aggregate score of total GSCM activity (ΣGSCM) captures how much activity is happening in each respondent organisation. EDs consist of legislative (*L*), societal (*S*), SC and competitive factors (*C*). We also incorporate measures of internal obstacles (IO) and SO. The model shows in Figure 2 can be summarized as:

$$\Sigma\text{GSCM} = \text{IF} + \text{ED} \text{ where } \text{IF} = (\text{EA}, \text{ID}, \text{SO}, \text{IO}) \text{ and } \text{ED} = (L, SC, C, S).$$

The previous section has also suggested that there may be some moderating influence by organisational contingencies such as size, nationality or levels of environmental risk and impact.

First, we must establish whether the EA variable and IDs are actually measuring the same construct. Earlier we argued that the EA variable is used as a surrogate measure of the environmental "attitude" of the organisation, in the event that the IDs scale does not fully capture the complexity of intra-organisational factors. If the IDs and EA scales measure the same concept they would be highly correlated. Whilst there is a significant correlation a bivariate regression between them produces a solution of $r = 0.634$, explaining 40 percent of the variance between the two scales. This suggests that EA and the IDs, though highly correlated; measure slightly different aspects of the internal forces driving green supply management practices and both should be incorporated.

Having established that the measure of IDs and EA measure different aspects we now question the relationship between EDs and the construct of EA. The four components of the EDs scale are used (legislative, SC, societal, and competitive) in a stepwise multiple regression to produce an initial solution where the legislative scales predicts 36 percent of the variance in the EA scale. The addition of the SC factors adds an additional 5 percent, explaining 41 percent of the total variance in the dataset ($r = 0.639$). Entering all four driver scales in forced multiple regression produces a R^2 value of 0.421. Therefore, EA within the manufacturing group can be predicted mainly by the legislative drivers, followed by SC drivers. However, this only explains 42 percent of the variance in the EA suggesting that whilst legislation has a major role in shaping EAs there are some other factors at play, suggesting a role for IDs. Therefore, predicting GSCM activity requires the incorporation of IDs, EA, and the EDs.

Resultant GSCM operational practices. There is a highly significant relationship between EA and resultant GSCM activity ($R = 0.665$). This solution is improved slightly by the addition of the IDs to the regression equation ($R = 0.696$), with an R^2 value of 0.484. However, just EA alone is not enough to explain the variance in GSCM activity in the sample, though it is clearly important. If all of the EDs and IF are added to a stepwise multiple regression to predict total operational activity, EA remains the only significant predictor ($R = 0.690$) explaining 47.6 percent of variance. However, if all of the variables are forced into the equation the R^2 value improves explaining 49.7 percent of the variance in GSCM activity. If EA is removed from the predictive equation the R value drops dramatically to 0.532, with only the legislative factors identified as significant in the stepwise equation ($R^2 = 0.283$).

The exploration of this model suggests that EA is a key variable to explore in more detail. There is a clear correlation between some of the variables and GSCM activity, especially the EA and legislative drivers. However, the variability in the regression equations still suggests that other factors are influential. Exploration of contingencies of size, nationality and level of environmental risk all suggest that the model may be moderating by these factors and this should be explored further. This finding suggests that organisations may respond differently to GSCM initiatives, especially those initiated externally, based on their specific organisational contingencies and that these maybe a better predictor of GSCM response, and a better targeting tool for initiatives. The internal construct that measures EA is a key aspect to explore in future work and suggests that organisational culture may be a key control over levels of GSCM activity. This is a significant finding as this suggests that it may be the internal, culture driven factors that promote the most GSCM activity. However, the influence of legislation does suggest that for some organisations this maybe a controlling factor, perhaps related to those larger and more visible high risk organisations.

Conclusions

This paper sought to examine two key aspects: the extent and nature of GSCM in a selection of manufacturing organisations and the factors that may influence this activity. The exploration of this data set suggests some initial conclusions:

- That on average manufacturers perceived the greatest pressure to improve environmental performance through legislation and IDs.
- That the least influential pressures are related to societal drivers and SC pressures from individual customers.
- GSCM practices amongst this "average" group of UK manufacturing organisations are focusing on internal, descriptive activities (such as internal environmental operations management control practices) rather than proactive, external engagement processes (such as supplier outreach).
- That EA is a key predictor of GSCM activity and those organisations that have a progressive attitude are also operationally very active.
- That EA shows some relationship to legislative drivers but other factors are also influential.
- Operational activity may also be moderated by organisational contingencies such as risk, size and nationality.

The most common green supply chain practices focus on internal cost saving activities. There is less effort in the case of in-bound and out-bound logistics. This suggest that there a great deal more that manufacturing organisations can do in greening their SCs. One key aspect might be greater awareness and dissemination of best practice that quantifies costs and benefits. The role of the "EA" variable suggests that engagement of managers is crucial to drive forward an internal environmental culture and this might be facilitated by building awareness, best practice examples and the establishment of green supply purchasing bench marking clubs.

This study uses a relatively small manufacturing sample and should be replicated in a larger group. Future studies should also seek to validate the influence of potential environmental risk and impact by using universal measures that allow direct comparability. The statistical tests used in this paper are affected to some extent by the small sample size, especially multiple regression and further testing is necessary.

The dominant ED is legislation and potential health and safety risks are also influential moderating factors suggesting a reactive rather than pro-active stance by some organisations. Lack of engagement with the SC through outreach activity is an interesting finding and also suggests a compliance led approach. There is a clear focus on internal operational improvements – that relate mostly to operational efficiencies rather than proactive engagement with the SC. This suggests that few organisations reach out to support their suppliers in a proactive, collaborative manner, and tend towards supplier auditing.

Using the typologies of attitude and activity is also an interesting avenue to pursue and future work should examine the characteristics of these groups in more detail to see if there are key contingencies that are more prevalent in the progressive and proactive groups. The characteristics of this data sample (the "average" nature rather than best practice) should be considered in future work. Another contingency that may be influential is a measure of "distance" to the end consumer. For some organisations individual consumers were obviously not important suggesting that position within the SC could be important. It is clear that the contingencies we explored here (size, risk, and nationality) are leading to variability in GSCM activity and other factors may also be important. Thus, policy and legislative responses that consider GSCM pressures/drivers and responses amongst manufacturers to be homogeneous may be under estimating the influence of such contingencies.

The ultimate aim of GSCM policy and practice is to improve the environmental performance of the SC and industry as a whole. Until we fully understand the forces that control the level and breadth of this activity it will be difficult to instigate policy instruments that encourage and/or force improvements in such activity. Whilst learning from best practice firms is a valuable way to learning the types of activities that can take place, if we are to effect industry wide improvements we need to engage the "average" manufacturer who is more akin to the respondents detailed in this study.

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