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**Developing Green Supply Chain Management Taxonomy Based Decision Support Systems**

V. Kumar<sup>1</sup>, D. Holt<sup>2</sup>, A. Ghobadian<sup>3</sup>, and J. A. Garza-Reyes<sup>4</sup>

<sup>1</sup> Faculty of Business and Law, University of West of England, UK,

<sup>2</sup> Essex Business School, University of Essex, UK,

<sup>3</sup> Henley Business School, University of Reading, UK,

<sup>4</sup> Centre for Supply Chain Improvement, University of Derby, UK,

**Abstract**

The aim of this paper is to develop a comprehensive taxonomy of green supply chain management (GSCM) practices and develop a structural equation modelling-driven decision support system following GSCM taxonomy for managers to provide better understanding of the complex relationship between the external and internal factors and GSCM operational practices. Typology and/or taxonomy play a key role in the development of social science theories. The current taxonomies focus on a single or limited component of the supply chain. Furthermore, they have not been tested using different sample compositions and contexts, yet replication is a prerequisite for developing robust concepts and theories. In this paper, we empirically replicate one such taxonomy extending the original study by (a) developing broad (containing the key components of supply chain) taxonomy; (b) broadening the sample by including a wider range of sectors and organisational size; and (c) broadening the geographic scope of the previous studies. Moreover, we include both objective measures and subjective attitudinal measurements. We use a robust two-stage cluster analysis to develop our GSCM taxonomy. The main finding validates the taxonomy previously proposed and identifies size, attitude and level of environmental risk and impact as key mediators between internal drivers, external drivers and GSCM operational practices.

**Keywords:** green supply chain management; taxonomy; decision support; environmental attitude; structural equation modelling

**Introduction**

Over the last two decades, environmental issues have mainstreamed into the public sphere (Barkemeyer et al. 2009; Holt and Barkemeyer 2012) and policy domains (e.g. De Gobbi 2011). Businesses are increasingly under pressure to address their potential negative impacts on the environment, not only within their organisations but out into their supply chains. Supply chain management (SCM) as defined by Stock and Boyer (2009) is the management of a network of relationships within a firm and between interdependent organisations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing and related systems that facilitate the forward and

reverse flow of materials, services, finances and information from the original producer to final customer, with the benefits of adding value, maximising profitability through efficiencies and achieving customer satisfaction. The practice of green supply chain management (GSCM) goes a step further and combines environmental management practices with the traditional SCM concepts. GSCM also considers upstream, downstream and internal operational practices (e.g. Murphy, Poist, and Braunschwig 1994; Carter and Ellram 1998; Bowen et al. 2001b; Zhu, Sarkis, and Lai 2008b) and encompasses policies and activities adopted by organisations to reduce their negative impacts on the natural environment (Mollenkopf et al. 2010; Sarkis, Zhu, and Kee-hung 2011). GSCM is an integral component of an organisation's overall strategy of moving towards an environmentally sustainable business model (Zhu, Sarkis, and Geng 2005). Not surprisingly, GSCM is attracting increasing attention from operations and SCM researchers (Srivastava 2007; Verghese and Lewis 2007; Mishra, Kumar, and Chan 2012; Bhattacharya et al. 2013; Wang and Chan 2013; Govindan et al. 2014; Tseng et al. 2014). A common critique of the majority of GSCM-related publications is their anecdotal and descriptive nature (e.g. Srivastava 2007; Carter and Rogers 2008; Seuring and Muller 2008; Sarkis, Zhu, and Kee-hung 2011; Kim and Rhee 2012). Some prior studies offer concepts, models or propagate theories, but these are rarely tested empirically. The empirical research has tended to be based on small samples or a limited number of cases. Where concepts are tested empirically, in common with a young field of study, there is little empirical replication or validation of previous research to facilitate cumulative theory development (Mollenkopf et al. 2010).

In the social sciences, classification using taxonomies or typologies can play an important role in the development of theory. Although often used as interchangeable descriptors, distinct differences exist between a typology and a taxonomy. A typology is generally a multidimensional conceptual classification, whereas taxonomy is a classification of empirical entities (after Bailey 1994). By their nature, taxonomies are more robust because they rely on empiricism and objective characteristics of firms to develop archetypal clusters of organisations. Taxonomies offer a convenient tool for measurement and facilitate (amongst others): description; reduction of complexity; identification of similarities; identification of differences; identification of relationships between types and dimensions; and comparisons between types (Bailey 1994). Clustering firms into archetypal groups is considered critical to theory development (Bacharach 1989), and to the identification of strategic configurations (Ketchen and Shook 1996; Tsiriktsis 2004). The aim of this paper is to replicate and test the veracity of one of the early, influential GSCM studies, namely the work by Murphy, Poist, and Braunschwig (1996) which examined the logistics end of the supply chain and proposed a taxonomy (empirically driven) of manufacturing and merchandising organisations' green logistics behaviour. We extend the boundaries of Murphy, Poist, and Braunschwig's (1996) research by (a) developing a comprehensive (including all the key components of supply chain) taxonomy of GSCM practices; and (b) enhancing its generalisability by drawing on a broader sample of organisations both in sectoral and size terms. Moreover, we explore the impact of external and internal drivers on GSCM operational practices through a structural equation modelling (SEM) approach. We also contribute to practice by equipping GSCM practitioners with necessary decision-making information that is vital for designing GSCM policies.

The objectives of this paper therefore are:

1. To replicate the Murphy, Poist, and Braunschwig's (1996) constructs and examine whether their taxonomy extends to a differently configured sample, and operating in a different geographical area;
2. To extend the Murphy, Poist, and Braunschwig's taxonomy beyond logistic practices;
3. To develop a GSCM taxonomy for the totality of a supply chain based on external variables, internal variables and operational practices of firms;

4. To test the relationship between internal drivers, external drivers and GSCM operational practices to assist decision-makers; and
5. To develop an SEM-driven decision support (DS) system following the GSCM taxonomy for managers.

We begin by examining the literature in greater depth including a reflection on previous GSCM typologies and taxonomies. Then we present the methodology and data analysis utilised in this study before developing a GSCM taxonomy through two-stage cluster analysis. We then propose the use of SEM as a DS tool to assist managers to better understand the interrelationship between the variables and to shape their decision-making. The paper concludes by discussing the implications of this study and providing directions for future research.

## **Background to research**

### ***Previous empirical research***

The previous empirical GSCM research is dominated by two sets of studies augmented by a number of other significant one-off studies. The Carter and colleagues set uses one main data-set to examine environmental purchasing issues (Carter and Carter 1998; Carter, Ellram, and Ready 1998; Carter and Jennings 2002, 2004), while the Murphy and colleagues set focuses on green logistics issues (Murphy, Poist, and Braunschweig 1994, 1995, 1996; Murphy and Poist 2000, 2003). Other notable studies include research examining green logistics (Autry, Daugherty, and Richey 2001; Ciliberti, Pontrandolfo, and Scozzi 2008; Mishra, Kumar, and Chan 2012); supplier performance and selection (Zhu and Geng 2001; Awasthi, Chauhan, and Goyal 2010); or drivers and benefits of environmental management (Yang et al. 2010; Blome, Hollos, and Paulraj 2013). A common feature of all these studies is an exclusive rather than inclusive focus, i.e. they all examine an individual component of SCM rather than adopting an inclusive approach by including all the components in a single study.

For GSCM to develop beyond an embryonic discipline – rooted either in anecdotal studies or empirical studies exclusively focusing on an individual component of the supply chain – it is necessary to conduct more systematic empirical research and more importantly to conduct systematic empirical research that spans all components of the supply chain (Beamon 1999; van Hoek 1999; Zhu, Sarkis, and Lai 2008b). A number of scholars have taken up the challenge of conducting inclusive integrated empirical GSCM research. Most notable is a series of work by Zhu, Sarkis, and Lai (2008a, 2008b) based on the manufacturing and processing industries in China. The data for these studies were collected from managers participating in management workshops at the workshops (Zhu and Sarkis 2004, 2006, 2007) or through postal surveys (Zhu, Sarkis, and Geng 2005; Zhu, Sarkis, and Lai 2007, 2008a, 2008b; Zhu et al. 2008). These studies, while making a significant contribution, suffer from three limitations. First, they are reliant on purposive sampling techniques drawing on experience of firms adopting best practice providing a one-dimensional perspective. Second, the response of participants in a managerial workshop is likely to be influenced by the cues received during the workshop. Third, the sample for these studies was drawn from a narrow geographical area. Using random sampling, seeking responses from respondents in their natural habitat without cues other than those present in the workplace and broader geographic area will provide greater reliability.

### ***Lack of replication research***

Mature fields of science rely on serial testing of new theories to establish their veracity, a process Kuhn (1962) termed 'normal science'. This point is well recognised and accepted within the extant literature. For example, Amir and Sharon (1991) and Flynn et al. (1990) argue that verification and elaboration of theory through replication is an

essential component of theory building. Business and management disciplines, in general, suffer from lack of research that replicates and builds on the previous research leading to incremental verification and development of robust theories (Hubbard 1996; Hubbard, Vetter, and Little 1998; Eden 2002; Tsikriktsis 2004). The position is arguably more acute in the operations and SCM disciplines (Frohlich and Dixon 2006). Systematic replication of previous research studies is indispensable in the scientific process because it offers protection against uncritical assimilation of erroneous empirical results (Hubbard 1996), and it is a critical ingredient of meta-analysis, which is an important step in the systematic evaluation of the body of empirical evidence (Eden 2002). Replication with extension is even more crucial as it determines the limits and scope of original findings to see if they can be generalised to other contexts (Hubbard, Vetter, and Little 1998). Yet the use of replication research, and especially that with extension, remains limited (Tsikriktsis 2004), especially in the SCM and GSCM fields.

Keller et al. (2002) encourage researchers to utilise existing scales, especially those well represented in the literature, and when necessary combine and refine these measures in an effort to achieve more accurate and valuable research conclusions. Based on this advice, our study builds on the constructs and the resultant taxonomy developed by Murphy, Poist, and Braunschwig (1996). We use the same constructs (as the replication component of our study) and we extend the study by considering the entire components of the supply chain rather than focusing narrowly on the reverse logistic as well broadening the sectoral scope, size and geographic scope of the sample.

### ***Use of taxonomies and typologies***

Typologies (conceptually based) and taxonomies (empirically based) not only offer a robust route to developing general theories but they also allow researchers to generalise, stratify and construct mid-range theories and they offer managers a robust mechanism for benchmarking their organisations against other appropriate organisations. Whilst both typology and taxonomy are classification systems, we suggest that taxonomy is more robust than typology because taxonomies are empirically based.

Scholars have put forward a number of classifications (typically typologies) categorising firms' strategic behaviour towards the environment (e.g. Handfield et al. 1997; Aragon-Correa 1998; Henriques and Sadorsky 1999). Apart from the conceptual classification of GSCM behaviours offered by Handfield et al. (1997), others such as Aragon-Correa (1998) and Henriques and Sadorsky (1999) focused on a firm-level behaviour, rather than specifically focusing on GSCM behaviour. Higher level classifications implicitly assume that such behaviour applies to all functions and in practice such assumptions may not hold. We suggest that it is better to develop such classifications bottom-up (functional level up) rather than top-down as is the case with most of the current conceptually based typologies.

Taxonomies are arguably more robust than typologies because of their reliance on empiricism. Again, firm-level taxonomies dominate the environmental literature (e.g. Aragon-Correa 1998; Henriques and Sadorsky 1999). However, a number of scholars have developed organisational level environmental taxonomies (Murphy, Poist, and Braunschwig 1996; Bowen et al. 2001a; Ciliberti, Pontrandolfo, and Scozzi 2008; Gattiker and Carter 2010). These, even more than typologies, need to be developed bottom-up. Highly aggregated taxonomies while valuable are likely to fail to capture what in reality happens at functional levels of the organisation. This is particularly serious in the case of functions covered by SCM as in many organisations these functions have the greatest impact on the physical environment. Previous taxonomies in the GSCM field, while making a significant contribution, focus on narrow components of GSCM. The Murphy, Poist, and Braunschwig (1996) study identified three types of logistics behaviours – progressives, moderates and conservatives – using a score developed from a series of survey questions

on the environmental stance of the organisations. The focus of this study was reverse logistics. Ciliberti, Pontrandolfo, and Scozzi (2008) also considered logistics from a socially responsible environmental perspective. Bowen et al. (2001a) predominately examined the purchasing function of organisations and to a lesser extent aspects of logistics, and identified four archetypal practices. In developing their taxonomy, Bowen et al. (2001a) used K-means cluster analysis (similar to the firm-level taxonomies developed by Aragon-Correa 1998 and Henriques and Sadosky 1999), whilst Murphy, Poist, and Braunschwig (1996) used self-selected cut-off points.

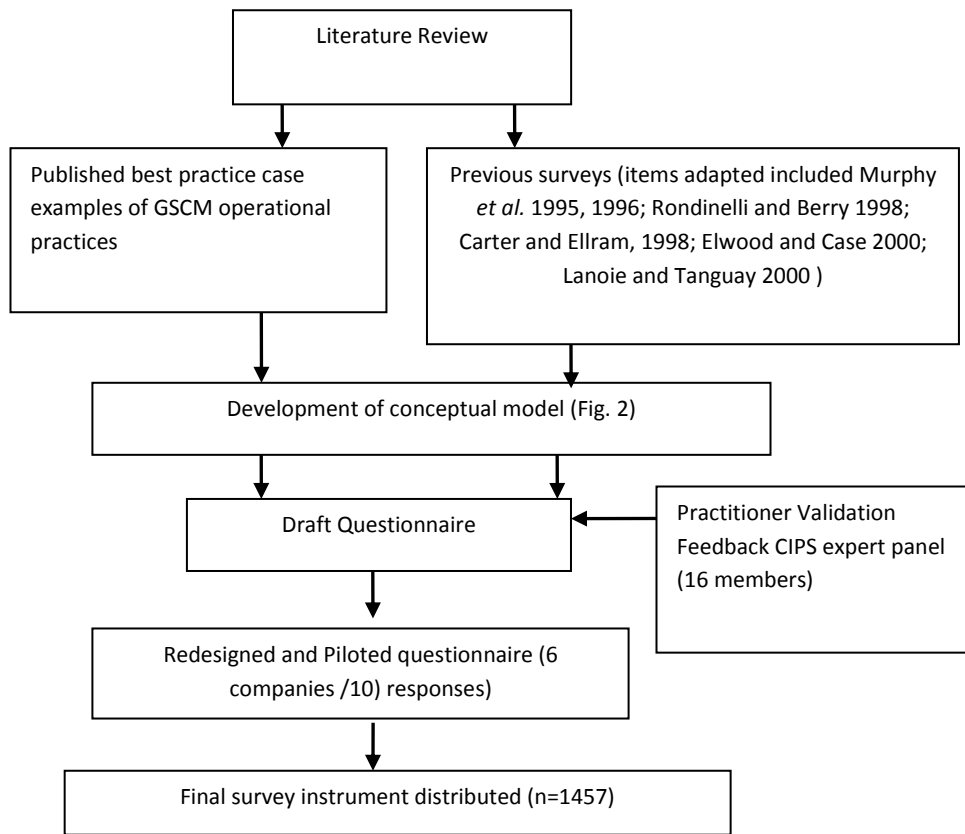
There is a paucity of taxonomies examining and describing the behaviour of constituent components of GSCM. The situation is more acute when it comes to inclusive taxonomies covering all components of GSCM. Arguably the most influential exclusive taxonomy addressing a constituent component of GSCM is the Murphy cluster of studies because it is widely cited in literature reviews (e.g. Carter and Dresner 2001; Carter and Rogers 2008; Sarkis, Zhu, and Kee-Hung 2011). Despite being widely cited and leaving aside its narrow focus, Murphy's proposed taxonomy has not been tested extensively. Greater confidence in the taxonomy proposed by Murphy calls for replication across different types of samples and different geographic locations. The study presented in this paper attempts to address some of the weaknesses of the previous studies. Apart from the points made previously, we draw our sample from across the firms with varied GSCM practices rather than the 'best practice firms', hence, increasing the generalisability of our findings. Furthermore, generalisability is enhanced by drawing our sample from among a wide range of industries. We have also partially replicated the original constructs developed by Murphy, Poist, and Braunschwig (1996), hence, assessing the robustness of Murphy, Poist and Braunschwig's taxonomy. However, in line with sentiments expressed by scholars such as Beamon (1999) and van Hoek (1999), we have adopted an inclusive approach developing a GSCM taxonomy for the totality of supply chain. To this end, we have developed and tested additional scale variables. We have adopted a more robust statistical methodology than Murphy, Poist, and Braunschwig (1996) by drawing on the statistical approach outlined by Aragon-Correa (1998), Henriques and Sadosky (1999) and Bowen et al. (2001a).

We also believe that the understanding of all GSCM constructs is vital for decision-makers looking after supply chain design and operations. In model-driven DS systems the general types of quantitative models used involve various decision analysis tools including analytical hierarchy process, decision matrix and decision tree, multi-attribute and multicriteria models, forecasting models, Monte Carlo and discrete event simulation models, etc. (Bonczek, Holsapple, and Whinston 1981; Power and Sharda 2007). In this paper, we propose the use of SEM as a support tool for decisionmakers. We have therefore tested the relationship between internal drivers, external drivers, and GSCM operational practices using the SEM technique. We believe that the understanding of these relationships will be valuable for decision-makers.

## **Methodology**

### ***Research design***

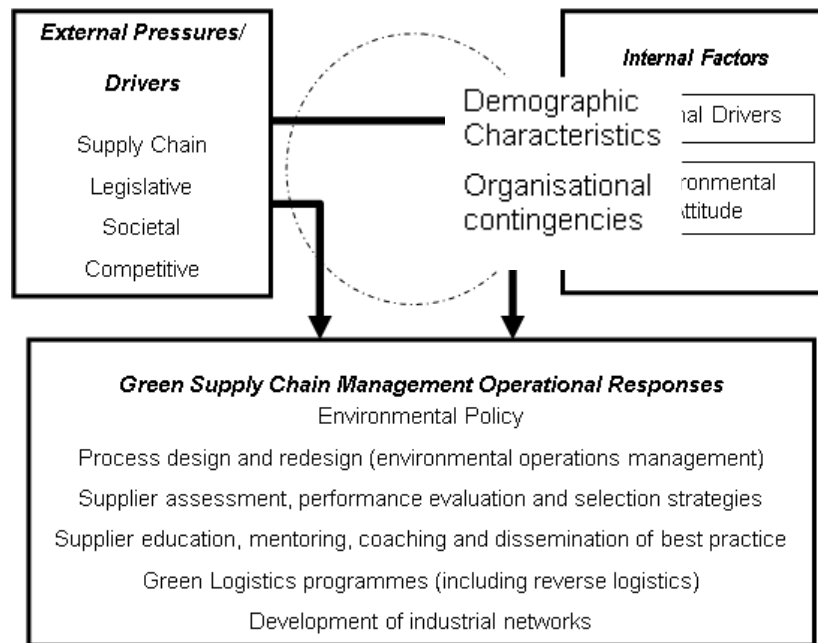
Data were collected through a postal survey using the offices of the Chartered Institute of Purchasing and Supply (CIPS). The survey was addressed to middle and senior managers working in organisations of different size and operating in different sectors who were members of CIPS. The process used for developing the scales is shown in Figure 1. To assure reliability and validity, where possible we have used scales suggested in previous studies published in peer reviewed journals. In addition, new scales were developed following analysis of 'best practice' case examples for 38 organisations. This process not only led to the development of the initial survey but it also led to the development of the conceptual model presented in Figure 2



**Figure 1. Overview of research design process**

This model was inspired from our previous work on GSCM practices (reported in Holt and Ghobadian 2009). The validity of the questionnaire was further assured by obtaining feedback from a panel of six experts proposed by CIPS for their knowledge and expertise in this field. Following the validation phase, the questionnaire was piloted to further assure validity. SEM and path analysis have emerged as statistical tools to explore the interrelationship between the variables (Kline 1998; McQuitty 2004; Shah and Goldstein 2006; Kumar et al. 2008; Kumar, Batista, and Maull 2011). Hence, SEM was used as a main methodological framework to illustrate the inter-relationships between internal drivers, external drivers and GSCM operational practices. We propose that SEM can also act as a DS tool for GSCM decision- and policy-makers by providing a better understanding of the relationships between these factors.

Of the total number of questionnaires distributed (1457), there were 149 usable responses, a 10.2% response rate (of which 147 were used in the cluster analysis). This response rate is similar to those from other GSCM postal surveys (Zsidisin and Hendrick 1998; Rao 2002) and represents a reasonably large number of responses exceeding the total number from other similar studies (e.g. Carter, Ellram, and Ready 1998; Autry, Daugherty, and Richey 2001). Nonresponse bias was tested using late vs. early respondents (Lambert and Harrington 1990). T-tests on 103 variables comparing the responses between the early (first three quartiles) and late respondents (final quartile) was found statistically insignificant at  $p < 0.01$  level (after Autry, Daugherty, and Richey 2001).



**Figure 2. Conceptual GSCM pressure-response model including moderating factors**

Table 1 details the size and sectoral classifications of the 147 cases used in the analysis presented in this paper. The sample is dominated by larger organisations, a feature in common with previous studies that used databases from professional organisations (Murphy, Poist, and Braunschweig 1994, 1995, 1996; Carter and Carter 1998; Carter, Ellram, and Ready 1998; Carter, Kale, and Grimm 2000; Murphy and Poist 2000, 2003; Carter and Jennings 2002, 2004).

**Table 1. Description of Respondents in Study**

Sector	n	%	Size	n	%
Public	42	28.6	Small (<50)	8	5.4
Service	15	10.2			
service and manuf.	16	10.9	Medium (50-249)	37	25.2
retail/wholesale	7	4.8			
Utilities	10	6.8	Large (250-999)	29	19.7
Construction	10	6.8			
Manufacturing	44	29.9	very large (1000+)	73	49.7
transport and logistics	3	2.0			

**Scale development**

GSCM practices were determined by identifying which of the 32 operational activities (Appendix 1) were undertaken (yes/no) by the organisations, to provide a total percentage score and a percentage score for each of the six sub-groupings of operational activity. These activities were based on the best practice case examples and ranged from actions most organisations would undertake, to those only the most proactive would embrace. There were few missing values and the scales developed for the internal and external drivers were calculated using average scores for each group of constructs to compensate for any missing values (Jonsson 2000). In each case, each construct was also factorised using principal components analysis, with varimax rotation (after Ketchen and Shook 1996) to check the number of dimensions and correlated with the average score scale to confirm the suitability of either scale.

## Findings and discussions

### Cluster analysis

The taxonomy presented in this paper was developed using two-stage cluster analysis of the scale variables measuring GSCM operational practices, and internal and external drivers (Table 2). Two-stage cluster analysis is an exploratory tool designed to independently determine clusters of organisations that share highly similar configurations, and is capable of using continuous scale data (e.g. average scores for internal and external drivers and percentage scores for GSCM activity) and categorical data (e.g. characteristics of respondents). This analysis independently produced three clusters, which is within the range specified by Lehmann (1979) that the numbers of clusters should be between  $n/30$  and  $n/60$  (in this case 2.45–4.9), where  $n$  represents the total number of cases ( $n = 147$ ).

**Table 2. Cluster means (std dev) and classification**

Mean (std dev.)				
Centroids	1 n=39	2 n=36	3 n=72	Combined n=147
green logistics %	24.4 (27.0) low	26.4 (24.0) low	<b>49.1</b> (27.2) moderate	37.0 (28.8)
supplier education coaching & mentoring %	<b>12.0</b> (19.8) very low	<b>17.6</b> (16.4) very low	<b>40.3</b> (25.8) low	27.2 (25.7)
internal environmental operations management %	<b>52.4</b> (25.7) moderate	71.0 (23.8) high	76.2 (23.4) high	68.6 (25.9)
green procurement & logistics policy %	<b>20.5</b> (18.1) very low	30.6 (20.9) low	<b>50.2</b> (24.1) moderate	37.5 (25.3)
industrial networks %	21.2 (27.2) low	24.3 (29) low	38.5 (29.7) low	30.4 (29.8)
supplier assessment %	<b>17.1</b> (18.5) small	37.0 (28.5) moderate	<b>51.6</b> (28.4) moderate	38.9 (29.7)
supply chain drivers	<b>2.4</b> (0.9) moderate	2.9 (0.9) moderate	3.3 (0.9) moderate	3.0 (1.0)
legislation drivers	<b>3.0</b> (1.0) moderate	3.4 (0.8) moderate	<b>4.3</b> (0.6) great	3.7 (1.0)
societal drivers	<b>2.6</b> (0.9) moderate	<b>2.5</b> (0.7) moderate	<b>3.5</b> (0.8) great	3.0 (0.9)
internal drivers	2.9 (1.0) moderate	<b>2.9</b> (0.7) moderate	<b>3.8</b> (0.7) great	3.3 (0.9)
Competitive drivers	2.7 (1.1) moderate	3.0 (1.1) moderate	3.3 (1.2) moderate	3.1 (1.1)
<b>Numbers in bold</b> exceed the critical limit when the Bonferonni adjustment is applied identifying statistically significant variables				

The descriptive characterisation of operational activity is based on the percentage score of each group of items. Using the 32-item total GSCM scale, self-selected cut-offs were developed (high 66–100%; moderate 44–65%; low 20–43%; very low 0–19%) to describe operational activity within each construct relative to the total operational activity across the sample. The classification of the driver scales was based on the mean score for the construct related to the original Likert scale used.

The third cluster is operationally more active than clusters 1 and 2. Cluster 3 also experiences the greatest amount of external and internal pressures to adopt environmentally responsible behaviour, especially from societal, legislative and internal sources. In all three clusters, there are low levels of industrial networking, suggesting that even the most operationally active are still not getting involved in outreach activities, such as green business networks or lobbying groups. Supplier education, coaching and mentoring is also very low or low in all three groups, again related to lack of outreach activities. Whereas, internal environmental operations management practices, such as eco-efficiency measures are the most frequently undertaken activities in all three clusters.

The categorical variables are examined in Table 3, identifying which groups of organisations dominate the various clusters. The public sector, construction and utilities are predominantly based in cluster 3, with more than 50% of these groups in that cluster. The transport and logistics group is evenly distributed across all three clusters, and to a



certain extent this is also true of the service/manufacturing and the manufacturing group. The largest proportion of the service sector (40%) is based in cluster 2.

**Table 3. The characteristics of respondents within each cluster (%)**

Clusters	1	2	3		1	2	3
<b>sector type</b>				<b>size groupings</b>			
public	23.8	11.9	<b>64.3</b>	small/medium (<250)	<b>53.3</b>	24.4	22.2
service	33.3	40	26.7	large	10.3	31	<b>58.6</b>
service & manufacturing	31.3	31.3	37.5	very large (1000+)	16.4	21.9	<b>61.6</b>
retail/wholesale	28.6	71.4	0	<b>environmental impact</b>			
utilities	0	0	<b>100</b>	lower	30.8	41	28.2
construction	20	0	<b>80</b>	higher	21.7	5.8	<b>72.5</b>
manufacturing	31.8	31.8	36.4	<b>Environmental risk</b>			
transport and logistics	33.3	33.3	33.3	lower	35.6	35.6	28.7
				higher	13.3	8.3	<b>78.3</b>
<b>&gt;50% of cases from that group in one cluster</b> highest % of respondents for that group in a cluster							

Higher risk and impact organisations are predominantly based in cluster 3, whereas those organisations designating themselves as lower risk or impact are spread over all three clusters. Cluster 3 is also dominated by large and very large organisations, while cluster 1 contains many of the small and medium size organisations. This suggests that the most proactive organisations are large and/or high environmental risk. This finding supports the work by both Banerjee (2001) and Bowen et al. (2001a). Banerjee (2001) identified a link between operational proactivity and levels of risk. The taxonomy developed by Bowen et al. (2001a) also demonstrated a link between size and operational proactivity with the smallest business units operationally less active. Thus 11% of those that considered environmental issues to be very important are in cluster 1, and 78% in cluster 3. However, as Table 3 indicates, some of the smaller organisations and/or those with lower levels of environmental impact and risk were still operationally very active. This suggests that some other factor(s) apart from risk and size influence the adoption of advanced GSCM practices.

### **Replicating the Murphy constructs**

The previous section established that some other factor(s) other than size or risk might influence environmental proactivity. Walton, Handfield, and Melnyk (1998) and Seuring and Muller (2008) suggest that the most advanced companies have the most strategically proactive approach to leveraging environmental management for competitive advantage. Srivastava (2007) also describes GSCM as a source of competitive advantage, with Kopicki et al. (1993) and van Hoek (1999) describing reactive, proactive or value-seeking environmental management strategies of firms. This overall environmental culture of an organisation might be very important as a driver. However, it is sometimes difficult to establish whether it is employees, upper management, founder ideals, middle management or 'green champions' who drive environmental programmes (Carter, Ellram, and Ready 1998; Ghobadian, Viney, and Holt 2001; Ogbonna and Harris 2001). Therefore, a range of 'actors' within an organisation may influence GSCM initiatives and their relative success. Perhaps trying to identify which specific group is the most influential is less important than assessing the influence of the overall organisational environmental attitude or commitment to improving environmental performance.

Aspects such as the internal environmental culture of an organisation might not be fully captured by the internal driver construct in this research instrument, as the internal dynamics of each case are extremely difficult to identify and measure without detailed case study work. Alternatively, publicly available environmental policies can be analysed to assess the strategic approach to environmental issues of each organisation (in a similar manner to Henriques and Sadorsky 1999, and Holt and Anthony 2000) and validate the results using surveys. Since the respondents in this sample were anonymous, it was not possible to do this.

Therefore, it is important to validate the internal factors driving environmental management using additional measures. This is where the concept of 'environmental attitude', after Murphy, Poist, and Braunschwig (1996), might be replicated and extended, to encapsulate the overall environmental culture of the organisation. This concept may act as a surrogate measure of internal factors, based on a series of indicator questions. Rather than using a simplistic measure, such as the presence/absence of an environmental policy, a multiconstruct measure of environmental attitude might be developed based on the principles established by Murphy, Poist, and Braunschwig (1996).

Therefore, this variable of 'environmental attitude' was replicated using the scale previously identified by Murphy, Poist, and Braunschwig (1996) which classified organisations into attitudinal clusters described as 'conservative', 'moderate' or 'progressive', using a series of constructs to develop an environmental attitudinal score. This scale variable (as indicated in Figure 2) represented a cumulative score from the results of four questions originally proposed by Murphy as detailed below (score allocated indicated).

1. General importance of environmental issues: (4) extremely important (3) important (2) of moderate importance (1) of slight importance (0) of no importance.
2. Importance of environmental issues and how this will change over time: (3) increase (2) stay the same (1) decrease.
3. Which of the following most accurately describes your organisation's environmental policy? (3) formal environmental policy and guidelines (1) informal environmental policy and guidelines (0) no specific environmental policy.
4. The extent to which environmental issues are considered in purchasing and logistics: (3) above that of other factors (2) equal consideration (1) secondary consideration (0) not considered during purchasing and logistics, or (0) not considered at all.

Organisations were classed as progressives if they gained a cumulative score of 11 or above, moderates gained between 8 and 10 and conservatives 7 or below. The scores ranged from 2 to 13, with a maximum possible of 13 and cut-off points between the three classifications self-selected in a similar manner to Murphy, Poist, and Braunschwig (1996).

### ***Comparing the clusters and the replicated taxonomy***

The findings from the two-stage cluster analysis were then compared with the replicated constructs from Murphy, Poist, and Braunschwig (1996). Table 4 indicates the percentage (%) of respondents within each cluster that responded to the items measured in the Murphy, Poist and Braunschwig study. Hence, 78% of those in cluster 3 believed that managing environmental issues was extremely important.

Bowen et al. (2001b) identifies a positive link between the strength of environmental 'attitude' of the organisation and the proactivity of GSCM practices, and this is supported by the findings in Table 4. An organisation in cluster 3 tends to believe that managing environmental and ethical issues is of great importance to their organisation,

has a formal environmental policy, and tends to consider environmental issues in purchasing and logistics on a par with other criteria. Organisations in cluster 1 tend to consider environmental and ethical issues of ‘slight or no importance’, typically have only an informal environmental policy if at all, and do not consider environmental issues in purchasing or logistics. In comparison, organisations in cluster 2 tend to occupy the middle ground, considering managing environmental and ethical issues as moderately important, and if environmental issues are considered in purchasing and logistics, they are of minor consideration.

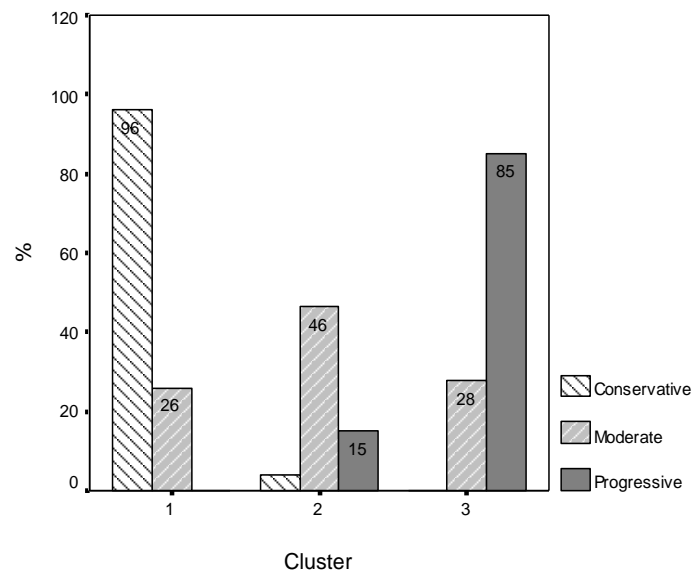
**Table 4. Percentage of respondents within each cluster for the Murphy et al. criteria**

* adapted from <i>Murphy et al.</i> criteria	1	2	3	n
<b>How important do you think the management of environmental issues *</b>				
Extremely important	11	11	78	64
Important	32.3	33.9	33.9	62
of moderate importance	36	57	7	14
of slight importance	100	0	0	5
not at all	100	0	0	2
<b>How important do you think the management of ethical issues, such as fair trade and human rights is to your organisation?</b>				
Extremely important	24	0	76	50
Important	16.1	32.3	51.6	62
of moderate importance	28.6	71.4	0.0	14
of slight importance	60.0	33.3	6.7	15
not at all	66.7	16.7	16.7	6
<b>To what extent does the consideration of environmental issues affect decisions made in purchasing and logistics *</b>				
Environmental issues are considered above other factors	0	0	100	1
Environmental issues are given equal consideration with other factors	6.3	14.6	79.2	48
secondary consideration after other more important factors	26.4	31.9	41.7	72
not considered during purchasing or as part of logistics	65	20	15	20
Environmental issues are not considered by the organisation at all	66.7	33.3	0	6
<b>Importance of environmental issues over next 5 years *</b>				
increase	24.6	23.1	52.3	130
stay the same	41.2	35.3	23.5	17
<b>Status of environmental policy *</b>				
We have a formal environmental policy and guidelines	0.	33.3	66.7	108
Primarily an informal or unwritten environmental. policy and guidelines	100	0	0	19
we have no specific environmental policy or guidelines	100	0	0	20
<b>Length policy</b>				
no formal policy	100	0	0	39
less than 1 year	0	20	80	5
1-3 years	0	56	44	50
4-5 years	0	35	65	20
5-10 years	0	0	100	23
10 years +	0	0	100	10

Previously, we presented the items used from Murphy, Poist, and Braunschwig (1996) to designate each respondent as progressive, moderate or conservative. In Figure 3, we now present the makeup of each of the clusters developed in the GSCM taxonomy and relate membership of each to the attitudinal designation of each member

replicated from the Murphy constructs. This comparison suggests that the Murphy constructs show similarities with the clusters developed within this paper. Cluster 1 contains the majority of the conservative organisations, cluster 3 contains the majority of the progressive organisations and cluster 2 contains the majority of the moderate organisations.

However, some of the attitudinally progressive (15%), and conservative (4%), organisations are also in cluster 2. This suggests some organisations espouse conservative values but are operationally more active than the majority of the rest of the conservative group. Equally some organisations espousing progressive views are operationally less active than expected. This points to a gap between the rhetoric of environmentalism and actual GSCM practices. In summary, their espoused values overstate the operational reality and in others their espoused values are more conservative than their actual operational practices.



**Figure 3. Distribution of different environmental attitudinal groups within cluster in the GSCM taxonomy (after Murphy et al. 1996)**

Therefore in studies of GSCM, and other environmental/social issues, it is important that the research instrument captures not only their espoused values and strength of opinion on the importance of such issues, but also the actual operational activity that occurs, as espoused values do not necessarily capture the operational reality. In a similar manner, having an environmental policy in an organisation is still only a written statement of these values and may not represent the actual extent of operational practices that enables the 'level' of environmental responsiveness to be compared between organisations. The GSCM taxonomy developed by Bowen et al. (2001a), focusing mainly on the purchasing component of the supply chain, displays many similarities with the taxonomy developed in this paper and that of Murphy, Poist, and Braunschwig (1996). In the Bowen et al. (2001a) study, a link was identified between units with high environmental commitment and interest amongst employees following a more proactive green supply strategy.

However, whilst a pattern exists between levels of environmental concern and operational activity, in our findings some of the organisations are operationally less, or more, active than their attitudinal designations (based on Murphy, Poist, and Braunschwig) would suggest. It should be noted that the full range of constructs developed in the original 1996 study are not used here and this may have affected the relative comparability of the attitudinal designations used in this paper. The cut-off points between the attitudinal classes are self-selected by the researchers

in both the Murphy, Poist and Braunschwig study and this study and these may not fully reflect actual divisions between the groups.

However, the use of the two stage cluster analysis does provide a measure of objectivity in the cut-off points between the groups and the strong similarities between the self-selected attitudinal classification of moderate, progressive and conservative and the designations of cluster 1, 2 or 3 suggests that the Murphy, Poist and Braunschwig protocol has merit. This replication with extension supports the validity of their approach and suggests that this attitudinal classification is still valid in a different geographical and sectoral setting, and also in the context of the whole supply chain rather than just the green logistics as examined in the original study.

**Testing the linkages between external drivers, internal drivers, and GSCM practices**

The final objective of this paper is to use SEM as a DS tool for GSCM managers. In order to act as a DS tool, SEM needs to investigate the linkages between the external drivers, internal drivers and GSCM operational practices. The investigation of the inter-relationship between the factors will assist green supply chain managers to decide where they need to pay more attention to improve the operational practices. In order to investigate these relationships, the GSCM conceptual model earlier presented in Figure 2 was tested. SEM allows detailed understanding of the particular variable in terms of key influencing factors. Once the model is established, it is compared using various fitness measures such as goodness of fit index, normed fit index (NFI) and comparative fit index (CFI), to identify the best fit model supporting the data (Jöreskog and Sörbom 1989). In this paper, we tested the conceptual framework for all the three clusters to identify the relationship between the variables studied.

**Table 5. Correlations Analysis**

	Legis	Comp	SC	Soc	IntD	EAtt	GSCM_OP
Legislative	1						
Competitive	.291**	1					
Supply Chain	.248	.618**	1				
Societal	.638**	.449**	.258	1			
Internal Drivers	.616**	.398**	.135	.706**	1		
Enviro Attitude	.524**	.324**	.420**	.434**	.535**	1	
GSCM_OP	.535**	.252**	.372**	.401**	.456**	.658**	1

\*\* . Correlation is significant at the 0.01 level (2-tailed)

Legis: Legislative; Comp: Competitive; SC: Supply Chain; Soc: Societal; IntD; Internal Driver;

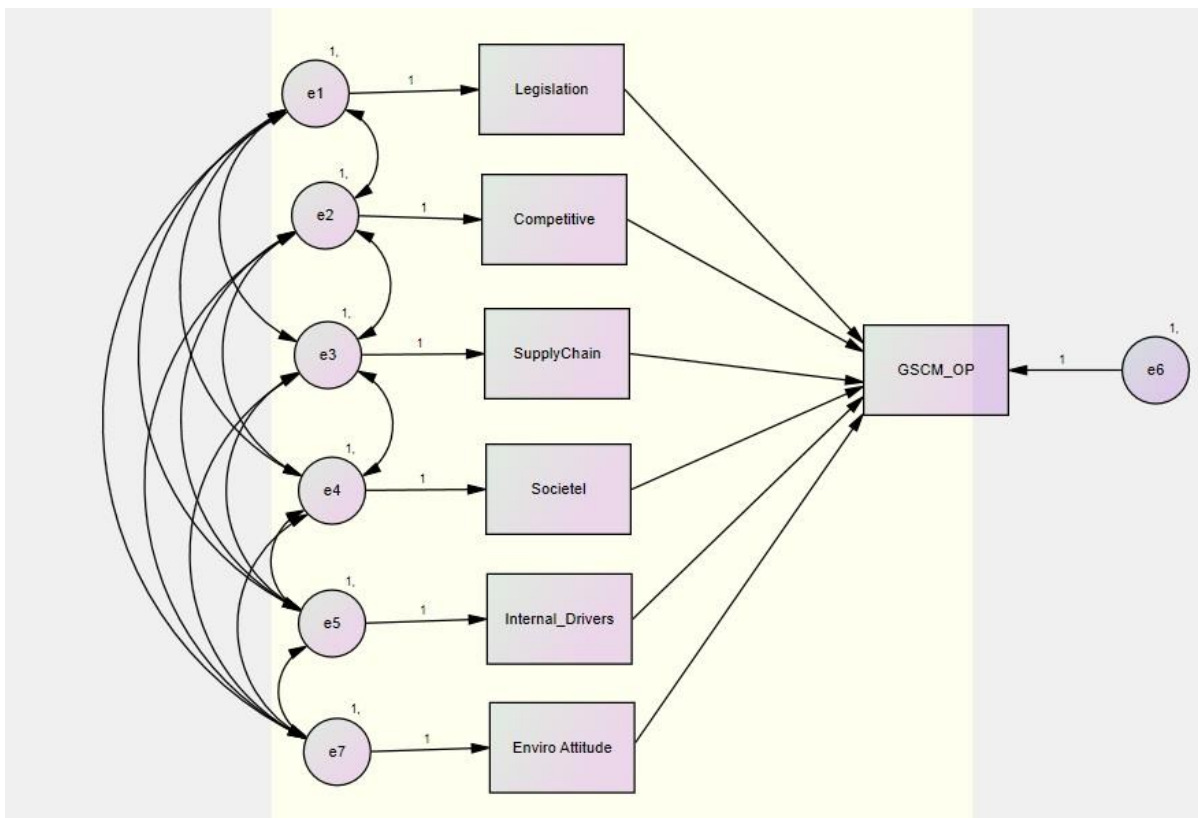
EAtt: Environmental Attitude; GSCM\_OP: Green Supply Chain Operational Practices

Firstly, correlation analysis was carried out for all clusters together and analysis showed that all factors were significantly correlated (Table 5). All the constructs were initially measured on a multidimensional scale, however the reliability test result showed that for all constructs Cronbach’s Alpha value was >0.70 (Table 6) and thus they were converted into single scale items.

**Table 6. Reliability Statistics**

Variables	Cronbach's Alpha	No. of Items
Legislative	.879	4
Competitive	.873	4
Supply Chain	.774	4
Societal	.841	5
Internal drivers	.842	5

The SEM model (Figure 4) was then constructed following the conceptual model for all the three clusters. Since SEM advocates testing alternative models and then identifying a best fit model, this procedure was followed for all three clusters. The fitness values of the best fit SEM models for the three clusters are presented in Table 7.



**Figure 4. Default SEM Model**

For cluster 1 (Figure 5(a)), SEM analysis reveals that all the external and internal factors were positively correlated with the GSCM operational practices. However, the best fit model had no links between the competitive factor and GSCM practices. One of the internal factors that measure the risks, culture and leadership also had no direct links with the GSCM operational practices. To cross-verify this, regression analysis was carried out for both these factors. The regression analysis supported the SEM modelling outcome as the adjusted R2 value for competitive and internal factor was found to be very low, i.e. 0.071 and 0.141, respectively. This finding indicates that competitive factors and factors linked to risks, leadership and culture are not primary drivers of GSCM practices for smaller organisations. However, the findings do not point out that they are not important, but rather suggest that other

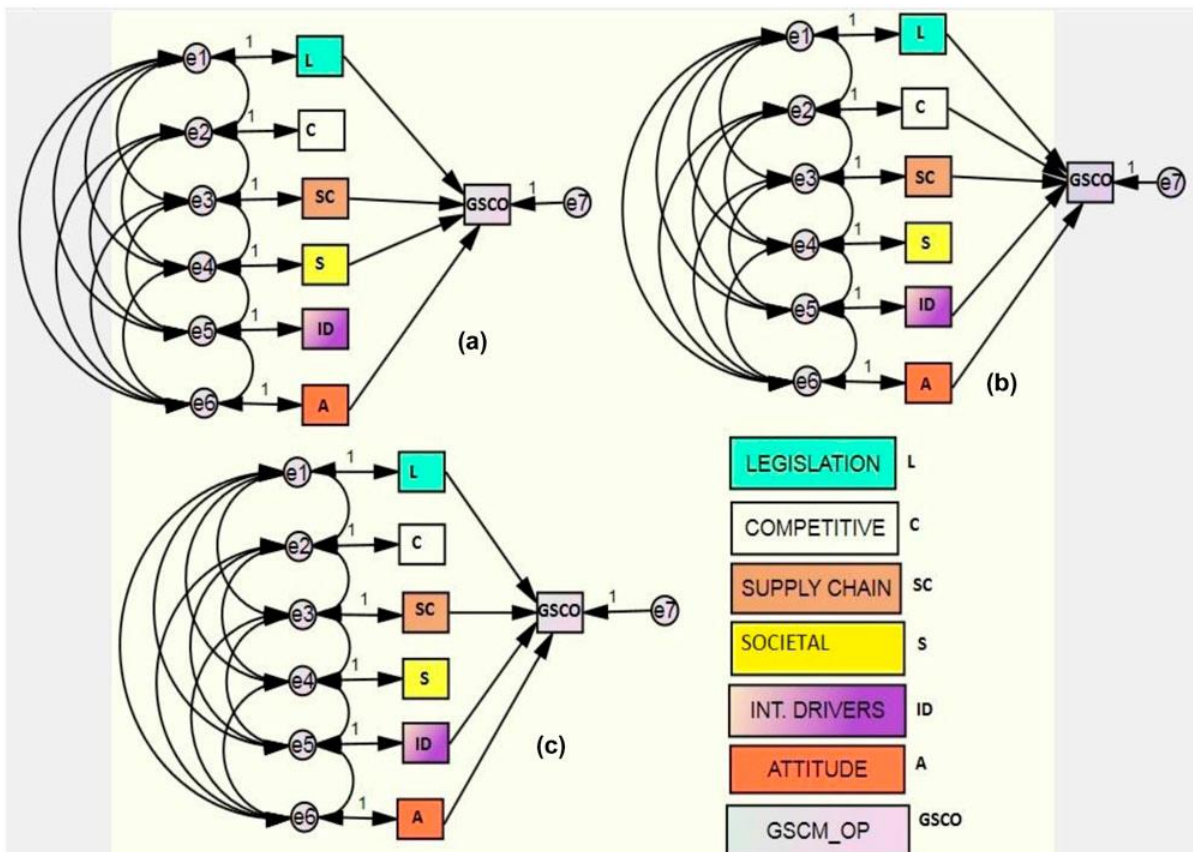
factors such as legislative pressures and general supply chain practices are significant drivers of GSCM operational practices.

**Table 7. Fitness Indices for Best Fit SEM Models of Three Clusters**

Clusters\Fitness Indices	Chi-Square/df	NFI ( $\approx 1$ )	IFI ( $\approx 1$ )	CFI ( $\approx 1$ )	RMSEA ( $\approx 1$ )
Cluster 1	1.86	0.953	0.969	0.961	0.077
Cluster 2	0.20	0.998	1.009	1.000	0.000
Cluster 3	0.26	0.995	1.014	1.000	0.000

The best fit SEM model for cluster 2 (Figure 5(b)) showed that unlike cluster 1, competitive and internal factors do play a crucial role in driving green supply chain operational practices. However, no direct link between societal factor and GSCM operational practices was observed. Again regression analysis was performed to verify the SEM model findings and analysis shows that the adjusted R2 value for the societal factor was just 0.29. This is an interesting finding opposed to cluster 1 and shows that large organisations do not follow GSCM operational practices to just build their image but rather their motivation is driven by both external and internal pressures.

**Figure 5. Best fit SEM model for cluster 1 (a); cluster 2 (b); and cluster 3 (c).**



The SEM model for cluster 3 (Figure 5(c)) showed no direct links between the competitive and societal factors with GSCM practices. The adjusted R2 value for competitive and societal factors was found to be 0.032 and 0.064, respectively. Thus, regression analysis verified the outcome of SEM analysis, suggesting that for very large

organisations competitive pressure and societal image are not primary drivers but rather other external and internal drives are primarily responsible for driving GSCM practices. The findings of the SEM analysis of the three clusters show the differing nature of external and internal drivers and their impact on GSCM practices. Having a better understanding of what factors contribute to GSCM operational practices is vital for GSCM managers and decision-makers, since it helps them to design the right policies and allocate resources to factors that are more prominent for each cluster. SEM also identifies how these variables are linked with each other, i.e. the inter-relationship between the variables, thus acting as a DS tool for GSCM managers. By knowing how these factors influence each other, decision-makers can make informed judgements about assigning priority to a particular factor as well as planning the right strategy. For instance, if SEM identifies a strong and positive linkage between legislative and supply chain factors, GSCM managers can closely align their supply chain practices following any changes in legislation since these changes will directly affect their green supply chain practices. Thus, SEM can act as a DS tool for GSCM managers by assisting them in planning the right strategy. This fulfils the final objective of this study.

## **Conclusions**

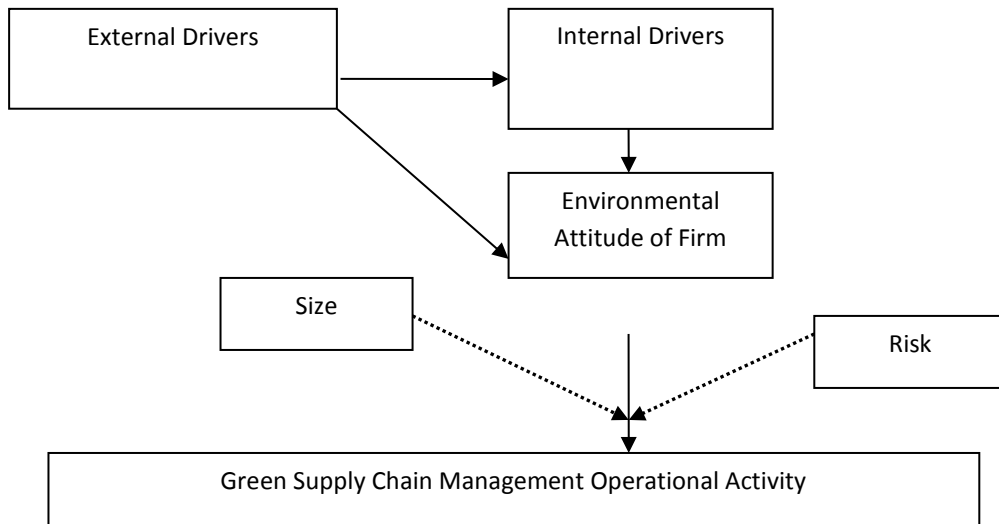
This paper develops a taxonomy of GSCM drivers and operational practices that consists of three distinct clusters, with clear differences emerging between each. Cluster 1 is operationally less active and more likely to comprise smaller organisations. When examining attitudes rather than objective practices, organisations in this cluster attached a lower level of importance to managing environmental issues. We are not in a position to establish causality, that is to say, is it limited resources or know-how in smaller organisations that results in lower level utilisation of practices designed to reduce environmental impacts or specific lack of concern or awareness? In either case, these findings have clear implications for policy-makers and practising managers of larger organisations. In terms of policy, it is important to publicise and offer benchmarks that organisations can aspire towards as part of a proactive GSCM approach. In terms of practice, the results indicate the important role that larger organisations can potentially play in educating their suppliers.

Members of cluster 3 are the most active in implementing practices designed to reduce their organisation's negative impact on the physical environment. They tended to be the larger organisations and/or those with the higher levels of environmental risk and impact. From an attitudinal point of view, they also placed significant importance on managing environmental issues. Again we are not in a position to determine causality. Is it slack resources that encourage larger organisations to implement many operational practices designed to reduce their negative impact on the environment or is it simply their attitude towards environmental protection? One clear message emerging is the level of risk organisations face towards damaging the environment and taking steps to mitigate those risks.

Cluster 2 occupies the middle ground between these two opposing positions. These three clusters show an emerging link between levels of operational activity and drivers (Table 2) and levels of risk and size (Table 3). In part, there is some influence by sector on the clusters; however, this is not clear cut. On the other hand, the level of environmental risk and impact plays a key role in the adoption of operational practices designed to mitigate negative impact on the physical environment. Interestingly some organisations with lower levels of risk and impact are also in the more operationally active cluster 3. One explanation for this observation lies in organisations' attitudes towards the physical environment; for example, Interface, the American carpet manufacturer, that is seeking zero carbon emission by 2020 because of its founder's attitude towards the environment. In this respect, our study supports Murphy, Poist, and



Braunschwig's (1996) conclusions. The relationships suggested by the findings in this study are conceptualised in Figure 6.



**Figure 6: Mediating factors affecting GSCM response**

This GSCM taxonomy does suggest that the higher risk, larger organisations are operationally the most active, which is to be expected. However, those with lower levels of risk yet positioned in highly visible sectors, such as the public sector, are also highly active. The most inactive, attitudinally conservative organisations are also typically smaller and of lower risk. Yet, the presence of these smaller, lower risk organisations within the highly active cluster (3) and moderately active cluster (2) suggests that environmental attitude remains a critical factor driving operational activity even when their peer group is, on the whole, inactive. The fact that the most operationally active group (cluster 3) is not composed exclusively of high risk and large organisations does suggest that other factors are affecting the adoption of proactive GSCM practices in some instances, and this is perhaps related to the internal culture of the organisations and their level of environmental 'responsiveness'.

Thus, the influence of 'environmental attitude' as originally discussed by Murphy, Poist and Braunschwig remains a key factor to explore in further detail. The apparent relatively 'crude' attitudinal designations originally used in 1996 without recourse to advanced statistical techniques, remain valid and show clear similarities with the clusters developed in this paper.

This study also proposes the novel use of SEM as a DS tool to assist GSCM managers and policy-makers. It can assist managers in decision-making by exploring the relationship between the external factors, internal factors, and green supply chain operational practices. In this study, the outcome of the SEM tool shows that the relationship between the factors varies from one cluster to the other, thus no common policy framework would work uniformly across the different sectors. Each cluster needs to be understood properly, and accordingly green policies and strategies must be devised.

Further studies should seek to explore in more detail the influence of progressive environmental attitude in the smaller, lower risk groups, which are traditionally more conservative. Future research can also aim at testing the mediating impact of environmental attitude using SEM analysis, as that would provide new insights to GSCM decision-makers. In such organisations, it may be that internal factors are critical driving forces of this increased operational activity. In addition, further studies should seek to investigate the green supply chain taxonomy developed in this

paper in different cultural and sectoral settings. Moreover, future studies can aim to explore other model-driven decision-making tools such as the analytical hierarchy process or decision tree to better assist green supply chain managers.

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### **Appendix A: GSCM Operational Practices**

#### **Internal environmental management practices**

- 1 We recycle toner cartridges in the offices
- 2 We actively manage the disposal of packaging wastes
- 3 We actively manage the disposal of all solid wastes in the organisation
- 4 Paper recycling in offices is standard practice
- 5 We are required by law to control the disposal of some of our wastes (e.g. medical waste)
- 6 Energy efficiency measures are adopted for lighting and heating
- 7 We have accredited to an environmental management standard such as ISO14001 or EMAS

#### **Logistics**

- 8 We ask suppliers to use recyclable pallet system when they deliver supplies to us
- 9 We have energy efficiency systems in operation in our warehouses
- 10 We consider environmental matters generally in our transport decisions
- 11 We expect our suppliers to take back their packaging or pallet systems they use to supply goods to us
- 12 We plan the routes of our vehicles in order to reduce environmental impacts
- 13 We have invested in vehicles that are designed to have reduced environmental impacts

#### **Supplier assessment and evaluation**

- 14 We assess the environmental acceptability and performance of our suppliers informally in our assessment criteria
- 15 We assess the environmental acceptability and performance of our suppliers in a formal process
- 16 We set environmental criteria that suppliers must meet

#### **Green procurement and logistics policy**

- 17 We consider ethical and human rights/welfare issues informally in our purchasing decisions
- 18 We have a green purchasing or logistics guidelines that recommend the environment is considered
- 19 We consider ethical and human rights/welfare issues formally in our purchasing decisions
- 20 We have a formal policy on green procurement/purchasing
- 21 We are bound by external purchasing directives (e.g. the EC procurement directive or franchise agreements)
- 22 We have a formal policy on green logistics/transport

#### **Supplier education, coaching and mentoring**

- 23 We have received environmental guidance from our own customers
- 24 We communicate to our suppliers our environmental and/or ethical criteria for goods and services we buy
- 25 We educate our suppliers through written material
- 26 We have been the recipient of educational workshops and visits by our customers to educate us on what environmental improvements can be made
- 27 We (or someone on our behalf) goes into our suppliers' organisations to help them improve environmental performance
- 28 We run workshops/seminars to educate our suppliers

**Industrial networks**

- 29 The organisation is part of an industry specific partnership that shares good practice/lobbying
- 30 The organisation is part of a SC initiative that is involved in active dialogue with suppliers and/or stakeholders
- 31 The organisation is part of a general “green” network that shares environmental or ethical good practice or information
- 32 The organisation is part of an group that sources products and suppliers (such as the ethical trading initiative)