THE UNIVERSITY OF HULL

Developing and Testing Green Performance Measures for the Supply Chain

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by

Sarah Louise Shaw BSc., MBA.

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ABSTRACT

Performance measurements evolve as new challenges are met and the natural environment is one of the biggest challenges facing society and the evolution of performance measurement today. Consequently, a cross-disciplinary interest in the field of green supply chain management (GSCM) has grown amongst researchers and practitioners in recent years because of climate change issues, diminishing raw materials, excess waste production, increasing levels of pollution and because it is a source of competitive advantage. Yet, there has been little work done in developing and incorporating green measures into the existing bank of supply chain performance measures. Only 18 articles have been published in the last 18 years on green supply chain performance measurement (GSCPM). The aim of this thesis is to address this challenge by empirically developing and testing green performance measures for the supply chain.

Based on an extensive literature review, five research questions were proposed for this thesis to address gaps in the body of knowledge. This is a new area of theory development and demanded theoretical and methodological triangulation to maximize the amount of data collected to explore the research phenomena from different perspectives. The study used a rigorous three-phased methodological framework originally developed by Churchill (1979) for items and scales development. The first phase comprised generating variables and constructs from the extant literature and focus groups. The second phase involved testing these items and constructs in a survey. Finally, a focus group was conducted in Phase Three to verify and validate the overall results.

The thesis proposes a battery of 29 GSCPM variables and 12 GSCPM constructs that can be used by organisations to measure their impact on the environment. The study found that GSCPM variables used by organisations, such as usual performance measures, remain primarily driven by cost. Furthermore, there are significant differences in the capabilities and the way in which organisations view the importance, enablers, barriers and benefits of GSCPM. This thesis contributes to knowledge by proposing a universal set of GSCPM variables and reporting tools that organisations can use to manage their GSCPM. Finally, the use of methodological pluralism in this research has helped to provide a more complete picture of this phenomenon and represents one of only a few studies which have explored GSCPM in this way.

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CHAPTER ONE

INTRODUCTION

1.1 Research Background

The issues of global warming and climate change are a worldwide concern (IPCC, 2007; IPCC, 2012). Supply chain and energy security are two major emerging issues that will fundamentally shape our future and are central to the functioning of the world economy and well-being of the global society (World Economic Forum, 2008). In the field of business and management, there is an onus on organisations to minimise the impacts on the natural environment (Hart, 1995; Henriques and Sadorsky, 1999; Walker et al., 2008).

The UK government has a number of goals to improve its environmental performance, both internationally and domestically, including reducing greenhouse gas emissions; it has set an aggressive domestic goal of reducing carbon dioxide (CO_2) emissions by 80 per cent below base levels by 2050 (Defra, 2007; Defra, 2009). With 75 per cent of an organisation's carbon footprint attributable to logistics and transport activity (IOMA, 2008) and the total UK transport sector contributing to one third of UK carbon emissions (Transport and Climate Change, 2007), it is no surprise that non-energy companies are beginning to assess energy consumption and emissions in their supply chains as a way to reduce their carbon emissions.

With the increased globalisation of supply chains, logistics and supply chain managers are thus faced with the challenge of how to incorporate green management practices into daily decision making processes while at the same time ensuring their supply chains remain lean and competitive (Mollenkopf et al., 2010). Aligning green and lean management practices along the supply chain can lead to significant cost savings and productivity gains (Klassen and McLaughlin, 1996).

Despite the pressures from government and the importance of this emerging green research agenda to supply chain practitioners, there has been little work done in developing, testing and incorporating green measures into the existing bank of supply chain performance measures (Shaw et al., 2010). There is also a lack of published empirical research in green supply chain performance measurement (GSCPM) within the field of supply chain management. This thesis has identified 70 articles devoted to green supply chain management (GSCM) published between 1994 and 2012. In contrast, only 18 articles have been published in the last 18 years on GSCPM and half of these publications are published outside the field of supply chain management, showing a lack of maturity in the literature and research. The literature which exists both within and outside the scholarly academic journals is fragmented, complex and focuses on specific nodes or functions within the supply chain rather than the entire supply chain.

An in depth assessment of the existing empirical research revealed a lack of theoretical rigour with the existing GSCPM studies mainly comprised of general reviews, literature reviews, single methodological approaches and small sample cases. Yet, there are demands for more rigorous research in logistics and supply chain management (Näslund, 2002; Mangan et al., 2004).

The purpose of this thesis is to address these gaps in the body of knowledge by developing a universal set of GSCPM variables and reporting tools which organisations can use to mitigate their impact on the natural environment. This will be accomplished by exploring what GSCPM variables and reporting tools exist, how they are being applied and how they may vary by company or sector. Furthermore, it will explore the key enablers and barriers to GSCPM adoption in supply chains.

1.2 Research Context

The aim of this thesis is to empirically develop and test green performance measures and reporting tools for supply chains. The researcher has selected the United Kingdom (UK) as a study sample for this thesis; however many of the organisations involved in this research study have both global and domestic supply chains that extend beyond the UK. The UK has been selected for two primary reasons: 1) the UK has set one of the most aggressive carbon reduction strategies globally, and 2) the UK is ranked within the top ten highest global emitting countries in the world (Guardian, 2009). Therefore, organisations operating in the UK are coming under increased scrutiny from their customers and the government regarding their compliance with environmental and social responsibility. There is also the additional concern that developed countries like the UK have outsourced or off-shored much of their environmental impact (carbon emissions and pollution) to developing countries like China where their goods are produced but not necessarily consumed. This falsifies some of the claims made by developed countries, like the UK, that they have reduced their carbon emissions since the ratification of the Kyoto protocol (Guardian, 2009).

Taking on board these challenges, the UK therefore presents an ideal research context in which to begin to explore and develop green performance measures for the supply chain as it will address not only domestic but global supply chains. The scope of the research is to develop and test GSCPM variables and reporting tools applicable to the entire supply chain and not just specific nodes. The sustainability matrix proposed by the UK food retail trade association in 2011 for assessing the sustainability issues along the supply chain is used to set the boundary lines for this research and shows a typical grocery supply chain (Figure 1.1).

Figure 1.1: A Typical Grocery Supply Chain (Adapted from the Environmental Sustainability Matrix, IGD, 2011:2)

1.3 Research Problem

Five research questions are therefore proposed for this thesis based on the foregoing research background. Firstly, what GSCPM variables are being used in practice today? Secondly, which GSCPM variables are important to users, i.e. are they useful and easy to measure? Thirdly, can GSCPM variables be integrated within existing supply chain performance frameworks? Fourthly, what are the enablers and barriers in adopting GSCPM? Finally, do any of the emerging variables and constructs mirror those found in extant literature on GSCPM? These five primary research questions are set out in a conceptual model in Chapter Six and synthesise the extant GSCPM literature and address the key gaps in the body of knowledge.

1.4 Research Methodology

The above research questions represent a fairly new area of research and theory development, thus this thesis is using theoretical and methodological triangulation to maximise the amount of data collected to explore the research phenomena from different perspectives (Miles and Huberman, 1994; Mangan et al., 2004). The thesis uses a rigorous three-phased methodology framework for item and scale development which was developed by Churchill (1979) for the marketing discipline and applied more recently to logistics research by Dunn et al. (1994) and Grant (2003).

The empirical study comprised three phases: (Phase One) an inductive phase that involved conducting focus groups with leading logistics/supply chain managers and directors to explore the five research questions, identify current and/or required practices employed in industry, and generate a battery of variables and constructs; (Phase Two) a deductive phase that consisted of an online survey of UK logistics and supply chain professionals through the Chartered Institute of Logistics and Transport UK (CILT) to test and validate the variables and constructs emerging in Phase One; and (Phase Three) a final inductive phase that consisted of conducting a focus group with a different group of logistics/supply chain managers and directors to verify the overall research findings. Factor analysis was used to examine the data sets from the online survey (Phase Two) using principle component analysis (PCA). It analysed the interrelationships among a large group of GSCPM variables and respondents to identify any underlying, common components which are not usually visible using traditional statistical assessments (Hair et al., 1995).

1.5 Thesis Structure

The thesis is divided into two main parts. Firstly, Part One comprised the background literature which underpins this thesis (Figure 1.2). Secondly, Part Two presented the research undertaken (Figure 1.3).

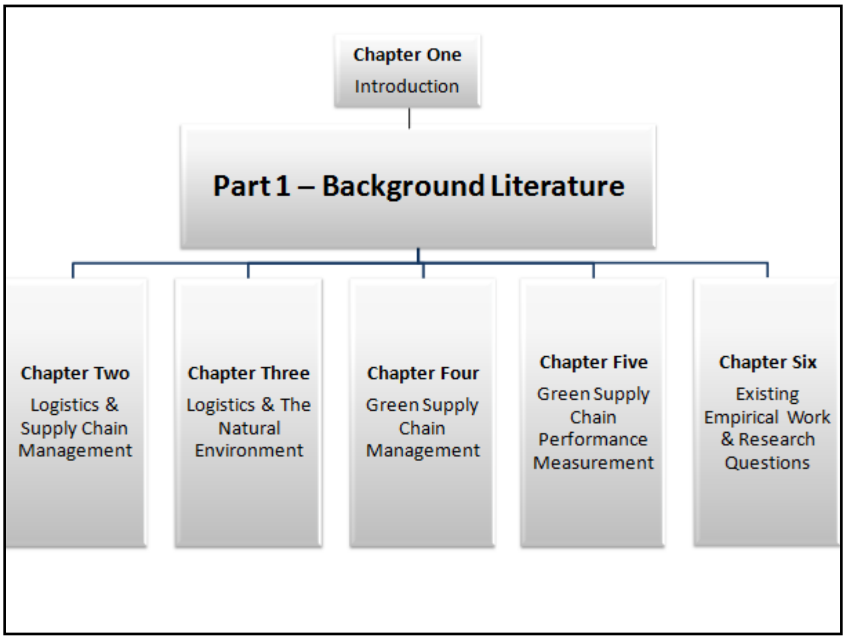


Figure 1.2 – Thesis Structure – Part One

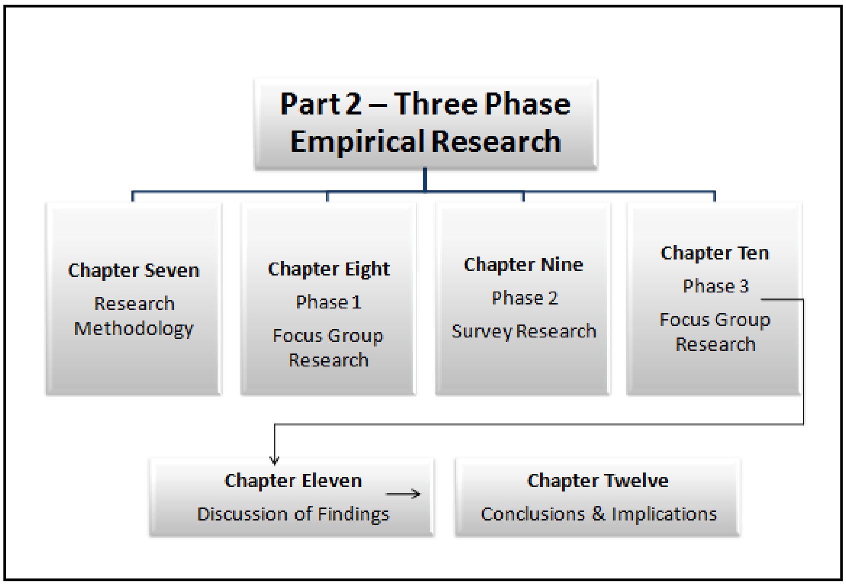


Figure 1.3 – Thesis Structure – Part Two

1.5.1 Part One – Background Literature

Chapter Two - Chapter Two discusses definitions of logistics and supply chain management and examines the historical, current and future perspectives associated with the discipline. This sets the stage for examining the relationship between supply chain management and the natural environment in Chapter Three.

Chapter Three – Chapter Three discusses issues surrounding the natural environment and climate change and why this is so relevant to logistics and supply chain management. The chapter examines in detail the history and science behind climate change and addresses not only the impact of supply chains on the environment but the impact of the natural environment on the sustainability of future supply chains, linking this to organisational theory.

Chapter Four – As a consequence of the growing environmental challenges and anthropogenic impacts of supply chains, Chapter Four goes on to discuss how the cross disciplinary field of GSCM has emerged onto the research stage in recent years and grown in interest amongst practitioners and academics alike. This chapter discusses the green practices which organisations engage in and explains this in the context of organisational theory. Furthermore, this chapter summarises some of the key barriers and enablers to organisations implementing green supply chain management practices (GSCMPs).

Chapter Five – Following a discussion of GSCMPs, Chapter Five discusses the principle area of focus of this thesis which is the importance of measuring the performance of these supply chain management practices. Chapter Five reviews in detail the background and history of organisational and supply chain performance measurement and examines the existing literature and work done in the field of GSCPM. It identifies the metrics which are being used or discussed in this field. Furthermore, this chapter examines what existing supply chain and business performance reporting tools and environmental management frameworks exist and which are the most popular.

Chapter Six – Chapter Six examines existing empirical studies in the field of GSCPM to identify the key contributions, gaps and disparities in the work conducted in this field. Chapter Six draws together the findings from the literature and proposes a conceptual model and five research questions for this thesis which address the gaps in the body of knowledge.

1.5.2 Part Two – Three Phase Empirical Research

Chapter Seven – Chapter Seven discusses the research objectives, research design and methods used in this thesis. It also discusses in detail how the data and results will be examined. It justifies the philosophical stance undertaken by the researcher and describes the rigorous three-phased methodology framework for item and scale development which was developed by Churchill (1979).

Chapter Eight, Nine and Ten **–** Chapters Eight, Nine and Ten present the results from the three phases of this research, i.e. focus groups (inductive), online survey (deductive) and focus group validation (inductive) respectively. In each of these chapters, the results are presented in such a way that they can link back to answering each of the five primary research questions.

Chapter Eleven **–** The purpose of Chapter Eleven is to discuss and summarise the key empirical findings from all three phases of the research in an integrated and holistic way to answer the research questions and draw conclusions. Chapter Eleven pulls together the key findings across all three phases of the research to propose a universal set of GSCPM variables and reporting tools that organisations can use to manage their green supply chain performance, which can be used as a source of competitive advantage and will help to guide future policy decisions.

Chapter Twelve **–** Chapter Twelve is the final chapter and summarises the main theoretical and practical contributions of this research along with an assessment of the managerial implications, research limitations and a guide for future research.

PART ONE – BACKGROUND LITERATURE

CHAPTER TWO

LOGISTICS AND SUPPLY CHAIN MANAGEMENT

2.1 Introduction

The goal of this chapter is to review the background literature which underpins this thesis by linking together the issues surrounding the discipline of logistics and supply chain management, the natural environment and green performance measurement. This chapter reviews the definitions of logistics and supply chain management, providing a glimpse over the last 15 years of how the discipline has evolved and discusses the future issues and challenges expected. This sets the stage for Chapter Three which discusses the relevance of logistics and supply chain management to the natural environment.

The literature review was conducted in two phases. Firstly, the contents of the five leading logistics journals (Menachof et al., 2009) were examined for articles relating to the following five-word search: performance management (PM), supply chain management (SCM), green supply chain management (GSCM), environmental SCM (ESCM) and environmental management (EM). The key words were selected by constructing a relevance tree used to identify other related areas of the literature requiring exploration. Second, a key word search was performed on the ISI Web of Science database (2009) to specifically identify a list of key authors, journals and research outside the field of logistics and SCM relating to green performance management. The bibliographies and reference lists from key journals were used to trace new journals relevant to the research area.

The remainder of this chapter sets out the definitions of logistics and supply chain management and the historical, current and future perspectives. The relationship between logistics and the natural environment are then explored, with the relevance logistics plays in terms of green supply chain management. Lastly, conclusions to this chapter are drawn.

2.2 Definitions

2.2.1 Definition of Logistics

There are various ways of defining logistics. Christopher (1998:4) employs the current marketing orientated definition for logistics management:

“The process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organization and its marketing channels in such a way that current and future profitability are maximised through the cost-effective fulfilment of orders.”

That definition highlights the relationships between the logistics and marketing disciplines. It describes the scope and the activities associated with logistics from the management of the raw materials at source through to the fulfilment and delivery of customer orders. It is the efficient and effective co-ordination of all these discrete activities and actors which can give an organisation competitive advantage. The definition also highlights the importance of logistics to the profitability of a company.

The Council of Supply Chain Management Professionals (CSCMP), a global US-based organisation defines logistics in a similar way in terms of managing the flow of product and information from the point of origin to the customer:

“Logistics is that part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customer’s requirements.” (CSCMP, 2010).

The CSCMP (2010) definition is appropriate in the context of the thesis as it is concerned with the efficient and effective forward and reverse flows of goods from source to customer. This is important in the context of environmental/green management, as this is where organisations can have the most significant anthropogenic impact on the natural environment through the processes of manufacturing, transportation and storage (IOMA, 2008). Furthermore, three key supply chain trends have emerged over the last decade: a move towards green initiatives, utilisation of lean processes, and increased globalisation, all of which have created a very complex business environment for organisations to operate within. This has led to both synergistic and contradictory points across these three supply chain strategies (Mollenkopf et al., 2010). For example, some lean, green and global supply chain practices are incompatible while others are not.

Globalisation increases the distance and time that a product needs to travel from source to consumer and therefore has a corresponding impact on the environment and makes it difficult for the supply chain to respond to sudden business changes. This was the case for the 'well-travelled yogurt pot' discussed by Böge (1995), who determined the transport intensity to deliver 150 gramme yogurt pots across German supply chains meant that 24 fully-packed trucks each had to travel 1,000 kilometres to distribution centres, collectively using over 10,000 litres of diesel fuel in the process. In contrast, Toyota is a prime example of an organisation that has successfully integrated a green but lean supply chain strategy in a global setting and is proof that it can be achieved (Mollenkopf et al., 2010).

Figure 2.1 illustrates that the scope of logistics does indeed span the entire organisation from the management of raw materials at point of origin through to the delivery of the final product to the customer and back (Christopher, 1998:13).

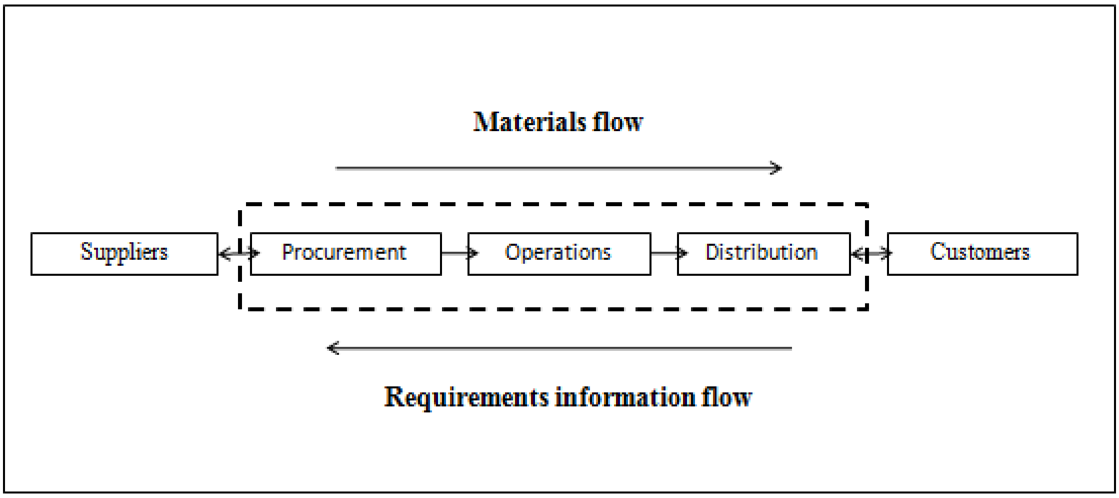


Figure 2.1 – The Logistics Management Process (Christopher, 1998:13)

Logistics covers a range of business functions, each with its own challenges and skills, they are all interdependent and practitioners must work together to understand the impact on the whole supply chain in order to deliver results (CILT, 2010).

2.2.2 Definition of Supply Chain Management (SCM)

The term SCM is relatively new and was first coined by a group of consultants in the early 1980's. It was not, however, until the early 1990's, that academics first described SCM and attempted to differentiate it from logistics management on a theoretical basis (Cooper et al., 1997; Lambert and Cooper 2000; Stock and Lambert, 2001). Its popularity has been driven by increased global supply, the requirement to work more closely with suppliers on new product developments and the demands of the customer to deliver cheaper and faster (Mentzer et al., 2001).

There appears to be little consensus over the definition of SCM, with it being poorly defined and with a high degree of variability over what it is meant to be (Kathawala and Abdou, 2003; Burgess et al., 2006). For example, Bechtel and Jayaram (1997) classified 50 SCM definitions into five schools of thought and Cooper et al. (1997) provided a valuable review of 13 early SCM definitions which enabled them to build a robust argument that SCM and logistics are not identical. Finally, Mentzer et al. (2001) identified more than 20 SCM definitions when they proposed different terms to be used to represent different aspects of supply chain management, supply chain orientation (SCO) and supply chain management (SCM).

Some have argued that academics and practitioners see logistics and SCM management as interchangeable concepts (Cooper et al., 1997; Stock and Lambert, 2001; Grant 2012). Others however, conclude that they are quite different and there is a need for some level of co-ordination and integration of the logistics activities and processes within and between organisations that goes beyond logistics (Cooper et al., 1997; Mentzer et al., 2001). It is this integration and co-ordination of the business processes and activities across the supply chain which defines what SCM is and distinguishes it from logistics management.

Mentzer et al. (2001:4) describe the supply chain as "*a set of three or more organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer.*" They also proposed that supply chain management can be classified into three distinct categories: (1) a management philosophy, (2) implementation of a management philosophy and (3) a set of management processes. They go on to describe the activities required to implement this SCM philosophy (Figure 2.2).

1. Integrated Behavior
2. Mutually Sharing Information
3. Mutually Sharing Risks and Rewards
4. Cooperation
5. The Same Goal and the Same Focus on Serving Customers
6. Integration of Processes
7. Partners to Build and Maintain Long-Term Relationships

Figure 2.2 – Supply Chain Management Activities (Mentzer et al., 2001:8)

SCM as a philosophy takes a systems approach, viewing the supply chain as a single, unified entity rather than fragmented parts. Within a supply chain, organisations have a set of beliefs about their core purpose which is to collaborate together to improve overall supply chain performance and create customer value. SCM is a combination of value adding processes (Kotler, 1997). Similarities can be drawn between this philosophy and the definition used by Christopher (1998:18):

"The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole."

Organisations within a single supply chain will work in close partnership to deliver enhanced customer service and achieve a more profitable outcome for all parties in the chain, including the customer. The success of the supply chain relies on the effective management of these relationships. Christopher (1998:16) argued that while the concept of SCM is new it *"is no more than an extension of the logic of logistics. Logistics management is primarily concerned with optimizing flows within the organization whilst supply chain management recognizes that internal integration by itself is not sufficient."*

Christopher (1998:18) also described SCM as *"demand chain management"* to reflect that the supply chain should be driven by the market and not by the suppliers, and also recommended that the word *"chain"* should be replaced by *"network"* as this more appropriately describes the multiple suppliers and customers included in the total system, with the firm being at the centre of a network of suppliers and customers.

Christopher (1998:19) therefore suggests the supply chain could more accurately be defined as:

"A network of connected and interdependent organizations mutually and co operatively working together to control, manage and improve the flow of materials and information from suppliers to end users."

Furthermore, real competition is now not company against company; rather supply chain against supply chain (Christopher, 1992).

CSCMP (2010) broadly defined SCM as a set of flowing processes and activities similar to those identified by Mentzer et al. (2001). CSCMP, however, also identified the specific channel partners involved in the supply chain, describing it as:

"The planning and management of all activities involved in the sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes co-ordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies."

In contrast, the UK's Chartered Institute of Logistics and Transport (CILT, 2010) by virtue of their name, focus on 'logistics' and 'transport' more prominently as a strategic concept rather than SCM. This contradicts the proposition made by Cooper et al. (1997) which suggested that logistics is a functional area within the broader strategic context of SCM. The CILT (2010) also acknowledged in their definition the importance of channel partners, defining logistics on their internet site (2010) as:

"Getting the right product to the right place in the right quantity at the right time, in the best condition and at an acceptable cost is the challenge of logistics. It's an area that embraces purchasing and supplier management, materials management and manufacturing, inventory management and warehousing, distribution and transport, and customer service."

The CILT, like CSCMP do acknowledge that while logistics covers a wide range of business functions and activities, these are interdependent and must be co-ordinated very carefully by practitioners for the benefit of the supply chain as a whole. The process flow chart on their internet site illustrates this concept (Figure 2.3).

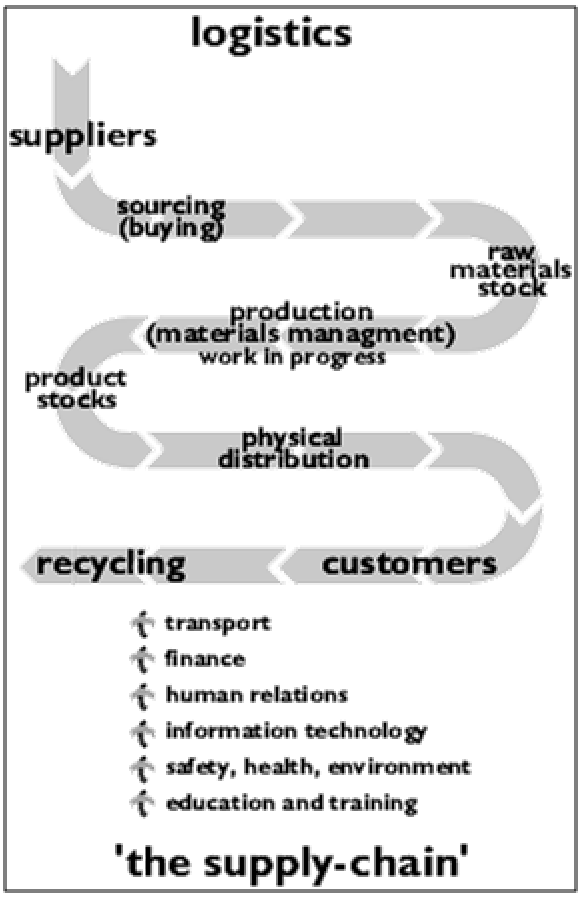


Figure 2.3 – The Chartered Institute of Logistics and Transport Flow Chart (CILT, 2010)

It is therefore important to clarify the definition used for this thesis. The CSCMP (2010) definition will be used for this thesis as it outlines the role that logistics plays within the supply chain. It also acknowledges the scope of the supply chain, from point of origin to the point of consumption and the fact that supply chain encompasses more that just logistics management. Therefore, according to the CSCMP (2010) definition, SCM includes eight main processes: sourcing, procurement, conversion, transportation, warehousing, inventory management, order processing and reverse logistics (Pfohl, 2000; Abukhader and Jönson, 2004; CSCMP, 2010).

2.3 The Logistics Discipline

2.3.1 The Evolution of Logistics and SCM

Logistics as an activity has been around for centuries particularly in the military and agriculture and can be traced back to ancient war times, namely the Greek and Roman empires (Christopher, 1992). Logistics only really took hold as a scholarly discipline in the early 1900's. Early logistics literature is predominantly US focused and only in the late 1990s did Martin Christopher emerge on the stage with a book on the development of logistics and supply chain management from a European perspective. From 2000 onwards, logistics takes an international perspective with an increase in globalisation (Spens and Kovács, 2010).

Kent and Flint (1997) discussed the perspectives on the evolution of logistics thought. They identified six eras of evolutionary thought, starting from the beginning of the 1900's and ending as a progression into the future. During Era One (farm to market) at the turn of the century, attention centred on transporting product from the farms to the point of sale, with World War II and agriculture being of central influence at that time. Logistics has played a central role in war. "*Wars have been won and lost through logistics strengths and capabilities"* (Christopher, 1998:3). During Era Two (segmented functions), two sectors were embraced: business and the military. Still influenced by the end of the World War II and military engineering, this era was characterised by efficient physical distribution and the functions which comprise distributing goods. The interest in logistical capabilities for moving products more efficiently from production to consumption points did not occur until the mid 1950's as part of the era of 'modern marketing' (Shapiro and Heskett, 1985).

Inspired by the success of the military in World War II, managers first took notice of well managed logistics operations, with physical distribution being viewed as a subset of marketing and viewed from a functional perspective (Shapiro and Heskett, 1985; Spens and Kovács, 2010). Era Three (integrated functions) was characterised by linking these functions together which were required to deliver an integrated logistics approach (warehousing, transportation, inventory control and materials handling). Lewis et al. (1956) introduced the concept of 'total cost analysis' which provided an integrative systems approach to logistics. There had been a shift from just viewing logistics as physical distribution to an entire system of discrete activities which relied upon one another (Spens and Kovács, 2010).

During Era Four (customer focus) a new perspective had emerged in the 1970's. The customer was regarded as the primary focus of the organisation and physical distribution became a key component of customer service. A significant milestone in the history of logistics management was the introduction of Porter's (1985) Value Chain. This helped to raise awareness of how logistics capabilities could be used as a source of competitive advantage (Figure 2.4). As a result of this, logistics became very fashionable as a discipline for academics and practitioners in the early 1990's.

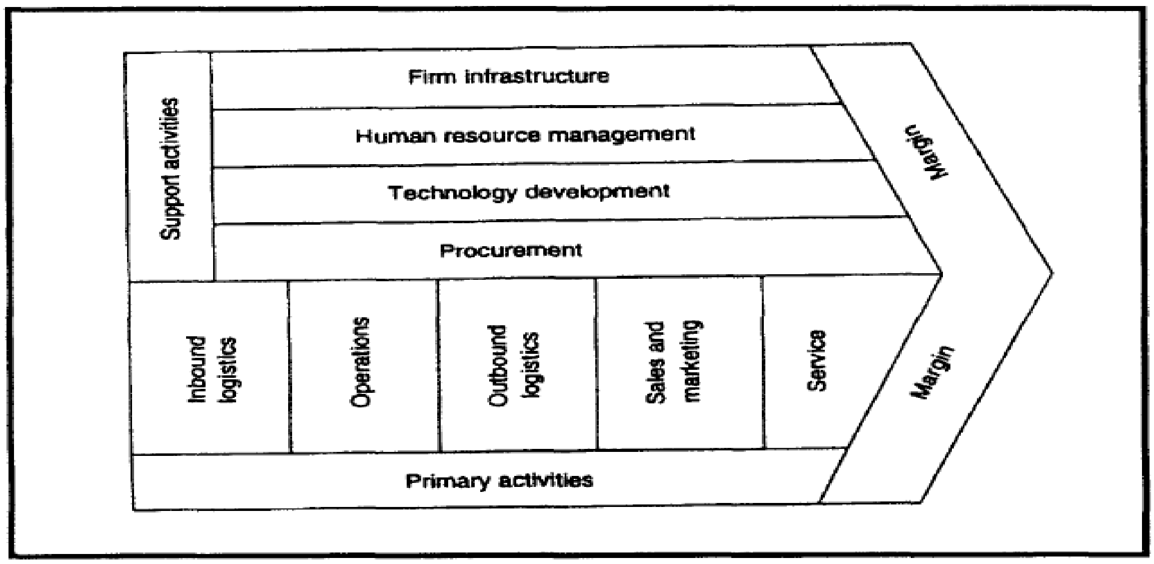


Figure 2.4 – Porter's Value Chain (Porter 1985:37)

2.3.2 The Current State of Logistics and SCM

Mentzer and Kahn (1995:240) evaluated the "*state of logistics research*" by examining *Journal of Business Logistics (JBL)* articles between 1978 and 1993. As a result of this review, they called for a maturation process of the journal. As a follow up to that study, Davis-Sramek and Fugate (2007) revisited and reviewed the same journal from 1993 through to 2005 to assess the current state of logistics. As one of the top three ranked logistics journals in the composite index, *JBL* is representative as an indicator of the current state of logistics internationally (Menachof et al., 2009). Davis-Sramek and Fugate (2007) concluded that more rigorous research has been conducted in logistics over the last decade with a growth in the use of qualitative/exploratory approaches used for theory building. These approaches and mixed methodological approaches are required if academics are to develop and advance the logistics discipline (Näslund, 2002; Mangan et al., 2004). Since 2007, numerous authors have recommended the use of various qualitative research methods/techniques to build theory and add rigor to logistics and SCM research (Trautrims et al., 2012; Randall and Mello, 2012; Goffin, et al., 2012; Borgström, 2012).

Stock and Broadus (2006) reviewed 410 doctoral dissertations published between 1999 and 2004 and found the topics multi-faceted and complex, making it difficult to classify dissertations into particular topics. This is a positive attribute of the logistics and SCM discipline as it demonstrates the diversity of research and the ever evolving logistics landscape.

Menachof et al. (2009) identified 82 periodicals relevant and important to academics in the SCM discipline. *Journal of Business Logistics, Harvard Business Review* and the *International Journal of Physical Distribution and Logistics Management* were the top three ranked journals in the composite index. They found a global consensus emerging on the most respected SCM journals. McKinnon (2013), however, conducted a recent review of logistics journals and their associated rankings. The findings revealed a mismatch between those SCM journals which [logistics and supply chain] academics viewed as important versus the official [business school] ranking schemes. Thus, it is important not to view journal rankings in isolation when considering their impact and importance to a research discipline.

Menachof et al. (2009) also found a trend in the emergence of more *Operations Management/Operations Research* based journals into the rankings, which indicated the importance of this field to SCM. There has been a decline or transition from traditional transportation and physical distribution journals to more SCM and logistics orientated journals. This supports Kent and Flint's (1997) transition from Era Two/Three to Four/Five. There has been a shift in focus from a functional perspective to more systems integrated approaches were the customer is of primary importance. Operations management is one of many discrete activities in which a firm can deliver superior value to the customer (Porter, 1985) and therefore important to future research in the discipline.

In terms of Kent and Flint's (1997) six eras of evolutionary thought, logistics is at a critical juncture and in a state of flux between Eras Five and Six. The world has experienced exceptional global trading conditions over the last two decades. There has been rapid economic expansion of third party logistics (3PL) providers which has given rise to boundary spanning, global supply chains. The recent economic downturn has had unprecedented impacts on supply chains, for example: unpredictable customer demand, volatility in fuel costs, currency valuation changes and excess inventory. In the US, total logistics costs declined 18.2 per cent in 2009, and logistics as a percentage of GDP dropped to 7.7 per cent, the lowest level measured since 1981 (CSCMP, 2010). This left huge and unexpected capacity in global transport and shipping networks.

Economic recessions have a huge influential impact on logistics management. Spens and Kovács (2010) found that logistics evolution is linked to economic cycles with its evolution being cyclical rather than linear as previously thought. During economic downturns supply chains have adopted a 'survival of the fittest' strategy to survive and prosper, with cost taking over as a primary consideration and little attention being given to the impact on the natural environment or resource efficiency.

Organisations must rethink and redesign their supply chains and use the downturn as an opportunity to collaborate with trading partners and even competitors. Redesigning supply chains to increase agility and responsiveness to changing trading conditions is paramount. This represents a behavioural shift in terms of how supply chains operate and very much supports Kent and Flint's (1997) Era Six, behavioural and boundary spanning changes (Langley and Cap Gemini, 2009).

Over the past 15 years transportation costs have been a dominant focal area for supply chains and areas such as energy efficiency, corporate social responsibility (CSR) and green logistics have been at the bottom of the supply chain agenda. Interestingly, energy efficiency now ranks second on the list of focal areas for the future, along with service orientation (Spens and Kovács, 2010). Therefore, energy efficiency and the green agenda will be very much the focus for practitioners and for future academic research.

2.3.3 Future Issues in Logistics and SCM

SCM is still emerging in terms of theory and practice with substantial gaps in its definition and understanding. The logistics landscape is continually changing and has undergone significant changes throughout the past decades. The scope of the field has broadened, bringing new challenges for academics and practitioners (Ballou, 2007). There has been a shift in focus from cost efficiencies and physical distribution management to customer service focus, green initiatives and energy efficiency. At times of economic recession, supply chains will re-focus on cost as a way to survive and improve profit. A glimpse over the last 15 years has given an indication of how the logistics landscape will change in the future, influenced by economic cycles, with more focus on cost, service, talent retention, green issues and less importance attached to globalisation (Skjoett-Larsen, 2000). This may indicate a shift in organisations sourcing from suppliers which are closer to the consumer market as a way of eliminating transportation costs and being more energy efficient (Spens and Kovács, 2010). Kent and Flint's (1997) Era Six (behavioural and boundary spanning) provides useful insight into future speculative research particularly around customer perception, behaviours and logistics.

An important and perhaps neglected part of SCM theory is the people and behavioural dimension. For example: Who manages the supply chain? How can corporate culture influence supply chain success (Storey et al., 2006)? The people dimension could be an important area of future research, with more emphasis on accountability and responsibility within the supply chain. People hold the key to future decisions and where the discipline will go.

Understanding the past helps to extrapolate what might happen in the future. For example, over the last decade, before the world recession, there had been a trend towards increased globalisation, free trade and outsourcing which generated a focus on logistics and SCM (Ballou, 2007). The world recession, however, presented major challenges to the global supply product market. This may result in a migration from global to more local, greener supply chains.

Green issues and energy efficiency are also very topical and will be very much at the forefront of future empirical research. The UK government, like many other developed nations have already committed to a 'Carbon Reduction Strategy' in response to the Climate Change Act (2008). The Carbon Reduction Strategy will help to decarbonise the UK transport system by 2050 and create a low carbon future. There will be greater emphasis on renewable energy and increased governance by government on how organisations can be greener and more energy efficient.

In order to improve energy efficiency and reduce the impact of supply chains on the natural environment, organisations need to measure and understand their anthropogenic impact and actions required to bring this to an acceptable level. As the old adage goes, 'you cannot manage what you cannot measure.' It is therefore essential that organisations are able to measure this impact to provide them with a baseline from which to improve.

Performance measurement within supply chains is difficult when dealing with numerous tiers and activities. It is often centred around retrospective financial indicators, giving little insight to managers on where they should take corrective action (Zingales et al., 2002). GSCPM is virtually non-existent but essential if organisations are to respond to pressures from the customer, stakeholders and regulatory bodies (Hervani et al., 2005). There is a gap in the body of knowledge which requires theoretical exploration and conceptualisation.

It is very difficult to propose future directions for the discipline because the diversity of the current research is broad and diverse. In contrast, the diversity narrows considerably with respect to theoretical perspectives and research methods with the continued dominance of positivist approaches (Burgess et al., 2006). In order to speed up the rate of knowledge development, logistics methods of enquiry need to expand (Burgess et al., 2006). This thesis will help to address this gap.

2.4 Summary

Logistics has been around for centuries, however it is relatively new as a scholarly discipline and it is an emerging area of research. The world economic recession has had a huge impact on logistics and SCM with cost efficiency indicators taking over as a primary area of focus. A glimpse over the last 15 years has given an indication of how the logistics landscape will change now and in the future. Business environments like natural environments change over time and logistics must be ready to change and adapt to these ever changing circumstances (economic cycles and climate change) through mitigation and adaptation. Logistics and SCM professionals are coming under increased pressure to review the implications of their activities on the natural environment. People will be instrumental in delivering innovative practices which could lead to the improvement in environmental outcomes and overall business performance. An organisation's internal resource will play an important role in the ability to respond to external environmental changes (Hervani et al., 2005). Energy efficiency and service orientation are high on the future logistics agenda (Spens and Kovács, 2010).

The next chapter explores these discussions further by considering the relationship between logistics and the natural environment.

CHAPTER THREE

LOGISTICS AND THE NATURAL ENVIRONMENT

3.1 Introduction

Issues surrounding the natural environment and climate change have come to the fore over the last two decades since an article appeared in a 1995 issue of *Nature* documenting a large seasonal disappearance of ozone from the earth's atmosphere over Antarctica. This finding galvanised the scientific community and triggered a sequence of events that have dramatically raised the profile of the natural environment and climate change around the world. The logistics and supply chain management community is not immune to these events and efforts to recycle materials and packaging in a reverse logistics process have received considerable attention for several decades. An early piece of research by Böge (1995) was one of the first discussions regarding the impact of 'food miles' on consumer products and that also quantified the environmental impact of transport. Since then the environmental agenda has grown in terms of interest and activity, particularly in the context of logistics and SCM (Carter and Rogers, 2008) and has stimulated a growth in green logistics research. It is vitally important that organisations ensure that the planet's future requirements are met and their supply chains are sustainable (Grant et al., 2013).

3.2 The History of Climate Change

In order to evaluate the anthropogenic impact of supply chains on the environment, it is important to understand the history behind climate change and global warming. Atmospheric scientists first used the term 'greenhouse effect' in the early 1800's. At that time, it was used to describe the naturally occurring functions of trace gases in the atmosphere and did not have any negative connotations. It was not until the mid-1950's that the term greenhouse effect was coupled with concern over climate change. The realisation that the earth's climate might be sensitive to the atmospheric concentrations of gases that create a greenhouse effect is more than a century old (Fleming, 1998).

In 1985 an article appeared in *Nature* announcing a large seasonal disappearance of ozone from the atmosphere over Antarctica (Farman et al., 1985). Their announcement shocked the scientific community; there was proof that a hole existed in the ozone layer.

This triggered a sequence of events, which would dramatically raise the profile of climate change across the world. Previously other scientists, notably Molina and Roland (1974) studied the effects of CFC molecules in the atmosphere. They discovered that CFC molecules were stable enough to remain in the atmosphere until they got up to the middle of the stratosphere where they would finally be broken down by ultraviolet radiation releasing chlorine atoms. They then proposed that these chlorine atoms might be expected to cause the breakdown of large amounts of ozone (O_3) in the stratosphere.

In 1985, immediately following the Farman publication, 20 nations signed the Vienna Convention, which established a framework for negotiating international regulations on ozone-depleting substances. The Vienna Convention, however, was not legally binding. It was the Montreal Protocol on substances that deplete the ozone layer which came into effect in 1987 which was a landmark international agreement designed to protect stratospheric ozone (UNEP, 2007).

In 1988, the Intergovernmental Panel on Climate Change (IPCC) was set up jointly by the World Meteorological Organisation and the United Nations Environment Programme to provide an authoritative international statement of scientific understanding of climate change (IPCC, 2007). The IPCC (2007) have published three working group documents, which provide a comprehensive overview of climate change:

- Working Group I – The Physical Science Basis (2007)
- Working Group II – Impacts, Adaptation and Vulnerability (2007)
- Working Group III – Mitigation of Climate change (2007)

These three documents represent the first major Global Climate Change Assessment in six years. They were written by 152 leading authors from 30 countries and reviewed by over 600 experts. It provides an up-to-date scientific assessment of past, present and future climate change (IPCC, 2007).

In 1997, the Kyoto protocol was introduced as a way of combating global warming, specifically greenhouse gases. The goal was to achieve a stabilisation of greenhouse gas concentrations in the atmosphere that would prevent dangerous anthropogenic interference with the earth's climate system. Under the protocol, industrialised countries commit themselves to the reduction of four greenhouse gases (GHG) (carbon dioxide, methane, nitrous oxide and sulphur hexafluoride) by 5.2 per cent from the 1990 level. Emission limits do not include emissions of chlorofluorocarbons, which are dealt with under the 1987 Montreal Protocol. As of November 2009, 180 states have signed and ratified this legally binding agreement (Kyoto Protocol Status of Ratification, 2009).

Since this landmark agreement and more recent agreements, countries continue to meet to discuss progress, issues and targets in relation to climate change. In 2010, a United Nations (UN) conference was held in Cancun. The attendees agreed to a further global deal to tackle climate change. The Cancun agreement represented a significant step forward in renewing the determination and focus of the international community to tackle climate change (Defra, 2011).

3.3 The Physical Science behind Climate Change

The climate system is a complex, interactive system consisting of the atmosphere, land surface, snow and ice, oceans and other bodies of water, and living things (IPCC, 2007). Climate changes can occur as a result of internal variability within the climate system and external variability (natural or anthropogenic). Natural variability includes natural phenomena such as volcanic eruptions and solar variations. Anthropogenic variability includes human-induced changes in the composition of the atmosphere, for example a change in the concentration of greenhouse gases.

3.3.1 The Greenhouse Effect

The greenhouse effect is a naturally occurring phenomenon and without it, life on earth would not exist. This is because it acts as a natural thermostat for the earth's atmosphere. Without a natural greenhouse effect, the temperature of the earth would be 0°F (-18°C) instead of its present 57°F (14°C) and a decline of 8-10°C would plunge Europe and North America into an ice age (NOAA, 2007).

The earth's surface temperature is maintained and controlled by a blanket of greenhouse gases in the atmosphere. These gases act as a partial blanket for long-wave radiation being reflected from the earth's surface. This blanket effect is known as the 'green house effect'. Clouds can exert a blanketing effect similar to the greenhouse gases; however this is offset by how much they reflect back to space, so they also help to cool and well as warm the atmosphere (Figure 3.1).

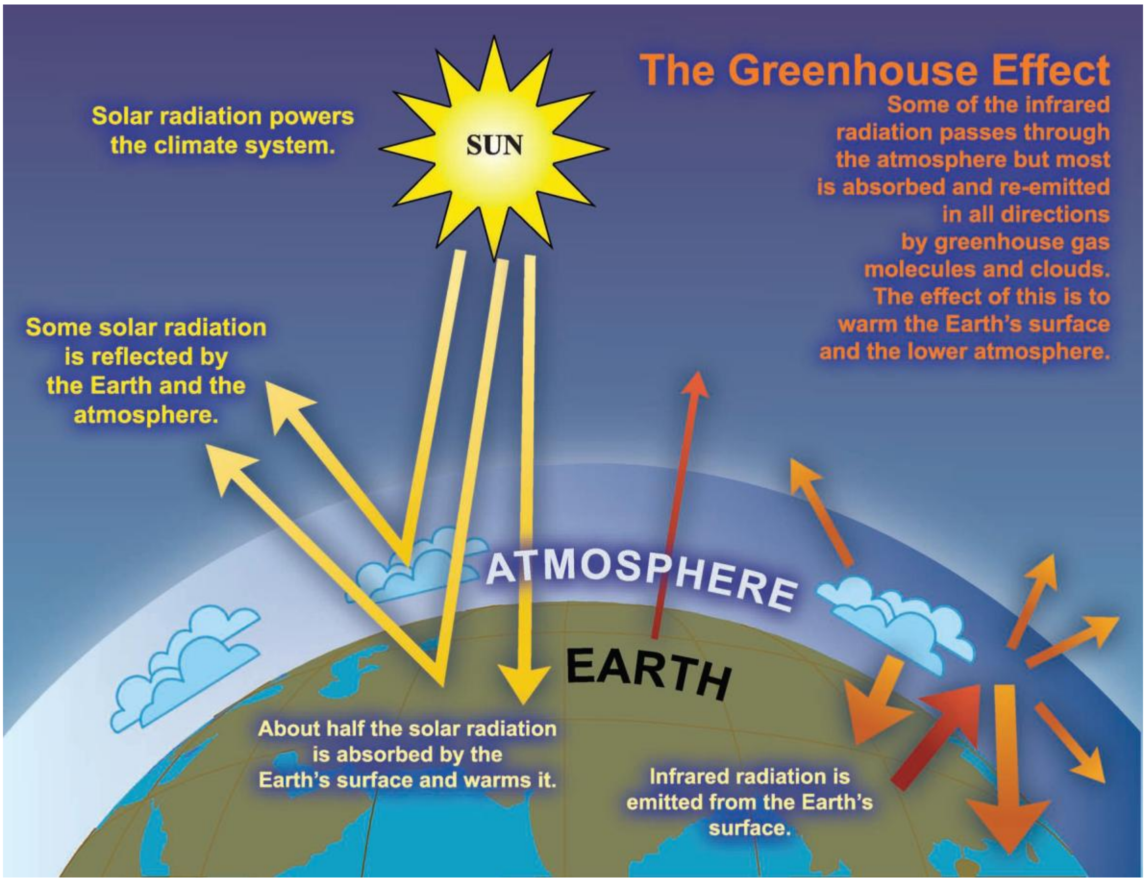


Figure 3.1: The Natural Greenhouse Effect (IPCC, 2007:115)

It is solar radiation that powers the earth's climate system. Approximately 30 per cent of sunlight that reaches the top of the earth's atmosphere is reflected back into space. Scientists use the term 'albedo' to define the percentage of solar energy reflected back by a surface. Approximately two-thirds of this reflectivity is due to clouds and small particles in the atmosphere. The remaining one-third is due to snow, ice and deserts (IPCC, 2007). The Earth also emits long-wave radiation back to space (Figure 3.1). The local, regional and global 'albedo' effects are critical in predicting future climate changes.

3.3.2 Greenhouse Gases (GHG)

Water vapour (H_2O), carbon dioxide (CO_2), ozone (O_3), methane (CH_4) and nitrous oxide (N_2O) are naturally occurring greenhouse gases, and together create a natural greenhouse effect. The most vital greenhouse gases are water vapour and carbon dioxide. Water vapour is by far the most important greenhouse gas. Water vapour evaporates, mostly in the tropics, in response to heating by the sun. It is a mechanism, which allows the ocean to remain cool. This water vapour then continues through the earth's hydrological cycle. Some of the water vapour is carried into the Inter-tropical

Convergence Zone (ITCZ) where it rises, condenses as rain, and releases the stored solar energy. This energy in the form of latent heat drives the convection in the ITCZ and drives the atmospheric circulation. This heat is carried pole-ward by the circulation and has the effect of reducing the temperature contrast between the poles and tropics. This circulation, known as the 'Hadley circulation', named after George Hadley an English Meteorologist (Persson, 2006), carries water vapour high into the atmosphere, allowing it to radiate heat efficiently to space. Some of the water vapour remains as clouds helping to reflect the sunlight and cooling the earth's surface temperature; while some helps to absorb infrared energy emitted by the earth helping to warm the earth.

Carbon dioxide (CO_2) is one of the most abundant and naturally occurring greenhouse gases. It absorbs infrared radiation from the earth's surface, helping to keep the atmosphere warm. Carbon dioxide (CO_2) has increased in the atmosphere from the burning of fossil fuels used in transportation, manufacturing, heating and cooling. Carbon dioxide (CO_2) is important in the context of anthropogenic climate change as it is classified as a Long-lived Greenhouse Gas (LGHG), contributing to the largest positive radiative forcing (RF) between 1750 and 2002 (Figure 3.2). The concentration of carbon dioxide (CO_2) has increased from a pre-industrial value of 280 parts per million to 400 parts per million (Guardian, 2013). The natural range over the last 650,000 years is between 180 to 300 parts per million (IPCC, 2007). Although the ocean acts a natural sink for carbon dioxide (CO_2), there is a limit to how much it can store.

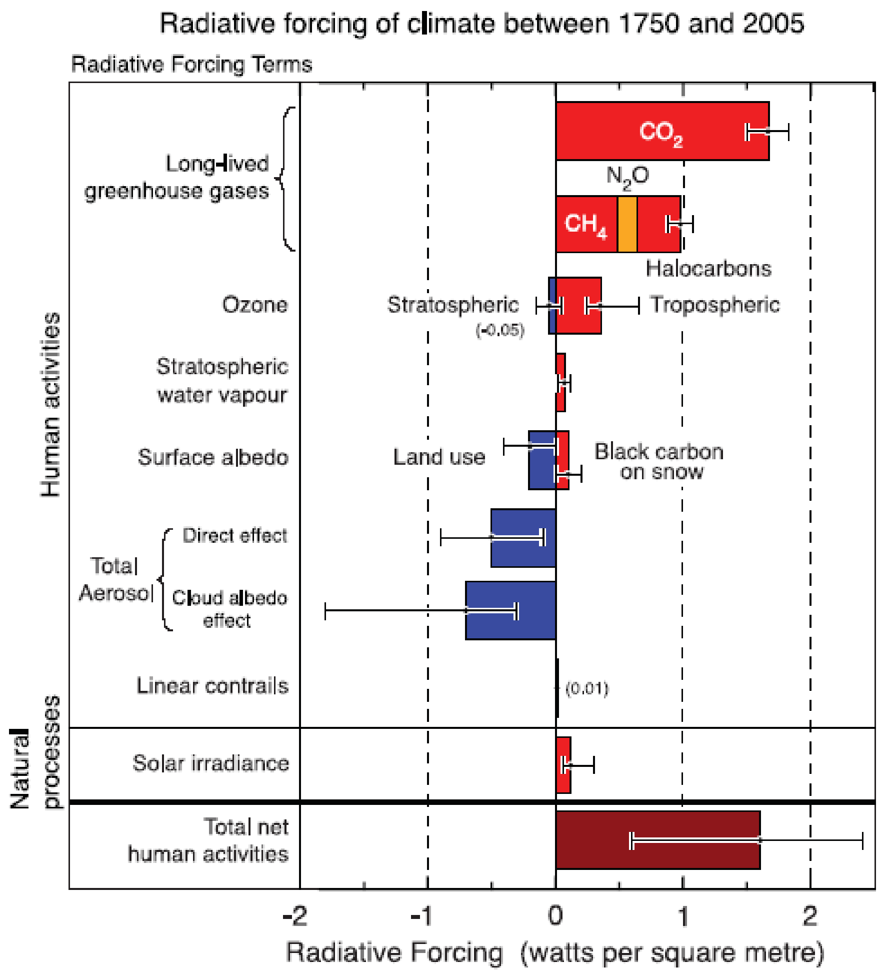


Figure 3.2 Radiative Forcing of Climate between 1750 and 2005 (IPCC, 2007:136)

3.3.3 The Evidence of Anthropogenic Impacts on the Natural Environment

Based on the evidence presented by the IPCC (2007) and taking into account remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations. Also, global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores (IPCC, 2007). Fossil fuel use, agriculture and land use have been the dominant cause of increases in greenhouse gases over the last 50 years.

Greenhouse gas emissions are not the only area of focus in environmental management, however, they have gained the most attention because of the observed long term impact they are having on the climate system. Defra, (2006) have identified 22 environmental performance indicators which are also considered to be significant to UK businesses; these are split into four key areas:

1) Emissions to air
2) Emissions to water
3) Emissions to land
4) Resource use

To help manage these four emission categories, some organisations have now adopted Environmental Management Systems (EMS) like the International Organisation for Standardisation (ISO 14001) or the Europeans Commission's Eco-management and Audit Scheme (EMAS) to provide guidance on mitigating their impact on the environment.

3.4 The Relevance of the Natural Environment to Logistics and SCM

Supply chain and energy security are the two out of four emerging issues that the World Economic Forum has identified as an area that will "*fundamentally shape"* our future and that are "*central to the functioning of the world economy and to the well-being of the global society"* (Halldórsson and Kovács, 2010:6). There is significant pressure on organisations from the government, regulatory bodies, the media and the consumer to reduce emissions of greenhouse gases, to use renewable sources of energy and to reduce the need for energy.

The UK's domestic CO_2 emissions, excluding international aviation and shipping, are generated from three key sectors; energy supply (40 per cent), road transport (26 per cent) and business (15 per cent) (Department for Energy and Climate Change, 2012; Grant et al., 2013) (Figure 3.3, 3.4 and 3.5). Carbon dioxide emissions from transport are rising faster than any other sector and are likely to become the largest source of UK emissions in the near future (Carter, 2007). Since 1990, emissions from road transport have increased by 11 per cent, while emissions from the energy supply industry have reduced by 12 per cent and business emissions have reduced by 19 per cent (Defra, 2009). Within the UK transport sector, 54 per cent of CO_2 emissions are attributable by source to cars, 22 per cent to lorries and 13 per cent to vans. Road Transport therefore is a major contributor to the UK's total carbon emissions and a key area of focus (Figure 3.3).

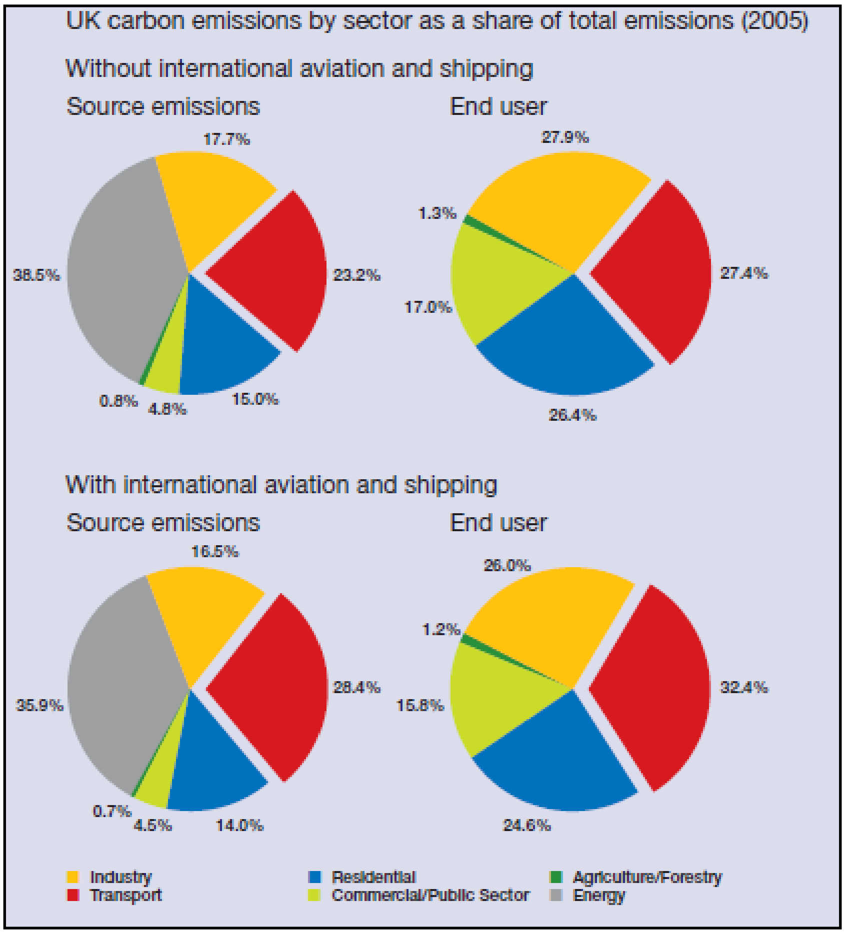


Figure 3.3: Transport and Climate Change (Committee for Integrated Transport, 2007:20)

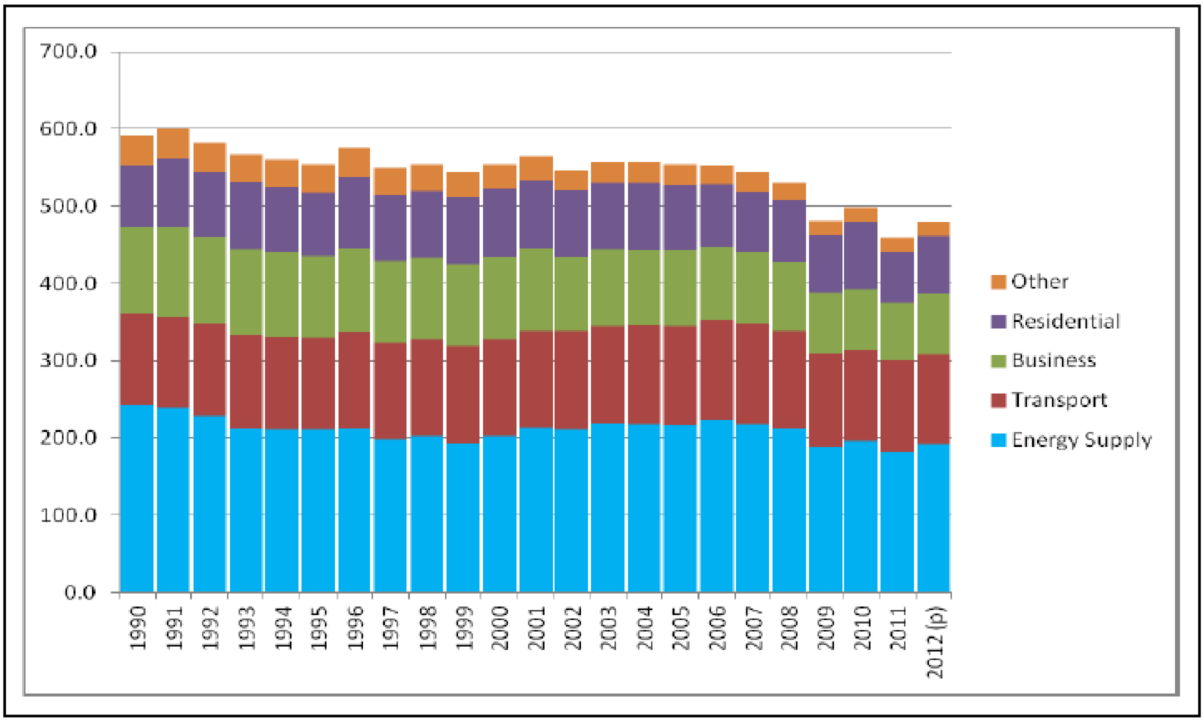


Figure 3.4: UK Carbon Dioxide Emissions by Source in Mt (Department for Energy and Climate Change, 2012:5)

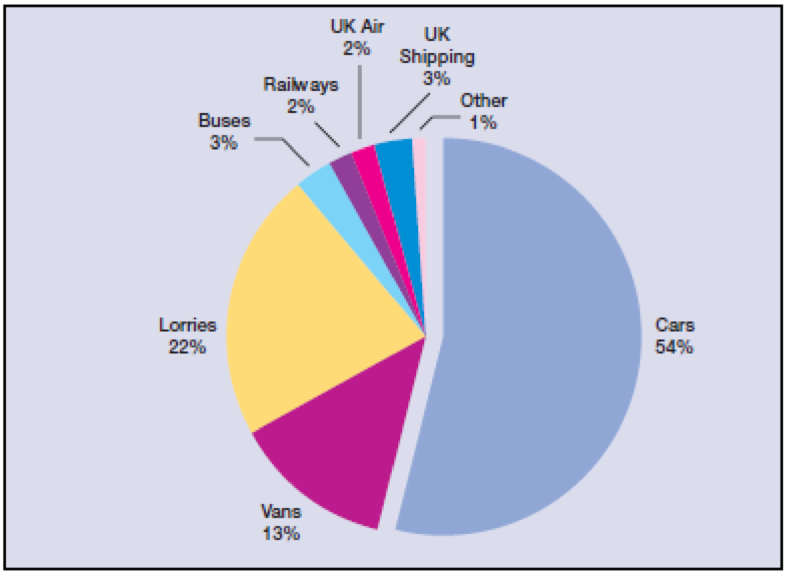


Figure 3.5: UK Transport Carbon Emissions by Mode (Committee for Integrated Transport, 2007:22)

In response to this, the UK government sponsored a KPI benchmarking programme in 1997 and 2002, with the aim of producing a standard set of key performance indicators for private sector companies to use, to make their distribution operations more sustainable. Five key performance indicators were agreed and established: vehicle loading, empty running, fuel efficiency, vehicle time utilisation and deviations from the schedule (McKinnon and Ge, 2004; McKinnon, 2009a). The key themes which emerged are around vehicle utilisation and efficiency. Evidence suggests that CO_2 efficiency increases when companies implement IT based scheduling technology such as telematics to help with route scheduling and improve fuel efficiency (Leonardi and Baumgartner, 2004).

The UK contributes approximately two per cent to global man-made CO_2 emissions and CO_2 accounts for around 85 per cent of the UK's greenhouse gas emissions (Defra, 2009). The transport sector is one of the main sources of pressure on the environment, particularly air pollution. The transport sector accounted for 32 per cent of the total energy consumed in the EU in 2001 and the production of 91 million tonnes of CO_2 (Aronsson and Huge-Brodin, 2006). Furthermore, regardless of country, the energy, transport and business sectors are the key source producers of greenhouse gas emissions globally (IPCC, 2007).

With almost 75 per cent of an organisation's carbon footprint attributable to logistics and transport activity (IOMA, 2008), and the UK transport sector contributing to one third of UK carbon emissions (Transport and Climate Change, 2007), it is no surprise that non-energy companies will begin by assessing the energy consumption of their supply chains as a way to reduce their impact on the natural environment.

3.4.1 The Impact of the Natural Environment on Supply Chains

The word 'natural environment' is referred to in this thesis as an environmental/natural science concept. It describes the interaction of human beings and their organisations (and supply chains) with the natural world.

Abukhader and Jönson (2004) posed two interesting questions in their academic article:

1. What is the impact of logistics on the environment?
2. What is the impact of the environment on logistics?

The extant literature thus far has focused on the impact of supply chains on the natural environment, but not the impact of the natural environment on supply chains. Abukhader and Jönson (2004) found that the existing literature on logistics and the environment was scarce and unbalanced. Abukhader and Jönson (2004) also found that compared to other themes, such as commercial logistics management and information technology, there was much less research on logistics/supply chain management and the environment. With increased focus on global warming and surging oil prices, more emphasis is required on developing GSCM concepts and theories.

Environmental adaptation and preparedness presents an alternative and imperative perspective on environmental management. This is because global supply chains are subject to disruptive risks that are a consequence of natural environmental hazards. This raises the question of how robust and resilient are supply chains against these natural environmental disruptions? (Halldórsson and Kovács, 2010; Macbeth et al., 2009) and how should supply chains learn to predict and adapt to these external disruptions? This is vital to the long term sustainability of supply chains and the natural environment.

The increased frequency of natural environmental disruptions, for example; hurricanes and floods, can be often linked to climate change (both anthropogenic and natural). This has huge consequences on global supply chains and can often highlight the vulnerability of single points of sourcing, export or logistics activities. For example, in June 2008, floods in the US closed a grain and ethanol plant, resulting in delayed shipments of corn syrup, soy meal, ethanol and grain which had major impacts on domestic exports. Earlier in the same year, heavy rainfall caused landslides in Queensland, Australia. This damaged mining operations and access to the rail networks, having a severe impact on mine operations which were responsible for the production of over half of Australia's coal exports (Halldórsson and Kovács, 2010). In April 2010, a 2,000 mile long Icelandic volcanic ash plume stretched across the Atlantic Ocean and into Europe forcing the cancellation of all flights to and from much of Northern Europe. This had a huge impact on travellers, air traffic control, airline companies and airfreight into and out of the UK (Telegraph, 2010). Organisations need to prepare and be aware of early warning systems (EWS) in place to detect and plan for environmental disruptions (IFRC, 2009).

Figure 3.6 illustrates the dyadic relationship between the natural and business environment, highlighting this alternative view, along with the key constructs in the relationship. The success of the relationship is reliant on the organisation's ability to mitigate impacts on the natural environment as well as adapting to future environmental change. It highlights people as an important construct in this process.

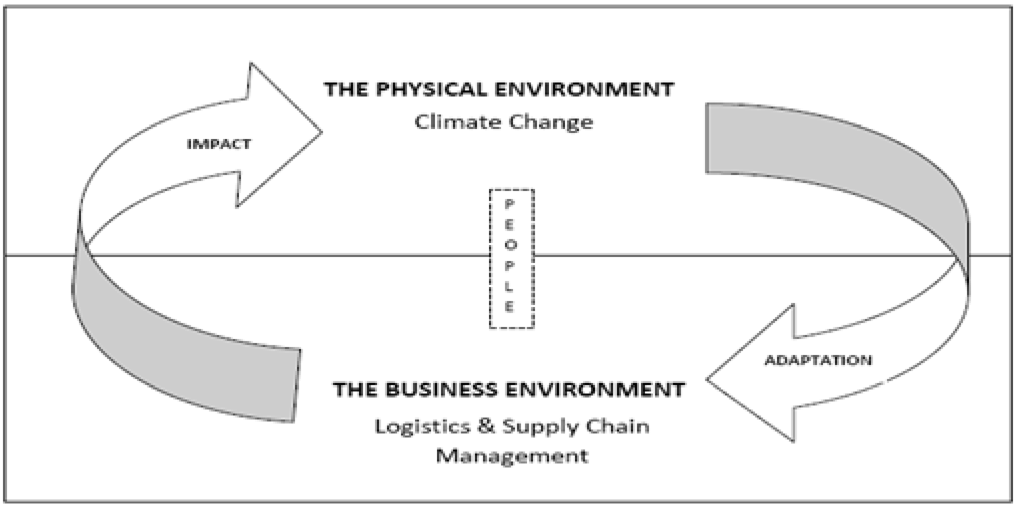


Figure 3.6 Conceptual Model of the Relationship between Logistics and the Natural Environment

3.5 Resource Based View of the Firm and Supply Chain Management

Environmental management both internal and external to the supply chain can be analysed through the resource based view (RBV) of the firm. The RBV of an organisation (Barney, 1986; 1991; Teece, 1987; Wernerfelt, 1984) argues that organisations incorporate privately held knowledge which can be used as a source of sustainable competitive advantage. The RBV distinguishes between resources which can be acquired externally from markets and those that can be developed inside the organisation. To achieve sustained competitive advantage these resources must be unique and not imitable and contribute positively to the organisation's performance (Barney, 1991). Penrose (1959) maintained that a firm can create economic value not by just owning these resources, but by the effective and innovative management of these resources. Resources developed through environmental management can generate unique capabilities such as technological innovation (Russo and Fouts, 1997). The RBV provides an alternative theoretical lens in which to view supply chain management in the context of environmental management (Klassen and Vachon, 2003). People will therefore play an important role in a firm's ability to adapt to changing environmental conditions but at the same time mitigate the firm's impact on the environment (Figure 3.6).

In a study of 164 manufacturing plants, Schroeder et al. (2002) empirically demonstrated that sustained competitive advantage in manufacturing results from proprietary processes and equipment, which in turn are driven by internal and external learning. This inter-organisational learning provides additional capabilities to an organisation. This process of capability development in a supply chain is often referred to as the relational view of supply chain management and is a complimentary perspective to RBV (Klassen and Vachon, 2003). The relational view suggests that organisational capabilities can be developed by the combination of resources existing in different organisations in the supply chain. (Dyer 1996; Lorenzoni and Lipparini 1999; St. John and Harrison 1999; Kaufman et al., 2000; Takeishi, 2001; Dyer and Nobeoka 2002; Schroeder et al., 2002) Therefore, it is possible to make a theoretical link between supply chain activities (green supply chain performance management/adaptation) and overall organisational performance (Klassen and Vachon, 2003).

The RBV theory however "*systematically ignores the constraints imposed by the biophysical environment.*" (Hart, 1995:986). Hart (1995) therefore developed the natural resource based view of the firm (NRBV) which incorporates the natural environment and how this interacts with an organisation (Markley and Davis, 2007).

3.5.1 Natural Resource Based View of a Firm and the Natural Environment

The natural resource based view of the firm (NRBV) offers a similar perspective in which to view environmental management (Klassen and Vachon, 2003). Hart (1995) looked at how internal and external factors are important to a firm’s competitive success. Also how the natural biophysical environment could significantly constrain and affect organisations now and in the future. Hart (1995) believed that the source of competitive advantage in the coming years would be rooted in the capabilities that facilitate environmental sustainable economic activity. Essentially, a firm's competitive advantage will be dependent on the relationship it has with the natural environment and vice versa.

Industrial ecology is gaining in popularity amongst corporate and research communities, particularly given the growing concerns over climate change and energy efficiency. Industrial ecology views the industrial world as a natural ecosystem and offers a fundamental understanding of the value of modelling the industrial system on ecosystems to achieve sustainable environmental performance (Sarkis, 2003). Industrial ecology highlights the importance of the natural environment as a key stakeholder in organisations (Carter and Rogers, 2008) and the role every organisation must play in being sustainable.

An organisation’s capability and willingness to adapt and adopt GSCMPs can be affected by the culture and people within the organisation. Figure 3.6 identifies ‘people’ as a key construct in this relationship. Personal commitments of individuals have been found to be positively related to the adoption of GSCMPs (New et al., 2000). Wycherley (1999) found that environmental activities undertaken at a company site were seen as a way of life and the ethical values of the founder filtered through the whole organisation. This could be further reinforced by the implementation of green performance measures to help drive this cultural/behavioural change ‘top down’ and supports the fact that those organisations that are successful at implementing GSCMPs have incorporated the environment into their corporate strategy. Klassen and Whybark, (1999) argued that the selection of pollution prevention technologies enabled manufacturing organisations to develop capabilities which were often very difficult for a competitor to replicate. Therefore, the leaders in an organisation are imperative to the successful implementation of GSCMPs and are tuned into seeing the commercial as well as the environmental benefits of doing so. Henriques and Sadorsky (1999) also found compelling evidence that an organisation's commitment to the stewardship of the natural environment differed from less environmentally committed organisations in their perceptions of the relative importance of different stakeholders.

Similarly, Hunt and Auster (1990) found different categories or stages of corporate environmental management programs: 1) the beginner, 2) the fire-fighter, 3) the concerted citizen, 4) the pragmatist, and 5) the proactivist. Saha and Darnton (2005) also brought into question motivations for 'greening' and what exactly is green. They identify a number of categories, which are negative viewpoints:

1. Putting their head in the sand
2. Taking a defensive approach
3. Paying lip service to concerns
4. Reactive approaches (following competitors, green marketing, piece meal activities)

Ironically, organisations which tend to be pro-activists or demonstrate green initiatives can be susceptible to attacks from 'green wash' activists who specialise in auditing their reports and actions. In their article, Lyon and Maxwell (2011) looked at how public disclosure of green credentials can be good for public perception but also bad due to exposure to activists labelling them as 'green washing' As a result some firms may only partially disclose their environmental information to the public.

Thus, there are cultural differences between organisations in terms of their capabilities to implement and embrace effective environmental management. The contingency theory perspective can explain why different types of organisations may act in different ways with a 'no one size fits all' approach (Woodward, 1958). Contingency theory is a behavioural theory which helps to explain the differing capabilities a firm may possess which influence how they respond and behave. Woodward (1958) argued that technologies directly determine differences in company attributes, such as, span of control, centralisation of authority, and the formalisation of rules and procedures. The next section explores the importance of logistics and environmental performance to sustainability.

3.6 Logistics and Environmental Sustainability

Environmental sustainability is one of the most important challenges facing the world today. The future challenge is to develop a sustainable global economy, one that the planet is capable of supporting indefinitely (Hart, 1997). At the United Nations Ambassadors Conference on April 20, 2006, the UK Prime Minister made the following speech (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 the 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… A new paradigm that sees economic growth, social justice and environmental care advancing together can become the common sense of our age."

The most well adopted and utilised definition of sustainability is that of the Bruntland Commission (1987:8) defining sustainability as "*development that meets the needs of the present without compromising the ability of future generations to meet their needs."* These broad macro-economic definitions of sustainability often make it difficult for organisations to implement sustainable strategies because they are not explicit and intuitive, for example; where does an organisation begin in becoming sustainable? Micro definitions of sustainability are therefore more useful to organisations to apply, for example, Shrivastava (1995:955) describe sustainability as "*the potential for reducing the long term risks associated with resource depletion, fluctuations in energy costs, product liabilities, and pollution and waste management.*" To an organisation this is far more intuitive and specific and provides a clear guidance on what they should be focusing on. This generic approach to sustainability and green logistics is what causes confusion and ambiguity, resulting in a lack of action and paralysis.

Sustainability is important in the context of SCM as there is a demand from consumers for more sustainably sourced products which has led to an increased competiveness in the market place. Organisations are also under pressure from the government and non-governmental organisations to demonstrate sustainable business practices, particularly in the light of energy security and increased fuel costs (Wolf and Seuring, 2009). It is becoming increasingly important for organisations to evaluate the impact that a sustainable supply chain strategy has on the triple bottom line (Markley and Davis, 2007). There is a need for organisations to move away from evaluating just their traditional financial bottom line, but to also evaluate their social and environmental performance. This is important because of a genuine care for the long term future of the planet and also the obvious win win opportunities in terms of environmental and organisational performance which translate into competitive advantage, leading to greater profitability (Klassen and Vachon, 2003). Companies that understand and value their ecosystem impacts, dependence and holdings will have a major advantage over their competition, according to a key presentation by The World Business Council for Sustainable Development (WBCSD, 2011).

Halldórsson and Kovács (2010) also demonstrated the importance of sustainability to supply chains by illustrating the tensions between the use of these natural resources, such as fossil fuels and the ecosystem (Figure 3.7). Natural resources such as water and non renewable fossil fuels are consumed by industry during manufacturing and during the transportation of products between different sites in the supply chain. This results in the emission of greenhouse gases and waste for landfill, which in turn affect the climate system; resulting in the creation of natural disasters and disruptions. These in turn disrupt supply chains. Rising costs of energy have a direct impact on supply chain operating costs and the cost of goods sold globally. Energy efficiency and reduction is vitally important in the context of SCM as the supply chain is one of the biggest energy consuming parts of a business; thus particularly sensitive to environmental disruptions. Figure 3.7 helps to conceptualise this close and sensitive relationship.

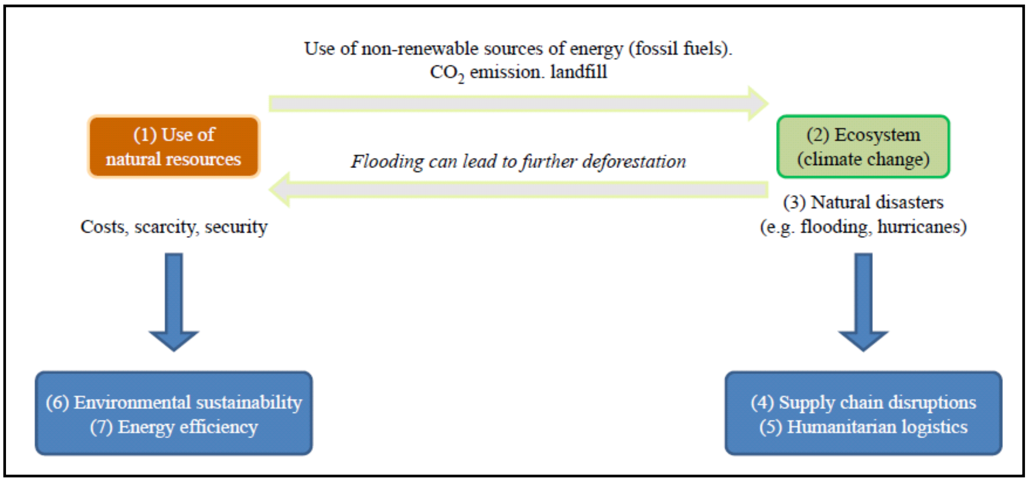


Figure 3.7 - The Energy and the Sustainability Agenda in Logistics and Supply Chain Management (Halldórsson and Kovács, 2010:7)

The natural environment contains, amongst other things, air, water and land, without which ecosystems would not exist. Society and humans are both a participant in and exploiter of the natural environment. Society's use of the natural environment's resources to produce economic goods and services does and can upset the fragile balance (Murphy et al., 1994).

Logistics and SCM present a major challenge to sustainability in the way products are transported, handled, stored, manufactured and supplied throughout the world. Fresh air and excess packaging are shipped, with empty return loads (McKinnon and Ge, 2006), products sit idle and become obsolete in warehouses, unnecessary products move backwards and forwards. Supply chain networks are not robust and innovation is thwarted as every company works to achieve targets within their own silos, all of which has an impact on the natural environment. It is therefore important for organisations to be able to measure this environmental impact and reduce it.

Carter and Rogers (2008) introduce the concept of sustainability as the integration of environmental, social and economic criteria. The integration of these criteria enables an organisation to fulfil long term economic viability. The authors explore the concept of organisational sustainability and look at how it can be applied to SCM. Following a synthesis of the literature, they present a framework that suggests that organisational sustainability in its broadest sense includes three key concepts: environmental, social and economic performance (Figure 3.8). This directly corresponds with the idea of the '*triple bottom line'* which was developed by Elkington (1998; 2004) and highlights that environmental performance is a key component of measuring sustainability.

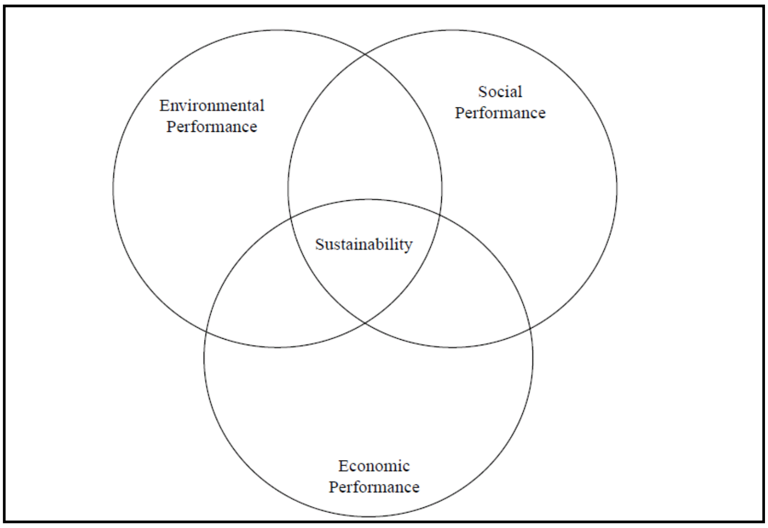


Figure 3.8 – The Triple Bottom Line (Carter and Rogers, 2008:365)

Carter and Rogers (2008: 368) define sustainable supply chain management (SSCM) as:

"The strategic, transparent integration and achievement of an organization's social, environmental, and economic goals in the systemic coordination of key interorganizational business processes for improving the long-term economic performance of the individual company and its supply chain."

Carter and Rogers (2008) illustrate this in Figure 3.9, by demonstrating the good, better and best approach to SSCM. They suggested that true sustainability occurs when an organisation explicitly and comprehensively incorporates social, environmental and economic goals within their overall business strategy; only then can it be embedded within the strategy and culture of an organisation. This was also noted by Carter and Jennings (2002) and they found that Logistics Social Responsibility (LSR) can be positively influenced by an organisational culture and those individuals whose personal beliefs and values support LSR. Carter and Rogers (2008) found that most logistics research has examined issues such as the environment, safety, human rights in a standalone fashion without exploring the interrelationship among these. They believe that supply chain professionals are in an outstanding position to impact sustainable practices.

Environmental and social goals can often go beyond a company's organisational boundaries and extend into the larger supply chain networks. This presents a number of challenges for organisations when implementing sustainability, firstly, the control they have over other parts of the supply chain network can often make the triple bottom line difficult to implement and co-ordinate (Carter and Jennings, 2002; Carter and Rogers, 2008). Secondly, with no measurement scales in place, it is difficult for organisations to know how they are doing in relation to others (Shaw et al., 2010). Thirdly, some organisations have already captured the low hanging fruit and now need to make long term investments to take sustainability to the next level; this represents a huge step with no guarantees of a return on their investment.

There are some obvious advantages to implementing sustainability. There are cost savings due to reduced packaging waste (Mollenkopf et al., 2010), reduced health and safety costs, and lower recruitment and labour turnover costs because of safer and better working conditions (Brown, 1996; Carter et al., 2007). The authors suggest the next logical step would be to develop measurement scales for the triple bottom line. This corresponds with the objective of this thesis, which is to develop and test appropriate green performance measures for the supply chain. It also helps to conceptualise and position this research in terms of where it fits within the overall supply chain sustainability framework (Figure 3.9).

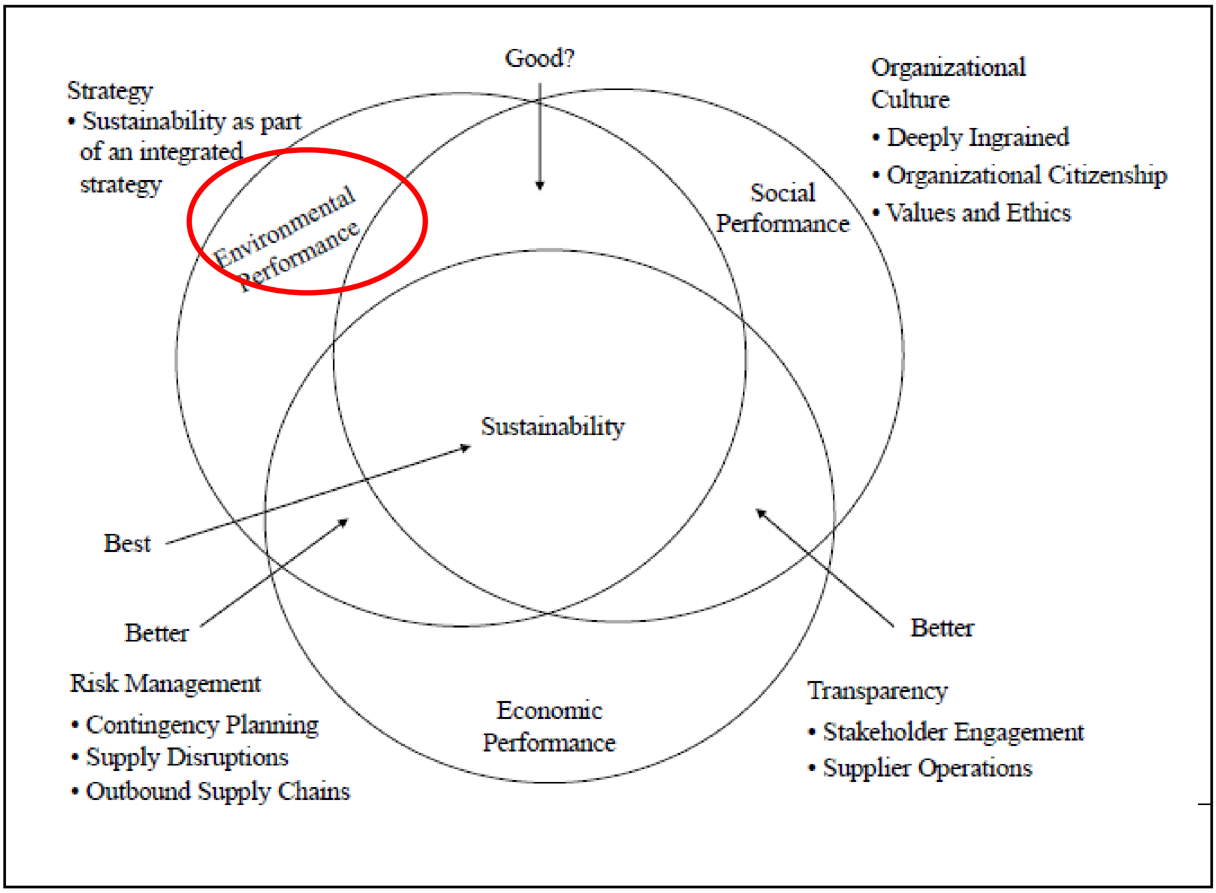


Figure 3.9 – Sustainable Supply Chain Management Framework (Carter and Rogers, 2008: 369). Red circle defines the scope of this thesis.

Organisational ecological theory presents an interesting and important angle in which to view sustainability and has theoretical links to NRBV. It analyses populations of organisations (like organisms) to examine their birth and mortality over long periods of time. By viewing firm size, age, density and various other factors it draws attention to what helps organisations survive over long periods of time (Connelly et al., 2011). This is particularly important in the context of this thesis, as those firms which are proactive in implementing sustainability initiatives, and that are prepared to measure their environmental impact, are the ones which adapt and survive (Shrivastava, 1995). Being proactive towards a challenge of this kind requires some element of a performance management system (Epstein and Wisner, 2001). Sustainability is one of the biggest challenges facing the future of supply chains in terms of supply chain design, integration and management (Beamon, 2008).

3.7 Summary

This chapter has discussed the issues surrounding the natural environment and climate change and why this is so relevant to the logistics and SCM discipline. The chapter has also examined in detail the history and science behind climate change, addressing not only the impact of supply chains on the environment but the impact of the natural environment on supply chains. It has done so by linking GSCPM to existing organisational theory which has helped to position this research within the broader field of supply chain sustainability. Chapter Four will now explore the concept of GSCM to understand its history and scope as a management theory.

CHAPTER FOUR

GREEN SUPPLY CHAIN MANAGEMENT

4.1 Introduction

The cross-disciplinary field of green supply chain management (GSCM) is growing and in its early phases of development both academically and practically. To effectively and empirically advance theory within this field, some useful and testable multi-item measurement scales are required (Zhu et al., 2008a). GSCM is growing in interest amongst supply chain researchers and practitioners because of climate change issues, diminishing raw materials, excess waste production, increasing levels of pollution and because it is a good source of competitive advantage. GSCM has its roots in environmental management and SCM. Incorporating the green component into SCM involves addressing the influence and relationship of SCM with the natural environment. It is therefore important to explore and understand the field of environmental management within a general business context prior to reviewing GSCM (Srivastava, 2007).

4.2 Green Supply Chain Management Definitions

The scope of the term 'green' is considerable; at least 1,500 articles have been published in GSCM in scholarly journals and edited in books thus far (Srivastava, 2007). GSCM can relate to issues such as ecological concerns, conservation, corporate social responsibility (CSR), humanitarian concerns, fair trade, clean water, animal welfare, equality and sustainability. This presents a number of challenges as the broad and complex definition can imply different things to different people (Saha and Darnton, 2005).

Similar to the concept of SCM, the definition and scope of GSCM in the literature is broad and complex and ranges from internal environmental management practices such as ISO 14001 and European Community Eco-management and Audit Scheme (EMAS) through to green purchasing, eco-product design, investment recovery, waste management, pollution control, customer co-operation and reverse logistics (Zhu et al., 2008a; Zhu and Sarkis, 2004) (Figure 4.1).

Numerous acronyms have been used in the literature to describe GSCM, for example GrSCM (Srivastava, 2007), GSCM (Zhu and Sarkis, 2004) and G-SCM (Sheu et al., 2005). For this thesis, the term green supply chain management will be used. It is important to note that in some research, the term GSCM represents global supply chain management; however in the context of this thesis, it is defined as green supply chain management (Zhu and Sarkis, 2004).

Categories of green supply chain management from literature
Internal environmental management
Commitment of GSCM from senior managers
Support for GSCM from mid-level managers
Cross-functional cooperation for environmental improvements
Total quality environmental management
Environmental compliance and auditing programs
ISO 14001 certification
Environmental management systems exist
External GSCM practices
Providing design specification to suppliers that include environmental requirements for purchased item
Cooperation with suppliers for environmental objectives
Environmental audit for suppliers' internal management
Suppliers' ISO14000 certification
Second-tier supplier environmentally friendly practice evaluation
Cooperation with customer for eco-design
Cooperation with customers for cleaner production
Cooperation with customers for green packaging
Investment recovery
Investment recovery (sale) of excess inventories/materials
Sale of scrap and used materials
Sale of excess capital equipment
Eco-design
Design of products for reduced consumption of material/energy
Design of products for reuse, recycle, recovery of material, component parts
Design of products to avoid or reduce use of hazardous of products and/or their manufacturing process

Figure 4.1 – Green Supply Chain Management Categories (Zhu and Sarkis, 2004:268)

There are various definitions of GSCM in the literature, some are very specific, referring to discrete parts of the supply chain, for example Gilbert (2001) described greening supply chains as the process of incorporating environmental criteria or concerns into organisational purchasing decisions and long term relationships with suppliers (Diabat and Govindan, 2011). In contrast, authors such Zsidisin and Siferd

(2001), Srivastava (2007) and Sarkis et al. (2011) have taken a broader view of SCM and GSCM. Zsidisin and Siferd (2001:69) defined GSCM as:

"The set of supply chain management policies held, actions taken and relationships formed in response to concerns related to the natural environment with regard to design, acquisition, production, distribution, use, re-use and disposal of the firm's good and services."

Srivastava (2007:54) defined GSCM as:

"Integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end of life management of the product after it useful life."

Sarkis et al. (2011:3) defined GSCM as:

"Integrating environmental concerns into the inter-organizational practices of SCM including reverse logistics."

These three definitions have a number of themes in common; firstly, people are vital to the process of GSCM, in terms of how they influence the process through leadership, decision making, management practices, actions and policies. This supports the NRBV theory discussed in Section 3.5.1. Secondly, GSCM is boundary spanning and very similar to the SCM definitions described in Section 2.3.2, in that GSCM covers all elements of the supply chain network, upstream and downstream, from sourcing through to delivery to the customer and reverse logistics. Thirdly, the natural environment is an essential part of why organisations are implementing GSCM; organisations are under pressure to mitigate their impacts on the natural environment. No definition exists so far on environmental adaptation (Figure 3.6) or competitive advantage. The existing definitions are internalised and describe what the concept is, from an inter-organisational perspective, but not a great deal is described on what drives or motivates GSCM from a corporate strategy point of view.

GSCM is essentially a concerted effort throughout an organisation to provide a holistic improvement of the environmental performance at all levels of management right through to the shop floor (Davies and Hochman, 2007). It is a managerial approach that seeks to minimise a product's environmental and social impact (Rettab and Ben Brik, 2008). There have been a large number of special issues devoted to this research area, which have concentrated on specific nodes or activities within the supply chain, for example: green purchasing or reverse logistics. The fragmentation and complexity of this research supports the fact that this is fertile and growing area of research. Srivastava (2007) also found the literature and existing empirical research on GSCM compartmentalised and identified the need to integrate the contribution. There is a requirement to pull together the research and make sense of it all, in order to help move the discipline forward and provide guidance to practitioners.

4.3 Green Supply Chain Management Implementation and Organisational Theories

Sarkis et al. (2011) use organisational theories to categorise the GSCM literature. This provides opportunities to address both the objectives and understanding of where the field currently stands and identifies research opportunities and future direction. They categorise GSCM under nine broad organisational theories (Table 4.1).

Table 4.1 – GSCM Organisational Theory (Sarkis et al., 2011:4)

Organisational Theories with abbreviations
1. Complexity theory (CT) 2. Ecological Modernization theory (EMT) 3. Information theory (IFT) 4. Institutional theory (IST) 5. Resource Based View (RBV) 6. Resource Dependence theory (RDT) 7. Social Network theory (SNT) 8. Stakeholder theory (ST) 9. Transaction costs and economics theory (TET)

The CT, RBV and RDT are particularly relevant in the context of this thesis as they tie together the issues and barriers which surround GSCPM. Firstly, as complexity increases such as pressure from the government, customers, suppliers, regulations and stakeholders; organisations find it difficult to plan and predict organisational actions. Organisations also find it difficult to make sense of what they are expected to measure and it is the aim of this thesis to answer these questions and provide direction/clarity.

Secondly, RBV, inter-organisational learning and knowledge are crucial to the development of GSCM practices and in developing competitive advantage. Those organisations that have a strong learning and innovative culture will be the first to measure their GSCPM, act upon this information and benchmark this against their peers. These organisations will generate a rare, valuable, non substitutable ability to implement and manage GSCMPs (Barney, 1991). Zhu et al. (2008b) found significant positive relationships between organisational learning mechanisms, organisational support and the adoption of GSCM practices in Chinese manufacturing firms; thus people are a vital part of the GSCM process.

Finally, RDT highlights the fact that GSCM performance is "*fertile for investigation*" (Sarkis et al., 2011:4). There is an opportunity for supply chain partners to collaborate together (rather than working in isolation or silos) to seek higher GSCM performance gains. They should do this rather than seeking expensive short term performance gains. An important assumption of RDT is that organisations cannot be self sufficient in terms of survival; they need to depend on other organisations to compete and survive (Sarkis et al,. 2011). Inter-organisational relationships are essential for managing the internal and external co-ordinations for GSCM to gain performance outcomes (Zhu et al., 2010; Sarkis et al., 2011). Vachon and Klassen (2006a) also found similar findings in their study of green project partnerships in the print packaging industry. They identified that interaction with suppliers and customers can help develop more effective solutions to environmental challenges. Cheng et al. (2008) also found that trust is a pivotal factor influencing inter-organisational knowledge sharing in green supply chains. There is also empirical evidence showing a positive relationship between resource dependency in the form of relational resources and supply chain performance (Yang et al., 2008). Therefore, the collaborative paradigm as well as people, is essential in the implementation of GSCM. Together, these three theories highlight the organisational motivations and pressures, (both internal and external) in the adoption of GSCMPs, and are important in understanding and developing GSCPM variables.

4.4 Green Supply Chain Management - Drivers, Barriers and Motivations

Walker et al. (2008) explore in some detail the factors that drive or hinder GSCMPs and which generate complexity in the private and public sectors. In their exploratory study they found more studies identifying drivers than barriers to GSCMPs. They also found that drivers and barriers could be both internal and external to an organisation. The main categories of internal and external drivers of GSCM practices include organisational factors. Other drivers categorised include regulations, customers, competitors and society in general. Internal barriers include cost and poor supply chain partner co-operation. Similarly, Saha and Darnton (2005) found that the principle reason for going green was not a genuine care for the environment; it was a reactive response to the pressures from government legislation, non governmental organisations (NGO), customers and stakeholders. It was also seen as a way to gain more business, save costs, and to enhance the company image.

Holt and Ghobadian (2009) identified that GSCM outputs are influenced by external and internal factors (Figure 4.2). They looked at the extent and nature of greening the supply chain in the UK manufacturing sector and the factors which affect this. They found on average that manufacturers perceived the greatest pressure to improve GSCM practices through legislation and internal drivers, with the least influential pressures being societal and customers. They also found that manufacturers were more likely to focus on higher risk GSCMPs rather than engaging in more proactive, external engagement processes. Similarly to the RBV, Holt and Ghobadian (2009) also found organisations that had a positive environmental attitude are more likely to engage in more progressive GSCMPs. The engagement of managers is crucial to drive forward an internal environmentally focused culture.

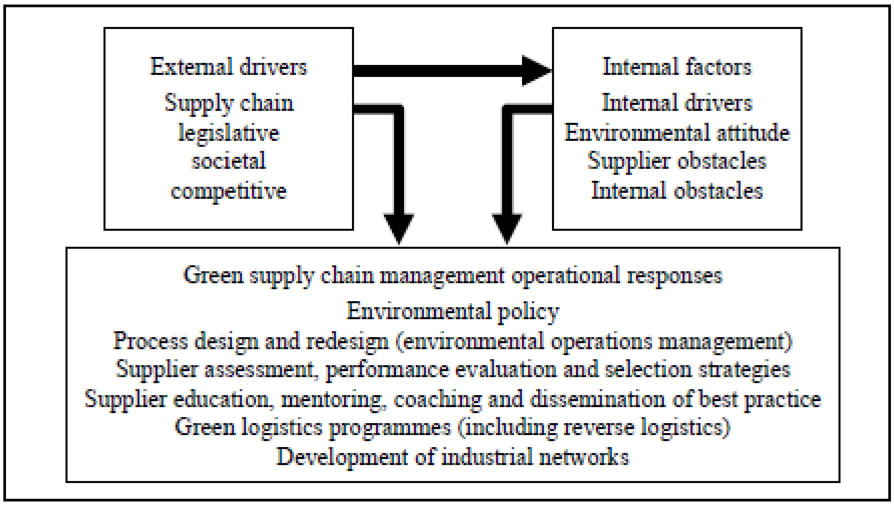


Figure 4.2 – GSCM Pressure/Response Model (Holt and Ghobadian, 2009:938)

Other important variables can affect the implementation of GSCM, for example, company size is an important variable in GSCM and the environmental management literature (Grant et al., 2002; Klassen, 2000). In an academic survey of 135 companies Murphy, et al. (1995, 1996) found smaller companies attached less importance to the management of environmental issues when compared to larger firms. Walton et al. (1998) also found in a study of manufacturers that convincing small companies to become involved in green purchasing was a major barrier. In a more general study of corporate performance and environmental consciousness, Ahmed et al. (1998) found that larger companies are more inclined to be environmentally conscious (Sarkis, 1999) and more inclined to adopt and embrace green purchasing practices than smaller organisations. In fact, small organisations are more preoccupied with short-term issues and more reactive to environmental issues and regulations than larger organisations (Grant et al., 2002; Vachon and Klassen, 2006b).

In terms of RBV theory, smaller organisations have fewer resources and less knowledge to share with suppliers and customers which means they cannot capitalise on the collaborative paradigm like larger organisations. There are also trust issues in sharing the limited resources and knowledge they possess. Other important contextual variables include country of origin and sector, for example, Zhu et al. (2008b) found a difference in the extent to which GSCMPs were adopted by Chinese manufacturers and that the electronics industry in China has the highest level of adoption of GSCMPs compared to other industries in China. This was because of high degree of government pressure and legislation imposed on this sector. Zhu et al. (2008b) also found that investment recovery in the four Chinese industries gained less attention than in more developed countries and that Chinese manufacturers are still lacking the knowledge, experience and tools to effectively and efficiently improve their environmental performance. Azzone et al. (1997) also found industrial differences in how organisations incorporate environmental strategy and that GSCMPs and their associated benefits are influenced by sector, company size, risk and nationality, with no 'one model fits all' solution (Sarkis, 1999).

There is compelling evidence that the adoption of GSCMPs can lead to substantial cost savings, increased market share and greater profit margins (Rao and Holt, 2005; Ubeda et al., 2011). Contradictions, however, can be found in the literature, for example Testa and Iraldo (2010) found that cost efficiency appears to be a weak driver of GSCM because the upfront investments are expensive and largely turn companies off investing in these practices. GSCM is deemed as an expensive activity and often results in increases in price in the short term. Therefore, the investment in GSCM should be viewed by organisations as a long-term opposed to short term strategy.

Mollenkopf et al. (2010) examined the relationship between lean, green and global supply chain strategies (Figure 4.3). They provided an in-depth examination of the barriers, drivers, contradictions and synergies associated with the three supply chain strategies. They found that it has become increasingly difficult to have a global supply chain which is both lean and green and the three strategies are not always compatible. The existing literature has so far concentrated on individual strategies but not how these strategies can be implemented concurrently.

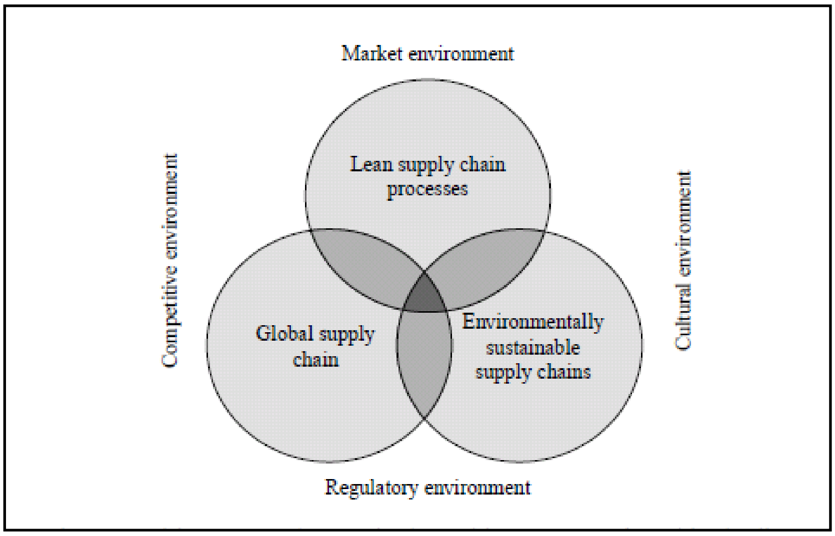


Figure 4.3 – Green, Lean and Global Supply Chains (Mollenkopf et al., 2010:16)

Figure 4.3 is relevant to this thesis because it provides an alternative theoretical lens in which to view GSCM and thus GSCPM. One key finding from the work of Mollenkopf et al. (2010) was a significant lack of integrated metrics and measurements tools for managers to implement lean and green strategies across global supply chains. These metrics and measurements would help to facilitate integration and holistic decision making across the supply chain. Mollenkopf et al. (2010) also found that there was a significant opportunity to study the role of corporate culture in the implementation of lean and green strategies in global supply chains. This supports the importance of RBV and NRBV theory which was discussed in Section 3.5. People play a vital role in the green logistics process and undoubtedly will in the development and implementation of GSCPM.

Mollenkopf et al. (2010) also make reference to the RDT theory in their review of GSCM literature, identifying that organisations are under pressure by stakeholders to be more environmentally conscious and to integrate environmental management into their processes and strategy. Collaboration across all nodes of the supply chain develops knowledge sharing capabilities that will serve as a source of sustainable competitive advantage (Hart, 1995; Vachon and Klassen, 2008).

Organisations are therefore faced with a great deal of complexity in terms of implementing both GSCMPs and GSCPM. There is a requirement to simplify and provide clarification on how this can be achieved.

4.5 Summary

The recent and continuous growth in the GSCM literature demonstrates that this is an area of significant research potential and that the research problem is still developing and in its infancy. Most of the extant literature on GSCM has been descriptive, and anecdotal with existing empirical research focusing predominantly on individual nodes within the supply chain. Academic journals have only just begun to address issues that have been appearing in the trade journals since the early 1990's. With only a few empirical studies (mainly in the manufacturing sectors), which have been exploratory; there is a requirement to expand the theoretical lens across the broader supply chain to enable managers to effectively manage their green, lean and global supply chains.

There are also gaps in the current GSCM literature, firstly, a lack of integration or systems thinking to tackling the complexity and barriers associated with greening global supply chains, and secondly, a lack of metrics and measurement tools to help drive the GSCM process throughout the entire supply chain.

The next chapter will examine the literature on GSCPM, which will set the stage for the development and testing of GSCPM variables for the supply chain.

CHAPTER FIVE

GREEN SUPPLY CHAIN PERFORMANCE MEASUREMENT

5.1 Introduction

Business environments, like physical environments, change over time. To survive and prosper in a rapidly changing environment, organisations must be ready and willing to adapt. One of the most important agenda items in any boardroom is to ensure that performance measurements reflect the business requirements today and in the future (Kennerley et al., 2003; Clarke and Watkins, 2003). A significant amount of literature and research on performance measurement has been published and analysed; and although research in this field is relatively young and immature, it is still rapidly developing and evolving (Taticchi et al., 2010). This chapter introduces the concepts of performance measurement in the context of logistics, SCM and the natural environment and reflects back on the literature in Chapters Three and Four to help contextualise and develop green performance measures for the supply chain.

5.2 The History of Performance Measurement

A performance measure can be defined as a set of metrics or measures used to quantify the efficiency and/or effectiveness of an action (Neely et al., 1995). It is a verifiable measure, which can be expressed in either quantitative or qualitative terms with respect to a reference point. Performance measures are important in translating an organisation's mission or strategy into reality. Their role is to communicate, control and improve (Melnyk et al., 2004) and to analyse both the effectiveness and efficiency in accomplishing a given task (Mentzer and Konrad, 1991). Performance measures can also be measured on three levels: strategic, tactical and operational (Gunasekaran et al., 2001).

Performance measures are essential for managing and navigating organisations through turbulent and competitive global markets. They allow organisations to track progress against their strategy, identify areas for improvement and they act as a good benchmark against competitors or industry leaders. The information provided by performance measures allows managers to make the right decisions at the right times (Gunasekaran et al., 2004).

Traditionally, performance measures have been orientated around financial metrics such as return on investment (ROI), return on capital employed (ROCE) or profit, that record how an organisation has performed in the past but not necessarily how it will perform in the future. Traditional financial performance measures worked well previously, but are now out of step with the skills and competencies organisations are trying to master today (Kaplan and Norton, 1992).

There are a number of theories regarding how the concept of performance measurement was first developed. Johnson and Kaplan (1987) believed it originated during the industrial revolution. In contrast, Morgan (2004) suggested that modern performance measurement originated in Venice during the fifteenth century with the invention of double book-keeping in accounting. In any event, performance management emerged as a dominant field of research as early as the 1950's when academics and practitioners became interested in the need to measure and the unanticipated consequences of such measurement (Argyris, 1952; Ridgway, 1956).

Morgan (2007) identified five stages in the evolution of performance measurement (Figure 5.1) starting with the basic measurement of financial transactions (Step One) which was important from a 'buy cheap, sell dear and make profit' perspective. Step Two developed with the onset of the industrial revolution and with increased focus on manufacturing and operations management. Efficient resource utilisation was vital with increased competition for products, services and customers and therefore performance measurement around making the manufacturing process more efficient were vitally important. Step Three prevailed up until the end of World War II, after this, there was a slow emergence of the 'quality revolution'; Step Three. During Step Three, there was a shift from an internal to external performance measurement focus with the customer becoming central to performance measurement, such as product and service quality and customer satisfaction. Similar parallels can be drawn between this phase and Kent and Flint's (1997) Era Four in the evolution of logistics. Kent and Flint (1997) also identified this customer centric phase which resulted in the generation of multiple performance metrics, which demonstrated how both concepts have developed side by side. In parallel to this and with the increased level of business complexity, there was a call for a more balanced and simple view of the organisation. There were too many metrics in circulation, with some organisations using hundreds of metrics often not aligned to their business strategy (Hoffman, 2006). This generated Step Four, with the introduction of the most widely reviewed and evaluated article by Kaplan and Norton (1992), the balanced scorecard (BSC) as a performance measurement system. The objective of the BSC was to provide a more simplified and balanced set of measures for organisations to focus on. The final step identifies a new phase which Morgan (2007) describes as a shift from unitary to pluralist perspective. Morgan (2007) posits that customer satisfaction can only come from a fully effective supply chain network and set of processes. There is a requirement for performance measurement systems to break through the dyadic relationship barrier and make the management of the entire supply chain a more realistic aspiration. What Morgan (2007) may be describing here is very similar to Kent and Flint's (1997) Era Five and Six. Like the evolution of logistics, performance measurement is also at a critical juncture and in a state of flux. Generated off the back of the world recession; the rapid expansion of global supply chains, unpredictable customer demand, climate change, political unrest and volatility in fuel costs. This has caused firms to re-address their supply chain strategies and performance measurements to ensure they are equipped for this changing business environment. Performance measurement is entering a new era of change.

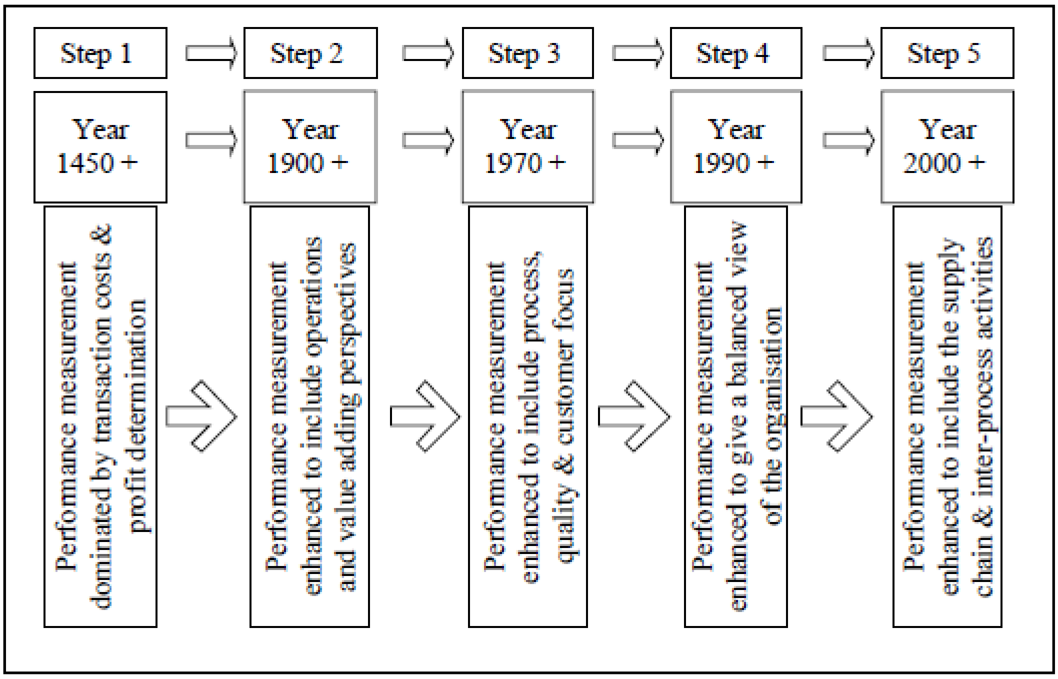


Figure 5.1 – The Phases of Development of Performance Measurement (Morgan 2007:256)

Performance measurements continually evolve as new challenges are met and traditional performance measurement approaches are being called into question because of the changing nature of business and the environment. Morgan (2007) identified a significant move away from the traditional transaction focused measurements to process focused measurement systems; from ‘process only’ to ‘process and process interface’ systems; from monoculture to polycultural measurement systems; and from measurement proliferation to measurement simplification (Glaister and Buckley, 1998; Bititici et al., 2005; Yilmaz and Bititci, 2006). Morgan (2007) also identified the environment as one of the key challenges facing performance measurement evolution, which is central to this thesis.

A significant amount of literature has been published on the subject of performance measurement. Between 1994 and 1996, some 3,615 articles were published on performance measurement. In 1996, one new book on performance measurement appeared every five hours of every working day. Neely (1999) described this as a ‘performance measurement revolution’. The evidence suggested that this revolution happened because of seven main drivers (Neely 1999:210):

1. The changing nature of work
2. Increasing competition
3. Specific improvement initiatives
4. National and international awards
5. Changing organisational roles
6. Changing external demands
7. The power of information technology

One common theme emerges from Neely’s (1999) seven main drivers for the performance measurement revolution and that is ‘change’. Performance measurements and systems must be continually reviewed to ensure they meet the needs of the organisation and the changing business environment.

Kennerley et al. (2003) also identified the key barriers to and enablers of good performance measurement evolution and the four steps to effective performance measurement evolution (Figure 5.2). They drew similar conclusions to those posited by Neely (1999), however, Kennerley et al. (2003) also identified four critical steps which influence the performance measurement evolution: 1) culture, 2) process, 3) people, and 4) systems.

Critical Factors	*Barriers to Measures Evolution*	*Enablers of Measures Evolution*
Culture	• Management inertia towards measures due to other priorities • *Ad hoc* approach to measurement • Measures not aligned to strategy • Actions not aligned to measures • Lack of management concern for non-investor stakeholders	• Senior management sponsorship • Consistent communication of multi-dimensional performance to staff • Open and honest application of measures • No blame / No game environment • Integration and alignment of reward systems
Process	• Lack of proactive multi-dimensional performance review process • Poor measures selection approach • Lack of data analysis and insights • Insufficient measure ownership delegation • Ownership of cross-functional measures not addressed	• Integration of measures with strategy development • Integration of measures with process redesign • Inclusion of non-financial measures in business performance reviews • Formal measures review process conducted at regular intervals
People	• Lack of manager / supervisor training in managing with measures • Shortage of data analysis skills and specialist resources • Shortage of expert IT data extraction programming staff • High staff turnover	• Provision of appropriate performance measurement resource • Investment in measures usage and analysis skills-building • Inclusion of appliance of measures in employee performance reviews • Community of measures users who make improvement suggestions
Systems	• Inflexible legacy systems • Poorly or partially implemented ERP systems • Difficult to tailor 'off-the-shelf' performance reporting software • Poor use of graphical representation • Excess of raw data	• Investment in IT hardware and software • Data mining / warehousing capability • Readily customisable information systems • Internal systems development and adaptation capability
External/ Internal Triggers	• Changes in regulatory/legislative requirements • Changes in competitive environment • Changes in company ownership • Changes in management • Changes in technology	

Figure 5.2 Barriers to and Enablers of Performance Measurement Evolution (Kennerley et al., 2003:39)

In their literature review of performance measurement and management, Taticchi et al. (2010) also found a certain maturity of the literature relating to large organisations and a significant lack of performance measurement and management literature for small and medium sized enterprises (SMEs). They also noted that the development and evolution of this research field is at a critical point, entering a phase or new direction, categorised by context, by theme and by challenge. One of the key challenges identified is the natural environment.

Taticchi et al. (2010) also analysed all publications on the ISI Web of Knowledge database (2009) containing the key word 'performance measurement' in the title or abstract. They found 6,618 papers published in 546 journals with the earliest publication in 1970 and the most recent in 2008 (Figure 5.3).

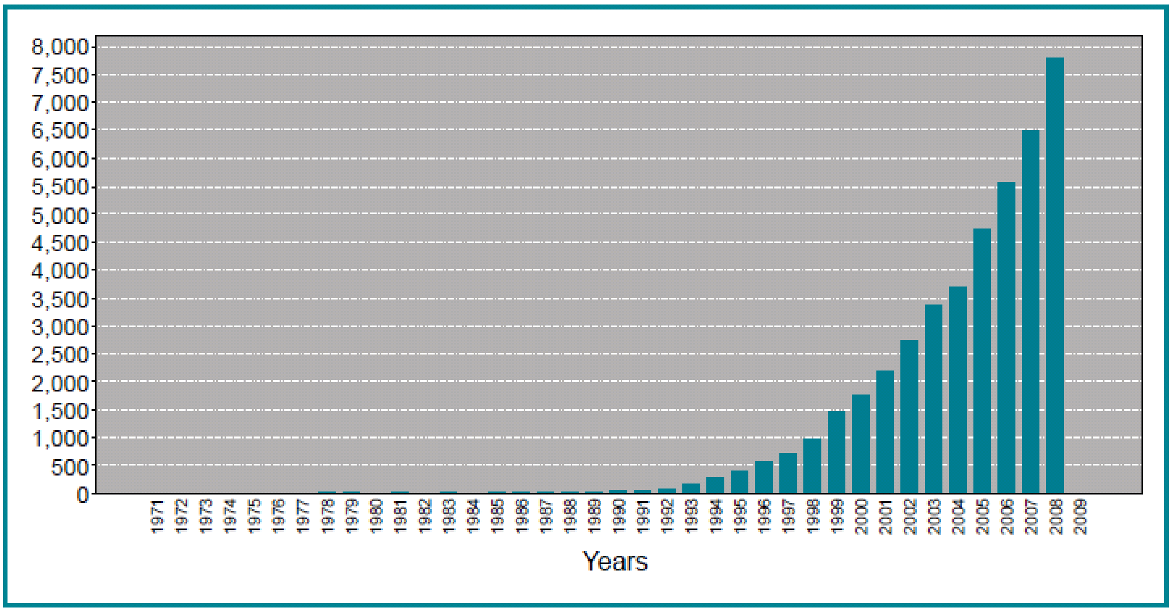


Figure 5.3 – Citations per Year (Taticchi et al., 2010:7)

Figure 5.3 highlights the exponential rise in publications between the 1970's and 2008. This supports Neely's (1999) 'performance measurement revolution'. Taticchi et al. (2010) also analysed the frequency of the most cited works and authors (Figure 5.4) with only ten works cited more than 30 times.

Author	*Title*	*Year*	*Citations*
Kaplan, R.S. and Norton, D.P.	"The Balanced Scorecard: measures that drive performance", *Harvard Business Review*, January-February, pp. 71-9	1992	168
Kaplan, R.S. and Norton, D.P.	*The Balanced Scorecard: Translating Strategy Into Action*, Harvard Business School Press, Boston, MA	1996	92
Charnes, A., Cooper, W.W. and Rhodes, E.	"Measuring efficiency of decision-making units", *European Journal of Operations Research*, Vol. 2 No. 6, pp. 429-44	1978	135
Dixon, J.; Nanni, A.and Vollmann, T.	*The New Performance Challenge*, Business One, Irwin, Burr Ridge, IL	1990	63
Neely, A.D., Gregory, M. and Platts, K.	"Performance measurement system design: a literature review and research agenda", *International Journal of Operations & Production Management*, 15 No. 4, pp. 80-116	1992	67
Eccles, R.G.	"The performance measurement manifesto", *Harvard Business Review*, January-February, pp. 131-7	1991	41
Lynch R.L. and Cross, K.F.	*Measure Up!*, Blackwell Publishers, Cambridge, MA	1991	40
Kaplan, R.S. and Norton, D.P.	"Putting the Balanced Scorecard to work", *Harvard Business Review*, September-October, pp. 134-47	1993	48
Banker, R.D.; Charnes, A. and Cooper, W.W.	"Some models for estimating technical and scale inefficiencies in data envelopment analysis", *Management Science*, Vol. 30 No. 9, pp. 1078-92	1984	88
Kaplan, R.S.	"Using the balanced scorecard as a strategic management system", *Harvard Business Review*, Vol. 74 No. 1, pp. 75-85	1996	48

Figure 5.4 – Most Frequently Cited Performance Measurement Works (Taticchi et al., 2010:6). These sources are not included in the thesis reference list unless they are discussed in the text.

Taticchi et al. (2010) found the most cited authors include R.S Kaplan (552 citations). Abraham Charnes (271 citations), Andy Neely (249 citations) and Rajiv Banker (226 citations); therefore their research and work will be important in the context of this thesis and to the development of this research field.

Undoubtedly one of the most popular and influential cited works is that of Kaplan and Norton's (1992) BSC framework. The BSC framework highlights the importance of the development of performance measurement systems to performance management theory, which will be discussed later in this chapter.

5.3 Supply Chain Performance Measurement (SCPM)

Supply chain performance measurement (SCPM) is a rapidly growing multi-dimensional decision making problem. Having the right performance measures is critical to the competitiveness and success of the organisation (Bhagwat and Sharma, 2007). A practical supply chain performance measurement assessment tool should be able to quantify the efficiency and effectiveness of a supply chain action (Shepherd and Gunter, 2006; Banomyong and Supatn, 2011). This is important in the context of this thesis as it is concerned with understanding what a practical (useful and easy to calculate) GSCPM should look like and what existing performance frameworks could be used to integrate these measures.

SCPM has emerged as one of the major business areas where companies can obtain a competitive advantage (Lee, 2002). It is a key strategic factor for increasing organisational effectiveness and for better realisation of organisational goals such as enhanced competitiveness, better customer care and profitability (Gunasekaran, 2001). A key feature in the business environment is that supply chains, not companies, compete with one another (Christopher, 2005). Therefore, in order to develop and test GSCPM, it is important to understand if the scope of SCPM is at a company level only, a network level or both.

Traditionally, logistics and supply chain performance measures have been quantitative and orientated around measuring cost, time and accuracy. For example, Gunasekaran et al. (2004) make reference to order lead-times, delivery performance, customer query time and total cash flow time within their framework of strategic, tactical and operational performance levels; however, Beamon (1999) believes such an approach makes supply chain measures inadequate as they rely too heavily on cost as a primary measure.

In a literature review of performance measures and metrics in supply chain management between 1995-2004, Gunasekaran and Kobu (2007) identified almost 90 supply chain metrics, many of which overlap. The most widely used metrics identified were financial (38 per cent), but 60 per cent of all measures were functionally based. The proliferation of functionally based supply chain measures is a symptom of how supply chains have been managed. Supply chains are complex networks and as a consequence practitioners have created lots of metrics to manage them, often duplicating the same metrics within and across supply chain nodes. Therefore, there is a requirement to simplify these measures, which is what Morgan (2007:256) alluded to when he referred to a move from "*measurement proliferation to measurement simplification.*"

Lee and Billington (1992) observed that discrete sites in a supply chain do not maximise efficiency if each site pursues its own goals independently, the latter being the traditional practice. Furthermore, Bhagwat and Sharma (2007) proposed the BSC as an appropriate framework from which to create a more balanced set of supply chain measures and to make a clear distinction between operational, tactical and strategic measures (Gunasekaran et al., 2004). This suggests the scope of SCPM should be boundary spanning and not measured in isolation; company by company or node by node.

Cooper et al. (1997) argued that much of the logistics performance measurement research to date has focused upon: 1) introducing characteristics that measures should possess; 2) perspectives that measures should assume; or 3) specific measures that a firm should choose. With little consideration being given to organisations own reporting needs and unique strategies and environment, they argue and develop a framework to enable organisations to choose measures which are appropriate with the organisation's specific missions and goals. Therefore, a certain degree of flexibility is required in the development of supply performance measures with the consideration of a 'no one size fits all' perspective. This explains why there are so many supply chain performance measures in circulation.

Mentzer and Konrad (1991) identify different stages or levels of sophistication in the logistics performance measurement process adoption, for example, in Stage One organisations implement very simple financial performance measures and generally represent very inactive organisations in terms of performance measurement. Stage One tends to be smaller businesses that do not have the resources or infrastructure to implement sophisticated performance measurement systems. In contrast, Stage Four organisations implement very sophisticated performance measures which are integrated across the entire company linked to financial indicators and are able to balance departmental goals. Stage Four organisations are more likely to be larger and more proactive organisations.

In their review of logistics performance measurement in a supply chain, Keebler and Plank (2009) also identified ‘inactive’ or Stage One organisations in the US. They found that most US organisations do not comprehensively measure logistics performance. The focus tends to be on organisational performance and not performance between networks of organisations. This suggests that logistics and SCM performance measurement is still new and evolving in industry, this presents challenges for GSCPM development.

In contrast, Stevens (1989) and Udin et al. (2006) suggested that rather than measuring the entire network performance, organisations should, as a prerequisite measure internal supply chain performance. This is because internal supply chain performance ensures that employees work closely together within a function and this will help in developing better relationships with suppliers and customers in the network. This contradicts Lee and Billington’s (1992) original view which was discussed earlier in this section.

The Council of Supply Chain Management Professionals (CSCMP) has published a number of studies on logistics performance measurement (Kearney, A. T. 1984; Bowersox et al., 1989; Global Logistics Research Team at Michigan State, 1995; Keebler et al., 1999). Their research suggested four key findings (Keebler and Plank, 2009:785):

1. Most US organisations do not comprehensively measure logistics performance
2. Even the best performing organisations do not appear to take advantage of the benefits of performance measurement
3. Logistics competency is increasingly viewed as a differentiator
4. Logistics measurement at a supply chain level is limited

These findings suggest that although there has been a significant amount of literature published in the academic field on SCPM this has not been completely implemented in practice. Also, theoretical development appears to be advancing well ahead of practice. This lack of practical implementation could be driven by the complexity of SCPM and a lack of understanding about what to measure.

In order to understand the key components which require measurement in supply chains, it is important, first of all, to identify the key supply chain activities or functions which require measurement. Mentzer and Konrad (1991) initially identified five common logistics performance measures:

1. Warehousing
2. Inventory Control
3. Transportation
4. Order Processing
5. Logistics Administration

These are very traditional and functional operational measures and do not include the customer as a part of the measurement process. Almost seven years later there was a shift in the use of terminology, for example Lambert et al. (1998) identified eight components of supply chain management which required measurement, and rather than 'logistic measures' they referred to 'supply chain' components. They also used the terms 'order fulfilment' opposed to 'order processing' and 'demand management' opposed to 'inventory control'. There was also an inclusion of the terms: customers, the suppliers, product development and reverse logistics, as part of the performance measurement system. There had been a shift from purely a company level, which is what Mentzer and Konrad (1991) described, to a supply network level by inclusion of the terms supplier management and manufacturing:

- Customer relationship management
- Customer service management
- Demand management
- Order fulfilment
- Manufacturing flow management
- Procurement and supplier management
- Product development and commercialisation
- Returns

Chan and Qi (2003) also suggested that the following supply chain processes required performance measuring, thus continuing the operational theme but also including other primary organisational activities like marketing and sales:

- Supply base management
- Inbound material transportation and storage
- Outbound transportation and distribution
- Manufacturing
- Warehousing
- Marketing and sales

Therefore, the scope of SCPM extends from raw material source, right through to the consumer and the reverse logistics process (closed loop). The scope is boundary spanning and vast and without collaboration it would be difficult for practitioners to measure the supply chain pipeline from end to end.

Charan et al. (2008:514) proposed ten items for supply chain performance management:

1. Effective information system
2. Employees commitment
3. Dynamic, inter-connectable, cross-functional
4. Partnership with dealers and distributors
5. Appropriate performance metrics
6. Overcoming trust
7. Funds for performance measurement implementation
8. Commitment by top management
9. Awareness about performance measurement system in supply chain
10. Strategic goals

These components, however, are more strategic and tactical in nature opposed to being operational and functional. They included elements of RBV theory and highlighted the importance of organisational resources like people and robust information systems to the successful implementation of performance measurement. This reinforced the importance of RBV theory which was discussed in Section 3.5 to the development of GSCPM.

Identifying the key areas of the supply chain network help in understanding what areas need to be measured and which metrics should be used, for example, Banomyong and Supatn, (2011) proposed a list of supply chain performance metrics (Figure 5.5). They identified nine supply chain performance measures and categorised these across three dimensions: cost, time and reliability. They clearly identify customer service and support as a key supply chain measure. This framework is useful in the context of this thesis as it highlights the depth and complexity of supply chain performance measurements.

Supply chain activity	Cost dimension	Time dimension	Reliability dimension
Customer service and support	Customer service cost/sale	Average order cycle time	Delivery to in full and on time
Demand forecasting and planning	Forecasting and planning cost/sale	Average forecast period	Forecast accuracy
Purchasing and procurement	Procurement cost/sale	Average procurement cycle time	Supplier in full and on time
Inventory management	Inventory cost/sale	Average inventory days	Out of stock rate
Order processing and logistics communications	Order processing cost/sale	Average order processing cycle time	Order accuracy rate
Material handling and packaging	Value of damaged goods/sale	Average material handling and packaging time	Damage rate
Transportation	Transport cost/sale	Average delivery cycle time	Delivery in full and on time
Facilities site selection, warehousing and storage	Facility cost/sale	Average inventory cycle time	Inventory accuracy
Return goods handling and reverse logistics	Return goods value/sale	Average cycle time for customer return	Rate of returned goods

Figure 5.5 - Proposed Supply Chain Performance Metrics (Banomyong and Supatn, 2011:24)

Supply chain performance measures are therefore multi-dimensional and evolving; they can measure efficiency and effectiveness (Mentzer and Konrad, 1991; Neely et al., 1995), they can be measured strategically, tactically and operationally (Gunasekaran, 2001). They can also comprise multiple dimensions: cost, time, quality, flexibility, reliability and innovativeness (Shepherd and Gunter; 2006; Banomyong and Supatn, 2011). The various taxonomies provide a degree of complexity to practitioners; thus there is a need for simplification and guidance.

To address this confusion and as a guide, Caplice and Sheffi (1995) recommended that managers should continually review and evaluate their supply chain performance metrics in order to make sense of the growing number of supply chain metrics, and to ensure the metrics reflect the ever-evolving supply chain and business environment. They were not trying to propose new metrics but recognised that metrics needed to evolve with the changing external business environment. They described the importance of evaluating individual metrics, as well as the performance system as a whole, as the individual metrics are the building blocks which support the entire system. They also provided eight criteria on which to judge the quality of metrics: validity, robustness, usefulness, integration, compatibility, economy, level of detail and behavioural soundness, which could be used to assess the quality of GSCPM variables. With organisations facing increased pressure from the government, customers and competition on their environmental and social performance, now is an appropriate time for this review process to take place and for organisations to begin quantifying their impact on the environment.

Defining and measuring supply chain performance is problematic for both researchers and practitioners. Chow et al. (1994:25) proposed four recommendations to address this:

- More efforts to develop performance measures
- Encouragement of more innovative designs
- Development of contingency models in logistics performance
- Recognition of the implications of SCM
- More bridge building between theory and practice

Brewer and Speh (2001:53) also identified a number of concerns in applying performance measurements across the entire supply chain network:

- Overcoming mistrust
- Lack of understanding
- Lack of control
- Different goals and objectives
- Information systems
- Lack of standardised performance measures
- Difficulty in linking measures to customer value
- Deciding to where to begin

The key challenge for organisations is developing the most appropriate and effective supply chain performance measures. The supply chain is a complex network which makes it difficult to identify and understand the measures. To address this, a number of supply chain performance frameworks have been developed as a guide on what to measure.

5.4 Existing Supply Chain Performance Frameworks

A number of supply chain performance frameworks exist, some of which have been adapted from generic performance management systems. Neely et al. (2000) summarised the key components of measuring business performance and the criteria for performance measurement system design (Figure 5.6).

Neely et al. (2000) identified four important themes: implementation, use and ongoing management, the people, processes, infrastructure and culture. This is a dynamic process which must be reviewed continually to ensure the performance management system meets the changing business requirements. Neely et al. (2001) identified 'environmental considerations' as a key component in the design of performance measurement systems, for example: to check whether each of the performance measures are appropriate to the existing business environment. Neely et al. (2000) illustrated this dynamic and continual review process in Figure 5.6.

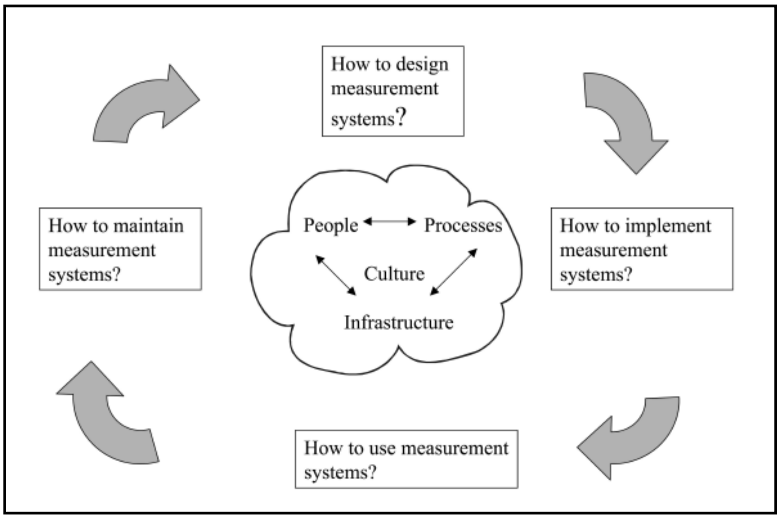


Figure 5.6 - Measuring Business Performance – Emerging Research Themes (Neely et al., 2000:1143)

A good performance measurement system must take into consideration the organisation's strategy and goals, reflecting the wants and needs of all stakeholders (Neely et al., 2001). It should also be designed with the intention of reducing the complexity of performance measurement (Olugo et al., 2011). Beamon (1996) identified universality as important for benchmarking to take place. Benchmarking is another important method in the performance evaluation process and it identifies areas for improvement and enables organisations to track their progress against their peer groups and competitors. The majority of benchmarking activities are concerned with financial and management activities, however environmental benchmarking is becoming a major element in the environmental management process. Shaw et al. (2010) found that environmental benchmarking was still very much in its infancy and required more academic research.

Other performance measurement systems include the Supply Chain Operations Reference (SCOR) model (Version Five) which was developed by the Supply Chain Council (SCC) and has been designed as a strategic management tool to help senior managers to simplify the complexity of their supply chain. It acts as a guide on what to measure and enables organisations to compare performance (Huan et al., 2004; Persson 2011). Unfortunately, SCOR is often too complicated for SME's to implement due to the number of measures proposed but it does provide some useful categories in which to position the metrics (Banomyong and Supatn, 2011). Figure 5.7 identifies SCOR Level One performance metrics:

Level 1 Performance Metrics

	Customer-Facing			Internal-Facing	
Performance Attribute	Reliability	Responsiveness	Flexibility	Cost	Assets
Delivery performance	✓				
Fill Rate	✓				
Perfect order fulfillment	✓				
Order fulfillment lead time		✓			
Supply-chain response time			✓		
Production flexibility			✓		
Supply chain management cost				✓	
Cost of goods sold				✓	
Value-added productivity				✓	
Warranty cost or returns processing cost				✓	
Cash-to-cash cycle time					✓
Inventory days of supply					✓
Asset turns					✓

Figure 5.7 – Supply Chain Operations Model (SCOR) Version Five (Supply Chain Council, 2002:8)

The SCOR model identifies traditional performance measures such as cost, time and accuracy, all these type of measures still play an important role in measuring SCPM; despite criticism that they are now too functionally based (Beamon, 1999; Gunasekaran et al., 2007).

To address current environmental concerns, the SCC also developed the Green Supply Chain Operations Reference (GreenSCOR) in 2003; this is a modification of Version Five of the Supply Chain Operations Reference (SCOR) model (GreenSCOR, 2003). The GreenSCOR enables organisations to integrate environmental management within supply chain management and track environmental impacts simultaneously (Metta, 2011). GreenSCOR integrates environmental metrics into the existing SCOR framework; however it is only useful to those organisations which have already implemented SCOR and GSCM practices; such as life-cycle analysis and green procurement. Therefore, this restricts it somewhat to SMEs or those organisations which are not already managing GSCM.

An alternative supply chain performance framework, the Life Cycle Analysis (LCA) tool assesses the environmental impacts of a product throughout its lifecycle (cradle to grave) from raw material production through to disposal (Hagelaar and Vorst, 2001). The procedures of LCA are used as part of ISO 14000 environmental management standards (ISO 14040, ISO 14044, ISO 14041 and 14043). LCA presents a useful way of gathering environmental data from across the supply chain and avoids a narrow view of environmental impact assessment. It is, however, fraught with difficulty for the following reasons (Hagelaar and Vorst, 2001:6):

- Representativeness and legitimacy (does not produce absolute values)
- Specific usefulness (missing data and assumptions)
- Returns (data gathering is expensive)
- Comprehension and transparency (the more complex the less transparent)

The application and usefulness of LCA to this research is limited as the thesis focuses on performance measurement at a company level, rather than a product level.

Similar to LCA and adopting the principles of LCA, is the ecological supply chain analysis tool (EcoSCAn) proposed by Faruk et al. (2001). The aim of EcoSCAn is to map the environmental impacts of selected equivalent products along a supply chain. Its purpose is to capture the level of impacts but also to stimulate decisions and innovations which will help to reduce environmental impacts at various points within the supply chain. It provides a detailed assessment of specific product lines and therefore its application to companies with hundreds or thousands of product lines is limited and not viable; however, application to single product lines could prove useful and scalable.

In contrast, and in more generic business terms, the most popular performance framework was the pioneering BSC because it addressed both financial and non-financial performance measures (Figure 5.8). It helped managers to focus on a handful of critical measures that were aligned with the business strategy. These measures include both financial and non-financial information and Kaplan and Norton (1992) described it as like the "*dials in an airplane cockpit*" (Kaplan and Norton, 1992:71).

A recent survey conducted by Rigby and Bilodeau (2011) found that the BSC was still one of the top ten most used tools globally, however, more popular tools have now emerged, they include: customer segmentation, change management and core competency tools. This links back to the continued theme of 'change' which was identified in Section 5.2 underpinning Neely's (1999) performance measurement revolution. Organisations are now faced with the challenge of continually evolving and reinventing themselves to ensure they are still relevant to their customers, to do this requires a better understanding of what customer's most value (customer segmentation) and then organisations are able to transform in response to this (change management). Companies are using the world recession to improve their competitive position, survive economic stagnation and to prepare themselves for growth. This calls for other tools and the BSC is no longer the most popular or most widely used performance tool in practice (Rigby and Bilodeau, 2011).

The results from the same survey also concluded that revenue growth was the key priority for company executives, shortly followed by customer satisfaction and loyalty; with sustainability of less importance (Rigby and Bilodeau, 2011). This reinforces the findings from Chapter Two that business priorities are linked to economic cycles; during economic downturns cost takes over as a primary consideration (Spens and Kovács, 2010) and during times of economic growth and inflation the green agenda comes back on the agenda for executives. Organisations must prepare themselves to emerge from the recession to grow but at the same time ensure their businesses are green and sustainable.

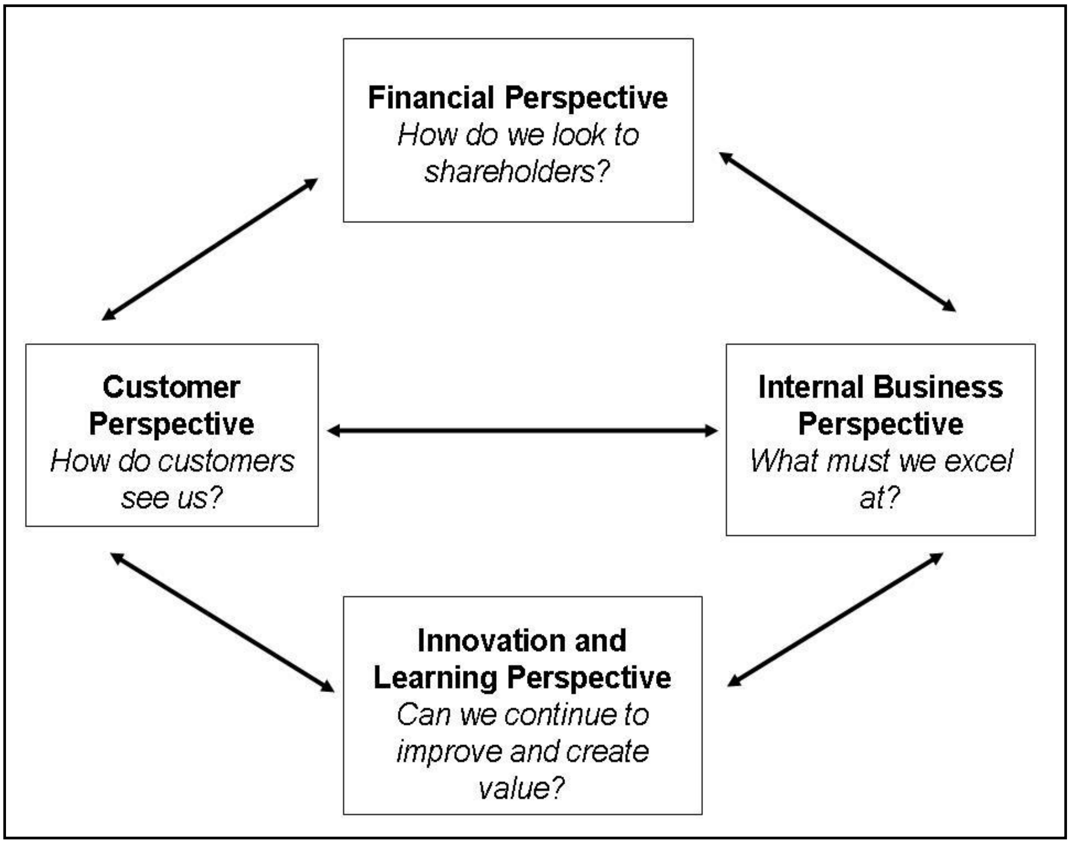


Figure 5.8 – The Balanced Scorecard (Adapted from Kaplan and Norton, 1992:72)

The BSC has been adapted for use by different organisations in different contexts (Bourne et al., 2000; Brewer and Speh, 2001; Barber, 2008). Several studies have attempted to adapt the BSC approach to supply chain management, (Brewer and Speh, 2001; Bhagwat and Sharma, 2007). In addition, extensions to the BSC to incorporate environmental performance measures have also been advanced but not extensively studied (Epstein and Wisner, 2001; Zingales et al., 2002; Hervani et al., 2005; Shaw et al., 2010). Although pioneering and popular, the BSC is now over fifteen years old and criticisms of the BSC and its applications are: people, competitive environments, environmental and social aspects of industry are excluded (Paranjape et al., 2006; Barber, 2008). Furthermore, there is no evidence to suggest that the application of the BSC improves performance (Paranjape et al., 2006). There are some arguments to suggest that adding the environment to the BSC may over complicate it. In its current form the BSC does not include the ability to manage environmental performance within the overall business strategy; it also excludes people and suppliers which are key stakeholders in the environmental management process. The BSC is a static tool and does not have a dynamic ‘cause and effect’ evaluation loop process (Paranjape et al., 2006) which means it has no ability to guide businesses through change, which is of central importance to performance measurement.

In contrast, another popular framework, the Performance Prism, shown in Figure 5.9, was developed (Neely et al., 2001) and addressed the wants and needs of all stakeholders, rather than a subset. The Performance Prism is defined as a second-generation performance measurement framework design, and could be used to enable organisations to select appropriate performance measurements. It serves to address shortcomings of other traditional performance frameworks such as the BSC and consists of five facets: stakeholder satisfaction, strategies, processes, capabilities and stakeholder contribution. Its priority is to identify the stakeholders and assess their requirements before deciding on a strategy and a set of performance measures. No work however, has yet been conducted on applying the performance prism to the supply chain specifically or environmental performance management, and therefore would require significant exploration.

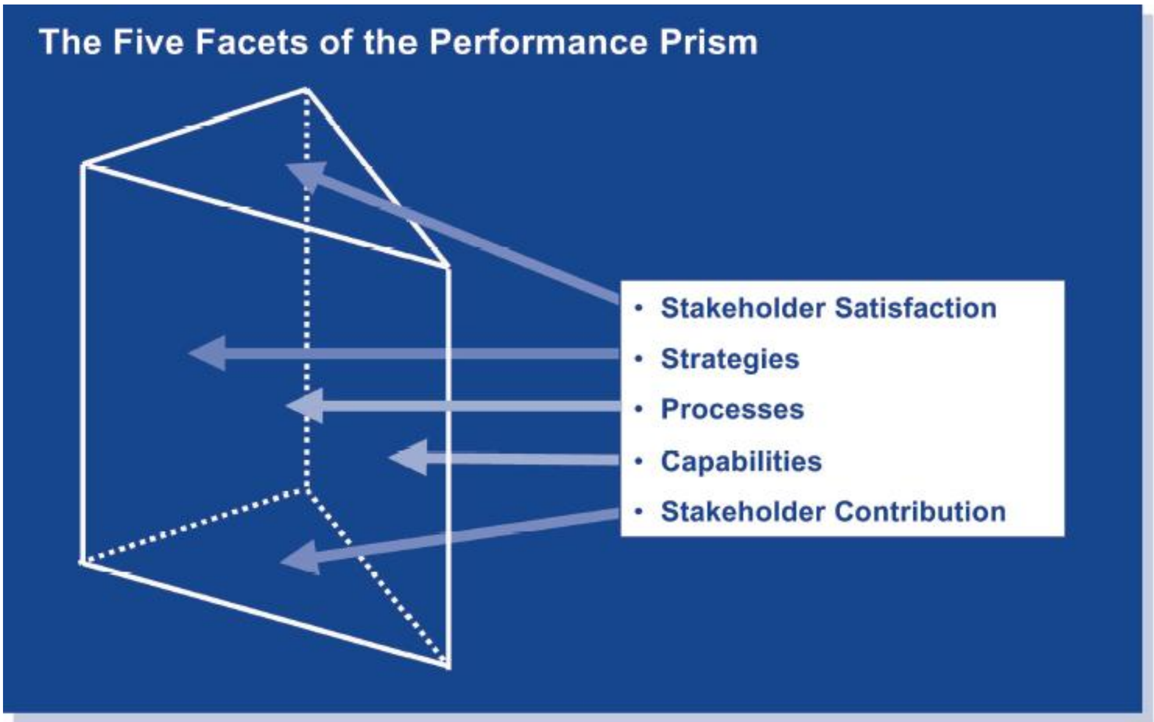


Figure 5.9 - The Performance Prism (Neely et al., 2001:12)

More recently, Banomyong and Supatn (2011) proposed a framework for supply chain performance measurement which is based on the work of Lambert et al. (1998). The details of their model are illustrated in Figure 5.10.

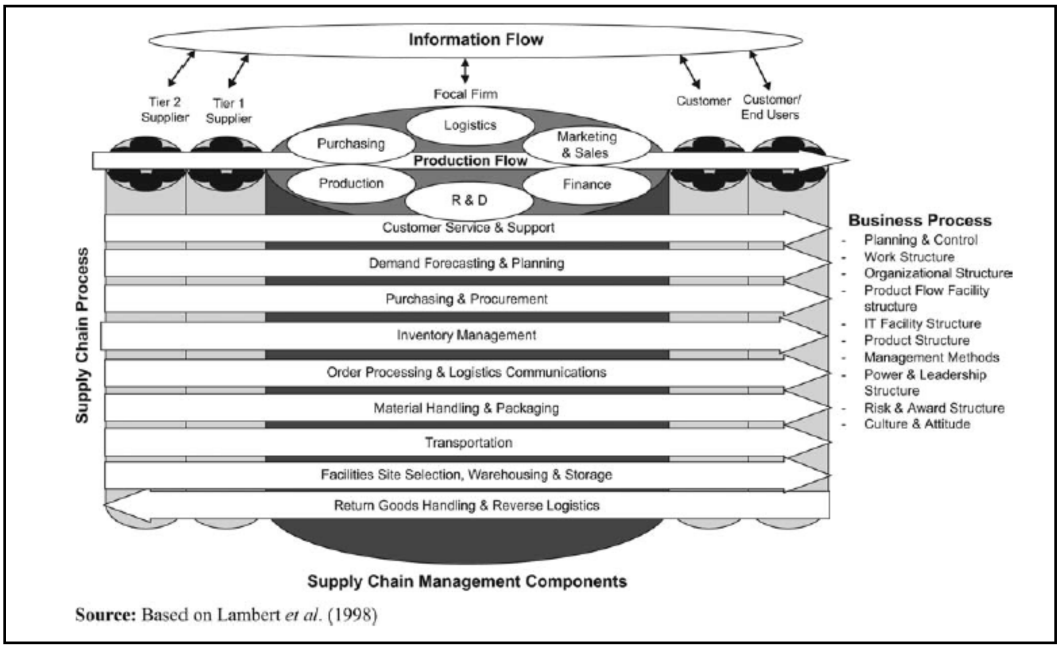


Figure 5.10 – A Proposed Framework for Supply Chain Performance Measurement (Banomyong and Supatn, 2011:24)

In their framework, Banomyong and Supatn (2011) propose nine supply chain performance activities. They recommend that the understanding of a supply chain starts with an understanding of internal activities and processes. Although they identify three dimensions: cost, time and reliability, they do not give any consideration to environmental supply chain management activities.

Other existing supply chain performance assessment tools include the quick scan audit methodology (QSAM) (Naim et al., 2002). This was designed to assess the health of the supply chain and is a powerful diagnostic tool. Foggin et al. (2004) also developed a quick and simple decision making tree approach termed the ‘supply chain diagnostic tool’. This was designed to diagnose potential supply chain problems for supply chain clients. Finally, the performance measurement team (PMT) proposed by Chan and Qi (2003) is a novel approach. They recommend developing an internal cross functional team called PMT to analyse the enormous amount of data generated from each supply chain activity to assess the overall supply chain performance. Its complexity, however, makes it difficult for practitioners to implement and only suitable for large organisations (Banomyong and Supatn, 2011). Little evidence exists on whether these tools are used in industry and if indeed they have been useful and effective.

A number of challenges have been identified in the literature so far; there is a need to simplify supply chain performance measures in general if they are to be fully adopted and embraced by practitioners, and supply chain performance measures must be appropriate and relevant to the organisation in which they are being used and not necessarily universal. Multiple performance frameworks and conceptual models exist, which can be used to help develop and measure GSCPM, but more importantly, these measures must also change in response to the increasing environmental challenges (Morgan, 2007). It is vital, therefore, that the most appropriate performance measurement tools/frameworks for GSCPM are the ones which are able to cope with ‘continuous improvement’ and evolve to meet new business challenges.

Logistics and supply chain management processes impact not only on the profit and loss account of an organisation but also on the natural environment. It is therefore vital that measures are put in place to help practitioners evaluate the impact of their operations on the natural environment. It is evident from the foregone literature that not many organisations specifically measure their supply chain performance and therefore GSCPM, thus there is a gap in the body of knowledge which requires investigation.

Environmental management in a general business context is not a new concept and has been in place in organisations for a number of years; however its application to the supply chain has not been extensively studied. The next section will review environmental management within a general business context before exploring the literature on GSCPM.

5.5 Environmental Measurements and Systems

Environmental management research in a general business context is significantly well advanced. An ISI Web of Science keyword database (2009) search for environmental management from 1970-2009, returned 22,012 articles. Table 5.1 lists the top ten journal titles from this database search.

Table 5.1 - The Top Ten Journal Titles from a Word Search of "Environmental Management" on *ISI Web of Science Database* (∑=22,012)

Journal Title	Count	%
ENVIRONMENTAL MANAGEMENT	500	2.27%
JOURNAL OF ENVIRONMENTAL MANAGEMENT	445	2.02%
JOURNAL OF CLEANER PRODUCTION	215	0.97%
AGRICULTURE ECOSYSTEMS & ENVIRONMENT	209	0.94%
FOREST ECOLOGY AND MANAGEMENT	203	0.92%
ECOLOGICAL ECONOMICS	200	0.90%
ECOLOGICAL MODELLING	162	0.73%
ECOLOGICAL APPLICATIONS	159	0.72%
RESOURCES CONSERVATION AND RECYCLING	154	0.69%
JOURNAL OF APPLIED ECOLOGY	152	0.69%

Additionally, a word search of environmental performance management and supply chain environmental performance between 1970-2009 returned 2,141 (10 per cent) and 112 (0.5 per cent) articles respectively, which illustrated that environmental performance management particularly in a supply chain context, is very much in its infancy and is a relatively new area of theory development. The *Journal of Cleaner Production* is the most frequently cited periodical source for supply chain environmental performance (Table 5.2).

Table 5.2 -The Top Ten Journal Titles from a Word Search of "Environmental Supply Chain Performance" on *ISI Web of Science Database* (∑=2,141)

Journal Title	Count	%
JOURNAL OF CLEANER PRODUCTION	14	12.50%
INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	11	9.82%
INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS	8	7.14%
JOURNAL OF OPERATIONS MANAGEMENT	8	7.14%
INTERNATIONAL JOURNAL OF OPERATIONS & PRODUCTION MANAGEMENT	5	4.46%
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH	4	3.57%
PRODUCTION AND OPERATIONS MANAGEMENT	4	3.57%
INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCE AND TECHNOLOGY	3	2.67%
INTERNATIONAL JOURNAL OF LIFE CYCLE ASSESSMENT	3	2.67%
JOURNAL OF ENVIRONMENTAL MANAGEMENT	3	2.67%

In the 1970-80's the environmental agenda was 'non-existent' and seen by most organisations as a 'fringe issue' (Beamon, 1999; Walton et al, 1998). The business environment, however, has changed and organisations are now coming under increasing pressure to provide evidence of their commitment to corporate social responsibility (CSR), particularly the environment.

One of the key and fundamental aims of environmental management across all countries and industries is to reduce the emission of all the greenhouse gases, particularly CO_2. This is why organisations have become focused on measuring their carbon emissions or their 'carbon footprint'. For example, IBM (2008) use the House of Carbon (HoC) to communicate their green initiatives across all areas of their business, Wal-Mart are using the Carbon Disclosure Project (CDP) to manage the energy footprint of their suppliers (Carbon Commentary, 2008) and Tesco are working with the Carbon Trust to put carbon labels on 70,000 products (Carbon Trust, 2008). Carbon emissions have become an industry-recognised measurement in the environmental management process and in the fight against climate change.

Greenhouse gases are not the only area of focus in environmental management, however they have gained the most attention because of the observed impact they are having on the climate system. Defra (2006) identified 22 environmental performance indicators which are also considered to be significant to UK businesses, these are split into four key areas:

1. Emissions to air
2. Emissions to water
3. Emissions to land
4. Resource use

To help manage these four emission categories, some organisations have now adopted Environmental Management Systems (EMS) such as ISO 14001.

5.6 Environmental Management Systems and Measures

Environmental management systems such as the International Organisation for Standardisation (ISO 14001) or the European Commission's Eco-Management and Audit Scheme (EMAS) provide guidance to organisations on mitigating their impact on the natural environment. The International Organisation for Standardisation has also developed ISO 14031, an environmental performance evaluation tool (EPE). ISO 14031, which is not a standard for certification, provides organisations with specific guidance on the design and use of environmental performance evaluation, and on the identification and selection of environmental performance indicators. This allows any organisation regardless of size, complexity, location and type to measure their environmental performance on an on-going basis (ISO 14001). ISO 14031 defines environmental performance indicators as "*specific expression that provides information about an organisation's environmental performance.*" (ISO 14031, 1999). Examples of ISO 14031 indicators are provided in Table 5.3.

Table 5.3 - Examples of ISO 14031 Performance Indicators and Metrics (Putman, 2002:4)

Operating Performance Indicator (OPI)	Management Performance Indicator (MPI)	Environmental Condition Indicator (ECI)
Raw material used per unit of product (kg/unit)	Environmental costs or budget ($/year)	Contaminant concentrations in ambient air (μg/m^3)
Energy used annually per unit of product (MJ/1000 L product)	Percentage of environmental targets achieved (%)	Frequency of photochemical smog events (#/year)
Energy conserved (MJ)	Number employees trained (% #trained/to be trained)	Contaminant concentration in ground- or surface water (mg/L)
Number of emergency events or unplanned shutdowns (#/year)	Number of audit findings (#)	Change in groundwater level (m)
Hours of preventive maintenance (hours/year)	Number of audit findings addressed (#)	Number of coliform bacteria per liter of potable water
Average fuel consumption of vehicle fleet (L/100 km)	Time spent to correct audit findings (person-hours)	Contaminant concentration in surface soil (mg/kg)
Percentage of product content that can be recycled (%)	Number of environmental incidents (#/year)	Area of contaminated land rehabilitated (hectares/year)
Hazardous waste generated per unit of product (kg/unit)	Time spent responding to environmental incidents (person-hours per year)	Concentration of a contaminant in the tissue of a specific local species (μg/kg)
Emissions of specific pollutants to air (tonnes CO_2/year)	Number of complaints from public or employees (#/year)	Population of an specific animal species within a defined area (#/m^2)
Noise measured at specific receptor (dB)	Number of fines or violation notices (#/year)	Increase in algae blooms (%)
Wastewater discharged per unit of product (1000 L/unit)	Number of suppliers contacted about environmental management (#/year)	Number of hospital admissions for asthma during smog season (#/year)
Hazardous waste eliminated by pollution prevention (kg/year)	Cost of pollution prevention projects ($/year)	Number of fish deaths in a specific watercourse (#/year)
Number of days air emissions limits were exceeded (days/year)	Management levels with specific environmental responsibilities (#)	Employee blood lead levels (μg/100 mL)

ISO 14031 is based on the Plan-Do-Check-Act (PDCA) continuous improvement model (as shown in Figure 5.11) and focuses directly on environmental protection, cleaner production, sustainable development and communication of related achievements without burdening organisations with the demand for written reports and stringent system documentation (Jasch, 2000).

Continuing the theme of ISO 14000 environmental management standards, Hervani et al. (2005) provide an integrative framework for study, design and evaluation of GSCPM tools. By using experiences, case studies and literature, they sought to design a GSCPM framework that would integrate: supply chain management, environmental management and performance management. They believed that a GSCM/PMS framework should sit within existing environmental management systems like: ISO 14000 or a Total Quality Management (TQM) system that an organisation is already using. They recommended the already accepted ISO 14031 Plan-Do-Check-Act model to design a GSCM/PMS (Figure 5.11). They believed in order for organisations to sustain long term competitive advantage, organisations must broaden their focus on the natural environment. Their study is very relevant in the context of this thesis as it is the only performance measurement framework along with GreenSCOR which really integrates and helps to develop environmental performance measures for supply chains. ISO 14031 Plan-Do-check-Act is already used by a significant number of organisations internationally regardless of size or sector. In 2008, there were an estimated 188,000 companies ISO 14001 compliant across 155 countries (ISO 14001, 2010). The application and implementation of ISO 14031 is less onerous and expensive than models such as SCOR, which is not widely implemented.

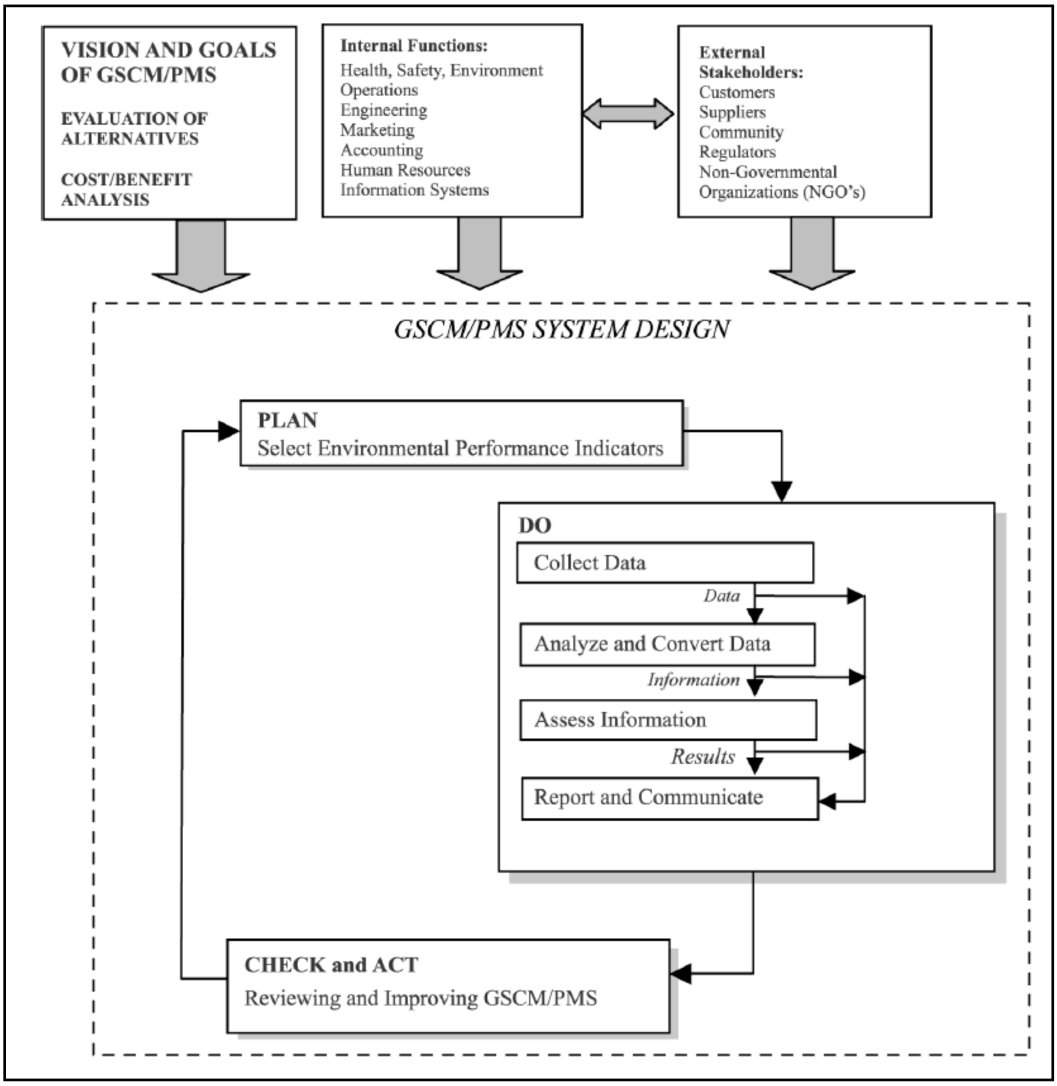


Figure 5.11 - The Design of a Green Performance Measurement System that utilises ISO 14031 (Hervani et al., 2005:343)

The integrative framework illustrated by Hervani et al. (2005:342) addresses a number of questions in relation to the design of an environmental supply chain performance framework:

- What are the goals/scope of the framework?
- What is the most appropriate framework?
- What are the most appropriate measures?
- How does this framework fit within the strategy of the supply chain?
- How should this be linked in with existing environmental management systems?
- How should the framework be designed?
- How should external stakeholders be integrated?

The conceptual model for this thesis will be developed on the foundations and disciplines of the Hervani et al. (2005) integrative framework. It is a relevant framework as it deals with the issues of strategy, measurement selection, evaluation and implementation. ISO 14001 and the principles of Plan-Do-Act-Check are now the most widely utilised environmental management system (EMS) internationally (Nawrocka et al., 2009) and it is a dynamic continuous improvement tool able to cope with change.

Although the Hervani et al. (2005) framework is the most applicable and appropriate tool identified so far in the literature (Figure 5.11) it does have limitations. Firstly, it is a proposal and has yet to be tested in a real world setting to see if it will work; secondly, no specific GSCPM variables are proposed as part of this framework and therefore it does not deal with the 'what' 'who' or 'how' to measure GSCPM variables in the supply chain, which is very important. Finally, it does not explicitly deal with the issues of how to measure the entire supply chain end to end, from point of production through to point of consumption. This represents a gap in the body of GSCPM knowledge which necessitates the need for more research.

The BSC framework discussed earlier has also been used by organisations to measure environmental, social and economic performance. Epstein and Wisner (2001:6) explored two case studies to understand how the Balanced Scorecard could be used to measure sustainability (Figure 5.12). They described some of the key benefits of using the BSC to measure sustainability:

- There is a positive link between implementing social and environmental strategy and corporate value
- It links sustainability directly to the company strategy
- Highlights the importance of social and environmental performance
- Enables senior managers to reposition their organisations to corporate social responsibility
- Provides social and environmental accountability

Financial		Customer	
Environmental	**Social**	**Environmental**	**Social**
– environmental $ saved – $ fines/penalties – EH&S costs (% of sales) – % proactive vs. reactive expenditures – increase in relative % of proactive expenditures – % environmental costs direct-traced – $ capital investments – energy costs – disposal costs – recycling revenues – revenues from green products – $ operating expenditures – reduction in cost of debt – cost avoidance from environmental actions	– philanthropic $ contributed – $ workers compensation costs – # employee lawsuits – $ employee benefits – legal actions / costs – training budgets – reduction in hiring costs – revenue from socially positioned products – increased sales from improved reputation	– $ cause-related marketing – # "green" products – product safety – # recalls – customer returns – unfavorable press coverage – % products reclaimed after use – # stakeholder communications – product life – functional product eco-efficiency (e.g., energy costs of a washing machine)	– customer perceptions – # of cause-related events supported (e.g., breast cancer, AIDS) – $ community support (parks, safety, recreation, etc.) – # community meetings – customer satisfaction – social report requests – # product recalls – customer group demographics

Internal Business Processes		Learning and Growth	
Environmental	**Social**	**Environmental**	**Social**
– # LCAs performed – % materials recycled – % waste to landfill – # certified suppliers – # accidents/spills – # audits/year – # truck miles – % office supplies recycled – internal audit scores – energy consumption – % facilities certified – % of product remanufactured – packaging volume – nonproduct output – # supplier audits/year – fresh water consumption – greenhouse gas emissions – air emissions – water emissions – hazardous material output – vehicle fuel use – habitat changes due to operations	– # employee accidents – # lost workdays – # days work stoppages – hours overtime work – average work week hours – $ warranty claims – $ minority business purchases – # plant tours/visitors – # non-employee accidents – certifications – # suppliers certified – # supplier violations – environmental quality of facilities – observance of international labor standards – # safety improvement projects	– % of employees trained – # training programs/hours – reputation per surveys – inclusion in "green" funds – # employee complaints – # community complaints – # shareholder complaints – unfavorable press coverage – # violations reported by employees – # of employees with incentives linked to environmental goals – # of functions with environmental responsibilities – management attention to environmental issues – % of employees using car pools	– workforce diversity (age, gender, race) – management diversity – # internal promotions – employee volunteer hours – average length of employment – # involuntary discharges – employee education $ – # family leave days – $ employee benefits – salary gaps between genders/races – employee satisfaction – $ "quality of life" programs – % of employees owning company stock – # applicants/job openings – # employees with disabilities – # employee grievances – workforce equity

Figure 5.12 - Examples of Balanced Scorecard Measures for Sustainability (Epstein and Wisner, 2001:7)

There are key drawbacks to the work of Epstein and Wisner (2001); firstly, their research proposal is built upon just two case studies and therefore not rigorous or robust enough to make generalisations across country, sector and company size; secondly, their framework contains too many measures which may lead to confusion and 'analysis paralysis' and alienate smaller to medium sized companies.

Länsiluoto and Järvenpää (2010) also recommended the BSC as a PMS to manage environmental issues. They posit that the BSC could be used as a way of conveying environmental information and not necessarily as an implementation strategy. They also summarised some very important issues when a company considers integrating EMS and PMS. They state this is not merely a 'technical issue' of how to incorporate environmental metrics within an existing PMS but there are important cultural and management theories which need to be understood and overcome which are illustrated in Figure 5.13; for example, how do culture and management systems interact with one another to drive the right environmental behaviour and thus environmental performance (Figure 5.13).

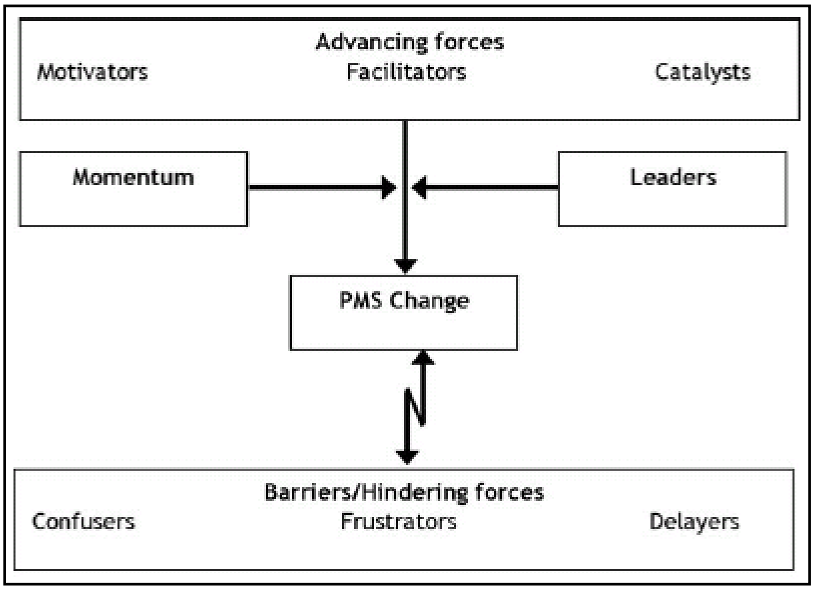


Figure 5.13 - PMS Change Model (Länsiluoto and Järvenpää, 2010: 387)

Länsiluoto and Järvenpää (2010) identified two forces which act on an organisation's ability to integrate EMS within an existing PMS: advancing motivating forces (for example: customer orientation, competition and quality management systems) and hindering forces (for example: a finance driven culture, we have to be a good citizen or we have to have an environmental policy attitude). It is, therefore, important to understand these two theoretical influences in this research, if GSCPM variables are to be implemented successfully (Table 5.4).

Table 5.4 - Environmental Performance Measurement Change Factors (Länsiluoto and Järvenpää, 2010:389)

	Environmental management (1995-)	Environmental measures (2000-)	Balanced Scorecard (2004-)
Advancing forces Motivators	Competition Fear of being left out of something important (following the competitors)	Management by objectives External reporting	Management by objectives
Catalysts	Customer orientation Need to have ISO 14001 certificate	Environmental system requires environmental objects and measures	Process orientation Challenges related to multiple information systems
Facilitators	Quality management New operational system Balanced scorecard (after 2004)	Connection to finance-driven culture (cost savings) Balanced scorecard (after 2004)	Quality management New operational system Computer software New controllers
Hindering forces Barriers	Finance-driven culture (In the beginning)	Several reporting medias	Old CEO does not value BSC (earlier) Lack of resources (earlier) Uncertainty about the BSC's future role Too many measures Role of existing reporting systems
Momentum	"We have to get environmental certification"	"We have to be a good corporate citizen" "There have to be environmental objects and measures in an environmental system"	"Environmental objects and targets should be aligned in the organization and be part of an organization-wide reporting system"
Leaders	Quality Manager Technical Director	Quality Manager Technical Director	Quality Manager Technical Director Director of IT & Controlling

Shaw et al. (2010) also identified that the BSC could be used to measure and manage environmental performance (Figure 5.14). This could be achieved by incorporating environmental measurement as part of the internal perspective or as an additional fifth BSC perspective. This would enable organisations to measure all three dimensions of sustainability (environmental, social and economic) within their supply chain (Figure 5.14).

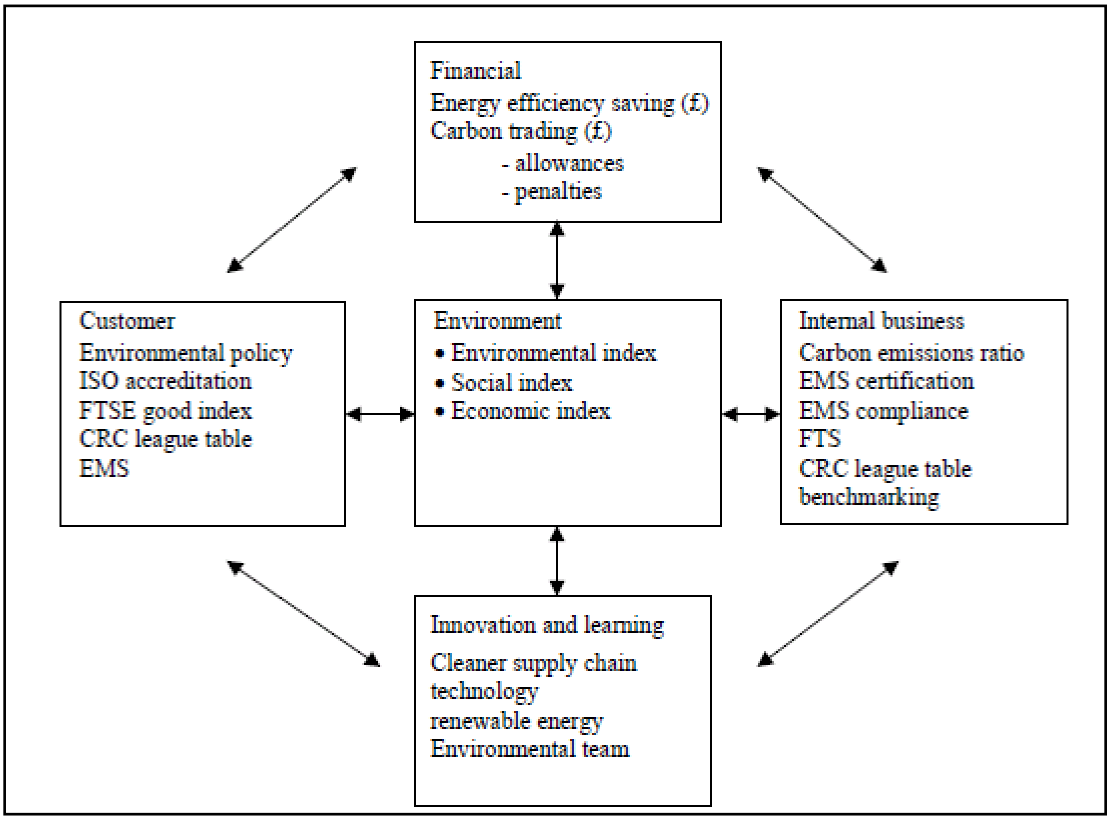


Figure 5.14 – A Fifth Environmental Perspective: The Balanced Scorecard (Shaw et al., 2010:335)

Having reviewed the foregone literature on performance measures, systems and environmental management, it is clear that multiple performance measurements and systems exist in which to potentially develop and test green performance measures for supply chains, however there are gaps. The challenge is selecting the most appropriate measurements and frameworks and understanding the theoretical challenges involved in integrating and implementing EMS with PMS. Hervani et al. (2005) posit that in order to design and develop GSCPMs and systems, it is important that the design fits within the existing environmental management system of the organisations. The most prevalently used and recognised international environmental management system is the ISO 14001 standard, Plan-Do-Check-Act (PDCA) model, thus it is central to the design and testing of GSCPM variables in this thesis. This is not say, that the BSC and other frameworks should be discounted, however, they contain significant limitations, which need further exploration and testing.

The next section will now explore the extant literature on GSCPM and will tie together the constructs and variables in the literature to help build the conceptual model for this thesis in preparation for Chapter Six.

5.7 Green Supply Chain Performance Measures and Systems

Performance measurement of supply chains is fraught with difficulty due to the numerous tiers and echelons found within supply chains; and GSCPM as a discipline and practice is virtually non-existent (Hervani et al., 2005). Yet there is a proven link between environmental management practices, financial performance and competiveness, with obvious win-win opportunities (Klassen and McLaughlin, 1996; Rao and Holt, 2005). A major barrier to the adoption of GSCPM is financial; organisations are put off by the large investment required upfront resulting in low adoption rates (Zhu and Sarkis, 2004) and organisations are also confused over what and how to measure. Those organisations which are closer to the consumer market deem environmental supply chain practices as more important than small to medium sized organisations, which do not have the resources or investment to implement such practices (Nawrocka et al., 2009). The challenge is convincing organisations that this is a worthwhile investment.

The purpose of measuring GSCPM is two-fold; there is a requirement for external reporting for example, public disclosure programs like the Global Reporting Initiative (GRI) and for benchmarking. There is also a requirement for internal analysis, to help improve internal processes and to manage pollution control. There are also a number of other specific pressures/motivators which were identified in Chapter Four in the GSCM pressure/response model which highlight the important purpose of measuring green performance in supply chains (Holt and Ghobadian, 2009). These include external pressures from customers, competitors and government legislation, and internal pressures from stakeholders and suppliers.

Despite these pressures and motivations, there has been very little empirical research conducted specifically on the development of GSCPM variables. The research and practice is very much in its infancy and requires in depth exploration in order to address this gap in the body of knowledge (Hervani et al., 2005; Shaw et al., 2010).

Beamon (1999) produced one of the earliest studies which attempted to link traditional performance measurement with environmental supply chain performance. Beamon (1999) suggested that the traditional performance measurement system of the supply chain could be extended to include processes like reverse logistics and product recovery and to include a new type of environmental measure. Nine years later Beamon (2008) continued to describe the same challenges and opportunities facing the supply chain of the future and looked at how sustainability would help shape the design, management and integration of supply chains. This highlighted that this issue has still not been fully resolved.

Hervani et al. (2005) presented a more recent overview of the various issues related to GSCPM. They identified that the types of environmental performance measures used are reflected by an organisation's evolutionary stage in the environmental management process. One of the key issues relates to the number of potential environmental metrics in circulation which range from air emissions through to water usage. To address this complexity and volume of metrics, they present a GSCM/PMS based on ISO 14001 Plan-Do-Check-Act EMS to help design and evaluate environmental performance measures for supply chains; however, they do not recommend or propose any specific GSCPMs in their paper (Figure 5.11).

Similarly, Shaw et al. (2010) presented a literature review on the development of environmental supply chain performance measures. They examined what environmental performance measures are available and whether they could be integrated within an existing supply chain performance framework and the associated benefits. In their study, they present nearly all EMS developed so far, worldwide, but mostly aimed at reducing greenhouse gas emissions and carbon dioxide. Shaw et al. (2010) also identified that there is a need to develop a common environmental supply chain performance measure that captures the impact of the entire supply chain.

The Global Reporting Initiative (GRI) identified a series of hierarchy indicators which are relevant to this thesis. The GRI enable organisations to report on their economic, environmental and social performance (also known as the 'triple bottom line' or 'sustainability') and not just their environmental performance. The 2002 GRI guidelines identified two categories of performance indicators: core, which are relevant to most organisations and additional which are only relevant to certain organisations (GRI, 2009).

GRI encourages the active disclosure of sustainability performance data and has the ability, like ISO 14031, to generate multiple environmental performance indicators. GRI are very stringent over the calculation and reporting of these indicators which helps to standardise the outputs for benchmarking. GRI provides an alternative perspective on how organisations can measure and report on their environmental performance, however, it is designed purely as an external sustainable reporting tool to aid external benchmarking, and although it provides a useful guide of what GSCPMs to measure, there is no indication of how these are applied to the end to end supply chain and with little emphasis on continuous improvement (Table 5.5). The GRI is also a generic sustainability framework whereas the focus of this thesis is centred on the environmental and not the social elements of performance measurement. There is also a lack of published empirical research on the benefits of implementing the GRI.

The UK government, as part of their KPI benchmarking programme in 1997 and 2002, also identified five key performance indicators to make freight transportation more sustainable: vehicle loading, empty running, fuel efficiency, vehicle time utilisation and deviations from the schedule. However, little evidence exists of the benefits to a company of participating in this scheme both financially and from an environmental perspective (McKinnon, 2009a). Furthermore, these measures only focus on one aspect of the supply chain.

Table 5.5 - Examples of GRI Environmental Performance Indicators for the Transport and Logistics Sector (GRI, 2006:26)

Category	Core Indicator	Additional Indicator
Materials	EN1. Total materials use other than water, by type.	
Materials	EN2. Percentage of materials used that are wastes (processed or unprocessed) from sources external to the reporting organisation.	
Energy	EN3. Direct energy use segmented by primary source.	E17 Initiatives to use renewable energy sources and increase energy efficiency
Energy	EN4. Indirect energy use.	
Water	EN5. Total water use.	E20 Water sources and related ecosystems/habitats significantly affected by use of water
Biodiversity	EN6. Location and size of land owned, leased, or managed in biodiversity-rich habitats.	E23 Total amount of land owned, leased or managed for production activities or extractive use
Emissions, effluents and waste	EN8. Greenhouse gas emissions.	E30 Other relevant indirect greenhouse gas emissions
Emissions, effluents and waste	EN9. Use and emissions of ozonedepleting substances.	
Emissions, effluents and waste	EN10. NOx, SOx, and other significant air emissions by type.	E32 Water source and other ecosystem/habitats significantly affected by discharges of water and run off
Emissions, effluents and waste	EN11. Total amount of waste by type and Destination.	
Transport		E34 Significant environmental impacts of transportation used for logistical purposes
Suppliers		E33 Performance of suppliers relative to environmental components of programmes and procedures described in response to Governance Structure and Management systems

So what are the most appropriate green measures for supply chains and what measures are being used or explored thus far according to the extant literature?

Olugo et al. (2011) conducted a three part survey and literature review to establish key performance measures for the green automobile supply chain. They identified ten key performance measures for the ‘forward chain’ and six key performance indicators for the ‘reverse chain’ (Table 5.6).

Table 5.6 – List of Key Performance Measures for the Green Automobile Industry (Olugo et al., 2011)

Categories	**Forward chain key performance measures**	**Backward chain key performance measures**
1.Upstream measures	1.Supplier commitment	1.Customer involvement
2.Midstream measures	2.Greening cost	2.Recycling cost
	3.Level of process management	3.Management commitment
	4.Product characteristics	4.Recycling efficiency
	5.Traditional supply chain cost	5.Material feature
	6.Responsiveness	
	7.Quality	
	8.Flexibility	
	9.Management commitment	
Downstream measures	10.Customer perspective	6.Supplier commitment

There are limitations associated with the work of Olugo et al. (2011), firstly the survey they conducted was only an expert evaluation exercise rather than a fully fledged industrial survey, hence their results are not transferable to the wider population; secondly, their research was restricted to one sector (automobile industry) and thirdly, the metrics tested in the survey were based on findings from the background literature an opposed to practitioner insight. In their study, they also identified that the measures proposed would need testing together in practice to see if they are capable of assessing the green performance of the supply chain.

The closed loop supply chain offers an alternative perspective in which to view the traditional forward supply chain. It is also seen as a way in which organisations are able to meet the demands set upon them regarding energy efficiency and their commitment to corporate social responsibility (Coronado Mondragon et al., 2011) (Figure 5.15).

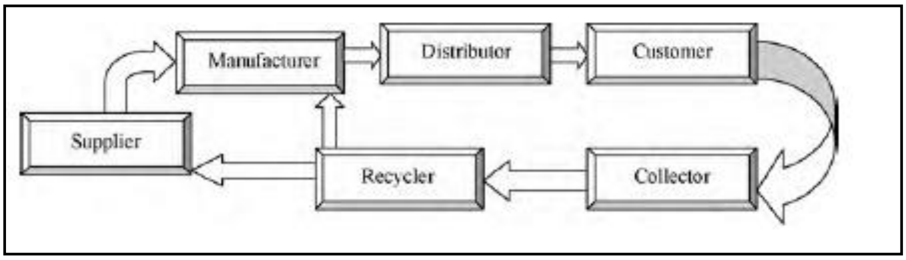


Figure 5.15 – Closed Loop or Green Supply Chain (Olugo et al., 2011:3)

Coronado Mondragon et al. (2011) also evaluated forward and reverse performance measurements for a closed loop supply chain. They identified and tested 16 performance measures for the forward chain and 12 performance measures for the reverse chain with a European mobile phone network operator, however, they did not identify any green measures in their list of proposed measures; only traditional performance measures based around cost, time and accuracy.

Carbon emissions have become an industry-recognised measurement in the environmental management process and in the fight against climate change, however the challenge is where to draw the boundary line over what should and should not be carbon audited, also allocating energy and emissions to particular activities is complex (McKinnon, 2009b). The complexity of supply chains, their variability, scalability and cost make carbon auditing or LCA, as is used by the Carbon Trust (2008), fraught with difficulty. Carbon auditing or carbon footprint analysis also requires huge investment upfront (Lynas, 2007).

The Lowell Center from the University of Massachusetts developed an Indicator Level Hierarchy to identify at what evolutionary stage an organisation is at, in the environmental performance process. There are five levels to the hierarchy which are identified by Veleva et al. (2003) and presented in Figure 5.16. This is a useful hierarchy for this thesis as it identifies company variations in the use of environmental indicators (Figure 5.16). Unfortunately, the study conducted by Veleva et al. (2003) contained gaps; firstly they used a single industry sample of six large multi-national pharmaceutical companies, thus their study and results are biased towards larger companies; secondly their study sample was small and has not been tested across the wider industry which makes generalisations problematic. Nonetheless, they provide a useful list of 147 used and reported sustainability issue indicators which range from employee health and well-being through to global warming (Figure 5.17).

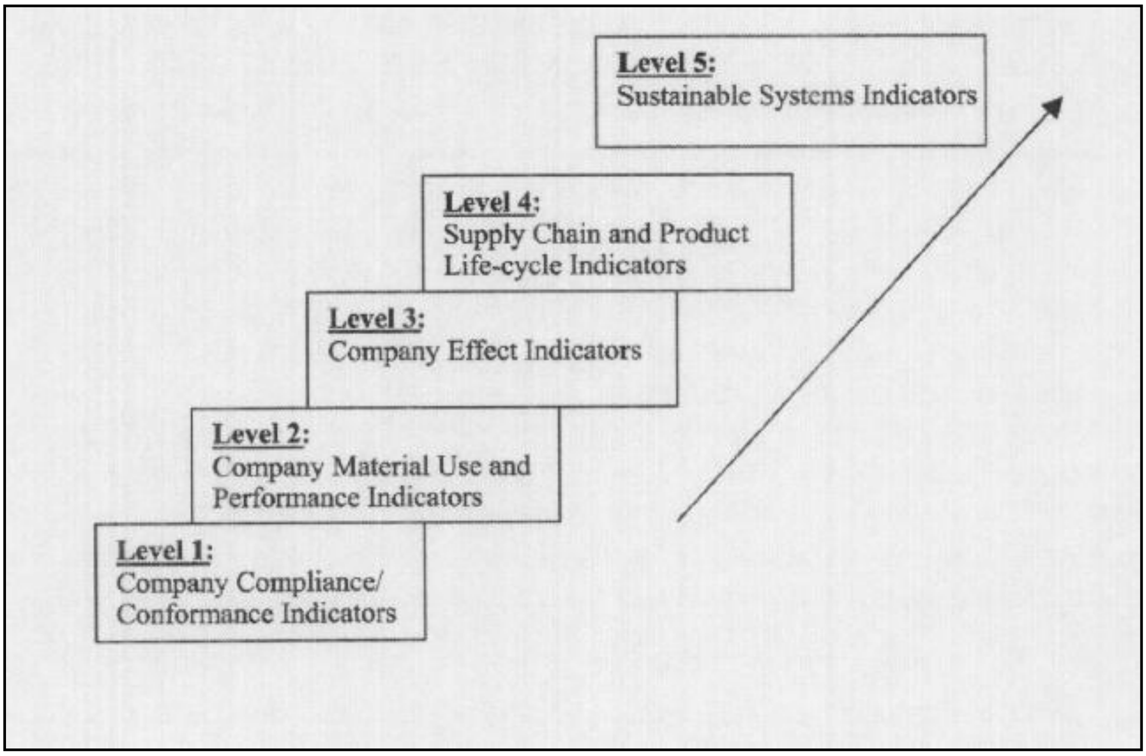


Figure 5.16 - The Lowell Center Indicator Hierarchy (Veleva et al., 2003:110)

	GRI pilot companies			Not GRI pilot companies		
Issues/areas addressed	American home products (USA)	Astra-Zeneca (UK)	Bristol-Myers Squibb (USA)	Novartis (Switzerland)	Pfizer (USA)	Roche (Switzerland)
Compliance	√	√	√	–	√	–
Remediation	√	√	√	–	–	–
EHS expenditures and benchmarking	–	√	–	√	–	√
External recognition	√	–	–	–	√	–
Employee health, safety and well-being	√	√	–	√	√	√
Material use and eco-efficiency	√	√	√	√	√	√
Emissions (to air, water, land; noise and odor)	√	√	√	√	√	√
Global warming and other environmental effects	√	√	√	√	√	√
Land use and biodiversity	√	√	√	–	–	–
Products and services	√	√	√	–	–	–
Transport	–	√	√	–	–	–
Supplier performance	–	√	√	–	–	–

Figure 5.17 – Reported Sustainability Indicators by Company (Veleva et al., 2003:115)

5.8 Summary

SCPM is vital for organisations to survive and prosper in an ever changing environment. Influenced by an organisation's corporate strategy and vision, these supply chain measures have been retrospective, traditionally focused on; cost, time and accuracy, with little consideration given to the natural environment.

Existing SCPM research is complex, fragmented, focusing on specific nodes within the supply chain rather than taking a holistic view of the entire supply chain. Academic research is advancing faster than practice (Keebler and Plank, 2009). This makes it difficult for practitioners to know what to measure, how to measure, where to start measuring; leading to 'analysis paralysis.'

This research field (SCPM) is at a critical point and juncture; entering a new direction, categorised by context, by theme and by challenge. One of the key challenges identified is the natural environment (Neely, 1999). This is important because of the concerns around the impact humans are having on the environment, particularly in the supply chain. One thing is very clear; performance measurements must continually evolve to ensure they meet the needs of the changing business environment; they must also be fit for purpose (Caplice and Sheffi, 1995).

There is a need for organisations to move away from evaluating just their traditional financial bottom line, but to evaluate their social and environmental performance. This is important because of the long term future of the planet and the obvious win win opportunities in terms of environmental and organisational performance which translate into competitive advantage, leading to greater profitability (Klassen and Vachon, 2003).

There is also still no consensus or evidence to suggest which performance measurement frameworks are the most appropriate in a general business performance context, this presents challenges for GSCPM integration and evaluation. The ISO 14031 (PDCA) continuous improvement framework, however, is by the far the most appropriate for environmental management, because it is the most widely adopted and accepted in industry, and it is familiar and relevant to practitioners.

The literature thus far suggests there is a real opportunity to explore the development of GSCPM and how environmental impacts caused by the supply chain affect the natural environment and society at large. A number of GSCPM variables have been discussed in the literature so far; CO_2 emissions are of significance to this thesis as they are attracting increased attention from government because of climate change issues. There are however others; they include emissions, people, energy, efficiency, water, greenhouse gases, recycling, waste reduction and cost.

There has been little work done in developing and incorporating these green measures into the existing bank of supply chain performance measures. This necessitates the urgent need for further research to guide practitioners as they emerge out of the recession and prepare for revenue growth. This thesis, will therefore, address the foregoing gaps by developing and testing GSCPM variables and reporting tools for organisations.

The next chapter will draw together the findings from the background literature to propose the research questions for this thesis. A conceptual model will be produced to help articulate and underpin this research agenda within the field of GSCPM.

CHAPTER SIX

EXISTING EMPIRICAL RESEARCH AND PROPOSED RESEARCH QUESTIONS

6.1 Introduction

Chapters Two through to Five have reviewed the existing literature which has helped to develop and shape this research debate. Firstly, this chapter will begin by examining a total of 88 empirical studies in the field of GSCM and categorise these according to their relevance to this thesis. Secondly, an analysis will be conducted to assess the 18 most relevant GSCPM empirical studies in terms of their key contributions, shortcomings and disparities. Finally, the research framework is discussed and the author summarises the key findings and gaps in a conceptual model with the proposed research questions/objectives for this thesis.

6.2 Review of Existing Empirical Studies

A total of 88 empirical studies have been identified as relevant to this research; 18 of these empirical studies specifically relate to GSCPM and are therefore important to this thesis. The remaining 70 empirical studies relate to GSCM, which is the field upon which GSCPM has developed and continues to evolve (Table 6.1). There have been a large number of special journal issues devoted to GSCM research, which have concentrated on specific nodes or activities within the supply chain, for example; green purchasing or reverse logistics (Holt and Ghobadian, 2009). The fragmentation and complexity of this generic research area support the fact that this is fertile ground for research and requires further exploration (Srivastava, 2007). The 70 GSCM studies identified are important in the context of this thesis as they provide a foundation from which extant GSCPM theory and research have emerged.

A significant amount of literature has also emerged from within the field of SCPM. Current research in this field evaluates how supply chain performance measures are currently selected, analysed and classified within organisations (Gunasekaran et al., 2004). The majority of studies in this research field are general reviews and literature reviews with very little empirical contribution. The key categories of measurement identified from the extant literature include: cost, time, accuracy, customer service, reliability and flexibility (Banomyong and Supatn, 2011). Performance measurement systems (PMS) have also migrated from traditional, financial systems to more balanced, cross functional and integrated ways of measuring performance (Kaplan and Norton, 1992).

The purpose of this thesis is concerned specifically with the development and testing of GSCPM variables. A review of the five leading logistics journals (Menachof et al., 2009), an ISI Web of Science database (2009) search and a review of other various publications, journals, texts and books between 1994 and 2012 have identified 18 articles which are of primary importance and relevance to this research debate. The 18 articles specifically address issues associated directly with the development of green/environmental supply chain performance (Table 6.1, right column). Those authors marked in bold under the heading of GSCPM (Hervani et al., 2005; Olugo et al., 2011) have conducted empirical studies which have specifically discussed or attempted to develop GSCPM; thus their contribution is relevant and closely aligned to this thesis.

Table 6.1 – Articles Examined in the Field of Green Supply Chain Management (GSCM) and Green Supply Chain Performance Measurement (GSCPM)

<table>
<tr><td colspan="2">Author & Year - These sources are not included in the thesis reference list unless they are discussed in the text.</td></tr>
<tr><td>Green Supply Chain Management (GSCM)</td><td>Green Supply Chain Performance Measurement (GSCPM)</td></tr>
<tr><td>1. Aronsson and Brodin (2006)
2. Abukhader and Jőnson (2004)
3. Bai and Sarkis (2010)
4. Bloemhof-Ruwaard, Beck, Hordijk and Wassenhove (1995)
5. Carter, Kale and Grimm (2000)
6. Carter and Jenning (2002)
7. Carter and Roger (2007)
8. Cheng and Yeh (2008)
9. Cheng, Yeh and Tu (2008)
10. Chung and Tsai (2007)
11. Cruz and Matsypura (2009)
12. Davies and Hochman (2007)
13. Diabat and Govindan (2010)
14. Epstein and Weisner (2001)
15. Florida (1996)
16. Gilbert (2001)
17. Gonza lez-Benito and Gonza lez-Benito (2008)
18. Gupta (1995)
19. Gunther and Scheibe (2004)
20. Holt and Ghobadian (2009)
21. Lamming and Hampson (1996)
22. Lee, Kim and Choi (2012)
23. Linton, Klassen and Jayaramara (2007)
24. Lippman (2001)
25. Klassen and McLauglin (1996)
26. Klassen (2000)
27. Klassen (2002)
28. Kovács (2004)
29. Kovács (2008)
30. Matthews (2003)
31. Min and Galle (1997)
32. Mollenkopf, Stolze, Tate and Ueltschy (2010)
33. Murphy, Poist and Braunschweig (1995)
34. Murphy, Poist and Braunschweig (1996)
35. Murphy, Poist and Braunschweig (2000)
36. Putnam (2002)
37. Rao (2002)
38. Sanchez Rodrigue, Potter and Naim (2009)
39. Sarkis (1995)
40. Sarkis (1999)
41. Sarkis (2002)
42. Sarkis (2003)
43. Sarkis (2011)
44. Seuring and Muller (2008a)
45. Seuring and Muller (2008b)
46. Shang, Lu and Li (2010)
47. Sharfman, Shaft and Anex (2009)
48. Shen, Olfat, Govindan, Khodaverdi and Diabat (2012)
49. Sheu (2008)
50. Sheu, Chou and Hu (2005)
51. Simpson, Power and Samson (2007)
52. Srivastava (2007)
53. Testa and Iraldo (2010)
54. Ubeda, Arcelus and Faulin (2011)
55. Vachon and Klassen (2006 a)
56. Vachon and Klassen (2006 b)
57. Walker, Sisto and McBain (2008)
58. Walton, Handfield and MeInyk (1998)
59. Wolf and Seuring (2009)
60. Wu and Dunn (1995)
61. Young and Kielkiewicz-Young (2001)
62. Zhu and Sarkis (2006)
63. Zhu, Sarkis and Lai (2007)
64. Zhu, Sarkis and Lai (2008a)
65. Zhu, Sarkis and Lai (2008b)
66. Zhu, Sarkis and Lai (2011)
67. Zhu, Geng, Fujita and Hashimoto (2010)
68. Zhu, Sarkis, Condeiro and Lai (2008)
69. Zinglales O'Rourkeand Orssatto (2002)
70. Zsidisin and Siferd (2001)</td><td>1. Braithwaite and Kinivett (2008)
2. Burgos Jimenez and Lorente (2001)
3. Characklis and Richards (1999)
4. Edwards, McKinnon and Cullinane (2009)
5. Faruk, Lamming, Cousins and Bowen (2002)
6. Hervani , Helms and Sarkis (2005)
7. McIntyre, Smith, Henham and Pretlove (1998)
8. McKinnon (2009a/b)
9. Nawrocka, Brorson and Lindhqvist (2009)
10. Olugo, Wong and Shaharoun (2011)
11. Paksoy, Bektas amd Ozceylan (2011)
12. Rao and Holt (2005)
13. Rothenberg, Schenck and Maxwell (2005)
14. Shaw, Grant and Mangan (2010)
15. Sundarakani, Souza, Goh, Wagner and Manikandan (2010)
16. Veleva, Hart, Greiner and Crumbley (2003)
17. Zhu and Sarkis (2004)
18. Björkland, Martinsen and Abrahamsson (2012)

BOLD = Articles which specifically discuss and address the development and testing of GSCPMs</td></tr>
</table>

Despite the importance of this research problem to practitioners and academics, a lack of published empirical research exists within this research area; with approximately half of the GSCPM articles published in journals outside the field logistics (Table 6.2). This trend suggests that it has not been fully explored and embraced within the supply chain and logistics discipline but instead is evolving and developing from within other environmental related disciplines such as: *Industrial Ecology, Cleaner Technology, Waste Recycling, Resource Management and Benchmarking* disciplines. The same trend was identified by Abukhader and Jönson (2004) between 1992 and 2002, they found that eight main logistics related journals treated the publication of 'logistics/SCM and the environment' subject less favourably than other established subjects such as management science, business science and information technology.

GSCPM is important because of the long term future of the planet and the human exploitation of its non renewable resources (Elkington, 1992). In the short term, there are also obvious win win opportunities in terms of environmental and organisational performance which translate into competitive advantage, leading to greater profitability (Klassen and Vachon, 2003). Companies that understand and value their ecosystem impacts, dependence and holdings will have a major advantage over their competition (WBCSD, 2011).

Eighteen articles published in the last 18 years is not a significant contribution and reinforces the need for further research in this area. This is a fertile ground for research in logistics and supply chain management and a new area of theory development. Table 6.2 outlines the 18 key articles and authors with their study description, findings, gaps and country of origin which are most relevant to this thesis.

Approximately 56 per cent of the 18 published articles are UK/EU based work, with the remaining split 22 per cent Asia based and 22 per cent US based. The majority of the US/Asia articles have been published in journals outside the field of logistics (Table 6.2). This trend suggests that the governance and focus on environmental management may vary by country and be influenced by their environmental management legislation or be representative of their countries evolutionary stage within the environmental management process. Also, only six of the 18 articles are published within the top ten ranked logistics journals (Menachof et al., 2009; McKinnon, 2013), four of which are

UK/EU based publications. This could perhaps suggest a greater acceptance of this research problem within logistics in the UK/EU.

Furthermore, of the 18 articles published thus far on GSCPM, approximately half are empirical studies and the remaining studies are literature reviews or general reviews. The earliest publication date is 1998; the most recent is 2012. This suggests that the research is very immature and still at an exploratory stage dominated by qualitative research methods. There is a real opportunity and requirement to empirical test within this research area to build upon the existing research and contribute to the body of knowledge. This is the primary aim of this thesis. Figure 6.1 graphically illustrates the number of GSCM and GSCPM publications by year which have been analysed through the thesis literature review process.

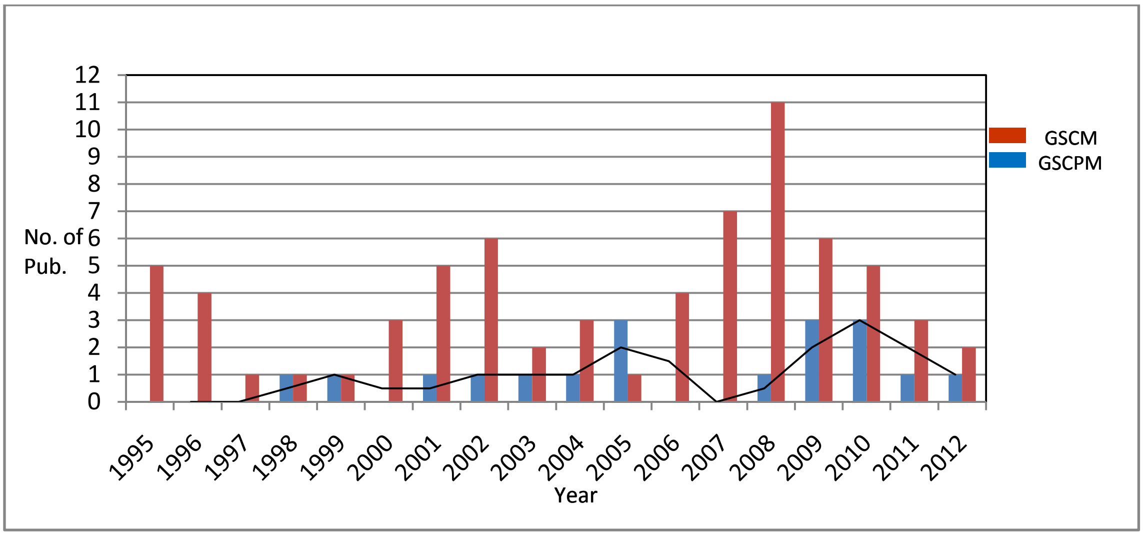


Figure 6.1 - Green Supply Chain Management (GSCM) and Green Supply Chain Performance Measurement (GSCPM). Publications by year (1994-2012)

GSCM emerged in the early nineties as a research debate (1994), since then it has gathered momentum and focus as a research area with publications increasing significantly in the early part of this century and between 2006 and 2012, with a peak in 2008. GSCPM entered the research arena slightly later, around 1998 and has slowly increased, declined and increased (as indicated by the moving average trend line). Figure 6.1 suggests that both research areas are growing and developing, however, GSCM is developing at a faster and more prominent pace than the GSCPM.

The most frequently cited works within the 18 key articles are: Hervani et al. (2005), with six citations, McIntyre et al. (1998a), with five citations, Rao and Holt (2005), with three citations and Rothenberg et al. (2005) also with three citations (Figure 6.2). Hervani et al. (2005) provide an integrative framework for the design and evaluation of GSCPM which is of relevance to this thesis as they design a framework from within which green performance measures for supply chains can be selected and evaluated; this is closely aligned to the thesis objectives. Hervani et al. (2005) call for more research in GSCPM and reporting systems as they are yet to fully exist in organisations. There a number of shortcomings with the work of Hervani et al. (2005), firstly, their study is based purely on experiences, literature reviews and case studies and therefore lacks empirical rigour. Secondly, they discuss various measures, for example the GRI measures, however they do not propose or recommend any measures only the PDCA framework as a tool for evaluation. Nonetheless, it is one of the first studies to explore the development of GSCPM selection specifically related to the supply chain.

McIntyre et al. (1998a) also presented a review of two diverging mindsets: performance measurement and greening supply chains. This is of relevance to this thesis as the literature so far has revealed there are key barriers and motivators to the adoption of green supply chain management practices from board level (strategically) right down to a tactical and operational level (Chapter Four). There is a risk that the two management areas will disappear down diverging paths. This will affect the rate of adoption of GSCPM in practice; however, one way of increasing the rate of adoption can be explained by the work of Rao and Holt (2005). They identified key linkages between GSCM, economic performance and competitiveness, however, more of this research type is required to change practitioner mindsets and convince companies that measuring supply chain environmental performance will deliver tangible benefits. Once these benefits are quantified, environmental benchmarking activities can take place (Rothenberg et al., 2005). The study by McIntyre et al. (1998b) again relies solely on a case study approach and their results are therefore valid but not necessarily transferable across wider industry.

Hervani et al. (2005) are also cited four times within the 70 generic GSCM articles and therefore ten citations in total across the two fields (Figure 6.2). This reinforces the importance of their contribution not only in the field of GSCM but also to GSCPM. No other authors have been so extensively cited across both categories in this area of research; their work will therefore be of central importance to this thesis. Furthermore, their paper calls for more research to conceptualise GSCPM to aid its introduction and implementation, which is the direct aim of this thesis.

Another very prominent and popular article in the field of GSCM is that of Zhu and Sarkis (2004). It is cited fifteen times within the 70 GSCM articles. Their article reviews the relationship between operational practices and performance amongst early adopters of GSCMPs in the Chinese manufacturing sector. They identify a positive relationship between GSCMPs and economic performance, with 'win win' opportunities (similar findings to the work of Rao and Holt, 2005). This is probably why it has been cited so extensively within this field as it provides key financial justifications for further research and exploration. These key citations reinforce the need to explore this research debate further and help organisations to develop and implement their own GSCPMs.

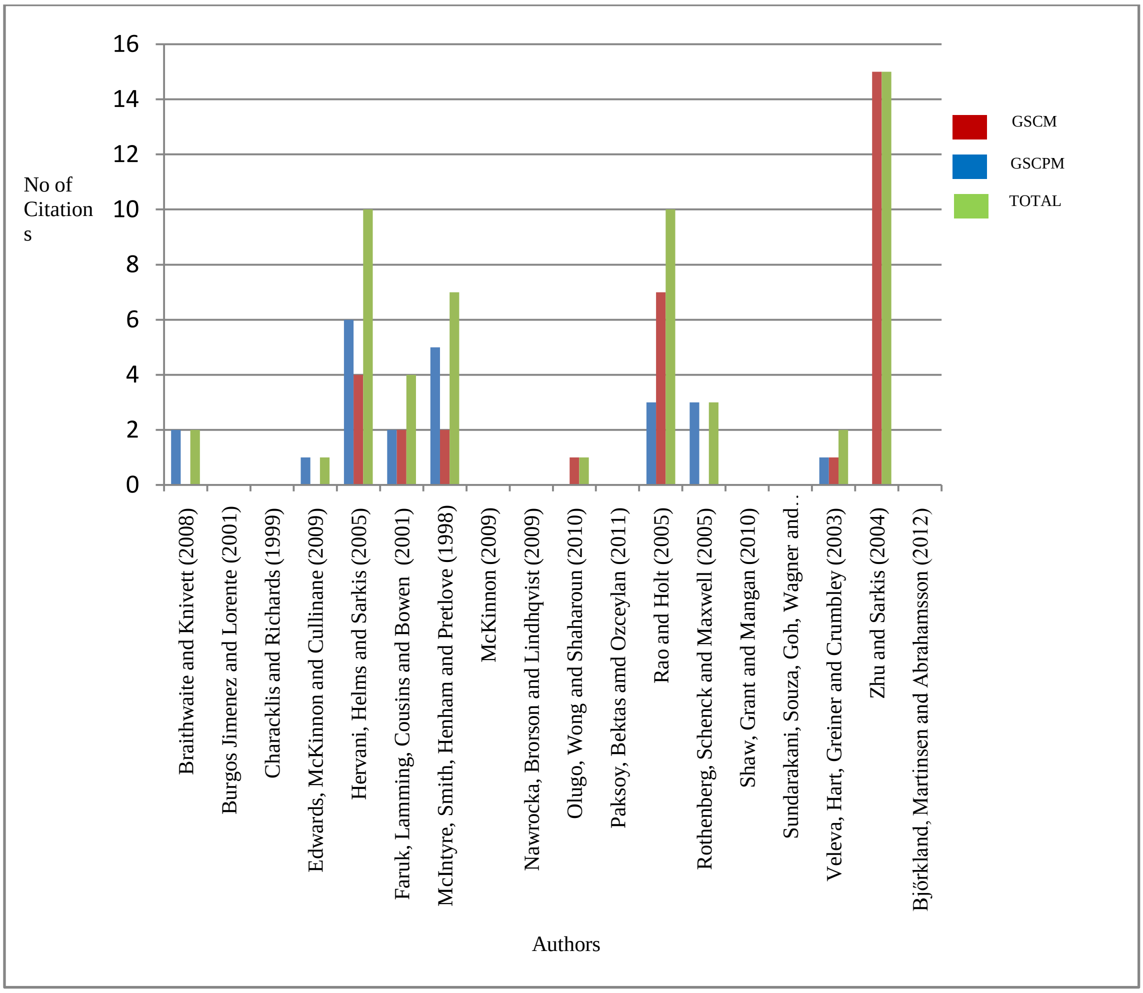


Figure 6.2 – Citation analysis of GSCM and GSCPM articles between 1994 -2012

Table 6.2 summarises the key findings, gaps and disparities for 18 GSCPM articles.

The empirical study produced by Olugo et al. (2011) is also extremely relevant and closely aligned with this thesis. This is because they conducted a three part survey and literature review to establish key performance measures for the green automobile supply chain. They identified ten key performance measures for the 'forward chain' (getting vehicles to the consumer) and six key performance indicators for the 'reverse chain'. There are shortcoming associated with the work of Olugo et al. (2011), firstly the survey they conducted was only an expert evaluation exercise rather than a fully fledged industrial survey, hence their results are not transferable to the wider population; secondly, their research was restricted to one sector (automobile industry) and thirdly, the metrics tested in the survey were based on findings purely from the background literature opposed to actual practitioner input. In their study, they also identified that the measures proposed would need testing together in practice, to see if they are capable of assessing the green performance of the supply chain. This study emphasised the gap which exists in nearly all of the existing GSCPM studies; that is, there is an urgent requirement to develop and test a battery of GSCPM variables for the entire supply chain. This battery of GSCPM variables must be joined up to avoid duplication; be universal to all organisations, regardless of country of origin, sector or size, and meet the evaluation criteria proposed by Caplice and Sheffi (1994).

Table 6.2 – A Review of the 18 Key GSCPM Articles, their Findings, Gaps and Disparities

Author (s)	Description	Findings & contributions	Gaps/Shortcomings	Origin	Journal Title
1. Braithwaite and Knivett (2008)	Evaluating a supply chains carbon footprint using 'carbon to serve' auditing	A case study applying carbon to serve is demonstrated	Does not include the assessment of economic or social performance of supply chains	UK	*Logistics Research Network (2008)*
2. Burgos Jimenez and Lorente (2001)	Review of the literature on operations management and environmental performance	Environmental and operational objectives compliment each other	Does not include the assessment of economic or social performance of supply chains	EU	*International Journal of Operations & Production Management*
3. Characklis and Richards (1999)	To highlight the findings from the (NAE/NRC) study which analysed environmental performance metrics in four US sectors	Environmental metrics are measuring stick enabling organisations to direct resources towards pressing problems	Old review, only focusing on 4 US sectors. Research may have moved on since then. Review of secondary data	US	*Corporate Environmental Strategy*
4. Edwards, McKinnon and Cullinane (2009)	Insights into the carbon footprint of online retailing from a 'last mile' perspective	Home delivery options is likely to generate less C02 than conventional shopping	Only focus on small non-food retail companies. Need to empirical test their findings	UK	*International Journal of Physical Distribution & Logistics Management*
5. Hervani, Helms and Sarkis (2005)	To introduce and present an overview of the issues relating to environmental supply chain performance measurement	Provide an integrative framework for the design and evaluation of GSCP measure	Propose only one model. Discuss only environmental measures and not TBL measures. Do not recommend measures	US	*Benchmarking: An International Journal*
6. Faruk, Lamming, Cousins and Bowen (2001)	The application and use of EcoSCan tool in analysing and mapping environmental effects along the supply chain	No findings, only a description of how it can be used	Does not include the assessment of economic or social performance of supply chains	UK	*Journal of Industrial Ecology*
7. McIntyre, Smith, Henham and Pretlove (1998b)	A review of two diverging mindset: performance measurement and greening supply chains	The two mindset appear to be diverging and require amalgamating	Does not empirical test divergent mindset	UK	*International Journal of Logistics Management*
8. McKinnon (2009b)	A review of product level carbon auditing in supply chains (IJPDLM)	Carbon product level auditing is costly and time consuming and requires a simplification of the process	Only look at carbon auditing	UK	*International Journal of Physical Distribution & Logistics Management*
9. Nawrocka, Brorson and Lindhqvist (2009)	Discuss and review the existing and future role of ISO 140001 in environmental supply chain management practices	Co-operation between the purchasing and environmental functions is not achieved through ISO 14001	Only assessed two Swedish companies and a small sample	EU	*Journal of Cleaner Production*
10. Olugo, Wong and Shaharoun (2011)	To develop a set of measures for evaluating the performance of green automobile supply chains	Identified KPIs for the forward and reverse chains in the green automobile industry	Only look at the automobile industry. Only an expert evaluation survey and not	Asia	*Resources, Conservation and Recycling*

			industrial		
11. Paksoy, Bektas and Ozceylan (2011)	To investigate environmental performance measures in relation to transportation operations, within a closed loop supply chain	Costs of environmental impacts are not as apparent as operational measures	Only looks at the transport sector and does not empirically test industry data.	UK/EU	*Transportation Research Part E*
12. Rao and Holt (2005)	To understand if green supply chains lead to competitiveness and economic performance	Identifies linkages between green supply chain management, economic performance and competitiveness	Focuses on a small sample of organisations in South East Asia	Asia	*International Journal of Operations & Production Management*
13. Rothenberg, Schenck and Maxwell (2005)	To understand the benefits and problems with different environmental performance benchmarking approaches	Develop four categorise of environmental measures for benchmarking. Firms have different approaches to benchmarking depending on their strategy	It draws on data from only one industry (automobile) and focus on performance benchmarking	US	*Benchmarking: An International Journal*
14. Shaw, Grant and Mangan (2010)	To review the extant literature on the development of environmental performance measures for supply chains and suitable performance frameworks(IJB)	Their literature suggests an opportunity to explore further the relationship between the environment, logistics and performance measurements	The proposed framework and measures have not been empirically tested	UK	*Benchmarking: An International Journal*
15. Sundarakani, Souza, Goh, Wagner and Manikandan (2010)	Analyses the carbon footprint of supply chains by using analytical modelling (IJPE)	Carbon emissions can and should influence the design of the supply chain	Not applied to real industry data. Does not take into consideration turbulent, multi-echelon supply chains	Asia	International Journal of Production Economics
16. Veleva, Hart, Greiner and Crumbley (2003)	Focuses on the voluntary use of environmental indicators in six US pharmaceutical companies	Most indicators publically reported include eco efficiency or economic indicators and not environmental indicators	Need to empirically test in other sectors, countries and with a larger sample	US	*Benchmarking: An International Journal*
17. Zhu and Sarkis (2004)	Examine relationships between operational practices and performance amongst early adopters of green supply chain management practices with Chinese manufacturers	Strong relationship between GSCM practices and economic performance	Purely based on Chinese manufacturing companies. Used a convenience opposed to random sample. Small sample size.	Asia	*Journal of Operations Management*
18. Björkland, Martinsen amd Abrahamsson (2012)	Propose a framework of dimensions which are important environmental supply chain performance measurement	Provide insights on how environmental supply chain performance can be applied across managerial levels and company borders	A case study only and not empirically tested on a larger sample	EU	*Supply Chain Management: An International Journal*

The research methodologies used predominantly across the 18 studies are literature reviews/general reviews (Table 6.3). This included reviews or personal experiences by authors (McIntyre and Smith, 1998b; Burgos Jimenez and Lorente, 2001; Shaw et al., 2010). However, some studies used a mixed methodological approach, for example focus groups, face to face interviews and case based research to explore the research phenomenon (Hervani et al., 2005; Edwards et al., 2009; McKinnon, 2009b; Nawrocka et al., 2009). This indicates a qualitative nature to the existing empirical studies, one of exploration and explanatory rather than a complete picture of reality; this approach is important in such a new research area and has helped to provide insights or snap shots into particular contextual settings, organisations or industrial sectors. The sectors which have been researched previously in this field include: manufacturing, transport operations, pharmaceutical, automobile and operations management (Table 6.3); therefore, the empirical research conducted so far has been industry or supply chain node specific.

The sample sizes are also small in these articles which help the authors to gain an in-depth insight into the nature of the problem. In contrast, four of the 18 articles used a questionnaire based survey methodology with a significantly larger study sample (Zhu and Sarkis, 2004; Rao and Holt, 2005; Olugo, et al., 2011). The survey based questionnaires were sent to between 200-300 respondents, with a response rate of between 10 – 66.6 per cent. The four page questionnaire survey issued by Olugo et al. (2011) was tested for content validation by a panel of industry and academic experts before being issued. Their survey was deemed as an expert evaluation rather than a fully fledged industrial survey. This is because the respondents comprised industrial and academic experts and not industry practitioners. The purpose of their survey was to validate proposed environmental metrics for the automobile supply chain which is why their survey contained multiple questions and was issued to over 200 expert respondents. They were looking for expert views and opinions.

Zhu and Sarkis (2004) issued 281 surveys and received 186 responses, consisting of 21 questions (likert scale); this high response rate was achieved through ‘close contact’ between the research team and respondents and by a member of their research team being on site to help the Chinese respondents answer the questions and deal with translation issues. The purpose of their survey was to examine the relationship between operational practices and performance amongst early adopters of GSCM and to test various hypotheses. They required a large sample in order to test their hypotheses for statistical significance and used convenience sampling to select respondents (as they struggled to achieve a satisfactory response rate). They too had their questionnaire validated by industry experts prior to issue. Also, using likert scale, Rao and Holt (2005) issued a 64 point questionnaire based survey to ISO 14001 registered organisations in Asia to empirically test the link between GSCM and economic performance, achieving 52 responses and a 10 per cent response rate.

In contrast, the questionnaire based survey issued by Nawrocka et al. (2009) was issued to a much smaller industrial sample; it was issued to 29 sites across just two companies and only asked three general questions to gain in-depth insights. It was not clear in this study the method of sampling or if the questionnaire had been content validated before issue. To compliment this study they also used focus group discussions and semi-structured interviews to capture additional experiences and views on environmental practices. The latter research approaches adopt a more quantitative research approach; however, Nawrocka et al. (2009) demonstrated the use of a traditional based research methods (survey) combined with a qualitative approach to gain a rich contextual understanding of ISO 14001 in two particular organisations.

Only two pure quantitative studies were identified in the GSCPM literature review which used mathematical scenario modelling to model the carbon footprint across the supply chain (Sundarakani et al., 2010) and scenario based modelling to assess the environmental measures for the transport sector (Paksoy et al., 2011). This is a significant finding as it suggests it is increasingly difficult to build theory in a new research area using purely quantitative methodologies and without real industry data.

Notwithstanding the empirical rigour of mathematical modelling of over 663 variables and 4854 constraints (Sundarakani et al., 2010), the issue with this type of study in such a new research debate means it has little internal validity as it does not use any real industrial data. It therefore has a high reliability (external validity) but low internal validity and provides little insights into these new research phenomena. Literature reviews are the most commonly used methodology in the 18 GSCPM articles. The GSCM literature is dominated with a large number of articles using survey based empirical methods, case based research and mathematical tools/techniques (Srivastava, 2007); however this is not reflected in the 18 GSCPM articles.

The literature review has revealed that GSCPM research has been orientated predominately around the interpretative paradigm (inductive), which contrasts with the traditional positivist paradigm associated with logistics research (deductive). The interpretative and a mixed methodological approach are appropriate in such a new and developing research area to provide new insights and to build theory. There is clear evidence that some authors are applying deductive methodological approaches in an attempt to obtain causality for example; proving the link between economic performance and environmental management which is imperative to the future justification of this research field (Zhu and Sarkis, 2004). The research contexts and samples also vary significantly, and are very fragmented with a tendency for small sample frames, for example; specific companies under assessment, particular sectors, such as manufacturing companies in China and companies using ISO 14001 in Asia (Table 6.3). The findings, therefore, only provide snapshots of reality in very specific contexts and this needs expanding considerably to understand the research area in more generalisable ways. Also, previous research on environmental performance management in the UK has been primarily conducted in the transport sector (Edwards et al., 2009; McKinnon, 2009b) and led by a prominent lead author, Alan McKinnon. Therefore, there is an opportunity to expand upon the works of Hervani, et al. (2005) (US) and Alan McKinnon (UK) to explore other industry sectors and to empirically test in this research area.

Table 6.3 – A Review of the 18 Key Articles, Their Methodologies, Statistical Analyses and Sample size

Author (s)	Article Type	Methodology	Statistical Analysis	Sample	Empirical Rigour & Robustness
1. Braithwaite and Knivett (2008)	Review	Literature review and case study	N/A	1 xAustralian wine company	High validity, low reliability
2. Burgos Jimenez and Lorente (2001)	Review	Literature Review	N/A	N/A	Low as not empirically tested
3. Characklis and Richards (1999)	Review	Review of secondary data	N/A	4 x US sectors (auto, chemical, electronics and paper)	Low
4. Edwards, McKinnon and Cullinane (2009)	Research Paper	Secondary data and interview (face to face and over the phone)	N/A	Not stated	Assumption base, sample is not clear. Use of secondary data
5. Hervani, Helms and Sarkis (2005)	General review	Experiences, literature review and case studies	Propose only one model. Propose only environmental measures and not TBL measures	N/A	High, due to mixture of methodologies
6. Faruk, Lamming, Cousins and Bowen (2001)	Review	Case study	Mapping data using data confidence indicators	One UK public sector service provider	High validity, low reliability because of small sample
7. McIntyre and Smith (1998)	Viewpoint	Literature Review	N/A	N/A	Low
8. McKinnon (2009b)	Viewpoint	Literature review, informal discussions with managers and personal experience	N/A	N/A	Low validity and reliability as no empirical test or sample
9. Nawrocka, Brorson and Lindhqvist (2009)	Empirical study	Interviews, focus groups and a survey	Only assessed 2 x Swedish companies, small sample	2 x multi national companies	High validity, low reliability because of small sample
10. Olugo, Wong and Shaharoun (2011)	Empirical study	Literature review and postal survey	Importance and applicability mean measurement	n= 200 questionnaires	Medium
11. Paksoy, Bektas amd Ozceylan (2011)	Empirical study	Mathematical modelling (linear programming formulation)	Scenario based modelling, no statistical analysis	663 variables and 4854 constraints	High reliability, low validity

12.	Rao and Holt (2005)	Research paper	Structured survey questionnaire	Chi-squared, *t*-test and SEM approach	Dillman method: All ISO 14001 registered companies in the Philippines, Indonesia, Maylasia, Thailand and Singapore (n = 52)	Focuses on a small sample of organisations in South East Asia
13.	Rothenberg, Schenck and Maxwell (2005)	Review	Research paper: Sharing experience from a research program	N/A	N/A	Low, no empirical study, small sample
14.	Shaw, Grant and Mangan (2010)	Review	Literature review	N/A	N/A	Medium
15.	Sundarakani, Souza, Goh, Wagner and Manikandan (2010)	Empirical study	Analytical mathematical modelling	N/A	N/A	High reliability, low validity
16.	Veleva, Hart, Greiner and Crumbley (2003)	Empirical study	Case study & scorecard methodology	N/A	Six US pharmaceutical companies	Medium, high validity, low reliability
17.	Zhu and Sarkis (2004)	Empirical study	Survey based questionnaire. Hierarchical regression.	Factor analysis, bi-variate analysis using Pearson correlation.	Convenience sampling of (281 questionnaire administered, 186 responses)	Medium
18.	Björkland, Martinsen amd Abrahamsson (2012)	Research Paper	Literature review and case study	N/A	No reference to sampling strategy	Swedish recycling company

6.3 Development of Research Items and Constructs

Mentzer and Kahn (1995) argued that logistics literature and research lacked a rigorous orientation toward theory development, testing and application. They developed a framework for logistics research that followed a scientific approach using a quantitative paradigm which would help researchers to follow a rigorous, scientific approach to their logistics research (Figure 6.3). This approach is used to provide a structured framework for this thesis.

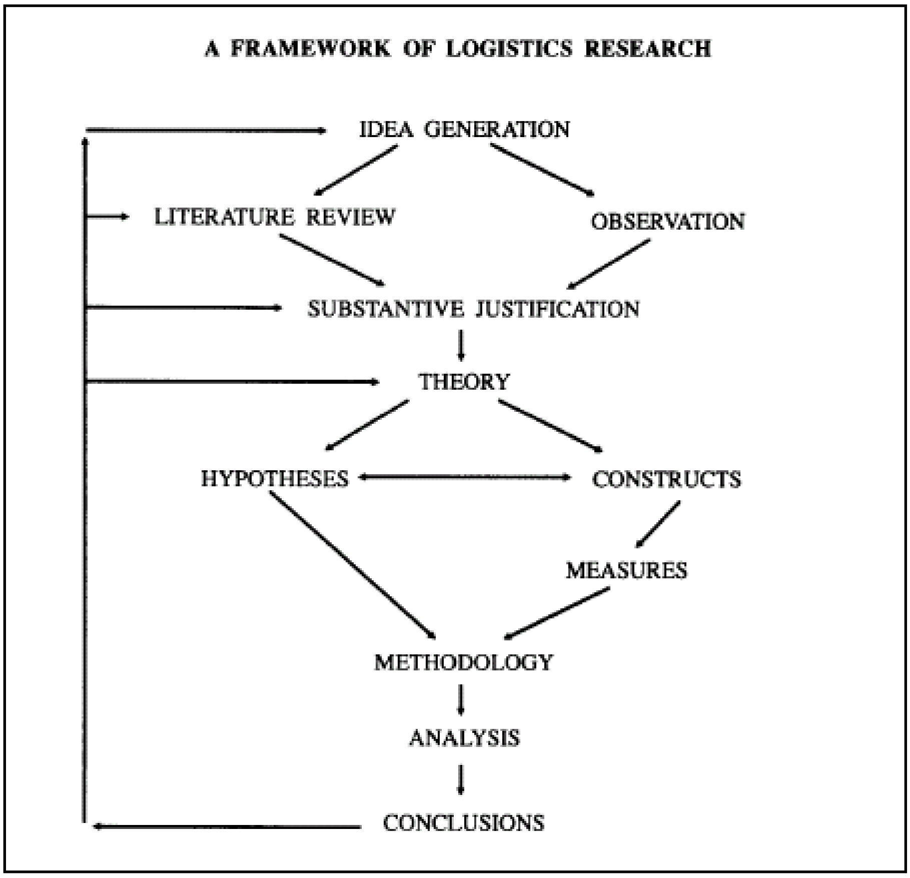


Figure 6.3 – A Framework for Logistics Research (Mentzer and Kahn, 1995:234)

The Mentzer and Kahn (1995) framework is not unique; there are other authors who have proposed similar frameworks (Churchill 1979; Malhotra and Birks 2000; Remenyi, et al., 1998; Robson 2002), however, it is appropriate and useful in this research context as it is presented within a logistics background.

6.3.1 Step One - Idea Generation & Substantive Justification

The research process starts with an idea generation, which may occur via the literature review process or an observational technique. The author originally took an interest in green logistics and performance measurement from working in industry in a UK based logistics role. The author also had previously completed an undergraduate degree in biology and therefore had an interest in the natural environment/ecosystems. A combination of brainstorming techniques with the PhD supervisor and a review of the key literature in logistics identified a gap in the extant GSCPM literature. With the UK contributing to two per cent of man made greenhouse gas emissions (Defra, 2009), the landmark Kyoto agreement (1997) taking effect and very few empirical studies on GSCPM in existence; GSCPM was quickly identified as an emerging research debate and worthy of further investigation (Figure 6.4). Furthermore, supply chain and energy security were identified as the two out of four emerging issues that will fundamentally shape the future and are central to the functioning of the world economy and to the well-being of the global society (Halldórsson and Kovács, 2010). This identified the central importance of supply chain management to climate change and the energy security agenda. There was a distinct lack of theory and practice on environmental measures for supply chains. Empirical research was required to grasp and address this logistics research debate, this thesis therefore focuses on the development and testing of a battery of green performance measures for the supply chain.

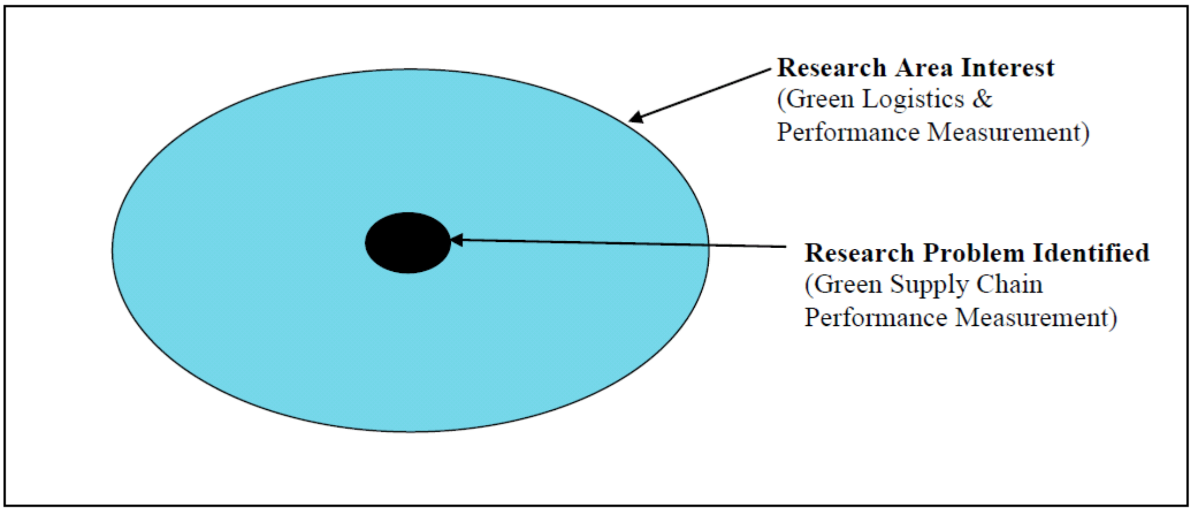


Figure 6.4 – Research Problem Interest and Definition (Adapted from Ghauri and Gronhaug, 2002:26)

6.3.2 Step Two Literature Review

The literature review and/or observational techniques are forms of logical induction which help form substantive justification for the research but also help in the development of the conceptual model and research questions. In this thesis, as discussed in Chapter Two, the literature review was conducted in two phases. The results of the literature review concluded that there were indeed gaps in the body of knowledge on

GSCPM with very few empirical studies being conducted which have developed, tested and proposed a universal set of GSCPM variables for industry; that deal with the entire supply chain from point of production through to the point of consumption. This necessitates the requirement for further research to explore and empirically test within this research area, with the ultimate aim of developing a universal battery of GSCPM variables which can be used by practitioners. Eighteen articles in the last 18 years is not a significant contribution and therefore provided substantive justification for further research.

6.3.3 Step Three - Construct Development

The next stage in the research process is to develop the research constructs. Theory construction comes from the review of the literature, previous theories, previous research approaches, author beliefs, attitudes and paradigms. The purpose of theory is to increase understanding which helps to build scientific knowledge and explain and predict the research phenomena in question (Hunt, 1991a). Theory construction is directly linked to construct development, for example, the construct of GSCPM for this thesis is defined within 'organisational theory' and its meaning can be understood through the development of questions/measures which ask organisations to explain this construct; hence operationalising it.

Following an extensive review of the literature, the next step in this thesis is to link the existing theory from the literature to the development of these key constructs. This will enable formulation of the thesis conceptual model and the research questions (Step Four) and development of research methodology (Step Five) which will be discussed in Chapter Seven.

Developing a battery of GSCPM variables for organisations forms the core contribution of this thesis. Firstly, it is important to understand what GSCPM variables exist in the extant literature in order to develop better measures for future practice and to build theory. Table 6.4 identifies the key GSCPM items identified in the literature thus far.

Table 6.4 – GSCPMs Identified in the Literature Review

Categories Identified	GSCPM Identified	Author(s)
Carbon footprint mapping, carbon to serve and carbon modelling	Carbon Dioxide Emissions (CO2)	Braithwaite and Knivett (2008), Edwards et al., (2009) McKinnon, (2009b), Sundarakan et al., (2010) and Paksoy et al (2011)
Forward, mid stream and reverse measures	Supplier commitment, greening cost, level of process management, product characteristics, traditional supply chain cost, responsiveness, quality, flexibility, management comittment, customer perspective, customer involvement, recycling cost. , recycling efficiency, material feature.	Olugo et al., (2011)
Strategic, tactical and operational	Fugitive non-point air emissions, stack or point air emissions, discharges to receiving streams and water bodies, underground injection on-site, releases to land on-site, discharges to publicly owned treatment works, other off-site transferson-site and off-site energy recovery, on-site and off-site recycling, on-site or off-site treatment, non-production releases, source reduction activities, spill and leak prevention, inventory control, raw material modification, process modifications, cleaning and decreasing, surface preparation and finishing, product modifications, pollution prevention opportunity audits and materials balances audits, employee and participative management, publicly available missions and values statement(s), management systems pertaining to social and environmental performance, magnitude and nature of penalties for non-compliance, number, volume, and nature of accidental or non-routine releases to land, air, and water, costs associated with environmental compliance, environmental liabilities under applicable laws and regulations, site remediation costs under applicable laws and regulations, major awards received, total energy use, total electricity use, total fuel use, other energy use, total materials use other than fuel, total water use.	Hervani et al (2005)
N/A	Toxic Release Indicator (TRI) (pollution to air, water and land)	Burgos Jimenez and Lorente (2001)
Environmental, social and economic Core and additional indicators	Total materials use other than water, by type, percentage of materials used that are wastes (processed or unprocessed) from sources external to the reporting organisation, direct energy use segmented by primary source, initiatives to use renewable energy sources and increase energy efficiency, indirect energy use, total water use, water sources and related ecosystems/habitats significantly affected by use of water, location and size of land owned, leased, or managed in biodiversity-rich habitats, total amount of land owned, leased or managed for production activities or extractive use, greenhouse gas emissions, other relevant indirect greenhouse gas emissions, use and emissions of ozonedepleting substances, NOx, SOx, and other significant air emissions by type, water source and other ecosystem/habitats significantly affected by discharges of water and run off, total amount of waste by type and Destination, significant environmental impacts of transportation used for logistical purposes, performance of suppliers relative to environmental components of programmes and procedures described in response to Governance Structure and Management systems	Global Reporting Initiative (2009) – Logistics Sector
Management Performance Indicators (MPI), Operational Performance Indicators (OPI) and Environmental Condition Indicators (ECI)	Raw material used per unit of product (kg/unit), Energy used annually per unit of product (MJ/1000 L product), Energy conserved (MJ), Number of emergency events or unplanned shutdowns (#/year), Hours of preventive maintenance (hours/year), Average fuel consumption of vehicle fleet (L/100	ISO 14031

	km), Percentage of product content that can be recycled (%), Hazardous waste generated per unit of product (kg/unit), Emissions of specific pollutants to air (tonnes CO_2/year), Noise measured at specific receptor (dB), Wastewater discharged per unit of product (1000 L/unit), Hazardous waste eliminated by pollution prevention (kg/year), Number of days air emissions limits were exceeded (days/year), Environmental costs or budget ($/year), Percentage of environmental targets achieved (%),Number employees trained (% #trained/to be trained), Number of audit findings (#),Number of audit findings addressed (#),Time spent to correct audit findings (person-hours), Number of environmental incidents (#/year), Time spent responding to environmental incidents (person-hours per year), Number of complaints from public or employees (#/year), Number of fines or violation notices (#/year, Number of suppliers contacted about environmental management (#/year), Cost of pollution prevention projects ($/year), Management levels with specific environmental responsibilities (#),Contaminant concentrations in ambient air ($\mu g/m^3$), Frequency of photochemical smog events (#/year), Frequency of photochemical smog events (#/year), Change in groundwater level (m), Number of coliform bacteria per liter of potable water, Contaminant concentration in surface soil (mg/kg), Area of contaminated land rehabilitated (hectares/year), concentration of contaminant in the tissue of local species, pop of species within the contaminated area, increase in algal blooms, no of hospital admission of asthman during smog periods, no of fish deaths in a specific water course, empolyee blood lead levels.	
Environmental Supply Chain Performance Measurement (ESCP) Fifth Perspective (BSC)	ISO 14031 Indicators (as shown above) GRI core and additional indicators (as shown above) Carbon dioxide emissions (CO2), environmental, social and economic index	Shaw et al., (2010)

The literature review has confirmed that the most predominately used measures in the field of GSCPM are CO_2 emissions (Braithwaite and Knivett, 2008; Edwards et al., 2009; McKinnon, 2009b; Sundarakani et al., 2010; Paksoy et al., 2011). Given carbon dioxide's long term impact on the environment and its increased focus in the media and by government, it is no surprise that both academics and practitioners have focused on this measure as a way of gauging the environmental impacts of their supply chain. It has become a useful measure that can be used to calculate carbon emissions across all nodes of the supply chain (Braithwaite and Knivett, 2008). CO_2 emissions are measured in 'kilograms' or 'tonnes' of carbon dioxide emitted per annum (Carbon Trust, 2008) and are the only measure which has been empirically tested within the field of GSCPM (Braithwaite and Knivett, 2008); Edwards et al., 2009; McKinnon, 2009b, Sundarakani et al., 2010; Paksoy et al., 2011).

Other authors demonstrate that CO_2 emissions are not the only measure in circulation, there are others, which can be used to measure GSCPM, such as the GRI (2006) core and additional indicators and ISO 14031 indicators (Hervani et al., 2005; Shaw et al., 2010). The number or range of measures, however, makes the process of measuring GSCPM very complex and difficult for practitioners, often resulting in ‘paralysis by analysis.’ Key categories/themes have emerged from the extant GSCPM literature which could help to simplify and categorise the number of metrics: the triple bottom line (TBL). The TBL links together the themes of: people, profit and planet (Elkington, 1992) which are central to the justification for this research.

Other categories include the hierarchy of strategic, tactical and operational measures (Hervani et al., 2005). Originating from within the traditional field of performance measurement this hierarchy helps to categorise GSCPM into clearly defined areas which reduces the complexity and the number of measures. Similarly, forward, mid-stream and reverse flow categories proposed by Olugo et al., (2011) could also help to simplify and categorise measures around the key structures of the supply chain.

Other commonly reviewed environmental metrics identified in the literature are: air emissions, energy use, recycling, fuel use and water use (Björkland et al., 2012). These are extensively used by organisations who are accredited to ISO 14031 and GRI (2009). These measures demonstrate the scope and scale of measuring environmental management in organisations and the level of detail which an organisation can measure in order to comply with government legislation and regulations.

Cost is a significant measure to the field of GSCM and GSCPM. Originating from within the field of SCPM, it is still a very important measure to GSCPM and underpins most empirical studies. This is because the literature so far has revealed that organisations need to see the return on investment (ROI) on measuring GSCPM, which helps to build a business case to measure and implement it. It was also identified in Chapter Five that the single biggest focus for business executives is revenue growth (Rigby and Bilodeau, 2011) and therefore ‘finance’ is a major construct in this thesis. Cost is, however, also a barrier to GSCPM adoption and organisations are put off by the upfront investment required to implement GSCMPs (Zhu and Sarkis, 2004). Organisations are financially driven and therefore need to see recovery on their investment within a few years.

The background literature has identified the following three GSCPM categories; firstly GSCPM constructs (Table 6.5), secondly, reporting tools (Table 6.6) and thirdly the key themes which underpin these GSCPM constructs and reporting tools (Table 6.7) which will be important in the development, testing and implementation of these GSCPM variables in practice.

Table 6.5 – Nine Key GSCPM Constructs Identified from the Background Literature

GSCPM Key Constructs
1. Financial
2. Energy
3. Emissions
4. Efficiency
5. Water
6. Triple Bottom Line/ Sustainability
7. People
8. Transport
9. Systems

Table 6.6 – Eight GSCPM Reporting Tools Identified from the Background Literature

GSCPM Reporting Tools
1. ISO 14001 PDCA Continuous Improvement Tool
2. Life cycle analysis (LCA)
3. Balanced Scorecard
4. Performance Prism
5. Global reporting initiative
6. Other Environmental Management Systems (EMS)
7. GreenSCOR
8. CEN Standard for measuring CO_2 (EN 16258:2012)

Table 6.7 – GSCM/GSCPM Categories/Themes

GSCPM Themes
1. ***Natural/External Business Environment*** • Context, theme and challenge • Climate change and global warming issues 2. ***Strategy*** • Competitive Advantage • Mitigation and adaptation (dyadic relationship) • Benchmarking • Stakeholder engagement • Divergent mindsets • Lean, green and global strategies • Collaboration and trust • Energy efficiency • Internal controls and external pressures • GSCM drivers and barriers • From Silos to boundary spanning measurement 3. ***Implementation and Management*** • Selection, implementation, reporting and evaluation • Systems to support measurement and reporting • Ownership and RACI (Responsible, accountable, consulted and informed) • Continuous change • Existing frameworks/tools (ISO 14001) 4. ***Classification*** • Evolutionary stage • Firm size, sector and country • Strategic, tactical and operational measures • Proliferation versus simplification • Industrial sector focus/specific • Good, better and best • Quality Criteria (Caplice and Sheffi, 1994) 5. ***Supply chain structure*** • Closed loop • Scope of measurement • Green supply chain design 6. ***Products*** • Product design (eco-efficiency) 7. ***Theory*** • Organisational theory (RBV, RDT and complexity theory) • Relationship between environmental management, economic performance and competitiveness (win win opportunities)

Nine GSCPM constructs have been identified from the background literature and existing empirical studies which range from financial through to sustainability (Table 6.5) along with eight potential GSCPM reporting tools (Table 6.6). Very little evidence exists of which ones are actually being used and viewed as important by practitioners. The author identified seven useful themes and categories from the background literature which are of importance to this thesis as they will help to develop, test and implement GSCPM in practice (Table 6.7).

Caplice and Sheffi (1994) also recommend eight criteria on which to judge the quality of metrics, they are: validity, robustness, usefulness, integration, compatibility, economy, level of detail and behavioural soundness; all of which will be considered in the development and testing of GSCPM variables. No other authors, have thus far, evaluated the usefulness (importance) of GSCPM variables to industry; this is, therefore, a unique contribution of this thesis. The 18 articles which have been published in the last eighteen years have focused mainly on the types of measures used but not necessarily which are the most important to practitioners.

Figure 6.5 builds upon the foregoing by identifying the key areas of focus within this thesis which are GSCPM development and reporting.

1. GSCPM Development → Research Primary Focus Area
2. GSCPM Implementation
3. GSCPM Reporting → Research Primary Focus Area
4. GSCPM Evaluation

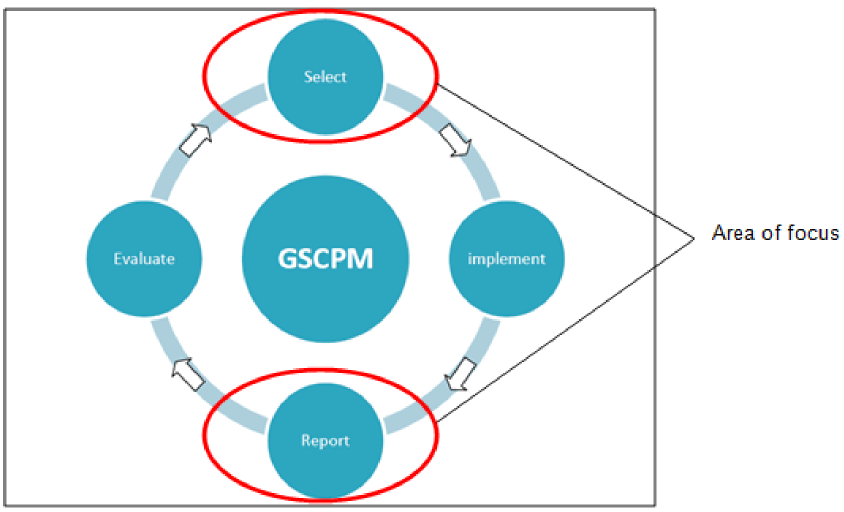


Figure 6.5 – Green Supply Chain Performance Measurement (GSCPM) Development, Implementation, Reporting and Evaluation Basic Conceptual Cycle.

Figure 6.5 illustrates the basic principles on which GSCPM can be developed and conceptualised. To really understand this in more detail a further conceptual model is presented (Figure 6.6), which builds upon the work of Hervani et al. (2005) and embraces existing EMS theory and the practice of the Plan-Do-Check-Act approach. This is important in the context of this thesis because GSCPM development forms part of a wider GSCPM management system which must be understood in order to develop and test new GSCPM variables. Figure 6.6 also links in closely with the seven GSCPM themes identified in Table 6.7, which are important for GSCPM implementation. Figure 6.6 illustrates this wider GSCPM system and takes into consideration internal and external factors which influence the GSCPM process along with the overall business strategy, which is central to this thesis.

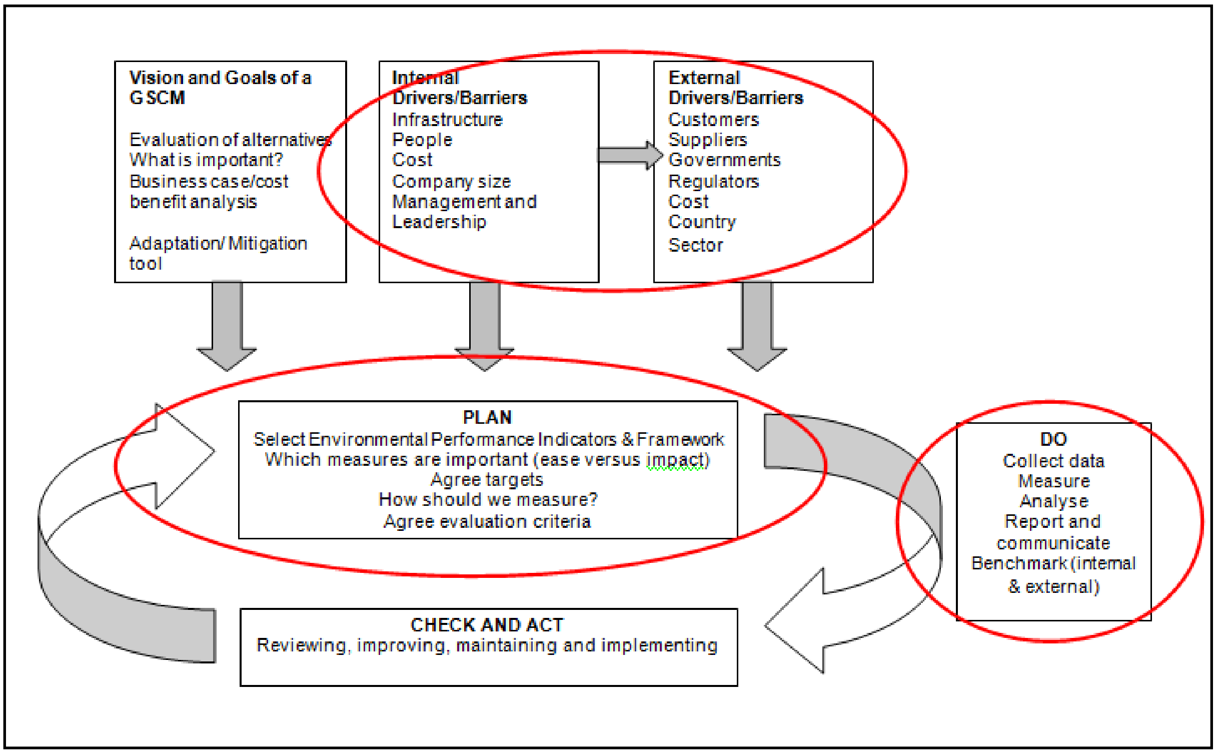


Figure 6.6 – Conceptual model to study the development and selection of green supply chain performance measurements and systems (adapted from Hervani et al., 2005:343). Red circles indicating the areas which will be addressed as part of this thesis.

The aim of this thesis is to focus on the development and testing of a universal battery of GSCPM variables for the entire supply chain, (from point of production through to point of consumption); no other author has attempted this before. The thesis is also concerned with understanding how to report and integrate this battery of GSCPM variables into an existing supply chain performance framework so that GSCPM can be incorporated and evaluated within the overall existing business strategy. Figure 6.7 provides the final and most important conceptual model of the thesis, which draws to together the key gaps in the background literature and body of knowledge to propose five research questions:

RQ1: *What GSCPMs are currently being used?*
RQ2: *Which GSCPMs are important?*
RQ3: *What are the enablers and barriers to measuring GSCPM?*
***RQ4**:* *Can GSCPM be integrated within existing SCPM frameworks?*
***RQ5**:* *Do any emerging variables and constructs mirror those found in extant literature on GSCPM?*

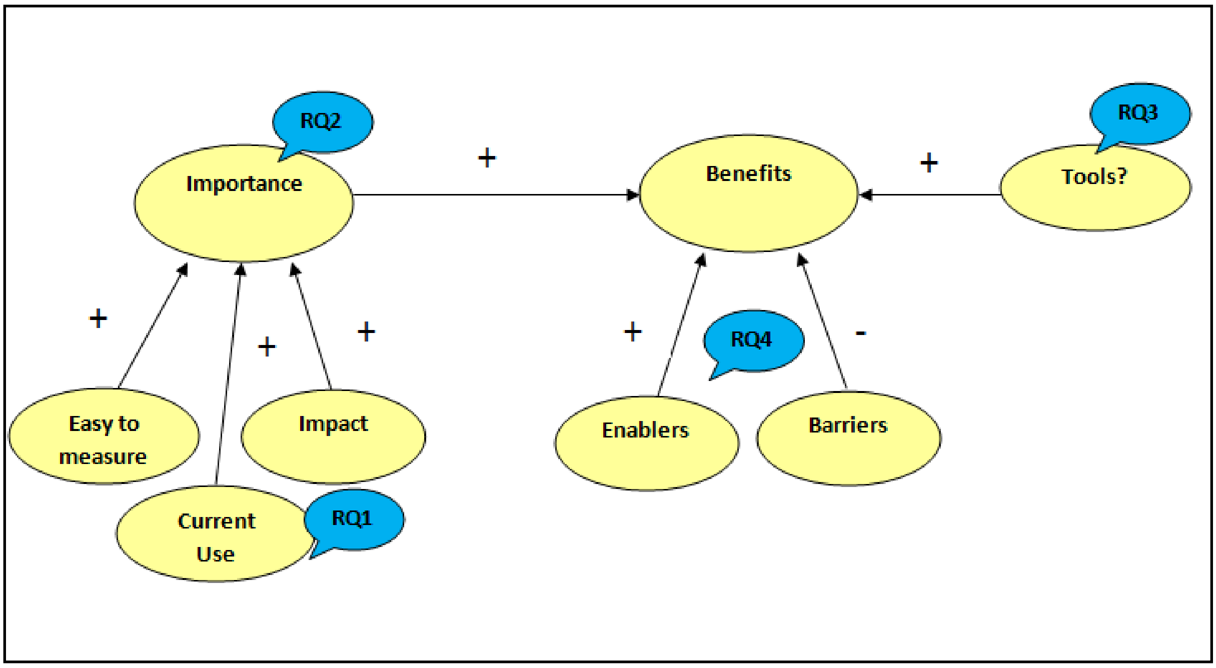


Figure 6.7 – Final Conceptual Model of the Research Core Purpose

6.3.4 Step Four – Methodology & Analysis

After establishing the research questions and conceptual model for this thesis, the next stage is to develop a robust research methodology in which to empirically test and validate GSCPM. This thesis will adopt the three phased methodology similar to the two staged process proposed by Churchill (1979) for scales and construct development (Figure 6.8).

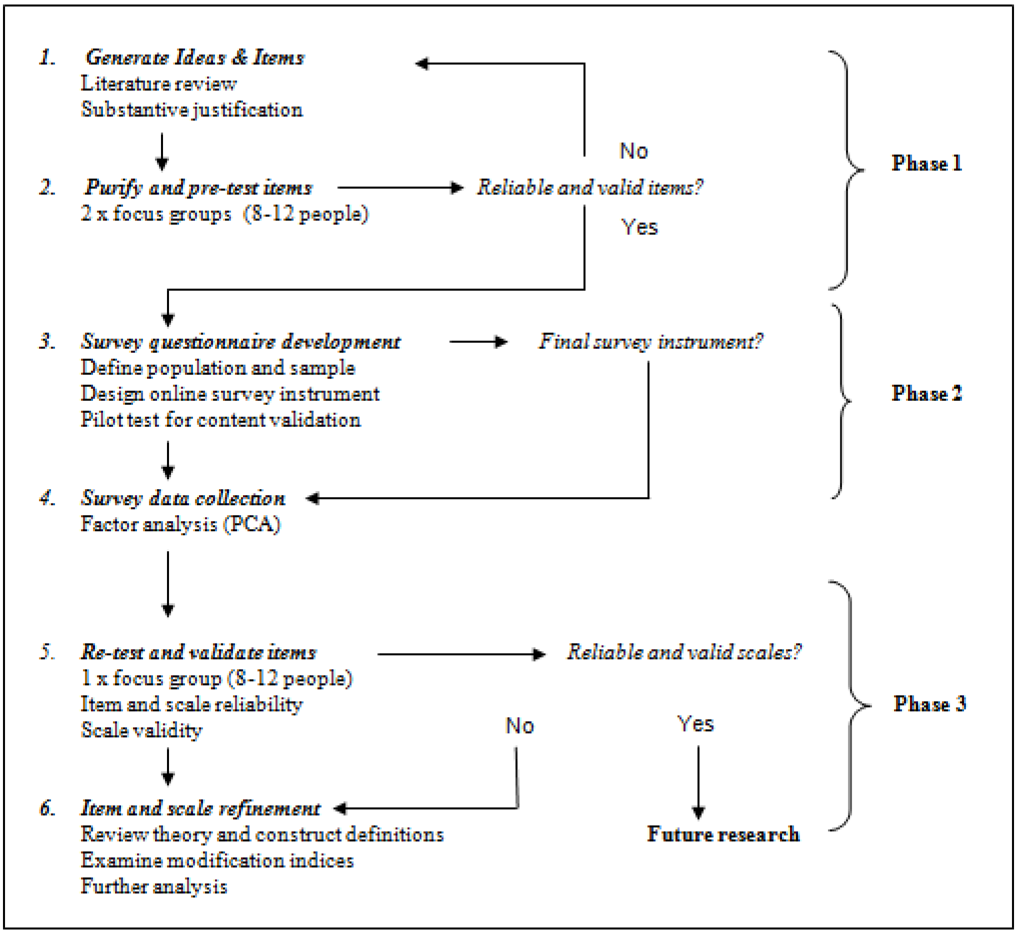


Figure 6.8: Three Phase Approach for New Item and Scales Development (adapted from Churchill, 1979; Dunn et al., 1994)

The first phase involves generating the ideas, specifying the research domain and identifying key items and constructs from the literature. Most importantly, it is about providing substantive justification for further research. Phase One also includes purifying and testing the key items and constructs. This will be achieved by conducting focus groups with industry and academic experts. The second stage consists of validating these items and variables by conducting an industry wide online survey which will be sent to logistics and supply chain practitioners. During Phase Three, a final focus group will take place on a different group of supply chain and logistics practitioners to ask for their feedback and validate the overall research findings. The full methodology and proposed analysis for this thesis will be presented in Chapter Seven.

6.3.5 Step Five - Conclusions

Following the data analysis stage, the researcher can form conclusions and rational explanations about the research problem (Mentzer and Kahn, 1995). It is hoped that the output of this thesis will yield new insights into the development of GSCPM for the organisations, sectors and wider society. It will attempt to close the gaps in the body of knowledge by providing guidance to academics and practitioners on this new research area. It will also stimulate further research and act as a foundation to build new theory, acting as link between extant theory and new.

6.4 Summary

Chapters Two through to Six have explored the existing literature which has helped to shape this research problem. This chapter has examined in detail the existing empirical studies in the field of GSCM and GSCPM to specifically understand existing approaches, paradigms, beliefs, constructs/items, dominant authors/articles and theories in GSCPM, which are important to the future theory development in this field. The Mentzer and Kahn (1995) and Churchill (1979) framework has been utilised to ensure the thesis followed a rigorous step by step research approach in a logistics context to enable valid and accurate conclusions to be drawn. Finally, the research questions proposed will address the gaps and disparities in the current GSCPM literature helping to link existing theory to new in the field of GSCPM.

The next section (Part Two) will now turn to the research itself, with Chapter Seven describing the full research methodology.

PART TWO

THREE PHASE EMPIRICAL RESEARCH

CHAPTER SEVEN
RESEARCH METHODOLOGY

7.1 Introduction

Chapters Two through to Five have discussed the background literature which has defined the research objectives proposed in Chapter Six. This chapter provides the research methodology under which this thesis will be conducted. Firstly, the research objectives and research questions are restated. This is followed by a discussion on the philosophical underpinnings of this research with emphasis on the theories and paradigms in logistics research, the importance of rigor and relevance and the researcher's paradigmatic position for this thesis. Next both quantitative and qualitative research approaches are compared and contrasted as well as the use of combinatory methodologies. The research design is discussed next, along with design issues and limitations for consideration. Finally, the chapter is summarised as a prologue to the presentation of the empirical results in Chapters Eight through to Ten.

7.2 Research Objectives Restated

The research questions represent a fairly new area of research and theory development, and thus this thesis is using theoretical and methodological triangulation to maximize the amount of data collected and to explore the research phenomena from different perspectives (Miles and Huberman, 1994; Mangan et al., 2004).

RQ1: *What GSCPMs are currently being used?*
RQ2: *Which GSCPMs are important?*
RQ3: *What are the enablers and barriers to measuring GSCPM?*
RQ4*:* *Can GSCPM be integrated within existing SCPM frameworks?*
RQ5*:* *Do any emerging variables and constructs mirror those found in extant literature on GSCPM?*

The core contribution of this thesis is to develop and test a universal set of GSCPM variables and reporting tools that organisations can use, which should provide insights on measuring and mitigating their impact on the environment and which can be used as a source of competitive advantage to help guide future policy decisions. This thesis will raise awareness among academics and practitioners of the importance of environmental impact, mitigation and adaptation in supply chains and bring order to the complexity and fragmentation which exists in the current research.

The next section examines the theoretical and paradigmatic issues concerned with business research, particularly in logistics research. It will also explore the epistemological framework and position for this research, the importance of rigour and relevance and an examination of the research methodologies appropriate for this thesis to answer the research questions.

7.3 Research Philosophy and Strategy

Philosophy is central to business research design, bound up in the notions of ontology, epistemology and axiology, it enables researchers to consider what type of data or evidence is required, how it will be gathered, interpreted and to clearly identify which research designs will work and those which will not. Philosophy will often challenge the researcher's past experiences, assumptions and world view (Easterby-Smith et al., 2003). Research philosophy relates to the development and nature of knowledge and what do we know as knowledge. The research philosophy adopted by a researcher, often referred to as a paradigm, contains important assumptions about the way in which the researcher views the world and essentially underpins the entire research strategy (Saunders et al., 2007). Ontology, epistemology and axiology have direct implications on the research methodology, each having important consequences on the way the researcher attempts to investigate and obtain knowledge (Burrell and Morgan, 1979); failure to consider philosophical issues in business research "*while not fatal, can seriously affect the quality of management research*" (Easterby-Smith et al., 2003:27).

It is important to understand the key assumptions used in research philosophy, particularly the assumptions of epistemology, ontology and axiology, prior to reviewing paradigms in business research.

7.3.1 Epistemology, Ontology and Axiology

Epistemology is defined in the Cambridge Dictionary as "*the part of philosophy that is about the study of how we know things"* (Cambridge, 2013). Saunders et al. (2007:102) describe it as "*what constitutes acceptable knowledge in the field of study*" and Bryman and Bell (2007:16) similarly describe it as "*acceptable knowledge in the discipline.*" Epistemology is concerned with the study of knowledge and what we accept as being valid and acceptable knowledge. Epistemology deals with how we perceive the world and the relationship between the researcher and the known (Näslund, 2002). The two most extreme positions in the field of epistemology are those of positivism and interpretivism.

In contrast, ontology is defined in the Cambridge Dictionary as "*that part of philosophy that studies what it means to exist"* (Cambridge, 2013). Ontology is the picture of how the world looks; our worldview (Solem, 2003). Researchers who adopt a positivist paradigm view reality as objective and external to the individual. In contrast, researchers adopting an interpretive paradigm view reality as subjective, socially constructed and only understand the social world by examining the perceptions of the human actors within it (Collis and Hussey, 2003).

Within ontology there are two very different positions and schools of thought: Realism and Nominalism. Realism postulates that the social world external to individual cognition is a real world made up of hard, tangible and relatively immutable structures. For the realist, the social world is external and it has an existence which is hard and concrete (positivism). The nominalist position (which is also referred to as social constructionism) revolves around the assumption that the social world is made up of nothing more than names, concepts and labels which are used to structure reality (Burrell and Morgan, 1979). A researcher's ontological assumptions will feed into the way the research questions are answered and how the research is carried out (Bryman and Bell, 2007).

Finally, axiology is a branch of philosophy that studies judgements about values (Saunders et al., 2007). Axiology considers the role of the researcher's values in the research process and how these values may influence the credibility of the research. Positivists believe that science and the process of research is value-free and that the objects they are studying are unaffected by their research activities. They look for causal relationships between variables. At the other extreme, interpretivists (or often referred to as phenomenologists) consider that researchers have values, even if they are not explicit. Interpretivists are interested in gaining an in depth and rich understanding of a particular context. These values help to determine what are recognised as facts and the interpretations which are drawn from them (Collis and Hussey, 2003). The combination of these three elements is known as a 'paradigm'.

7.3.2 Paradigms

A paradigm includes three elements: epistemology, ontology, and axiology (Denzin and Lincoln, 1994). It defines the way in which a researcher views the world or *Weltanschuugen* (Checkland, 1993). Kuhn (1996:175) described a paradigm as "*an entire constellation of beliefs, values and techniques, and so on, shared by the members of a given community"* essentially "*a cluster of beliefs and dictates which for scientists in a particular discipline influence what should be studied, how research should be done and how results should be interpreted*" (Bryman, 1988:4). It is a way of examining social phenomena from which particular understandings of these phenomena can be gained and explanations attempted (Saunders, et al., 2007). A paradigm offers a framework comprising of an accepted set of theories, methods and ways of defining data (Collis and Hussey, 2003). Two main paradigms exist, although there is '*considerable blurring'* between them (Collis and Hussey, 2003:47): positivism and phenomenological. They are also referred to by authors as quantitative or qualitative or interpretivist and functionalist.

A researcher's epistemological and ontological assumptions consequently influence their methodological approach. Burrell and Morgan (1979) illustrated this using a framework which highlights the difference between positivist and non-positivist (phenomenological) paradigms. This is based on a subjective-objective dimension. They conceptualise social science in terms of four sets of assumptions related to ontology, epistemology, human nature and methodology. In current research and philosophy these polarised extremes of positivism and non-positivism represent alternate views of social reality. In their framework, the vertical axis is concerned with assumptions about the nature of society, while the horizontal axis is concerned with the assumptions about the nature of social science (Mangan et al., 2004).

A positivist researcher usually has an objective position in ontology and takes an unbiased stance in axiology. They believe an objective reality exists and that it can be studied using objective methods such as surveys and questionnaires; for example, a survey which is sent to a large sample of supply chain practitioners would be an appropriate tool to test and quantify what GSCPM variables are being used in industry. In order to develop and test GSCPM variables in a survey, the researcher would firstly need to know which GSCPM variables are being used. To capture this insight, the research would need to adopt a subjective approach or interpretivist stance, enabling an exploration and 'deep dive' into what GSCPM variables are being used and why.

An interpretivist researcher will therefore use exploratory methods, for example: focus groups, in-depth interviews, case studies and ethnography to understand the world from the inside out; in contrast, a positivist researcher would seek to understand the world from the outside in. Conducting focus groups with leading supply chain professionals and academics would be a useful way of obtaining an in-depth understanding of what GSCPM variables are being used and why.

Although the distinction between paradigms may be very clear at the philosophical level, Burrell and Morgan (1979) argued that when it comes to the choice of specific methods, and to the issues of research design, the distinction breaks down. Therefore in some contexts the researcher may choose to mix methods because it provides more perspectives on the research phenomena (Easterby-Smith et al., 2003). This is known as 'triangulation' and is useful when exploring new research problems; for example in developing and testing new GSCPMs. It is evident from Chapter Six that the predominant philosophy and methodology used in GSCPM is non positivist. One study, however, used triangulation by combining interviews and focus groups with a survey (Nawrocka et al., 2009). Post positivism, a more recent branch of philosophy recognises the criticisms of pure positivism and supports the use of methodological triangulation while still maintaining a commitment to objectivity (Robson, 2002).

GSCPM is a new research area and will therefore require a degree of exploration and testing to build theory. Methodological triangulation would therefore be appropriate to achieve the research outcomes. The natural positionality for this thesis is interpretivism or non-positivist. This is because the questions are largely exploratory, however, some validation and explanation is required to propose new measures to wider society. Therefore, ontology, epistemology and axiology are continuums and a researcher can take a position between the two extremes.

Burrell and Morgan (1979:25) identify four 'mutually exclusive' and distinct paradigms for social science research: functionalist; interpretive, radical humanist and radical constructionist. The purpose of these four distinct paradigms is to: 1) help researchers clarify their assumptions about their view of the nature of science and society, 2) to offer a useful way of understanding the way in which other researchers approach their work, and 3) to help researchers plot their own route through their research (Saunders et al., 2007:112).

Researchers adopting an interpretive paradigm would adhere to the subjective end of the axis and those adopting a positivist paradigm would adhere to the objective end of the axis. Debate and discussion has emerged about the adherence to the two extreme ends of the framework but Burrell and Morgan (1979) state that the four paradigms are mutually exclusive and a synthesis is not possible.

In contrast, Tashakkori and Teddlie (1998) suggested that it is more appropriate for the researcher in a particular study to think of the philosophy adopted as a continuum rather than opposing positions. Mangan et al. (2004:565) also suggested that the trend in management research is "*to use methods and approaches which provide the middle ground between the contrasting positivist and phenomenological paradigms and perspectives.*" This will enable researchers to generate multi-dimensional insights into their research and therefore generate greater contributions to the discipline. Arlbjorn and Halldórsson (2002) also posit that logistics researchers should not hold one unilateral view or paradigm that is purely based on positivism alone as this will limit their research findings. Hyde (2000) also argued that researchers who adopt a positivist paradigm can and should also apply qualitative research methodologies. He stated that often researchers do this but fail to admit or acknowledge this in their research.

The purpose of the thesis is to make sense of the world of GSCPM; seeking to clarify and explain 'what' GSCPM variables and reporting tools are being used and which are important to organisations. It therefore requires inductive procedures like focus groups to identify and extract what GSCPM variables practitioners are using and what is enabling or preventing them from measuring. After capturing the 'what' and 'why' type questions, there is a requirement to then test these GSCPM variables for statistical significance on a larger population of practitioners to build theory and generalise the findings. The latter can only be achieved by using a deductive technique like a survey instrument. Further validation is required in the form of interviews or focus groups to help validate the overall findings from Phases One (focus groups) and Two (survey).

Based on the forgoing, this thesis is largely exploratory, the five research questions ask ‘what, which, why’ type questions and therefore naturally sit within the interpretivist paradigm. Within the social sciences there are numerous research methodologies; however, it is the research question along with the researcher’s paradigm which affects the appropriate methodological choice. The researcher’s paradigmatic position for this thesis is between the two extremes, but more dominantly located in the bottom left hand corner of Burrell and Morgan’s (1979) framework. The research will adopt an interpretive paradigm but employ both quantitative and qualitative procedures to answer the research question. A more detailed discussion about the researcher’s philosophical position for this thesis will be discussed in Section 7.3.5.

7.3.3 Multi Paradigm Debate

In attempt to address the criticisms of pure extreme positions of positivism and interpretivism and recognising there is a ‘middle ground’ (Mangan et al., 2004:565) post positivism was introduced as a movement. Karl Popper (1999) was one of the first thinkers of post positivism (falsification). He believed that reality does exist, but considered it not to be totally uninfluenced by the researcher (Hunt, 1991b; Guba and Lincoln, 1994). The paradigm still commits to objectivity but recognises that theories, mechanisms, hypotheses and the researcher can influence what is being observed.

Few researchers now adopt pure forms of the traditional paradigms of interpretivism and positivism, but use a combination as a compromise between two extremes (Collis and Hussey, 2003). In fact, there are now more calls for pragmatic and ‘real world’ approaches to conducting business research to help build new theory (Robson, 2002).

Robson (2002:43) refers to the traditional positivist and interpretivist paradigm debate as the ‘*paradigm wars’* and calls for a reapproachment of those researchers which continue to debate the subject, labelling it ‘*unproductive*’. There is need to test the feasibility of combining two or multiple paradigms and their associated methodological procedures or the acknowledgement of one paradigm but employment of two methodological procedures (methodological triangulation) which will be the approach used in this thesis.

Mixing methods and philosophies has advantages and disadvantages. Easterby-Smith et al. (2003:41) urge caution to researchers who consider mixing methodologies “*simply* *for the sake of getting a slightly richer picture because they can lead to contradictions and confusion.*" On the other hand, it can provide more perspectives on the research phenomena being investigated. Mangan et al. (2004:569) state that "*methodological triangulation can compensate for the flaws, and leverage the strengths, of the various available methodologies.*" It is, however debated, whether the researcher really shifts between paradigms by using inductive and deductive methods, or rather stays within one single paradigm using various methods? Saunders et al. (2007:110) summarise the debate very well and provide clarification for researchers very succinctly: "*if the research question does not suggest unambiguously that either positivist or interpretivist philosophy is adopted, this confirms the pragmatist's view that its perfectly possible to work with both philosophies.*"

It is important to note that there is no right or wrong paradigm, but the researcher must be aware of their own paradigmatic preferences because it will ultimately influence what they research and how it will be conducted. The paradigm is essentially the 'modus operandi' of how to conduct business research. Research questions themselves inform the choice of paradigm and thus research methodology (Ellram, 1996; Yin, 2003). Table 7.1 clarifies the key characteristics and methodologies of each paradigm which will be of important consideration in the research design and strategy:

Table 7.1 – The Key Methodologies Associated with Positivism and Interpretivism (Adapted from Collis and Hussey, 2003:47; Mangan et al., 2004:568)

Positivism	**Interpretivism**
Cross- sectional studies	Action research
Experimental studies	Case studies
Longitudinal studies	Ethnography
Surveys	Construct elicitation
Models and simulation	**Focus groups**
Structured interviews and questionnaires	Participative enquiry
	Hermeneutics
	Unstructured interviews and questionnaires

A wide range of methodologies exist and "*lend themselves more so but not necessarily exclusively, as some methodologies can be under either paradigm"* (Mangan et al., 2004:568). This is important in the context of this thesis as the research is positioned within the interpretivist paradigm but will use mixed methodological procedures (focus groups and a survey) to answer the research questions.

7.3.4 Logistics Research Theory and Philosophy

Logistics research became established as a scientific discipline in the early 1960's (Spens and Kovács, 2005) evolving from within the transportation and agricultural sectors (Kent and Flint, 1997). It has been largely influenced by economic and behavioural approaches such as profit maximisation and cost analysis which has orientations and links to the positivist paradigm (Mentzer and Kahn, 1995). Since the 1960's there have been calls for more "*rigorous orientation toward theory development, testing and application*" (Mentzer and Kahn, 1995:231). To address this, Mentzer and Kahn (1995) developed a framework for logistics research that followed a scientific approach using a quantitative paradigm which would help researchers to follow a rigorous, scientific approach to their logistics research (Chapter Six, Figure 6.3). Mentzer and Kahn (1995) also did an analysis of articles in the *Journal of Business Logistics (JBL)* between 1978 and 1993 which showed that the discipline of logistics was still dominated in the positivist paradigm and needed to move onto the next stage of maturation (Table 7.2).

Table 7.2 Percentage of Articles Published in *JBL* Mentzer and Kahn (1995:242)

Category	Per cent of articles published in *JBL*
Survey	54.3
Simulation	14.9
Interviews	13.8
Archival studies	9.6
Math modeling	4.3
Case studies	3.2

The dominance of surveys suggests that a positivist paradigm and quantitative research methods are still preferred in logistics research. An explanation for this dominance is that researchers feel it is easier to publish in the positivist paradigm (Näslund, 2002; Vafidis, 2007) or the belief that it will deliver a better sound theoretical framework which will enable rigorous testing (Halldórsson and Aastrup, 2003).

Samuel (1997) however found a difference between the dominant paradigms and research methods used in the US versus Europe. The US researchers predominantly use survey based research and the European researchers employ more qualitative based research (Table 7.3).

Table 7.3: Dominating Paradigm (US versus Europe) (Samuel, 1997:4)

Paradigm/method	UK/Europe	US
Positivist (e.g. survey)	2	17
Naturalist (e.g. interviews)	9	7

New and Payne (1995) argued that this traditional way of thinking in logistics (the positivist paradigm), rigor, relevance and adherence to a strict set of rules is not the answer. As long as researchers adhere to the general rules on internal, external validity, reliability and objectivity then they may conduct research outside the boundaries of positivism and quantitative procedures. This is the aim of this thesis.

Näslund (2002) also calls for more qualitative research methods in logistics research to gain extreme relevance and to enable logistics academics to lead rather than follow practitioners. He stated that qualitative research can add valuable insights to logistics research and that concentrating on purely quantitative approaches will limit the development of the discipline. Näslund (2002), however, does not criticise quantitative research, rather, researchers should include more qualitative methods in their research in order to develop and evolve logistics as a research discipline. Logistics research, however, is slowly changing; Solem (2003) identified that logistics research from an epistemological view is under change, signalling this paradigmatic revolution.

Mangan et al. (2004) also highlighted the dominance of quantitative research in logistics research. They promoted and ‘urged’ the application of methodological triangulation as a way of increasing rigour and maximising the amount of data collected. Mangan et al. (2002) demonstrated how methodological triangulation is used in their study of *Modelling port/ferry choice in RoRo freight transportation.* Methodological triangulation helped to yield greater insights and it can also compensate for the flaws and leverage the strengths of various methodologies (Mangan et al., 2004). As discussed earlier, it is debated whether the researcher really shifts between paradigms by using inductive and deductive methods, or rather stays within one single paradigm using various methods.

Despite the dominance of quantitative based research there has been a recent emergence of more qualitative procedures such as direct observation (Sachan and Datta, 2005). Sachan and Datta (2005) analysed 442 articles from three leading logistics journals between 1999 and 2003. Their findings showed that there is still a dominance of quantitative research, such as surveys. There has, however, been a shift towards more qualitative publications, which suggests a greater acceptance of qualitative methods/approaches in logistics research. They concluded this might be explained by the fact that researchers are now interested in finding out the 'how' and 'why' type research questions as is the case in this thesis. Consequently, the discipline is moving towards more holistic supply chain thinking rather than looking at functional parts.

Spens and Kovács (2005) analysed the same three leading logistics journals between 1998 and 2002. The aim of the research was to explore and discuss the different research approaches (deductive, inductive and abductive) in logistics research. They concluded that deductive approaches still dominate logistics research and that the deductive approaches seem to be implicitly assumed in logistics research. Although there are more inductive research approaches; they believed there is a need for more induction in logistics research.

In light of the above discussion, a combination of quantitative and qualitative procedures can overcome a number of constraints imposed by adhering to one extreme approach in logistics research (Mangan et al., 2004; Spens and Kovács, 2005; Sachan and Datta, 2005). The question of paradigm position is an additional debate. In summary, it is possible to mix methodologies in logistics research and from a philosophical perspective to view research from both the positivist and interpretivist paradigms. Deductive and inductive research approaches are both relevant paths for advancing logistics knowledge and should not be seen as competing but complimentary approaches in logistics research (Kovács and Spens, 2007). Also, Halldórsson and Aastrup (2003) point out that other complimentary quality criteria on which logistics research is judged should be considered, for example: not just reliability and validity but credibility, transferability, dependability and confirmability, which are criteria generated by qualitative research using the interpretive position.

7.3.5 Researcher's Paradigm and Philosophical Position

Epistemologically, this research is rooted in the interpretative paradigm, adopting a relativist ontological approach and following a subjectivist epistemological tradition. This philosophical position has been adopted because GSCPM is a new research area and interpretive research is based on the belief that a deeper and richer understanding of the phenomena is only possible through understanding the interpretations of that phenomenon from those experiencing it (Shah and Corley, 2006). The researcher is concerned with understanding practitioner's perceptions of GSCPM. These are the actors who are experiencing it first hand and potentially measuring GSCPM in industry. The research questions are largely exploratory in nature seeking to understand and explain more about GSCPM as research phenomena.

The research is concerned with 'developing' GSCPM and gaining a rich understanding and in-depth picture of which GSCPM variables exist and which are important (Phase One). The second purpose of the thesis is to 'test' the GSCPM variables identified in Phase One across a wider population (Phase Two). The research will therefore use a combination of research methodologies to answer the 'what, which, why, can, do they' type questions, which are positioned firmly within the interpretivist paradigm. This is a very new area of research development and there is a need to build theory. As discussed in Chapter Six, 18 articles published in the last 18 years is not a significant contribution and further reinforces the need for further exploratory research in this area. This is a fertile ground for research in logistics and supply chain management. The thesis will therefore employ both qualitative and quantitative research methods to answer the five research questions.

7.3.6 Combining Quantitative and Qualitative Strategies

Quantitative research methods are predominantly used with descriptive and causal research designs but are occasionally associated with exploratory research. Quantitative research methods are closely associated with the positivist paradigm and their purpose is to obtain data to (Hair et al., 2010).

Quantitative research is a distinctive strategy aimed at collecting numerical data and analysing the relationships between the variables. It adopts a rigid, structured approach, largely associated with theory testing and deduction and involves testing various hypotheses. There are various advantages of quantitative research; it is more often associated with large samples to test for statistical significance in a population. This allows for generalisations of the findings to the rest of the population, for example; the employment of a GSCPM industrial survey as in this thesis. The very structure and clinical approach to quantitative research means it can easily be replicated by other researchers to prove or disprove theories postulated. In contrast, it has its criticisms; quantitative research methods can tell researchers that a relationship exists, but not why and how this exists? It fails to distinguish people and social institutions from the world of nature, and the measurement process can be artificial and clinical (Bryman and Bell, 2003). One of the main weaknesses of quantitative research is that complex problems cannot be explained by numbers and data alone (Bentz and Shapiro, 1998). On its own, quantitative research would not answer the proposed research questions for this thesis, it would not uncover new constructs and theories which are essential to build theory.

Qualitative research, on the other hand, lends itself more to words than numbers (Bryman and Bell, 2003). It is an inductive view of the relationship between theories and is epistemologically closely aligned with the interpretivist paradigm, but not exclusively. Qualitative methods are a set of data collection and analysis techniques that can be used to provide description, build theory and to test theory (Van Maanen, 1979).

The aim of qualitative research strategies is to understand and interpret social phenomena in their real-life contexts. Qualitative research is associated with smaller samples, so a central issue for qualitative researchers is validity and authenticity but reliability. It is concerned with gaining a rich in-depth picture of a contextual setting and can help to understand the reasons behind phenomena. A criticism of qualitative research is the time it takes to conduct the research; it is much slower than quantitative research methodologies and often more complex to analyse. The findings are also not generalisable which means it is difficult to prove or disprove theories posited. Qualitative research can also be prone to researcher bias (Snow and Thomas, 1994). One of the main advantages of qualitative research is its role in building theory in areas where little is understood or known; which is vital to this thesis.

In light of the discussion above, quantitative and qualitative methods are not mutually exclusive; they can be successfully paired and implemented in logistics and SCM research to provide multi-dimensional insights into many management research problems (Mangan et al., 2004). This pairing is known as ‘triangulation’ and refers to the application of both methodology types used in the study of the same phenomenon (Ghauri and Gronhaug, 2002). Collis and Hussey (2003) state that the use of different research approaches can overcome potential bias and sterility of single method approaches.

Methodological triangulation presents a problem at a philosophical level as it leads to conflicts between paradigms. Easterby-Smith et al. (2003) recommend to use different research methods from within the same paradigm, which is the objective of this thesis; or to move across paradigms occasionally and with care to avoid this conflict. Näslund (2002) however believed there is a necessity to use both quantitative and qualitative methods if we really what to develop and advance logistics research. Furthermore, Mentzer and Flint (1997) also advocate the use of methodological triangulation to enable logistics research to approach the level of rigor sought in other areas of business research and to fully understand the phenomena we are trying to research.

Mangan et al. (2004) call for more logistics research to include methodological triangulation. They believe the use of quantitative and qualitative methodologies will provide a middle ground between the contrasting positivist and phenomenological paradigms and perspectives, which will ultimately lead to greater insights that would not have been the case in a single method approach.

Within the social sciences there are numerous research methodologies; however, it is the research question along with the researcher’s paradigm which affects the appropriate methodological choice. Ellram (1996) provide a scheme for the selection of research methods which is shown in Table 7.4.

Table 7.4: Classification of Research Methods According to Key Research Objectives and Questions (adapted from Ellram, 1996 and Yin, 2003)

Objective	Question	Examples of Appropriate Methodologies
Exploration	how, why	*Qualitative:*
		experiment
		case study
		participant observation
	how often, how much, how many, who, what, where	*Quantitative:*
		survey
		secondary data analysis
Explanation	how, why	*Qualitative:*
		experiment
		case study
		grounded theory
		participant observation
		ethnography
		case survey
Description	who, what, where, how many, how much	*Quantitative:*
		survey
		longitudinal
		secondary data analysis
	who, what, where	*Qualitative:*
		case study
		experiment
		grounded theory
		participant observation
		ethnography
		case survey
Prediction	who, what, where, how many, how much	*Quantitative:*
		survey
		secondary data analysis
	who, what, where	*Qualitative:*
		case study
		experiment
		grounded theory
		participant observation
		ethnography
		case survey

The research is primarily exploratory; however the combined use of focus groups and survey research is a useful way of extending the explanatory range of this research while still maintaining its exploratory potential. The various methodologies which are associated with interpretivism were reviewed with regards to their appropriateness and consistency for the research design and will now be discussed below in Section 7.4.

7.4 Research Design

The empirical study, conducted in 2012, comprised three phases which were adapted from the Churchill (1979) and Dunn et al. (1994) framework for scale and construct development. Phase One was an inductive phase and involved conducting focus groups with leading logistics/supply chain managers and directors to explore the five research questions, identify current and/or required practices employed in industry, and generate a battery of variables and constructs. Phase Two, was a deductive phase and consisted of an online survey of UK logistics and supply chain professionals through the Chartered Institute of Logistics and Transport (UK) to test and validate the variables and constructs emerging in Phase One. Phase Three was a final inductive phase that consisted of conducting a focus group with a different group of logistics/supply chain managers and directors to verify the overall research findings. This three phased framework ensured the research design followed the level of rigour and relevance sought after and required in logistics research.

7.4.1 Scale Development, Reliability and Validity

Scale development is an important concept in this thesis because the research seeks to understand which GSCPM variables are being used and their relative importance (ease versus impact). Likert (1932) developed a five-point rating scale to measure attitude statements; this five-point Likert scale is used in the online survey in Phase Two to test the importance of the GSCPM and reporting tool variables to practitioners and gain an understanding of the enablers and barriers to measuring GSCPM in practice. The use of such a scale generates good reliability and validity (Spector, 1992; Grant, 2003; Xing 2007).

There are three ways in which the rigour of a research design can be evaluated; these are: validity, reliability and generalisability. Table 7.5 summarises these important perspectives.

Table 7.5 – Perspectives on Validity, Reliability and Generalisability (adapted from Easterby-Smith et al. (2003:53)

Evaluation Terms	Positivist	Relativist	Constructionist
1. *Validity*	Do the measures closely correspond to reality?	Have a sufficient number of perspectives been included?	Does the study clearly gain access to the experiences of those in the research setting?
2. *Reliability*	Will the measures yield the same results on other occasions?	Will similar observations be reached by other observers?	Is there transparency in how sense was made from the data?
3. *Generalisability*	To what extent does the study confirm or contradict existing findings in the same field?	What is the probability that patterns observed in the sample will be repeated in the general population?	Do the concepts and constructs derived from this study have any relevance to other settings?

Validity is concerned with the extent to which the research findings accurately represent what is actually happening in the situation (Collis and Hussey, 2003), for example, is the relationship between the two variables a causal relationship? (Saunders et al., 2007). Researchers adopting a positivist paradigm focus on the precision of the measurement and the ability to repeat the experiment reliably, therefore there is a risk that the validity of the research will be low. In contrast, a researcher adopting an interpretive paradigm is focused on capturing an in-depth and meaningful explanation of the phenomena; as such internal validity is usually high. As noted by Mangan et al. (2004:569), however, by combining methods a researcher can "*compensate for the flaws, and leverage the strengths, of the various available methodologies*", therefore generating results which are not only generalisable but also internally valid; thus addressing the criticisms of both positivism and interpretivism.

Reliability on the other hand refers to the extent to which a researcher's data collection techniques or analytical procedures yield consistent results (Saunders et al., 2007). The meaning of the term reliability varies with research philosophy (Easterby-Smith et al., 2003).

In this thesis, focus groups are considered to have a high internal validity and potential for providing insight (Fernández et al., 2005). This allows participants to express their concerns and ideas within a context that is useful to the scientific community (Zeller and Carmines, 1980). Conversely, these methods are considered to have a low reliability which means it is difficult to generalise the findings across different populations and contexts. In contrast, the survey strategy in Phase Two allows the collection of a large amount of data about the defined population in an efficient way (Kotzab, 2005). The survey compensates for the weaknesses found in the focus groups by providing high reliability but low validity. Inferences and generalisations can be made from the survey because it covers a larger sample size and helps in testing the GSCPM variables and constructs. In contrast, the focus groups will enable theory to be built in the field of GSCPM which is paramount to this new research area.

It is important that new in-depth insights are sought in the development and testing of GSCPM. It is equally important however, that generalisations can be made across the industries in order to build theory and enable future testing. This is the core contribution of this thesis and why a combinatory research approach has been adopted.

There are various other ways of estimating the validity of research (Easterby-Smith et al., 2003). Face validity is an intuitive process; it questions whether the measures seem to be getting at the phenomena in question (Bryman and Bell, 2007). In this research, the pilot survey, which will be issued to a selection of supply chain practitioners, will test for content validation/execution to sanity check whether or not the questions asked in the survey reflect the research phenomena concerned and answer the proposed research questions. By using methodological triangulation, the research project deals with the issues of convergent validity. Essentially, different methodologies such as focus groups and a survey are being used to test the same phenomena and will ensure sufficient perspectives have been included and understood. This research design therefore addresses the issue of more rigorous logistics research (Mentzer and Kahn, 1995) but also addresses the more recent calls for the use of qualitative research procedures to help build logistics theory (Mangan et al., 2004; Näslund, 2002).

7.5 Focus Group Methodology (Phase One)

7.5.1 Introduction

Two focus group sessions (FG1 and FG2) were undertaken as part of the overall research design and strategy. Focus groups are used in this thesis during the preliminary stage of the research design as an exploratory tool and as a precursor to the design of the structured online survey. Focus groups are also used during the final stage of the research design (Phase Three) as a technique to help interpret, amplify and validate the overall research findings (Easterby-Smith et al., 2003; Robson, 2002).

7.5.2 History and Background

Focus groups or 'group interviews' as they are commonly referred to, originated in marketing research in the early nineteenth century arising from the recognition that many consumer decisions were made in a group context (Robson, 2002). They have been extensively used in market research to test reactions or new product developments (Saunders et al., 2007). They have increased in popularity over recent decades as a technique for gathering rich and in-depth qualitative data and are associated with the phenomenological paradigm (Collis and Hussey, 2003). Focus groups developed after the rise of statistical methods such as surveys and addressed the need for techniques that would provide insight, flexibility and an understanding of words and themes rather than just numbers (Grudens-Schuck et al., 2004).

Focus groups can take many different forms, such as: discussion groups, focused interviews, group interviewing and group research (Ghauri and Gronhaug, 2002). They can be used in isolation or in combination with other research methods, such as surveys. Krueger and Casey (2000) considered focus groups to be 'naturalistic' in approach as they generally allow participants the freedom and spontaneity to say what they like without any major restrictions, therefore allowing insight to be generated. The focus group technique provides the "*opportunity to study the ways in which individuals collectively make sense of a phenomenon and construct meanings around it*" (Bryman and Bell 2003:369). They also provide a safe environment which promotes self-disclosure enabling the researcher to really understand what people think and feel (Krueger and Casey, 2009). Johnson (1996) also argued that they have considerable potential to race consciousness and empower the participants.

A focus group typically comprises of between eight to ten participants (Bryman and Bell, 2007) and during a focus group session the participants will interact with one another to obtain information about a particular issue or set of issues. This interaction elicits a conversation which paints a particular picture about the research problem in question. There is a strong emphasis on questioning the participants in a focus group discussion on a tightly defined problem, issue or topic. This generates a rich interactive discussion between participants which can then be captured by the researcher (Saunders et al., 2007; Bryman and Bell, 2007). Often researchers will engage the help of a professional moderator to conduct the focus group session, as facilitating a focus group requires significant training and experience. As such, the researcher is then able to listen to and learn about what is unfolding in front of them, observing and listening for: content, emotion, interaction, reaction and body language among the participants. The aim of a focus group is to invite participants from diverse backgrounds with different characteristics (heterogeneous groups), however, in reality this is not always feasible as there is a requirement to recruit participants that "*have something in common*" (Krueger and Casey, 2009:66), for example: occupation, age, gender or particular characteristics. A major aim of focus group research is to identify areas of agreement and controversy and to better understand how the perspectives arise and change.

7.5.3 Focus Group Advantages

The major advantage of focus groups is the production of insight and in building theory (Grudens-Schuck et al., 2004). As a research tool they produce very rich and in-depth qualitative data, expressed in the participants own words and reactions, which is very difficult to capture using other structured methods such as questionnaires and surveys (Ghauri and Gronhaug, 2002).

Focus groups are a very efficient, flexible and fast way of collecting large amounts of qualitative data from several participants at the same time. They are informal and participants generally enjoy the interactive experience of being able to contribute something to the group discussion. If moderated correctly, every participant will be able to have an equal opportunity to contribute and engage in the group discussion.

Focus groups can be used as a primary data collection method or in the case of this thesis as a precursor to the development of a structured online survey. They can also be used in reverse (Phase Three) as a way of validating and amplifying the findings from a survey (Evason and Whittington, 1997; Robson, 2002).

7.5.4 Focus Group Disadvantages

Focus groups are also difficult to organise and facilitate. Without any major incentive, a researcher may have difficulty in securing the attendance of quality participants to a focus group session. A no-show of participants is a major issue for the researcher. It is, therefore, often commonplace to over recruit for a focus group session or provide a follow-up on the initial invitation by telephone to ensure sufficient participants attend (Sanchez-Rodrigues et al., 2010).

A second challenge of focus group research is the type of data produced is often difficult to summarise and categorise; the data comprises of words rather than numbers and can be open to interpretation. It is important, therefore, for the researcher to develop a clear analysis strategy upfront to avoid any ambiguity (Bryman and Bell, 2007).

It is also commonplace for the focus group session to be hijacked by more dominant participants and it is the moderator's role to ensure that every participant has their say. Setting the ground rules with participants before the session begins is vitally important so the participants know who is in charge without stifling the discussion.

In summary, it is vital for the researcher to plan well ahead in conducting and preparing for focus group research to avoid the documented pitfalls. Hiring a professional moderator is critical in ensuring a focus group is facilitated professionally, accurately and without bias, to ensure neutral and non biased responses.

7.5.5 Methodology Selection and Rationale

In Phase One, the research followed the 'focus group design process' which was created by Sanchez-Rodrigues et al. (2010) in their study on the *Application of focus groups as a method for collecting data in logistics* (Figure 7.1). This ensured the research design followed a rigorous and robust planning process.

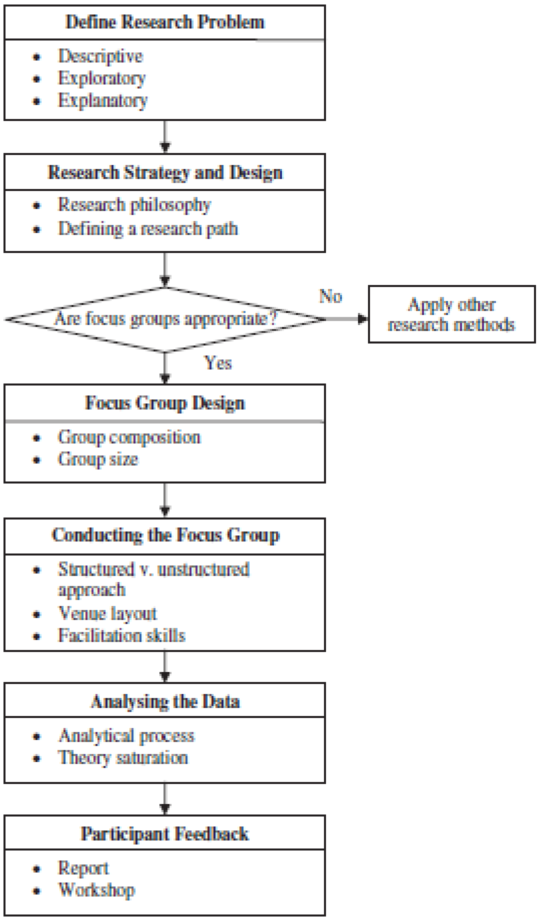


Figure 7.1: Generic Focus Group Process (Sanchez-Rodrigues et al., 2010:80)

Focus group research has been selected for this thesis because there is a need for more methodological triangulation in logistics research (Näslund, 2002; Mangan et al., 2004; Sanchez-Rodrigues et al., 2010). GSCPM is a new research area and therefore requires an exploratory approach to data capture. Furthermore, there is a dominance of case-based research and literature reviews in the field of GSCPM with limited studies using focus group research; thus there is an opportunity to use focus group research to capture a range of company views simultaneously, thereby increasing the heterogeneity of the sample and results.

Focus group research has not been extensively used within the logistics discipline compared to other methods like case studies (Sanchez-Rodrigues et al., 2010; Larson and Halldórsson, 2004). As such, there is a unique opportunity to use focus group research in the logistics discipline to gather a deeper and richer understanding of the research phenomenon by creating a forum in which participants may interact with other participants to generate and test new ideas and opinions. "*The intent of focus groups is* *not to infer but to understand, not to generalise but to determine the range, and not to make statements about the population but to provide insights on how people in the groups perceive a situation*" Kruger and Casey (2009:66). Very few logistics studies have captured the opinions of logistics practitioners, this has resulted in a gap in the literature and body of knowledge which must be addressed (Frankel et al., 2005).

The aim of FG1 and FG2 (Phase One) was to canvass expert opinion on GSCPM by identifying a potential list of GSCPM variables and constructs. The focus group technique was selected because of its ability to stimulate new thinking in this area and to identify new constructs which could be tested in an online survey (Sanchez-Rodrigues et al., 2010). It would be difficult for the researcher to test the importance of these GSCPM variables and constructs without having any prior knowledge of what these are. Therefore focus groups provided an excellent way in which do this very quickly and effectively (Patton, 2002).

There are significant opportunities in using multiple methods in the logistics discipline (Frankel et al., 2005). For example, Easterby-Smith et al. (2003:106) identified that focus groups can be "*used to good effect as a means of validating the questionnaire responses.*" As such, during this thesis, focus groups will also be used in Phase Three as a means of validating the overall research findings.

7.5.6 Phase One Approach and Overview

In Phase One a series of two focus group discussions (FG1 and FG2) were held on 25th and 26th January 2012 at the University of Hull's Logistics Institute, in the UK. The focus groups were held over two evenings, between 16.00 and 18.30 hrs. An online invitation notice, describing the aim of the focus groups was sent out via email to approximately 11,500 members of the Chartered Institute of Logistics and Transport (UK). The CILT is a professional body for the individuals associated with logistics, supply chains and all transport activities throughout their careers (CILT, 2010).

Those participants interested in attending the focus groups emailed the researcher directly to register for the event. Participants were screened to ensure they had relevant experience and industry knowledge. The aim was to recruit between 8-12 participants per focus group. The CILT membership database provided an excellent way in which to access and target the appropriate participants.

Each focus group session ran for two hours, from 16.00 and 18.30 hrs, and the participants were invited to arrive at 16.00 hrs for refreshments and a buffet supper by way of an incentive. An introductory icebreaker session was conducted at the beginning of each focus group by the researcher between 16.00 – 16.30 hrs to enable the participants to get to know each other and to encourage interaction.

The focus groups were audio recorded for transcription purposes, with one back up audio recorder in place, in case the first failed, both focus groups were professionally moderated with two researchers present to observe and take notes at the back of the room. The audio recordings, with notes, formed a full written transcript of each focus group. The participants of FG1 and FG2 were asked a series of questions that linked directly back to the primary research questions.

Careful planning went into the focus group question design and important factors such as question phrasing, sequencing and categorising were all taken into consideration to ensure the focus groups produced high quality relevant data. The questions were sequenced to provide a good questioning route (Krueger and Casey, 2009), this helped to evoke the right reactions at the right times and provide a level of content needed to answer the five research questions. The questions were designed to be clear, unambiguous and open-ended.

7.5.7 Group Composition

It is important that GSCPM is understood by those people who are directly involved in measuring GSCPM in the supply chain (Denzin and Lincoln, 2003). It is also important to reflect back on the overall research strategy to identify those people which can give the researcher the information required to answer the research questions; for example, Mangan and Christopher (2005) targeted executive education participants to identify the skills required for supply chain managers. In a similar way, the aim of this thesis was to target experienced supply chain practitioners to understand and provide insight on GSCPM.

Krueger and Casey (2009:66) stated that a "*focus group is characterized by homogeneity, but with sufficient variation among participants to allow for contrasting opinions.*" Sanchez-Rodrigue et al. (2010:80) also recommend a "*diversity of background and knowledge*" is required "*to build new ideas and make participants* *think outside the box.*" In this research thesis, participants were selected from the CILT membership database. Therefore, the participants generally had one thing in common (homogeneity) in that they were all members of the Chartered Institute of Logistics and Transport (UK) and worked within a logistics and supply chain management role within their organisation. Heterogeneity however, was still achieved because these participants came from a variety of roles, industrial sectors, ages and genders.

Figures 7.2 and 7.3 detail the industry sector breakdown of participants from FG1 and FG2 using the NAIC Industrial Classification System. The focus group participants came from a wide range of sectors, however, with a significant number of participants from the transportation and warehouse sector because of the sampling frame used (CILT membership database). Although this looks like a fairly homogenous sample, the participants came from a wide range of occupations, therefore they were able to provide diverse insight into GSCPM (Figure 7.4). Although heterogeneity is beneficial, Sanchez Rodrigue et al. (2010:80) state that some "*group discussions work best if conducted with like-minded people.*"

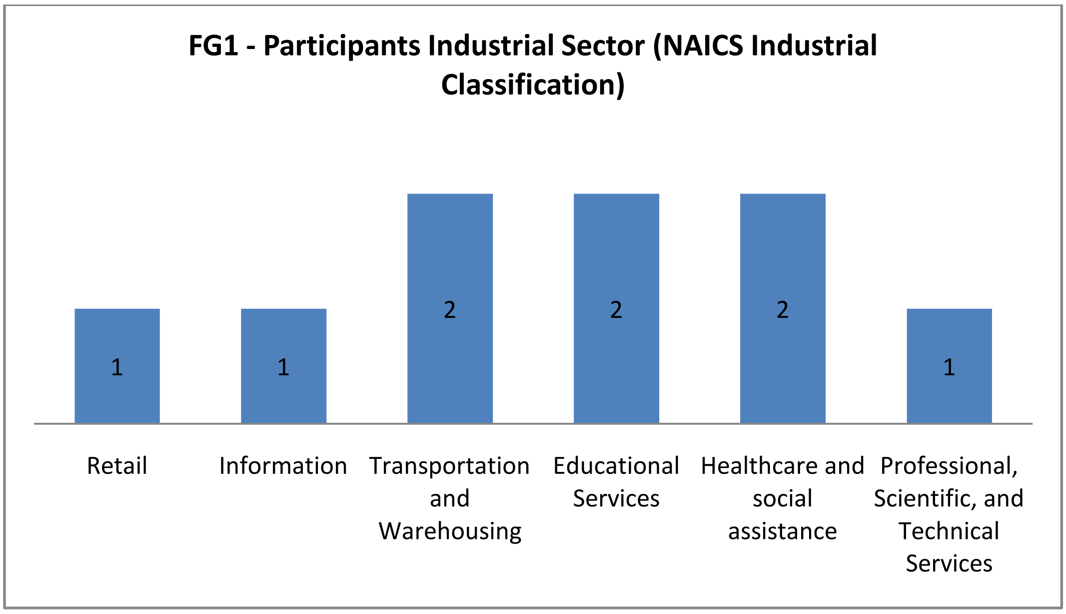


Figure 7.2 - The Industrial Sector Breakdown of Participants from FG1

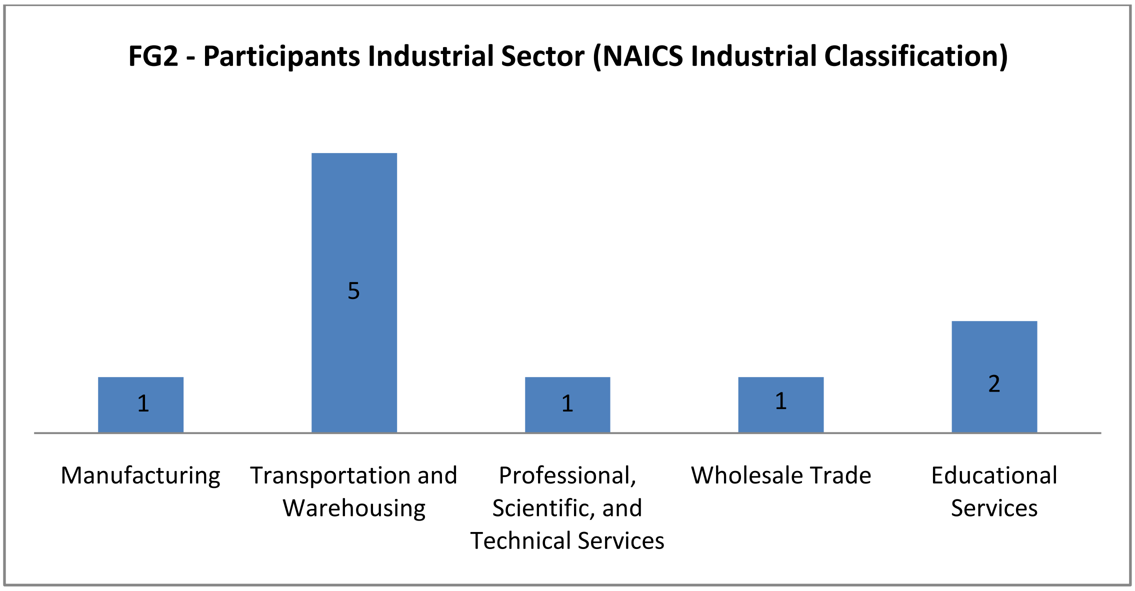


Figure 7.3 - The Industrial Sector Breakdown of Participants from FG2

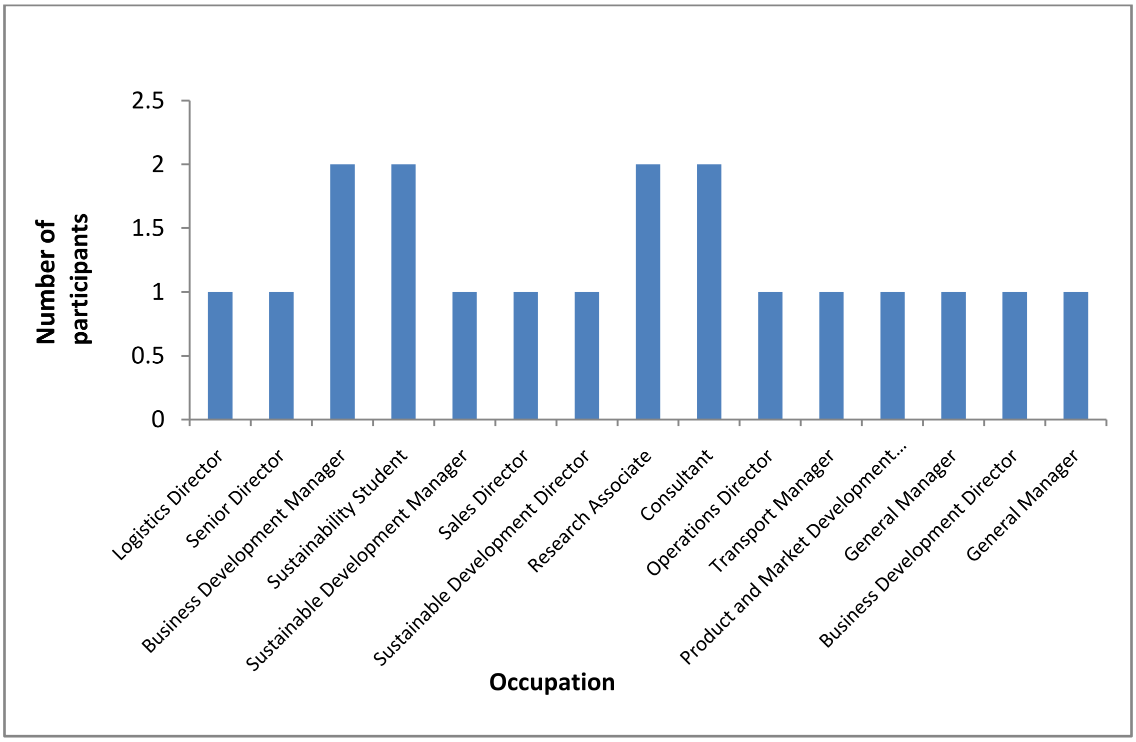


Figure 7.4 – Focus Group Participants (FG1 and FG2) by Occupation

Logistics and supply chain management is a very male dominated industry; as such there were significantly more males in the focus group sample because of this (Figure 7.5).

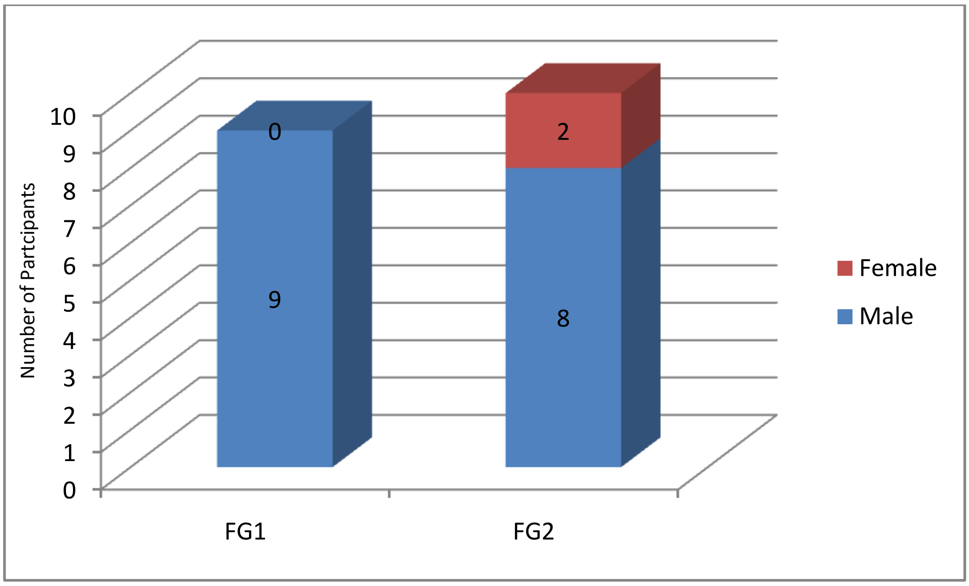


Figure 7.5 Gender Break down of Focus Group Participants

7.5.8 Group Size

The size of each focus group is detailed in Table 7.6, according to Krueger and Casey (1998, 2009) the ideal size of a focus group is between five to ten participants. It was decided given the background literature that between eight to ten participants would be appropriate and consistent for FG1 and FG2.

Table 7.6 – Actual Focus Group Size

Focus Group	**Size (No of Participants)**
FG1 (25th January 2012)	10
FG2 (26th January 2012)	9

It is important that the participant's expectations are managed prior to attending a focus group session to avoid any uncertainty or confusion (Sanchez-Rodrigues et al., 2010). The participant expectations were managed by using a follow-up telephone call with those participants who had registered to attend FG1 and FG2 so they clearly understood the aim and purpose of the sessions. Sanchez-Rodrigues et al. (2010) also found that personal contact with the participants was important in securing their attendance and commitment.

Another important consideration of focus group design is how many groups to hold. As noted by Bryman and Bell (2003:373) when a moderator or researcher "*is able to anticipate fairly accurately what the next group is going to say, then there are probably* *enough groups already. This notion is similar to theoretical saturation.*" In this thesis, three focus groups of between nine and ten participants were considered sufficient to achieve theory saturation.

A number of incentives were offered in the focus group invitation to secure a satisfactory attendance:

- An opportunity to network with other expert supply chain professionals
- Access to the research findings once complete
- To be apart of cutting edge research on GSCPM
- Buffet supper with drinks and other refreshments

Follow-up calls and emails were also conducted in the weeks and days prior to the focus group sessions in January 2012 to ensure all who had registered, did indeed attend.

7.5.9 Structured versus Unstructured

Preparing to conduct focus group research is a difficult, lengthy and challenging process, much harder than survey research (Mason, 2007) with structured and unstructured focus groups requiring considerable planning. As noted by Mason "*Just because you are planning a loosely structured or semi-structured interview which is going to feel (to the interviewee) like a 'conversation with purpose'. This does not mean that you do not need to engage in some detailed rigorous planning*" (Mason, 2007:67). In fact, qualitative researchers have to be able to think on their feet to steer and control the conversation.

It is often a researcher's philosophical paradigm which influences their choice of structure (Sanchez-Rodrigues et al., 2010). Epistemologically, this research is rooted in the interpretative paradigm, adopting a relativist ontological approach and following a subjectivist epistemological tradition, the focus group session therefore followed a loosely structured approach which allowed the participants the freedom to engage in dialogue during each session. The questions were open ended and a 'catch all' question was introduced at the end of the focus group to explore any major gaps.

The planning and execution of the focus group had to follow a degree of structure to ensure all questions were answered during the allocated two hour window thus the moderator laid down some ground rules at the beginning of the session to keep the agenda on track. Bryman and Bell (2003) noted that a moderator has two roles; firstly they have to allow the discussion to flow freely but then intervene at the salient times to bring it back on track. Table 7.7 illustrates the format and structure of FG1 and FG2.

Table 7.7 – Focus Group (FG1 and FG2) Format and Agenda

Agenda Item	Where	When	Who
Buffet, register and preparation for the introductory icebreaker	The University of Hull, Logistics Institute social area	16.00 – 16.30 hrs	Participants, moderators and researcher
Shown to seat (place cards), welcome, introduction and ground rules	Focus group meeting room	16.30 hrs	Moderator, researcher and participants
Question session commences, each participant given an opportunity to contribute, asks for consensus of opinion	Focus group meeting room	16.30 – 18.10 hrs	Moderator and participants
Catch all question and reflections as a group	Focus group meeting room	18.10 hrs	Moderator and participants
Researcher opportunity to question	Focus group meeting room	18. 25 hrs	Researcher and participants
Thank you, what next and close	Focus group meeting room	18.30 hrs	Moderator

7.5.10 Venue Layout

The focus groups where conducted at the University of Hull, in the North East of England and participants travelled from all parts of the UK including London, the Midlands and the North East to attend. In contrast, the venue for FG3 was held at University College London (UCL) and therefore provided an alternative geographical location for participants during Phase Three. The University of Hull and UCL both provided a neutral and unbiased location for the participants outside of their normal working environments. Factors such as the venue layout are classed by Sanchez-Rodrigues et al. (2010:81) as "*controllable success factors in the organisation of focus groups sessions.*"

7.5.11 Facilitation Skills

The art of conducting focus groups requires considerable experience and training. The quality of the data collected from a focus group is dependent on how well moderated a focus group is and it is vital that the moderator understands the purpose of the research study and has sufficient background knowledge of the research area (Krueger and Casey 2009).

A professional moderator was used to chair and facilitate the FG1 and FG2 group sessions to enable the researcher to observe, transcribe and record notes. The moderator used a variety of skills to obtain different views, gain consensus of opinion and probe to gather new information using questions such as ‘can you give me an example of this? Would you all agree? Is there anything else you would like to contribute to this question?’ The moderator quickly identified those individuals who were experts, ramblers, shy participants and dominant talkers to ensure everyone had their say (Krueger and Casey, 2009). Concluding comments were summarised at the end of the evening and the moderator gave the researcher an opportunity to ask one last question. The moderator also asked a ‘catch all’ question before the session closed to ensure all information had been captured, for example: ‘Given your position and experience, what do you think is important in terms of GSCPM? Where are the gaps? What is missing? This process allowed participants to have their say if they missed an opportunity earlier; thus embracing the exploratory nature of this thesis.

According to Krueger and Casey (2009) it is important to be prepared for the unexpected; for example, not enough people attend, you get some gate crashers and late arrivals. Such scenarios can cause severe disruption to the flow of the focus group session. As such, in the preparation and planning of FG1 and FG2 these eventualities were prepared for and could be acted upon quickly.

The role of the researcher throughout FG1 and FG2 was as a passive observer, with the primary aim of making notes and observing: body language, interaction and emotion; the types of things not captured by an audio recorder. Although, audio recording is generally recommended, there are some situations which cannot be captured purely by audio alone (Robson, 2002). There are considerable advantages in having a focus group audio recorded, having a moderator and a second researcher present Robson (2002: 288):

- A second person can make notes
- The second person can note non verbal interactions and
- Can give feedback on the moderators performance

There is a huge amount to consider in conducting focus groups, the right equipment, marketing, venue, but above all, the moderator can and does have a significant impact on the effectiveness of the group sessions. The moderator chosen for this thesis came from a market research background that specialised in conducting focus groups for products launches and product developments in the retail sector. He therefore, had the right skills and experience and was able to use these principles in conducting FG1 and FG2 successfully. It also enabled the researcher to learn these new skills and apply them to Phase Three.

7.5.12 Analysis

To ensure successful content analysis, it is important that during the focus groups sessions, conversations, notes, minutes are carefully logged by the researcher to facilitate transcription later into larger schematic themes (Hair et al., 2010).

Focus group data can be analysed using software packages such as NVIVO where there is a significant amount of data to process (Bazeley, 2011). However, only three focus groups were conducted in total, it was therefore practical for the researcher to analyse all the focus group data manually.

A full transcription of the participant's dialogue from FG1 and FG2 was produced from the audio recording and the researcher's field notes. Once transcribed, the detailed dialogue was coded into themes using the data reduction, data display and conclusion drawing/verification technique described by Miles and Huberman (1994). During the data reduction and display phases the following steps took place to help reduce the data:

1. A transcription of the full FG1 and FG2 conversation dialogue (Appendix One)
2. A summary of the full transcription coded into themes by question (Appendix Two)
3. The use of MindJet Mind Manager 2012™ to reduce the GSCPM variables into themes and constructs

The data reduction and display process is iterative and continued throughout Phase Two and Phase Three of the research design. FG1 and FG2 enabled the researcher to clearly identify the key GSCPM variables being used and those which were important to practitioners along with the associated constructs and themes for each of the questions. Once fully analysed, the data identified from FG1 and FG2 was used to develop the questions for the online survey which was issued in June 2012.

7.6 Online Survey (Phase Two)

The main purpose of survey research is to obtain information from, or about, a defined set of people, or population in a very efficient way (Easterby-Smith et al., 2003; Kotzab, 2005). It is usually associated with the deductive approach (Saunders et al., 2007) and is a traditional methodology tool associated with logistics research.

Oppenheim (1992:7) stated that "*too often, surveys are carried out on the basis of insufficient design and planning or on the basis of no design at all. 'Fact-gathering' can be an exciting and tempting activity to which a questionnaire opens a quick and seemingly easy avenue; the weaknesses in the design are frequently not recognised until the results have to be interpreted.*"

To mitigate this risk, the following steps were used to ensure the survey design followed a robust planning framework (Figure 7.6).

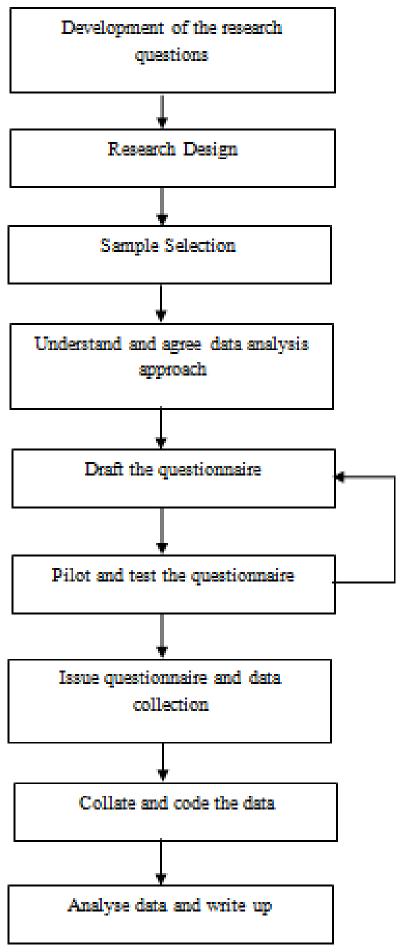


Figure 7.6 - A Framework for Questionnaire Design (Adapted from Collis and Hussey, 2003:178; Robson, 2002:229)

Survey methods are one of the most frequently used and preferred methods of data collection in logistics research (Mentzer and Kahn, 1995; Craighead et al., 2007; Sachan and Datta, 2007). As much as 54.3 per cent of logistics research is conducted using surveys, closely followed by simulation and interview techniques as other preferred methods (Table 7.2). The dominance of survey research suggests that a positivist paradigm and quantitative research methods are still preferred in logistics research.

There has been considerable growth in the last few years in surveys being administered online. Online surveys are now one of the most frequently used (59 per cent) survey methods in marketing research (Hair et al., 2010) and there are clear advantages of using this approach compared to more traditional survey methods such as postal, email or telephone surveys (Grant et al., 2005).

Once the population had been identified for this thesis, it was unlikely given the researcher's resources and time that it would be possible to survey all of the respondents in that population (Bryman and Bell, 2007). A sample, if chosen correctly, is normally representative of the entire population. Therefore, there is a need to sample and develop a sampling strategy at the earliest opportunity in the research design. The sampling strategy adopted for this thesis is a census approach on the target sampling frame; for example, all supply chain and logistics practitioners who are members of the Chartered Institute of Logistics and Transport (CILT) were included in the sample.

7.6.1 Research Design and Development of the Research Questions

In research, there is a requirement for a good design to generalise findings (Oppenheim, 1992). Investment and planning up front in the overall research design are critical to the success and quality of the research output.

Structured surveys are considered to have a high external validity because the findings can be used to make generalisations about the target population. In contrast, they have a low internal validity because they cover such a wide range of respondents; it then becomes difficult to control and understand the findings in a contextual setting (Mentzer and Kahn, 1995). As such, Mentzer and Kahn (1995) called for more rigorous data analysis in logistics research to improve the validity and reliability of logistics research. The use of combined focus group and survey methodologies is a useful way in which to increase the exploratory and explanatory potential of this research. The survey findings will also be subject to univariate and multivariate statistical analysis to help to draw accurate conclusions.

7.6.2 Sample Selection

The main purpose of the survey was to test the findings from FG1 and FG2 and to obtain information about GSCPM from middle/senior supply chain and logistics practitioners in the UK. These were the key people or 'subject matter experts' who would have a good knowledge of this research problem and therefore, an appropriate target population in which to initially test this. Given the size of this population, it would be difficult to survey all supply chain and logistics practitioners in the UK due to time, resources and costs. It was therefore more practicable to search for a suitable sampling frame which would be representative of this entire population.

The survey sample was taken from a sampling frame which consisted of approximately 11,500 members of The Chartered Institute of Logistics and Transport (CILT). CILT is a national and internationally recognised professional body of logistics and supply chain professionals in the UK. This sampling frame was selected because it consisted of the most comprehensive membership database of practicing logistics and supply chain professionals in the UK. The members predominately belong to the transport and warehousing industrial sector (SIC codes 49, 50, 51, 52 and 53 or NAIC codes 48 and 49) and the CILT further categorises their members into eight distinct professional sectors; Rail, Active Travel and Travel Planning; Bus and Coach; Ports Maritime and Waterways; Freight Forwarding; and Aviation (Figure 7.7). Figure 7.9 also shows the breakdown of the CILT membership database by occupation, with transport, operations and logistics the dominant occupations. The CILT also has significantly more males than females with the average age of members typically between 46-50 years (Figure 7.8). Sohal and D'Netto (2004) found similar demographic trends in their review of logistics managers in Australia and concluded that logistics roles are dominated by middle-aged male managers with over 10 years experience. They also found that over two thirds of logistics managers belong a professional institution like the CILT, thus reinforcing the point that this is a representative and appropriate sampling frame in which to test GSCPM variables.

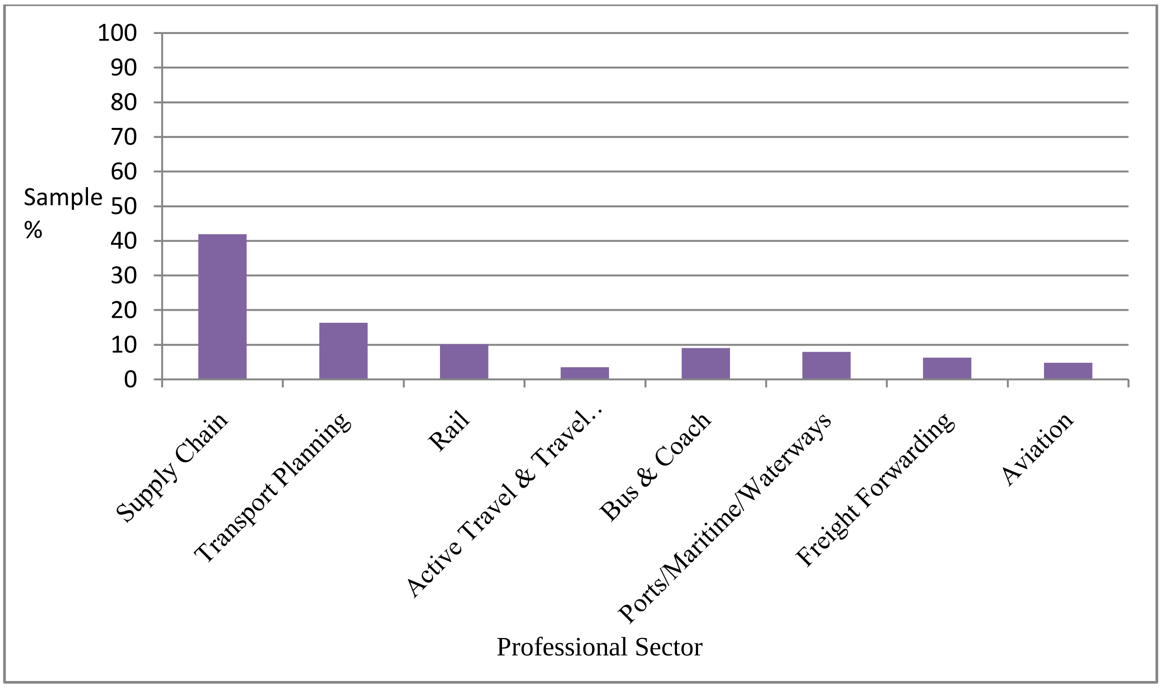


Figure 7.7 CILT (UK) Membership Break down by Professional Sector

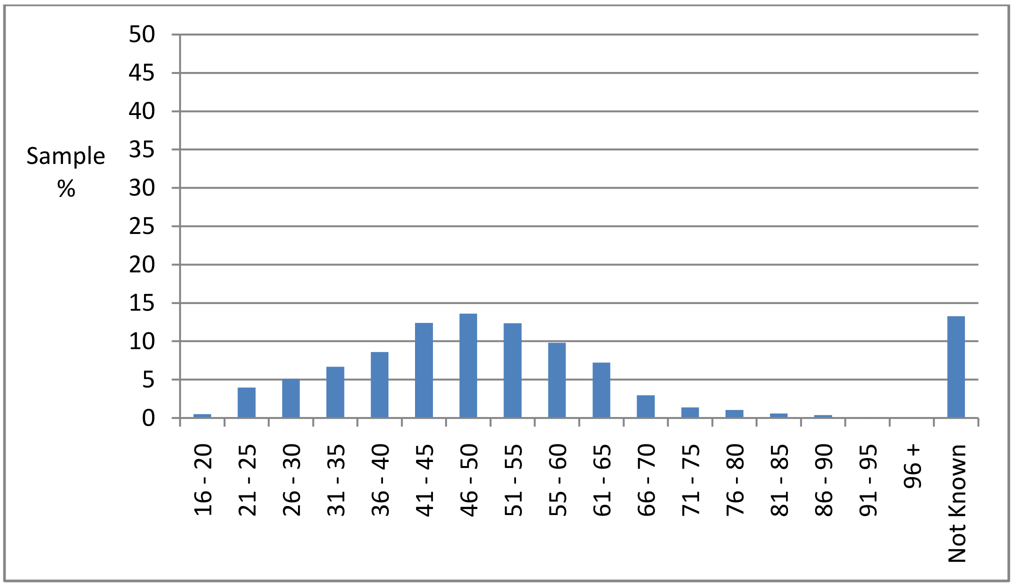


Figure 7.8 CILT (UK) Membership Break down by Age

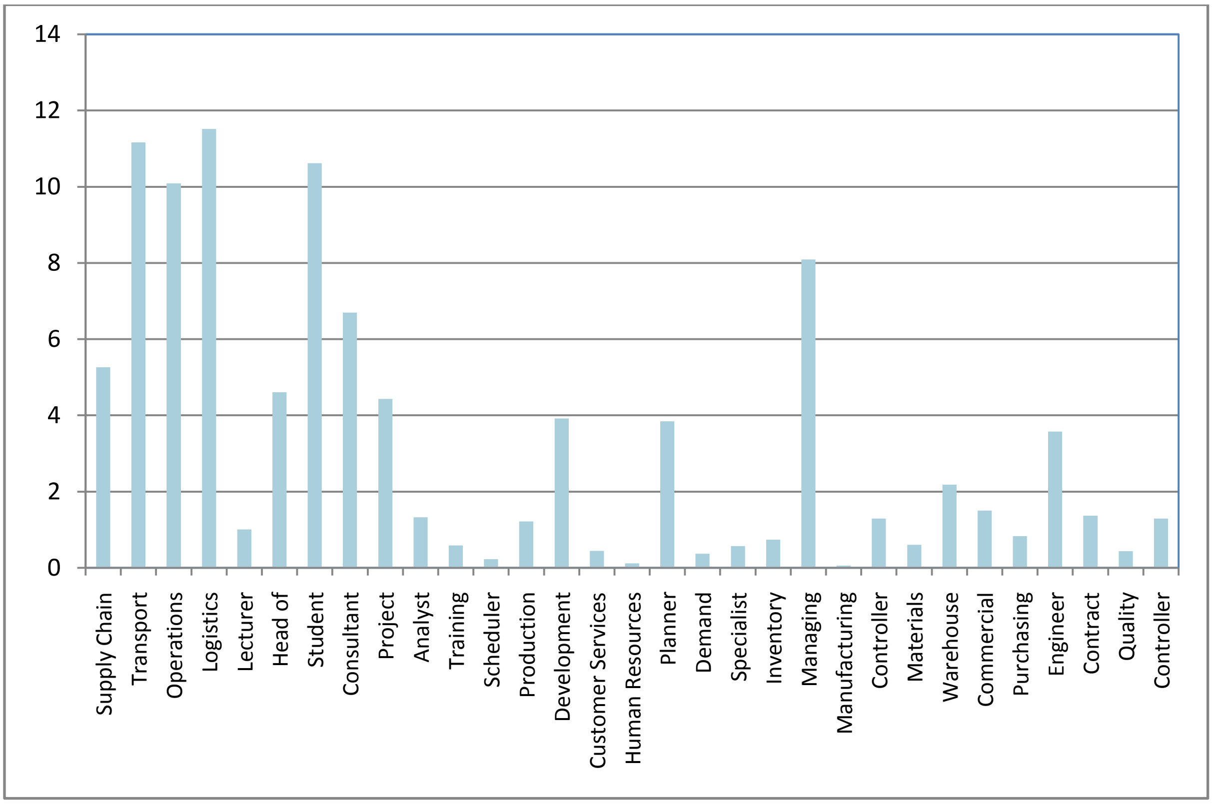


Figure 7.9 CILT (UK) Membership Break down by Occupation

There are two approaches which can be taken with sampling (Robson, 2002:261):

- Probability sampling
- Non-probability sampling

The most important aspect to probability sampling is that the sampling frame represents the population (Saunders et al. 2007). A major consideration, when choosing a sample is to ensure the results are externally valid and generalisable across the entire population; it is not just necessarily about the quantity but the quality of respondents surveyed. Robson (2002:107) recommended two strategies to discount any threats to external validity; 1) direct demonstration, which involves another researcher being able to extend or carryout the study in question and, 2) making a case, which involves putting a strong argument forward using a conceptual or theoretical framework that the results are generalisable.

To ensure the results were externally valid, a census probability sampling approach was adopted in this thesis. The survey was emailed by the CILT to all members on their database, which contained approximately 11,500 respondents. A similar approach was used by Holt and Ghobadian (2009); they drew a sample from The Chartered Institute of Purchasing and Supply (CIPS). There are some key advantages to sampling from a professional body like the CILT (Holt and Ghobadian, 2009:939):

- The researcher is able to target the 'precise' target respondents
- It is more likely that the actual respondents will answer the survey themselves rather than pass it onto a junior member of their team
- Knowledge of the subject matter reduces the risk of common method variance
- A census approach ensures the researcher captures a fully balanced sample which is representative of the entire population

Although the CILT members are predominantly from transport and warehousing industrial sectors, thus delimiting the research scope, this represents a good place in which to start to develop and test GSCPM variables, as the transport sector carbon dioxide emissions are rising faster than any other sector and are likely to become the largest source of UK emissions in the near future (Carter, 2007; Department for Energy and Climate Change, 2012). Therefore, there is a real focus on climate change impact and mitigation within this industrial sector and worldwide.

Figure 7.10 illustrates the sampling frame and sample for this thesis. "*A sample is a selection of the population*" (Robson, 2002: 260).

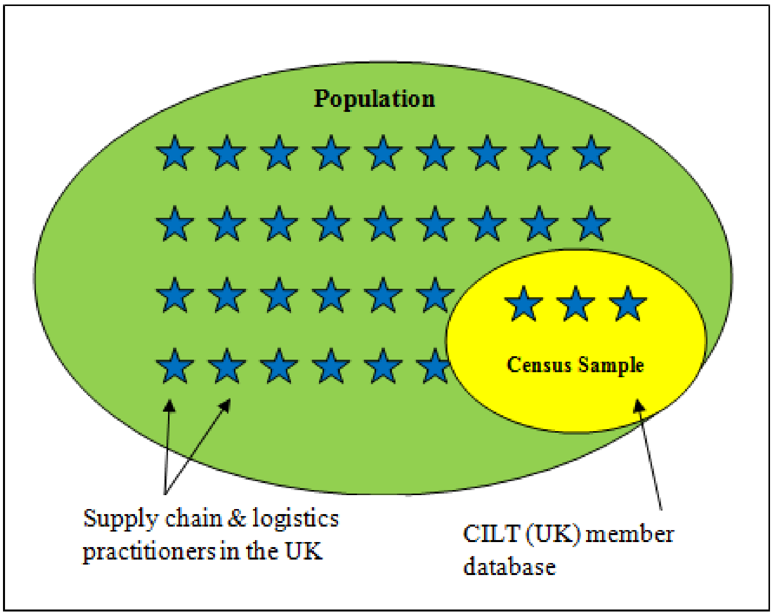


Figure 7.10 – Survey Population, Sample and Individual Cases (Adapted from Saunders et al., 2007: 2005). Not to scale

Several other authors have adopted a similar census sampling approach, for example Murphy et al. (1994, 1995, 1996) and Murphy and Poist, (2000) drew samples from the members of the US Council of Logistics. Carter et al. (2000), Carter and Jennings (2002), and Carter and Carter (1998) examined green purchasing and drew their sample from members of the US National Association of Purchasing Manager (NAPM). Zhu et al. (2008c:7) stated in their study of *Green Supply Chain Management Implications for Closing the Loop* that the respondents in this type of sampling approach act as "*key informants*" on the research problem as they are knowledgeable about the subject matter in question.

One issue, however, associated with conducting this sampling approach or indeed an online survey is that it infers the views solely of those people who have joined a professional organisation such as the CILT and therefore perhaps, not the entire population.

To counter this potential CILT sector sample bias, the final focus group (FG3) which took place in October 2012 after the survey was completed, deliberately targeted middle/senior supply chain and logistics/sustainability respondents outside the CILT sampling frame. Although it was not possible to test these findings empirically in the survey it acted as a validation and feedback technique by identifying any further GSCPM variables from a broader sampling frame, therefore improving the overall reliability and internal validity of this thesis.

An important consideration with any research study is firstly to understand how the data will be analysed before agreeing the most appropriate sample size and sampling approach. As Saunders et al. (2007:210) pointed out, that in order to "*undertake particular statistical analyses*" a "*threshold sample size*" will be required to ensure the data is normally distributed and thus "*more robust*" enabling the researcher to make statistical inferences from the sample.

7.6.3 Understand and Agree the Data Analysis Approach

At the pilot stage, researchers should be considering and looking ahead towards their analysis stage (Oppenheim, 1992), for example; what is meant by GSCPM importance? Can this be measured, analysed and presented in a meaningful way? How can current GSCPM variables be captured and what sample size is required in order to test for statistical significance? Oppenheim (1992:61) recommended that a researcher should continuously ask "*what is the question doing here, and how do we propose to analyse it later?"* to truly understand the analysis approach. Interesting questions alone will not provide adequate responses.

The survey results from Sections Two and Three (Table 7.10, p.169) were analysed using a multivariate analysis technique called factor analysis. The purpose was to understand statistically which GSCPM variables were the most important (useful and easy to measure). Factor analysis was also used to identify any underlying constructs which were not visible to the naked eye. Therefore, the questions have been designed and formatted in such a way to ensure that the responses are sufficiently robust and in the right format to allow for this testing and analysis. The other sections of the survey will be analysed using classical statistical techniques.

Multivariate analysis is the application of a group or family of statistical techniques. Hair et al. (1995:5) describe them as "*all statistical methods that simultaneously analyse multiple measurements on each individual or object under investigation*" and are "*extensions of univariate analysis.*" The application of multivariate analysis techniques have increased over recent years due to various reasons; including advances in computer technology/computer programmes and the need to answer more complex research questions (Hair et al., 1995). The requirement for multivariate analysis stems from the "*fact of life that just about everything is in some way interrelated with other things*" and that there is a need to make sense and simplify these multiple variables to achieve "*parsimony*" and explain these descriptions, explanations and relationships (Hair et al., 1995:6).

Multivariate analysis is a powerful tool and has the ability to look beyond the two dimensional relationships which are seen in univariate analysis. It should be used when a researcher has two or more variables to analyse and therefore creates the ability to look at multiple data sets and identify underlying relationships and variables (Hair et al., 1995).

There are various types of multivariate analysis techniques. Table 7.8 summarises these techniques and their abilities. This summary helped in agreeing the most appropriate multivariate techniques for this thesis.

Table 7.8 – Multivariate Techniques and Their Abilities (Adapted from Hair et al., 1995: 10) S= P = Primary ability, S = Secondary ability and NA = Not applicable or appropriate

Technique	**Describe**	**Explain**	**Predict**	**Control**
Multiple Regression	S	S	P	NA
Multiple Discriminant	S	S	P	NA
MANOVA	NA	S	S	P
Canonical Correlation	P	S	S	NA
Factor Analysis	**P**	**S**	**NA**	**NA**
Cluster Analysis	P	S	NA	NA
Multidimensional Scaling	S	P	S	NA
Conjoint Analysis	S	P	S	NA
Structural Equation Modelling	S	P	P	NA

The primary objective of multivariate analysis in this thesis was to attempt to identify and 'describe' the relationships between the GSCPM variables, their importance and indeed if there were any other underlying relationships or constructs for the GSCPM variables. This narrows down the selection of the multivariate analysis techniques to three techniques: factor analysis, canonical correlation and cluster analysis. The study is not concerned with classifying the variables into dependent or independent, as in techniques such as canonical correlation or cluster analysis but instead to "*analyse simultaneously*" the group of variables (Hair et al., 1995:13). Thus factor analysis was selected for this thesis.

All multivariate analyses were conducted using two statistical programmes; 1) SIMCA 13™ and 2) Minitab. SIMCA 13™ is supplied by a company called Umetrics in Sweden (Umetrics, 2012). SIMCA 13™ is predominantly used by chemists in the pharmaceutical and food manufacturing industries but has not been used at all in logistics and SCM research. This thesis therefore provided a unique opportunity to apply the software to the logistics and SCM discipline; thus contributing to the body of methodological knowledge. Minitab was used to conduct univariate analysis and create dendrograms for the GSCPM data.

Factor analysis has two basic decision points: 1) determine an extraction method and 2) decide on the number of factors to extract (Newsom, 2005). The key assumptions associated with factor analysis are, there is a sufficient homogenous sample with sufficient correlations to justify factor analysis (Hair et al., 1995). As a general rule, it is recommended at least five observations per variable (Hair et al., 1995). The common rule is 10 to 15 cases per variable in factor analysis (Field, 2000). In this thesis, there were 25 GSCPM variables, requiring at least 10 responses. The number of useable responses generated was 266, thus sufficient for factor analysis to be conducted.

Factor analysis can be used as an exploratory or confirmatory tool and there is much debate amongst researchers of its exact role (Hair et al., 1995). Exploratory (EFA), as its name suggests is linked to the interpretivist paradigm and very appropriate for analysing qualitative data but can also be used for analysing quantitative data. It is considered to be theory generating (Stevens, 2009). On the other hand, confirmatory factor analysis (CFA) is about the researcher already knowing what the measures mean and it is about testing these hypotheses (Table 7.9). This lends itself very much to the positivist paradigm/theory building. As this thesis is rooted in the interpretive paradigm, EFA will be used to analyse the GSCPM survey data thus embracing the exploratory nature of the research. The purpose of EFA was to understand any underlying GSCPM constructs, which are clusters of particular GSCPM variables to identify any relationships between the GSCPM variables.

Table 7.9 Differences between Exploratory and Confirmatory Factor Analysis (Stevens, 2009:345)

Exploratory – Theory Generating	**Confirmatory – Theory Testing**
Heuristic – weak literature base	Strong theory or strong empirical base
Determine the number of factors	Number of factors fixed *a priori*
Determine whether the factors are correlated or uncorrelated	Factors *a priori* as correlated or uncorrelated
Variables free to load on all factors	Variables fixed to load on a specific factor or factors

As discussed earlier, some degree of multi-collinearity is required for factor analysis to be applied, however, removal of outliers such as variables which do not correlate at all with each other and highly correlated variables must be removed to improve the quality and output of the data to clearly reveal any underlying constructs and relationships. A Pearson's correlation matrix was used to ensure that sufficient correlation existed between the variables so that the data factored well (Field, 2000).

The next step was to extract the factors. There are two methods in which to extract the factors: 1) component analysis and, 2) common factor analysis. The purpose of the multivariate analysis in this thesis was to identify an entirely new set of variables or underlying constructs. It was also to assess the set of 25 x GSCPM variables and their variance. There are two major approaches to factor analysis (Hair et al., 1995:13):

1. Principle component analysis (PCA) - where there is a concerned prediction or parsimony
2. Common factor analysis (CFA) - where there is a desire to reveal latent dimensions

The approaches differ in their variance estimates (Field, 2000). PCA considers total variance, which includes common, specific and error type variance, in contrast, the factors in CFA are only derived from common variance (Hair et al., 1995). CFA suffers from a number of issues, it is firstly theoretically based and it is prone to factor indeterminacy. It is also complex and difficult to use (Hair et al., 1995). On the other hand PCA is much easier and more robust to use and is generally used when the research purpose is to reduce the data from a large number of variables into a smaller set of components. (PCA) is the most commonly used version of factor analysis and was therefore selected and used in this thesis.

Once the extraction method had been determined; the next step was to decide how many factors to extract. In factor analysis not all factors can be analysed and it is important to extract those factors which have significant variance. A technique known as Latent Root Criterion can be used both for CFA and PCA as a factor extraction method. Hair et al. (1995:377) state that "*only the factors having latent roots or eigenvalues greater than 1 are considered significant*" the rest must be disregarded in the analysis. This is because of the rationale that any one factor must have at least an equal variance to a single factor, if not; it is not deemed significant (Hair et al., 1995).

7.6.4 Sampling Size Requirements

A sample response rate of three to five per cent was estimated for this survey; this was based on previous online surveys conducted by the CILT where on average a response rate of 1.5 per cent (or 176 responses) had been achieved over the last 18 surveys conducted between 2010 and 2012 by the CILT.

A total of 388 respondents completed this survey generating 266 useable responses. Therefore, well above the CILT survey average and generating a response rate of three per cent. Typically this seems low in business research were response rates of between 10-15 per cent are usually achieved and deemed sufficient (Gunasekaran et al., 2004). There is growing evidence that online surveys generate lower response rates than postal questionnaires (Tse, 1998; Sheehan, 2001; Bryman and Bell, 2007) and that the longer the survey takes to complete the lower the response rate (Saunders et al., 2007). Generally survey response rates in logistics research appear to be declining. A large enough mailing can "*generate a sufficient number of responses for application of multi variant statistical methods*" (Larson, 2005:219).

There are ways in which to increase survey response rates which will be discussed later in this section, however, as discussed earlier, based on 25 GSCPM variables, 250 responses would be sufficient for meaningful multivariate statistical analysis (Field, 2000; Hair et al, 1995).

It is important to note at this stage, the aim of the thesis and survey research was not simply to maximise the sample size and achieve a large response rate but more importantly about ensuring a heterogeneous sample which would be representative of the wider population; thus generating results which were transferable and both internally and externally valid. The CILT membership database provided a great opportunity to enable this to happen.

7.6.5 Non Response Bias

Surveys are prone to many types of errors, these can be divided into two groups: errors of non observation, where the sampled elements comprised only part of the target population, and errors of observation, where recorded data can deviate from the truth (Scheaffer et al., 1996). One of the major and most serious forms of survey error relates to non-observational errors, namely non-response bias. This can bring into question the validity and reliability of the entire study.

Oppenheim (1992:106) described non response bias as "*not the number of non-respondents, but the possibility of bias*" caused by these non-respondents. Non-respondents are different from the rest of the population as they have refused to respond to the survey (Saunders et al., 2007) and it is important to understand why and if they did answer at a later stage, would they have responded in a similar way. A good way to reduce non-response bias is to maximise the survey response rate. Also non-response can be overcome by issuing multiple waves of surveys to the target respondents, a similar method to that used in mailing surveys (Frohlich, 2002). If a low response rate is achieved during the first wave of questionnaires, then a follow up email will be issued with a second and third wave of online survey questionnaires. This technique will help to increase the overall response rate. A statistical weighting will be used in this research to compare early survey responses against later responses to test for non-response bias.

7.6.6 Drafting the Questionnaire

There has been considerable growth in the last few years in surveys being administered online. Online surveys are now one of the most frequently (59 per cent) used types of survey methods used in marketing research (Hair et al., 2010). Bryman and Bell (2007) pointed out that there is a clear distinction between online surveys and email surveys. Email surveys relate to questionnaires which are embedded or attached within the body of the email and the response or completed survey is emailed back to the researcher or an email address. In contrast, web surveys, like the one administered in this thesis; respondents are emailed a link which directs them to a website to complete the survey online. There are some clear advantages of doing a web survey over an email survey: firstly, web surveys can be far more sophisticated in the way they are designed and executed using logic such as radio buttons, question skipping, funnelling and so forth (Bryman and Bell, 2007). Online surveys are also less expensive per respondent than other survey methods such as mailing or by telephone and the results are ready for analysis almost immediately; with shorter response times, more convenience for the respondent, and there is a propensity for respondents to answer more openly in an online survey (Grant et al., 2005).

The survey was administered on the researcher's behalf by the CILT using Survey Monkey Professional TM. This ensured cost was kept low while at the same time accessing a large sampling frame. There are various online surveys to choose from such as Snap TM and Sphinx Survey TM (Saunders et al., 2007), however the CILT members are familiar with the format of Survey Monkey Professional TM and it provided a series of user friendly, professional and colourful screens which made it easier to create and complete.

The survey went through rigorous testing before the main survey was issued. It is vital in a self-administered survey that the questions are worded in such a way that they are intuitive and unambiguous as the respondent is on their own and has no one to ask if they require anything clarifying during the execution process.

One of the key phases in the questionnaire design related to deciding what questions to include and the overall format of the questionnaire (Easterby-Smith et al., 2003). Oppenheim (1992:101) recommended the following guidelines in the design of surveys, to understand:

- The main type of data collection instruments which we shall need
- The method of approach to the respondents
- The build-up of question sequences
- The ordering of questions
- The type of questions

Taking this into consideration, the following structure was used in the design of the questionnaire (Table 7.10).

Table 7.10 – The Phase Two Survey Structure

Survey - Selecting Green Supply Chain Performance Measurements	
Introduction	Survey Introduction and Background
Section One	Green Supply Chain Performance Measurement – **CURRENT USE**
Section Two	Green Supply Chain Performance Measurement – **USEFULNESS**
Section Three	Green Supply Chain Performance Measurement – **EASE OF MEASUREMENT**
Section Four	Green Supply Chain Performance Measurement – **ENABLERS**
Section Five	Green Supply Chain Performance Measurement – **BARRIERS**
Section Six	Green Supply Chain Performance Measurement – **BENEFITS**
Section Seven	Green Supply Chain Performance Measurement – **REPORTING**
Section Eight	Respondent and Company Information

Robson (2002:243) noted that "*a major part in the art and craft of producing a survey questionnaire is in writing it in such a way that respondents understand what you want from them, and are happy to give it to you.*" The covering letter in self-administered surveys, like the one used in this thesis, is vital and explains the purpose of the survey, helping to set the scene. The structure and content of the covering letter alone can affect the survey response rate, therefore it is important to articulate this clearly and unambiguously (Saunders et al., 2007).

The ordering of survey questions was an important consideration for this thesis. Where possible, the order of the questions followed a logical sequence, for example, what GSCPM does your company currently use? Are there any more – yes or no? If so, what are these? This is an example of question funnelling which is used where there is a "*broad question*" asked "*and then progressively narrows down the scope of the* *questions until in the end it comes to some very specific points*" Oppenheim (1992:110). This ensured the respondents were not alienated and decreased the chance of the respondent aborting the questionnaire early or failing to complete it altogether. Demographic questions (voluntary) were positioned at the end of the survey as they were deemed less critical to the overall research findings, therefore placing the most important questions (mandatory) first and ensuring that the respondent answered these.

The wording of questions was vital in the survey design. Oppenheim (1992:121) recommended that "*questions must be adequate*" for the "*sampling process; they must not be one-sided, and they must make it easy for the respondent to answer fully.*" Given that there were large sections of statements requiring ranking, particular care and attention was given to the wording of the questions and statements to ensure they were clear and intuitive to the respondent and therefore the respondents would not be subject to "*ordinal biases*" and respondent fatigue (Oppenheim, 1992:125). Oppenheim (1992:125) described "*each question also has a covert function: to motivate the respondent to continue to co-operate.*" The wording was tested during the pilot survey and recommendations from the pilot respondents were built into the main survey before issue.

There were eight sections to the survey; firstly, an introductory section describing the purpose of the survey and how long it would take to execute. Please see Appendix Three for a full copy of the survey and covering note. The covering note was designed to be easy to read and aimed at attracting the respondent's attention quickly. Two incentives were offered to encourage respondents to complete the survey:

1. An opportunity to have access to the research findings once complete,
2. An opportunity to be entered into a free prize draw for a new apple ipad.

Oppenheim (1992:82) classified incentives as "*intrinsic"* and "*extrinsic.*" The two incentives offered in this thesis were extrinsically designed to motivate respondents to complete the survey. Incentives and other factors, for example: advance warning of the survey, sponsorship by the CILT, making it easy to complete, publicity, reminders, appearance, length, topic and confidentiality have been known to increase survey response rates (Oppenheim, 1992:104).

Reflecting on Oppenheim's (1992:101) guidelines for survey design, it was agreed early on in the research design stage that the CILT database would potentially be a suitable sampling frame to use for this research, after attempts to review other databases like Financial Analysis Made Easy (FAME) were concluded as problematic, due to the lack of specific contact details of logistics and supply chain professionals. Permission was therefore obtained from the CILT's Chief Operating Officer to allow access to their member's database for this thesis at a meeting at their Head Quarters in February 2012. It was fully endorsed by the CILT because GSCPM was seen as a topical and valuable research area.

An important concept in this thesis was to develop GSCPM variables and understand which were important to practitioners. The types of questions used in the survey were predominately fact based with some opinion based questions (Easterby-Smith et al., 2003). For example in Section Eight, the demographic details of respondents (age, industrial sector, company size and occupation) were captured using factual based questions, making them easy and quick to execute. Section One through to Seven comprised mostly closed questions were respondents were given multiple statements or GSCPM variables to choose from, which would indicate their strength of agreement with each statement or the importance associated which a particular GSCPM. This type of question format was consistently used throughout the survey and is known as the Likert scale (Likert, 1932). It is a form of attitudinal rating against a range of statements and helped in capturing the intensity of the respondents feeling or opinion about a given GSCPM variable.

Section One of the survey was aimed at answering RQ1 by understanding what GSCPM variables supply chain and logistics practitioners currently used, with the unit of measurement being at company level. The respondents were then presented with a list of 25 x GSCPM variables (identified from Phase One) each with a selectable radio button to tick. The respondents were able to select as many GSCPM variables as applied (for example, which their company used). A final catch-all question was introduced at the end of Section One to identify if there were any other GSCPM variables used outside of this list. These types of open-ended questions ensured that the researcher continued to adopt an exploratory approach despite using a quantitative tool.

The aim of Section Two and Three was to gauge the level of importance which respondents attached to each of the 25 x GSCPM variables in terms of their 'usefulness' and 'ease of measurement', thus helping to answer RQ2 (Figure 7.11). The respondents ranked each of the 25 x GSCPM variables on a five-point Likert scale (Likert, 1932; Hair et al., 1995) were (1) was 'no use whatsoever' or 'exceptionally difficult to measure' respectively and (5) was 'exceptionally useful' or 'exceptional easy to measure.' The results were then plotted onto an ease versus impact scatter graph to understand the most and least important GSCPM variables to the respondents (Figure 7.12).

There has been much debate in the market research literature around whether researchers should use a five-point Likert or a seven/ten point Likert scale. This is because there is a propensity for respondents to select the middle scale (3) on a five-point Likert scale. Dawes (2008), however, found that data characteristics do not fundamentally change when using a five, seven or ten point Likert scale in survey research. The only slight change is that data from a five or seven point Likert scale has a slightly higher average mean than the same data using a ten point Likert. It was therefore agreed that a five-point Likert would be sufficient and appropriate to use in this thesis.

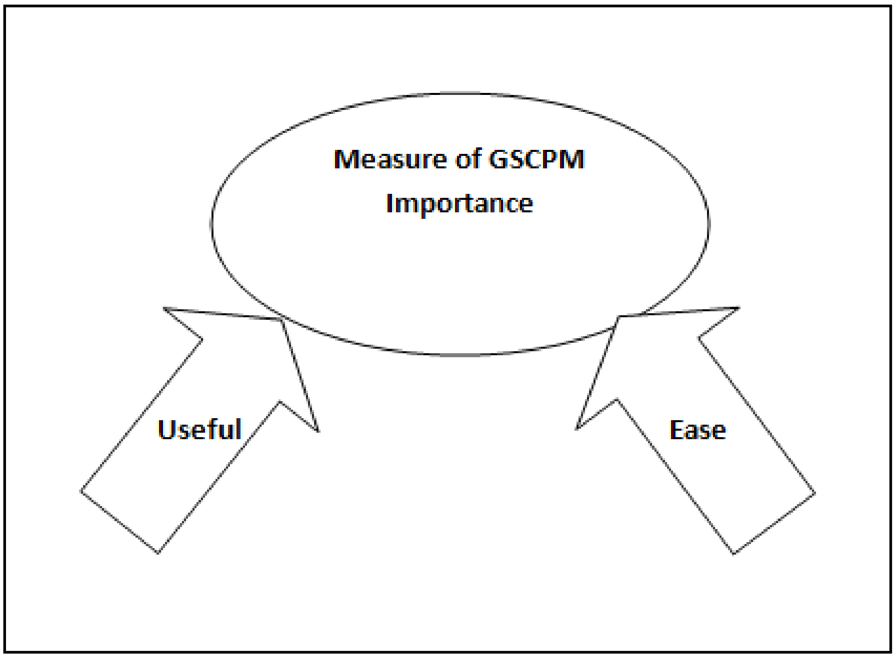


Figure 7.11 GSCPM Importance Conceptual Model

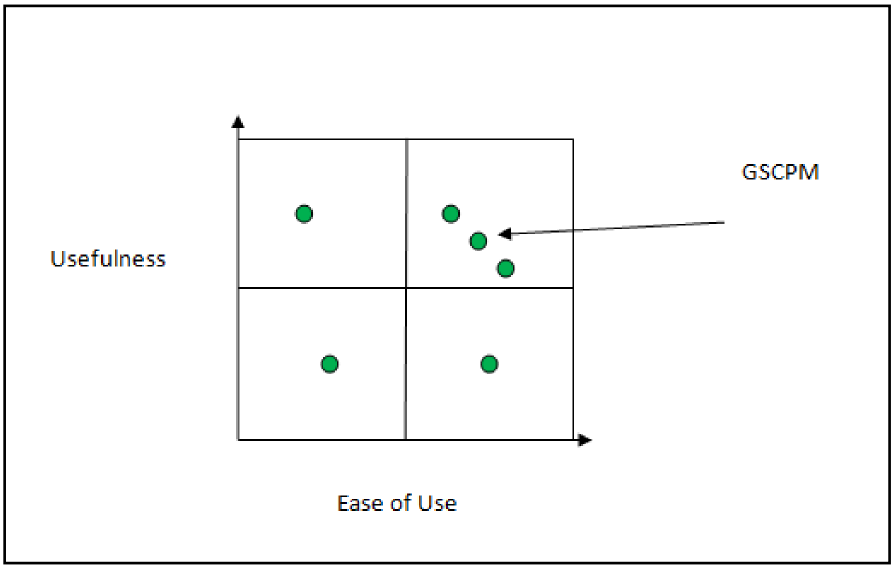


Figure 7.12 – Proposed Ease (of use) versus Impact (usefulness) Matrix

Sections Four and Five (Questions Five and Six) of the survey were aimed at answering RQ3 by understanding the key drivers and barriers that companies face in measuring GSCPM. The respondents were given a list of 18 enablers and 17 barriers statements, which had been identified by practitioners during Phase One. Each respondent was asked during the online survey to rank these on the same five-point Likert rating scale were (1) was 'strongly disagree' and (5) was 'strongly agree'.

Section Six (Question Seven) of the survey was aimed at supporting Sections Four and Five and thus provided more insights into RQ3. The purpose was to understand what the perceived benefits of measuring GSCPM were. This would ultimately identify the root causes behind why companies are measuring GSCPM. The respondents were asked to rank 11 benefit statements which had been identified in Phase One on the same five-point Likert rating scale.

Section Seven (Questions Eight, Nine and Ten) dealt with answering RQ4 by asking the respondents to identify what reporting tools they used and which they felt were appropriate for GSCPM integration. The respondents were also given the opportunity to respond 'other' with an option of a free text box to enter the reporting tool they used.

Finally, Section Eight dealt the respondents demographic information. Using a series of structured and closed questions, the respondents were asked to indicate their occupation, their length of service in the company, age, gender, the size of their company and their company industrial sector. This enabled the researcher to identify any major correlations between the demographic data and the way in which respondents answered the survey questions.

The questionnaire closed by thanking the respondent for their participation, providing an opportunity for them to leave their name and contact details for the two incentives detailed earlier in this section.

7.6.7 Pilot and Test the Questionnaire

According to Oppenheim (1992:47) "*Questionnaires do not emerge fully-fledged; they have to be created or adapted. Fashioned and developed to maturity after many abortive test flights. In fact, every aspect of a survey has to be tried out beforehand to make sure that it works as intended.*"

In the Churchill (1979) two stage method approach for developing better measures it is common for the empirical study to commence with a pilot survey with a carefully selected sample of respondents. In this thesis, a fully fledged pilot survey was not conducted but instead was tested on a group of ten senior supply chain practitioners and academics. The purpose of this was to test for execution issues, time taken to complete the survey, typos, content validation and any other recommendations for improvement. Following the pilot survey, the feedback was reviewed and the main survey was then amended and prepared for issue.

During the design and planning process, various stakeholder management sessions took place with the CILT, the PhD supervisor, the focus group moderator and marketing work colleagues to guide the researcher through the survey design and creation on Survey Monkey Professional™.

7.6.8 Issue Questionnaire and Data Collection

The CILT helped to sponsor the survey and by having clear sponsorship and endorsement from the CILT helped in accessing the sampling frame, improving the response rate and most importantly enabling access to specific membership email addresses details for the survey issue. Due to the Data Protection Act 1998, the CILT took ownership of emailing the survey monkey link out to all their members on the researcher's behalf. An advance warning note was sent out by the CILT's Chief

Operating Officer to all CILT Regional and Group Chairs two weeks prior to the survey being administered, with the aim of asking for their help to complete the survey and to raise its profile in all parts of the UK.

The survey took between 10-15 minutes to complete. The first survey was emailed out to 11,500 CILT members on 14th June 2012 by the CILT using their CABs email. A second wave was emailed again on the 20th June 2012 and finally a third wave was issued on the 21st June 2012. The email that was sent to respondents was customised, personal and very professional in a format which was clearly sponsored and endorsed by the CILT. The survey closed on 25th June 2012, where a winner for the prize draw was identified.

7.6.9 Collate and Code the Data

The online survey closed officially on 25th June 2012 and the data was immediately available to access from Survey Monkey Professional™. The benefit of online survey tools like Survey Monkey Professional™ is that the data is quickly available in two formats for analysis. First of all the summary results can be quickly downloaded by the researcher into an excel spreadsheet which contains the basic descriptive statistics such as tables and charts. Secondly, a spreadsheet of the raw master data ‘unformatted’ can be downloaded into an excel spreadsheet to enable the researcher to manipulate and prepare before inputting this into any statistical package. This automatic download reduces the risk of any clerical imputing errors which might occur using more traditional survey techniques (Oppenheim, 1992). When preparing the data for statistical analysis such as multivariate analysis the first step is to get the survey response coded into numbers. For example, the Likert rated responses for Questions Three and Four were coded one to five for each respondent. The same methodology can be applied for missing data, where a number may be assigned to signify missing data. Depending on the statistical package used, the data must be coded and prepared in various ways ready for statistical analysis. Oppenheim (1992:265) refers to this as the “*code book*” of data from the survey. The qualitative responses from the survey can also be coded and categorised in similar way although it is slightly more problematic. Similar techniques used in Phase One for FG1 and FG2 were used to put answers into key themes and categories using the Miles and Huberman (1994) technique of data reduction.

This survey used a combination of interval and nominal scaling, each demanding different analysis techniques. Interval scaling such as the Likert scale responses can be analysed using descriptive statistics like average, means, variance, standard deviation and multivariate analysis techniques (Oppenheim, 1992). On the other hand, nominal data like demographic data is non-numerical and linear and this makes it problematic to analyse using parametric techniques. There are, however, non parametric techniques such as Chi squared which can be used to compare observations.

7.6.10 Data Analysis and Write-up

Once coded, the data was analysed using a combination of descriptive, univariate and multivariate analysis techniques. Firstly, however, the data was cleaned and checked, for example, in this research; outliers and 'don't know' type answers were removed to ensure clear trends could be observed. The write-up of the analysis and statistical approach from Phase Two will be documented in Chapter Nine and was completed between June and October 2012.

7.7 Focus Group Validation (Phase Three)

Phase Three represented the final phase of the research design and completed the methodological triangulation process for the thesis. The main purpose of Phase Three was to diversify the respondent sample base from Phase One to help improve the validity and reliability of the overall research, and test for theory saturation. It was not intended to obtain industry feedback on the results of Phases One and Two, because the survey had not been fully analysed and interpreted at this point (October 2012).

The final focus group (FG3) was conducted in October 2012 and involved engaging with a new and diverse set of participants outside of the CILT membership database. It included supply chain and sustainability professionals from a wide range of leading UK and European companies. Figures 7.13 and 7.14 show the breakdown of the FG3 participants by sector and occupation. This focus group was a 'piggyback' session, which was held at UCL on the back of a sustainability logistics workshop which was being hosted by a major 3PL for their key clients.

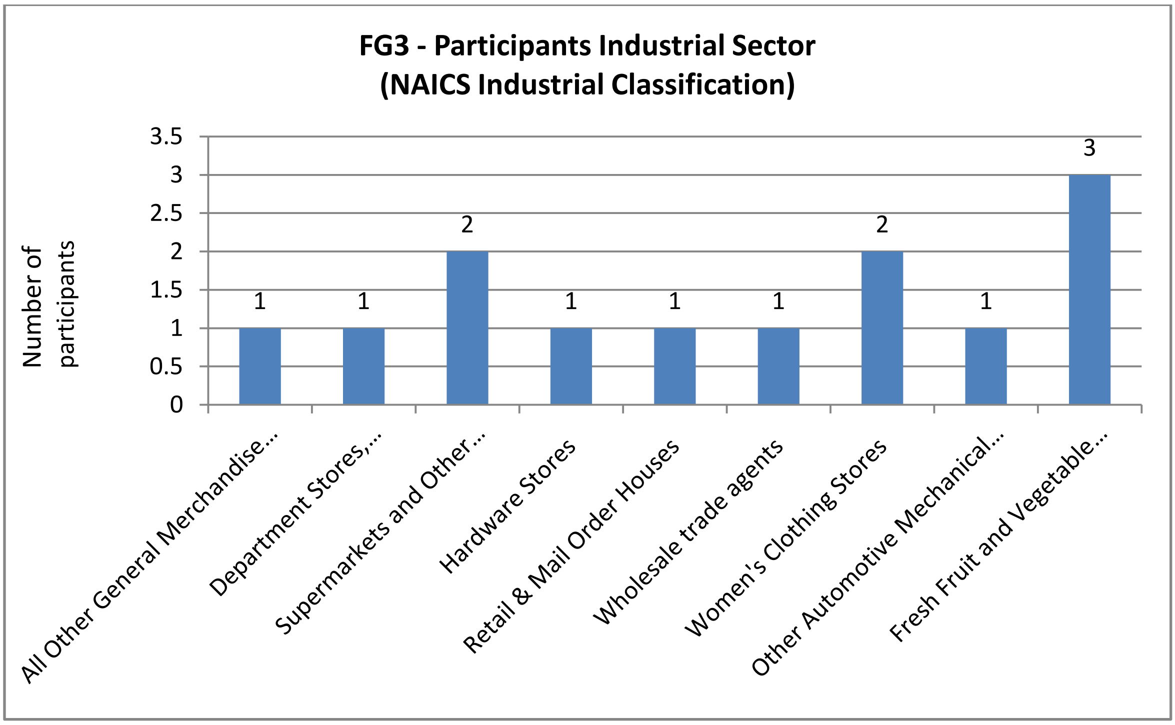


Figure 7.13 - The Industrial Sector Breakdown of Participants from FG3

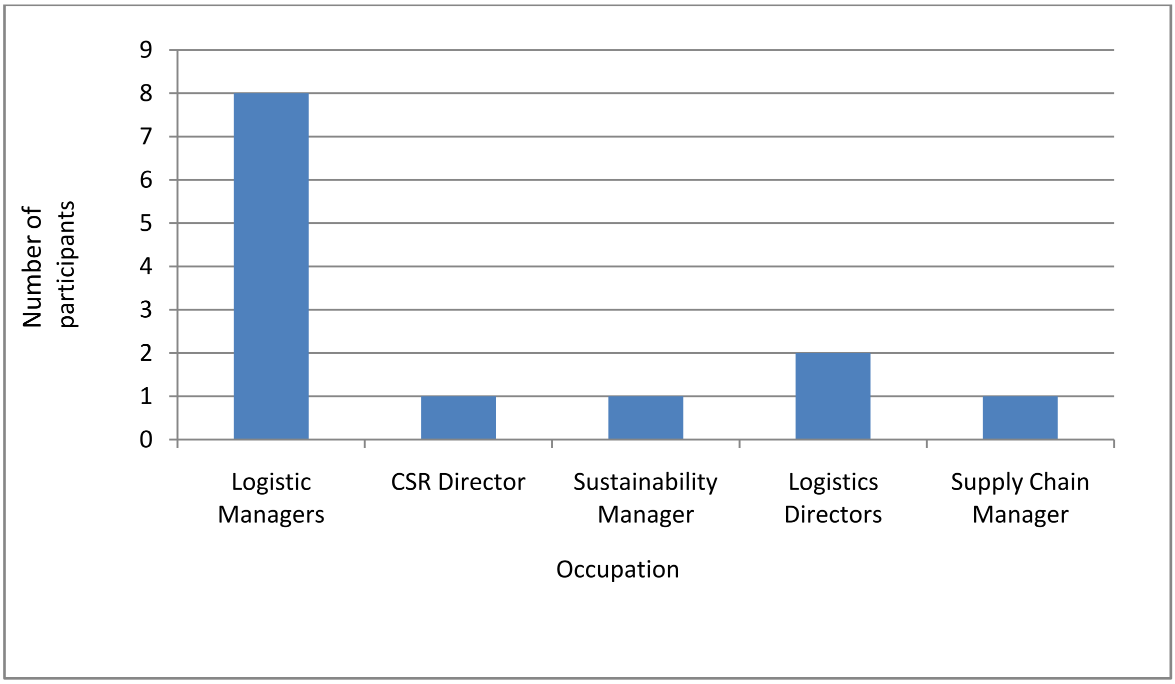


Figure 7.14 – Focus Group Participants (FG3) by Occupation

The aim of this final focus group session was to identify if the same GSCPM variables and constructs would be identified by a different sample of supply chain practitioners. There were 13 participants in total. The FG3 participants came predominantly from the retail and wholesale sectors. FG3 also consisted of two CSR/Sustainability Managers which were subject matter experts in this field. This helped to improve the validity and reliability of the overall research findings.

Using a different method to Phase One, the participants were divided into three groups; each group was given a 30 minutes session in which to brainstorm a number of questions which linked directly back to the main research questions: What GSCPMs do you use? Which are important? What are the enablers and barriers to measuring GSCPM? What reporting tools could be used for measuring GSCPM? The session was facilitated by the researcher using the techniques obtained in Phase One. The session was concluded by the researcher presenting a summary of the FG1 and FG2 findings to the participants to reflect upon. The participants were then asked to comment on the summary of their own discussions from FG3. This request for participant feedback which was also used be Sanchez-Rodrigues et al. (2010) helped to increase the overall validity and credibility of the focus group findings and to ultimately ensure theory saturation had been achieved. A short report of the findings from FG3 was created and circulated with each of the participants after the event (Appendix Five). The analysis and results for FG3 will be documented in Chapter Ten. This concluded the overall research design; the next chapters (Chapters Eight, Nine and Ten) will document the empirical results and analysis of this thesis.

7.8 Summary

This chapter has discussed the philosophical, theoretical and methodological foundations which underpin this research. The interpretivist paradigm is appropriate for the exploratory nature of this new research phenomenon. The research design will be comprised of quantitative and qualitative research methods to ensure multiple insights are sought to provide real world research contributions which are of practical relevance to industry and academia. The next chapter will begin by presenting the analysis and results from FG1 and FG2 (Phase One), followed by the analysis and results of the online survey in Chapter Nine (Phase Two) and finally FG3 in Chapter Ten (Phase Three).

CHAPTER EIGHT
PHASE ONE – FOCUS GROUP ANALYSIS AND RESULTS

8.1 Introduction

Chapter Seven discussed the research methodology which underpinned this study. This chapter will now present the analysis and results from the focus group research (FG1 and FG2) which was conducted in January 2012. The chapter's main purpose is to inductively answer research questions; RQ1, RQ2, RQ3 and RQ4. The results from Phase One provide the foundations and insights required for Phase Two of the research design, which commenced in June 2012. This chapter is structured as follows: firstly, the focus group (FG1 and FG2) findings are reviewed in the context of the five key research questions and finally the chapter is concluded with a summary which acts as a prelude to Chapter Nine.

8.2 Focus Group Findings

In Phase One, two focus groups (FG1 and FG2) were conducted on 25th and 26th January 2012 at the University of Hull. The focus groups were held over two evenings, between nine and ten participants attended each session. Each focus group was audio recorded and professionally moderated by a facilitator. The audio recordings and researchers notes were treated with confidentiality as not to disclose the participant's identity or company in anyway.

8.2.1 Data Reduction and Data Display

Each focus group (FG1 and FG2) was fully transcribed 'word-by-word' from the audio recordings into a Microsoft Word document by the researcher. The two full transcriptions were then overlaid with the researcher's field notes, which included comments, observations and key themes. "*It's been estimated that 80 percent of the content is found in the transcript and the remaining 20 percent are all the other things that occur in the room*" (Krueger and Casey, 2009:124). It is vital, therefore, that the researcher is present to observe these things to gain a complete view of the situation.

The full transcriptions of FG1 and FG2 enabled the researcher to reduce the data into key categories/themes by question; these were transcribed into two Microsoft Word documents. A final Microsoft Word document was produced which displayed a summary of the key themes from both focus groups. A key word count analysis (on Microsoft Excel) was performed on the full transcriptions to identify any other key words and constructs which emerged from FG1 and FG2. Figure 8.1 summarises the data display and reduction funnelling technique used for this thesis where the researcher started with a large amount of qualitative data from the focus groups and then progressively filtered this down to identify the main underlying variables and constructs.

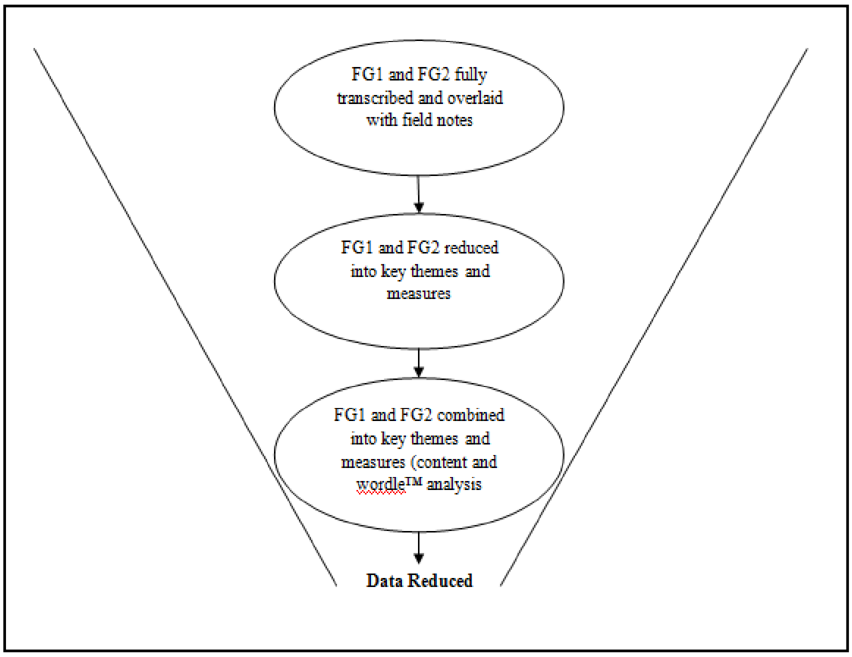


Figure 8.1 - The Data Reduction Funnel Process for FG1 and FG2 (adapted from Dey, 1993:43)

The focus group analysis was an iterative process and continued throughout the entire research embracing the exploratory nature of this research (Figure 8.2). According to Krueger and Casey (2009), conducting analysis throughout the research helps to improve the overall data collection of focus groups. Krueger and Casey (2009) also recommended that the researcher should step away from the data from time to time to reflect upon and understand the bigger picture. It is easy for a researcher to become immersed in the data during the analysis process and to potentially miss something.

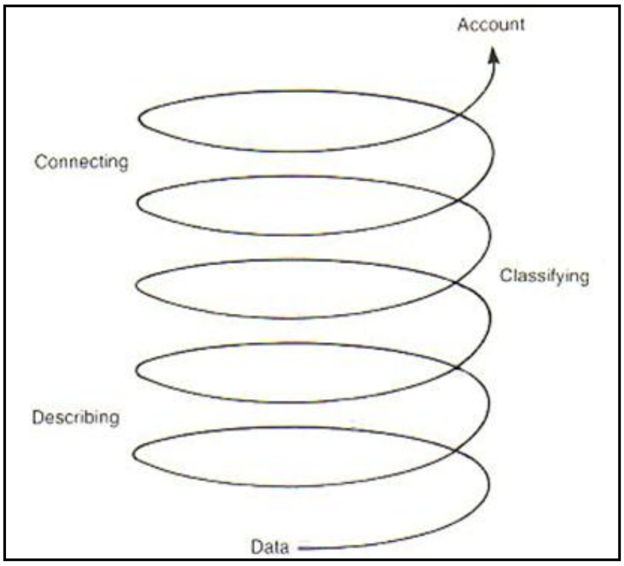


Figure 8.2 - The Qualitative Analysis Iterative Spiral (Dey, 2003:55)

8.2.2 – Using FG1 to Answer RQ1 – RQ4

Once the icebreaker and ground rules had been set in each focus group, the facilitator began by asking a series of questions which linked directly back to the five primary research questions. In the course of this entire research project and for the purposes of confidentiality, the participants in FG1 are coded and referred to in this chapter as follows (Table 8.1):

Table 8.1 – FG1 Participants

Participant Number	Company Size	Industry Sector
Participant 1	Large	Manufacturing
Participant 2	Micro	Transportation and Warehousing
Participant 3	Large	Transportation and Warehousing
Participant 4	Micro	Professional, Scientific, and Technical Services
Participant 5	Medium	Transportation and Warehousing
Participant 6	Medium	Transportation and Warehousing
Participant 7	Medium	Transportation and Warehousing
Participant 8	Medium	Wholesale Trade
Participant 9	Medium	Education
Participant 10	Medium	Education

With regard to the first primary research question:

RQ1: *What GSCPMs are being used?*

The FG1 participants identified a total of 26 x GSCPM variables which they currently used in their organisations (Table 8.2). The researcher used the mind map technique (Mindjet Mind Manager Professional™) to identify the major GSCPM constructs from the 26 x GSCPM variables which were discussed and captured in the FG1 transcript. This was a systematic and verifiable way of funnelling the data into more meaningful themes. Ten GSCPM constructs were generated by using this funnelling technique (Figure 8.3).

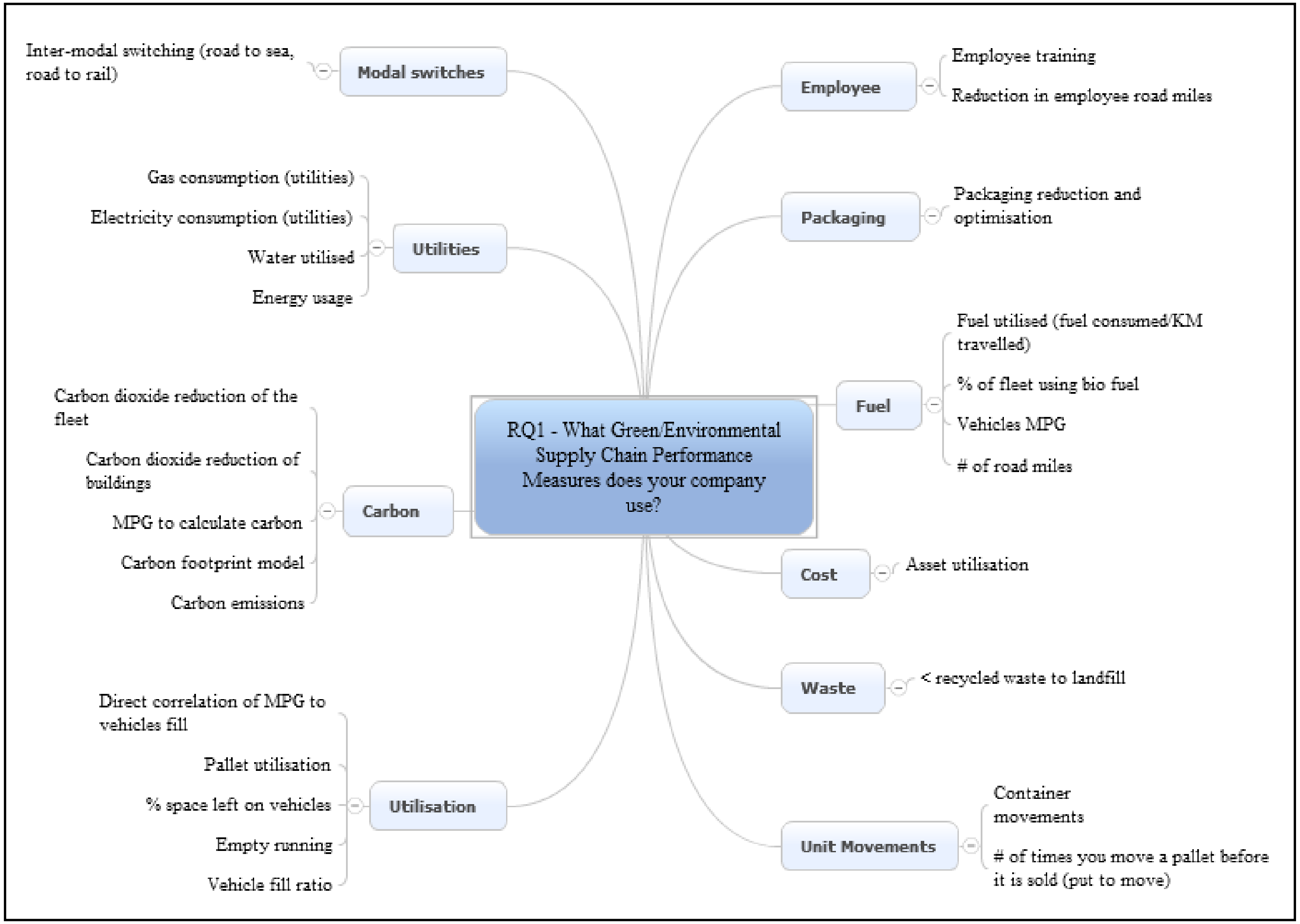


Figure 8.3 – A Mind Map of how the 26 x GSCPM Variables were Coded for FG1 (CURRENT USE)

The 26 x GSCPM items and ten constructs are also displayed in Table 8.2.

Table 8.2 – FG1 GSCPM (CURRENT USE)

26 GSCPM Variables	10 Constructs
1. Vehicles MPG 2. MPG to calculate carbon 3. Empty running 4. Vehicle fill ratio 5. Carbon emissions 6. Carbon footprint model 7. Intermodal switching (road to sea, road to rail) 8. Asset utilisation 9. % space left on vehicles 10. Pallet utilisation 11. Packaging reduction and optimisation 12. Electricity consumption (utilities) 13. Gas consumption (utilities) 14. Fuel utilised (fuel consumed/KM travelled) 15. < recycled waste to landfill 16. Container movements 17. Reduction in employee road miles (single visit fix) 18. Direct correlation of MPG to vehicles fill 19. Employee training and up skilling 20. % of fleet using bio fuel 21. Carbon dioxide reduction of buildings 22. Carbon dioxide reduction of the fleet 23. Energy usage 24. # of road miles 25. # of times you move a pallet before it is sold (put to move) 26. Water utilised	1. Modal switches **(Efficiency/Financial)** 2. Utilities **(Energy/water)** 3. Carbon **(Emissions)** 4. Utilisation **(Efficiency)** 5. Employee **(People)** 6. Packaging **(Efficiency/ Financial)** 7. Fuel **(Transport)** 8. Cost **(Financial)** 9. Waste reduction **(Efficiency/Financial)** 10. Unit movements **(Efficiency/Financial)** **IN BOLD – linking these FG1 RQ1 constructs to the nine constructs identified in the background literature (Chapter Six)**

When the facilitator initially asked RQ1, two out of the nine participants said that their organisations did not measure GSCPM specifically; instead they measured other metrics which were mainly driven by cost or service. However, they believed these measures could also be viewed as GSCPMs, for example:

<u>Participant Seven</u>

"We do not use any specifically or environmental. It's a relatively new area but we use a number of KPIs that measure the environmental impact. Things like 1) MPG on vehicles, 2) Vehicles fill ratio and 3) Empty running in vehicles."

<u>Participant Two</u>

"We do not measure our environmental impact."

It was evident from these initial discussions that the reason for measuring metrics like MPG (miles per gallon) on vehicles or vehicle fill ratios was primarily driven by cost with the environment viewed as a secondary benefit.

In contrast, other participants did state more confidently that their organisations measured GSCPM and it was clear that some of the organisations were taking more proactive steps to mitigate the impact of their supply chain on the environment. The language *"I think"* used twice by Participant Three suggested a lack of understanding in general about their metrics.

<u>Participant Three</u>

"We measure carbon for both fleet and building and energy consumption and MPG and <u>I think</u> we have a whole set of metrics which we report globally. <u>I think</u> we measure vehicle fill. There are lots of other metrics but these are mainly service focused and not environmental."

Participants Three and One where from large multi-national organisations. Participant One needed to measure and report their GSCPM because they were in the public eye and were required by law to complete a questionnaire annually on their carbon emissions for the UK Carbon Reduction Initiative (CRC) which is a government requirement. Participant Three was a director from a leading third party logistics provider (3PL) company and also very much in the public eye, thus answerable to shareholders. Both companies had well established GSCPM and reporting capabilities in place in comparison to the smaller to medium sized companies because of these external pressures.

In contrast, the participants from the smaller organisations either did not measure or were less confident about what they should be measuring in relation to GSCPM and tried to talk more about the initiatives they were completing for their customers rather than how their organisation directly measured GSCPM. It was clear this was not a priority to them.

Participant One also referred to the fact that her company measured "*a whole set of metrics*" and "*There are lots of other metrics but these are mainly service focused and not environmental."* This reinforced the findings of Hoffman (2006), Gunasekaran et al.

(2007) and Morgan (2007) that there has been a supply chain measurement proliferation, with too many metrics in circulation, many overlapping and measuring discrete parts of the supply chain; this leads to confusion and analysis paralysis.

It was evident from FG1 that most participants engaged in some form of GSCMPs, some more than others, such as reducing vehicle road miles and using bio-fuel in their vehicles as a way of adding value to their customer proposition or to simply reduce costs. A number of participants stated that retailers (who were their large customers) were a key driving force behind them implementing GSCMPs and GSCPM measurement; such as modal changes of transport from road to sea or road to rail to reduce the impact on the environment.

<u>Participant Six</u>

"We have developed a coastal feeder vessel to get trucks off the roads. You get less carbon emissions than you do with trucks. ASDA our main customer is saving 12 million road miles per year using this operation. We are also developing the rail service for Teesport to increase the utilisation and get trucks off the road. Trucks we operate use bio fuel and all new machinery that we now purchase are all energy efficient."

The most commonly discussed measurement areas were vehicle fuel use (MPG) and vehicle/building utilisation measures. This was closely aligned with the demographics of the focus group participants with most from transport and warehouse related occupations. Cost and effective utilisation of assets was also another important measurement area discussed in FG1. The importance of cost orientated measures in traditional supply chain performance measurement has been documented extensively in the literature (Gunasekaran et al., 2001; Beamon, 1999; Morgan, 2004; Bhagwat and Sharma, 2007). It is clear, however, from FG1 and the background literature, that even in GSCPM, cost as a primary measure is still very important to practitioners (Hervani et al., 2005; Olugo et al., 2011).

The participants also made a link between their costs and being green. For example:

<u>Participant Two</u>

"Report on cost but this drives also carbon emissions down"

"Cost is driving green. Cost is a big driver"

An additional question was introduced by the researcher and facilitator at the end of RQ1 to provide additional insight into RQ1. The question asked: *"How do you measure and report GSCPM?"* The intention was to understand in more detail how these organisations were currently measuring GSCPM, to really understand their capabilities around GSCPM and to remove any risk of potential 'green washing' (Lyon and Maxwell, 2011).

The response from the group was clear; the larger organisations report internally on GSCPM (Participants One and Three) but very little external reporting occurs regardless of company size unless it is a government requirement (for example, the CRC). This supports the findings in the literature review that reporting and benchmarking of GSCPM is still very much in its infancy (Shaw et al., 2010). One of the largest organisations (Participant Three) had designed their own in-house company performance management system to capture, report and benchmark their GSCPM internally but this was not used externally.

<u>Participant Three</u>

"We have a global metric system, so every operation in our supply chain will have the same things to report on and the same explicit definitions of how to collect the data and what to feed into the system. This then is played back to enable benchmarking and comparison and every business unit has improvement targets to focus on. Sites are expected to make improvements year on year."

In contrast, other medium sized organisations did not do any kind of reporting (internal or external) and monitoring, only when the customer asked for it directly. In some cases, the customers (for example, the large retailers) are providing the GSCPM information to their suppliers, for example, to the transport and logistics companies (3PLs). This is because the retailers or large customers have better visibility and control over their entire supply chain.

<u>Participant Six</u>

"I do not think we do a lot of direct monitoring at the moment. We are a facilitator, taking the logical link of the coastal feeder vessel. We tend to take this information from our customers of how many road miles they have saved because we can only see from

port to port and not from where the container has come from and where it is going to. So it's difficult to get an accurate value on that."

Reporting within small to medium sized companies was primarily driven by cost alone but there was evidence in FG1 that some organisations were ISO 14001 registered and they used this as a method to internally report their GSCPM.

An emerging theme in FG1 was that the retailers and customers appeared to be driving the need to measure through their contracts with these transport and warehouse/3PL organisations. Also, a key observation made by the researcher was that the larger and more powerful companies appeared to have a greater opportunity than the smaller less influential companies to measure their end to end GSCPM. The smaller companies/suppliers could only measure what they controlled and felt largely reactive in measuring GSCPM. Figure 8.4 illustrates this reactive customer/supplier GSCPM relationship conceptually which was discussed in FG1.

<u>Participant Seven</u>

"This whole green agenda is going to be driven by what the retailers want. They want to preserve their USP for their own customers and push more onto suppliers."

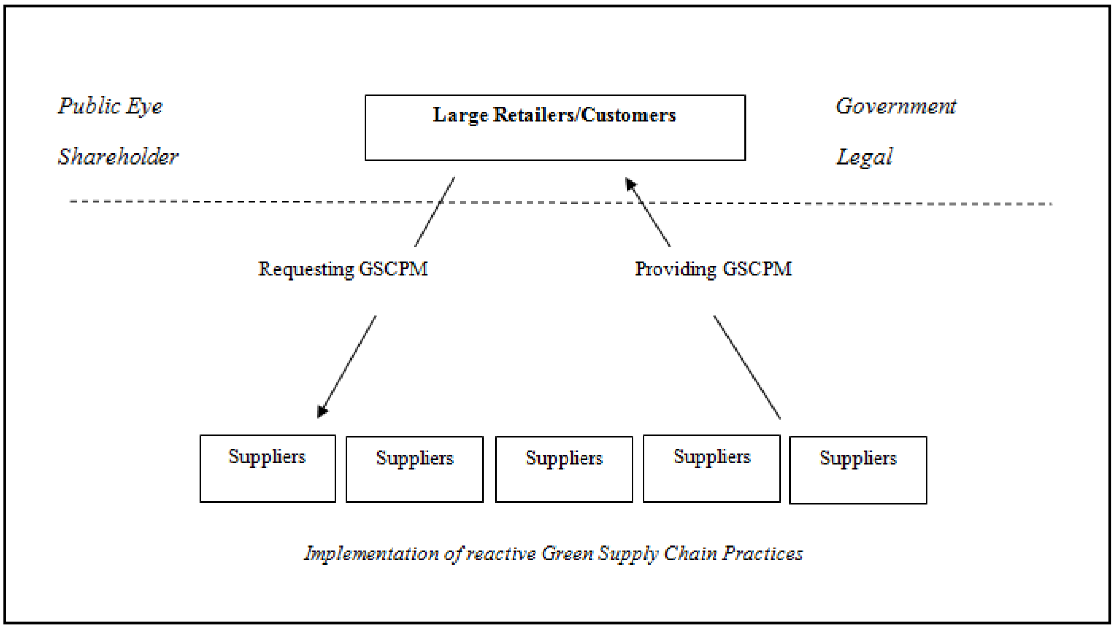


Figure 8.4 – Conceptual model of GSCPM Relationships between Large Customers and Suppliers

An additional concern raised by the FG1 participants was that their companies had outsourced their manufacturing to the Far East in recent years, by doing so they felt that they had effectively outsourced their carbon emissions and reporting responsibilities to another country. This was a major discussion point in FG1 and a concern of the entire group. This reinforced the need to be able to measure the end to end environmental impact of a company's supply chain regardless of the origin of their supply chain activities; otherwise organisations could be underestimating their total environmental impact. This concept of outsourcing carbon from the UK has been discussed in the literature (Helm, et al., 2007; Ecologist, 2011) and has implications for GSCPM and reporting.

Another interesting theme that emerged was that the FG1 participants did not really explain how they measured their GSCPM. Only Participants Five and Six referred to 'how they measured' for example, Participant Six referred to carbon emissions being measured per mile travelled by road or by sea and Participant Five referred to capturing driver behaviour using software known as 'telematics'. This question really highlighted the general lack of understanding the group had about how to measure GSCPM, which sharply contrasted with the clarity and confidence of how they measured supply chain cost. To reinforce this point, the researcher also identified that language used by the participants such as "*I think"* and *"difficult"* demonstrated a lack of confidence, understanding and capability around GSCPM.

When asked how the FG1 participants currently reported their generic supply chain performance, there was a mixed response; some participants did not report at all, others used tools such as the BSC, SCOR, six sigma tools, their own in-house reporting systems and ISO 14001. This demonstrated the sheer diversity and lack of consistency in supply chain reporting tools used. There appeared to be no 'one size fits all' tool for managing supply chain performance.

Incorporating GSCPM into the BSC developed by Kaplan and Norton (1992) has been documented in the academic literature (Epstein and Wisner 2001; Zingales et al., 2002, Hervani et al., 2005; Shaw et al, 2010) but was not evident in practice. The ISO 14001 standard however seemed a more widely used and understood technique by the group which included the ISO 14031 certification. It has been identified in the literature that

ISO 14031 can be used as a guide on how to measure environmental performance (Putnam, 2002).

An interesting concept which is not documented in the literature but a unique finding of this research is that companies are generally developing their own reporting tools to measure supply chain performance which makes it very difficult to perform benchmarking activities. This will also have implications for GSCPM reporting and will be discussed in more detail in Chapter Eleven.

The FG1 participants were then asked if any of these aforementioned performance frameworks could be used to report GSCPM in their supply chains, the consensus was a mixture of ‘perhaps’, ‘no’ and ‘yes’ with the BSC being posited as a potential tool, the Dow Jones Sustainability Index as another, the Carbon Trust tool to measure the LCA of a product and perhaps an extension to the CRC report; however, Participant Seven said it was important that the new reporting tool looked at ‘what we can do now’ and allows for future development, emphasising the continued theme of ‘change.’ A number of benefits of integrating GSCPM into an existing supply chain management performance framework were discussed but no consensus on the most appropriate tool was agreed:

Participant Three

“*It helps you make decisions which help the company to survive. If you are resource efficient then you are likely to survive because metals, minerals, fibres will get more and more expensive. The cost of resources are going up. It is not just about making sure you are cost efficient this year but that your supply chain is cost efficient for the next 10-15 years time.”*

This again supported the findings in the literature review that there are potentially two dimensions which must be considered in measuring GSCPM:

1) Mitigation – the ability for a company to measure their impact on the environment
2) Adaptation – the ability for a company to measure how sustainable their business

Mitigation is potentially a short/medium term goal with adaptation being a longer term goal but equally as important if the company is to survive (Abukhader and Jönson, 2004; Macbeth et al., 2009; Halldórsson and Kovács, 2010).

Participants Three and Five both believed that incorporating GSCPM into existing reporting systems enabled a change in mindset and behaviour of employees; helping to get buy-in from their teams and embed GSCPM practices within their organisations. Employees and people were identified as a key construct in FG1 for RQ1.

The third and fourth questions posed to the group by the facilitator were aimed at answering RQ2:

RQ2 *Which GSCPMs are important, i.e. which are useful and provide an impact?*

The questions were broken down into two sub-questions in the focus group session:

1. *In your opinion, which are the most appropriate environmental supply chain measures used in your organisation?*
2. *If you were given a free reign, what environmental supply chain measures would you propose and why? How would you measure these?*

Twenty five GSCPM variables were identified as important to practitioners during FG1. These closely aligned with the 26 x GSCPM variables, which were identified in RQ1. This suggested that those GSCPM variables which practitioners were using were also seen as important. The researcher used the same systematic and verifiable technique from RQ1 to code the 25 x GSCPM variables into 10 measurement constructs (Figure 8.5 and Table 8.3).

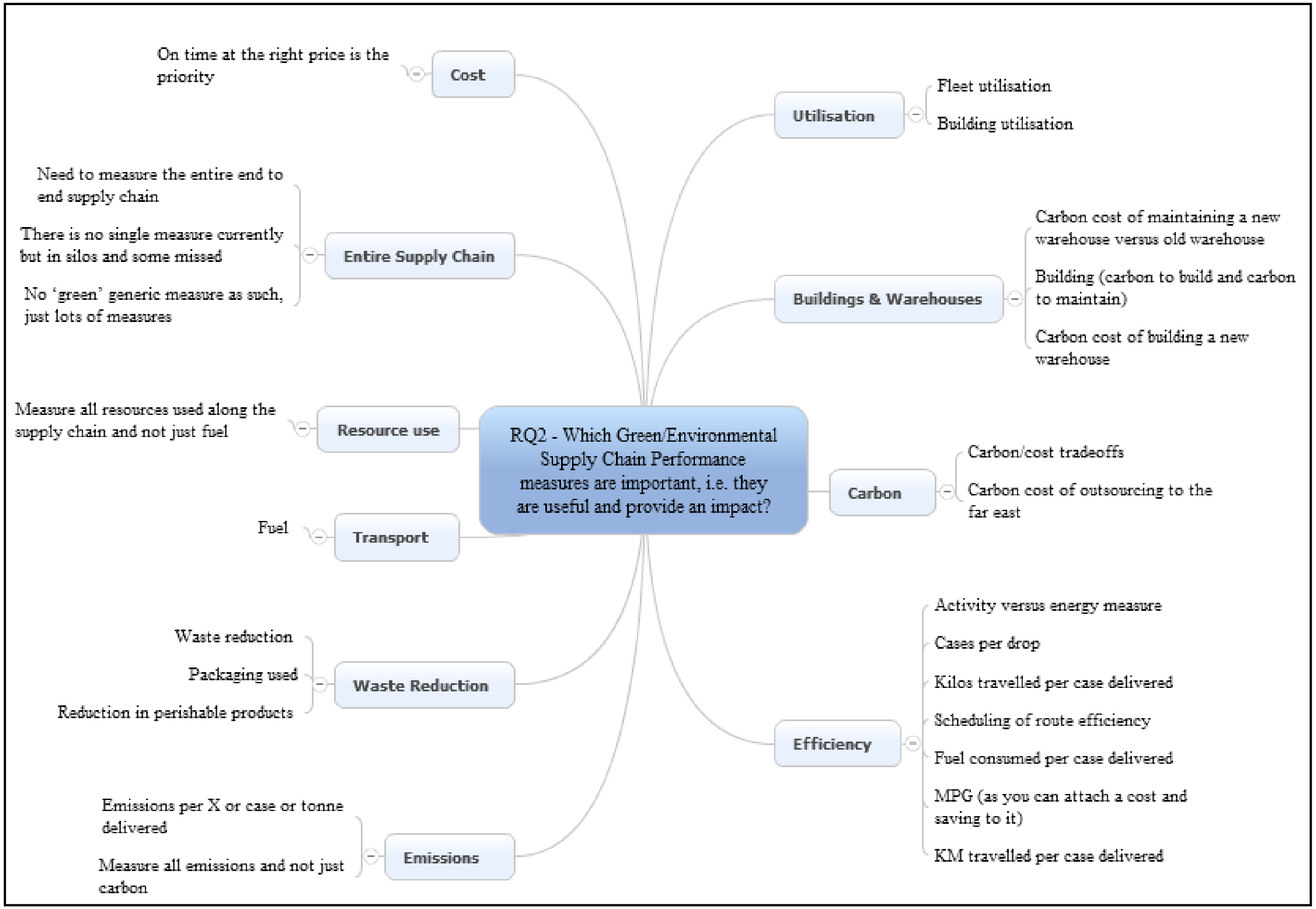


Figure 8.5 - A Mind Map of how the 25 x GSCPM Variables were coded for FG1 (IMPORTANCE)

Table 8.3 – The GSCPM Identified as Important in FG1

25 GSCPM Variables	10 Constructs
1. MPG (as you can attach a cost and saving to it)	1. Cost **(Financial)**
2. Kilos travelled per case delivered	2. Entire supply chain
3. Scheduling of route efficiency	**3.** Resource use **(Efficiency/Financial)**
4. Cases per drop	**4.** Transport **(Transport)**
5. Fleet utilisation	**5.** Waste reduction **(Efficiency/Financial)**
6. No 'green' generic measure as such, just lots of measures	**6.** Emissions **(Emissions)**
7. On time at the right price is the priority	7. Utilisation **(Efficiency/Financial)**
8. Fuel consumed per case delivered (encourages fuel economy)	**8.** Building and warehouses **(Gap in literature)**
9. KM travelled per case delivered	9. Carbon **(Emissions)**
10. Building utilisation	10. Efficiency **(Efficiency)**
11. Building (carbon to build and carbon to maintain)	**IN BOLD – linking these FG1 RQ2 constructs to the nine constructs identified in the background literature (Chapter Six)**
12. Activity versus energy measure (theme)	
13. Carbon cost of building a new warehouse	
14. Carbon cost of maintaining a new warehouse versus old warehouse	
15. Carbon cost of outsourcing to the far east (dirty production) and not just UK emissions	
16. There is no single measure currently but in silos and some missed	
17. Need to measure the entire end to end supply chain. Not impossible to do we are just not yet sophisticated to do this.	
18. Carbon/cost tradeoffs	
19. Emissions per X or case or tonne delivered	
20. Measure all emissions and not just carbon	
21. Fuel	
22. Measure all resources used along the supply chain and not just fuel	
23. Waste reduction	
24. Packaging used	
25. Reduction in perishable products (e.g. food supply chain)	

Table 8.4 shows the direct correlation between the GSCPM variables identified for RQ1 and RQ2 in FG1. Many of the other GSCPM variables also overlap for example 'fuel' and 'transport'.

Table 8.4 - The GSCPM Construct Correlations Between RQ1 and RQ2 in FG1

RQ1 – Current Use	RQ2 – Most Important
• **Cost** →	• **Cost**
• **Waste reduction** →	• **Waste reduction**
• **Carbon** →	• **Carbon**
• **Utilisation** →	• **Utilisation**
• Fuel	• Transport
• Modal switches	• Entire supply chain
• Utilities (energy)	• Resource use
• Employee	• Emissions
• Packaging	• Building and warehouses
• Unit movements	• Efficiency

The most appropriate GSCPM constructs raised by the group were the ones which governed cost and employee behaviour. The priority for most participants was the 'customer first', 'cost second' and then finally 'being green' appeared further down the list of priorities (Figure 8.6). For example:

<u>Participant Seven</u>

"Green measures are not something which we measure by. It is a 'nice to have' the first priority is to have the customer's product on time and at the right price."

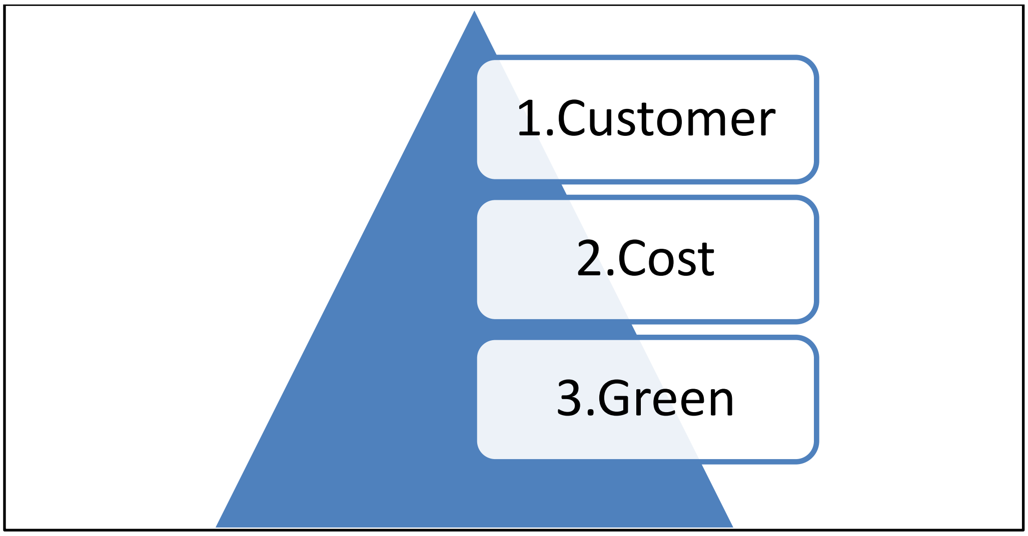


Figure 8.6 – The Hierarchy for Measuring GSCPM (Where One is the highest priority for organisations)

The important GSCPM variables identified were MPG and fuel consumed per case delivered as they were seen as important in encouraging fuel economy and reducing the amount of effort required to satisfy the customer needs. Another important variable identified by the group was building/warehouse utilisation. This is because there has been a reliance on larger warehouses in the UK since manufacturing has been outsourced to the Far East and this has created longer product lead times and a requirement for more warehouse space in the UK. The group discussed the importance of understanding the carbon emissions and energy associated with constructing and maintaining these warehouses and understanding how well these buildings are utilised.

Participant Seven

"Old buildings – is it better to have a new building that does not waste a lot of energy in the form of lighting and electricity but then compare this to the amount of carbon to build it . Is that more efficient than an old building?"

There is a large body of academic evidence that carbon is an important GSCPM variable. In Chapter Six, the researcher confirmed that the most predominately used measure in the field of GSCPM was CO_2 emissions (Braithwaite and Knivett, 2008; Edwards et al., 2009; McKinnon, 2009b; Sundarakani et al., 2010; Paksoy et al., 2011). Given carbon dioxide's long term impact on the environment and its increased focus in the media in the context of climate change, it is no surprise that both academics and practitioners have focused on this measure as a way of measuring the environmental impacts of their supply chains. The environmental impact however of warehouses/buildings has been largely overlooked academically, yet their environmental impact is significant (Dhooma and Baker, 2012). It was evident from FG1 that buildings are seen as a major consumer of energy and are important in the context of this research.

The main concern raised by the group was that GSCPM was measured potentially in silos; there is no one collective GSCPM for the supply chain and worse still, not everything is measured. When the facilitator asked the group if it was possible to have one collective GSCPM for the supply chain, they all reached a consensus of *"no."*

Participant Six

"It is measured in silos and not as a total measure."

Participant Seven

"Even worse not every element is being measured in the process. Only bits which the customer asks us to measure."

"It is customers and legislation that drive this – there is no proactive way as an industry to measure it, no tool or technique."

The researcher sensed the frustration of the group at this point. The participants felt frustrated because they wanted to measure GSCPM but it was difficult and too complex to measure. Participant Five, however, said on reflection, it is probably not impossible to have one GSCPM for the supply chain if a cost could be attached to carbon. This would make it possible and viable but unfortunately most companies do not have the capabilities to do this yet.

Participant Five

"It is probably not that difficult to measure as a whole thing. It is only the same as measuring the cost of things. We are all probably familiar with the terminology of tradeoffs between warehousing and transport and these tradeoffs change as fuel prices goes up. So why can you not have a trade off with the cost of carbon against your warehouse space then you could have a measure. If you are trying to deliver a cost/service trade off, then the customer will squeeze you on service and you will then be delivering half loads frequently and so forth."

Given a free rein, the FG1 participants would measure all emissions, not just carbon (emissions per case or tonne delivered) and natural resource use efficiency (so not just fuel, but packaging optimisation and waste reduction). They all agreed that the scope of GSCPM was indeed much larger than just carbon, transport and buildings.

In summary, the FG1 participants identified a number of areas which would be important to measure. It was also vital to the participants that they could measure the end to end supply chain and not just within silos, and that GSCPM variables could be linked to cost enabling a change in people's behaviour. Generally, there seemed to be an overlap between those GSCPM variables which were being used and those which were seen as important; and also a real sense of frustration in FG1 around the complexity and difficulty in measuring GSCPM.

The next part of the FG1 was aimed at understanding the enablers and barriers to measuring GSCPM which help in answering RQ4.

RQ4: *What are the enablers and barriers for GSCPM?*

The FG1 participants identified ten enablers and six barriers to measuring GSCPM. These are listed in Table 8.5:

Table 8.5 GSCPM Enablers and Barriers for FG1

GSCPM Enablers	GSCPM Barriers
1. Customers/Retailers 2. Fuel efficiency 3. The green agenda 4. Legislation 5. Cost 6. Board of Directors/Shareholders 7. Efficiency 8. Competitive advantage 9. Profit 10. The supply chain itself	1. Poor transport infrastructure (e.g. rail) 2. Time 3. Who should measure it? 4. People (social norms and attitudes) 5. No one is asking for it (nice to have) 6. Not in full control of the end to end supply chain

The FG1 participants identified more enablers than barriers to measuring GSCPM and initially the group seemed slow in identifying any barriers at all. An interesting point which emerged gradually during FG1 was that no one was really asking for this information; it was a nice to have but not a priority unless their customers asked for it.

<u>Participant Five</u>

"The customer wants you to demonstrate that you have mechanisms in place for being green."

<u>Participant One</u>

"M&S had a green plan – if you want to be our supplier you are going to need a green agenda. Big customers are driving this."

Cost and profit continued to be a major theme and focus throughout this part of the FG1 discussion with most of the enablers orientated around cost, profit and efficiency.

<u>Participant One</u>

"Cost and the environment are linked. You can dress it up as the environment but it is all about the cost. It is a drive for efficiency."

Participant Five made an interesting comment: there are no major barriers to organisations measuring and reporting GSCPM, the lack of action is because no one is asking for this information; there is no demand for GSCPM. There is an inertia associated with GSCPM which they believed needed addressing urgently.

<u>Participant Five</u>

"There is no real barrier, just no one is asking for this information."

There was also a realisation by the group that some directors and CEO's, particularly in larger companies, are now recognising the benefits of measuring GSCPM or implementing GSCMPs not necessarily to reduce the impact on the environment but to strengthen their customer value proposition, thus delivering financial benefits.

A frustration of FG1 was that they could not measure what they did not manage and that they were not in full control of their end to end supply chain. This complexity of not knowing what to measure and who is responsible for measuring was a barrier to measuring GSCPM. Rail transport infrastructure emerged as another frustration for the group, particularly Participant Six; they identified this as a barrier to being green.

<u>Participant Six</u>

"Principally rail is brilliant but the infrastructure is rubbish. The containers that we have are two high and wide to go through some tunnels. So this has created lots of investment in low lying wagons and where does all this money come from? Sometimes you have to go North to go South – doubling your mileage. So are we really getting a saving? Rail v Sea v Container feeder v inland water barges. Probably better option than rail. The government bats on about rail but do not invest in it."

People/employees were also identified as a major barrier to measuring GSCPM. They identified that it is key to change people's social norms and attitudes around the green agenda.

<u>Participant Five</u>

"There is a people thing, if people cannot see why it is relevant to measure it then what is the point? There is no physical barrier but getting people to measure and understand why it is important is the key thing to changing people's attitude towards measuring."

Caplice and Sheffi (1994) identified effectiveness as one of their three dimensions of supply chain performance measurement. They identified effective metrics as key to driving the behaviour of logistic personnel in the right direction. It is not just about the metrics but about the softer aspects of change management and changing people's behaviours, norms and attitudes. Mollenkopf et al. (2010) also found that there is a significant opportunity to study the role of corporate culture in the implementation of lean and green strategies in global supply chains. This supports the importance of RBV and NRBV theory which was discussed in Chapter Three in the development of GSCPM (Barney, 1991; Hart, 1995).

Participant Three raised an interesting remark during the discussion on GSCPM enablers. She identified Three Eras associated within GSCPM or what will be seen in the future:

"So it is all about carbon at the moment but next is waste and shortly followed by water."

Therefore like the Eras associated with the evolution of performance metrics and supply chain performance metrics discussed in Chapter Five, the researcher made a note at this point in the discussion to highlight a potential evolution associated with the development of GSCPM (Figure 8.7).

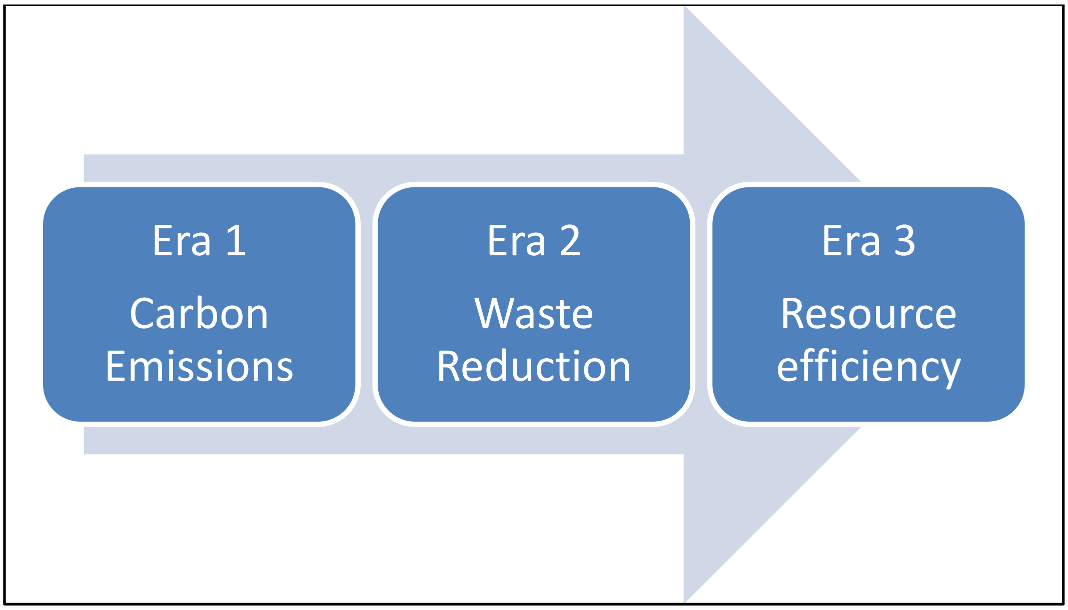


Figure 8.7 – GSCPM Evolutionary Eras

Carbon emissions are much more associated with environmental mitigation (climate change impact); however resource efficiency is associated with sustainability/adaptation measures (Halldórsson and Kovács, 2010).

In summary, depending on the company, there appears to be more factors driving than preventing organisations measuring GSCPM; however, in order to properly measure and remove this inertia, all these factors must be addressed and understood.

The facilitator concluded the FG1 session by asking one last ‘catch all’ question to ensure a complete view and insight of this research problem. This embraced the exploratory nature of this research.

“Given your position and experience, what do you think is important? Where are the gaps? What is missing?”

The participants stressed the importance of the following factors in GSCPM:

- The measurement of the entire supply chain is vital to ensure everything is measured
- Reverse logistics will be key in improving the sustainability of supply chains
- The scope of ‘green’ is greater than just fuel, it is also about people and other things like resource efficiency
- We can only act upon information provided to us as consumers
- Kyoto must be ratified and signed by all nations for this to work
- GSCPM is driven by government legislation and transport infrastructure

It was clear from the concluding remarks that the FG1 participants wanted to measure GSCPM and be greener, but they lacked the capabilities and resources to do this. They found it complex and difficult, this caused frustration. They also stated that they had seen a shift in focus of supply chain KPIs over the last 30 years from service to more environmentally focused. Cost and customers were major drivers of GSCPM and the group wanted to see a cost attached to carbon to enable GSCPM integration and acceptance. There was also recognition by the group that GSCPM was a much wider subject covering not just things like fuel and warehousing but people, resource efficiency and sustainability. Figure 8.8 below summarises the overall results from FG1 which helped to answer RQ1, RQ2, RQ3 and RQ4.

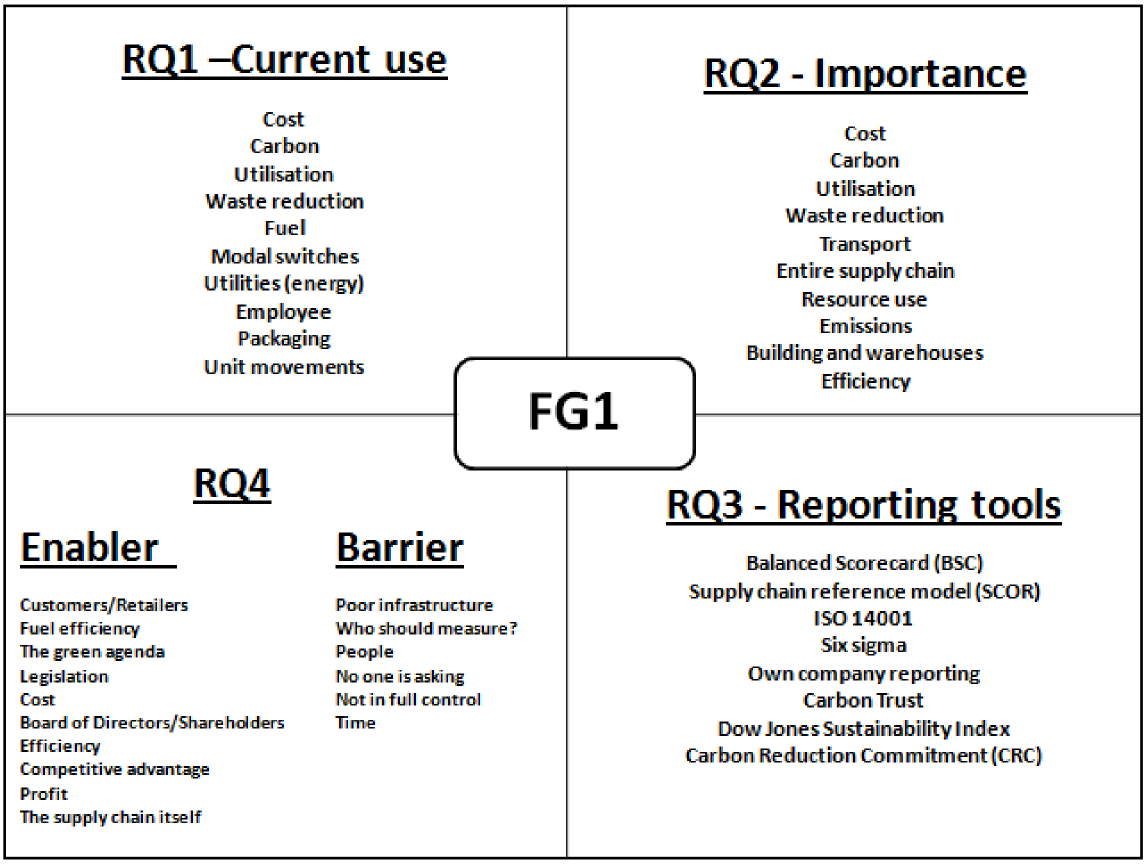


Figure 8.8 – A Summary of the GSCPM Results from FG1

The next section will now review the findings of FG2 using the same systematic and verifiable methods and techniques as used in the FG1 analysis.

8.2.3 – Using FG2 to Answer RQ1 – RQ4

In this section (as in Section 8.2.2) and for confidentiality, the participants in FG2 are coded and referred to in this section as follows (Table 8.6). The main reason for this confidentiality is not to reveal the participant's identity or organisation in anyway.

Table 8.6 – FG2 Participants Coding

Participant Number	Company Size	Industry Sector
Participant 11	Medium	Retail
Participant 12	Large	Information
Participant 13	Medium	Transportation and Warehousing
Participant 14	Medium	Educational Services
Participant 15	Large	Healthcare and Social Assistance
Participant 16	Large	Transportation and Warehousing
Participant 17	Large	Healthcare and Social Assistance
Participant 18	Medium	Educational Services
Participant 19	Micro	Professional, Scientific, and Technical Services

With regard to the first primary research question:

RQ1: *What Green Supply Chain Performance Measures (GSCPMs) are being used?*

The FG2 participants identified a total of 29 x GSCPM variables which their companies currently used. Using the same method as in FG1, these GSCPM variables were summarised into 11 measurement constructs using the mind map technique (Mindjet Mind Manager Professional)™ (Figure 8.9 and Table 8.7). Eight of the constructs identified in FG1 were also identified in FG2 which suggested the focus group research was reaching a point of theory saturation. Three new GSCPM measurement constructs emerged; these were the triple bottom line (TBL), buildings and emissions. Although, these new constructs may have been discussed in FG1, they were more explicitly discussed in FG2 in relation to GSCPM current use.

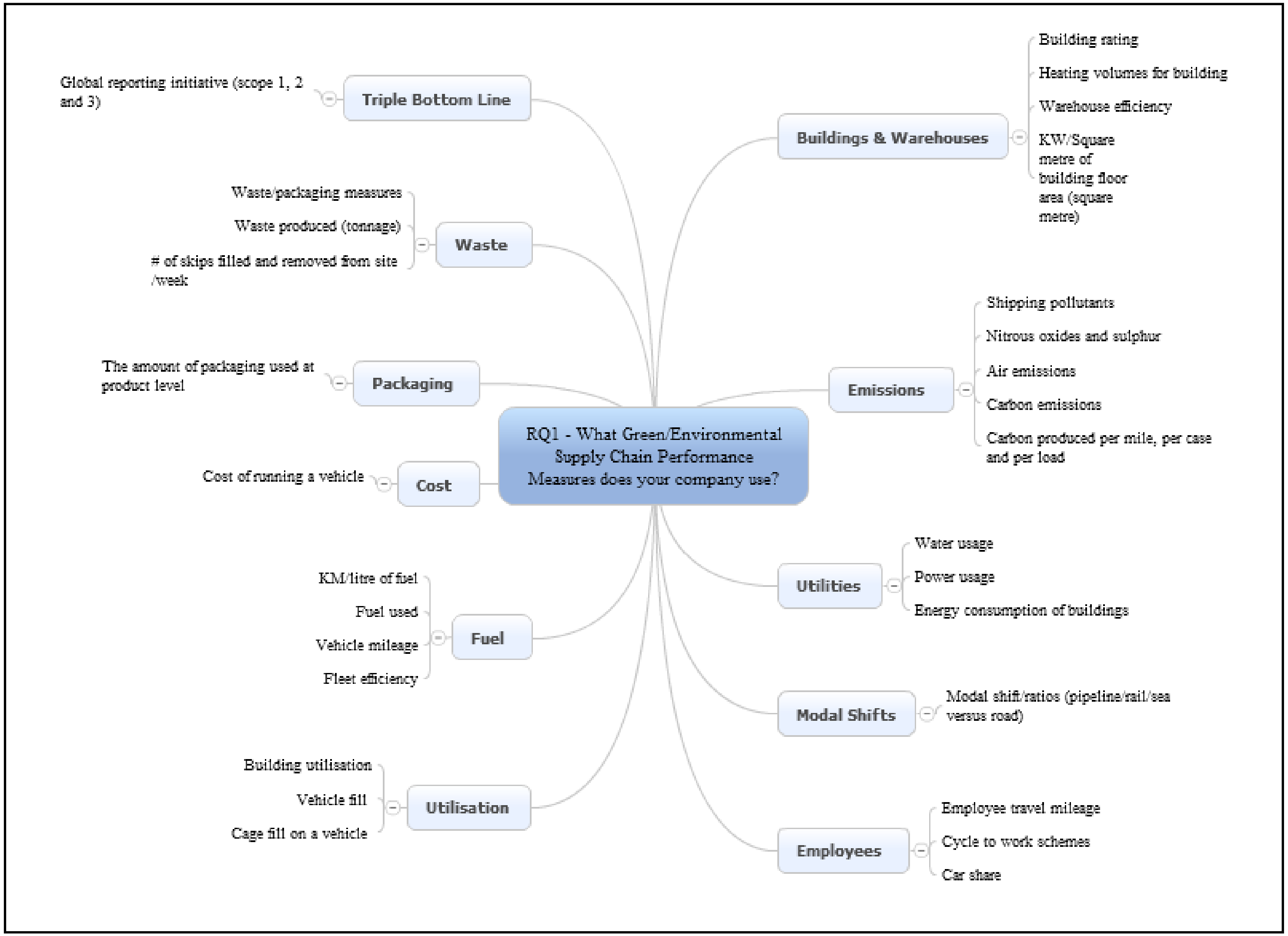


Figure 8.9 - A Mind Map of how the 29 x GSCPM Variables were Coded for FG2 (CURRENT USE)

Table 8.7 – FG2 GSCPM (CURRENT USE)

29 GSCPM Variables	11 Constructs
1. Global reporting initiative (scope 1, 2 and 3)	1. Triple Bottom Line (**TBL/Sustainability**)
2. Vehicle fill x 2	2. Waste Reduction (**Efficiency/Financial**)
3. Cage fill on a vehicle (FedEx)	3. Packaging (**Efficiency/Financial**)
4. The amount of packaging used at product level	4. Cost (**Financial**)
5. Waste/packaging measures	5. Fuel (**Transport**)
6. Warehouse efficiency	6. Utilisation (**Efficiency/Financial**)
7. Carbon emissions	7. Buildings and warehousing (**Gap in literature**)
8. Energy consumption of buildings	8. Emissions (**Emissions**)
9. Carbon produced per mile, per case and per load or tonne	9. Utilities (**Energy/Water**)
10. Water usage	10. Modal shifts (**Efficiency/Financial**)
11. Power usage	11. Employees (**People**)
12. Building utilisation	
13. Employee travel mileage	**IN BOLD – linking these FG2 RQ1 constructs to the nine constructs identified in the background literature (Chapter Six)**
14. Fuel used	
15. Car share	
16. Cycle to work schemes	
17. Modal shift/ratios (pipeline/rail/sea versus road)	
18. Fleet efficiency	
19. Air emissions	
20. Shipping pollutants (ballast water contamination) and affect on biodiversity	
21. Nitrous oxides and sulphur (affect on human health)	
22. Building rating (A,B,C,D or E) energy efficiency	
23. Cost of running a vehicle	
24. Waste produced (tonnage)	
25. KW/Square metre of building floor area (square metre)	
26. Heating volumes for building	
27. KM/litre of fuel	
28. # of skips filled and removed from site /week	
29. Vehicle mileage	

A key theme which emerged early in the FG2 discussion was that some of the participants (even from large companies) did not currently measure any GSCPM at all. As in FG1, cost and efficiency were seen as important measures to the group and GSCPM was not their priority in terms of measuring their supply chain performance.

<u>Participant 17</u>

"We do not actually measure but we do record for our potential tenders and contracts whether the suppliers have an environmental management system in place or a carbon management system in place, but we do not have a metric."

In contrast, once the conversation got underway, Participant 11 who came from a medium sized retail company seemed more confident in listing the GSCPMs which his company used. He identified energy consumption of buildings and the carbon emissions associated with this. He also highlighted the difficulty in being able to measure the elements of his supply chain which were outsourced to his third party logistics suppliers and understanding the clear boundary lines for measurement. Cost, however, continued to be a dominant construct throughout the discussion.

<u>Participant 11</u>

"We have got a few – we measure the amount of packaging we use in our product at line level. So we can report on it. We clearly measure energy consumption in all of our buildings we have got and as a company and then turn this into Co2 emissions. So we have that measure. Probably one of the biggest costs for us is freight distribution so the initial line haul taking freight from the distribution centre to the third party sortation. We can measure this element easily (cage fill, vehicle fill). The issue we have then is these parcels and pallets go on to a third party carrier. So how do we measure the impact of our parcel on a vehicle, because they are doing 120 parcel drops per day but four of our parcels are on it. So which element is related to us? That is something we would like to get to but even the carriers struggle with this as well."

Participant 12 was from a large multi-national software company, he touched on how his company was measuring the carbon footprint of their employees as they travelled significant distances overseas. They also measured metrics such energy usage (water and power) because they run hardware (large servers).

In contrast, Participant 19, who was from a micro sized firm (SME structure), simply did not measure any GSCPM variables at all but was aware of how other large companies he had dealt with as a supplier measured GSCPM. He just saw no need to measure GSCPM given his company size but understood why larger companies did this.

An interesting theme which occurred in FG1 and FG2 was that the large customers were the ones driving the smaller to medium sized suppliers to measure GSCPM, for example, Participant 14 used to work for a company that supplied Boeing:

<u>Participant 14</u>

"In the company I worked for before, we measured the performance of our suppliers in terms of environmental. However these measures were not designed by the company I worked for but by Boeing. The supplier Boeing was at the top of the supply chain and could control everything."

Likewise, Participant 16, who was from a large outsourced logistics business in the UK, had different measures and green supply chain practices for different customers, depending on their needs and industry. Participant 16 talked about a *"shared drive and focus*" to develop initiatives and GSCPM variables with their clients and this was part of their customer value proposition as a 3PL.

The FG2 participants were then asked:
"*How do you measure and report them?"*

Participant 17 was a Sustainable Development Director from a large public sector organisation and provided a totally different perspective on what they measured. It was evident his company was much more proactive and well advanced in their GSCPM reporting. This was driven more out of the need to report rather than the need to measure to improve. He stated that this was not really completed for his own company but driven by supplier tenders and contracts. Participant 17 dominated the FG2 reporting discussion at this point, confidently articulating the measurements his company captured, for example, his company measured energy consumed by different sources; their waste is recorded in line with the waste regulations, mileage covered between each of their different sites and the carbon footprint of their suppliers. They also used the Global Reporting Initiative (GR1) as a reporting framework. This demonstrated a real sophistication in the way they were reporting and a clear difference in the evolution of GSCPM between private and public sector companies and by occupation. Participant 17's role was focused on GSCPM/Sustainability and therefore he was confident discussing what his company did in FG2. This sharply contrasted with all the other FG2 participants who came largely from supply chain occupations. Public sector companies are also more closely aligned to government initiatives and policies such as '*The Environment Agency of the Department for Climate and Energy Change'* and very much in the public eye and therefore expected to conform in terms of their environmental compliance. More GSCPM variables were identified by Participant 17 as part of this question than any other part of the FG2 discussion.

Similarly, Participant 15 was also from the same large public sector company as Participant 17 but a different division. He was a Sustainable Development Manager and discussed confidently how he reported and categorised waste (domestic versus chemical) and also how much of this waste was going to landfill.

Participant 15

"We categorise into two groups chemical and domestic waste. Currently achieving 85% recycling of our domestic waste. In three months we will achieve 100% away from landfill. On the chemical side is more difficult. We measure by tonnage, how much plastic and paper we produced. It is recorded on a monthly basis. So that is how we can identify exactly 85%. We also will not have any landfill in three months for domestic waste. We are working towards 75% of our clinical waste going to recycling. And things like measuring the carbon content of transporting waste – not at present but will, but future plans to measure it."

Other FG2 participants seemed relatively confident in some of their GSCPM areas and how often they measured these. For example, Participant 13 made reference to how his company measured vehicle fill and kilometres travelled per litre which he reported *"internally and weekly."* He also made reference to waste reduction initiatives discussing the "*number of skips produced per week."* It was not clear however, whether his company measured this as he was speaking generically as opposed to what he was recently describing.

An overwhelming sense of tension pervaded the group about the *'how to measure.'* The researcher noted a real sense of frustration from Participant 11 in the colloquial language used to emphasise his frustration. There was a sense of wanting to measure GSCPM but it was very difficult to measure the various parts of an activity within the supply chain.

Participant 11

"For fuel measures (fleet) we can measure very clearly what we are paying our third party carriers for in trunking and line haul costs. But once that gets into a sortation hub how the hell do you capture this? At the moment we do not do this and the carriers struggle to do this as well. The carriers know what their overall cost is but how they then attribute that per customer is very difficult."

Participant 18 made reference to the Defra guidelines, the Carbon Trust methodology and the Green Cargo Working Group as a way of reporting GSCPMs (measure on emission factors/TEU) but it was unclear if any of these were being used by the FG2 participants referring to *"companies are using"* these. Participant 19 was also aware that large chemical companies (his customers) where actively measuring and reporting their fuel movements (road versus rail) to their refinery teams internally on a regular basis.

In summary, the FG2 participants identified a significant number of GSCPM variables which related to the variables and constructs identified in FG1 and the background literature; for example: cost, fuel, packaging, waste reduction, utilities, utilisation, employees and modal shifts. There was also a clear differentiation between the types and sizes of company and what they measured and reported (public versus private and micro versus large). There was also a noticeable difference between supply chain/logistics practitioners and sustainability managers/directors in their understanding of GSCPM and related practice. Although carbon was discussed, there was less emphasis on it in terms of GSCPM current use and more emphasis on emissions in general. The constructs which emerged in ‘currently used’ were: emissions, buildings, efficiency and transport.

The third and fourth questions posed to the group by the facilitator were aimed at answering RQ2:

RQ2 *Which GSCPMs are important, i.e. which are useful and provide an impact?*

As in FG1, the questions were broken down into two sub-questions in the focus group session:

- *In your opinion, which are the most appropriate environmental supply chain measures used in your organisation?*
- *If you were given a free reign, what environmental supply chain measures would you propose and why? How would you measure these?*

Seventeen GSCPM variables were identified as important to practitioners during FG2. They closely aligned with the 25 x GSCPM variables which were identified in RQ1; however there were significantly less of them. This again suggested that those GSCPM variables which practitioners were using were also seen as important. The researcher used the same systematic and verifiable technique from RQ1 to code the 17 GSCPM variables into six measurement constructs and compared these to the constructs identified in the background literature (Figure 8.10 and Table 8.8).

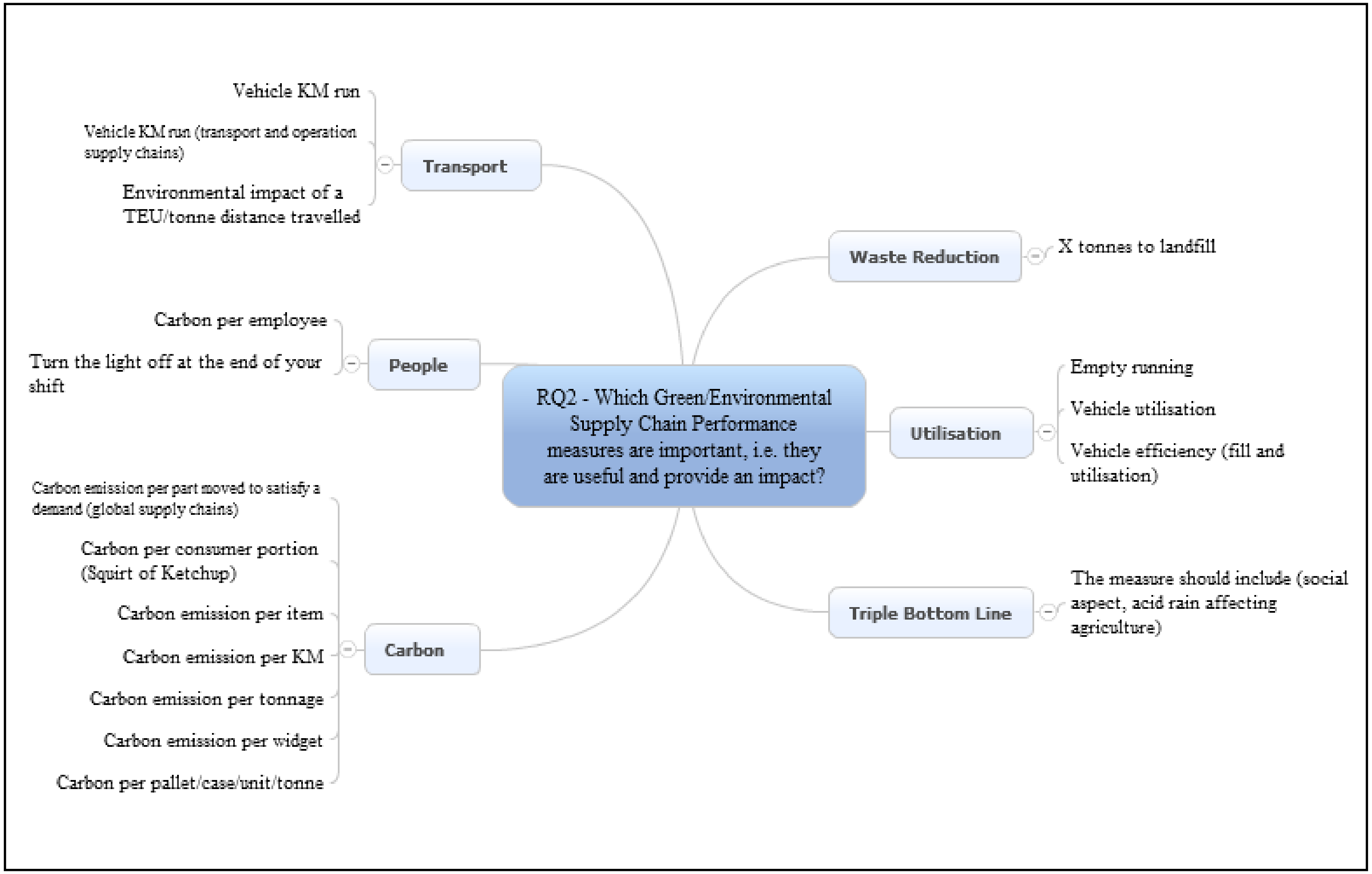


Figure 8.10 - A Mind Map of how the 17 x GSCPM Variables were Coded for FG2 (IMPORTANCE)

Table 8.8 – The GSCPM Identified as Important in FG2

17 GSCPM Variables	Six Constructs
1. Carbon emission per part moved to satisfy a demand (global supply chains) 2. Vehicle KM run (transport and operation supply chains) 3. Vehicle efficiency (fill and utilisation) 4. Vehicle KM run 5. X tonnes to landfill 6. Turn the light off at the end of your shift 7. Carbon per employee 8. Carbon per consumer portion (Squirt of Ketchup) 9. Carbon per pallet/case/unit/tonne 10. Vehicle utilisation 11. Environmental impact of a TEU/tonne distance travelled 12. Empty running 13. The measure should include (social aspect, acid rain affecting agriculture) 14. Carbon emission per widget 15. Carbon emission per tonnage 16. Carbon emission per KM 17. Carbon emission per item	1. Transport **(Transport)** 2. People **(People)** 3. Carbon **(Emissions)** 4. Waste reduction **(Efficiency/Financial)** 5. Utilisation **(Efficiency/Financial)** 6. Triple Bottom Line **(TBL/Sustainability)** **IN BOLD – linking these FG2 RQ2 constructs to the nine constructs identified in the background literature (Chapter Six)**

Table 8.9 shows the direct correlation between the GSCPM constructs identified in RQ1 and RQ2 for FG2. There were direct correlations between the triple bottom line, carbon, waste reduction, people and utilisation measures. Similar observations were made in FG1 where correlations existed between carbon, waste reduction and utilisation as in FG2.

Table 8.9 - The GSCPM Correlations Between RQ1 and RQ2 in FG2

RQ1 – Current Use		RQ2 – Most Important
Triple Bottom Line	→	Triple Bottom Line
Utilisation	→	Utilisation
Waste Reduction	→	Waste reduction
Employees	→	People
Emissions	→	Carbon
Fuel	→	Transport
Packaging		
Cost		
Buildings and warehousing		
Utilities		
Modal shifts		

The most dominant GSCPM variable identified for RQ2 in FG2 was carbon emissions. Seven carbon related measures were identified by the group. They related to carbon emissions per unit/movement which was clearly important to the group. Similar parallels can be drawn between this and the GSCPM identified for RQ2 in FG1. Seven efficiency related variables were identified, which again related to how efficient a business is in moving an item/unit from one destination to another to satisfy a customer demand.

The group discussion at this point was dominated by the key attributes of a good GSCPM. The group identified four attributes:

- The measure must be simple and easy to understand
- Requires no complex equations/algorithms to calculate it
- The measures must be clear, visible, simple, transparent and consistent
- Avoids duplication and double counting

This closely aligned with the attributes Caplice and Sheffi (1994) recommended in their review of supply chain metrics.

<u>Participant 11</u>
"The most appropriate measures are the ones which are simple and that people understand."

Initially the FG2 participants talked more about the attributes of a good GSCPM variable rather than which ones were specifically important to them. The conversation focused extensively on 'cost' as a driver and 'people' as key in developing and embedding GSCPM in their organisations.

<u>Participant 19</u>
"My philosophy is cost is the main driver and we talk about CSR, it is great because it gives a company a good public image so people will then buy your product and increase profits. Ultimately it is about the bottom line."

<u>Participant 15</u>
"The key to getting this across is simplicity. My experience in the XXX in delivering this message is to keep it very simple and for people to understand and digest. If you make it complex then people do not understand. For the private sector I think morally I think we are all in agreement we should do it but it is all about the bottom line."

Other participants however remained specific referring to variables such "*carbon/employee"* and *"carbon/pallet or carbon/tonne/shipment/case/unit."* At this point in the conversation the FG2 participants got into a real debate about GSCPM in general. The researcher again sensed a similar frustration to that observed in FG1. The participants used language throughout the discussion in reference to GSCPM; such as *"The problem is"* and *"There is a lack of commonality"* and *"I have concerns over."* They demanded a *"call to action"* by government:

<u>Participant 16</u>
"It is the call to action what we are looking for, so the government takes a measure, you are asked to measure and in ten years they legislate that you need to hit it – this will drive a change in behaviour."

An interesting finding from FG2 was that most of the participants did not know what environmental management schemes they subscribed to as a business. This highlighted a clear disconnect and lack of integration between their roles and those people in their business that manage such schemes. There was a lack of consistency and maturity in the adoption of these environmental management schemes with some FG2 participants not sure or vague when asked if they were certified and which parts of their sites were certified.

<u>Participant 11</u>
"Yes we do but not sure."
<u>Participant 13</u>
"Probably do but not aware."

When asked what reporting tools their organisations used to measure their supply chain performance, again there was a lack of consistency and diversity in the tools used. The BSC was identified along with ISO 14001, SCOR and the GRI. Participant 16 noted that his company developed different reporting tools to suit their different clients. This reinforced the findings from FG1 that there is no 'one size fits all' in terms of the tools used to measure supply chain performance. This would create some challenges for GSCPM integration.

FG2 participants did not really answer the specific question (RQ3) of the benefits of incorporating GSCPM into an existing performance reporting tool. There was, however, evidence that some of the practitioners were using various frameworks such as GRI and the BSC but not necessarily as an integrated tool.

Buyers were identified as driving the reporting requirements of their customers. A similar trend was identified in FG1 with an emphasis on ‘reporting’ for suppliers but not necessarily ‘measuring’ and doing something about it.

In summary, the FG2 participants agreed the best measures (variables) depended on the company in question and what parts of the supply chain were being measured. The constructs of emissions and people dominated this section with carbon emissions/efficiency per activity/unit being of great importance to participants. Other GSCPM variables were identified as important including tonnes of waste to landfill and vehicle utilisation. The most insightful findings of the section related to the attributes of a good GSCPM and the differences between occupation and sector (public and private) in their understanding of the research debate and where these companies are in their GSCPM evolutionary process. Furthermore, the FG2 participants seemed very passionate about developing GSCPM but were very frustrated about the lack of guidance, complexity, demanding a *‘call to action’* to resolve this. The next section will now turn to the enablers and barriers of GSCPM identified in FG2.

The FG2 participants identified seven enablers and fifteen barriers to measuring GSCPM. These are listed in Table 8.10.

Table 8.10 - GSCPM Enablers and Barriers for FG2

GSCPM Enablers	GSCPM Barriers
1. Cost 2. Legislation 3. Retailers 4. What the brand needs 5. Big suppliers can drive this 6. Customers drive this 7. Bottom line	1. Cost of the carbon versus the cost of measuring it 2. Where do you draw the boundary lines in the supply chain 3. What is the unit we should be measuring to enable benchmarking? 4. I can only measure parts of the supply chain I can control so only half the measure 5. Other countries do not have standards or need to measure (Far East) 6. If data is missing from the measure it will lose its impact 7. Who bears the cost of measuring? 8. Where is the cost borne in the supply chain? 9. How do we capture it? 10. Multiple measures and very complex so hard to measure 11. Where do you start and stop? 12. Supply chain is the most complex system to measure 13. How much strategic information can I share with my collaborative partners (suppliers)? 14. It is laborious and expensive? 15. Customer driven only

Significantly more barriers than drivers were identified in FG2. This was reinforced by the strength/frustration of the discussion and debate around answering RQ1 and RQ2. Cost and legislation were identified by the group as key enablers or drivers to measuring GSCPM. Other enablers were highlighted throughout the FG2 discussion, such as customers, suppliers and company brand. It was clear from the discussion, that often no driver is required if the benefit is financial, companies will be measuring it already if it relates to cost.

<u>Participant 19</u>

"With metal recycling – you do not need legislation it makes good money on its own without any driver."

In terms of GSCPM barriers, the group asked lots of questions about 'ownership' which demonstrated that this is an area which requires clarification and debate. *Who measures it? What is the scope of measurement? Who bears the cost of measuring? What is the unit of measurement*? *How much information can I share with my suppliers?* Cost and time dominated at least two of these questions. All of these act as barriers/blockers to GSCPM and highlighted the uncertainty and confusion in FG2 group. The participants made reference to the reactive nature of measurement and that it is only measured when someone asks them to measure it, a similar finding to FG1:

Participant 17

"It is customer demand driven and if they do not ask for it, we do not measure it."

Participant 17 also made reference to the fact his company purely reports GSCPM for supplier/customer tenders and contracts, but they do not really measure and do anything with their own company GSCPM.

"We do not actually measure but we do record for our potential tenders and contracts whether the suppliers have an environmental management system in place or a carbon management system in place. But we do not have a metric."

The supply chain itself was identified as a key barrier to measuring GSCPM, with most FG2 participants phased by the challenge of *'what is the scope of measurement?'*, '*where do you draw the boundary line?'* and *'we can only measure what we manage'*. All act as blockers to measuring GSCPM.

Participant 16 raised an interesting concept which companies generally face in business, he referred to the cost/service management equation which most companies try to balance to ensure they are profitable and meet their customer's needs. The environmental factor however, is growing as part of this equation. These are the same three factors which where identified in FG1 as part of the hierarchy/priorities companies face in balancing cost, their customers and being green.

Participant 16

"So there is this environmental and cost consideration. So we are always looking at the cost/service mgt equation but environmental is growing as part of this."

A further enabler to measuring GSCPM identified in FG2 was US/Europe legislation. Participant 12 was employed by a multi-national company. His parent company systems dictated what needed to be measured; driven by European legislation. Therefore multi-national companies have the added challenge of balancing different country legislative environmental requirements when trading within and across country borders.

Participant 12

"The metric we use are defined by a system called SMARTWAY which is part of the Environmental Protection Agency used in the US."

"These drivers are coming out of Europe."

Cost remained a key theme throughout FG2 as in FG1, with participants identifying cost as a major driving force behind measuring GSCPM.

Participant 19

"My philosophy is cost is the main driver and we talk about CSR, it is great because it gives a company a good public image so people will then buy your product and increase profits. Ultimately it is about the bottom line. The measures which affect the bottom line are the key measures. Legislation drives cost."

The group made the link between measuring carbon and the cost of measuring. If it is too costly to measure and it takes too much resource to measure, companies will not measure it.

Company brand was identified as an enabler of GSCPM. Participant 16 noted that companies such as Apple rely heavily on their brand image to sell to their products. If the way the product is manufactured kills the planet then this will destroy their brand value and will ultimately destroy their business. It is therefore important for these types of large companies to measure their GSCPM and mitigate their impact on the environment; protecting the environment is not their primary concern.

In summary, cost, brand, retailers, the public and legislation were identified as key enablers of GSCPM in FG2. In contrast, the key barriers related to the scope/complexity and ownership (responsible, accountable, consulted and informed) of the supply chain (who should measure, where does the data come from, how to measure).

The facilitator concluded the FG2 session by asking one last 'catch all' question (as in FG1) to ensure a complete view of this research problem.

"Given your position and experience, what do you think is important? Where are the gaps? What is missing?"

The respondents stated that they needed clear government guidelines on what to measure, this was the key gap and needed to be addressed. They identified that there were too many disparate bodies and legislation which caused confusion and complexity in measuring GSCPM. They required a *'call to action'* to address this and reinforced the need that this must be government led. Overwhelmingly cost dominated the discussion and whatever measure they discussed, they felt it had to stack up financially for companies to do it. The GSCPMs had to be transparent, clear and simple. They also raised the point that it is not just about measuring but what companies are going to do with the results. The participants of FG2 raised concerns about a global GSCPM and that political timeframes are working against companies in implementing GSCPM. Collaboration however across the supply chain is important to successful GSCPM implementation. Participant 16 also referred to the evolution of GSCPM, which was also discussed in FG1:

"*Those people doing our job in 10-15 years time will be conditioned by legislation. Rarity of fossil fuels, survivability of the human race. These are big macro factors. But cost, service/CSR are the big three."*

Figure 8.11 below summarises the overall results from FG2 which helped to answer RQ1, RQ2, RQ3 and RQ4.

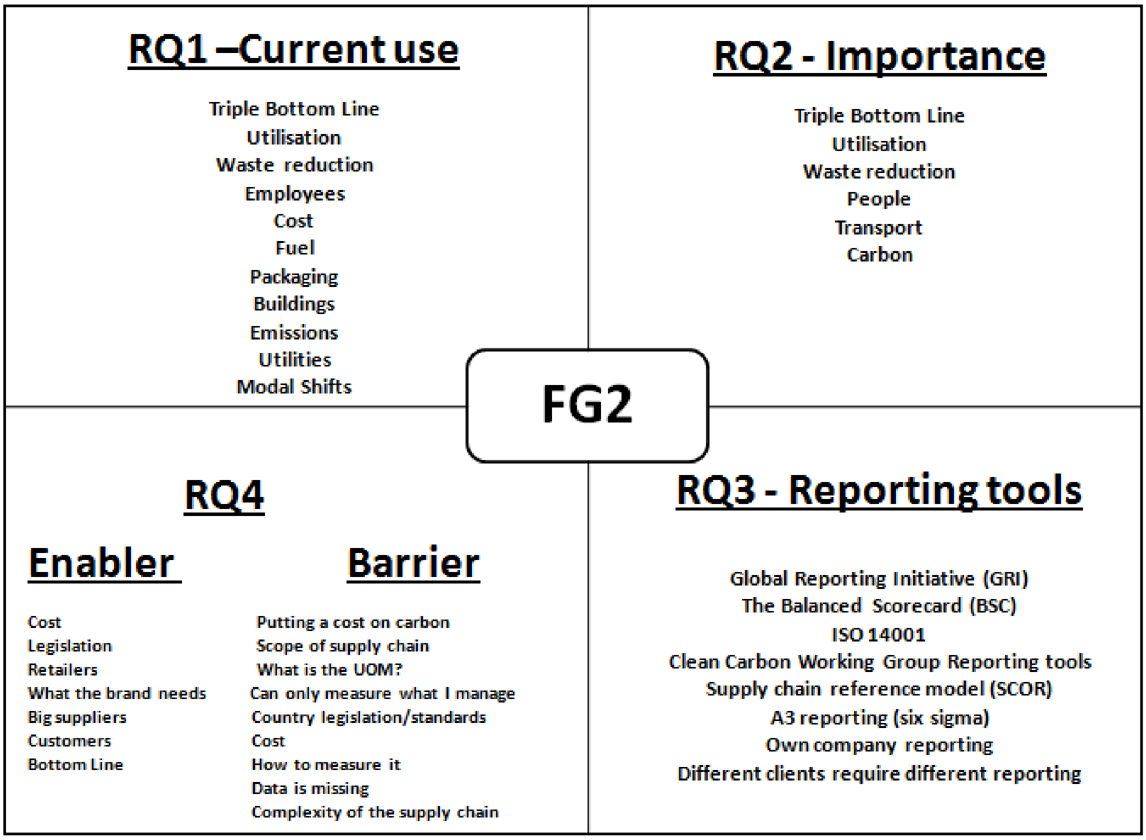


Figure 8.11 – A Summary of the GSCPM Results from FG2

The next section will briefly compare the results between FG1 and FG2, followed by a summary of this chapter which will act as a precursor to Chapter Nine.

8.3 Overall Results (FG1 and FG2)

A total of 19 practitioners were involved in the Phase One focus group sessions in January 2012. This enabled the researcher to address each of the four primary research questions and identify and develop key variables and constructs to test in the online survey in Phase Two. Figure 8.12 presents the combined results from FG1 and FG2 summarising the key findings.

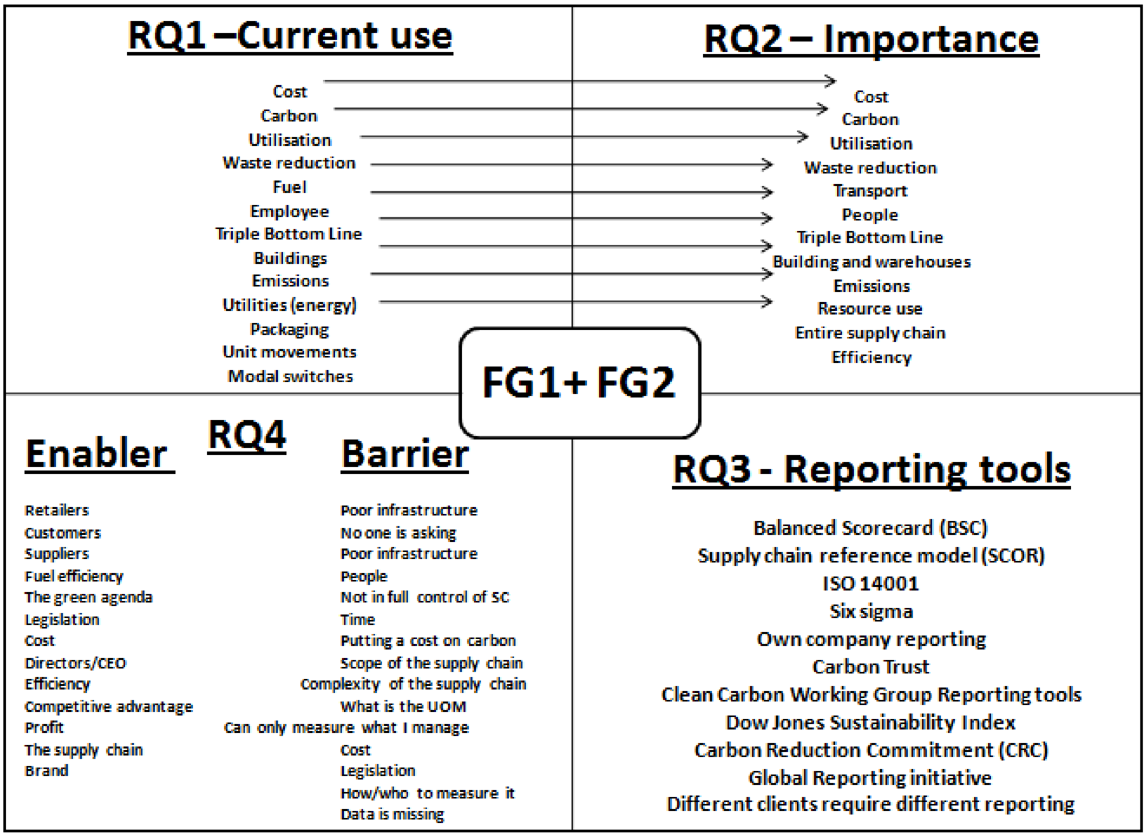


Figure 8.12 – A Summary of the GSCPM Results from FG1 and FG2

With regard to RQ1 and RQ2:

After some refinement, removal of duplications, the researcher identified a total of 25 individual GSCPM variables as 'currently being used' by practitioners in FG1 and FG2 and the background literature. Fourteen of these GSCPM variables were identified by the participants as important in FG1 and FG2. These 25 x GSCPM variables were then distilled down into 13 categories (Table 8.11). The GSCPM variables and categories underlined are the ones which are the most important to practitioners from FG1 and FG2 and the ones in bold help to answer RQ5 by understanding if they mirror the constructs in the background literature (Table 8.11). This reinforced the point made earlier that those GSCPM variables which companies are currently using are also seen as important.

Table 8.11 – GSCPM Items and Constructs Identified from FG1 and FG2

GSCPM Items - Current Use and Importance	Current Use and Importance Constructs
1. Electricity consumption measures 2. Driver behaviour 3. Carbon emissions of an activity 4. Carbon emissions per item/case/pallet delivered 5. Overall company carbon footprint measures 6. Vehicle mileage measures 7. Packaging consumption measures 8. Fuel consumption measures (MPG) 9. No of pallet movements or touches per delivery 10. Warehouse utilisation measures (e.g. pallet occupancy) 11. Fuel consumed per item/case/pallet delivered 12. Vehicle running costs 13. Waste recycling measures 14. Warehouse efficiency measures 15. Water consumption measures 16. Gas consumption measures 17. Overall supply chain carbon footprint measures 18. Vehicle fill/utilisation measures (e.g. empty running) 19. Energy used per item/case/pallet delivered 20. Greenhouse gas emissions (nitrous oxide, methane etc) 21. Cost measures (e.g. cost of running your warehouse, fleet etc) 22. Employee training (environmental training) 23. No of container unit movements (TEU) 24. Employee travel 25. Resource efficiency (raw materials, asset utilisation)	**1.** Cost **(Financial)** **2.** Carbon **(Emissions)** 3. Utilisation **(Efficiency/Financial)** 4. Waste reduction **(Efficiency/Financial)** **5.** Transport **(Transport)** 6. People **(People)** 7. Triple bottom line **(TBL/Sustainability)** 8. Buildings **(Gap in literature)** 9. Emissions **(Emissions)** 10. Utilities **(Energy)** 11. Packaging **(Efficiency/Financial** 12. Unit moves **Efficiency/Financial)** 13. Modal shifts **Efficiency/Financial/Transport** **IN BOLD – linking these overall categories to the nine constructs identified in the background literature (Chapter Six)**

There are, however, some GSCPM variables being measured by practitioners but not necessarily seen as important, for example: utility measures (water, gas and electricity) and modal shifts. This supports the fact that some organisations are measuring GSCPM variables because they have to (driven by legislation or customers) and not because they feel they are important. It also supports the comment made by Participant Three from FG1 about the Eras associated with GSCPM, with resources like water appearing further down the list of priorities currently:

"So it is all about carbon at the moment but next is waste and shortly followed by water."

This huge focus on carbon emissions is due to current climate change issues and resultant media/government led initiatives to combat it. This has led to an increased focus on carbon related metrics. It is evident from both focus groups that many organisations do not know how to or have the capabilities to measure the carbon emissions of their supply chain. There is also the issue that GSCPM is potentially measured in silos and worst still not all of it is being measured.

With regard to RQ4:

Thirteen enablers and 15 barriers were identified collectively by FG1 and FG2. It was apparent from both focus groups that cost was a major enabler and driver to measuring GSCPM. In fact, in both focus groups, the participants (except for some of the larger organisations) did not explicitly measure GSCPM but instead were using existing supply chain performance measures which had a bivalent role. The priority was to reduce cost and be more operationally efficient and if the measure was also environmentally friendly then this was an added bonus. The main driver however was cost; if a cost could be attached to carbon or a GSCPM, this would increase the level of adoption.

Five enablers from FG1 were also identified as enablers in FG2; these included suppliers, customers, cost, profit and legislation. In contrast, only one common barrier was found between FG1 and FG2, this related to ‘I can only measure what I manage’. Common barrier themes existed between FG1 and FG2 which related to phrases such as ‘who’ referring to a lack of ownership of the GSCPM process. This suggested that there were a lot questions which needed answering before practitioners could successfully implement GSCPM.

An interesting theme which occurred in FG1 and FG2 was that the large customers were the ones driving the smaller to medium sized suppliers to measure GSCPM. It was unclear however if the suppliers were simply reporting or improving.

The researcher sensed a degree of frustration in the focus groups about GSCPM and it was clear that the practitioners found GSCPM complex and difficult to implement. There was a strong desire to measure but this was blocked by a lack of capability /understanding about what and how to measure this in the supply chain, thus creating a sense of inertia. Without any clear direction from government, the practitioners would concentrate on serving the requirements of their customers first.

The researcher generated 18 enablers and 17 barrier statements from FG1 and FG2 to test in the online survey in Phase Two. This will be discussed in more detail in Chapter Nine.

Finally, with regard to RQ3:
The participants from FG1 and FG2 identified a total of nine reporting tools which they used to measure their supply chain performance. This highlighted the diversity of reporting tools being used and that companies are now developing their own in-house tools to measure their supply chain performance. Some of the FG1 participants believed there was a benefit to incorporating GSCPMs within existing business/supply chain performance measurement tools. The nine reporting tools will be tested in the online survey in Phase Two to identify those which are the most used and appropriate for GSCPM integration. Detailed discussions of the overall research findings will be discussed in Chapter Eleven were the results from Phase One will be underpinned with the findings/theory from the literature and the results from Phases Two and Three.

The next section will now reflect back upon the focus group analysis process and the overall results before the chapter is concluded.

8.4 Focus Group Analysis Criteria Review

The researcher followed the criteria outlined by Krueger and Casey (2009) and Sanchez Rodrigues et al. (2010) to ensure that the focus group analysis process was rigorous.

1. Credibility – testing for theory saturation
2. Systematic – the analysis follows a prescribed and sequential process
3. Verifiable – the findings can be replicated by another researcher
4. Sequential – the analysis must be an evolving process of enlightenment
5. Continuous – data collection and analysis are concurrent, no clear beginning and end
6. Confirmability – utilising focus groups as a methodological triangulation approach

8.4.1 Testing for Theory Saturation

Credibility of the focus group research was tested using theory saturation. Sanchez Rodrigues et al. (2010:82) recommended that focus group researcher’s test for theory saturation to ensure their findings are "*as complete as possible*." Sanchez Rodrigues et al. (2010) advise that theory saturation is met when additional focus groups do not add any new variables/constructs. To test for theory saturation, the number of new GSCPM constructs per group was calculated for RQ1, RQ2, RQ3 and RQ4 (Figure 8.13).

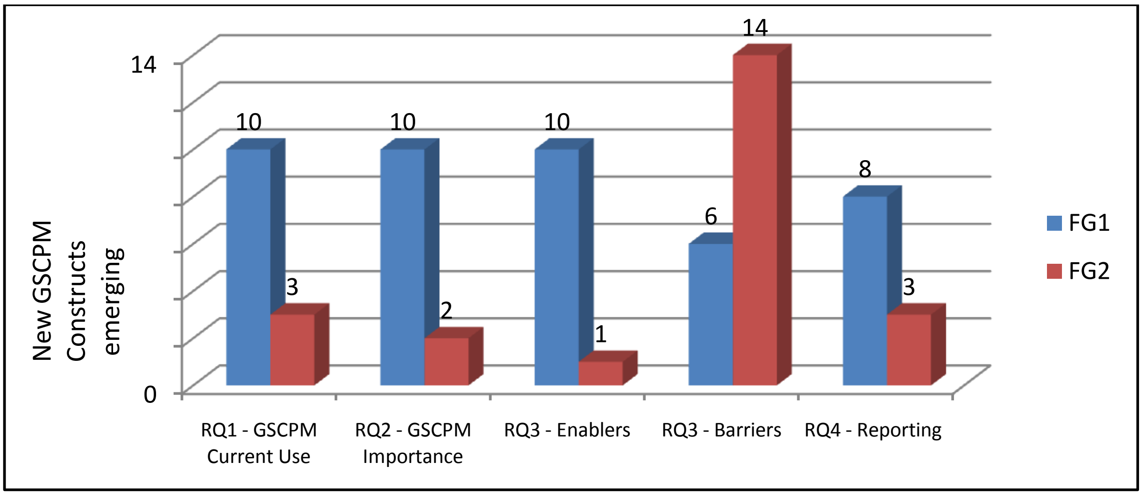


Figure 8.13 – New GSCPM Constructs Emerging from FG1 and FG2

With the exception of RQ3 where there was an increase in new GSCPM constructs per group emerging between FG1 and FG2, the results shown in Figure 8.13 show a significant decline in the number of new GSCPM constructs emerging between FG1 and FG2.

With regards RQ5:

RQ5: *Do any emerging variables and constructs mirror those found in extant literature on GSCPM?*

When the overall results from FG1 and FG2 were compared to the background literature, only one new overarching GSCPM construct emerged; this was buildings. Overall carbon was the most cited of all GSCPM variables in Phase One (falling under the construct of emissions). Thus, Phase One (literature and FG1 and FG2 combined) has yielded a total of 10 fundamental GSCPM constructs and 25 x GSCPM variables which are important to practitioners, and which will be tested in Phase Two (Chapter Nine).

It can therefore be said that theory saturation has been reached and sufficient data gathered to commence Phase Two of the research process. To account, however, for this surge in new barriers in FG2 (Figure 8.13); the researcher will conduct a participant feedback session with new participants in Phase Three of the research design to ensure a complete picture of the findings have been achieved. The results of the participant feedback session will be analysed and discussed in detail in Chapter Ten following the completion of the online survey.

8.4.2 Transferability/Verifiable

Transferability was achieved in the focus group research by ensuring both FG1 and FG2 had a diverse set of participants but with sufficient knowledge of the subject matter. A range of participants took part in the focus group research from various industries and occupations. This ensured that the results were generalisable even though they came from a small sample. Given the data capture and analysis process/techniques used in this focus group research (Full transcription, data funnelling, Mind Manager™) it will be possible for another researcher to replicate this process and deduce the same results and findings.

8.4.3 Dependable and Systematic

It is vital that the researcher is able to document the focus group analysis process from beginning to end to enable another researcher to easily replicate the study. This was achieved in this research by the researcher following a robust process outlined by Sanchez Rodrigues et al. (2010) for conducting focus group research. The researcher was also very transparent in articulating how the focus group data collection took place (Chapter Seven) and how the focus group data was analysed (Chapter Eight).

8.4.4 Confirmable

Focus groups have been used as a primary data capture tool throughout Phase One of the research design to enhance the exploratory and explanatory potential of this new research debate. Notwithstanding the limitations of drawing conclusions from a relatively small sample (19 participants in total) it would be remiss not to acknowledge the powerful insights which focus group research can bring to a largely unexplored research problem. In fact, it would be impossible to obtain a deep and meaningful understanding of this research problem by using only quantitative methods. The confirmability of this study has been enhanced by applying focus groups as part of a methodological triangulation strategy (Sanchez Rodrigues et al., 2010). The studies confirmability will be further enhanced by the application of a third focus group (FG3) which will be used to validate the overall thesis findings. The results of which will be presented in Chapter Ten.

8.5 Summary

This chapter has presented the results from Phase One of this research design. It has helped the researcher to partially answer RQ1 to RQ5 by identifying the 25 GSCPM variables and 10 GSCPM constructs for survey testing. In addition, it has also identified the key reporting tools, enablers and barriers used and classed as important by supply chain and logistics practitioners. These 25 x GSCPM variables and 10 constructs will now be tested in an online survey with a large sample of respondents to fully understand and empirically answer RQ1 to RQ5. The next chapter will present the results from Phase Two; the online survey.

CHAPTER NINE

PHASE TWO – SURVEY ANALYSIS AND RESULTS

9.1 Introduction

Chapter Eight discussed the results from the focus group research which was conducted in January 2012 (Phase One). This chapter will now present the survey analysis and results from Phase Two which was conducted in June 2012. The main purpose of this chapter is to test the outputs from the focus group research (FG1 and FG2) with the aim of deductively answering research questions; RQ1, RQ2, RQ3 and RQ4. This chapter is structured as follows: firstly, the purpose of the survey research is restated (background), secondly an overview of the survey data collection and analysis process is discussed; thirdly, the survey data analysis is presented and reviewed in the context of answering the four key research questions. Finally, Chapter Nine is concluded with an overall summary which will act as a precursor to Chapter Ten.

9.1.1 Survey Background

Practitioners are faced with a great deal of confusion regarding which GSCPM variables to use and why? With a lack of direction and government policy there is an 'urgent' need to develop a battery of GSCPM variables for survey testing to understand which are important and appropriate to practitioners. The background literature and focus group research in Phase One has helped to identify a list of 25 x GSCPM variables along with various reporting tools and enablers/drivers of GSCPM. The purpose of the survey in Phase Two is to test the importance of these GSCPM variables and related items to practitioners, enabling further refinement and understanding. The output of this thesis is to generate a 'universal' battery of GSCPM variables and reporting tools that are simple, easy to collect and manage, and which have policy implications for government and practitioners. At the same time the research will reveal the 'root causes' behind GSCPM (enablers and barriers) and will provide clarity on the benefits that GSCPM can bring to organisations. While the focus group research (Phase One) has provided insight and has inductively answered RQ1, RQ2, RQ3, RQ4 and RQ5, there is requirement to test these 25 x GSCPM variables and related items identified from Phase One on a much larger sample to enable theory to be built and generalisations to be made across a wider population.

The next section will now review the survey data collection process before a review of the survey data analysis presentation and discussion in Section 9.3.

9.2 Survey Data Collection and Analysis Process

The CILT (UK) sponsored the survey for this thesis. Having clear sponsorship and endorsement from the CILT (UK) helped to improve the response rate and enabled the researcher to access a large sampling frame of practicing supply chain and logistics professionals in the UK, which otherwise would have been problematic. Due to the Data Protection Act 1998, the CILT (UK) took ownership of emailing the survey link out to all their members on the researcher's behalf.

The survey was administered over a 12 day period. It was created online by the researcher using the online survey tool Survey Monkey Professional™ and took between 10-15 minutes for respondents to complete. The first survey was emailed out to 11,500 CILT (UK) members (which corresponded to 10,500 individual companies) on 14th June 2012 by the CILT (UK) membership team. A second wave was emailed out again to the same group of members on the 20th June 2012. Finally, a third wave was issued on the 21st June 2012 and the survey closed on 25th June 2012.

Figure 9.1 details the response pattern to the survey. The survey yielded a total of 388 responses with 266 useable responses (fully completed surveys), thus a response rate of between 2-3 per cent. This is a typical response rate for surveys issued to the CILT (UK) membership database.

The three peaks in survey responses coincided with the three email waves that were issued by the CILT (UK) membership team (Figure 9.1). There was a large peak in responses after the first email wave was issued (199 responses) followed by two further peaks on 18th June and 21st June. The second peak on 18th June could be accounted by the day of the week (Monday) with some respondents completing the first wave on their return to work on the Monday. However, 266 useable responses based on 25 x GSCPM variables was sufficient to conduct the multivariate analysis for Questions Three and Four as discussed earlier in Chapter Seven and this was in line with the authors original expectations.

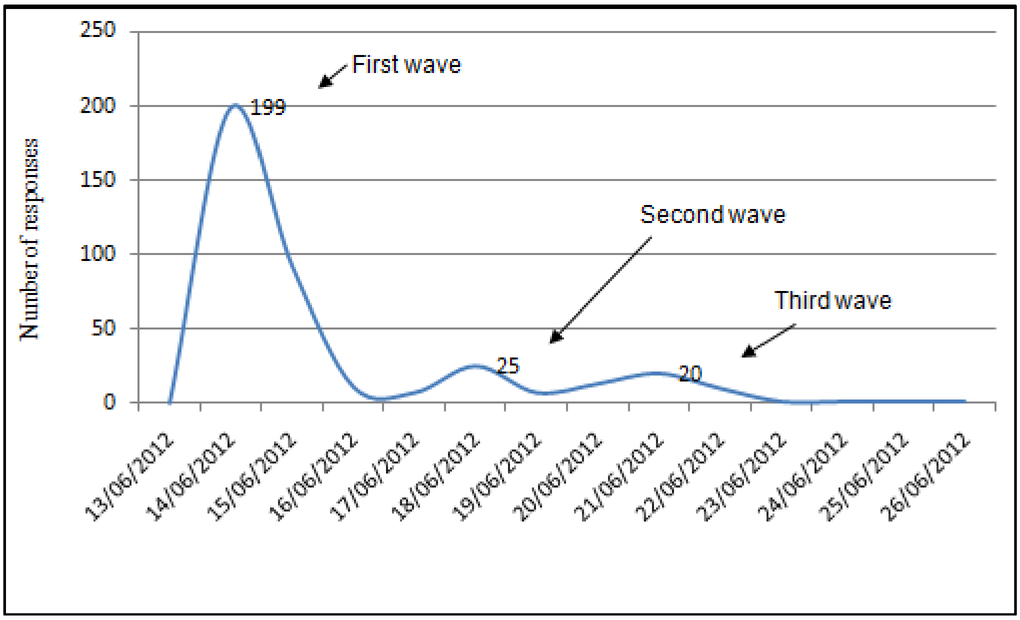


Figure 9.1 Survey Response Pattern

All data was entered into Minitab 16 ™ for descriptive statistical analysis and SIMCA-13™ for multivariate analysis. The survey data was firstly analysed for normality and survey bias using Minitab 16 ™ (Field, 2005). A normal probability plot was generated for all ordinal data for survey questions: three, four, five, six, seven, nine and ten. Normality was indicated if the survey responses clustered around a straight line as in Figure 9.2 (Field, 2005). A Kolomogorov-Smirnov (K-S) test was also performed on the data set in conjunction with the probability plot to decide whether or not the data distribution was significantly normal. The K-S test compares the scores in a sample to a normally distributed set of scores with the same mean and standard deviation. If the test is non-significant (p-value is > 0.05), this tells the researcher that the distribution of the sample is not significantly different from the normal distribution (Field, 2005). All normal probability plots and K-S tests reviewed by the researcher revealed that the majority of data were normal for parametric statistical analysis; therefore no data transformation was required.

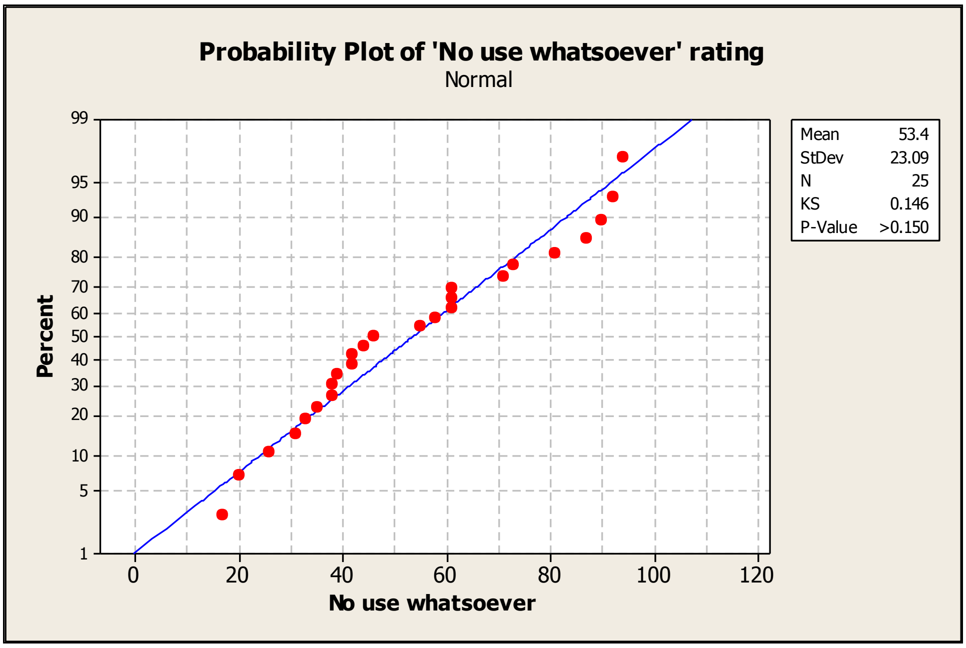


Figure 9.2 – Example Normal Probability Plot for Question Three data

It is common practice in survey research to test for non response bias (Oppenheim, 1992). This is to verify that the survey findings are not biased in anyway to those people who choose to respond from those who did not. To test for non response bias in this survey the respondents were split into three groups (first, second and third groups) according to when their responses were received. The three groups corresponded with the first, second and third survey issue dates by the CILT (UK) membership team. The first group of responses were received on or between 14th and 19th June, the second group of responses were received on 20th June and finally the third group were for responses received on or between 21st and 25th June 2012.

A one-way analysis of variance (ANOVA) was performed on the 25 x GSCPM 'usefulness' variables across the three groups of responses to test for any significant differences between the means of each group. If the probability value (p-value) is less than or equal to 0.05 then the researcher can conclude that a significant difference exists between the three response groups and non response bias exists. If the p-value is greater than 0.05 then no significant differences exist between the three groups of responses and non response does not exist. The results are displayed in Table 9.1 for Question Three. All p-values were greater than the significance value of P = 0.05, therefore it can be concluded that there were no significant differences between the three groups of survey responses and that non response bias did not exist.

Table 9.1 – Non Response Bias Test

25 x GSCPM Usefulness Variables	First Group Mean	Second Group Mean	Third Group Mean	P- Value
U1	3.435	3.222	3.407	0.820
U2	3.165	2.889	3.259	0.744
U3	2.852	2.778	2.889	0.968
U4	2.291	2.222	2.667	0.237
U5	3.078	3.333	3.259	0.614
U6	3.287	2.889	3.407	0.527
U7	2.770	2.778	2.519	0.566
U8	3.496	3.111	3.444	0.624
U9	2.361	2.111	2.593	0.507
U10	2.796	3.111	2.778	0.777
U11	2.448	2.000	2.519	0.527
U12	3.378	3.222	3.444	0.901
U13	3.461	3.333	3.444	0.941
U14	2.987	3.556	3.185	0.364
U15	3.096	2.889	2.741	0.292
U16	3.057	3.333	2.963	0.727
U17	2.870	2.556	2.815	0.746
U18	2.957	2.889	3.185	0.692
U19	2.265	1.889	2.556	0.257
U20	2.552	2.000	2.852	0.172
U21	3.243	3.333	3.444	0.751
U22	3.230	3.111	3.148	0.895
U23	2.365	1.889	2.222	0.431
U24	2.904	2.333	2.815	0.321
U25	2.778	2.222	2.889	0.361

9.3 – Survey Data Presentation and Analysis

There were eight sections to the survey (Table 9.2). The analysis and presentation will begin by presenting the demographic details of the survey respondents before presenting the main results from Sections One to Seven of the survey.

Table 9.2 – The Survey Structure

Survey - Selecting Green Supply Chain Performance Measurements	
Introduction	Survey Introduction and Background
Section One	Green Supply Chain Performance Measurement – **CURRENT USE**
Section Two	Green Supply Chain Performance Measurement – **USEFULNESS**
Section Three	Green Supply Chain Performance Measurement – **EASE OF MEASUREMENT**
Section Four	Green Supply Chain Performance Measurement – **ENABLERS**
Section Five	Green Supply Chain Performance Measurement – **BARRIERS**
Section Six	Green Supply Chain Performance Measurement – **BENEFITS**
Section Seven	Green Supply Chain Performance Measurement – **REPORTING**
Section Eight	Respondent and Company Information

9.3.1 Section Eight – Respondent and Company Information

The North American Industrial Classification System (NAIC) was the standard used to classify the survey respondent's businesses into different industrial sectors (NAIC, 2013). Figure 9.3 details the useable responses by NAIC industrial sector. Completion of the demographic details in the survey was optional and not mandatory. A total of 221 respondents out of the 266 respondents recorded their NAIC sectors as shown in Figure 9.3. Forty one percent of the survey respondents where from the transport and warehousing sector. This was in line with the author's expectations due to the CILT (UK) membership being used as the main sampling frame. However, 16 per cent of respondents were from the manufacturing sector and a further nine per cent from the retail sector, which helped to increase the heterogeneity of the sample.

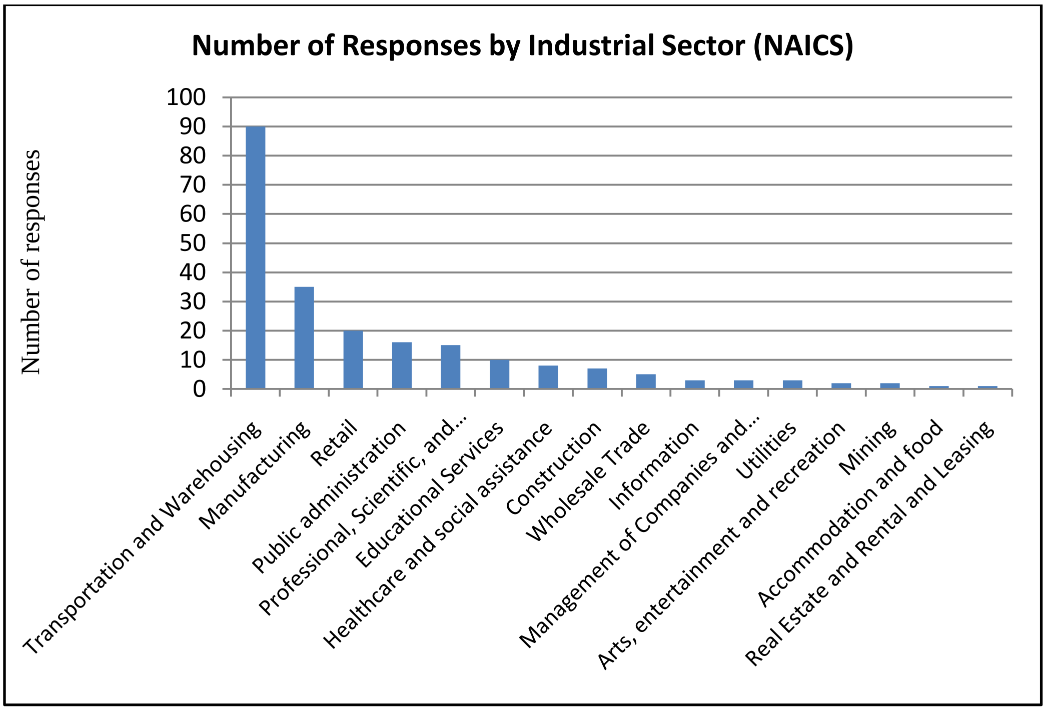


Figure 9.3 – Responses by NAIC Industrial Sector

Significantly more males (87 per cent) than females (13 per cent) completed the survey. This was in line with the researcher's expectations as the total CILT (UK) membership gender split was 88 per cent male and 12 per cent female at the time of the survey issue. A One Proportion Test was completed and a p-value of 0.617 also indicated that the gender split was consistent with the null hypothesis, that is, the proportion of males in the CILT (UK) membership database was similar to the proportion of male respondents that had completed the survey.

Logistics and SCM is a very male dominated industry with more males occupying logistics roles than females. A similar profile was also observed by the researcher during the FG1 and FG2 sessions and similar trends have been found in other logistics research (Sohal and D'Netto, 2004).

Respondents were split into eight distinct occupation groups which ranged from CEO positions through to logistics and transport managerial roles (Figure 9.4). A Pearson's chi-squared test was applied to the data to see if there was a significant association between gender and occupation. The p-value for the Pearson's chi-squared test was less than 0.05 (eight degrees of freedom and a Chi-squared value of 16). This indicated that there was a significant association between gender and role. It is evident from Figure 9.4 that the proportion of males is significantly larger than females in all occupations including senior logistics positions. Keller and Ozment (2009) found similar results with women strongly reporting barriers toward career advancement in logistics roles. Figure 9.4 also shows that 30 per cent of females do occupy Managing Director positions so this indicated a growth and progression of women in this role in recent years in line with the findings made by Adams and Ferreira (2009). It is also evident from Figure 9.4 that females are occupying middle management position in logistics, however to a lesser extent than males.

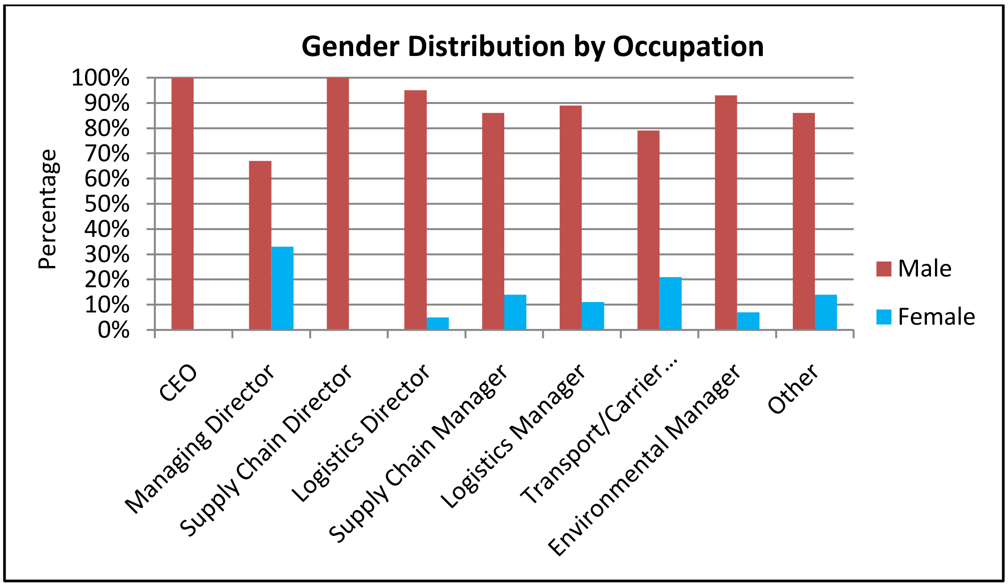


Figure 9.4 - Comparison of Gender Distribution by Occupation

The average length of time that survey respondents had worked for their company varied significantly with over 50 per cent having worked for their company in the one to six year service band and 80 per cent having worked for their companies for up to 14 years, and in extreme cases some respondents worked for their companies for up to 45 years. The service band which received the greatest number of responses (12 per cent) was respondents who had worked for their company for two years (Figure 9.5).

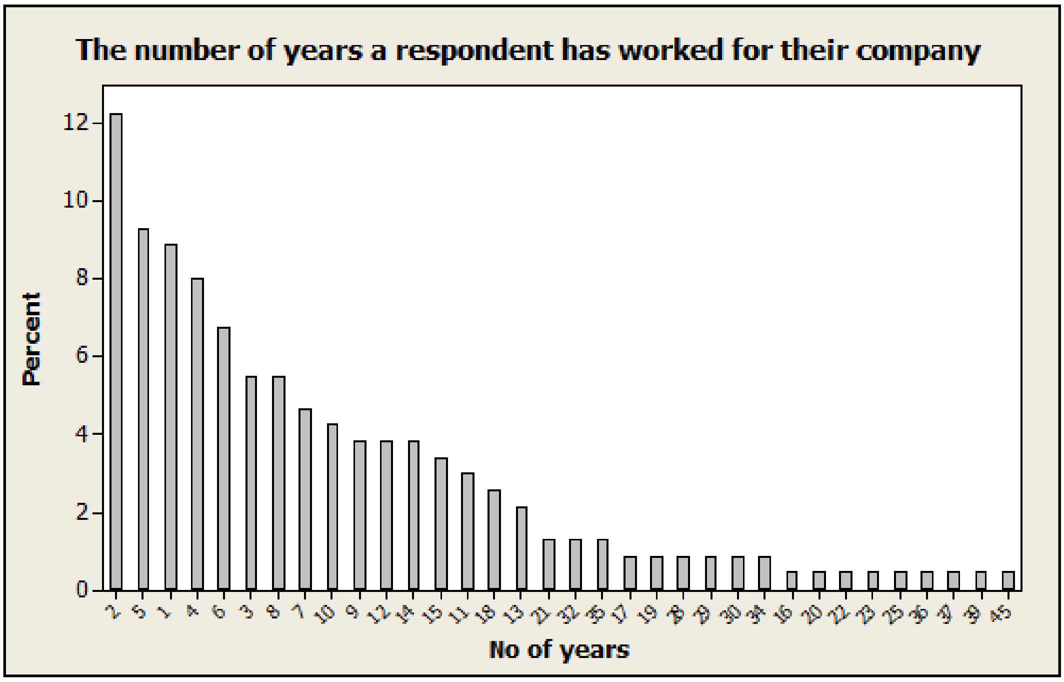


Figure 9.5 – Bar chart showing the length of time respondents had worked for their company

The data was also plotted in a histogram which showed a sharp peak indicating a positive kurtosis (2.77) and a positive skewness (1.77) (Figure 9.6), thus a non-normal distribution. This indicated that most respondents had worked for their company for nine years or less. The median was six years service.

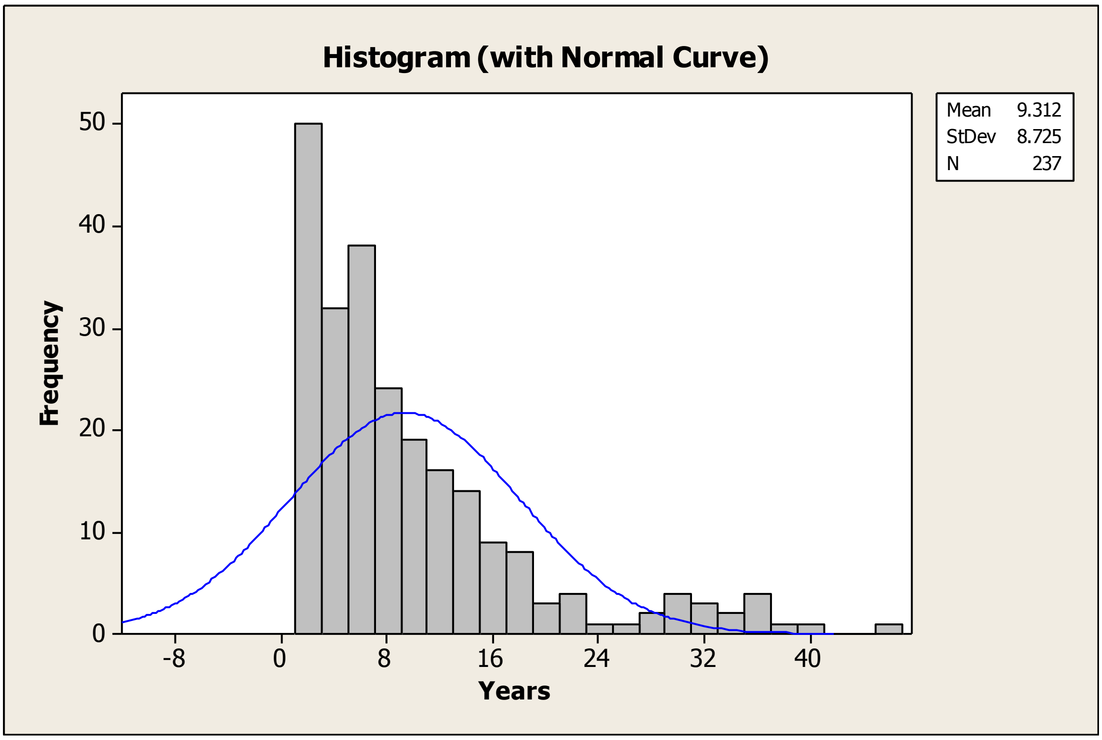


Figure 9.6 – Histogram Showing the Length of Time Respondents had Worked for Their Company

Sixty four percent of survey respondents were aged between 36 and 55 years with only four per cent aged between 18 and 25 years (Figure 9.7). This suggested a maturity of the respondents working in logistics or being affiliated with a professional institution such as the CILT (UK). This was consistent with the CILT (UK) membership with over 60 per cent of their membership between the age of 36 and 60 years. A One Proportion Test was completed and a p-value of 0.208 also indicated that the typical age group of survey respondents was consistent with the CILT (UK) membership age group.

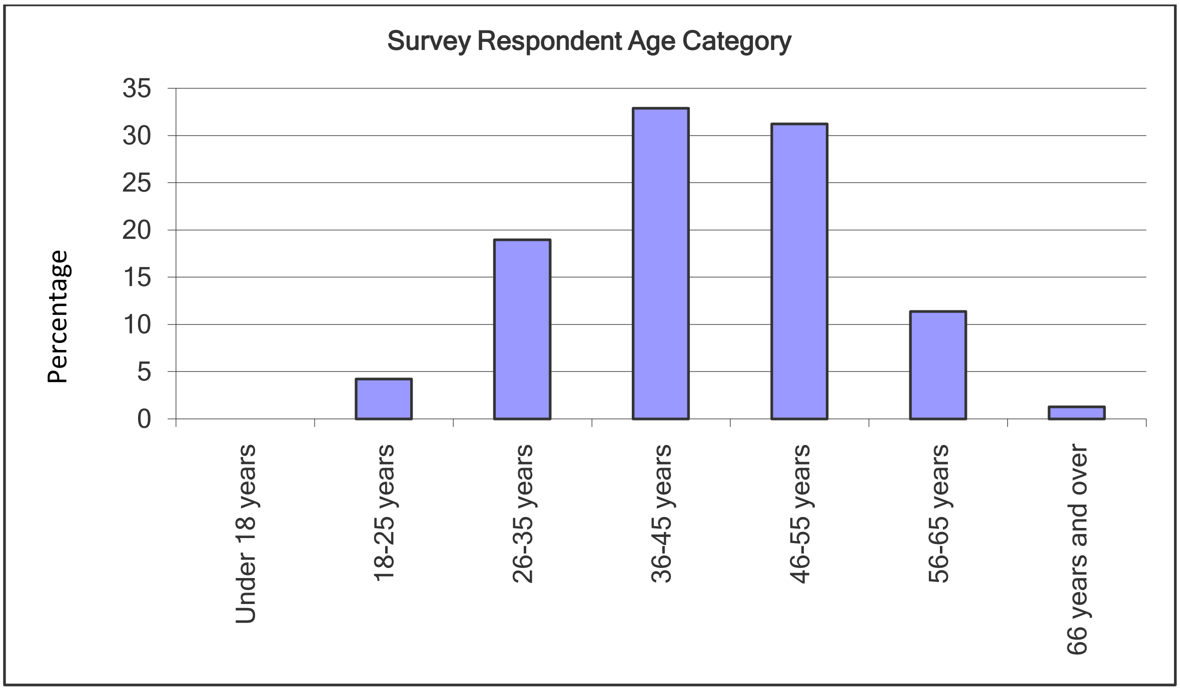


Figure 9.7 - Bar chart of the Survey Respondent Age Group

Based on the SME classification (EU, 2003), the majority (76 per cent) of survey respondents where from large organisations with 24 per cent from micro to medium sized organisations (Figure 9.8). This is in line with the author's expectations as typically CILT members are associated with larger organisations.

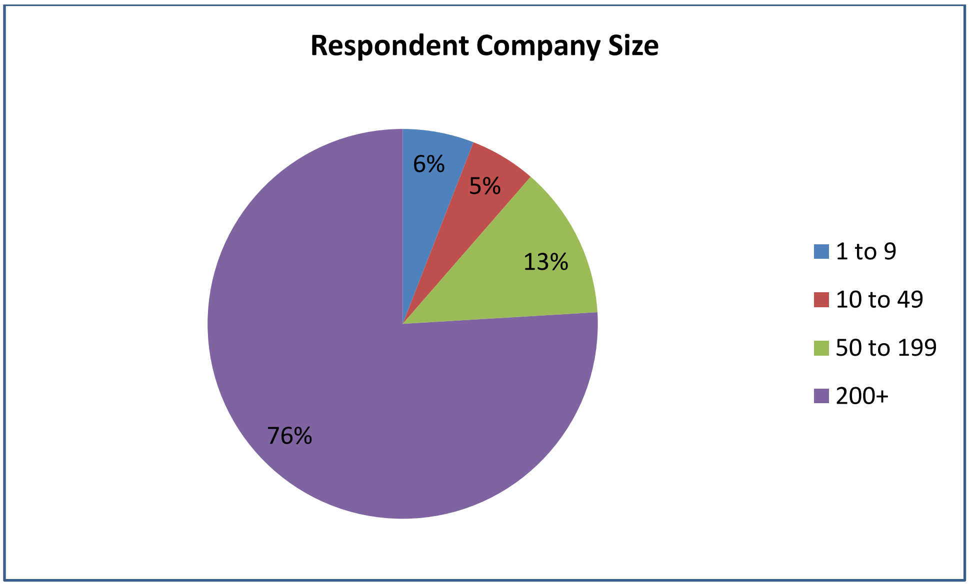


Figure 9.8 Respondent Company Size

In summary, the profile of the respondents who answered the survey were mainly from logistics/supply chain middle management positions, between the age of 36-45 years, working for medium to predominantly large sized businesses having served approximately nine years with their company. Further analysis of the respondent demographics will be discussed in relation to Section One to Seven of the survey. The next section will now turn to the presentation and analysis from Section One of the survey.

9.3.2 Section One - Green Supply Chain Performance Measures: CURRENT USE

Section One (Questions One and Two) was concerned with answering RQ1 by understanding what GSCPM variables respondents were currently using. The section consisted of two questions, one closed and the other open ended:

1. *Which of the following green supply chain performance measures does your company use? Please tick as many as apply.*

The respondents were given a list of the 25 x GSCPM variables from Phase One to choose from.

2. *Are there any other green supply chain performance measures which your company uses? Yes or No. If you answered "Yes" then please specify these green supply chain performance measures in the text box provided below:*

The respondents were provided with a free text box in which to identify any more GSCPM variables outside of the list given. This embraced the exploratory nature of this research and ensured a process of continuous enlightenment and discovery throughout the research.

Figure 9.9 shows the percentage of survey respondents who currently used each of the 25 x GSCPM variables. The respondents were able to tick *'as many GSCPM as applied'* and there were 3404 ticks selected by respondents in total for Question One. The most commonly used GSCPM was electricity consumption with 69 per cent of the total respondents selecting this. Over 80 per cent of the total respondents selected electricity consumption and waste recycling measures as the GSCPM variables they used. Furthermore, 15 GSCPM variables accounted for over 80 per cent (pareto) of the total responses to this question (3404 ticks). Table 9.3 shows the top fifteen most used GSCPM variables.

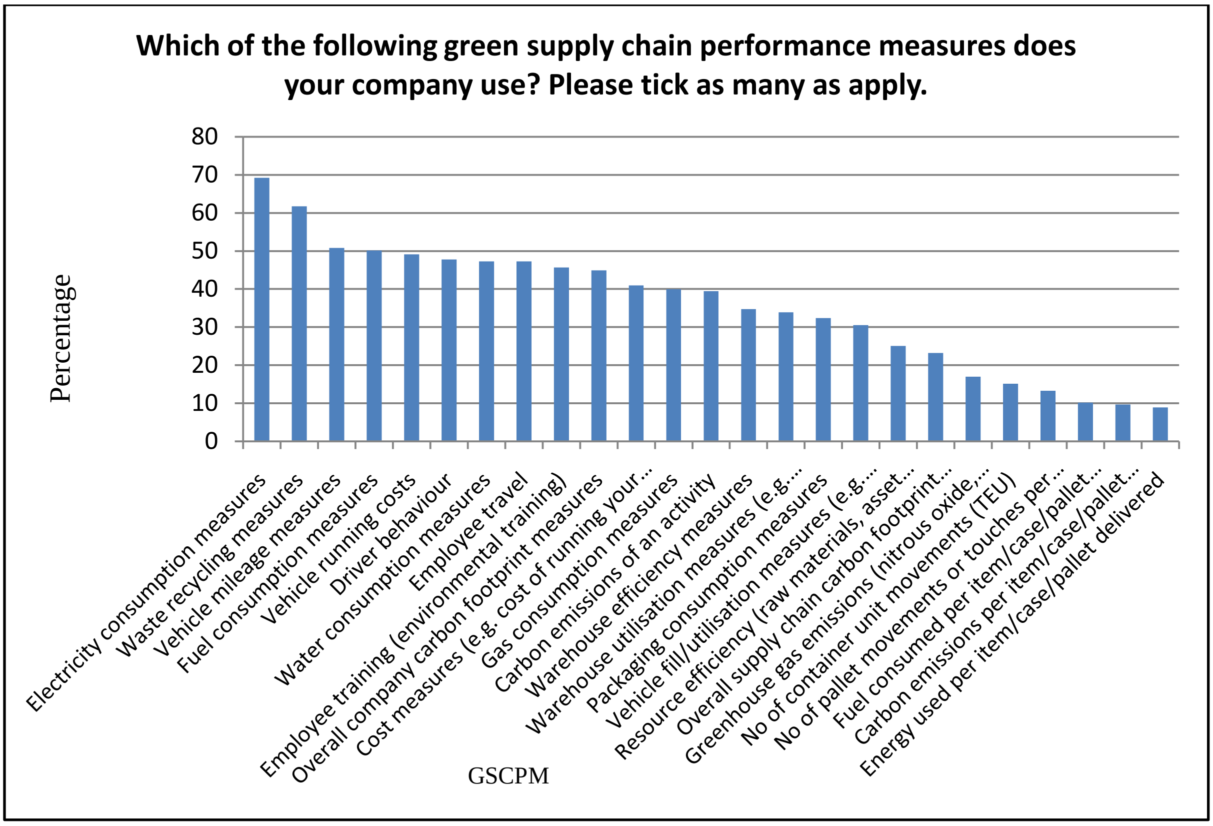


Figure 9.9 – GSCPM Current Use

Table 9.3 – The Top Fifteen most used GSCPM (Question One)

GSCPM Most Used
1. Electricity consumption measures **MOST USED**
2. Waste recycling measures
3. Vehicle mileage measures
4. Fuel consumption measures
5. Vehicle running costs
6. Driver behaviour
7. Water consumption measures
8. Employee travel
9. Employee training (environmental training)
10. Overall company carbon footprint measures
11. Cost measures (e.g. cost of running your warehouse, fleet etc)
12. Gas consumption measures
13. Carbon emissions of an activity
14. Warehouse efficiency measures
15. Warehouse utilisation measures (e.g. pallet occupancy)

It was also evident from Question One that some GSCPM variables identified in the FG1 and FG2 were not widely or frequently used by the survey respondents even though they had been identified as important in the focus groups (Phase One). One of the most important measures which participants identified in the focus groups was the ability to measure the amount of carbon, fuel or energy used 'per' item or case delivered to their customer; however this is something they said they found difficult and complex to measure. The survey results from Question One revealed that these measures are not widely used which is counter intuitive to the results from the focus group research, although some respondents did state they measured the carbon emissions of an activity (Table 9.3). These GSCPM variables are so difficult to measure, that they are not seen as useful and therefore not used, or there is a difference in the way different groups of respondents view certain GSCPM variables. This will be discussed later in this chapter and Chapter Eleven. Table 9.4 shows the least used GSCPM in order of the least used.

Table 9.4 – The Top Ten least used GSCPM (Question One)

GSCPM Least Used
1. Energy used per item/case/pallet delivered **LEAST USED**
2. Carbon emissions per item/case/pallet delivered
3. Fuel consumed per item/case/pallet delivered
4. No of pallet movements or touches per delivery
5. No of container unit movements (TEU)
6. Greenhouse gas emissions (nitrous oxide, methane etc)
7. Overall supply chain carbon footprint measures
8. Resource efficiency (raw materials, asset utilisation)
9. Vehicle fill/utilisation measures (e.g. empty running)
10. Packaging consumption measures

A Pearson Chi-squared test was performed on the data set to see if there was a significant difference between the type of GSCPM and its current use. The test generated a Pearson Chi-square of 1123 and a p-value of 0.000. The researcher regarded this as being statistically significant as p-values of less than 0.05 are significant. Therefore, it can be said, that significant differences exist between the observed and expected counts on some of the 25 x GSCPM variables and a relationship exists between the type of GSCPM variables and their current use.

There were significant differences between the observed and expected counts particularly on electricity consumption, waste recycling and vehicle mileage measures; where their observed responses were far greater than expected. In contrast, GSCPM variables such as energy used per item/case or pallet delivered, fuel consumed per item/case or pallet delivered and carbon emission per item/case or pallet delivered had significant differences between the observed and expected for opposing reasons; their observed responses were much less than expected. The result of this test was consistent with the findings displayed in Figure 9.9 and Tables 9.3 and 9.4.

It is important to understand how GSCPM 'current use' may vary by industrial sector. Figure 9.10 shows the number of responses (ticks) applied to the list of 25 x GSCPM by respondents from the manufacturing sector. This indicated that the top three most commonly used GSCPM variables in this sector are: 1) electricity consumption, 2) water consumption and 3) waste recycling measures. Manufacturing is heavily reliant on energy to run the manufacturing process and on commodities to manufacture the actual product. It is therefore not surprising that these GSCPM variables came out as the most used GSCPM variables in this sector.

Table 9.5 shows the top three most ‘currently used’ GSCPM variables by all other NAIC sectors. While it is evident that electricity consumption is the most widely used GSCPM across all sectors, there is also a degree of diversity between NAIC sectors in terms of what they currently measure, which perhaps reflects their differing requirements. For instance, the mining sector respondents currently use more vehicle and fuel related GSCPM variables. This is because the mining sector needs to move coal/minerals back and forth from the mining area to their collieries. In contrast, the retail sector respondents most frequently used GSCPM variables such as: cost, electricity consumption and waste recycling/warehouse efficiency measures. The cost of running a retail operation and ensuring the warehouse efficiency/running costs are kept to a minimum are vital in the retail sector. There is also a real focus in retail on reducing stock/waste which will attract financial provision and obsolescence, hence the use of the waste recycling measure.

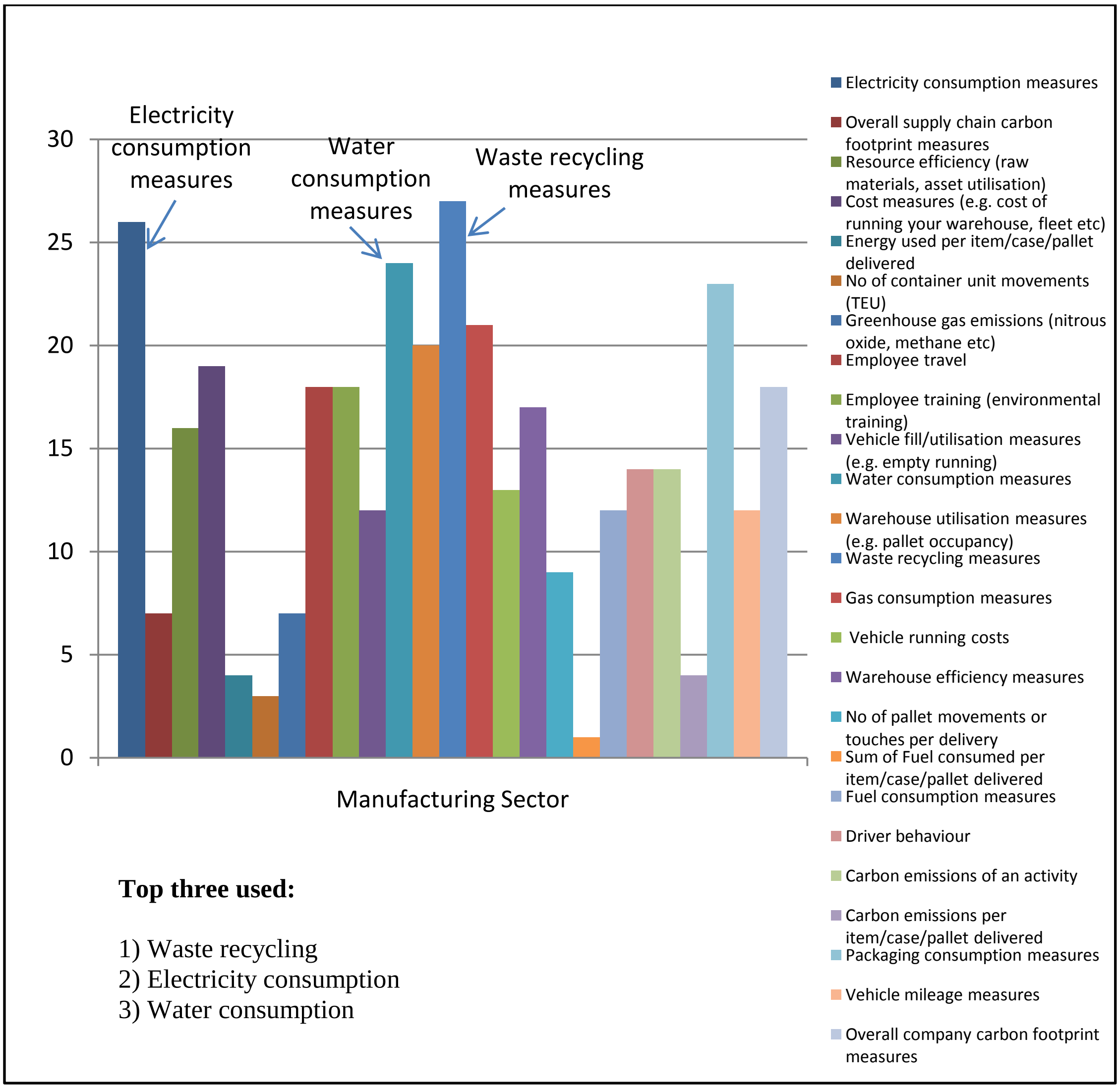


Figure 9.10 – GSCPM Current Use for the Manufacturing Sector

Table 9.5 – Top Three GSCPM used by Industrial Sector

NAIC Sector	Top 1 used	Top 2 used	Top 3 used
Manufacturing	Electricity	Waste recycling	Water
Mining	Vehicle running costs	Fuel consumption	Vehicle mileage
Professional, Scientific and Technical services	Electricity	Waste recycling	Overall carbon footprint
Public Administration	Electricity	Employee travel	Waste recycling/Vehicle mileage
Real Estate and Rental and Leasing	n/a only one response	n/a only one response	n/a only one response
Retail	Cost	Electricity	Waste recycling/Warehouse efficiency
Transport and Warehousing	Electricity	Fuel consumption	Vehicle mileage
Utilities	Employee training	Waste recycling	Vehicle running costs
Wholesale Trade	Employee travel	Electricity	Gas/Warehouse utilisation

Significant differences were also observed between the GSCPM variables currently used and organisational size. Table 9.6 and 9.7 illustrated this point highlighting that smaller (micro) organisations generally do not currently measure GSCPM variables such as their company carbon footprint, their overall supply chain carbon footprint and warehouse utilisation measures (Table 9.7). In contrast, these types of GSCPM variables are more likely to being measured by the larger organisations. The larger organisations also tend to be more preoccupied about monitoring cost measures (vehicle cost, MPG etc) whereas smaller organisations are not and are focused on GSCPM variables such as employee travel and electricity consumption. Electricity consumption and waste recycling are used consistently across all companies regardless of size.

Table 9.6 – Top Three GSCPM Used by Company Size

Company Size	Top 3 used GSCPM	Least 3 used GSCPM
Large	1. Electricity consumption 2. Waste recycling 3. Water consumption	1. Energy used per item/case/pallet delivered 2. Carbon emissions per item/case/pallet delivered 3. Fuel consumed per item/case/pallet delivered
Medium	1. Electricity consumption measures 2. Waste recycling measures 3. Vehicle mileage measures	1. Carbon emissions per item/case/pallet delivered 2. Energy used per item/case/pallet delivered 3. No of container unit movements (TEU)
Small	1. Employee travel 2. Electricity consumption 3. Vehicle mileage measures	1. Overall company carbon footprint measures 2. Overall supply chain carbon footprint measures 3. Energy used per item/case/pallet delivered
Micro	1. Electricity consumptions 2. Waste recycling 3. Employee travel	1. Carbon emissions per item/case/pallet delivered 2. Fuel consumed per item/case/pallet delivered 3. Carbon emissions of an activity

Table 9.7 – GSCPM Current Use and Company Size Differences

GSCPM Current Use & Company Size	P -Value (alpha)	What is significantly different?
Electricity consumption measure	0.451	n/a
Driver behaviour	0.021	n/a
Carbon emissions of an activity	**0.001**	**Large and micro means are significantly different**
Carbon emissions per item/case/	0.372	n/a
Overall company carbon footprint	**0.020**	**Large and micro means are significantly different**
Vehicle mileage measures	0.982	n/a
Packaging consumption measures	0.463	n/a
Fuel consumption measures	0.437	n/a
No of pallet movements or touch	0.582	n/a
Warehouse utilisation measures	**0.020**	**Large mean is significantly different from small/micro**
Fuel consumed per item/case/pallet delivered	0.562	n/a
Vehicle running costs	0.528	n/a
Waste recycling measures	**0.009**	**Large and micro means are significantly different**
Warehouse efficiency measures	0.068	n/a
Water consumption measures	**0.000**	**Large mean is significantly different from small/micro**
Gas consumption measures	**0.004**	**Large and micro means are significantly different**
Overall supply chain carbon footprint	**0.031**	**Large and micro means are significantly different**
Vehicle fill/utilisation measures	0.108	n/a
Energy used per item/case/pallet delivered	0.667	n/a
Greenhouse gas emissions (nitrous oxide)	0.598	n/a
Cost measures (e.g. cost of running a vehicle)	**0.015**	**Large and micro means are significantly different**
Employee training (environmental)	0.257	n/a
No of container unit movements	0.138	n/a
Employee travel	0.929	n/a

As part of Section One, the survey respondents were also asked Question Two of the survey:

2. *Are there any other green supply chain performance measures which your company uses? Yes or No. If you answered "Yes" then please specify these green supply chain performance measures in the text box provided below:*

Eighty six percent of respondents agreed that the list of 25 x GSCPM variables provided in Question One was an exhaustive list of all the GSCPM variables their organisation currently used. However, 14 per cent disagreed with this statement and went on to identify approximately 50 different types of GSCPM variables, some of which overlapped with the list of 25 x GSCPM variables already identified, however some were new GSCPM areas.

Thirteen GSCPM measurement areas were identified by the survey respondents in Question Two (Figure 9.11) and three new GSCPM variables were identified: 1) supplier environmental compliance, 2) CSR policy in place and 3) effluent and pollution controls.

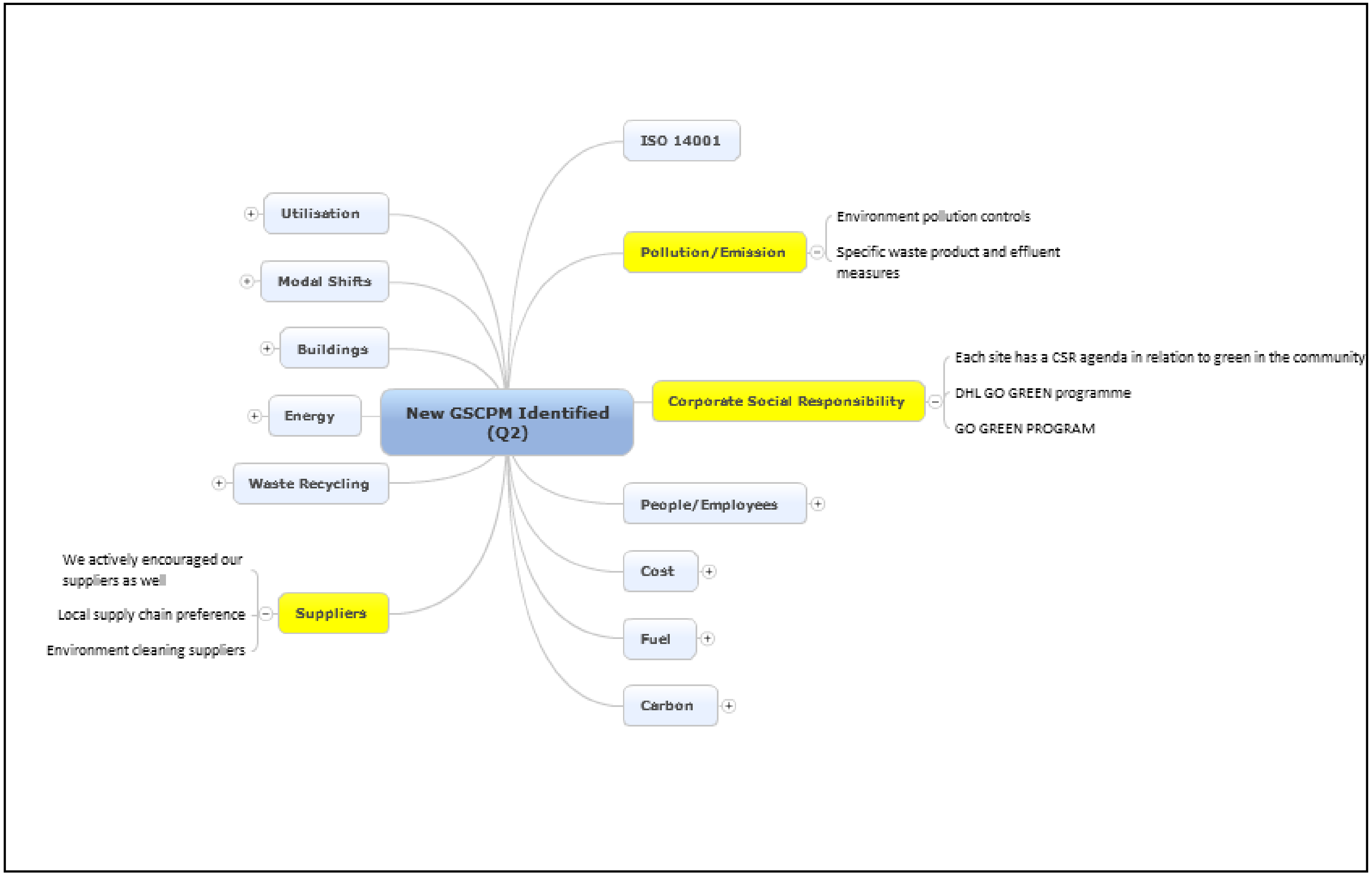


Figure 9.11 – Mind Manager of the GSCPM Variables Identified in Question Two

In summary, out of the 25 x GSCPM variables identified in the focus group research (Phase One), the three most commonly used GSCPM variables were: 1) electricity consumption, 2) waste recycling and 3) vehicle mileage, with electricity consumption by far the most widely used GSCPM variable across all industrial sectors. In contrast, the top three least used GSCPM variables were: 1) energy used per item/case/pallet delivered, 2) carbon emissions per item/case/ pallet delivered and 3) fuel consumed per item/case/pallet delivered. The majority of respondents (86 per cent) agreed that no new GSCPM variables existed outside the list offered in Question One, however 14 per cent of the respondents did believe there were more and went on to identify three new GSCPM construct areas (CSR, suppliers and pollution) and three new GSCPM variables. It was evident from Section One that energy, waste and fuel are dominant GSCPM measurement areas for respondents and important in the context of this thesis. The next section will now present the results from Section Two, which focused on GSCPM usefulness.

9.3.3 Section Two - Green Supply Chain Performance Measures: USEFULNESS

Section Two (Question Three) is concerned with answering RQ2 by understanding what GSCPM variables respondents believed were useful to their company.

This section consisted of one closed question:

3. *Please tick the button shown on the scale below which best indicates the 'usefulness' of each Green Supply Chain Performance Measurement to your company?*

The respondents were given a list of the 25 x GSCPM variables from Phase One each with a five-point Likert scale. This enabled the respondents to indicate the measure's strength of usefulness to their company (with one being *no use whatsoever* and five being *exceptionally useful*).

Table 9.8 shows a summary of the responses to Question Three in order of their usefulness. The top three 'most useful' GSCPM variables identified were: 1) fuel consumption, 2) waste recycling and 3) electricity consumption which had the highest average ratings. These were consistent with the two most commonly used GSCPM variables (electricity consumption and waste recycling) identified in Question One. This suggests that those GSCPM variables which respondents currently use are also seen by their companies as useful. The least useful GSCPM variables were 1) energy used per item/case/pallet delivered, 2) no of container unit movements (TEU) and 3) carbon emissions per item/case/pallet delivered. Two of these GSCPM variables were also consistent with the least used GSCPM variables identified in Question One, which indicated that those GSCPM variables which are not very useful are also not widely used. The researcher also identified that 'cost' received the highest number of responses under the 'exceptionally useful' category and is therefore important in the context of Question Three. Cost was also identified as a major construct in Phase One and in the extant literature.

Table 9.8 Question Three Summary Responses indicating the highest responses in each category (indicated in bold)

GSCPM	No use whatsoever	Not very useful	Useful	Very useful	Exceptionally useful	Rating Average
Fuel consumption measures	31	25	71	**114**	52	3.45
Waste recycling measures	20	32	84	109	48	3.45
Electricity consumption measures	17	22	**116**	102	36	3.40
Vehicle running costs	39	27	67	108	52	3.37
Vehicle mileage measures	35	30	84	104	40	3.29
Cost measures (e.g. cost of running your warehouse, fleet etc)	46	34	71	83	**59**	3.26
Employee training (environmental training)	26	35	111	86	35	3.24
Driver behaviour	42	39	91	77	44	3.14
Overall company carbon footprint measures	33	45	98	86	31	3.13
Water consumption measures	38	49	100	78	28	3.03
Gas consumption measures	44	46	93	77	33	3.03
Warehouse efficiency measures	61	42	70	84	36	2.97
Vehicle fill/utilisation measures (e.g. empty running)	61	44	76	68	44	2.97
Employee travel	38	64	98	74	19	2.90
Carbon emissions of an activity	42	61	105	60	25	2.88
Overall supply chain carbon footprint measures	55	60	84	67	27	2.83
Resource efficiency (raw materials, asset utilisation)	58	59	94	53	29	2.78
Warehouse utilisation measures (e.g. pallet occupancy)	71	53	73	64	32	2.77
Packaging consumption measures	61	57	97	63	15	2.71
Greenhouse gas emissions (nitrous oxide, methane etc)	73	67	88	45	20	2.56
Fuel consumed per item/case/pallet delivered	87	70	74	46	16	2.43
No of pallet movements or touches per delivery	90	80	71	36	16	2.34
Carbon emissions per item/case/pallet delivered	81	**91**	74	36	11	2.33
No of container unit movements (TEU)	92	76	75	35	15	2.33
Energy used per item/case/pallet delivered	**94**	79	70	41	9	2.29

In order to test whether there was any association between the types of GSCPM and how useful respondents saw these GSCPM variables; a Pearson's Chi-square test was applied to the ratio data in Question Three. This method tests whether the frequency distribution of the responses for each GSCPM across the five rating groups is similar or different to that which would be observed by random distribution alone (Field, 2005). This test generated a Pearson Chi-square of 811 and a p-value of 0.000. The researcher regarded this as being statistically significant as p-values of less than 0.05 are significant. Therefore, it can be said, that significant differences exist between the observed and expected counts on some of the 25 x GSCPM variables and a relationship exists between the type of GSCPM variables and how useful respondents see these GSCPM variables. For example, energy used per item/case/pallet delivered had the largest statistical difference (30.868) of all 25 x GSCPM variables in the 'no use whatsoever' category. This suggested that generally most respondents believed this GSCPM was 'no use whatsoever' to their company. In contrast, most respondents believed 'cost' was 'exceptionally useful' and the number of observed responses was statistically greater than expected for the category 'exceptionally useful'. The Pearson Chi-square test helped to corroborate the findings made in Section Two.

A one-way analysis of variance (ANOVA) was performed to assess if there was a significant difference between the type of industrial sector and how useful respondents in these sectors viewed each of the GSCPM variables. Table 9.9 shows those GSCPM variables where there is a statistically significant difference between the sector and how useful respondents viewed each GSCPM (indicated by p=values less than 0.05). The researcher then indicated for the foregoing, significant statistical differences of the top five sectors with the highest average means. This helped the researcher to understand and interpret why statistical differences existed between the type of GSCPM, their usefulness and their sector. The results show that some GSCPM variables are 'generic' and useful to all NAIC sectors and some are 'specific' and only useful to particular sectors (Table 9.9).

Table 9.9 – Statistical Differences between the type of GSCPM, their usefulness and the NAIC Sector

GSCPM Variable	P = value	Five highest average means (usefulness)
Electricity consumption measures	0.787	Not statistically significant (Generic)
Driver behaviour	0.001	Art, Entertainment and Recreation Mining Public Administration Transportation and Warehousing Healthcare and Social Assistance
Carbon emissions of an activity	0.842	Not statistically significant (Generic)
Carbon emissions per item/case/pallet delivered	0.394	Not statistically significant (Generic)
Overall company carbon footprint measures	0.533	Not statistically significant (Generic)
Vehicle mileage measures	0.003	Mining Art, Entertainment and Recreation Construction Retail Transportation and Warehousing
Packaging consumption measures	0.000	Accommodation and Food Art, Entertainment and Recreation Retail Manufacturing Wholesale Trade
Fuel consumption measures	0.008	Mining Art, Entertainment and Recreation Retail Construction Transportation and Warehousing
No of pallet movements or touches per delivery	0.028	Art, Entertainment and Recreation, Retail Manufacturing Transportation and Warehousing Utilities
Warehouse utilisation measures (e.g. pallet occupancy)	0.000	Accommodation and Food Retail Manufacturing Mining Art, Entertainment and Recreation
Fuel consumed per item/case/pallet delivered	0.042	Art, Entertainment and Recreation, Retail Transportation and Warehousing Manufacturing Public Administration
Vehicle running costs	0.001	Accommodation and Food Art, Entertainment and Recreation, Construction Retail Transportation and Warehousing
Waste recycling measures	0.078	Not statistically significant (Generic)
Warehouse efficiency measures	0.000	Accommodation and Food Retail Manufacturing Wholesale Transportation and warehousing
Water consumption measures	0.182	Not statistically significant (Generic)

Gas consumption measures	0.146	Not statistically significant (Generic)
Overall supply chain carbon footprint measures	0.100	Not statistically significant (Generic)
Vehicle fill/utilisation measures (e.g. empty running)	0.128	Not statistically significant (Generic)
Energy used per item/case/pallet delivered	0.236	Not statistically significant (Generic)
Greenhouse gas emissions (nitrous oxide, methane etc)	0.076	Not statistically significant (Generic)
Cost measures (e.g. cost of running your warehouse, fleet etc)	0.020	Accommodation and Food Art, Entertainment and Recreation Retail Manufacturing Transportation and warehousing
Employee training (environmental training)	0.368	Not statistically significant (Generic)
No of container unit movements (TEU)	0.051	Not statistically significant (Generic)
Employee travel	0.266	Not statistically significant (Generic)
Resource efficiency (raw materials, asset utilisation)	0.087	Not statistically significant (Generic)

The results of this test provided a number of insights, firstly, for GSCPM variables such as electricity consumption, carbon emissions of activity or waste recycling; there was no significant statistical difference between the type of GSCPM and the sector; generally respondents view their usefulness in a similar way regardless of sector, therefore they are generic in terms of classification. Secondly, for measures such as driver behaviour, vehicle mileage measures and packaging, where there is a statistically significant difference; respondents of specific sectors view the usefulness of these GSCPM variables in a different way to other sectors, they are specific to sectors. For example, driver behaviour is seen as particularly useful to the Arts, Entertainment and Recreation, Mining, Public Administration, Transportation and Warehousing and Healthcare and Social Assistance sectors. Likewise, packaging consumption measures are particularly useful to Accommodation and Food, Arts, Entertainment and Recreation, Retail, Manufacturing and Wholesale Trade. These trends are important in the context of this thesis as they highlight potentially sector differences in the way respondents view GSCPM and their usefulness. This is a unique and unexpected contribution of this thesis.

The 'usefulness' data set was also analysed in Minitab ™ by using a Dendrogram which helped to cluster and classify the GSCPM 'usefulness' variables and corresponding survey responses into similar groups (Figure 9.12). The procedure is an agglomerative hierarchical tool that takes all the variables and forms a cluster and may help to create new variables, the main aim is to reduce the number of variables (Minitab™, 2012). In the first step, two variables which are the closest are joined together. Next, a third joins the first two, or two other variables join together, the process continues until all key clusters are formed. The final group of clusters are called the ‘final partition’ and go someway in explaining the similarities or characteristics of a group of variables (Minitab™, 2012). A dendrogram is essentially a cluster analysis technique; the aim is to divide a multivariate data set into a natural set of groups or clusters. It is used in this thesis as a way of validating the PCA analysis to identify any underlying variables or clusters using a different statistical software package. A dendrogram is best used on smaller samples (i.e. approximately 250) and it is the responsibility of the researcher to specify the similarity/distance, how the clusters are aggregated and how many clusters are required (Minitab™, 2012).

The test was completed to understand if the survey respondents scored the usefulness of each GSCPM in a similar way and if there were a group of variables which had very similar response characteristics. The results revealed eight key ‘usefulness’ clusters and thus eight emerging constructs (Table 9.10).

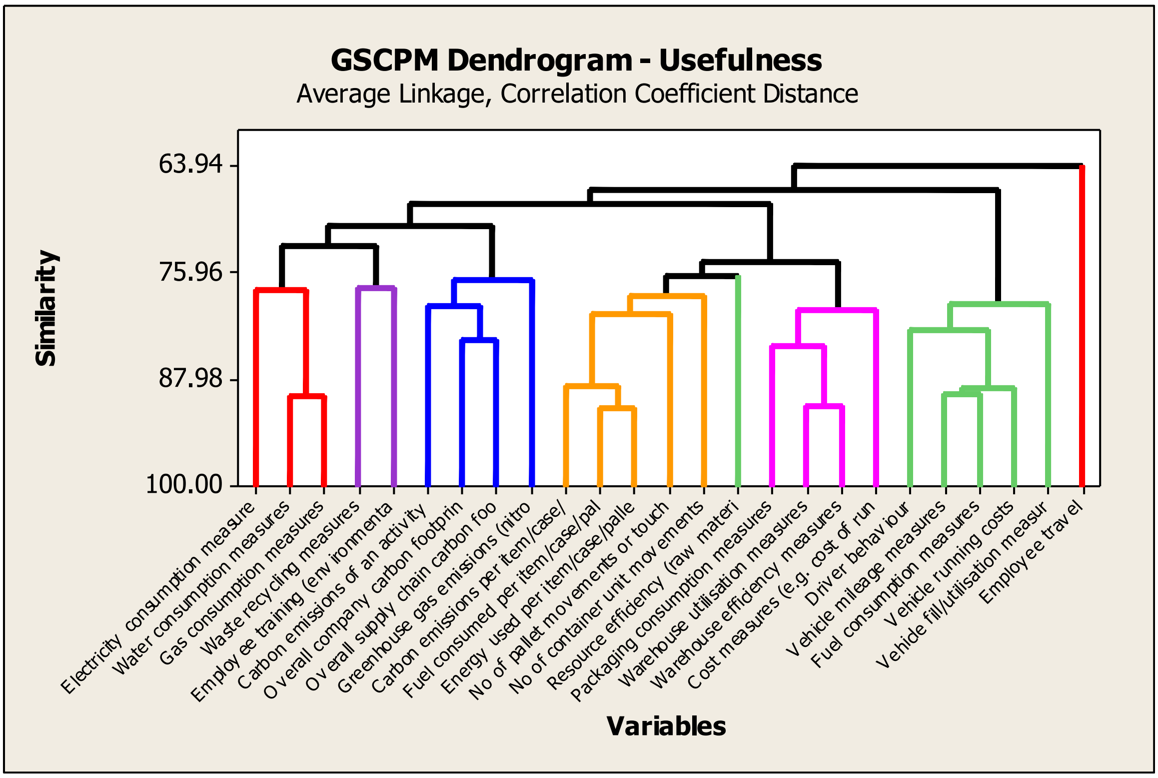


Figure 9.12 – GSCPM Usefulness Dendrogram

Table 9.10 – GSCPM Usefulness Clusters and Emerging Constructs

Final Partition Clusters	GSCPM Variables	Emerging Constructs	Usefulness
Cluster 1	Electricity consumption measure, Water consumption measures and Gas consumption measures	Utilities (energy)	Useful/very useful **GENERIC**
Cluster 2	Driver behaviour, Vehicle mileage measures Fuel consumption measures, Vehicle running costs and Vehicle fill/utilisation measures	Transport/fuel	Useful/very useful? **SPECIFIC**
Cluster 3	Carbon emissions of an activity, Overall company carbon footprint, Overall supply chain carbon footprint and Greenhouse gas emissions	Carbon/emissions	Not very useful/useful **GENERIC**
Cluster 4	Carbon emissions per item/case/ No of pallet movements or touches , Fuel consumed per item/case/pallet delivered, Energy used per item/case/pallet delivered and the No of container unit movements	Per unit moves	Not very useful **GENERIC/SPECIFIC**
Cluster 5	Packaging consumption measures, Warehouse utilisation measures, Warehouse efficiency measures and Cost measures	Warehouse/cost measures	Useful **SPECIFIC**
Cluster 6	Waste recycling measures and Employee training	Waste recycling	Useful **GENERIC**
Cluster 7	Employee travel	People	Useful **GENERIC**
Cluster 8	Resource efficiency	Resource Efficiency	Useful **GENERIC**

Cluster One indicated that the survey respondents view the usefulness of electricity, water and gas consumption in similar way. These measures had a 'useful' average rating of 3.45, 3.03 and 3.03 respectively, which indicated that respondents generally found these GSCPM variables useful. Cluster One also reinforced the findings from FG1, FG2 and Question One of an emerging utilities (energy) construct. Cluster Two indicated that respondents find the transport/fuel related measures as very useful, Clusters Three and Four are seen as not very useful and Five, Six, Seven and Eight are also useful. These results back up the findings from Question One that those GSCPM variables which are used are also seen as useful, in contrast, those measures from Clusters Three and Four are not very useful and therefore not used. The GSCPM variables also cluster discretely around some of the key constructs which were identified in FG1, FG2 and Question One such as utilities (energy), transport, carbon, waste, people and warehousing.

In summary, based on the average ratings; three GSCPM variables have been identified as the most useful by the survey respondents, they are; 1) fuel consumption, 2) waste recycling and 3) electricity consumption. Waste recycling and electricity consumption measures are consistent with the GSCPM variables which respondents currently use. It is therefore evident from Question Three that those GSCPM variables which respondents use are also seen as useful, which is intuitive and in line with the author's expectations. Cost was also statistically 'exceptionally useful' to respondents and is therefore an important consideration in this thesis. Finally, it is evident from the Pearson Chi-squared analysis that there is a statistically significant difference between the type of GSCPM variables and how useful respondents see these GSCPM variables. There are also differences between how useful certain GSCPM variables are to particular NAIC sectors (specific versus generic). The constructs of energy, waste and fuel (transport) continue to be dominant GSCPM measurement areas for the survey respondents.

The next section will now present the results from Section Four of the survey (Question Four).

9.3.4 Section Three - Green Supply Chain Performance Measures: EASE OF MEASUREMENT

Section Three (Question Four) was concerned with answering RQ2 by understanding which GSCPM variables respondents believe are 'easy to measure'.

This section consisted of one closed question:

4. *Please tick the button shown on the scale below which best indicates how 'easy it is to measure' each Green Supply Chain Performance Measurement in the context of your company?*

In a similar way to survey Question Three, the respondents were given a list of the 25 x GSCPM variables from Phase One with a five-point Likert scale (Likert, 1932) which would enable the respondents to indicate how easy it was to measure each of the GSCPM variables in the context of their company (with one being *exceptionally difficult to measure* and five being *exceptionally easy to measure*).

Table 9.11 shows a summary of the responses to Question Four. The top three 'easiest to measure' GSCPM variables were: 1) vehicles mileage, 2) electricity consumption and 3) fuel consumption. These three GSCPM variables are consistent with the most commonly used and most useful GSCPM variables found in Questions One and Two, with electricity consumption consistent across all top three categories. This suggests that respondents find electricity consumption 'useful', 'easy to measure' and therefore they measure it.

In order to test whether there was any statistical association between the types of GSCPM and how easy respondents viewed these to measure, a Pearson's Chi-square test was applied to the ordinal data in Question Four. The test generated a Pearson Chi-square of 1493 and a p-value of 0.000. The researcher regarded this as being statistically significant as p-values of less than 0.05 are significant. Therefore, it can be concluded, that significant differences exist between the observed and expected counts on some of the 25 x GSCPM variables, thus a relationship exists between the type of GSCPM and how easy respondents believe these are to measure.

The vehicle mileage measure was statistically significant in terms of being 'exceptionally easy to measure' and statistically 'very useful' to respondents. This meant that respondents did indeed measure them (third most used GSCPM from Question One). Fuel consumption was statistically 'very easy to measure' and 'very useful'; therefore respondents were also measuring it (forth most used GSCPM from Question One). On the other hand, the waste recycling measure was statistically significant in terms of being 'very useful' to respondents and it was evident from Question One that it was ranked as the second most commonly used GSCPM. However it was not in the top three 'easiest to measure' GSCPM, but ranked in tenth place on the 'ease of measurement' scale, with most respondents indicating it was 'straight forward to measure' (Table 9.11). This suggests that although it may not be 'exceptionally easy to measure'; waste is a very useful GSCPM to respondents and therefore they are measuring it.

In contrast, energy used per item/case/pallet delivered and carbon emissions per item/case/pallet delivered were consistently identified across all bottom three categories indicating their lack of usefulness, complexity to measure and therefore respondents were simply not measuring these two GSCPM variables.

Table 9.11 Question Four Summary Responses Indicating the Highest Response in each Category (indicated in bold)

GSCPM	Exceptionally difficult to measure	Difficult to measure	Straightforward to measure	Easy to measure	Exceptionally easy to measure	Rating Average
Vehicle mileage measures	19	27	79	84	**57**	3.50
Electricity consumption measures	13	30	93	80	50	3.47
Fuel consumption measures	23	23	86	**95**	39	3.39
Vehicle running costs	24	31	92	82	37	3.29
Gas consumption measures	25	32	100	69	40	3.25
Water consumption measures	25	39	108	60	34	3.15
Employee travel	16	58	93	78	21	3.11
Employee training (environmental training)	21	52	112	60	21	3.03
Cost measures (e.g. cost of running your warehouse, fleet etc)	33	40	109	69	15	2.97
Waste recycling measures	17	67	**115**	55	12	2.92
Warehouse utilisation measures (e.g. pallet occupancy)	41	53	86	65	21	2.89
Warehouse efficiency measures	42	68	96	48	12	2.70
Vehicle fill/utilisation measures (e.g. empty running)	54	52	92	57	11	2.70
Packaging consumption measures	43	78	89	45	11	2.64
No of container unit movements (TEU)	54	66	84	45	17	2.64
Driver behaviour	42	97	73	45	9	2.56
Resource efficiency (raw materials, asset utilisation)	50	85	88	35	8	2.50
No of pallet movements or touches per delivery	62	90	68	32	14	2.42
Fuel consumed per item/case/pallet delivered	73	91	73	24	5	2.24
Overall company carbon footprint measures	63	122	49	30	2	2.20
Overall supply chain carbon footprint measures	77	100	59	21	9	2.19
Carbon emissions of an activity	61	**133**	50	21	1	2.13
Energy used per item/case/pallet delivered	90	108	44	21	3	2.02
Greenhouse gas emissions (nitrous oxide, methane etc)	**93**	115	44	12	2	1.93
Carbon emissions per item/case/pallet delivered	**93**	125	37	10	1	1.88

A one-way analysis of variance (ANOVA) was performed on the data set to assess if there was a significant difference between the type of industrial sector and the ease of measurement of each GSCPM. Table 9.12 shows those GSCPM variables where there is a statistically significant difference between the sector and the ease of measurement (indicated by p=values less than 0.05). The researcher then indicated in the adjacent column in Table 9.12 those sectors which had the highest average means. This helped the researcher to understand and interpret why statistical differences existed between the type of GSCPM, their ease of measurement and sector. The results showed that some GSCPM variables are 'generic' and respondents from all NAIC sectors view their 'ease of measurement' in a similar way. In contrast, some are 'specific' and their 'ease of measurement is viewed differently depending on their particular sector. There are some similarities between generic and specific GSCPM variables in Questions Three and Four.

Table 9.12 – Statistical Differences between the type of GSCPM, their ease of measurement and the NAIC Sector

GSCPM	**P = value**	**Five highest average means (ease of measurement)**
Electricity consumption measures	0.389	Not statistically significant (Generic)
Driver behaviour	0.006	Mining Utilities Accommodation and Food Transportation and Warehousing Public Administration
Carbon emissions of an activity	0.368	Not statistically significant (Generic)
Carbon emissions per item/case/pallet delivered	0.270	Not statistically significant (Generic)
Overall company carbon footprint measures	0.649	Not statistically significant (Generic)
Vehicle mileage measures	0.031	Mining Real Estate and Rental and Leasing Utilities Construction Transportation and Warehousing
Packaging consumption measures	0.099	Not statistically significant (Generic)
Fuel consumption measures	0.006	Mining Retail Utilities Transportation and Warehousing Manufacturing
No of pallet movements or touches per delivery	0.084	Not statistically significant (Generic)
Warehouse utilisation measures (e.g. pallet occupancy)	0.009	Accommodation and Food Retail Manufacturing Wholesales Trade Transportation and Warehousing
Fuel consumed per item/case/pallet delivered	0.009	Arts Entertainment and Recreation Retail Transportation and Warehousing Manufacturing Utilities
Vehicle running costs	0.006	Mining Utilities Arts Entertainment and Recreation Transportation and Warehousing Construction
Waste recycling measures	0.081	Not statistically significant (Generic)
Warehouse efficiency measures	0.000	Retail Manufacturing Arts Entertainment and Recreation Accommodation and Food Utilities
Water consumption measures	0.066	Not statistically significant (Generic)
Gas consumption measures	0.016	Management of Companies Real Estate and Rental and Leasing Arts Entertainment and Recreation Manufacturing Retail
Overall supply chain carbon footprint measures	0.150	Not statistically significant (Generic)
Vehicle fill/utilisation measures (e.g. empty running)	0.043	Transportation and Warehousing Utilities

		Mining Arts Entertainment and Recreation Retail
Energy used per item/case/pallet delivered	0.172	Not statistically significant (Generic)
Greenhouse gas emissions (nitrous oxide, methane etc)	0.191	Not statistically significant (Generic)
Cost measures (e.g. cost of running your warehouse, fleet etc)	0.018	Retail Arts Entertainment and Recreation Health and Social care Wholesale Trade Transport and Warehousing
Employee training (environmental training)	0.368	Not statistically significant (Generic)
No of container unit movements (TEU)	0.020	Retail Wholesale Trade Accommodation and Food Real Estate and Rental and Leasing Utilities
Employee travel	0.787	Not statistically significant (Generic)
Resource efficiency (raw materials, asset utilisation)	0.504	Not statistically significant (Generic)

The results of this test indicated a number of insights; firstly, for measures such as electricity consumption, carbon emissions of activity or waste recycling, there was no statistical difference between the type of GSCPM and sector; generally respondents view their ease of measurement in a similar way regardless of sector. These results are consistent with the findings from Question Three on usefulness and sector. Secondly, for measures such as driver behaviour, vehicle mileage measures and fuel consumption there is a statistically significant difference; respondents of specific sectors view the ease of measurement of these GSCPM variables in a different way to other sectors. For example, driver behaviour is seen as 'straight forward to measure' by the Mining, Utilities, Accommodation and Food, Transportation and Warehousing and Public Administration sectors, however, not that easy to measure, by other sectors. These trends are important in the context of this thesis as they highlight potential sector trends in the way respondents view GSCPM variables and their ease of measurement.

The 'ease of measurement' data set was also analysed in Minitab ™ using a Dendrogram which helped to cluster the GSCPM 'ease of measurement' variables and corresponding survey responses (Figure 9.13). This test was completed to understand if the survey respondents scored the ease of measurement of each GSCPM in a similar way and if there were any similar characteristics between the GSCPM variables. The results revealed eight key clusters and eight emerging constructs (Table 9.13).

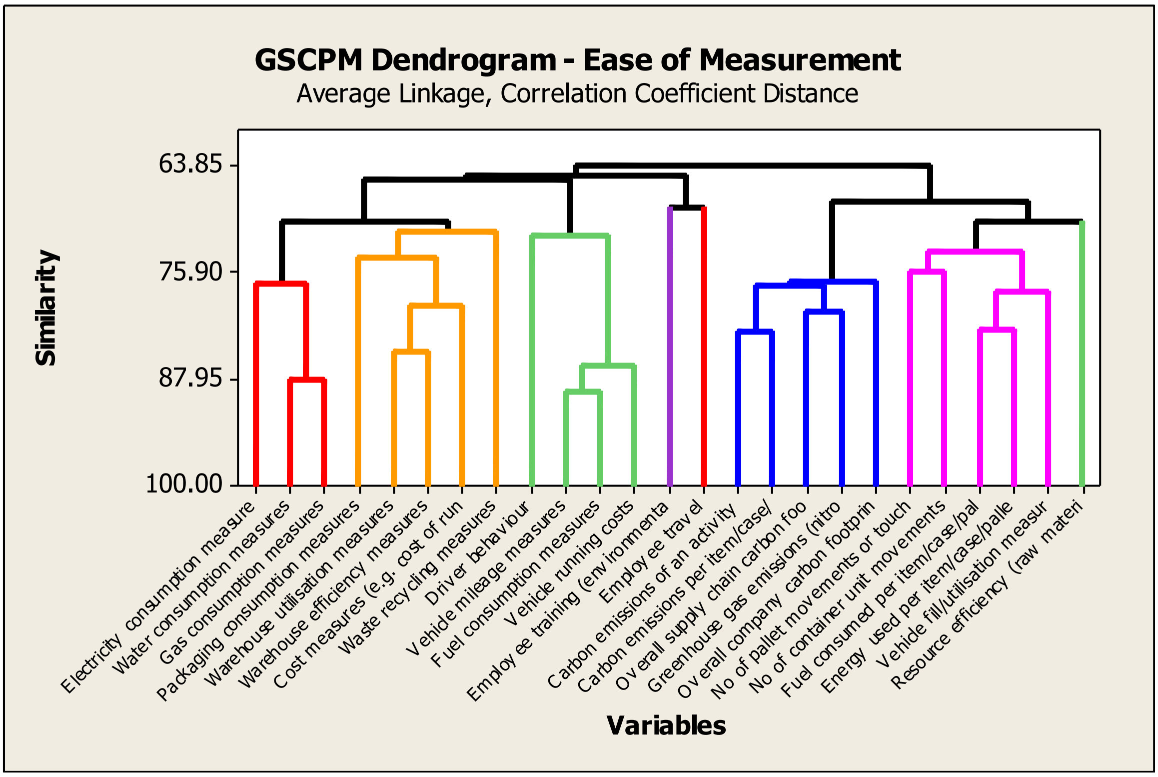


Figure 9.13 – GSCPM Ease of Measurement Dendrogram

Table 9.13 – GSCPM Ease of Measurement Clusters and Emerging Constructs

Final Partition Clusters	GSCPM Variables	Emerging Constructs	Ease of Measurement
Cluster 1	Electricity consumption measures, Water consumption measures and Gas consumption measures	Utilities (energy)	Straight forward to measure/Easy to measure
Cluster 2	Driver behaviour , Vehicle mileage measures, Fuel consumption measures and Vehicle running costs	Transport/fuel	Straight forward to measure/Easy to measure
Cluster 3	Carbon emissions of an activity Carbon emissions per item/case/ Overall company carbon footprint Overall supply chain carbon footprint and Greenhouse gas emissions	Carbon/emissions	Difficult to measure/Exceptionally difficult to measure
Cluster 4	Packaging consumption measures, Warehouse utilisation measures, Waste recycling measures, Warehouse efficiency measures and Cost measures	Warehousing/Waste/Cost	Straight forward to measure
Cluster 5	No of pallet movements or touches, Fuel consumed per item/case/pallet, Vehicle fill/utilisation measures, Energy used per item/case/pallet delivered and No of container unit movements	Per unit movements	Difficult to measure
Cluster 6	Employee training	People	Straightforward to measure
Cluster 7	Employee travel	People	Straightforward to measure
Cluster 8	Resource efficiency	Resource Efficiency	Difficult to measure/Straightforward to measure

The final partition of clusters indicated that there were similar characteristics associated with certain groups of GSCPM variables. For instance, Cluster One indicated that electricity, water and gas consumption were easy and straightforward to measure. On the other hand, Cluster Three included GSCPM variables which are difficult to measure. Similar parallels can be drawn between those GSCPM variables which are easy to measure and those which are both useful and currently used by respondents, for example, greenhouse gas emissions are difficult to measure, not useful and therefore not used by the respondents.

In summary, three GSCPM variables have been identified in Section Three as the easiest to measure 1) vehicle mileage, 2) electricity consumption and 3) fuel consumption. Electricity appears consistently across all three top three categories which indicated that, it is being used because it is both useful and easy to measure. At this point in the analysis process, it is important to note that there is a trend emerging in the data which indicates that generally those GSCPM variables which respondents find useful and/or easy to measure (electricity, fuel consumption, vehicle mileage measures, vehicle running costs, waste recycling, employee training and water consumption) are the ones which respondents are currently measuring. If a GSCPM is seen as easy to measure, this may be driving the perception that it is useful.

The combined data set (usefulness and ease of measurement) was also analysed together using a Dendrogram which helped to cluster the GSCPM variables into smaller groups (Figure 9.14). The test was completed to understand if there were groups of GSCPM variables which expressed similar characteristics with regard to usefulness and ease of measurement (Figure 9.14 and Table 9.14).

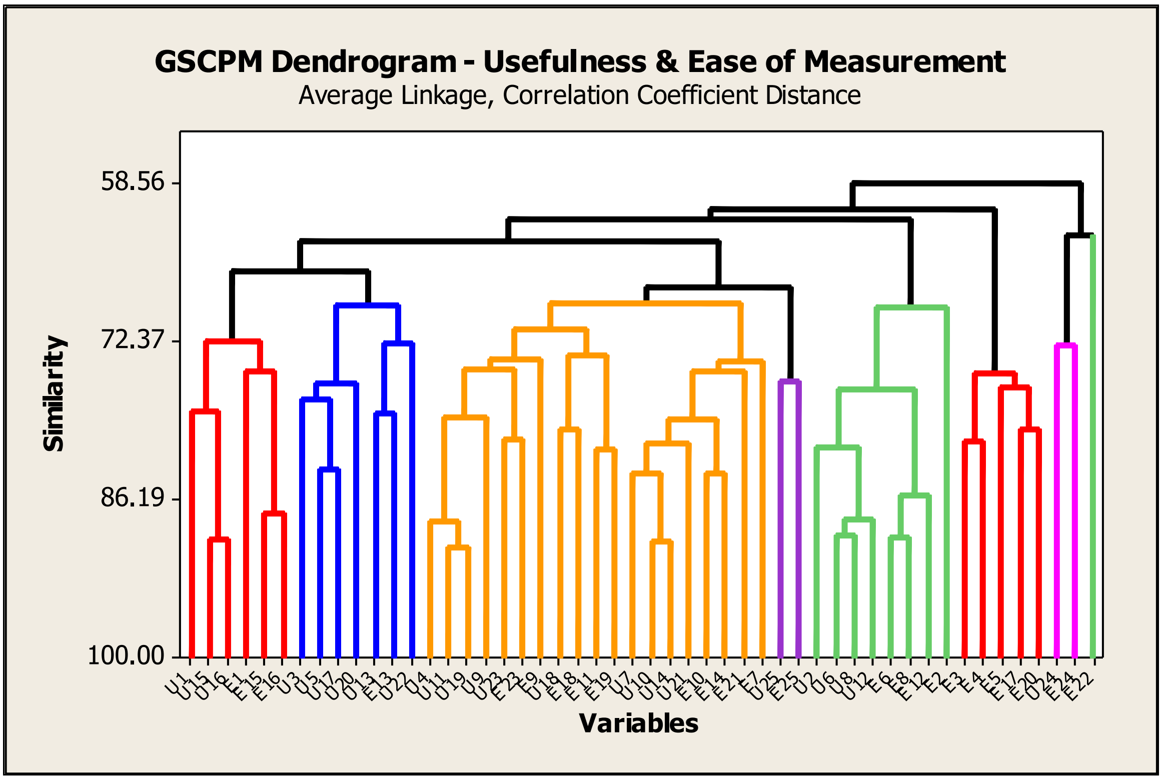


Figure 9.14 – GSCPM Usefulness and Ease of Measurement Dendrogram

Table 9.14 – GSCPM Ease of Measurement Clusters and Emerging Constructs

Final Partition Clusters	**GSCPM Variables** **U = Usefulness** **E = Ease**	**Emerging Constructs**	**Ease of Measurement and Usefulness commonalities**
Cluster 1	U - Electricity consumption measures U - Water consumption measures U - Gas consumption measures E - Electricity consumption measure E - Water consumption measures E - Gas consumption measures	Utilities/Energy	Useful/very useful AND Straight forward to measure/Easy to measure
Cluster 2	U - Driver behaviour U - Vehicle mileage measures U - Fuel consumption measures U - Vehicle running costs E - Driver behaviour E - Vehicle mileage measures E – Fuel consumption measures E - Vehicle running costs	Transport/fuel	Useful/very useful AND Straight forward to measure/Easy to measure
Cluster 3	U - Carbon emissions of an activity U - Overall company carbon footprint U – Waste recycling measures U - Overall supply chain carbon footprint U - Greenhouse gas Emissions U - Employee training E - Waste recycling measures	Overall carbon footprint/emission/waste	Useful AND Difficult to measure
Cluster 4	U - Carbon emissions per item/case/ delivered U - Packaging consumption measure U No of pallet movements or touches U- Warehouse utilisation measure U - Fuel consumed per item/case/p U - Warehouse efficiency measures U - Vehicle fill/utilisation measures U - Energy used per item/case/pal U - Cost measures U - No of container unit movement E -Packaging consumption measures E- No of pallet movements or touch Warehouse utilisation measures	Warehouse/utilisation/unit moves/cost	Not very useful/useful AND Straight forward/Difficult to measure

	E - Fuel consumed per item/case/pallet E - Warehouse efficiency measures E – Vehicle fill/utilisation measures E - Energy used per item/case/pallet E - Cost measures E - No of container unit movements		
Cluster 5	U - Employee travel E - Employee travel	People	Useful AND Straightforward to measure
Cluster 6	U- Resource efficiency E -Resource efficiency	Resource Efficiency	Useful AND Difficult to measure/Straightforward to measure
Cluster 7	E - Carbon emissions of an activity E -Carbon emissions per item/case/ E - Overall company carbon footprint E - Overall supply chain carbon footprint E - Greenhouse gas emissions	Carbon/green house gas emissions	Useful AND Difficult to measure
Cluster 8	E - Employee training	People	Useful AND Straightforward to measure

The final partition of clusters indicated that there were similar characteristics associated with certain groups of GSCPM variables with regard to their ease of measurement and usefulness. For instance, Cluster One indicated that electricity, water and gas consumption are both easy/straightforward to measure and very useful to all respondents and there is evidence they are being used. Similar trends applied to Clusters Two, Five and Eight. On the other hand, respondents view the GSCPM variables in Clusters Three, Six and Seven as useful but difficult to measure. There is evidence that some of these GSCPM variables are being used (waste recycling and employee training) but some are not (resource efficiency and greenhouse gas emissions). In contrast, respondents view the GSCPM variables in Cluster Four as not very useful and difficult to measure. The only exception to this is cost, which was found to be useful and straightforward to measure and respondents are currently measuring it. There is evidence from the results in Question One that many of the GSCPM variables in Cluster

Four are predominantly not measured, due to the difficulty in measurement or their perceived lack of usefulness.

The results at this stage indicate that those GSCPM variables which respondents find useful and easy to measure are the GSCPM variables which respondents currently use. Table 9.15 displays the top ten most used, most useful and easiest to measure GSCPM variables from Questions One, Three and Four. The highlighted cells indicate whether there is consistency across all three categories. There are seven GSCPM variables in the top ten which respondents believe are both useful, easy to measure and which they currently use. In terms of answering RQ2, these seven GSCPM variables are the most important to the respondents. There is, however, exceptions to this rule which must be taken into account, for example, driver behaviour is useful, used but not necessarily easy to measure. New onboard driver monitoring systems greatly facilitate driver behaviour measurement, though not all companies can afford to invest and install these devices into vehicles, which is why measuring driver behaviour may currently be seen as difficult.

Table 9.15 – Top Ten GSCPM Variables (Use, Useful and Ease of Measurement) G = Generic, S = Specific to a Sector

Top Ten Most Used	Top Ten Most Useful	Top Ten Easiest to Measure
Electricity consumption measures	**Fuel consumption measures (S)**	**Vehicle mileage measures (S)**
Waste recycling measures	**Waste recycling measures (G)**	**Electricity consumption measures (G)**
Vehicle mileage measures	**Electricity consumption measures (G)**	**Fuel consumption measures (S)**
Fuel consumption measures	**Vehicle running costs (S)**	**Vehicle running costs (S)**
Vehicle running costs	**Vehicle mileage measures (S)**	Gas consumption measures (S)
Driver behaviour	Cost measures (S)	**Water consumption measures (G)**
Water consumption measures	**Employee training (G)**	Employee travel (G)
Employee travel	Driver behaviour (S)	**Employee training (G)**
Employee training	Overall company carbon footprint measures (G)	Cost measures (S)
Overall company carbon footprint measures	**Water consumption measures (G)**	**Waste recycling measures (G)**

Based on the average ratings from Questions Three and Four, Table 9.16 shows the importance index associated with each of the GSCPM variables. GSCPM variables such as vehicle mileage, electricity consumption and fuel consumption measures are the most important GSCPM variables to the survey respondents. In contrast, GSCPM variables such as greenhouse gas emissions are not that important.

Table 9.16 – GSCPM Table (Ease versus Impact)

GSCPM	Impact X Ease		Importance Factor
Vehicle mileage measures	3.45	3.5	12.075
Electricity consumption measures	3.45	3.47	11.9715
Fuel consumption measures	3.4	3.39	11.526
Vehicle running costs	3.37	3.29	11.0873
Gas consumption measures	3.29	3.25	10.6925
Water consumption measures	3.26	3.15	10.269
Employee travel	3.24	3.11	10.0764
Employee training (environmental training)	3.14	3.03	9.5142
Cost measures (e.g. cost of running your warehouse, fleet etc)	3.13	2.97	9.2961
Waste recycling measures	3.03	2.92	8.8476
Warehouse utilisation measures (e.g. pallet occupancy)	3.03	2.89	8.7567
Warehouse efficiency measures	2.97	2.7	8.019
Vehicle fill/utilisation measures (e.g. empty running)	2.97	2.7	8.019
Packaging consumption measures	2.9	2.64	7.656
No of container unit movements (TEU)	2.88	2.64	7.6032
Driver behaviour	2.83	2.56	7.2448
Resource efficiency (raw materials, asset utilisation)	2.78	2.5	6.95
No of pallet movements or touches per delivery	2.77	2.42	6.7034
Fuel consumed per item/case/pallet delivered	2.71	2.24	6.0704
Overall company carbon footprint measures	2.56	2.2	5.632
Overall supply chain carbon footprint measures	2.43	2.19	5.3217
Carbon emissions of an activity	2.34	2.13	4.9842
Energy used per item/case/pallet delivered	2.33	2.02	4.7066
Greenhouse gas emissions (nitrous oxide, methane etc)	2.33	1.93	4.4969
Carbon emissions per item/case/pallet delivered	2.29	1.88	4.3052

The next section will now validate the survey results from Questions Three and Four (usefulness and ease of measurement) by using factor analysis to identify any underlying factors or relationships which exist between the 25 x GSCPM variables and responses from Questions Three and Four. This will help to corroborate the results from Questions Three and Four and will answer RQ2 (Hair et al, 1995; Field, 2005).

9.3.5 Factor Analysis (Principle Component Analysis)

To assess whether any of the 25 x GSCPM variables were items underlying any of the constructs identified in Phase One and the extant literature, the data from Questions Three and Four was tested using factor analysis using SIMCA-13™. Factor analysis is a technique used for identifying groups or clusters of variables and has three main uses: 1) to understand the structure of the variables 2) to reduce a large number of variables down to a smaller number of factors, and 3) to create an entirely new set of variables

(Field, 2005; Hair et al., 1995). Correlations may exist between the 25 x GSCPM variables and it is the aim of the factor analysis process to uncover and summarise these underlying relationships by reducing the data and presenting it in a more meaningful way.

The reliability of factor analysis is largely dependent on the sample size. Hair et al. (1995) recommend as a general rule at least five observations per variable. In this thesis, there are 25 variables each with 266 useable responses for Questions Three and Four, therefore this is considered sufficient for factor analysis.

One of the most basic assumptions of factor analysis is that there must be sufficient interrelationship (multicollinearity) between the existing variables (Field, 2005). A Pearson's correlation matrix was used to ensure that the variables correlated well with one another (Field, 2000). Table 9.17 displays the correlation matrix for the usefulness GSCPM variables. Correlation coefficients lie between -1 and +1, a coefficient of +1 indicates a perfectly positive linear relationship between two variables. On the other hand, a coefficient of -1 indicates a perfectly negative linear relationship (Field, 2005). Visual inspection of correlation matrices for both Questions Three and Four indicates a substantial number of correlations equal to or greater than 0.30 (Table 9.17). Hair et al., (1995) recommend that correlations 0.30 or greater are appropriate for factor analysis. All GSCPM variables were therefore included at this stage.

Table 9.17 – Pearson Correlation Matrix for GSCPM variables

GSCPM		U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15	U16	U17	U18	U19	U20	U21	U22	U23	U24	U25
U1	-0.02	1																								
	0.741																									
U2	-0.002	0.3	1																							
	0.978	0																								
U3	-0.013	0.327	0.315	1																						
	0.839	0	0																							
U4	0.082	0.168	0.309	0.512	1																					
	0.183	0.006	0	0																						
U5	0.028	0.334	0.176	0.628	0.557	1																				
	0.653	0	0.004	0	0																					
U6	-0.038	0.291	0.668	0.365	0.38	0.289	1																			
	0.536	0	0	0	0	0																				
U7	-0.107	0.345	0.202	0.21	0.477	0.301	0.32	1																		
	0.081	0	0.001	0.001	0	0	0																			
U8	-0.06	0.372	0.663	0.348	0.342	0.238	0.793	0.251	1																	
	0.33	0	0	0	0	0	0	0																		
U9	0.002	0.273	0.348	0.247	0.55	0.234	0.336	0.539	0.275	1																
	0.971	0	0	0	0	0	0	0	0																	
U10	-0.034	0.3	0.279	0.188	0.435	0.269	0.31	0.674	0.311	0.666	1															
	0.576	0	0	0.002	0	0	0	0	0	0																
U11	0	0.208	0.385	0.409	0.789	0.37	0.402	0.464	0.389	0.67	0.526	1														
	0.999	0.001	0	0	0	0	0	0	0	0	0															
U12	-0.045	0.242	0.636	0.301	0.384	0.215	0.785	0.291	0.77	0.314	0.307	0.458	1													
	0.461	0	0	0	0	0	0	0	0	0	0	0														
U13	-0.042	0.526	0.206	0.407	0.297	0.505	0.281	0.491	0.263	0.324	0.401	0.286	0.307	1												
	0.493	0	0.001	0	0	0	0	0	0	0	0	0	0													
U14	0.019	0.339	0.269	0.184	0.449	0.303	0.343	0.669	0.305	0.599	0.81	0.504	0.395	0.458	1											
	0.755	0	0	0.003	0	0	0	0	0	0	0	0	0	0												
U15	-0.101	0.553	0.219	0.345	0.277	0.394	0.275	0.457	0.312	0.317	0.43	0.297	0.281	0.557	0.461	1										
	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0											
U16	-0.043	0.574	0.268	0.406	0.353	0.5	0.369	0.527	0.376	0.403	0.554	0.389	0.328	0.509	0.566	0.784	1									
	0.486	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0										
U17	-0.041	0.341	0.276	0.528	0.604	0.689	0.309	0.426	0.309	0.401	0.36	0.526	0.335	0.46	0.432	0.445	0.525	1								
	0.504	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
U18	0.014	0.195	0.547	0.257	0.453	0.213	0.614	0.397	0.571	0.53	0.466	0.528	0.596	0.281	0.467	0.378	0.459	0.381	1							
	0.823	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
U19	0.055	0.221	0.36	0.434	0.783	0.437	0.336	0.486	0.342	0.623	0.49	0.829	0.368	0.344	0.522	0.359	0.453	0.601	0.537	1						
	0.374	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
U20	0.049	0.286	0.246	0.537	0.525	0.535	0.311	0.328	0.299	0.339	0.283	0.438	0.265	0.339	0.31	0.412	0.47	0.55	0.253	0.545	1					
	0.428	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0						
U21	-0.013	0.286	0.342	0.172	0.434	0.287	0.429	0.543	0.433	0.533	0.654	0.478	0.464	0.437	0.678	0.402	0.475	0.415	0.538	0.468	0.32	1				
	0.828	0	0	0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
U22	-0.017	0.364	0.457	0.407	0.342	0.423	0.414	0.379	0.423	0.385	0.372	0.386	0.455	0.569	0.369	0.475	0.481	0.429	0.412	0.433	0.47	0.465	1			
	0.782	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
U23	-0.087	0.174	0.263	0.316	0.537	0.291	0.306	0.479	0.285	0.613	0.501	0.587	0.322	0.243	0.486	0.298	0.339	0.452	0.415	0.616	0.422	0.437	0.351	1		
	0.158	0.004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
U24	-0.056	0.466	0.308	0.386	0.22	0.36	0.298	0.191	0.333	0.165	0.155	0.227	0.275	0.382	0.155	0.348	0.335	0.346	0.184	0.313	0.338	0.215	0.427	0.266	1	
	0.359	0	0	0	0	0	0	0.002	0	0.007	0.011	0	0	0	0.011	0	0	0	0.003	0	0	0	0	0		
U25	-0.016	0.328	0.224	0.414	0.503	0.326	0.208	0.513	0.285	0.482	0.467	0.552	0.272	0.425	0.518	0.402	0.471	0.52	0.417	0.604	0.393	0.522	0.408	0.486	0.337	1
	0.796	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Cell Contents: Pearson correlation
P-Value

There are four key steps which must be followed by a researcher when conducting factor analysis (Hair et a., 1995; Erikkson et al., 2006):

<u>Step One - Factor Extraction Method</u>

The first step in the factor analysis process is to extract the factors. There are two methods of factor extraction; 1) common factor analysis (CFA) and 2) principle component analysis (PCA). As discussed in Chapter Seven, PCA was selected as a sound theoretical method in which to perform the factor extraction method.

Step Two – Removal of Outliers

It is important in the factor analysis process to remove any outliers and noisy data. This was done by assessing the raw data and by reviewing the score plot which was produced by the SIMCA-13™ software. The score plot identified any respondents who fell outside the 95 per cent confidence region. The assessment of the survey raw data resulted in the exclusion of six respondents who had answered the same rating for each GSCPM in both Questions Three and Four. No other significant outliers fell outside of the 95 per cent confidence region in the score plot; therefore no further respondents were removed from the analysis process.

Step Three – The Number of Factors (Components) to Extract

The third step in the factor analysis process is to decide on how many factors to extract. The most commonly used method for deciding on the number of factors to extract is the latent root criterion (Hair et al., 1995). Only factors which have a latent root or eigenvalue greater than one are considered significant to retain for factor analysis, the rest can be discarded (Hair et al., 1995). Within SIMCA-13™ the rule is much harsher; it regards eigenvalues greater than 2 as significant and worthy of analysis, the rest are discarded.

Within SIMCA-13™ the rule of how many factors to extract is based on two parameters; firstly, R^2, which indicates how well the model fits the data and secondly Q^2 which indicates how well the model predicts new data. A large R^2 (close to 1) and a large Q^2 (close to 0.5) is a necessary condition for a good model and indicates good predictability. Poor scores in both categories can be experienced when there is noise and outliers in the data (Erikkson et al., 2006).

Step Four - Data Set Analysis

The final step in the PCA process is to analyse the dataset in the smallest possible homogenous groupings across the significant components before analysing the entire dataset together. This helped with interpretation of the results particularly when little is known about the research problem. This enabled the researcher to build up a picture and draw conclusions from the emerging results. The first group to be analysed was the GSCPM usefulness dataset from Question Three, followed by ease of measurement for Question Four and finally both data sets were analysed together to help draw overall conclusions.

9.3.5.1 GSCPM Usefulness (Question Three)

Figure 9.15 shows that four significant components were extracted for the GSCPM usefulness dataset in Question Three. Component One accounted for 41 per cent of the total model fit, Component Two accounted for nine per cent, Component Three was eight per cent and finally Component Four accounted for six per cent of the model fit. The predictive ability of the usefulness model declined after adding a fifth or high-order component, therefore four components were extracted and subject to assessment.

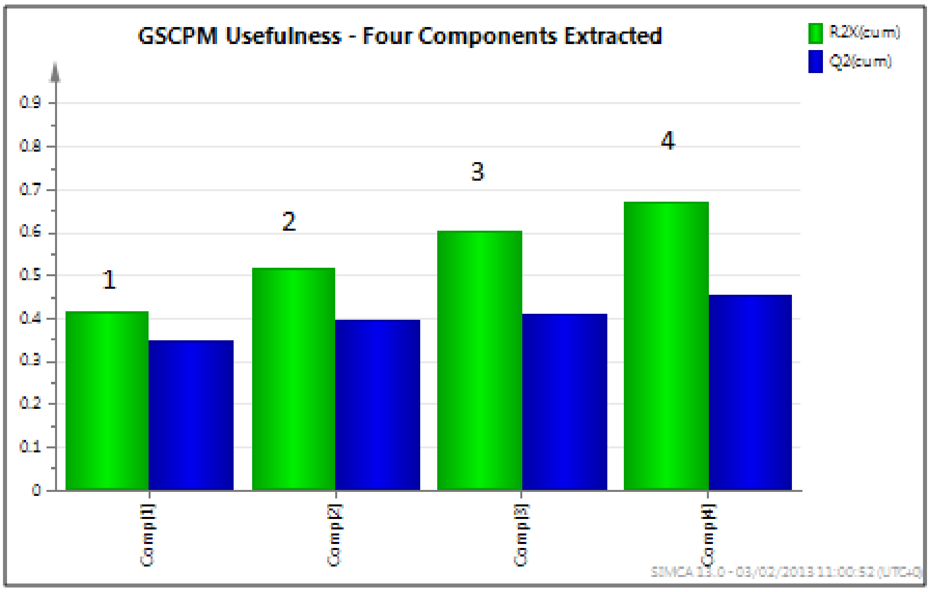


Figure 9.15 – Factor Extraction in SIMCA-13™ (Usefulness – Impact)

Figure 9.16 shows, using the same dataset, a score plot generated by SIMCA-13™ which summarises the relationships amongst the survey respondents in Question Three. The scoreplot also shows the 95 per cent confidence region, indicating if any of the survey respondents fell outside of this. No significant outliers were identified for this data set and therefore no respondents were removed at this stage. The score plot indicated a large clustering of respondents in the right hand quadrant indicating they shared similar positive views on GSCPM usefulness within Components One and Two (see red circle demarking this group).

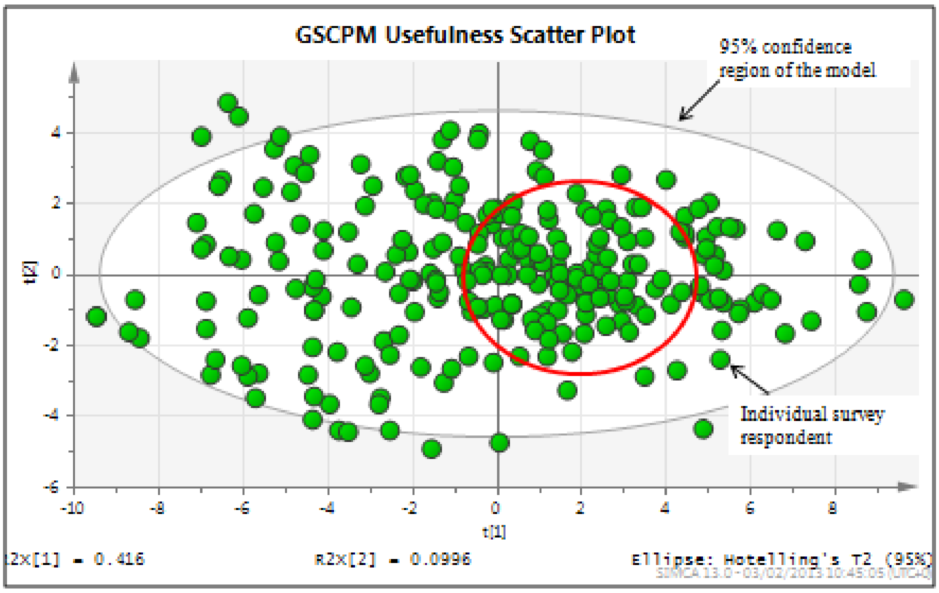


Figure 9.16 – Score Plot Summarising the Relationship between Survey Respondents

The next most important step in the PCA process is to assess which GSCPM variables load onto each of these four components (Table 9.18). This is done by assessing the scores of each of the four components. The author re-coded the scores with a -/0/+ symbol to indicate the type of score to aid interpretation (Erikkson et al., 2006). Scores with an absolute value lower than 0.2 were set to zero, those which were a negative value were set to (–) and those greater than 0.2 are set to (+) (Erikkson et al., 2006:37). A positive score (+) indicated that respondents found the GSCPM variables very or exceptionally useful. A neutal score (0) indicated that respondents found the GSCPM variables useful and finally a negative score (-) indicated that respondents found the GSCPM variables not very useful.

Table 9.18 – Which GSCPM Variables Load onto each Component (USEFULNESS)

GSCPM variables	GSCPM category	Component 1	Component 2	Component 3	Component 4
Vehicle fill/utilisation measures (e.g. empty running)	Transport	+	+	-	-
Gas consumption measures	Utilities	+	-	0	+
Warehouse efficiency measures	Warehouse	+	-	-	0
Cost measures (e.g. cost of running your warehouse, fleet etc)	Cost	+	-	-	0
Warehouse utilisation measures (e.g. pallet occupancy)	Warehouse	+	-	-	0
Packaging consumption measures	Warehouse	+	-	-	0
Resource efficiency (raw materials, asset utilisation)	Efficiency	+	-	-	-
Overall supply chain carbon footprint measures	Carbon	+	-	+	-
No of pallet movements or touches per delivery	Warehouse	+	-	-	-
No of container unit movements (TEU)	Transport	+	-	-	-
Energy used per item/case/pallet delivered	Energy	+	-	0	-
Carbon emissions per item/case/pallet delivered	Carbon	+	-	0	-
Fuel consumed per item/case/pallet delivered	Transport	+	-	-	-
Fuel consumption measures	Transport	0	+	0	0
Vehicle mileage measures	Transport	0	+	0	0
Vehicle running costs	Transport	0	+	-	0
Driver behaviour	People	0	+	0	0
Water consumption measures	Utilities	0	-	0	+
Electricity consumption measures	Utilities	0	-	0	+
Waste recycling measures	Waste	0	-	0	+
Overall company carbon footprint measures	Carbon	0	-	+	-
Greenhouse gas emissions (nitrous oxide, methane etc)	GHG	0	-	+	-
Carbon emissions of an activity	Carbon	0	-	+	-
Employee training (environmental training)	People	0	0	0	0
Employee travel	People	0	0	+	0

Four definitive constructs emerged from this data:

1. Warehouse/Buildings
2. Transportation
3. Carbon and GHG emissions
4. Utilities and waste

This means that there are four groups of respondents who share similar views on which GSCPM variables are useful. For example, within Component One, there is a group of respondents who find warehousing/building based GSCPM variables as exceptionally/very useful and they find most other GSCPM variables useful. This is the largest group of respondents and can be seen clearly on the score plot clustering together in the right hand side of the quadrant under Component One (T1) (Figure 9.16). Component Two on the otherhand describes a group of survey respondents who find only the transportation GSCPM variables as exceptionally useful. They view most other GSCPM variables as not very useful at all. Component Three describes a group of survey respondents who find carbon and GHG emission GSCPM variables as exceptionally/very useful but they do not find the transport and warehouse based GSCPM variables useful. Finally, Component Four respondents view the energy based

GSCPM variables as very useful but do not find the carbon or transport GSCPM variables very useful. The four emerging constructs detailed above mirror those identified in the Phase One focus groups and the extant literature.

The next step of the PCA process is to assess if each of the four components (constructs) are made up of particular types of respondents; for example, do particular occupations or industrial sector respondents view usefulness in similar/different ways. The four components were assessed independently for occuption and sector differences and the results are presented in Table 9.19.

Table 9.19 Four Components assessed by Occupation and Industrial Sector (USEFULNESS)

Usefulness Components	GSCPM Category	Occupation	Sector	Usefulness Views
C1	Warehousing/Buildings	Logistics Manager (24), Other (21), Supply Chain Manager (14), Logistics Director (8), Environmental Manager (6), Managing Director (4), Supply Chain Director (2), Transport/Carrier Manager (2) and CEO (1)	Transportation & Warehousing (36), Manufacturing (13), Other (11), Retail (8), Professional, Scientific, and Technical Services (3), Educational Services (2), Arts, entertainment and recreation (2), Wholesale trade (2), Healthcare and social assistnce (1), Management of Companies and Enterprises (1) Public Administration (1), and Utilities (1)	These respondents find most GSCPM very useful and score these positively (particuarly the warehousing metric and some transport metrics)
C2	Transport	Other (14), Logistics Manager (6), Transport/carrier Managers (5), Logistics/Supply Chain Directors (3), Environmental Managers (3), Supply Chain Manager (2), Managing Director (1)	Transportation & Warehousing (13), Other (7), Public Administration (5), Professional, Scientific, and Technical Services (3), Construction (3), Mining (1), Manufacturing (1) and Healthcare & Social assistance (1)	These respondents find 'transport/vehicle' related GSCPM very useful and score these positively BUT do not find the warehouse, carbon and efficiency GSCPM as useful
C3	Carbon Emissions, GHG Emissions, Carbon Footprint, People	Other (11), Supply Chain Manager (5), Transport/Carrier Manager (3), Managing Director (2), Logistics Manager (2), Supply Chain Director (1) and Logistics Director (1)	Other (7), Transportation & Warehousing (4), Professional, Scientific, and Technical Services (3), Construction (2), Educational Services (2), Public Administration (2), Wholesale Trade (2), Utilities (1), Manufacturing (1), Management of Companies and Enterprises (1) and Information (1)	These respondents find the overall carbon emissions, footprint and GHG emissions very useful and score them positively BUT do not find the warehouse and transport GSCPM as useful
C4	Energy and waste	Logistics Manager (9), Logistics Director (4), Other (3), Supply Chain Manager (2), Environmental Manager (2) and Transport/Carrier Manager (1)	Transportation & Warehousing (6), Manufacturing (3), Educational Services (2), Professional, Scientific and Technical Services (2), Retail (2), Arts, entertainment and recreation (1),Construction (1), Healthcare and social assistance (1), Mining (1), Public administration (1) and Wholesale trade (1)	These respondents find the utility and waste recycling GSCM as very useful and score them positively BUT do not find metrics which include carbon or transport GSCPM as useful

In summary, Component One (warehousing/buildings) is made up of respondents who are logistics managers, supply chain managers and others mainly from the transportation and warehousing, manufacturing, other and retail sectors. They view warehouse based GSCPM variables as exceptionally useful and generally view most other GSCPM variables as useful. Component Two is made up of respondents which are: others, logistics managers, transport/carrier managers that are mainly from the transportation and warehousing, other and pubic adminstration sectors. They find transport and vehicle based GSCPM variables as exceptionally/very useful but do not find the warehouse, carbon, energy and efficiency GSCPM variables as useful at all. Component Three on the otherhand are made up of respondents who are: other, supply chain managers and transport/carrier managers mainly from the other, transportation and warehousing and professional, scientific and technical sectors. They are generally a mix of sectors with less transportation and warehousing respondents in this group. They view carbon and GHG emission GSCPM variables as exceptionally/very useful but do not find the transportation and warehousing GSCPM variables as useful. Finally, Component Four is made up of respondents who are: logistics directors, logistics managers and others mainly from the transportation and warehousing, manufacturing and educational services sectors. Again, there are less transportation and warehousing respondents in this group as in Component Three. They view the energy based GSCPM variables as exceptionally/very useful but do not find the carbon and transportation GSCPM variables as useful. Components Three and Four represent the views of more non transportation and warehouse industry respondents. They clearly have differing views on GSCPM usefulness to the respondents in Components One and Two and are representative of the views logistics and supply chain managers operating in different sectors with different requirements. This supports the sector difference results identified in Section Two.

The dendrogram from Section Two was re-run in Minitab based on four clusters (four components) to see if it also identified the four emerging constructs identifed in this PCA data set (Figure 9.17).

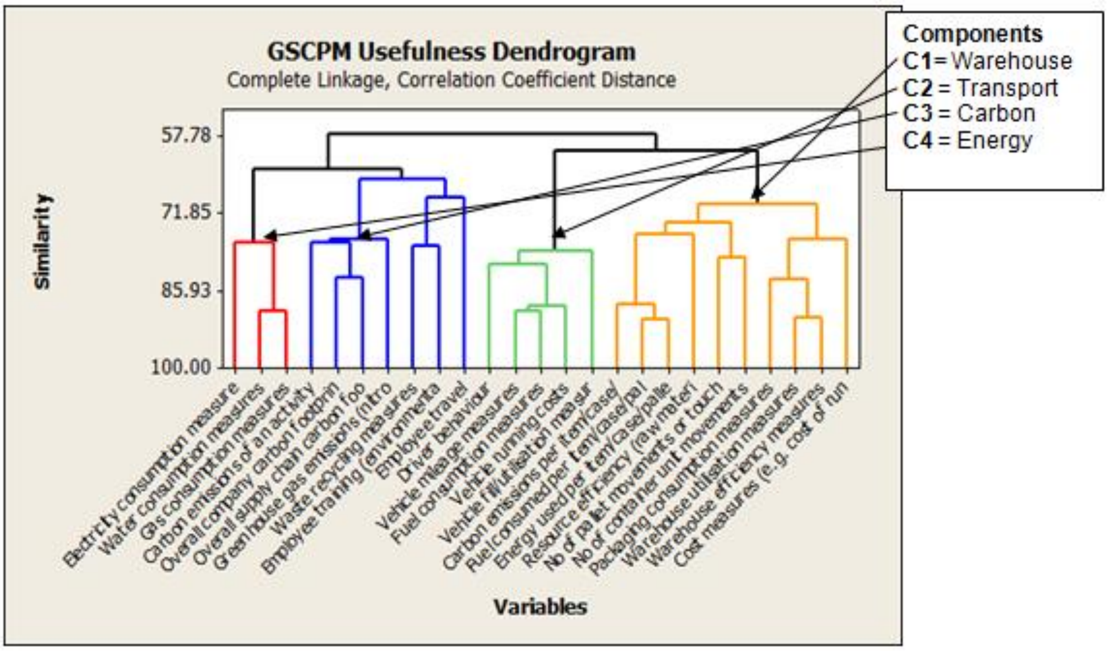


Figure 9.17 - Re-run Dendrogram based on four components (USEFULNESS)

The Dendrogram showed four distinct clusters of GSCPM variables which mirror the results explained by the four components in the PCA analysis in SIMCA-13™. The test was completed to understand if the survey respondents scored the usefulness of each GSCPM in a similar way and if there were a group of variables which had similar response characteristics. Four groups of response characteristics were identified which mirror those found in the PCA analysis:

Cluster 1 = Warehouse

Cluster 2 = Transportation

Cluster 3 = Carbon (air emissions)

Cluster 4 = Energy

In summary, the PCA modelling has revealed four significant components for the usefulness category: 1) Warehousing, 2) Transportation 3) Carbon and 4) Energy. The PCA results reinforced the findings made earlier in Section Two that there are statistically significant differences between the type of GSCPM variables and how useful respondents see these GSCPM variables. There are also clear occupation and sector differences in how useful GSCPM variables are viewed. For example, Component One is made up of a large group of transportation and warehousing sector respondents and they view the warehousing GSCPM variables as very/exceptionally useful. In contrast, Component Four is made up of manufacturing and educational services sector respondents and they view energy and waste GSCPM variables as very/exceptionally useful. The score plot illustrates that the vast majority of survey respondents (mainly Component One) do view GSCPM usefulness in a similar way. There are also more senior occupations in Component Four such as logistics directors, this suggests a difference between respondent occupation/seniority and their view of GSCPM usefulness pointing to a potential hierarchy of GSCPM variables with some GSCPM variables being viewed as strategic (energy/carbon), some tactical (vehicle utilisation) and operational (fuel consumption).

Fuel consumption, waste recycling and electricity consumption were identified as the most useful measures in Section Two. Given that Components One and Two make up 50 per cent of the model fit and that they are all predominantly from the transportation and warehousing sector, it is no surprise that fuel consumption featured as the number one most useful GSCPM in Section Two. However, Components Three and Four are significant as they represent the views of different sectors where GSCPM variables such as carbon and energy are viewed as the most useful. In their review of the GSCPM background literature, Björkland et al. (2012) also found air emissions, energy use and fuel use as the most frequently cited and reoccurring GSCPM items. The next section will now present the PCA modelling results for ease of measurement.

9.3.5.2 GSCPM Ease of Measurement (Question Four)

Figure 9.18 shows that four significant components were extracted for the GSCPM ease of measurement dataset in Question Four. Component One accounted for 34 per cent of the total model fit, Component Two accounted for nine per cent, Component Three is eight per cent and finally Component Four accounted for six per cent of the model fit. This reflected closely the component structure identified in the usefulness dataset. The predictive ability of the ease of measurement model declined after adding a fifth or high-order component, therefore four components were extracted and subject to assessment.

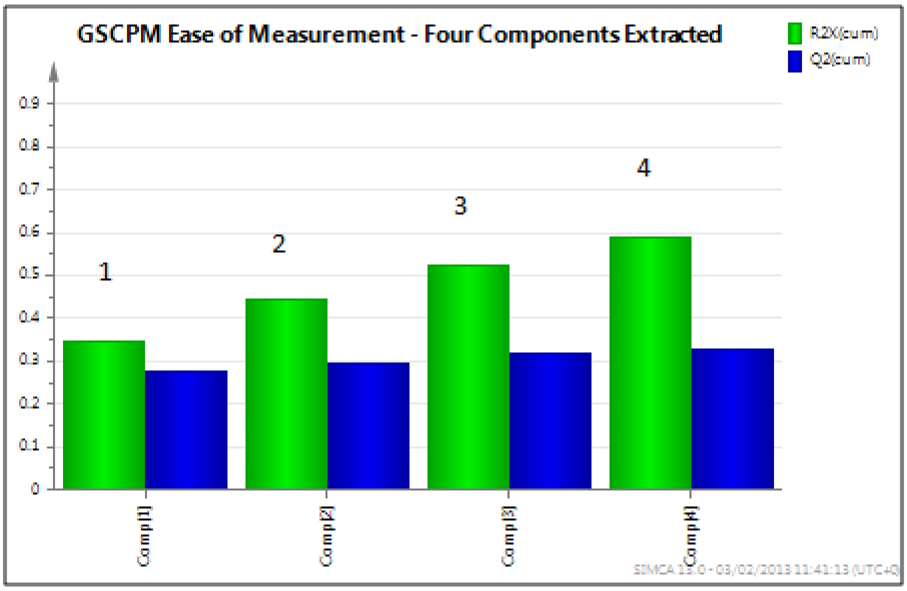


Figure 9.18 – Factor Extraction in SIMCA-13™ (Ease of Measurement – Impact)

Figure 9.19 shows, for the same dataset, the score plot which summarises the relationships amongst the respondents for Question Four. This indicated a large clustering of respondents across the middle of the quadrant indicating that there are groups of respondents which share similar and differing views on GSCPM ease of measurement within Components One and Two (see red circle demarking this group). Some respondents view certain GSCPM variables as positive (very easy to measure) and some as negative (very difficult to measure) and those close to the central axis as straight forward to measure.

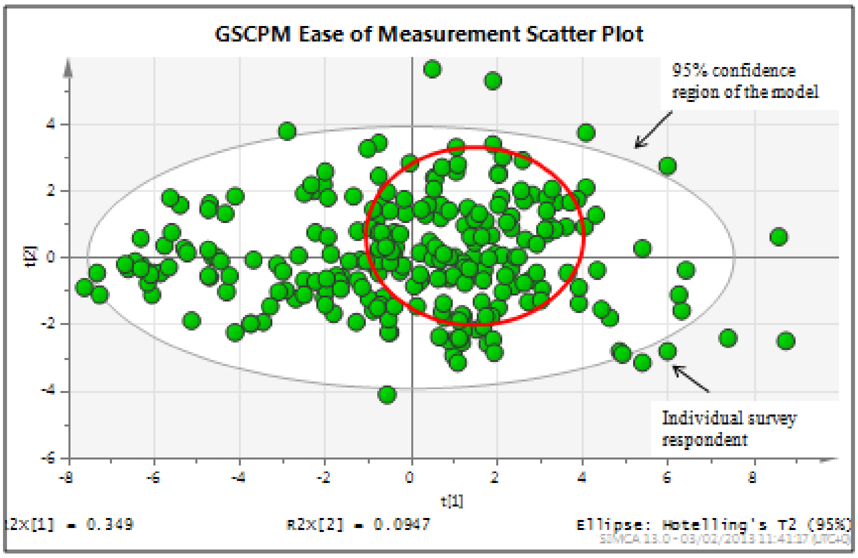


Figure 9.19 – Score Plot Summarising the Relationship between Survey Respondents

An asessment was made using SIMCA-13™ to understand which GSCPM variables load onto each of the four ease of measurement components (Table 9.20). The same methodology and re-coding was applied by the author as in the usefulness dataset.

Table 9.20 – Which GSCPM variables load onto each component (EASE OF MEASUREMENT)

GSCPM Ease of Measurement variables	GSCPM category	Component 1	Component 2	Component 3	Component 4
Fuel consumption measures	Transport	+	+	+	-
Vehicle running costs	Transport	+	+	+	-
Vehicle mileage measures	Transport	+	+	+	0
Cost measures (e.g. cost of running your warehouse, fleet etc)	Cost	+	0	-	-
Warehouse utilisation measures (e.g. pallet occupancy)	Warehouse	+	0	-	-
Water consumption measures	Utilities	+	0	-	+
Gas consumption measures	Utilities	+	0	-	+
Warehouse efficiency measures	Warehouse	+	0	-	-
Packaging consumption measures	Packaging	+	-	-	-
No of pallet movements or touches per delivery	Warehouse	+	-	-	-
Vehicle fill/utilisation measures (e.g. empty running)	Transport	+	-	+	-
No of container unit movements (TEU)	Transport	+	-	-	-
Fuel consumed per item/case/pallet delivered	Transport	+	-	0	-
Resource efficiency (raw materials, asset utilisation)	Efficiency	+	-	-	0
Electricity consumption measures	Utilities	0	0	-	+
Employee training (environmental training)	People	0	0	-	0
Driver behaviour	People	0	0	+	-
Employee travel	People	0	0	-	+
Waste recycling measures	Waste	0	-	-	0
Energy used per item/case/pallet delivered	Energy	0	-	0	-
Carbon emissions per item/case/pallet delivered	Carbon	0	-	0	0
Carbon emissions of an activity	Carbon	0	-	0	0
Overall company carbon footprint measures	Carbon	0	-	0	+
Greenhouse gas emissions (nitrous oxide, methane etc)	GHG	0	-	0	0
Overall supply chain carbon footprint measures	carbon	0	-	0	0

Four definitive constructs emerge from this data:

1. Transportation/Warehousing/Energy
2. Transportation
3. Transportation/People
4. Energy/Utilities

This indicated that there are four groups of respondents who share similar views on GSCPM ease of measurement. For example, within Component One, there are a group of respondents who view the transport, warehousing and energy GSCPM variables as very easy to measure and generally find most other GSCPM variables straight forward to measure. This is the largest group of respondents and can be seen clearly on the score plot clustering together in the right hand side of the quadrant under Component One (T1) (Figure 9.19) as in the usefulness dataset. Component Two on the otherhand describes a group of survey respondents who view the transport GSCPM variables as very easy to measure but do not find the carbon/GHG emissions as easy to measure. Component Two is describing a very transport focused industry group. On the other hand, Component Three describes a group of survey respondents who view the transport GSCPM variables as very easy to measure (as in Component Two) but they also find the driver behaviour/pallet movements as exceptionally easy to measure. They do not find the warehouse GSCPM variables as easy to measure. This describes a more senior/generic group of transport focused repondents in contrast to Component Two who are very functionally focused. Finally, the Component Four respondents view the energy/employee travel GSCPM variables as very easy to measure but do not find warehouse/transport as easy to measure. The four emerging constructs mirror those identified in the Phase One focus groups and are similar to those components identified in the usefulness dataset. Generally no component group found the carbon/GHG emission GSCPM variables as easy to measure with the exception of Component Four, which found the overall company carbon footprint as easy to measure. This is in line with the authors expectations that carbon emission measurement of the supply chain is difficult and complex to measure.

The next step of the PCA process is to assess if each of the four components (constructs) are made up of particular types of respondents; for example, do particular occupations or industrial sector respondents view GSCPM ease of measurement in different ways. The four components were assessed independently for occuption and sectoral differences and the results are presented in Table 9.21.

Table 9.21 Four Components assessed by Occupation and Industrial Sector (EASE OF MEASUREMENT)

Ease of Measurement Components	GSCPM Category	Occupation	Sector	Ease of Measurement Views
C1	Transport & Warehousing/Energy	Logistics Manager (20), Other (18), Supply Chain Manager (13), Logistics Director (5), Supply Chain Director (4) and Environmental Manager (1)	Transportation & warehousing (25), Manufacturing (13), Other (8), Retail (6), Educational Services (3), Public Administration (2), Arts, entertainment and recreation (1), Mining (1), Professional, Scientific, and Technical Services (1) and Wholesale Trade (1)	These respondents find most GSCPM as easy to measure but particuarly the transport, warehousing and energy (as exceptionally easy to measure)
C2	Transport	Logistics Manager (9), Supply Chain Manager (8), Other (4), Logistics Director (3), Transport/Carrier Manager (2), CEO (1) and Environmental Manager (1)	Transportation and Warehousing(10), Retail (5) Other (3), Professional, Scientific, and Technical Services (2), Healthcare and social assistance (2), Manufacturing (2), Arts, entertainment and recreation (1), Mining (1), Public Adminstration (1) and Wholesale Trade (1)	These respondents find the transport (vehicle) GSCPM as exceptionally easy to measure BUT do not find the carbon/GHG GSCPMs as easy to measure
C3	Transport	Other (6), Logistics Manager (5), Transport/Carrier Manager (3), Environmental Manager (1), Logistics Director (1), Managing Director (1) and Supply Chain Manager (1)	Transportation and Warehousing (7), Other (4), Construction (2), Manufacturing (1), Mining (1), Professional, Scientific, and Technical Services (1), Public Administration (1) and Retail (1)	These respondents find the transport GSCPM as exceptionally easy to measure BUT do not find the warehouse GSCPMs as easy to measure
C4	Energy & Employee Travel	Other (5), Logistics Director (3), Logistics Manager (3), Transport/Carrier Manager (2), Environmental Manager (1), Managing Director (1) and Supply Chain Manager (1)	Transportation and Warehousing (4), Other (4), Educational Services (2), Arts, entertainment and recreation (1), Construction (1), Information (1), Professional, Scientific, and Technical Services (1), Public administration (1) and Wholesale Trade (1)	These respondents find the energy and employee travel GSCPM as exceptionally easy to measure BUT do not find the warehouse and transportation GSCPM as easy to measure

In summary, Component One (transportation and warehousing/energy) is made up of respondents who are are logistics managers, supply chain mangers and others mainly from the transportation and warehousing, manufacturing and other sectors. They find most GSCPM variables as easy to measure but find the transportation, warehousing and energy GSCPM variables as exceptionally easy to measure. Component Two is made up of respondents who are logistics managers, supply chain managers and others from the transportation and warehousing, retail and other sectors. They find the transportation GSCPM variables as exceptionally easy to measure but do not find the carbon/GHG emissions GSCPM variables easy to measure. Component Three on the otherhand are made up of respondents who are others, logistics managers, transportation/carrier managers from the transportation and warehousing, other and construction sectors. They find the transportation GSCPM variables as exceptionally easy to measure but do not find the warehousing GSCPM variables easy to measure. Finally, Component Four is made up of respondents who are: others, logistics directors, logistics managers from the transportation and warehousing, other and educational services sectors. They view the energy and people travel GSCPM variables as exceptionally/very easy to measure but do not find the transportation and warehouse GSCPM variables as easy to measure. Transport is a dominant construct within the ease of measurement PCA analysis featuring across three of the components. This indicated that most respondents find the transportation GSCPM variables as exceptionally easy to measure. This is intuitive and in line with the authors expectation as the sample of survey respondents are made up largely of respondents from the transportation and warehousing sector. However, it is interesting to see that different capabilities emerge on ease of measurement with non transportation and warehousing sector respondents; for example, Component Four respondents view GSCPM variables such as energy consumption (electricity, gas and water consumption) as exceptionally easy to measure which is counter intuitive to the rest. Component Four, therefore, represent the views of different sectors with different demands, capabilities and views of the GSCPM world.

The dendrogram from Section Three was re-run in Minitab™ based on four clusters (four components) to see if it also identified the four emerging constructs identifed in this PCA ease of measurement data set (Figure 9.20).

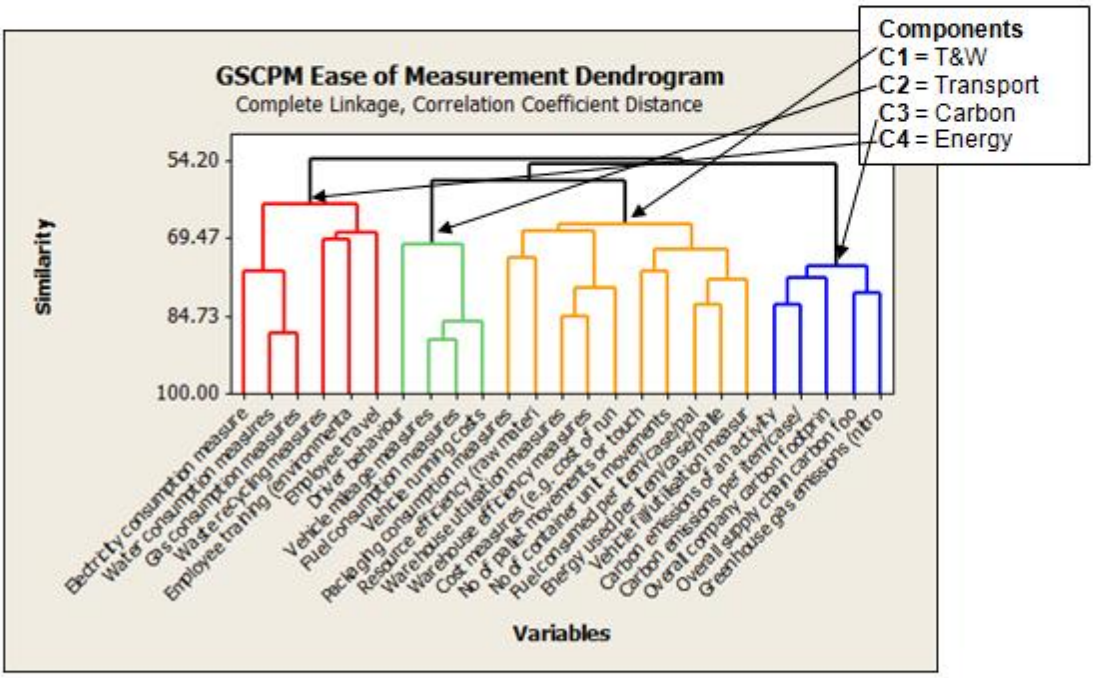


Figure 9.20 - Re-run Dendrogram based on four components (EASE OF MEASUREMENT)

The Dendrogram shows four distinct clusters of GSCPM variables which mirror the results explained by the four components in the PCA analysis. The test was completed to understand if the survey respondents scored the ease of measurement of each GSCPM in a similar way and if there were a group of variables which had very similar response characteristics. Four groups of response characteristics were identified:

Cluster 1 = Transportation and Warehousing (Component One)

Cluster 2 = Transportation (Components Two and Three)

Cluster 3 = Carbon (Component Two – find these difficult to measure)

Cluster 4 = Energy (Component Four – find these easy to measure)

In summary, the PCA modelling has revealed that there are four significant components for the ease of measurement category. There are four emerging constructs: 1) transportation and warehousing/energy, 2) transportation, 3) transportation/people and 4) energy which are similar to those constructs identified in the usefulness PCA. This means that those GSCPM variables which respondents find useful are the ones which they also find easy to measure and respondents within these groups share similar views on the GSCPM ease and usefulness. Generally, the respondents across all three components (Components One, Two and Three) view the transportation GSCPM variables as exceptionally easy to measure, with the exception of Component Four. What differentiates Components One, Two and Three is the GSCPM variables they find difficult to measure; for example, Component Two respondents find carbon emission GSCPM variables difficult to measure whereas Component Three find warehousing based GSCPM variables difficult to measure. This could be due to their differing occupations and sectors. Component Four describes a group of respondents who have a differing view on ease of measurement from the rest; they find energy and employee travel as exceptionally easy to measure and these respondents come from a range of different sectors and potentially highlight a non–transport and warehousing sector group. They also found the overall company carbon footprint as exceptionally/very easy to measure which is unique and describes a different capability and view compared to the other respondents. Component Four describes a more senior/generic set of respondents such as logistics directors and managing directors which have more holistic and strategic views of GSCPM ease of measurement. They are less concerned about the detail and more about the bigger picture.

In Section Three, three GSCPM variables were identified as the easiest to measure: 1) vehicle mileage, 2) electricity consumption and 3) fuel consumption. Two of which are transport based GSCPM variables. This reinforced the fact that most respondents find the transport based GSCPM variables the easiest to measure. The four components show that generally respondents view the GSCPM ease of measurement in a similar way and this can be explained by the focus on transportation and warehousing in the survey sampling frame. Component Four does identify that sector differences exist in the way respondents view GSCPM ease of measurement and this is explained by their differing sector focus and capabilities. For example, in the Phase One focus groups, the public sector where more advanced in their GSCPM and reporting than private sector participants. It highlights that those GSCPM variables relating to carbon emissions, greenhouse gas emissions or resource efficiency are viewed as ‘difficult to measure’ by most respondents and this is the reason why they are not extensively used and not classed as useful by some respondents. This is not to say these GSCPM variables are not useful to all respondents (Component Three – usefulness); however, it is just that companies do not yet have the capabilities to measure them.

9.3.5.3 GSCPM Usefulness and Ease of Measurement (BOTH)

The final stage of the PCA process is to view the usefulness and ease of measurement dataset together to reveal any underlying relationships and help to draw overall conclusions. Five components were extracted and classed as significant with the combined dataset (Figure 9.21). Component One accounted for 33 per cent of the total model fit, Component Two accounted for eight per cent, Component Three was seven per cent, Component Four accounted for six per cent and finally Component Five accounted for six per cent of the model fit. The predictive ability of the model declined when a sixth or high-order components are added. Thus five components were extracted and assessed. This component structure closely reflected the component structure identified in the individal usefulness and ease of measurement PCA dataset.

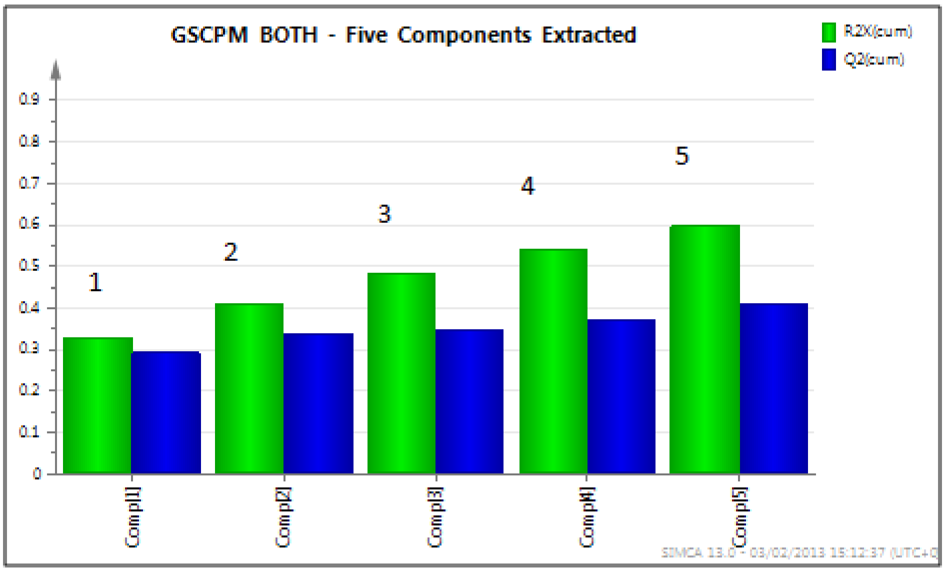


Figure 9.21 – Factor Extraction in SIMCA-13™ (BOTH)

It was evident as in the usefulness and ease of measurement datasets that there is a large cluster of observations in the middle of the right-hand quadrant on the score plot (Figure 9.22). This indicated that most respondents shared similar views on which GSCPM variables are useful and easy to measure. There are however, other groups of respondents who do not share these views, which are in different parts of the score plot quadrant (upper left and lower left) which must be assessed to understand their views and characteristics.

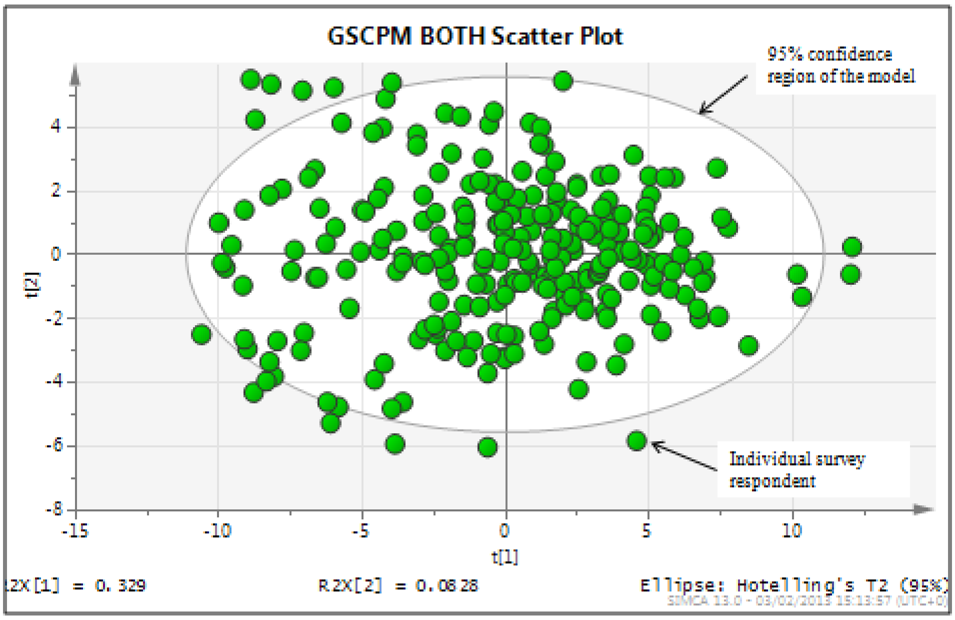


Figure 9.22 – Score plot summarising the relationship between survey respondents (BOTH)

To understand which GSCPM variables these are, the researcher then reviewed which useful and ease of measurement GSCPM variables loaded upon each of the five components (Table 9.22).

Table 9.22 – Which GSCPM variables load onto each component (USEFULNESS AND EASE OF MEASUREMENT)

GSCPM variables (BOTH)	GSCPM category	Component 1	Component 2	Component 3	Component 4	Component 5
U1Warehouse efficiency measures	Warehouse	+	-	-	0	-
U1Warehouse utilisation measures (e.g. pallet occupancy)	Warehouse	+	-	-	0	-
U1Vehicle fill/utilisation measures (e.g. empty running)	Transport	+	0	0	0	-
E1Driver behaviour	People	0	+	-	-	-
U1Fuel consumption measures	Transport	0	+	0	0	-
U1Vehicle mileage measures	Transport	0	+	0	0	-
U1Vehicle running costs	Transport	0	+	0	0	-
U1Driver behaviour	People	0	+	0	0	-
E1Vehicle running costs	Transport	0	+	-	0	0
E1Vehicle mileage measures	Transport	0	+	-	0	0
E1Fuel consumption measures	Transport	0	+	-	0	0
E1Employee travel	People	0	-	0	-	+
E1Gas consumption measures	Utilities (Energy)	0	-	-	0	+
E1Water consumption measures	Utilities (Energy)	0	-	-	0	+
E1Electricity consumption measures	Utilities (Energy)	0	-	-	0	+
U1Cost measures (e.g. cost of running your warehouse, fleet etc)	Cost	0	-	-	+	-
E1No of pallet movements or touches per delivery	Warehouse	0	-	-	-	-
U1No of pallet movements or touches per delivery	Warehouse	0	-	-	-	-
U1No of container unit movements (TEU)	Transport	0	-	-	-	-
U1Fuel consumed per item/case/pallet delivered	Transport	0	-	0	-	-
U1Greenhouse gas emissions (nitrous oxide, methane etc)	GHG	0	-	+	-	-
U1Energy used per item/case/pallet delivered	Energy	0	-	0	-	-
U1Carbon emissions per item/case/pallet delivered	Carbon	0	-	0	-	-
U1Packaging consumption measures	Warehouse	0	-	-	0	-
U1Employee travel	People	0	-	+	0	-
U1Employee training (environmental training)	People	0	-	0	0	-
U1Resource efficiency (raw materials, asset utilisation)	Efficiency	0	-	0	0	-
U1Waste recycling measures	Waste	0	-	0	+	0
U1Water consumption measures	Utilities (Energy)	0	-	0	+	0
U1Gas consumption measures	Utilities (Energy)	0	-	0	+	0
U1Electricity consumption measures	Utilities (Energy)	0	-	0	+	0
E1Packaging consumption measures	Warehouse	0	-	-	-	0
E1No of container unit movements (TEU)	Transport	0	-	-	-	0
E1Greenhouse gas emissions (nitrous oxide, methane etc)	GHG	0	-	0	-	0
E1Resource efficiency (raw materials, asset utilisation)	Efficiency	0	-	-	-	0
U1Overall company carbon footprint measures	Carbon	0	-	+	-	0
U1Carbon emissions of an activity	Carbon	0	-	+	-	0
E1Overall supply chain carbon footprint measures	carbon	0	-	0	-	0
E1Overall company carbon footprint measures	Carbon	0	-	0	-	0
E1Carbon emissions per item/case/pallet delivered	Carbon	0	-	0	-	0
U1Overall supply chain carbon footprint measures	carbon	0	-	0	-	0
E1Waste recycling measures	Waste	0	-	0	0	0
E1Warehouse utilisation measures (e.g. pallet occupancy)	Warehouse	0	-	-	0	0
E1Warehouse efficiency measures	Warehouse	0	-	-	0	0
E1Vehicle fill/utilisation measures (e.g. empty running)	Transport	0	0	-	-	0
E1Fuel consumed per item/case/pallet delivered	Transport	0	0	-	-	0
E1Energy used per item/case/pallet delivered	Energy	0	0	-	-	0
E1Carbon emissions of an activity	Carbon	0	0	0	-	0
E1Employee training (environmental training)	People	0	0	-	0	0
E1Cost measures (e.g. cost of running your warehouse, fleet etc)	Cost	0	0	-	0	0

Five definitive constructs emerged from this data:

1. Utilisation
2. Transportation
3. Air emissions (carbon)
4. Energy Consumption/Cost
5. Energy/Travel

There are five groups of respondents who share similar views on GSCPM usefulness and ease of measurement:

Component One (Utilisation) described a group of respondents who find the warehouse/vehicle utilisation based GSCPM variables exceptional/very useful and find most other GSCPM variables straight forward to measure and useful. This group of respondents find three GSCPM variables exceptionally useful, these three GSCPM variables are underpinned by the utiliation/efficiency constructs identified in Phase One (warehouse and vehicle utiliation measures).

Component Two (Transportation only) described a group of respondents who view specifically the transportation GSCPM variables as exceptionally/very useful and very easy to measure but they do not find anything else useful or easy to measure.

Component Three (Air Emissions/Carbon) described a group of respondents who view the carbon footprint/GHG emissions/employee travel GSCPM variables as exceptionally/very useful but they do not find the transportation and warehouse functional GSCPM variables as easy to measure or that useful.

Component Four (Energy Consumption/Cost) described a group of respondents who view the energy (utilities) and cost GSCPM variables as exceptionally/very useful but do not find some of the carbon, transportation and warehousing GSCPM variables as useful or easy to measure.

Component Five (Energy/employee travel) described a group of respondents that view the energy (electricity, water and gas consumption) and employee travel GSCPM variables as exceptionally/very easy to measure and useful. They also view some of the carbon, transportation and warehousing GSCPM variables as useful and straight forward to measure.

The next step of the PCA process is to assess if each of the five components (constructs) are made up of particular types of respondents; for example, do particular occupations or industrial sector respondents view GSCPM usefulness and ease of measurement in different ways. The five components were assessed for occupation and sector differences and the results are presented in Table 9.23.

Table 9.23 Five Components assessed by Occupation and Industrial Sector (BOTH)

BOTH Components	GSCPM Category	Occupation	Sector	BOTH Views
C1	Utilisation	Logistics Manager (28), Other (24), Supply Chain Manager (14), Logistics Director (7), Environmental Manager (6), Supply Chain Director (4), Managing Director (4), CEO (2), Transport/Carrier Manager (1)	Transportation and Warehousing (40), Manufacturing (15), Other (12), Retail (9), Professional, Scientific, and Technical Services (3), Arts, entertainment and recreation (2), Educational Services (2) and Public Administration (2), Healthcare and social assistance (1), Management of Companies and Enterprises (1), Utilities (1) and Wholesale Trade (1)	This group of respondents find the Utilisation GSCPMs very useful and find most other GSCPMs straight forward to measure and useful. Typical of a transport and warehouse view.
C2	Transport	Other (15), Transport/Carrier Manager (8), Supply Chain Manager (7), Logistics Manager (7), Environmental Manager (2), Logistics Director (2), Managing Director(1) and Supply Chain Director (1)	Transportation and Warehousing (18), Other (9), Public Administration (4), Construction (2), Manufacturing (2), Mining (2), Professional, Scientific, and Technical Services (2), Healthcare and social assistance (1), Retail (1), Utilities (1) and Wholesale Trade (1)	This group of respondents find the Transport GSCPMs only very useful and very easy to measure BUT do not find anything else useful or easy to measure. Typical of a transport focused view.
C3	Carbon	Other (13), Supply Chain Manager (4), Transport/Carrier Manager (4), Managing Director (3), Logistics Manager (2), Logistics Director (1) and Supply Chain Director (1)	Other (9), Transportation and Warehousing (4), Construction (3), Public Administration (2), Manufacturing (2), Professional, Scientific, and Technical Services (2), Educational Services (2), Information (1), Management of Companies and Enterprises (1), Retail (1) and Wholesale Trade (1)	This group of respondents find the carbon footprint/green house gas emissions/employee travel GSCPMs as very useful BUT they do not find the transport and warehouse functional GSCPMs easy to measure or that useful. Typical of a overall supply chain view.
C4	Energy Consumption & Cost	Logistics Manager (11), Supply Chain Manager (8), Other (6), Logistics Director (3), Environmental Manager (2), Transport/Carrier Manager (2) and CEO (1)	Transportation and Warehousing (12), Other (6), Manufacturing (4), Retail (2), Professional, Scientific, and Technical Services (2), Healthcare and social assistance (2), Accommodation and food (1), Arts, entertainment and recreation (1), Educational Services (1), Mining (1) and Wholesale Trade (1)	This group of respondents find the energy (utilities) consumption and cost GSCPMs as very useful BUT do not find some of the carbon, transport and warehousing GSCPMs as useful or easy to measure. Typical of a energy/cost group
C5	Energy & Employee travel	Logistics Manager (9), Other (8), Supply Chain Manager (8), Logistics Director (6), Transport/Carrier Manager (2), Supply Chain Director (2) and Managing Director (1)	Transportation and Warehousing (11), Manufacturing (7), Other (4), Educational Services (3), Wholesale Trade (2), Arts, entertainment and recreation (1), Construction (1), Information (1), Professional, Scientific, and Technical Services (1), Public administration (1), Real Estate and Rental and Leasing (1), Retail (1)and Utilities (1)	This group of respondents find the energy (utilities) and employee travel GSCPMs as very easy to measure BUT do not find some of the carbon, transport and warehousing GSCPMs as useful however they find them straight forward to measure. Typical of a energy and travel group

In summary, Component One (utilisation) is made up of respondents who view the utilisation construct as exceptionally useful and view most other GSCPM variables as straight forward to measure and useful. They comprised mainly logistics managers, others and supply chain managers from the transportation and warehousing, manufacturing and others sectors.

Component Two, is made up of respondents who view the transport (functional/vehicle) GSCPM variables as exceptionall/very useful and exceptionally/very easy to measure. They comprised: others, supply chain managers and transport managers and originate from the transportation/warehousing, other and public administration sectors.

Component Three respondents view the air emissions (carbon footprint/GHG emission/employee travel) GSCPM variables as exceptionally/very useful but they do not find the transportation and warehouse functional GSCPM variables easy to measure or that useful. The respondents of Component Three originate from the others, transportation and warehousing and construction sectors.

Component Four described a group of respondents who view the energy consumption and cost GSCPM variables as exceptionally/very useful but they did not view some of the carbon and transportation and warehousing GSCPM variables as useful or easy to measure. They are logistics managers, supply chain managers and others from the transportation/warehousing, manafacturing and other sectors.

Finally Component Five described a group of respondents who are logistics managers, others and supply chain managers also from the transportation/warehousing, manuafacturing and other sectors. They view energy and employee travel GSCPM variables as very easy to measure but do not find some of the carbon, transport and warehousing GSCPM variables as useful, however they find them straight forward to measure.

The dendrogram from Sections Two and Three (combined) was re run in Minitab™ based on five clusters (five components) to see if it also identified the five emerging constructs identifed in this PCA data set for both (Figure 9.23).

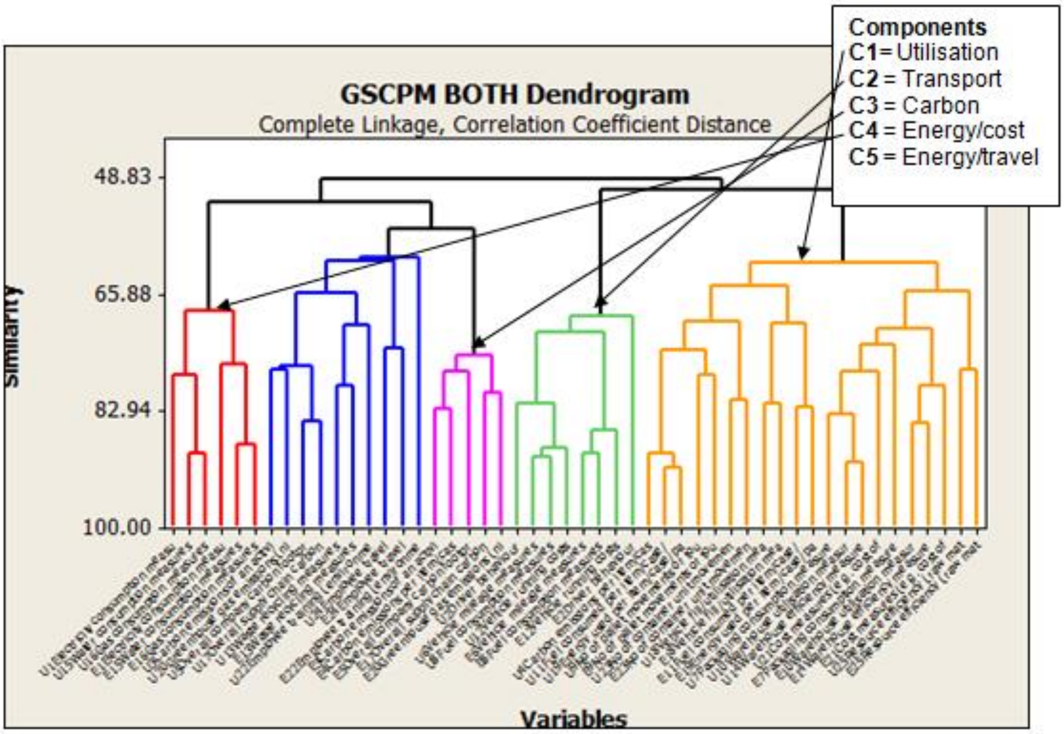


Figure 9.23 Re-run Dendrogram based on five components (BOTH)

The Dendrogram showed five distinct clusters of GSCPM variables which mirror the results explained by the five components in the PCA analysis. The test was completed to understand if the survey respondents scored both usefulness and ease of measurement of each GSCPM in a similar way and if there were a group of variables which had very similar response characteristics. Five groups of response characteristics were identified:

Cluster 1 = Utilisation
Cluster 2 = Transportation
Cluster 3 = Carbon
Cluster 4 = Energy and cost
Cluster 5 = Energy and travel

In summary, there are six underlying components which are associated with GSCPM importance. These constructs are: buildings, utilisation, energy, transport, air emission (GHGs) and waste. Furthermore, the results have revealed sector (public versus private) and potentially occupational differences in the way respondents view GSCPM importance (stategic, tactical and operational). Components Three, Four and Five identify a different/future view of GSCPM importance compared to the transportation and warehousing sector focus, potentially identifying an evolutionary trend in GSCPM development, in that some sectors are more advanced than others (public sector) and they are measuring the 'to be state' GSCPM variables, whereas other sectors (transportation and warehousing) are measuring 'as is state' and very much driven by cost.

The next sections will now turn to reviewing the enablers and barriers to measuring GSCPM. This will help to understand the root cause behind GSCPM and explain why certain GSCPM variables are classed as important by certain groups of survey respondents.

9.3.6 Section Four - Green Supply Chain Performance Measures: ENABLERS

Section Four (Question Five) was concerned with answering RQ4 by understanding the enablers to organisations measuring GSCPM. In conjunction with Section Five the results will help to understand the root causes behind GSCPM.

Section Four consisted of one closed question:

5. *The list of statements below focus on the various enablers with regard to measuring green performance in supply chains. Please tick the button on the scale below that best indicates the extent to which you agree or disagree with the following statements in the context of your company?*

Thirteen enablers were identified during Phase One and these were converted by the author into eighteen individual statements which could be survey tested. The respondents were presented with a list of eighteen enabler statements each with a corresponding five-point Likert scale in which they could indicate their strength of agreement with each statement. Table 9.24 details a summary of the results from Question Five. The cells highlighted in bold indicate those statements with the highest scores in each category.

Table 9.24 – A Summary of the GSCPM Enabler Survey Responses

Enabler Statement	Strongly disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Rating Average
Desire to reduce cost is an enabler	6	13	33	116	**84**	4.03
Improving operational efficiency is an enabler	5	10	33	136	68	4.00
Government regulation and legislation are enablers	7	11	34	**141**	59	3.93
Reducing energy consumption is an enabler	5	9	45	139	54	3.90
A genuine care for the environment is an enabler	7	11	55	126	53	3.82
The CEO/Board of Directors are an enabler	7	15	58	123	49	3.76
Employee involvement is an enabler	9	11	60	130	42	3.73
Re-using, recycling materials and packaging is an enabler	10	11	58	137	36	3.71
Collaboration with customers is an enabler	8	20	62	135	27	3.61
Pressure from customers is an enabler	10	28	59	120	35	3.56
ISO 14001 certification is an enabler	5	22	90	107	28	3.52
Product brand is an enabler	11	22	79	112	28	3.49
Public pressure is an enabler	10	27	71	120	24	3.48
Collaboration with suppliers is an enabler	7	24	82	120	19	3.48
Carbon emissions reduction is an enabler	9	26	89	102	26	3.44
Pressure from competitors is an enabler	14	27	74	107	30	3.44
Suppliers are enablers	8	**47**	72	113	12	3.29
Pressure from retailers is an enabler	**17**	41	**99**	80	15	3.14

The enabler statement which received the highest average rating was *'desire to reduce cost is an enabler'* whilst the statement receiving the lowest average rating was '*pressure from retailers is an enabler'*. However, all the statements rated relatively high indicating the respondent's level of agreement with the statements.

In order to test whether there was any statistically significant association between each GSCPM enabler statement and whether respondents agreed or disagreed with these statements, a Pearson's Chi-square test was applied to the data. This test generated a Pearson Chi-square of 1199 and a p-value of 0.000. The researcher regarded this as being statistically significant as p-values of less than 0.05 are significant. Therefore, it can be said that significant differences exist between the observed and expected counts on some of the eighteen GSCPM enabler statements and a relationship therefore exists between the type of statement and the respondent's strength of agreement to this statement.

For example, the largest statistical differences were observed on '*desire to reduce cost is an enabler'* and *'improving operational efficiency is an enabler'* with the observed counts significantly greater than expected in the strongly agree category. On the other hand, statements such as '*pressure from retailers'* or '*suppliers are enablers'* received observed counts significantly greater than expected in the strongly disagree and disagree categories.

It is therefore evident from these results that reducing cost, the need to be operationally efficient and government legislation are key drivers for respondents measuring GSCPM.

The next section will now review the barriers to measuring GSCPM.

9.3.7 Section Five - Green Supply Chain Performance Measures: BARRIERS

Section Five (Question Six) was concerned with answering RQ4 by understanding the barriers to organisations measuring GSCPM. In conjunction with Section Four the results will help to understand the root causes behind GSCPM.

Section Five consisted of one closed question:

6. *The list of statements below focus on the organisational barriers to measuring green performance in supply chains. Please tick the button on the scale below that best indicates the extent to which you agree or disagree with the following statements in the context of your company?*

The respondents were presented with the list of seventeen barrier statements each with a corresponding five-point Likert scale in which they could indicate their strength of agreement with each statement. Table 9.25 details a summary of the results from Question Six. The cells highlighted in bold indicate those statements with the highest scores in each category.

Table 9.25 – A Summary of the GSCPM Barrier Survey Responses

Enabler Statement	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Rating Average
Cost is a barrier	4	18	52	**140**	35	3.74
The complexity of the supply chain is a barrier	5	33	66	103	**42**	3.58
Obtaining data is a barrier	4	38	55	115	37	3.57
Too many disparate governing bodies and regulations is a barrier	6	20	81	109	33	3.57
Lack of reporting/measurement tools is a barrier	6	33	64	114	32	3.53
Lack of time is a barrier	9	35	53	123	29	3.51
Different sectors have different challenges is a barrier	5	35	75	113	21	3.44
Knowing who should measure it in the supply chain is a barrier	5	42	67	113	22	3.42
Lack of demand/requirement for measurement is a barrier	5	39	78	106	21	3.40
Knowing what to measure in the supply chain is a barrier	6	48	60	112	23	3.39
Suppliers unwilling to exchange data is a barrier	8	39	78	101	23	3.37
Lack of employee training and commitment is a barrier	9	46	62	110	22	3.36
Lack of legitimacy 'Greenwashing' is a barrier	7	23	**115**	81	23	3.36
The scope of the supply chain is a barrier	5	48	87	79	30	3.33
The recession/austerity measures are a barrier	**16**	39	87	87	20	3.22
Employee values and attitudes are a barrier	9	**65**	68	87	20	3.18
Trust in the supply chain is a barrier	9	53	97	74	16	3.14

The barrier statement which received the highest average rating was '*cost is a barrier*' whilst the statement receiving the lowest average rating was '*trust in the supply chain is a barrier*'. However, like the enabler statements, the respondents all rated the barrier statements relatively highly indicating the respondent's level of agreement with the majority of the statements.

In order to test whether there was any statistically significant association between each GSCPM barrier statement and whether respondents agreed or disagreed with these statements; a Pearson's Chi-square test was applied to the data. This test generated a Pearson Chi-square of 218 and a p-value of 0.000. The researcher regarded this as being statistically significant as p-values of less than 0.05 are significant. Therefore, it can be said, that significant differences exist between the observed and expected counts on some of the GSCPM barrier statements and a relationship therefore exists between the type of statement and the respondent's strength of agreement to this statement.

For example; the largest statistical differences were observed on '*employees values and attitudes are a barrier*' and '*the recession/austerity measures are a barrier*' with the observed counts significantly greater than expected in the strongly disagree category. Also, '*the complexity of the supply chain is a barrier*' received higher than expected counts in the strongly agree category, indicating that this was important to the respondents.

It is therefore evident from these results that reducing cost or cost to invest in greening, the complexity of the supply chain and being able to obtain the correct data are key barriers to measuring GSCPM. Cost is not only a driver but a barrier to measuring GSCPM. Table 9.26 summarises the top five enablers and barriers identified in the survey which answer RQ4. The next section will now summarise the benefits to measuring GSCPM which help to reinforce the results from Questions Five and Six.

Table 9.26 – The Top Five Enablers and Barriers to Measuring GSCPM

Top 5 Enablers	Top 5 Barriers
Desire to reduce cost	**Cost is a barrier**
Improving operational efficiency	**Complexity of the supply chain**
Government regulation/legislation	**Obtaining data is a barrier**
Reducing energy consumption	**Too many disparate governing bodies and regulations**
A genuine care for the environment	**Lack of reporting/measurement tools**

9.3.8 Section Six - Green Supply Chain Performance Measures: BENEFITS

Section Six (Question Seven) was concerned with answering RQ4 by understanding the direct benefits to organisations measuring GSCPM. In conjunction with Questions Five and Six the results will help to underpin the root causes behind GSCPM.

Section Six consisted of one closed question:

7. *The list of statements below focus on the organisational benefits of measuring green performance in supply chains. Please tick the button on the scale below that best indicates the extent to which you agree or disagree with the following statements in the context of your company?*

The respondents were presented in the survey with the list of eleven benefit statements each with a corresponding five-point Likert scale in which they could indicate their strength of agreement with each statement. Table 9.27 details a summary of the results from Question Seven.

Table 9.27 – A Summary of the GSCPM Benefit Survey Responses

Benefits Statements	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Rating Average
Measuring helps us to reduce waste	1	7	34	**138**	**66**	4.06
Measuring helps us to be more operationally efficient	3	6	41	132	64	4.01
Measuring helps us to innovate and continuously improve	2	8	42	136	58	3.98
Measuring gives us an improved image and reputation	2	7	38	152	47	3.96
Measuring helps to reduce cost	2	23	54	118	49	3.77
Measuring reduces our risk of consumer/public criticism	2	20	59	132	33	3.71
Measuring helps to improve profitability	4	15	76	114	37	3.67
Measuring gives us competitive advantage	**5**	21	73	122	25	3.57
Measuring helps us to collaborate with our customers	3	20	85	116	22	3.54
Measuring helps us to collaborate with our suppliers	4	28	95	104	15	3.4
Measuring gives us improved customer loyalty	4	**37**	**114**	73	18	3.26

The top three benefits identified to measuring GSCPM are to reduce waste, to be more operationally efficient and to continuously improve (Figure 9.24). A Pearson Chi-square test was applied to the data to see if there was a significant association between the types of statement and the strength of agreement to the statement. This test generated a Pearson Chi-square of 290 and a p-value of 0.000. The researcher regarded this as being statistically significant as p-values of less than 0.05 are significant. Therefore, it can be said, that significant differences exist between the observed and expected counts on some of the GSCPM benefit statements and a relationship therefore exists between the type of statement and the respondent's strength of agreement to this statement. For example, the statements with the most statistical differences in the strongly agree category are '*measuring helps us to be more operationally efficient'* and '*measuring helps us to reduce waste*'. However, most respondents disagreed with the statement that '*measuring gives us improved customer loyalty'*. It received significantly more counts than expected in the 'disagree' and 'strongly disagree' categories. Figure 9.24 identifies the top three benefits to measuring GSCPM in order of priority.

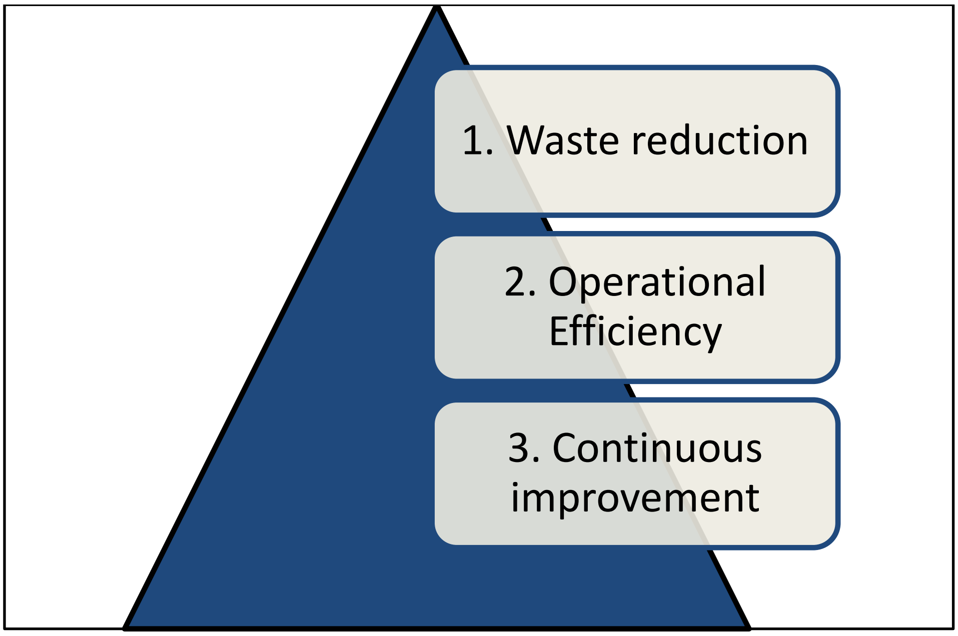


Figure 9.24 – The Top Three Benefits to Measuring GSCPM

The enablers, barriers and benefits data were then analysed through the PCA model in SIMCA-13 ™ to assess for any significant trends between the respondents view of the GSCPM enablers, barriers and benefit statements and their industrial sector. The purpose of conducting the PCA on the enablers, barriers and benefits is to identify any potential sector differences in what drives and prevents an organisation from measuring GSCPM. Equally, it helps to identify if there are any linkages between the enablers, barriers and the associated benefits, which are not obvious using traditional statistical techniques. Four components were extracted with an eigenvalue greater than two (Figure 9.25).

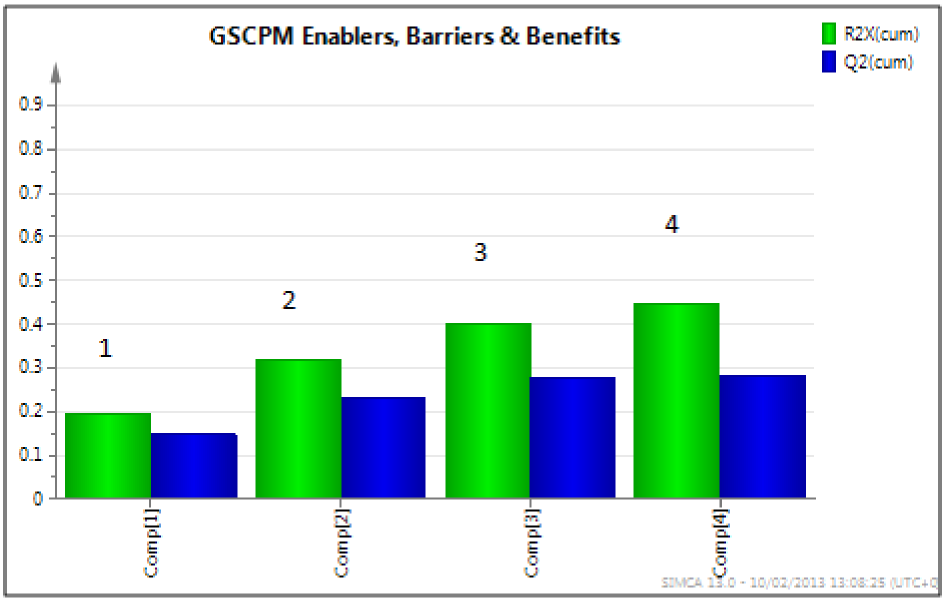


Figure 9.25 – Factor Extraction in SIMCA-13™ (Enablers, Barriers and Benefits)

The results are summarised in Table 9.28 and Table 9.29 and show that the transportation and warehousing, manufacturing and retail sectors strongly agree that operational efficiency is an enabler and benefit to measuring GSCPM (Component One), they also strongly agree that continuous improvement is an enabler. This group of respondents neither agree nor disagree with all other statements.

There is also a strong agreement across a number of sectors (within Component Two) on a set of barrier statements. For example the respondents strongly agree that the Who should measure? What should they measure? Where should the data come from? Lack of time, lack of direction from government bodies and the complexity and scope of the supply chain itself are all barriers to measuring GSCPM. These respondents generally disagree on all other statements.

There is a group of respondents (Component Three) that strongly agree that their customers, the competition and their brand drive them to measure GSCPM whereas data is definitely seen as a barrier to measurement.

Finally, Component Four describes a group of respondents that strongly agree that data and the supply chain itself is a barrier to measuring GSCPM and that operational efficiency, reducing energy consumption and cost are enablers.

Table 9.28 – Which GSCPM statements load onto each component (ENABLERS, BARRIERs and BENEFITS)

Statement	Component 1	Component 2	Component 3	Component 4
Improving operational efficiency is an enabler	+	-	0	+
Measuring helps us to be more operationally efficient	+	-	-	0
Measuring helps us to innovate and continuously improve	+	-	-	0
Obtaining data is a barrier	0	+	-	+
Knowing who should measure it in the supply chain is a barrier	0	+	-	+
Reducing energy consumption is an enabler	0	-	0	+
Desire to reduce cost is an enabler	0	-	0	+
Pressure from customers is an enabler	0	-	+	-
Suppliers are enablers	0	-	+	-
Product brand is an enabler	0	-	+	-
Pressure from competitors is an enabler	0	-	+	-
Too many disparate governing bodies & regulations is a barrier	0	+	-	-
Different sectors have different challenges is a barrier	0	+	-	-
Measuring reduces our risk of consumer/public critcism	0	-	-	-
Measuring gives us an improved image and reputation	0	-	-	-
Measuring helps us to collaborate with our customers	0	-	-	-
Measuring helps us to collaborate with our suppliers	0	-	-	-
Measuring gives us competitive advantage	0	-	-	-
Measuring gives us improved customer loyalty	0	-	-	-
Employee values and attitudes are a barrier	0	0	-	-
Lack of legitimacy 'Greenwashing' is a barrier	0	0	-	-
Suppliers unwilling to exchange data is a barrier	0	+	0	-
The recession/austerity measures are a barrier	0	+	0	-
Collaboration with suppliers is an enabler	0	-	0	-
Public pressure is an enabler	0	-	0	-
Collaboration with customers is an enabler	0	-	0	-
Pressure from retailers is an enabler	0	-	0	-
Cost is a barrier	0	0	0	-
Lack of employee training and commitment is a barrier	0	0	0	-
Knowing what to measure in the supply chain is a barrier	0	+	-	0
Lack of reporting/measurement tools is a barrier	0	+	-	0
The complexity of the supply chain is a barrier	0	+	-	0
Trust in the supply chain is a barrier	0	+	-	0
The scope of the supply chain is a barrier	0	+	-	0
Measuring helps us to reduce waste	0	-	-	0
Measuring helps to reduce cost	0	-	-	0
Measuring helps to improve profitability	0	-	-	0
Lack of demand/requirement for measurement is a barrier	0	+	0	0
Lack of time is a barrier	0	+	0	0
Government regulation and legislation are enablers	0	-	0	0
Re-using, recycling materials and packaging is an enabler	0	-	0	0
A genuine care for the environment is an enabler	0	-	0	0
ISO 14001 certification is an enabler	0	-	0	0
Carbon emissions reduction is an enabler	0	-	0	0
The CEO/Board of Directors are an enabler	0	-	0	0
Employee involvement is an enabler	0	-	0	0

Table 9.29 – Sector Difference – Enablers and Barriers to Measuring GSCPM

Component	View of Enablers and Barriers	Dominant Sectors
C1	Strongly agree that operational efficiency and continuous improvement are enablers	T &W, Manufacturing and Retail
C2	Strongly agree on a group of barriers (who, what, data, lack time, demand and reporting, the supply chain, too many disparate bodies)	T &W, Manufacturing and Professional, Scientific, and Technical Services
C3	Strongly agree that pressure from customers, competitors and brand are enablers and data is an barrier	T &W
C4	Strongly agree that data and the supply chain itself is a barrier and that operational efficiency, reducing energy consumption and cost is are enablers	T&W

These results clearly show that there are differences in what motivates and prevents certain companies from measuring GSCPM. It is evident from this analysis that there are links between the enablers of GSCPM, the perceived benefits of GSCPM and that operational efficiency and continuous improvement are key themes in the development of GSCPM. For instance, the T&W and Manufacturing respondents strongly agree that to improve operational efficiency and to continuously improve are key enablers to GSCPM; thus, there is a consensus of opinion over how they view GSCPM compared to other sectors which is statistically significant. This finding is useful in understanding how to get organisations bought into measuring GSCPM, so they can see the benefits clearly.

The next section will now review the reporting tools used by the respondents in measuring their supply chain performance and GSCPM.

9.3.9 Section Seven - Green Supply Chain Performance Measures: REPORTING

Section Seven (Question Eight) was concerned with answering RQ3 by understanding what reporting tools respondents used to measure their supply chain performance and if these tools could be used to integrate GSCPM.

Section Seven consisted of two questions:

8. *What supply chain performance measurement reporting tool does your company use? Please tick as many as apply:*

As in Question One, the survey respondents were presented with a list of nine reporting tools to which they could select as many as applied.

9. *What supply chain performance reporting tools would be appropriate to report your company green supply chain performance?*

The respondents were presented with the list of nine reporting tools each with a corresponding five-point Likert scale in which they could indicate their strength of agreement with each statement.

Figure 9.26 shows the percentage of survey respondents who currently used each of the nine reporting tools to measure their supply chain performance (as a per cent of total ticks) and Figure 9.27 shows it as a per cent of total respondents. The respondents were able to tick *'as many reporting tools as applied'* and there were 616 ticks selected by respondents in total for Question Eight. The most commonly used supply chain reporting tool was own company reporting with 72 per cent of the total respondents selecting this. The second and third most commonly used reporting tools were ISO 14001 and the BSC. This was in line with the results from FG1 and FG2 where participants were developing their own in house reporting tools to measure their supply chain performance.

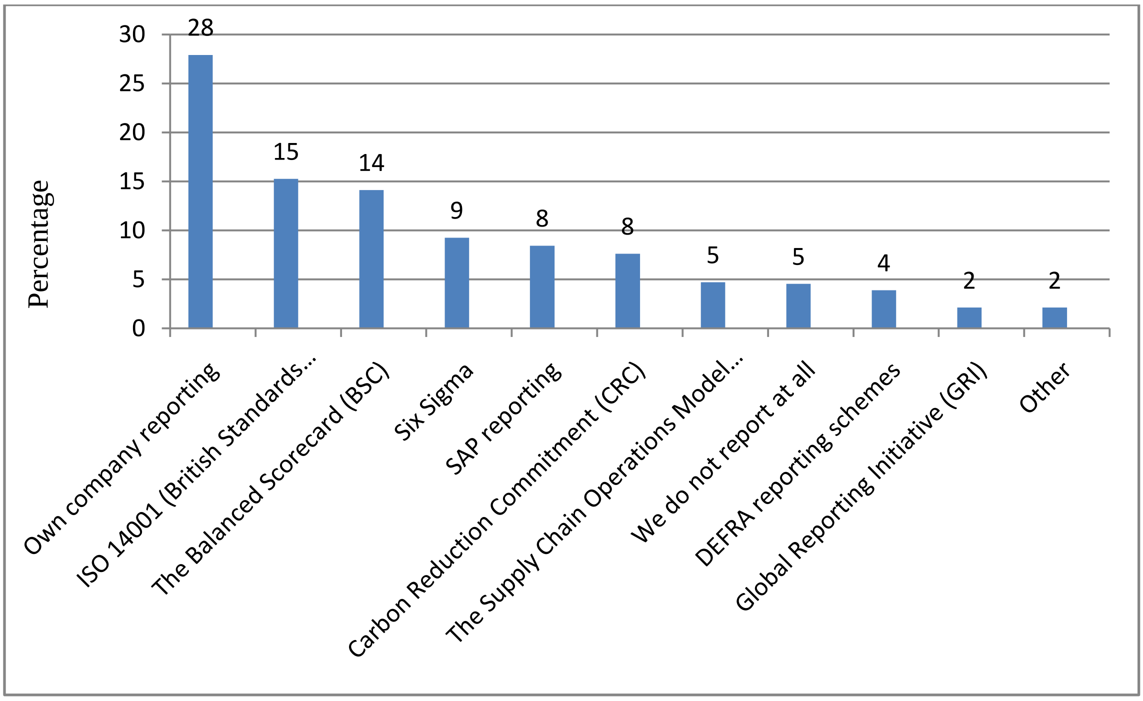


Figure 9.26 – Supply Chain Reporting Tool Use – Expressed as % of total ticks

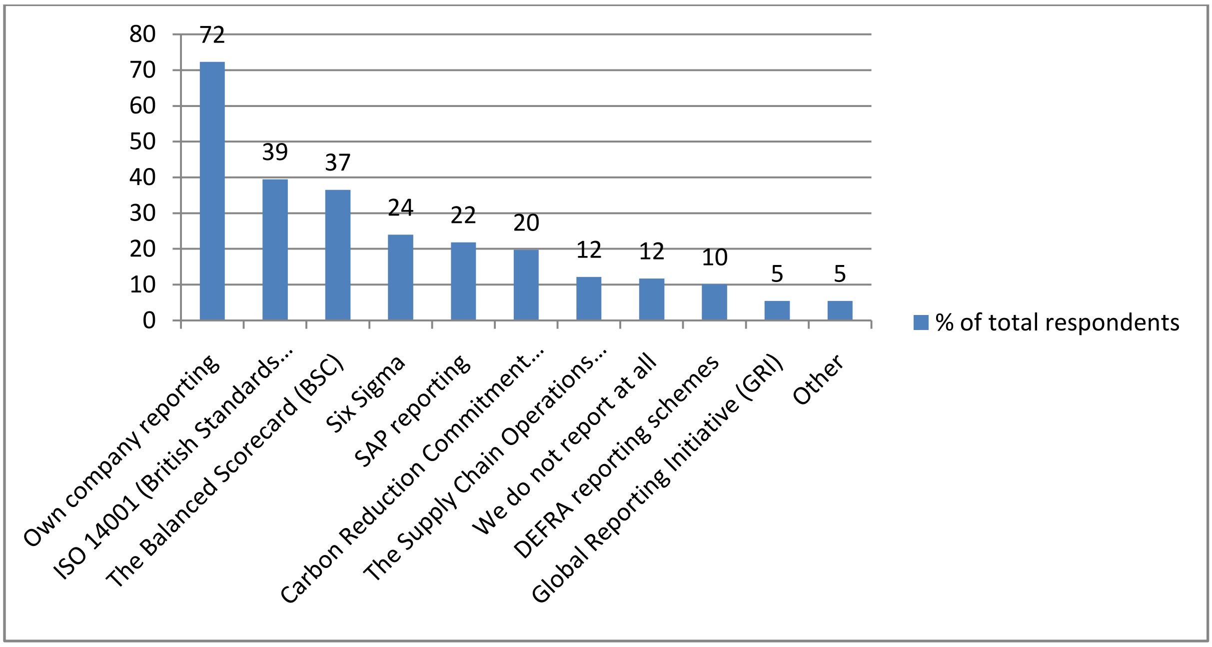


Figure 9.27 – Supply Chain Reporting Tool Use – Expressed as % of total respondents

The respondents who answered 'other' were also given an opportunity to stipulate any other tools not captured in the list provided. The majority of other tools recorded were internal company tools or classed as 'not relevant' by micro companies, who do not have any reporting tools in place for supply chain performance.

The penultimate question (Question Nine) in the survey asked the respondents which of the above reporting tools could be used to incorporate GSCPM. The results are summarised in Table 9.30 and the cells with the highest counts in each category are highlighted in bold.

Table 9.30 – GSCPM Reporting Tool Appropriateness

Supply Chain Reporting Tools	Very inappropriate	Inappropriate	Neither appropriate or inappropriate	Appropriate	Very appropriate	Rating Average
Own company reports	1	4	51	**130**	**52**	3.96
ISO 14001 (British Standards Institute)	5	11	94	95	33	3.59
The Balanced Scorecard (BSC)	7	15	96	101	19	3.46
Carbon Reduction Commitment (CRC)	7	13	117	77	24	3.41
The Supply Chain Operations Model (SCOR)	10	19	130	68	11	3.21
Six Sigma	12	**26**	126	57	17	3.17
Global Reporting Initiative (GRI)	11	19	143	52	13	3.16
SAP reports	16	24	137	49	12	3.07
DEFRA reports	**17**	22	**145**	50	4	3.01

A Pearson Chi-square test was applied to the data to test for any statistically significant differences between the type of reporting tool and its level of appropriateness for incorporating GSCPM. The results indicated that there were differences between observed and expected counts on some of the reporting tools. The most significant was on 'own company reporting' where cell counts were significantly greater than expected across the very appropriate and appropriate categories, thus indicating that the majority of respondents felt their own company reports were the most appropriate tools to integrate GSCPM. There were also significant cell counts for ISO 14001 and DEFRA reporting where the observed cell counts exceeded the expected for the category 'appropriate'.

One final question was asked in relation to reporting tools which completed Section Seven; respondents were asked:

10. Please tick the button on the scale below that best indicates the extent to which you agree or disagree with the following statements in the context of your company?

The respondents were asked to rate their level of agreement against two statements:

- *Green supply chain performance measures can be integrated within existing supply chain performance reporting tools (e.g. Balanced Scorecard)*
- *There is a significant benefit to incorporating green supply chain performance measures into existing supply chain performance reporting tools*

The results are presented in the Table 9.31 and show that although not statistically different (p = 0.09), over 65 per cent of respondents who answered these questions strongly agreed or agreed that there is a significant benefit to incorporating GSCPM into existing supply chain reporting tools and that this can be achieved.

Table 9.31 – GSCPM Reporting Tool Integration Benefits

Reporting Tool Statements	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree	Rating Average
There is a significant benefit to incorporating green supply chain performance measures into existing supply chain performance reporting tools	1	12	66	125	34	3.75
Green supply chain performance measures can be integrated within existing supply chain performance reporting tools (e.g. Balanced Scorecard)	4	15	56	142	20	3.67

9.4 Summary

This chapter has described the second phase of the researcher's empirical work which was conducted in June 2012, namely the questionnaire survey. The data generated across all eight survey sections has helped, with the outputs from the focus group research (FG1 and FG2), to deductively answer RQ1, RQ2, RQ3 and RQ4. It is important to note, that the combination of data collection techniques used in Phase One, Two and finally in Phase Three will together provide the answers to the five primary research questions. This is central to the authors overall research strategy and design.

The next chapter will continue to embrace the exploratory nature of this research by presenting the results from the final phase of the empirical research (Phase Three), a focus group (FG3), which was carried out in October 2012. The focus group is used to validate the overall results of the thesis and ensure theory saturation has been met before the conclusions can be drawn.

CHAPTER TEN

PHASE THREE – FINAL FOCUS GROUP RESEARCH

10.1 Introduction

This chapter will now present the analysis and results for the final stage of the research; a focus group (FG3), which was conducted in October 2012. The main purpose of Phase Three was to diversify the respondent sample base from Phase One to help improve the validity and reliability of the overall research, and test for theory saturation. This was achieved by conducting a third focus group (FG3) with a different group of supply chain and logistics practitioners. It was not intended to obtain industry feedback on the results of Phases One and Two, because the survey had not been fully analysed and interpreted at this point. The aim was to see if any new GSCPM variables and constructs emerged in FG3 and if they mirrored those identified in Phases One and Two. This will help to conclude if theory saturation has been met and will yield greater insights into GSCPM development and ensure the thesis results are not only valid but transferable. According to Krueger and Casey (2009) theory saturation is used to describe the point where a researcher has heard and reviewed the range of views and opinions from participants but is no longer getting any new information or insight. The next section will now discuss the FG3 analysis process.

This chapter is structured as follows firstly, an overview of the analysis process is discussed; secondly, the focus group (FG3) results are reviewed in the context of the five research questions and the previous phases of this research, finally; the chapter is concluded with a summary which will act as a prelude to Chapter Eleven.

10.2 Analysis Process

To ensure FG3 followed a rigorous and robust process, the author adopted the ‘focus group design process’ which was created by Sanchez-Rodrigues et al. (2010). FG3 was a ‘piggyback’ session, which was held at University College London (UCL) on the back of a sustainability logistics workshop which was being hosted by an international third party logistics company (3PL) for their key customers. The workshop presented an excellent opportunity in which to test for theory saturation with a different group of participants from a range of different sectors, some of whom specialised in sustainability as an occupation. There were 13 participants in total who were mainly logistics and sustainability managers from the supermarket and grocery, food and retail sectors. There were no participants from the transportation and warehousing sector and therefore this provided a contrasting view of GSCPM compared to the views obtained in Phases One and Two.

Using a different approach to FG1 and FG2 due to the workshop time constraints; the participants were divided into three groups (Groups One, Two and Three). Each group contained between four and five participants and each were given a 30 minute session in which to brainstorm a number of questions which linked directly back to the main research questions. The three sessions were held separately at different time intervals during the day. Each session was facilitated and chaired by the researcher and a representative from the 3PL company using a workshop planner (Appendix Four). The session was semi-structured to ensure adherence to the 30 minute deadline but also interactive to facilitate a free-flowing and unconstrained discussion.

The three sessions were concluded by the researcher presenting a summary of the Phase One findings back to the entire group at the end of the day. The participants were then asked to reflect upon the findings and give feedback. This request for participant feedback which was also used by Sanchez-Rodrigues et al. (2010) helped to increase the overall validity and credibility of the focus group findings and to ultimately ensure theory saturation had been achieved. A short report of the findings from FG3 was created and circulated with each of the participants after the event (Appendix Five). The results of FG3 (three brainstorm sessions) will now be presented in the next section.

10.3 FG3 Analysis and Results

10.3.1 Using FG3 to Answer RQ1

With regard to the first primary research question:

RQ1: *What Green Supply Chain Performance Measures (GSCPMs) are being used?*

Groups One, Two and Three were given a pack of post-it notes and pens and asked to identify which GSCPMs their company currently used (one GSCPM per post-it note). The participants then placed their completed post-it notes onto flip chart paper (Figure 10.1).

Figure 10.1 Group One – What GSCPMs Does Your Company Use Flip Chart and Post-it Notes

The FG3 participants (across all three groups) identified a total of 82 individual GSCPM variables (post-it notes) many of which overlapped and were duplicated (Figure 10.2). The author used the mind map technique (Mindjet Mind Manager Professional™) to identify the major GSCPM variables and constructs which underpinned these 82 GSCPM variables to reduce the data into more meaningful categories. Eighty two GSCPM variables was a much larger and disproportionate number of GSCPM variables for the length of the sessions compared to FG1 and FG2; however three mini focus groups were conducted in FG3 in two hours. They were also much smaller groups of participants than FG1 and FG2 and the pace was fast, structured and productive using the post-it note technique.

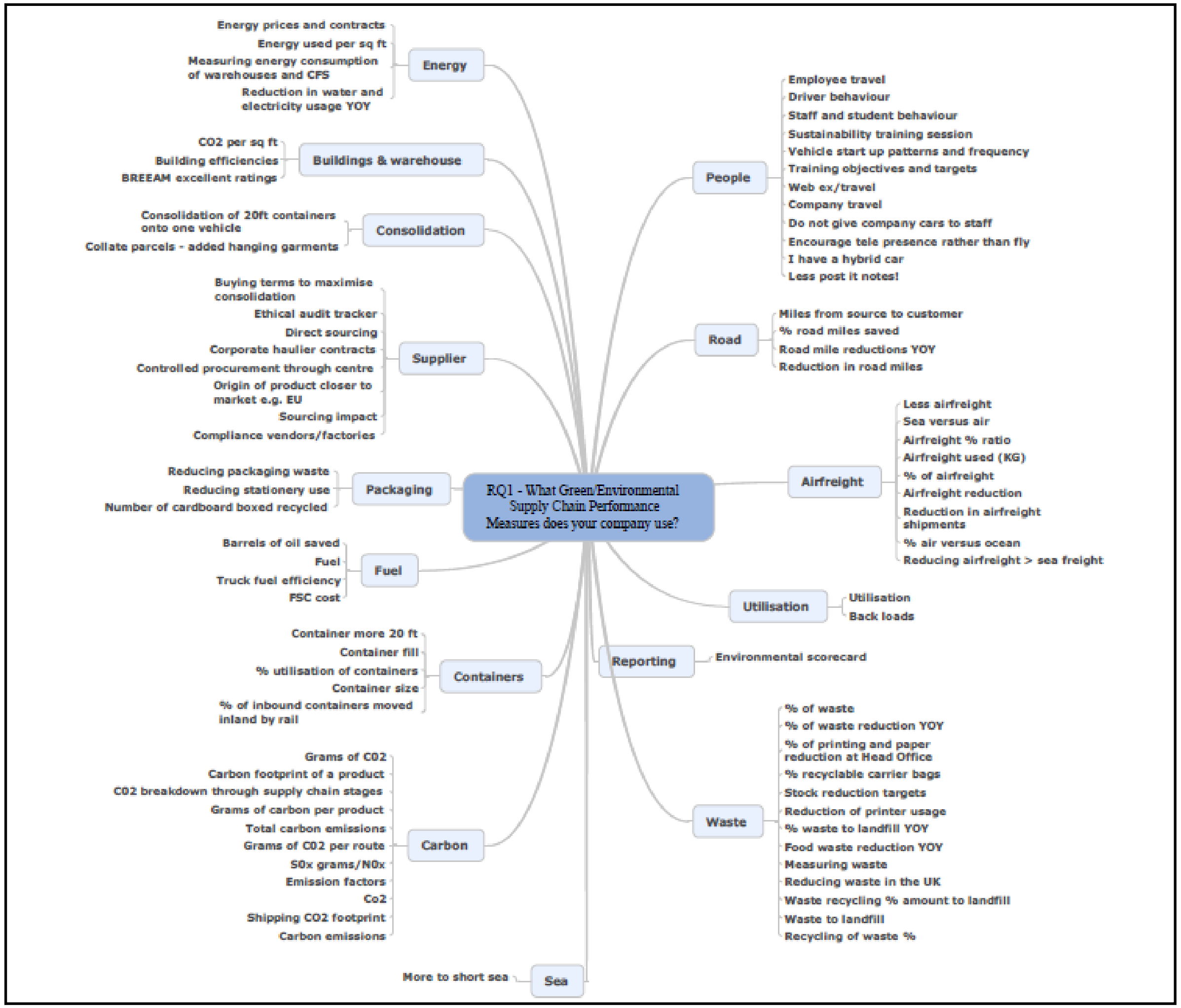


Figure 10.2 A Mind Map of how the 82 x GSCPM Variables were Coded for FG3 (CURRENT USE)

Fifteen GSCPM measurement categories were generated by using this data reduction technique (Table 10.1). The most dominant GSCPM measurement categories (with the most post-it notes) were waste, carbon and people and they mirrored those currently used by the FG1 and FG2 participants and the survey respondents. For instance, waste recycling was one of the most widely used GSCPM variables and the second most useful GSCPM in the survey results. Waste, carbon and people were also viewed as 'generic' sector GSCPM variables; which meant that respondents generally viewed their importance in a similar way, for example they were very important to them.

Table 10.1 FG3 GSCPM Variables (CURRENT USE)

Key	Phase Three GSCPMs
1	Air freight reduction
2	People
3	Buildings and warehouses
4	Carbon emissions
5	Containers
6	Reporting
7	Consolidation
8	Fuel
9	Ocean/sea (modal changes)
10	Packaging
11	Road
12	Supplier and procurement strategy
13	Utilisation
14	Energy (utilities)
15	Waste reduction and recycling

When these fifteen GSCPM variables are then compared to the GSCPM variables currently used in Phases One and Two, the results are very similar (Table 10.2).

Table 10.2 - FG3 GSCPMs Compared to Phases One and Two (CURRENT USE)

GSCPM Current Use (Phase 1 & 2) →	GSCPM Current Use (Phase 3)
Overall company carbon footprint measures *	Carbon emissions
Overall supply chain carbon footprint measures	
Carbon emissions per item/case/pallet delivered	
Carbon emissions of an activity *	
Waste recycling measures *	Waste reduction and recycling
Fuel consumed per item/case/pallet delivered	
Fuel consumption measures *	Fuel
Employee training (environmental training) *	People
Employee travel *	
Electricity consumption measures *	Energy (utilities)
Water consumption measures *	
Gas consumption measures *	
Driver behaviour *	Road
Vehicle running costs *	
Vehicle mileage measures *	
Warehouse utilisation measures (e.g. pallet occupancy) *	Utilisation & consolidation
Warehouse efficiency measures *	Buildings & warehouses
Cost measures (e.g. cost of running your warehouse, fleet etc)	No corresponding construct
No corresponding construct	Supplier and procurement strategy
Yes, was identified as a construct in FG1 and FG2	Ocean/sea (modal changes)
No of container unit movements (TEU)	Containers
No corresponding construct	Reporting
No corresponding construct	Air freight reduction
Packaging consumption measures	Packaging

** Top fifteen most used GSCPM in Phase Two*

Ten of the fifteen GSCPM variables identified in FG3 mirror those identified in Phase One and tested in Phase Two. For example energy (utilities) was identified as a key construct in FG3 and was also identified in Phase One. Electricity, water and gas consumption were also identified as three of the top fifteen most currently used GSCPM variables in Phase Two and are therefore important to practitioners. The other observation to be made is that there were less transport GSCPM variables identified in FG3 compared to Phase One. This is due to the absence of transportation and warehousing sector participants involved in FG3. However, 'fuel' was still identified as a key GSCPM variable in FG3 and viewed as exceptionally useful and therefore clearly important to a large group of participants (FG1, FG2 and FG3). In Phase Two, fuel was also identified under the 'specific' sector category in both usefulness and ease of measurement but to only six key sectors; three of which were representative of the participants in FG1, FG2 and FG3. This finding reinforces the results from Phase Two that there are sector differences in the way practitioners view the importance of certain

GSCPM variables and this is linked to the GSCPM variables they currently use, for example, fuel is important to retail, transportation and warehousing and manufacturing sectors.

Cost was identified as a GSCPM variable which was currently used in Phase One but not explicitly identified in Phase Three. Finance, however, can be viewed as an overarching construct and underpins nearly all of the constructs identified across the three phases of this research (road, utilisation and consolidation are just a few examples). This is because they relate to improvements in efficiency, which in turn reduces cost.

The real focus of the discussion in FG3 related to carbon, people and waste which can be linked to the demographics of the participants involved in FG3; who were mainly from the food/retail/grocery sectors. Within the food and retail sectors there is a focus on waste recycling/reduction ensuring end of line garments or food are sold on; reducing obsolescence and financial provision on the balance sheet. The same results were observed in the survey in Chapter Nine were the retail sector used waste and cost as two of their top three GSCPM variables. Packaging is also used heavily in the retail sector in the distribution of garments/food and thus, there is an emphasis on reducing waste to landfill and recycling along the supply chain. In contrast, packaging was one of the least used GSCPM variables in Phase One. This is because the transportation participants have less control over packaging in general compared to those who work in a warehouse-based or retail environment and can exert greater influence over the level of packaging used on products.

The FG3 participants generally seemed more advanced in their knowledge of carbon emissions than the FG1 and FG2 participants, referring to the specific unit of measurement of CO_2, for example: in grams of CO_2 or the carbon footprint of a product. They seemed more comfortable with the measure and acknowledged they used it. In contrast, the FG1 and FG2 participants generally struggled with the concept of measuring CO_2 and found it difficult to measure even though they knew it was very useful.

‘People’ (employee training and travel) was also identified as a frequently used GSCPM construct and was discussed by the FG3 participants in equal proportion to the FG1 and

FG2 participants. People was also ranked eighth as the most important GSCPM variable in the survey in Phase Two and classed as a 'generic' sector GSCPM variable; thus reinforcing this a important and significant GSCPM construct in the context of this thesis and to most practitioners.

All the GSCPM variables identified in FG3 for 'current use' mirror those identified in Phase One with the exception of two new GSCPM variables emerging (Table 10.3). They are:

1. Airfreight
2. Supplier and procurement strategy

Table 10.3 - FG3 GSCPMs Compared to Phase One Constructs (CURRENT USE)

Key	Phase Three GSCPMs	Phase One GSCPM Constructs Areas
1	Air freight reduction	**New**
2	People	✓ People
3	Buildings and warehouses	✓ Buildings
4	Carbon emissions	✓ Emissions/Pollution
5	Containers	✓ Efficiency/Financial
6	Reporting	N/A
7	Consolidation	✓ Efficiency/Financial
8	Fuel	✓ Transport
9	Ocean/sea (modal changes)	✓ Efficiency/Financial
10	Packaging	✓ Efficiency/Financial
11	Road	✓ Transport
12	Supplier and procurement strategy	**New and also identified as New in Phase Two**
13	Utilisation	✓ Efficiency/Financial
14	Energy (utilities)	✓ Energy
15	Waste reduction and recycling	✓ Efficiency/Financial

The GSCPM variable airfreight was not identified as a 'currently used' GSCPM variable in FG1 and only mentioned once by Participant 16 (a sales director from a major 3PL) in FG2. This was interesting given the dominance of transportation and warehousing sector participants involved in Phase One. Their focus however, was mainly on GSCPM variables relating to trucks and sheds.

This focus on air freight reduction explains something about the companies and participants who were involved in FG3. Firstly, they came from a retail and food/grocery sector background where the reliance on international air freight may be prevalent due to risk of food spoilage and perishables. This can be backed up by an early piece of research conducted by Böge (1995) which stimulated great debate regarding the impact of ‘food miles’ on consumer products and a more recent report produced for Defra in 2005 on food miles as an indicator of sustainable development. Since then there has been a great deal of media attention around this and a desire to reduce the transport intensity associated with an individual consumer product both from a consumer and retailer perspective. Thus, the retail participants expressed a keen interest in their discussions to ‘reduce airfreight’ over other modes of transport such as sea or road.

Airfreight has also not been identified anywhere else in the background GSCPM literature and therefore is a new and emerging GSCPM variable and itself is not a construct but sits beneath the overarching construct of ‘transport’. Airfreight does however, also fit within the financial and potentially TBL/Sustainability constructs identified in Phase One as the focus is very much on reducing airfreight in relation to other modes of transport.

Supplier and procurement strategy was also not identified in Phase One but ‘supplier environmental compliance’ was identified in Section One (Question Two) of the survey as a new emerging GSCPM variable currently used by large organisations. Also ‘suppliers’ in general were referred to throughout FG1 and FG2 but not in relation to procurement or compliance. Suppliers are therefore a significant and new GSCPM construct worthy of consideration in GSCPM research/practice and are particularly relevant to the FG3 participants and large organisations. Retail, food and grocery companies source the majority of their products from China/Asia Pacific regions where there is a large distance from the point of origin to the consumer. This makes the ‘supplier’ construct particularly important. It is important to have good supplier management agreements in place to ensure products are manufactured, shipped ethically, on time, error free and at the right price to their client’s expectations. If something goes wrong with the product along this supply chain it can take months to rectify due to the long shipment lead times.

In summary, with regard to RQ1, only two new significant GSCPM variables were identified in FG3: airfreight reduction and supplier management, thus potentially one new construct, which is suppliers (Figure 10.3).

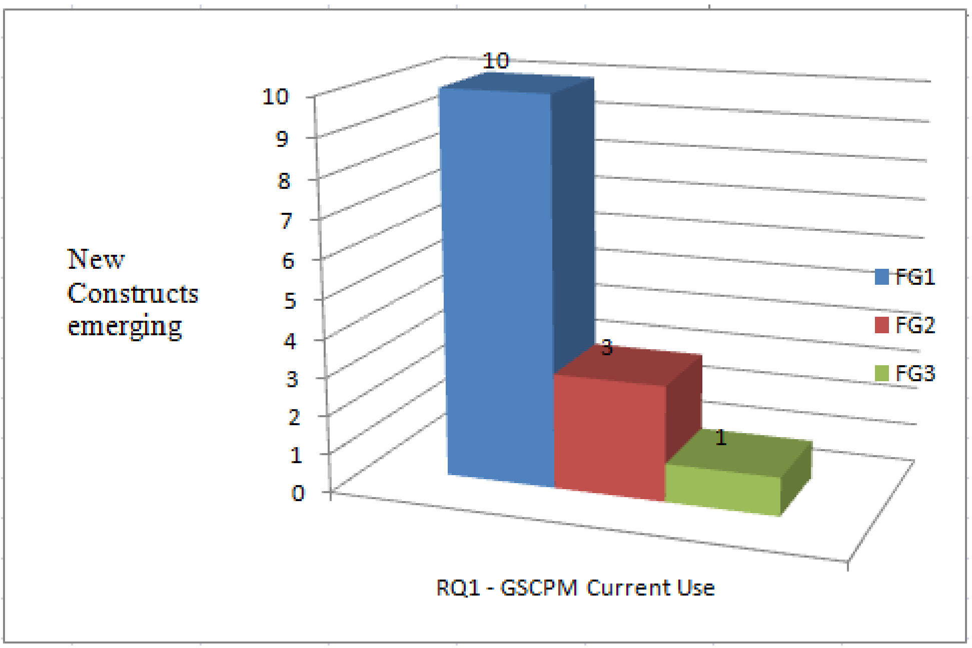


Figure 10.3 – New GSCPM Constructs Emerging from FG3 on GSCPM CURRENT USE

It can therefore be concluded that theory saturation has been met in relation to RQ1 and further focus groups would yield little or no new GSCPM variables and constructs but just add cost (Sanchez-Rodrigues et al., 2010). The next section will now turn to the validation of RQ2.

10.3.2 Using FG3 to Answer RQ2

With regard to RQ2:

RQ2*: Which GSCPMs are important, i.e. they are useful and easy to measure?*

After the completion of RQ1 with each of the three groups, the researcher clustered the GSCPM variables identified from RQ1 onto flip chart paper (as in Figure 10.1) into key measurement areas and labelled them with pink post-it notes clearly, for example ‘carbon’. The researcher had pre-prepared a white board in the room with an ease versus impact matrix. The participants were asked in their groups to position the pink post-it notes onto the matrix in terms of the variable’s ‘ease of measurement’ (x axis) and ‘impact’ (y axis) rating. Figure 10.4 shows the results of Group One. The aim of the matrix was to reach a consensus of opinion as a group on which GSCPM variables were the most important. The researcher also asked the group for any additional important

GSCPM variables which may have not been identified in RQ1 (current use). This helped to embrace the exploratory nature of the research and not to close off any potential new lines of enquiry.

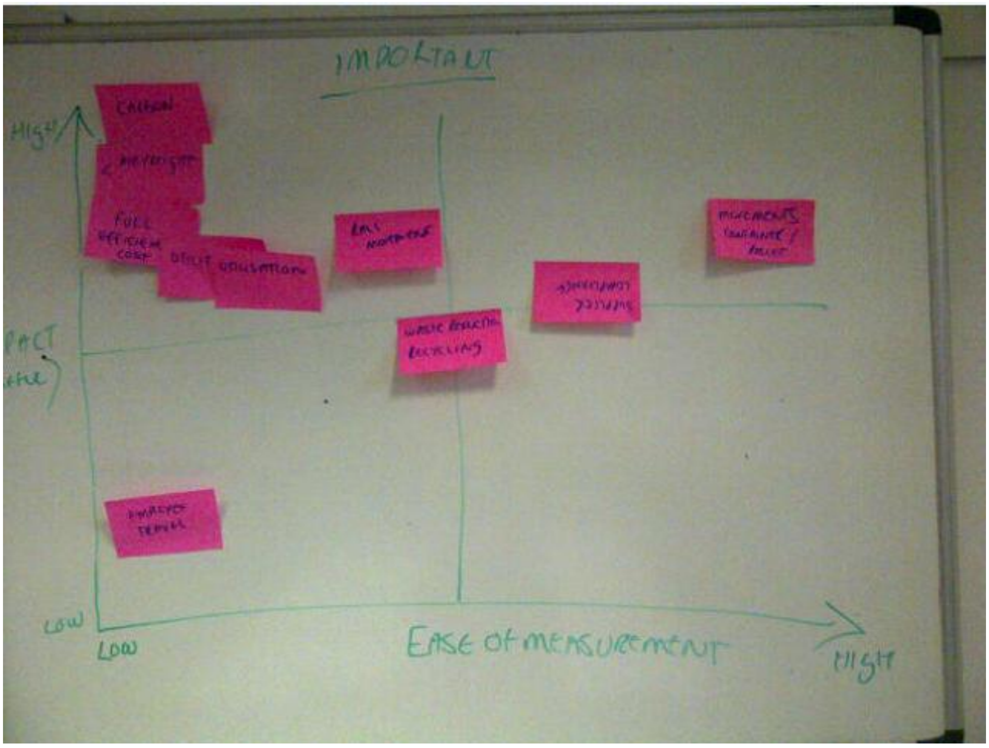


Figure 10.4 - Group One: Which GSCPMs are important? Ease versus Impact Matrix White Board and Post -it Notes

The results of the ease of measurement versus impact (useful) ratings from each group are displayed in the Table 10.4 and largely mirror the results of Phases One and Two.

Table 10.4 – FG3 GSCPM Importance

Groups	GSCPM Variables (as they were written in the actual session on pink post-it notes)	Impact (useful) H = very useful	Ease (easy to measure) H very difficult to measure
Group One	• Container/pallet movements • Supplier compliance measures • Rail/sea movements • Air freight reduction • Carbon • Utilities • Fuel efficiency costs • Utilisation • Waste reduction and recycling • Employee travel	H M H H H H H H M L	L L M L H L M M M L
Group Two	• Utilities (energy) • Training • Waste/reduction recycling measures • Employee Travel • Buildings efficiency • Sourcing/procurement • Behaviour • Carbon emissions	H H H L M M H H	L L L M H M H H
Group Three	• Modal change • Utilisation • Supplier and procurement strategy • Carbon emissions • Waste reduction • Packaging • Driver behaviour and tracking • Air freight reduction (linked to carbon)	H M M M H H M H	L M M H L H H L

The first observations to be made are those GSCPM variables which are identified across two or three of the FG3 groups (for example carbon is identified across all three FG3 groups). These are commonly used GSCPM variables, which are viewed as important by all FG3 participants. Seven GSCPM variables were identified that fitted this logic:

1. Carbon (x 3)
2. Supplier (x 3)
3. Waste (x 3)
4. People (x 3)
5. Energy (utilities) (x 2)
6. Airfreight (x 2)
7. Utilisation (x 2)

All but two of these GSCPM variables (airfreight and supplier and procurement strategy) were identified in Phase One and tested in Phase Two, thus reinforcing the validity and transferability of the findings from these earlier phases of the research and indicating that these are important GSCPM variables to this thesis.

Table 10.5 compares the importance factors associated with Phase Two versus Phase Three. This shows that there are more similarities than differences in the way the FG3 participants view GSCPM importance versus the respondents in Phase Two. This again validates the transferability of the findings from Phases One and Two.

Table 10.5 Phase One versus Phase Three Importance Factors

GSCPM	**Phase Two - Importance Factor** (the greater the number the greater the importance)	**Phase Three Importance Factor** (H = very important and L is not very important
Modal changes	n/a	M
Airfreight – NEW	n/a	H
Sourcing and procurement strategy – NEW	n/a	M
Vehicle mileage measures	12.075	n/a
Electricity consumption measures	11.9715	H
Fuel consumption measures	11.526	H
Vehicle running costs	11.0873	n/a
Gas consumption measures	10.6925	H
Water consumption measures	10.269	H
Employee travel	10.0764	L
Employee training (environmental training)	9.5142	H
Cost measures (e.g. cost of running your warehouse, fleet etc)	9.2961	n/a
Waste recycling measures	8.8476	H
Warehouse utilisation measures (e.g. pallet occupancy)	8.7567	H
Warehouse efficiency measures	8.019	L
Vehicle fill/utilisation measures (e.g. empty running)	8.019	H
Packaging consumption measures	7.656	M
No of container unit movements (TEU)	7.6032	H
Driver behaviour	7.2448	M
Resource efficiency (raw materials, asset utilisation)	6.95	L
No of pallet movements or touches per delivery	6.7034	n/a
Fuel consumed per item/case/pallet delivered	6.0704	H
Overall company carbon footprint measures	5.632	M
Overall supply chain carbon footprint measures	5.3217	M
Carbon emissions of an activity	4.9842	M
Energy used per item/case/pallet delivered	4.7066	M
Greenhouse gas emissions (nitrous oxide, methane etc)	4.4969	M
Carbon emissions per item/case/pallet delivered	4.3052	M

Carbon emissions was viewed by the FG3 participants as very useful and but very difficult to measure. The same results were observed in Phases One and Two of the thesis. Carbon was identified as a ‘generic sector’ GSCPM in Phase Two which means that all respondents regardless of sector view carbon in a similar way. This again validates and reinforces the findings across all three phases of the research.

Supplier and procurement strategy was viewed by the FG3 participants as a relatively useful and straight forward to measure. It was not explicitly identified in Phase One but identified as ‘another’ GSCPM by one of the survey respondents in Phase Two. It was evident from the discussions in FG3, that it was particularly important to the FG3 participants, highlighting sector differences in the way some GSCPM variables are viewed.

Waste reduction was also viewed by the FG3 participants as a very useful GSCPM variable and generally easy to measure, this mirrored the views of the FG1 and FG2 participants and the survey respondents. Waste was also identified as one of the top 15 GSCPM variables used and defined as a ‘generic sector’ GSCPM variable in Chapter Nine; thus viewed in the same way by all respondents regardless of sector.

People (employee training, travel and behaviours) on the other hand was viewed differently by the three groups in FG3. Group One identified behaviour/training as very useful but employee travel as not very useful or easy to measure. Group Two also found behaviour as exceptional useful but exceptionally difficult to measure. Likewise, Group Three found driver behaviour useful but exceptionally difficult to measure. In general, most participants found the construct of ‘people’ important, but their views differed depending on the type of variable under assessment.

Utilities (energy) was another GSCPM construct which FG3 participants found both useful and easy to measure, and therefore practitioners were currently measuring it. The same results where mirrored in Phases One and Two (Table 10.5). Utilities was also defined as a ‘generic sector’ GSCPM variable and therefore viewed in the same way by most respondents regardless of sector; therefore important to most logistics practitioners.

Air freight reduction was viewed by the FG3 participants as exceptionally useful and very easy to measure, making it very important to the FG3 participants. It was clear from the discussions that they were currently measuring airfreight, however, its absence in Phase One and Two indicated it as a potential sector specific GSCPM variable.

Packaging was identified as a very useful GSCPM to the FG3 participants, this contrasted with the views of the Phase Two respondents who did not find packaging very useful at all. This supports the findings from Phase Two that there are potential sector differences in the way certain GSCPM variables are viewed in terms of their importance. The respondents however, from Phase Two and the participants from FG3 did agree that packaging was not that easy to measure and this is perhaps why it was identified as one of the least used GSCPM variables in Phase Two. Packaging was identified in Chapter Nine as a generic sector GSCPM indicating that most respondents regardless of sector viewed its importance in a similar way.

Containers and fuel efficiency were also viewed by the FG3 participants as very useful; which supports the overall results that 'transport' and different modes of transport like shipping (using containers) are important across the three phases of the research.

Finally, utilisation (consolidation) was identified in two of the FG3 groups as being 'currently used' and was viewed as useful and straightforward to measure. This mirrored the views of the participants and respondents from Phases One and Two. Utilisation was identified as an underlying construct in the factor analysis, thus an important and new construct emerging in this thesis.

In summary, 11 GSCPM variables across all three groups were identified as being useful to the FG3 participants. All of these mirrored those identified as useful in Phases One and Two with the exception of airfreight, containers and packaging:

1. Air freight reduction
2. Carbon emissions
3. Waste
4. Utilisation
5. Utilities (energy)
6. Containers
7. People (behaviours/training)
8. Fuel efficiency
9. Packaging
10. Modal changes (rail, sea, road)
11. Supplier and procurement strategy

The least useful GSCPM variables were employee travel and efficiency measures. Employee travel was also identified as an 'outlier' in the survey results, being viewed by respondents in a similar way. In Phase Two, however, employee travel was viewed as useful and relatively easy to measure.

As discussed in 10.3.1, airfreight reduction, packaging and supplier procurement strategy and are new variables to emerge in FG3 in relation to RQ2 (importance) and are classed by FG3 participants as very useful (Figure 10.5). Thus, only one overarching new construct which is 'supplier' emerged in FG3 for RQ2. No new GSCPM variables were identified as important for RQ2 across all the three groups, thus reinforcing the findings from Phases One and Two that those GSCPM variables which companies use are also viewed as important.

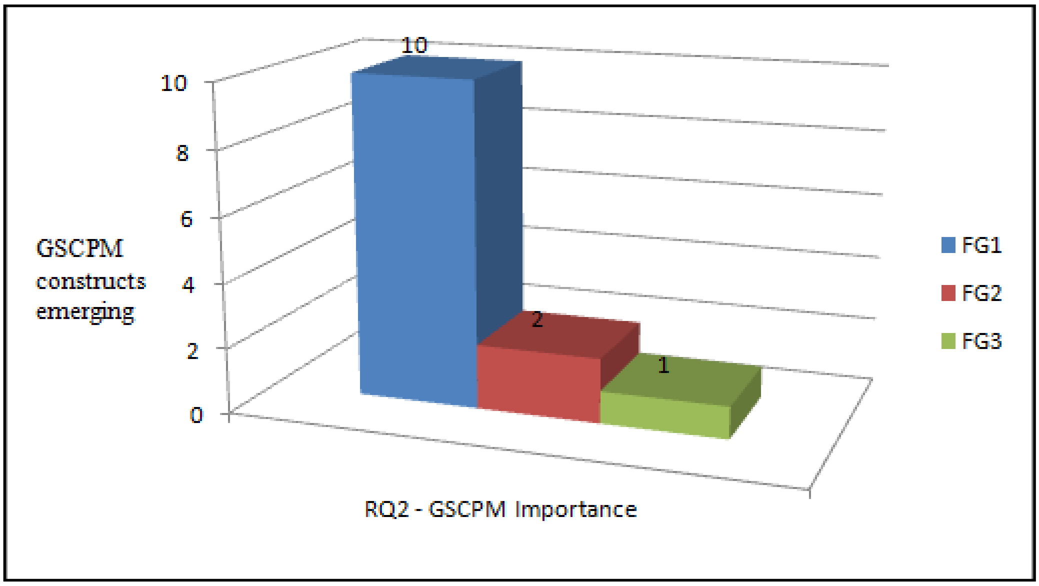


Figure 10.5 – New GSCPM Constructs emerging from FG3 on GSCPM IMPORTANCE

FG3 has provided an alternative view of GSCPM importance and has highlighted that there are three other GSCPM variables (air freight, packaging and supplier and procurement strategy) which are seen as important to participants highlighting that there are sector differences in how participants view GSCPM importance. The other GSCPM variables identified in FG3 for RQ2 closely align with those identified in Phases One and Two and reinforce the fact that GSCPM importance is viewed in a similar (generic) way by practitioners regardless of their sectors or occupations. Also, no other new GSCPM variables were identified during FG3 for RQ2. Thus, it can be concluded that theory saturation has been met and the views of the participants of FG1, FG2 and the respondents of the survey are representative of the wider population of logistics and supply chain practitioners.

The next section will now review the enablers and barriers identified by the FG3 participants to answer and validate RQ4.

10.3.3 Using FG3 to Answer RQ4

With regard to RQ4:

RQ4: *What are the enablers and barriers for GSCPM?*

The FG3 participants were then asked in their individual groups to list using post-it notes their top three enablers and barriers to measuring GSCPM in their organisation. Table 10.6 presents a summary of the results from all three groups.

Table 10.6 - FG3 GSCPM Enablers and Barriers

Groups	Enablers statements	Barriers statements
Group One	• Sustainability • To reduce cost • Carbon • Compliance regulations • Public perception/image • Continuous improvement • Reduce carbon emissions • To measure eventually cannot be ignored • Environmental impact reduction • Ethics (save the planet for my children)	• Accuracy and confidence in the data/information • Cost to measure • Lack of time and resources • Lack of knowledge • Knowing where to start • Not in corporate strategy • Process to measure (technology and resources) • Business unit buy in • Perception of importance
Group Two	• Marketing impact • Lower carbon freight • Commercial opportunity • Its the right thing to do • Image and reputation • Cost • Consolidation • Collaboration • Regulation and compliance	• Hard to measure • Hard to impact • Conflicting demands • Lack of standards • Never done it before • Resources and skills • Lack of knowledge • Lack of data • Tools to measure outputs • Where do you start? • 3PLs/modes and multiple sites • Cost and resources • Moving goal posts • Demands of the customer
Group Three	• Do it now before you have to do it • Customer • Efficiency • Cost savings • Legislation • Company reputation • Responsible sourcing	• Culture • Economic climate • Lack of time • Lack of information • Legacy restrictions • Old buildings • Poor perception • Freight cost • Behaviour • Organisational structure • Reliance on supplier • Cost • Customer

Three new enabler statements were identified from the FG3 sessions.

1. To measure eventually cannot be ignored/do it now before you have to do it
2. Environmental impact reduction (carbon emissions reduction)
3. Ethics – its the right thing to do

The enabler variables '*to measure eventually cannot be ignored'* provided a new perspective on what is motivating and driving organisations to measure GSCPM. There was a real sense, in all three groups, that why put off today what eventually your customers or legislation would demand and require in the future. Therefore, in the absence of any legislation right now, their view was to forge ahead in developing their own GSCPM variables and reporting tools. This suggested that industries (or even certain sectors) are leading rather than following guidance from academia or government legislation. This is a unique finding of this thesis and very important to the advancements and developments in this field.

Environmental impact reduction refers to the entire reduction of a supply chain's impact on the environment. It is less focused on one particular aspect such as carbon or pollution control but the participants were referring to a more generic impact reduction. The participants in FG3 did seem to take a more generic and holistic view of environmental impact and mitigation and seemed more advanced in terms of their thinking in this area. This is because these companies were large in terms of their SME classification and very much in the public eye (grocery industry), therefore needed to demonstrate good governance around environmental impact reduction from a brand and market image point of view.

Finally, the last enabler construct related to the ethics around measuring GSCPM (it's the right thing to do). This puts aside the benefits of cost reduction, green washing and concentrates on the main reason, which is about a genuine care for the environment (people, profit and planet) Elkington (1992).

Some new enabler statements emerged in FG3 such as 'consolidation' and 'collaboration' which are closely aligned with enabler statements identified in Phases One and Two. Consolidation was a unique theme identified in the FG3 current use and was closely aligned to the construct of utilisation identified in Phase One. This is because many retail companies like ASDA and Tesco now operate consolidation centres at source to consolidate their products into containers prior to shipment to ensure better economies of scale, reduce cost and the impact on the environment.

One overarching construct is common to nearly all enabler statements in Phases One and Three; that is 'financial'. Cost underpins many of the enablers statements either implicitly (continuous improvement) or explicitly (to reduce cost). The enabler statement which received the highest average rating in the survey was the *'desire to reduce cost is an enabler'*. It is clear from this that the priority and strategy of most companies is around reducing/avoiding cost or becoming more profitable and is therefore very important in the context of this thesis as a major enabler.

In summary, the most dominant enabler statements identified in FG3 were:

- To reduce cost – mirrors Phase One
- Reduce carbon emissions – mirrors Phase One
- Legislation – mirrors Phase One
- Efficiency – mirrors Phase One and also identified as a major benefit of GSCPM
- Brand/image - mirrors Phase One

The Phase Three enablers all closely aligned with the enablers identified in Phase One (albeit they may be phrased in a slightly different way but have the same meaning). There was a consensus across the three phases that to reduce cost, legislation and to be more operationally efficient are dominant enablers of GSCPM. The FG3 results support the survey results in Chapter Nine that there could be sector differences in the way respondents view the enablers of GSCPM, for instance transportation/warehousing, manufacturing and retail sector respondents strongly agreed that operational efficiency was a key enabler to measuring GSCPM. This is a unique finding of this research and vitally important to the future developments of the GSCPM field.

Finally, there are also linkages between the enablers of GSCPM and the perceived benefits of measuring GSCPM (operational efficiency – Chapter Nine). Therefore the results presented in Phase Two for GSCPM enablers represent the views of the wider supply chain and logistics population. It can therefore be concluded, that theory saturation has been met and bias does not exist.

With reference to the GSCPM barriers identified in FG3, the most dominant barrier statements were:

- Cost to invest – mirrors Phase One
- Lack of capabilities and resources – mirrors Phase One
- Legislation – mirrors Phase One
- The scope/complexity of the supply chain – mirrors Phase One

All of these barriers mirror those identified in Phase One and tested in Phase Two. Three new barriers constructs were identified as part of the FG3 sessions, they were:

1. The corporate strategy i.e. it's not seen as important or a priority
2. The demands of the customer are a barrier
3. Reliance on suppliers can be a barrier

Finance continues to be a dominant construct and is not only an enabler but a barrier to measuring GSCPM with the '*cost to invest'* being a major barrier to GSCPM. Other barriers identified related to the lack of capabilities and resources to measure, for example: lack of time, where do you start, it's never been done before and lack of data.

In summary, three new barrier constructs have been identified in FG3, however no obvious sector differences have been observed. Cost continues to be a dominant theme being both an enabler and barrier of GSCPM, emphasising that the priorities for businesses are around firstly, satisfying the demands of their customers, then cost and finally being green (Chapter Eight). The next section will now turn to answering and validating RQ3.

10.3.4 Using FG3 to Answer RQ3

The FG3 respondents were asked one final question in the breakout sessions, which was: *'What reporting tools could be used to measure and report GSCPM?'* The aim of this question was to help answer RQ3:

RQ3: *Can GSCPM be integrated within existing supply chain performance frameworks?*

The FG3 participants were given a set of post-it notes and pens in which to answer this question and list as many tools as applied. Table 10.7 lists all of the reporting tools which were identified in FG3 and identified as being potential tools to integrate and report GSCPM.

Table 10.7 – FG3 Reporting Tools

Groups	Possible Reporting Tools
Group One	• Carbon dashboard • Balanced scorecard • Supplier reports • Shipping line dash boards • 3PL tools • Environmental scorecard • Energy prices and contracts
Group Two	• Public and annual reports • Operations reporting • Carbon dashboard • Green PandL • Module within ERP system (SAP)
Group Three	• ERP/MRP systems • Dashboard • Standardised tool for market comparison • Triple Bottom line report • Don't care so long as its standardised • London based benchmarking

Four new reporting tools were identified in FG3. These were:

1. Carbon dashboard
2. Green Profit and Loss Report
3. Benchmarking tool
4. Module within ERP system (SAP)

The other tools identified mirrored those found in Phase One and fell under the categories of the BSC or the category of 'own company reporting'.

The results from FG3 validated the continued theme that 'no one size fits all' in relation to supply chain performance management reporting and organisations are developing their own diverse 'in house' reporting tools to measure GSCPM and SCPM. This is a unique contribution of this thesis and the results highlight the diverse number of reporting tools which exist in practice and which are being used to measure SCPM. This presents challenges when it comes to environmental benchmarking and agreeing targets, as it is impossible to make like-for-like comparisons between different measures and reporting tools (Shaw et al., 2010).

The FG3 participants appeared more advanced than the Phase One participants in their understanding of the most appropriate tools to measure GSCPM, referring to tools which they were using or trialling such as a carbon dashboard or a green profit and loss report. This suggested that potential sector and/or occupation differences exist in terms of GSCPM and reporting capabilities. FG3 was a dedicated sustainability workshop, it therefore attracted participants who were either very interested in GSCPM variables or who did this as their 'day job' and therefore their capabilities appeared more advanced because of this.

To answer RQ3, all the FG3 participants were in agreement (as in Phase Two) that it was possible and beneficial to integrate GSCPM into existing supply chain performance reporting tools and they provided examples of where they were doing this. The issue is, that so many different tools are being used to measure SCPM, it makes it very complex to integrate GSCPM; thus integration would be different for each company.

10.4 Overall Results and Testing for Theory Saturation

A total of 13 practitioners were involved in the Phase Three focus group sessions in October 2012. This enabled the researcher to answer each of the five primary research questions and test for theory saturation. Figure 10.6 presents the results from FG3 highlighting the key GSCPM measurement areas.

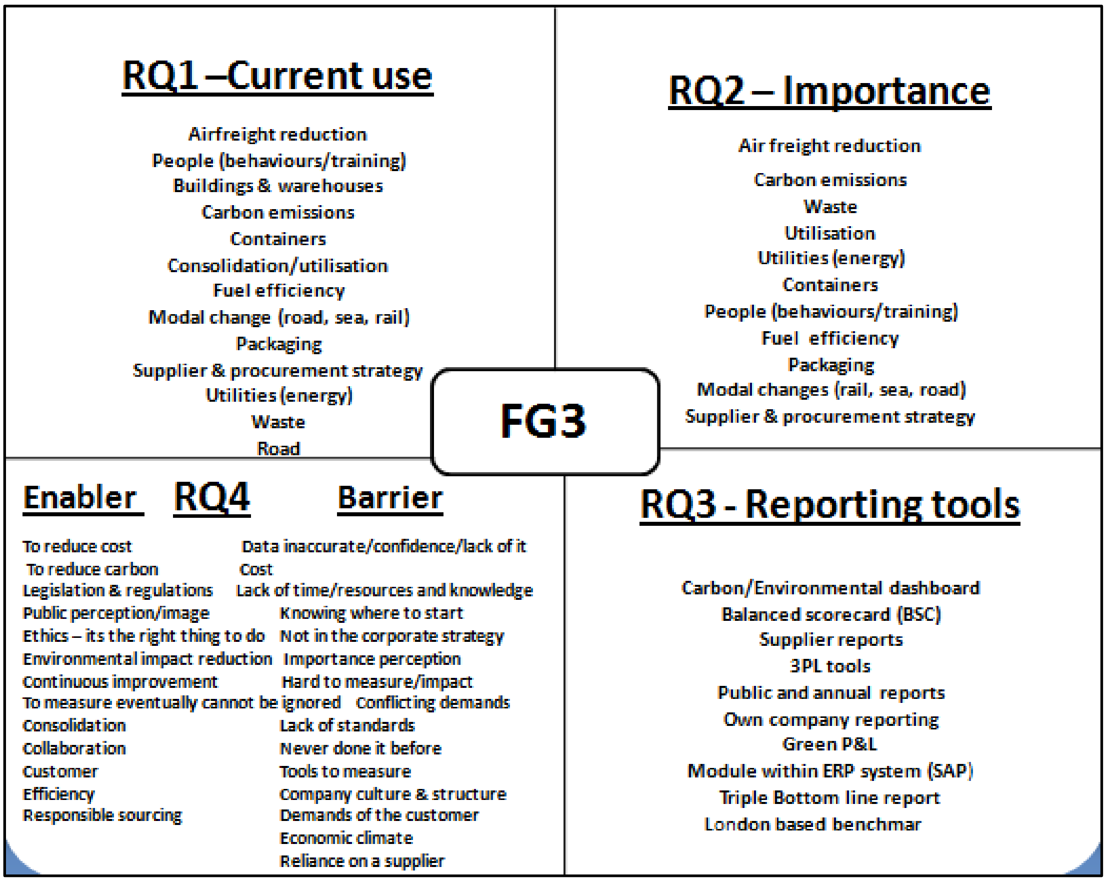


Figure 10.6 – A Summary of the GSCPM Results from FG3

The respondents were given an opportunity at the end of the workshop to review the overall results from FG3 and to review the high-level findings from Phases One and Two; they then had an opportunity to give feedback. The bullet points below are a summary of the 'take home' messages from the entire FG3 group:

- *Keep the GSCPMs simple*
- *Standardising is the way forward to enable benchmarking*
- *Let's understand what does good look like?*
- *Be transparent in the measurement and reporting of GSCPM*
- *It's what you do with the GSCPMs afterwards that are important (the so what?)*

These comments are remarkably similar to the concluding comments made in FG2 and echoed the frustration and desire of all the participants involved in the focus group research in this thesis. There is a great deal of confusion over what and how to measure and this was consistent throughout all the focus groups, however, it was more pronounced in FG1 and FG2, highlighting a potential difference in capabilities around GSCPM between the two groups; thus sectors.

Although FG3 comprised a different mix of sectors and similar occupations, still only two new GSCPM variables emerged in terms of current use (airfreight and supplier and procurement strategy) and three in terms of importance (airfreight, supplier and procurement strategy and packaging). The majority of the GSCPM variables and constructs identified in FG3 mirror those found in Phases One and Two and generally those GSCPM variables which companies use are also viewed as important (as in Phases One and Two), for example: utilities, people, fuel, waste and carbon emissions. Phase Three has also helped to validate that sector differences do indeed exist between the type of GSCPM variables and their current use and importance; this is a unique contribution of this thesis.

Only three new enablers and three new barrier statements emerged during FG3, which represented a significant decline on the numbers of constructs identified in Phase One. The other enabler and barrier statements mirrored those identified in Phase One and tested in Phase Two.

Four new reporting tools were identified during FG3 representing a slight increase on Phase Two, however this illustrated the greater capabilities of the FG3 participants around GSCPM reporting.

Figure 10.7 shows the combined GSCPM results from FG1, FG2 and FG3 giving a complete view of the GSCPM variables and helping to answer to each of the main research questions (RQ1 to RQ4).

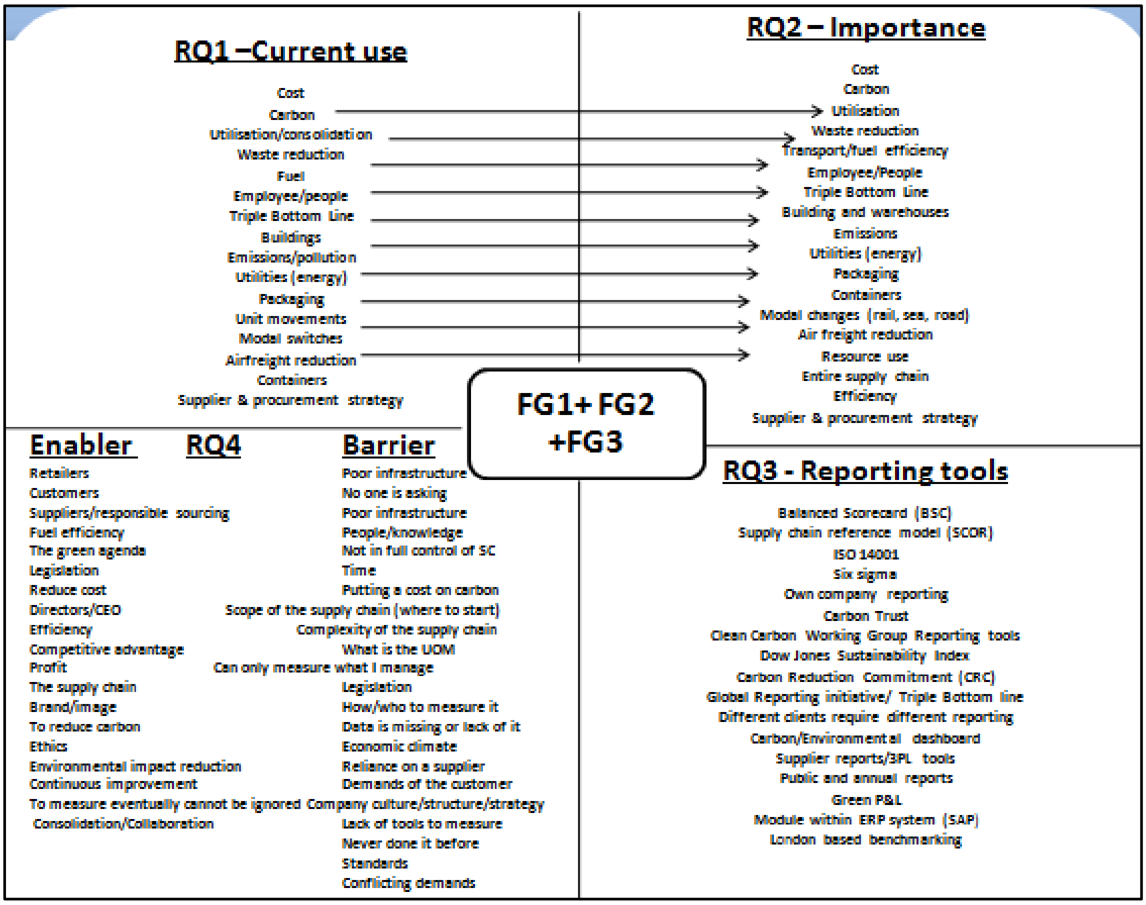


Figure 10.7 – A Summary of the Combined GSCPM Results from FG1, FG2 and FG3

Sanchez-Rodrigues et al. (2010) advise that theory saturation is met when additional focus groups do not add any new constructs. To test for theory saturation, the numbers of new constructs per group were calculated for each focus group session to test for theory saturation. The results in Figure 10.8 show a decline in the number of new GSCPM constructs emerging in FG3 for RQ1, RQ2, RQ3 and RQ4 with the exception of reporting, where there was a slight increase in tools emerging in Phase Three. This is expected with FG3 participants originating from different sectors to those in Phases One and Two.

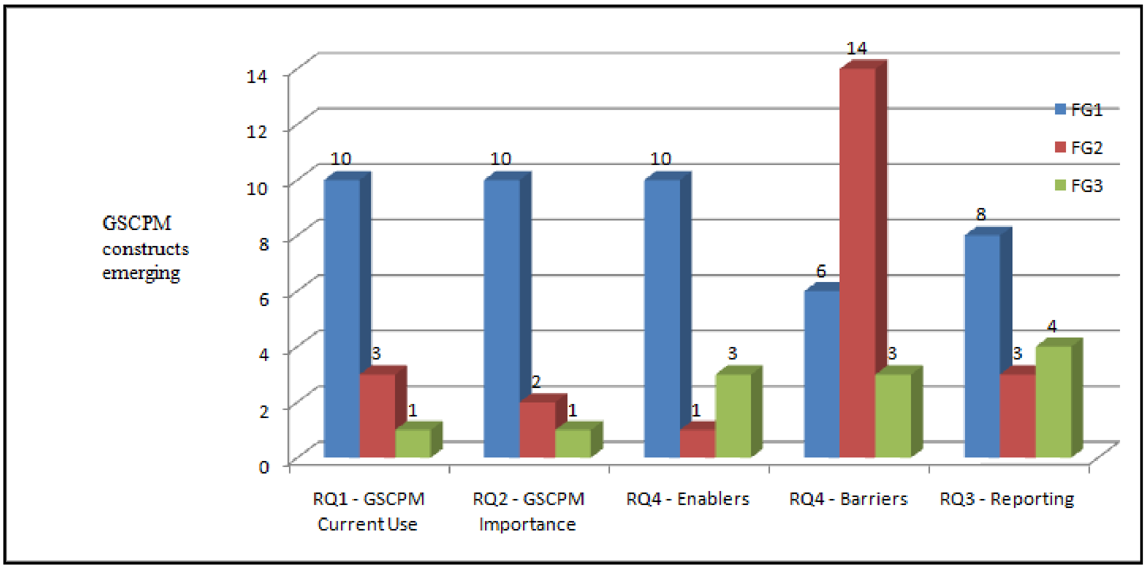


Figure 10.8 – New GSCPM Constructs Emerging from FG3 versus FG1 and FG2

It can therefore be said that theory saturation has been reached in the focus group research and sufficient data gathered to enable the researcher to discuss the findings and draw the overall conclusions.

With regards RQ5:

***RQ5**: Do any emerging variables and constructs mirror those found in extant literature on GSCPM?*

Figure 10.9 and Table 10.8 draw together the overall results from Phases One, Two and Three for RQ1 and RQ2 to propose 12 fundamental 'overarching' GSCPM constructs and 29 GSCPM variables which can be used to develop a universal battery of GSCPM variables for the supply chain. Four new GSCPM variables were identified as part of Phases Two and Three (air freight reduction, supplier performance, CSR policy in place and pollution). The GSCPM variables highlighted in bold are those which were identified as the most important across all phases of the research.

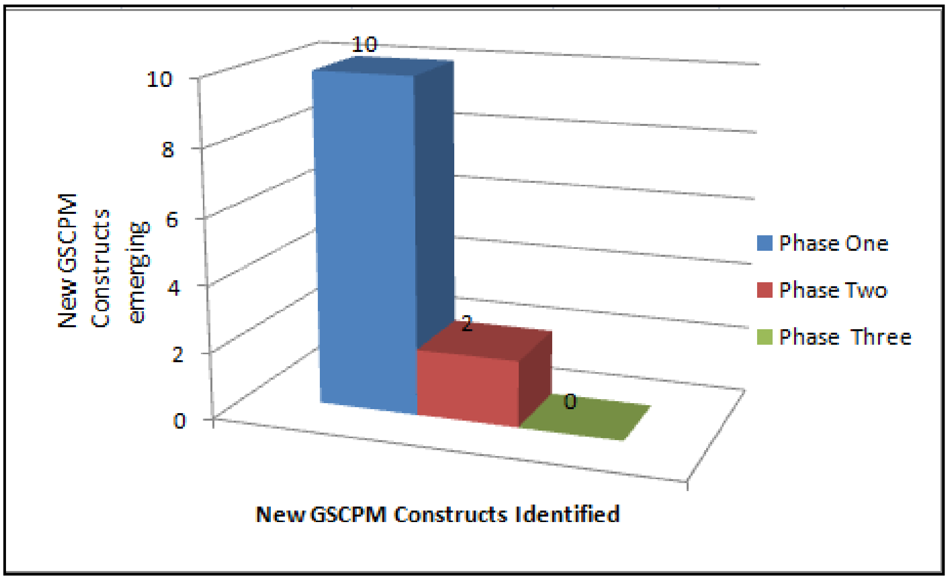


Figure 10.9 – Overarching GSCPM Constructs Emerging from Phase Three versus One and Two

Table 10.8 – Overarching GSCPM Constructs Emerging from Phases One, Two and Three (In Bold = most important from all three phases)

Phase Construct Identified	12 x Fundamental GSCPM Constructs	29 x GSCPM Variables
Phase One – Literature Review	1. Financial 2. Energy 3. Emissions 4. Efficiency 5. Water 6. Triple Bottom Line/ Sustainability 7. People 8. Transport 9. Systems	**1. Electricity consumption measures** **2. Driver behaviour (for e.g. telematics)** 3. Carbon emissions of an activity (route/product) 4. Carbon emissions per item/case/pallet delivered **5. Overall company carbon footprint measures** **6. Vehicle mileage measures** 7. Packaging consumption/reduction measures **8. Fuel consumption measures (MPG)** 9. No of pallet movements or touches per delivery **10. Utilisation/consolidation measures (warehouse/back haul/pallet occupancy)** **11. Fuel consumed per item/case/pallet delivered** **12. Vehicle running costs** **13. Waste recycling measures/reduction/% to landfill** 14. Warehouse efficiency measures **15. Water consumption measures** **16. Gas consumption measures** 17. Overall supply chain carbon footprint measures **18. Vehicle fill/utilisation measures (e.g. empty running)** 19. Energy used per item/case/pallet delivered 20. Greenhouse gas emissions (nitrous oxide, methane etc) **21. Cost measures (e.g. cost of running your warehouse, fleet etc)** **22. Employee training (environmental training)** **23. Container size/fill/movements (TEU)** **24. Employee travel** 25. Resource efficiency (raw materials, asset utilisation 26. Supplier (performance/strategy) (NEW) 27. CSR policy in place (NEW) 28. Pollution/emission factors (NEW) **29. Air Freight reduction/ratio/% (NEW)**
Phase One – Focus Groups	10. Buildings	
Phase Two - Sur vey Phase Three – Focus Group	11. Supplier 12. Utilisation/Consolidation	

10.5 Summary

This chapter has presented the results from Phase Three of this research design which has completed the methodological triangulation process for this thesis. The three phases of the research have generated 12 overarching and fundamental GSCPM constructs and 29 variables which can be used to generate a universal battery of GSCPM variables for the supply chain. The application of methodological pluralism has been necessary to explore this new research area and obtain a complete picture of the GSCPM development, and it has validated the answers to the main research questions (RQ1 to RQ5). Theory saturation has been met and no significant number of new GSCPM variables and constructs has been identified.

The next chapter will now discuss the findings of the research (Chapter Eleven) before the overall conclusions and implications for further research will be drawn in Chapter Twelve.

CHAPTER ELEVEN
DISCUSSION OF FINDINGS

11.1 Introduction

The purpose of this penultimate thesis chapter is to discuss and summarise the key empirical findings from all three phases of the research in an integrated and holistic way to enable conclusions to be drawn. This three-phased research approach (methodological triangulation) has enabled the researcher to alternate between inductive, deductive and inductive thought, thus generating an extensive and in-depth view of the world of GSCPM development; which up until 1998 was almost non-existent in the existing literature. This chapter draws together the key findings across all three phases of the research to propose a universal set of GSCPM variables and reporting tools that organisations can use to manage their green supply chain performance, which can be used as a source of competitive advantage and will help to guide future policy decisions. This is a core contribution and output of this thesis.

11.2 Key Empirical Findings in Relation to RQ1 to RQ5

This thesis has identified a total of 29 GSCPM variables (17 of which are defined as important to practitioners) and 12 overarching GSCPM constructs, which are either currently used and/or important to practitioners (Table 10.8, Chapter Ten). In total 25 GSCPM variables have been empirically tested in the survey in Phase Two and four new GSCPM variables emerged as a result of Phases Two and Three, they are: airfreight reduction, supplier performance, CSR policy in place and pollution. The next section will now discuss the findings in relation to each research question (RQ1-RQ5).

11.2.1 – *RQ1: What GSCPMs are being used?*

RQ1 was concerned with understanding which GSCPM variables were currently being used (GSCPM adoption) by practitioners. This helped in understanding which GSCPM variables were important and how they may vary by company and sector. GSCPM is a fairly new research area; the researcher therefore used focus group research (inductive) to explore and examine which GSCPM variables were being used to generate a set of GSCPM items and constructs for survey testing.

GSCPM Variables - Currently Used

The thesis identified a total 16 GSCPM measurement areas which are currently used by organisations. These measurement areas are diverse and range from carbon emissions through to measures such as supplier and procurement strategies. On the first initial assessment they simply look like traditional supply chain performance measurements; closer inspection reveals that most of these measurements have a dual role; firstly to manage the supply chain but secondly to reduce the impact on environment. Thus, there is a close relationship between traditional supply chain performance measurement and GSCPM and some organisations, without knowing it, are already measuring GSCPM. The two are inextricably linked.

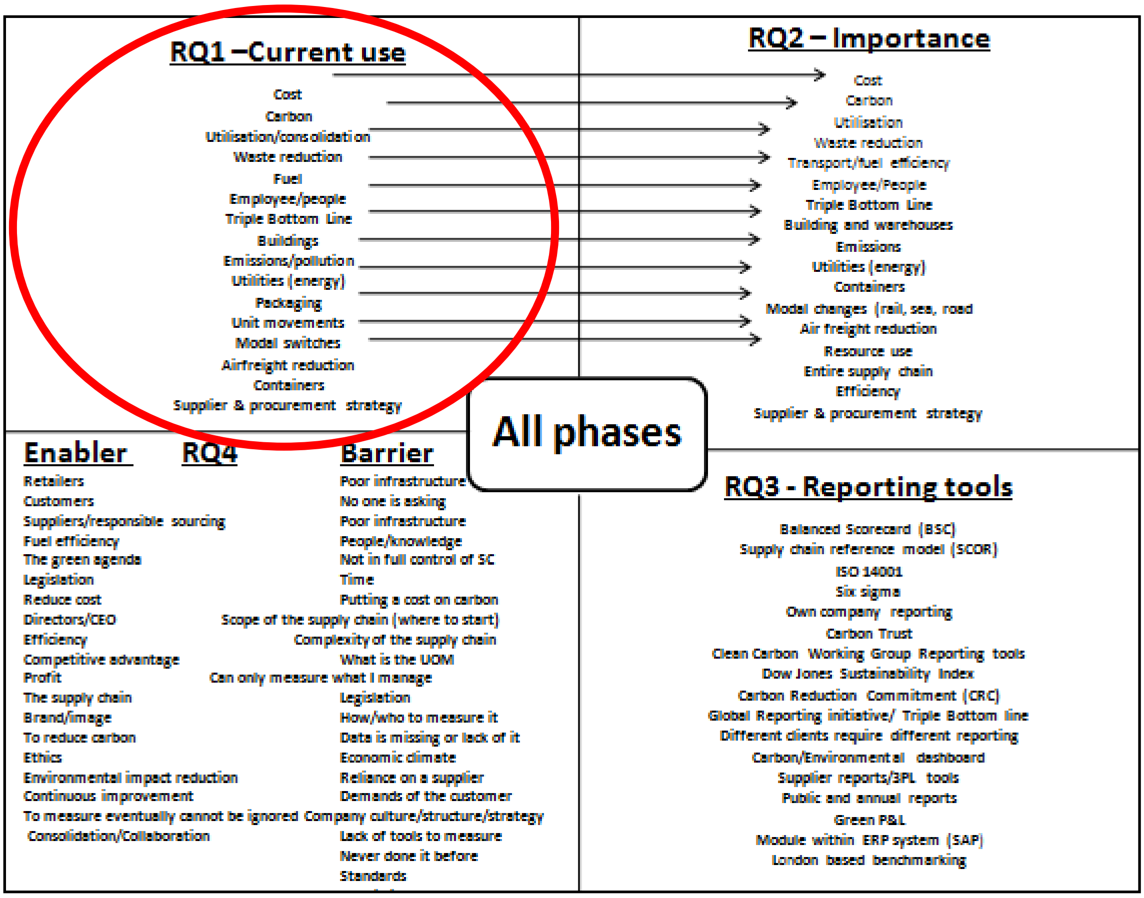


Figure 11.1 – Summary of the GSCPM Measurement Areas Identified for RQ1 (Current Use)

GSCPM Variables – Most Used

Empirically, the most commonly used GSCPM variables are: 1) electricity consumption, 2) waste recycling, and 3) vehicle mileage. Thus, the most commonly used GSCPM constructs are energy, efficiency and transport. Transport is a significant construct for RQ1, with four of the top 15 most used GSCPM variables being transport related. In part, some of this may have been reflective of the CILT respondents who took part in the survey (originating from the transportation and warehousing sector); however, this bias was removed when similar GSCPM variables on 'current use' where identified in Phase Three with a different group of practitioners (for example; waste reduction, utilities and fuel consumption). Nevertheless, some contrasting views on 'current use' were found in FG3, with airfreight reduction and supplier procurement strategy emerging as new and important GSCPM variables; thus reinforcing that sector differences exist with GSCPM adoption. Electricity consumption was identified as the most used GSCPM in RQ1 and is used consistently by all respondents, regardless of company size and sector, therefore relevant to most organisations, thus a universal GSCPM.

Despite the importance of this research problem to practitioners and academics, a lack of published empirical research exists in relation to GSCPM adoption and current use in organisations. Thus, this thesis represents one of only a few studies which have empirically tested GSCPM adoption.

Carbon emissions have been well documented in the supply chain management literature particularly in relation to freight transportation, reducing carbon emissions and improving fuel efficiency (Braithwaite and Knivett 2008; Edwards et al., 2009; McKinnon, 2009b; Sundarakani et al., 2010; Paksoy et al., 2011). Yet, this thesis has identified that it is empirically the least-used GSCPM in practice and the most difficult to measure (Phase Two). Vehicle fill and utilisation have also been well documented in the extant literature in relation to fuel efficiency and carbon emissions (McKinnon and Ge, 2006) and there is evidence that organisations are indeed measuring it and find it useful. The Carbon Trust (2008) also mapped the carbon footprint of specific products for organisations, although significant investment in time and resource is required to do this. ISO 14031 recommend environmental metrics such as energy conservation, fuel used per annum, carbon emissions and hazardous waste recycling; these mirror the GSCPM constructs found in this thesis (ISO 14001, 2010).

Waste management, energy used and greenhouse gas emissions have also been identified as key environmental measures in the GRI Initiative (1997). GreenSCOR also suggest the following measures for environmental accounting in supply chains: 1) carbon emissions, 2) air pollutant emissions, 3) liquid waste generated, 4) solid waste generated and 5) recycled waste. All of these mirror the GSCPM variables found in this thesis.

The only GSCPM variables which have not been well documented in the literature are the constructs of people and buildings. The environmental impact of buildings has been overlooked academically, yet their environmental impact is significant (Dhooma and Baker, 2012). Furthermore, people, their social norms and their resultant behaviours can have significant influence over the success of an organisation's environmental practices. Corporate culture and GSCPM has not been discussed anywhere in the GSCPM literature. The only authors who touch on the periphery of this in relation to GSCM are: Seuring and Müller (2008a) in their review of sustainable supply chain management, Länsiluoto and Järvenpää, (2010) in their review of greening the Balanced Scorecard, Sarkis et al. (2011) in identifying the social network theory (SNT) as a potential avenue for future research and Olugo et al. (2011) in terms of managerial commitment to environmental management in the green automobile supply chain. There is clearly a gap in the body of knowledge regarding buildings and people, and this thesis has helped to identify and bridge this gap.

GSCPM Variables - Least Used

Empirically, the least-used GSCPM variables are: 1) energy used per item/case/pallet delivered, 2) carbon emissions per item/case/pallet delivered, and 3) fuel consumed per item/case/pallet delivered. Thus, the least-used GSCPM constructs are carbon, resource efficiency and transport, for instance, energy used per item/case/pallet delivered and carbon emissions per item/case/pallet delivered were identified in Phase One as the most important GSCPM variables but identified as the least-used in Phase Two. The participants of Phase One viewed these as important as they believed these GSCPM variables would drive the right behaviours and reduce cost horizontally across their supply chains. It was evident however, in the survey results, these measures were simply not being measured by many respondents. An interesting concept was introduced in Phase One by one of the focus group participants which helped to explain why this was the case. Participant Three, a Sustainability Director, considered that there were three Eras associated with GSCPM, which could explain why certain GSCPM variables were being adopted now and some are not (Figure 8.7 – Chapter Eight). Therefore, like the Eras associated with the evolution of traditional supply chain performance measurement discussed in Chapter Five; there is an evolution associated with the development of GSCPM adoption, which is focused on carbon emissions right now because of climate change issues; however waste is next, shortly followed by resource and energy efficiency, highlighting a move from purely environmental mitigation to truly sustainable supply chains.

<u>Supply Chain Environmental Mitigation versus Adaptation</u>

This links in with the concept of environmental mitigation versus adaptation which was identified by Abukhader and Jönson (2004). The thesis findings suggest that right now everything is focused on the short-term (for example, fuel efficiency and reducing waste to landfill), is very reactive and the measures are transactional and focused on end of pipe solutions. Longer term, the scope of GSCPM is much bigger and transformational, extending beyond, to include organisational adaptation which prevents the impacts at source; thus creating less waste to dispose of and looking at different forms of energy that are less harmful to the environment and more sustainable. This reinforces the conceptual model presented in Chapter Three (Figure 3.6) of the relationship between environmental impact and adaptation and raises the question of how robust and resilient are supply chains against these natural environmental disruptions (Macbeth et al., 2009; Halldórsson and Kovács, 2010).

<u>GSCPM Evolution/Revolution</u>

GSCPM is at a critical juncture and in a state of flux. Although, it may not be seen as important right now to organisations; with increasing and emerging issues associated with energy security and the growing world population, GSCPM will be the top of an organisation's boardroom agenda in the near future with focus, not just on cost, but on the seven R's associated with sustainability (renew, reuse, recycle, remove, reduce, revenue and read) (Jedlicka, 2009).

The concept of a GSCPM evolution/revolution links in closely with what Neely (1999) identified in relation to traditional performance measurement. Performance measurement must continually change and adapt, responding to challenges which are characterised by context, theme and challenge; this principle also applies to GSCPM.

This GSCPM revolution would move organisations from being very reactive to proactive; from transactional to transformational and as a result, the GSCPM variables would look subtly different to those which are currently being used today. It also indicates that there could be potentially be a GSCPM revolution similar to that posited by Neely (1999) on traditional performance measurement, when the pressures of energy security come to the fore.

These types of proactive GSCPM variables such as resource efficiency (energy consumed per case/item/pallet delivered to a customer) have not been identified in the existing GSCPM literature before and provide a first glimpse of some new and emerging GSCPM variables, which will help shape the future GSCPM landscape. The aim of such GSCPM variables is to measure horizontally across the supply chain to enable the measurement of the end to end supply chain which is challenging and complex (Björkland et al., 2012). It also reinforced Morgan's (2007) recommendation that was discussed in Chapter Five that there is a need for performance measurement to break through the barriers and move from a unitary to pluralist perspective and make the management of the supply chain a more realistic aspiration.

RQ1 has highlighted there are two categories of GSCPM: 1) The 'current state', and 2) The 'to be' State. Firstly, there are those GSCPM variables which are being used now by organisations for a wide variety of reasons; they represent the 'as is state' in terms of GSCPM measurement. Secondly, there are those GSCPM variables which fall within the 'to be state', which represent those GSCPM variables which are seen as very important (Phase One) but organisations have yet to develop the capabilities to measure them (Phase Two) (Figure 11.2).

The 'as is state' is characteristic of traditional supply chain performance measures such as cost and electricity consumption. The 'to be state' consists of new and emerging GSCPM variables which are not extensively measured at present, such as overall company carbon footprint and resource/energy efficiency across the supply chain. This is a further unique and unexpected contribution of this research and builds upon the work of Hervani et al. (2005), that organisations are indeed at different stages of this evolutionary environmental journey, influenced by their sector and size. Furthermore, Spens and Kovács (2010) also identified energy efficiency as one of the focal areas for future supply chain management. Figure 11.2 illustrates this GSCPM evolutionary journey.

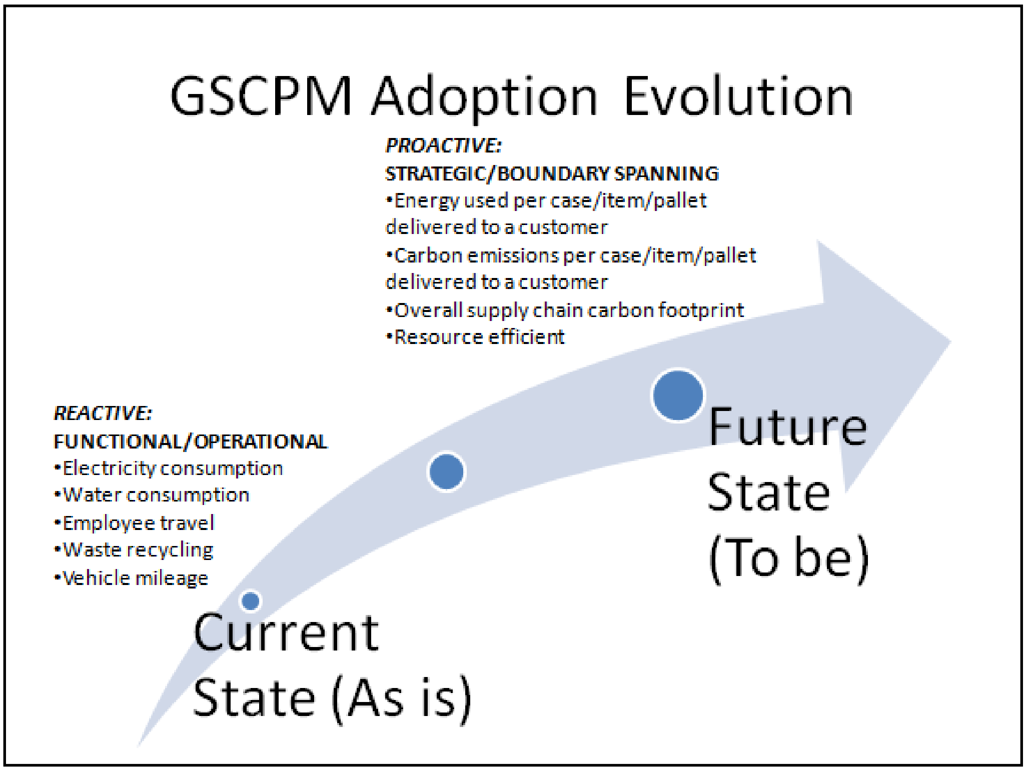


Figure 11.2 – The Evolution of GSCPM Variables Current Use (AS IS and TO BE STATE)

It is evident from the overall results that energy (electricity consumption), waste, cost and transportation are the most dominant GSCPM measurement areas for organisations. They are significant in the context of this thesis and in the development of a universal set of GSCPM variables for industry, yet very little empirical research exists on GSCPM current use (adoption) to compare it to. The only work that has been conducted related to either particular sectors (automotive) or countries, or to environmental management in a general business context (Characklis and Richards, 1999; Olugo et al., 2011). The findings for RQ1 therefore represent one of the first and most comprehensive insights into GSCPM adoption within organisations and help to advance the knowledge in the field of GSCPM.

Finance

The most notable finding for RQ1 is that those GSCPM variables which organisations use, such as usual performance measures, are primarily driven by cost (for example, vehicle mileage measures, reducing fuel and energy consumption). Some of the FG1 participants said they did not measure GSCPM at all, but instead measured those measures which were improving cost and service. In their review of the development of key performance indicators for the green automobile supply chain Olugo et al. (2011) also identified cost as very important GSCPM variable. Cost underpins almost all of the

GSCPM variables identified in this research and is later identified as a top enabler and barrier to measuring GSCPM. This is no surprise given that cost takes over as a primary focus during economic downturns (Spens and Kovács, 2010). The GSCPM variables which organisations use take on a dichotomous role; with the primary objective about reducing cost and being more operationally efficient and secondly about mitigating the impact on the environment. Cost/financial is, however, a primary focus and an overarching construct in thesis. This finding was repeated throughout all phases of the research and is identified in Chapter Eight and referred to as the cost/service management equation. There is also a strong body of evidence in the academic literature of linkages between environmental management and perceived financial performance which support this emerging cost/green linkage theme (Klassen and McLaughlin, 1996; Goldsby and Stank, 2000; Mollenkopf et al., 2010; Lee et al., 2012). A recommendation of this thesis is that more academic research is required to make the direct link between GSCPM and financial performance/environmental impact, in order that it is embraced by organisations. Unfortunately, linking individual GSCPM variables to environmental impact is problematic and requires further research (Characklis and Richards, 1999).

Sector Type

A second key empirical finding for RQ1 related to the differences between the type of GSCPM variables used and the organisation's industrial sector. For example, the top three most used GSCPM variables for the retail sector respondents (cost, electricity and warehouse efficiency) are significantly different to those used by the transportation and warehousing sector respondents (electricity, fuel consumption and vehicle mileage). This represents a huge gap in the body of knowledge and requires further research. Intuitively, it suggests that different sectors have differing requirements, capabilities and pressures and this is reflected in their choice of GSCPMs; suggesting that there is perhaps 'no one size fits all' in terms of a universal battery of GSCPM variables.

Furthermore key differences were also noted in Phase One between the number of GSCPM variables used and the sector type. For instance, the public sector participants were more advanced in their GSCPM measurement and reporting compared to private sector organisations. This is because they are more closely controlled by government policy. Similar sector difference in relation to environmental practices have been observed by other authors but not directly related to GSCPM (Wilmshurst and Frost, 2000; Connelly and Limpaphayom, 2004; Zhu et al., 2007). These sector differences are a unique and unexpected contribution of this thesis. They are important as they suggest that there are significant differences in GSCPM adoption with industrial sectors subject to different types of internal and external pressures.

Organisation Size

The size of an organisation also has a significant influence on GSCPM adoption, for instance, the results from all three phases of the research suggest that larger organisations are more advanced in terms of their capabilities around GSCPM measurement and reporting, having a greater ability and influence to measure their own end to end supply chain than smaller organisations. This is because larger organisations are able to financially back initiatives such as GSCPM and reporting whereas smaller organisations find it an expensive and time consuming exercise. A similar finding was noted by Nawrocka et al. (2009) with smaller/medium sized organisations having limited resources and occupying weaker upstream positions in their supply chains.

The results from Phase One also suggest that most medium to large sized organisations engage in some kind of GSCMPs; however the degree of maturity of these practices depends on a number of factors such as sector (Zhu et al., 2007). In contrast, smaller organisations tend to focus on survival as a priority rather than environmental mitigation and they measure what they are told to measure by the larger organisations or legislation. This can be explained by the RDT theory which is discussed in the existing literature by Lee et al. (2012). SME's have become dependent on their supplier/buyer relationships with larger organisations in their supply chain, in order to share green supply chain management (GSCM) resources and capabilities. There are pros and cons to this relationship; firstly, SME's must comply with what the larger customers dictate, secondly, because of this relationship SME's now have access to GSCM resources and capabilities which they would otherwise not.

On average, the survey results revealed that smaller companies measured less GSCPM variables in RQ1 (six GSCPM variables) than larger organisations (ten GSCPM variables). There were also statistically significant differences between company size and the type of GSCPM currently used. For example, smaller (micro) organisations generally do not currently measure GSCPM variables such as their company carbon footprint, their overall supply chain carbon footprint and warehouse utilisation measures. In contrast, these types of GSCPM variables are generally being measured by the larger organisations. The larger organisations also tend to be more preoccupied about monitoring cost measures (vehicle cost, MPG etc) whereas smaller organisations are not and are focused on GSCPM variables such as employee travel and electricity consumption; the ones which are the easiest and most relevant to measure. In both cases, these GSCPM variables are underpinned by the construct of finance/cost and this is a reoccurring theme throughout the thesis results and in the background literature. Electricity consumption and waste recycling are used consistently across all companies regardless of size emphasising that these are ‘core’ GSCPM variables to all companies.

Holt and Ghobadian (2009) found that larger organisations are exposed to greater societal and legislative external pressures which results in them proactively engaging in more GSCMPs. Given their size, larger organisations also have the greatest impact on the environment; therefore a government’s focus begins by applying pressure to the larger organisations first. In contrast, smaller organisations (SMEs) are classified as laggards, engaging in less GSCMPs because they experience less external pressure (Holt and Ghobadian, 2009). Ironically, Lee et al. (2012) found that in the EU, smaller companies account for 76 per cent of all companies and they contribute to 60-70 per cent of industrial pollution and 40-45 per cent carbon emissions; thus SME’s are significant in the context of GSCPM, the development of this field and require further research. This supports the finding in this thesis that there are significant differences in company size and the rate of GSCPM adoption; and this has implications for the design of a universal set of GSCPM variables for supply chains. GSCPM adoption and company size have not been discussed anywhere else in the existing GSCPM literature, apart from in the GSCMP literature, thus another unique and unexpected contribution of this thesis.

In Phase One, it was also identified that some smaller organisations simply do not measure GSCPM at all. This verified the findings in the literature proposed by Hervani et al. (2005) that organisations can be at different evolutionary stages in the environmental management process and this will influence what and how they measure. Furthermore, smaller companies attach less importance to environmental issues (Murphy et al., 1995; 1996), are preoccupied with short term issues and are more reactive to environmental issues and regulations than larger organisations (Vachon and Klassen, 2006b). This difference in approach between large and small companies can be explained by the RBV of a firm which was discussed in Chapter Three (Barney, 1991).

Smaller firms have fewer resources to be able to implement and measure GSCPM. This key finding also reinforced the finding made by Hervani et al. (2005:337) that organisations face "*external pressures*" to measure GSCPM, particularly larger firms which are in the public eye or who are answerable to shareholders. Sarkis et al. (2011) also make reference to stakeholder and organisational theory in their review of the GSCM identifying that organisations are under pressure by stakeholders to be more environmentally conscious and to integrate environmental management into their processes and strategy. Furthermore, customers (often the large retailers as outlined in Phase One in Figure 8.4) are dictating what GSCPM variables should be used by their suppliers and therefore are driving the whole GSCPM measurement and reporting agenda at present. Finally, a key finding from the focus group research was that those organisations which are currently reporting GSCPM are doing this purely for reporting purposes rather than to improve.

11.2.2 – *RQ2: Which GSCPM variables are important, (i.e. are they useful and provide an impact)?*

RQ2 was concerned with understanding which GSCPM variables are important to practitioners. The question was divided into two components; firstly, which GSCPM variables are useful? Secondly, which GSCPM variables are easy to measure? Along with current use (RQ1), RQ2 provides one of the first insights into GSCPM importance and is conceptualised in Figure 11.3. Figure 11.3 posits that those GSCPM variables that are currently adopted, viewed as very useful and are easy to measure are at present the most important GSCPM variables to practitioners.

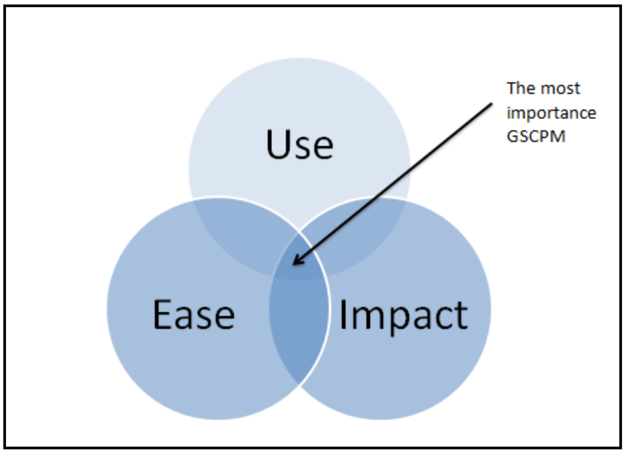


Figure 11.3 – The Most Important GSCPM Variables

GSCPM Variables – Impact (Are they useful?)

Eighteen GSCPM measurement areas (17 individual GSCPM variables) were identified as important across all three phases of the research (Figure 11.4). The top three most useful GSCPM variables were: 1) fuel consumption, 2) waste recycling, and 3) electricity consumption measures. In contrast, the least useful GSCPM variables were 1) carbon emissions per item/case/pallet delivered, 2) number of container movements, and 3) energy used per item/case/pallet delivered.

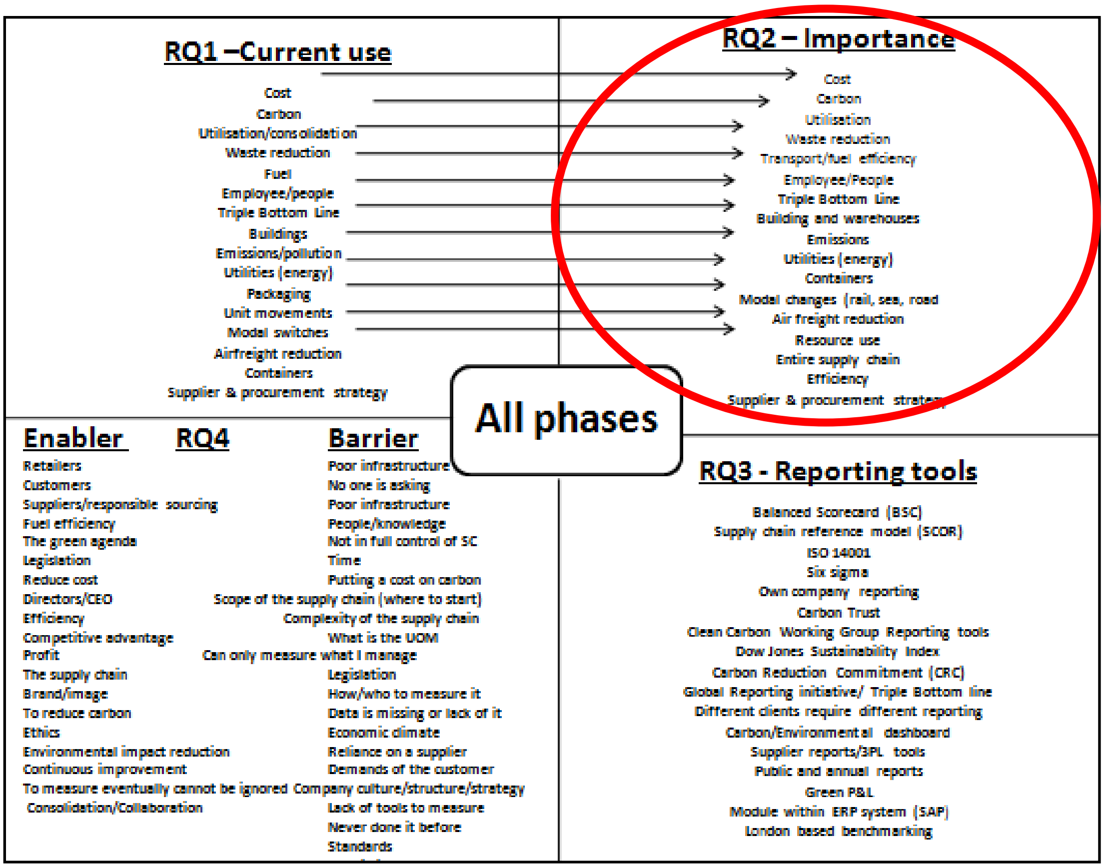


Figure 11.4 – Summary of the GSCPM Measurement Areas identified for RQ1 (Importance)

A key empirical finding of this thesis is that those GSCPM variables which organisations currently use are also seen as important as illustrated in Figure 11.4. For example, the GSCPM variables of utilities, fuel and waste reduction are currently used by organisations and also seen as important. Conversely, those GSCPM variables which are not seen as useful are not widely adopted (energy used per item/case or pallet delivered). Stakeholder theory can be used to explain why organisations view certain GSCPM variables as important. As outlined by Sarkis et al. (2011), stakeholder theory in relation to GSCPM suggests that organisations produce externalities that affect many parties (stakeholders such as customers, suppliers and shareholders). These externalities can be both internal and external to the company. These stakeholders increase the pressure on organisations to mitigate their impact on the environment and to produce positive outcomes. This ultimately influences which GSCPM variables organisations use and view as useful. Cost for instance was statistically 'exceptionally useful' to most respondents in the survey results which reinforces it as a very important construct in this thesis. Cost dominates the extant literature on supply chain performance measurement and therefore even when organisations are mitigating their impact on the environment, cost is still a primary consideration for most organisations.

A second key empirical finding for RQ2 is that there are statistically significant differences between a company's industrial sector and how useful these companies view certain GSCPM variables. There are also similarities in the way respondents view the usefulness of certain GSCPM variables. For instance, GSCPM variables such as electricity, gas and water consumption are viewed by the majority of survey respondents in the same way (very useful); thus important and universal to most organisations. GSCPM variables however, such as packaging consumption, are classed as a sector specific GSCPM variables as only organisations belonging to the retail, manufacturing and wholesale trade find them useful.

Four components (factors) were identified in Phase Two via the PCA modelling on GSCPM usefulness highlighting potential differences in the way respondents viewed certain GSCPM variables, they were:

1. Warehouse/Buildings
2. Transportation
3. Carbon and GHG emissions
4. Utilities and waste

This supports the finding that there are four groups of respondents which share similar views on which GSCPM variables are useful, thus reinforcing the key empirical finding that there are sector and occupational differences in the way respondents view GSCPM usefulness. The four components identified in RQ2 for usefulness underlie the key GSCPM constructs found in the literature and identified in Table 6.5 (Chapter Six), with the exception of warehouse/buildings. These sector differences in terms of GSCPM use and importance have not been identified anyway else in the existing GSCPM literature and are a unique and unexpected contribution of this thesis. This finding is exceptionally important as it highlights that within the proposed universal set of GSCPM variables, some measures will be generic/core and some will be specific to certain sectors. There may not be a 'one size fits all' set of GSCPM variables. The Global Reporting Initiative (GRI, 1997) which was discussed in Chapter Five also makes reference to 'core' and 'additional' metrics for sustainability reporting which support this finding. Core represents those metrics which are used by most organisations and additional represents additional measures which are important to the industry or the organisation's stakeholders.

The size of an organisation also has a significant influence on GSCPM usefulness as in current use (RQ1). For instance, large organisations find electricity consumption, fuel consumption, warehouse efficiency, vehicle fill/utilisation and cost measures on average more useful than smaller organisations. This is because smaller organisations are probably less likely to be running their own fleet of vehicles or warehouses such as the larger organisations. This again is a unique finding of this thesis and adds a further perspective to GSCPM importance.

GSCPM Variables – Ease of Measurement

The second dimension to GSCPM importance is 'ease of measurement', which provides an insight into how easy or difficult the set of 25 GSCPM variables are to measure. Vehicle mileage, electricity consumption and fuel consumption were identified as the easiest to measure of all 25 GSCPM variables. Electricity consumption and vehicle mileage measures were also the most used GSCPM variables. This indicates that the GSCPM variables which are the easiest to measure are the ones which organisations are more likely to be using and the ones which are seen as the most useful. This theory however does not always hold true as waste recycling was one of the top three most used GSCPM variables in Phase Two but not necessarily the most easiest to measure. In contrast, green house gas emissions, energy used per item/case/pallet delivered and carbon emissions per item/case/pallet delivered are exceptionally difficult to measure, the least useful and the least-used of all GSCPM variables. This suggests linkages between GSCPM adoption, impact and ease of measurement. For instance those GSCPM variables which are the easiest to measure are seen as more useful and therefore more likely to be measured. Therefore, in order to assess GSCPM, researchers should first of all review current use, ease and impact to get a view of which GSCPM variables are important and which should be prioritised by organisations. This supports the conceptual model in Chapter Six (Figure 6.7) and is a unique contribution of this thesis.

Those GSCPM variables associated with carbon/greenhouse gas emissions and resource efficiency are seen as very difficult to measure and this is identified throughout all phases of the research. There is a realisation by practitioners that carbon and resource efficiency are important (Phase One), unfortunately many lack the resources or capabilities to measure them. This is echoed in the extant literature with carbon auditing, labelling or carbon footprint analysis requiring huge investment upfront and often viewed as a wasteful distraction (Lynas, 2007; McKinnon, 2009b).

In Phase Two, statistically significant differences were identified between a company's industrial sector and how 'easy to measure' these companies viewed certain GSCPM variables. The sector differences mirrored those found in terms of GSCPM usefulness and highlighted the differing organisational capabilities around GSCPM. For instance; driver behaviour was viewed as easiest to measure by the transport sector respondents whereas electricity consumption was viewed exactly the same regardless of sector.

Four components were identified in the PCA modelling for ease of measurement:

1. Transportation/Warehousing/Energy
2. Transportation
3. Transportation/People
4. Energy/Utilities

This identified four groups of respondents which shared similar views on GSCPM ease of measurement. The largest group of respondents (Component One) found the transport related GSCPM variables very easy to measure but carbon emissions as very difficult to measure. This is in line with the author's expectations as 41 per cent of the survey respondents were from the transport and warehousing sector. There were however, a smaller group of respondents (Component Four) that found employee travel and energy very easy to measure but found the transport and warehousing GSCPM variables very difficult to measure. This again highlighted the differing lenses through which organisations view 'ease of measurement' indicating differences in organisational capabilities which can be explained by their sector, occupations, size and external pressures. Certain GSCPM variables and their ease of measurement, however, are viewed in the same way by organisations regardless of their sector and size. For instance, electricity consumption and carbon emissions of an activity are viewed by organisations in exactly the same way. All organisations, regardless of sector or size, find electricity consumption very easy to measure and carbon emissions very difficult to measure. This is perhaps because energy in the form of electricity is not a new measure; it has been around for decades, in contrast, carbon emission is a relatively new measure.

GSCPM Attributes

A key message which emerged from Phase One (FG2) of the research was that *"The most appropriate measures are the ones which are simple and that people understand."* The FG2 participants went onto identify four attributes of a good GSCPM which really underpin the findings from RQ2 for ease of measurement and importance:

1. *The measure must be simple and easy to understand*
2. *Requires no complex equations/algorithms to calculate it*
3. *The measures must be clear, visible, simple, transparent and consistent*
4. *Avoids duplication and double counting*

This closely aligned with the attributes Caplice and Sheffi (1994) recommended in their review of supply chain metrics. If the measure is too complex, the message and its impact are lost in translation. This reinforced the fact that people are vital in the success of GSCPM implementation and the two must be viewed and assessed together. The field of GSCPM is complex and influenced by multiple factors such as customers, suppliers, government legislation, and technology. This complexity can be explained by the complexity theory which describes the heterogeneity and diversity surrounding supply chain management and environmental management (Sarkis et al., 2011). It makes it very difficult for organisations to know what and how to implement GSCPM. There is also evidence to suggest that supply chain performance itself is not that well advanced in most organisations and in some cases does not exist at all (Keebler and Plank, 2009). This presents challenges for GSCPM implementation as there is no blueprint or baseline to follow.

So which are the most important GSCPM variables and what has the literature identified thus far? Limited research has been conducted on GSCPM importance; in fact only one article has been found which assessed GSCPM importance. This was produced by Olugo et al. (2011) were they assessed the importance and applicability of measures and metrics for the green automobile industry. They identified that the customer perspective and cost were the most important measures for this industry. Cost was identified as one of the most important variables in this thesis and although customers were referred to in Phase One by the participants of the focus groups, it was not explicitly identified as a GSCPM but more as a driver to measuring GSCPM.

Figure 11.5 identifies out of the 29 GSCPM variables identified in this thesis, there are 17 specifically which are the most important to practitioners (which were identified across all phases of the thesis). These are GSCPM variables which are currently adopted, viewed as very useful and generally easy to measure.

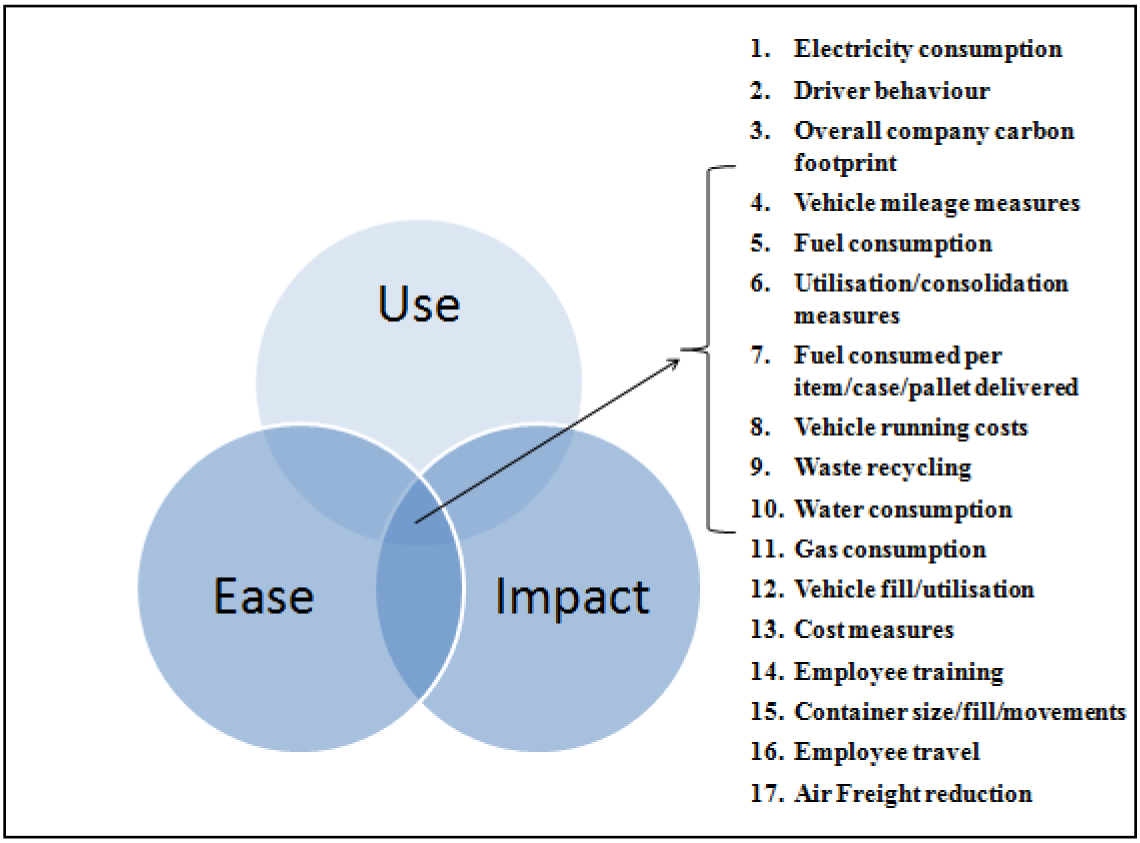


Figure 11.5 - The Most Important 17 x GSCPM Variables

11.2.3– *RQ3: Can GSCPM be integrated within existing supply chain performance frameworks?*

<u>GSCPM Reporting - No one size fits all</u>

A key empirical finding for RQ3 is that organisations currently use various reporting tools/frameworks to measure their supply chain performance and not one particular type. The most significant reporting tool used by organisations is their own in-house company reporting (72 per cent of survey respondents). This is a significant and unexpected finding not only in terms of GSCPM but for SCPM in general as it means there is a 'no one size fits all' in terms of SCPM reporting. This has consequences for integrating GSCPM into the existing business strategy and makes it difficult to conduct benchmarking activities both in SCM and GSCPM (Shaw et al., 2010).

<u>GSCPM Reporting – Integration</u>

Seventeen reporting tools were identified in total by practitioners across all three phases of the research (Figure 11.6). The consensus of opinion from the survey respondents was that GSCPM could be integrated into their existing supply chain performance frameworks (68 per cent of survey respondents) and they did indeed see some benefit in doing so (67 per cent of survey respondents). Little evidence existed both in the background literature, Phases One and Three that this was taking place, and this therefore suggested that environmental management is increasingly being viewed as separate and managed outside of the normal business strategy, thus validating the claim by McIntyre et al. (1998b) that green logistics is at risk of disappearing down a divergent path to the normal business strategy. The thesis results have highlighted that some focus group participants had very limited knowledge of their organisations environmental management systems and certification, for instance ISO 14001. It was clear, that environmental management was not their area of responsibility and not high on their list of priorities and was generally looked after by their HR/Finance departments.

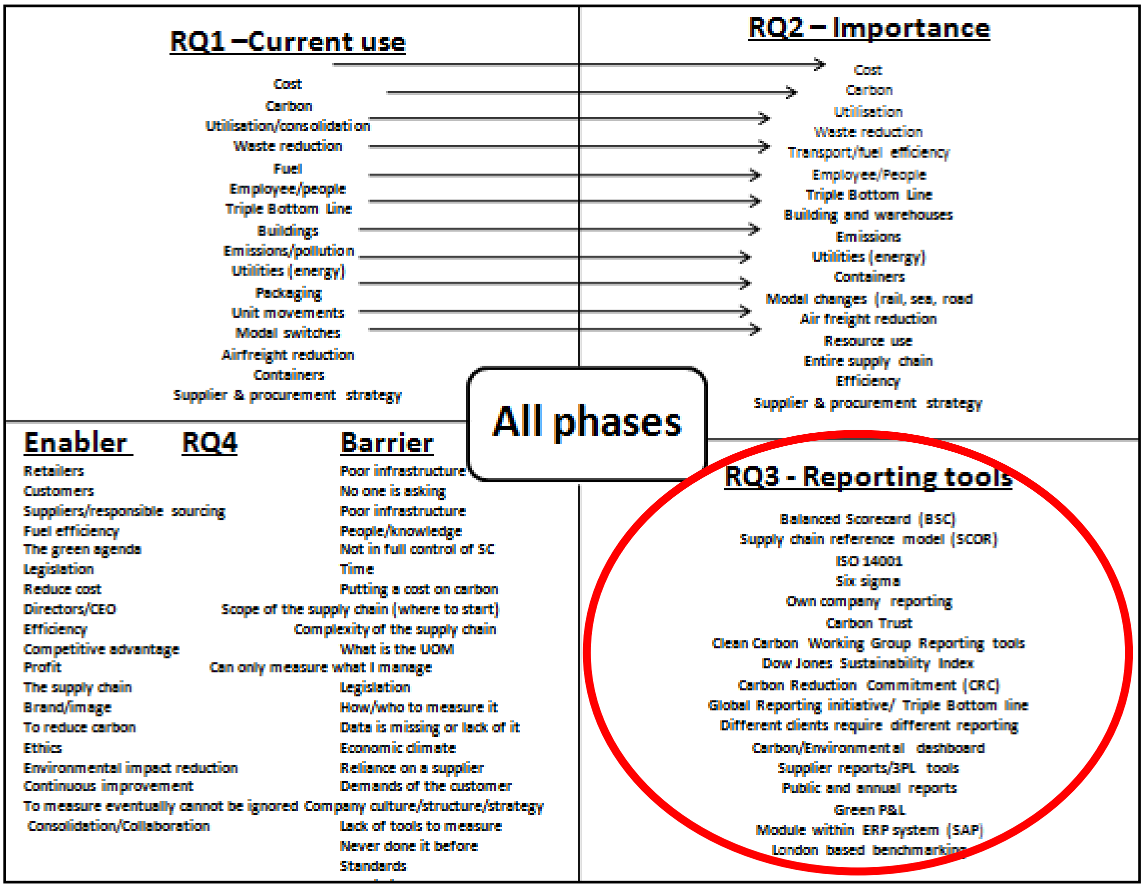


Figure 11.6 – Seventeen SCM Reporting Tools Defined as Currently Used by Practitioners (A Summary of the Three Phases of the Research)

GSCPM Reporting Capabilities

There was also a stark contrast in the language used and knowledge shared in the focus groups between logistics/supply chain managers and sustainability managers. A sustainability manager from the Public sector in Phase One spoke confidently and in detail about their GSCMPs and reporting, however some of the logistics managers and directors struggled with this concept and it was clear they did not have sufficient knowledge or capabilities in the field of environmental management. There was also a contrast between the capabilities of the Phase One respondents compared to Phase Three. The Phase Three participants had more advanced knowledge of GSCPM and some were already starting to develop their own environmental in-house company dashboards to manage this. Apsan (2000) identified that business people and environmentalists talk a different language and are therefore running in non concentric circles. He argued that communication was the key to resolving this diverging mindset and that a business leader's frame of reference was the balance sheet. This presents challenges for GSCPM integration and acceptance. If GSCPM could be linked to cost or customer value then this would act as a catalyst for integration into the business strategy. This reinforced the point made earlier that more research is required to make the link between cost and being green. "*If you can put a value on carbon it will change people's behaviour'* (Participant Twelve).

Reporting - Organisational Size

A key finding from Phase One was that smaller organisations do not do much reporting and larger organisations tend to report internally on GSCPM but not necessarily externally unless requested by government/legislation. This supports the findings in the literature review that reporting and benchmarking of GSCPM is still very much in its infancy (Shaw et al., 2010). It was evident from the survey results that a large number (12 per cent of survey respondents) of small, medium and large organisations do not report their supply chain performance at all, which reinforced the findings made by Keebler and Plank (2009) that a lack of maturity still exists in SCPM reporting.

The second most widely adopted reporting tool is ISO 14001 (39 per cent of survey respondents), shortly followed by the BSC (37 per cent of survey respondents). These two reporting tools are therefore significant as they are the most widely used frameworks outside a company's own in-house reporting and therefore considered by respondents as the most appropriate tools for GSCPM integration. Hervani et al. (2005) also suggested the ISO 14001 certification and ISO 14031 standard design principle of plan-do-check-act (PDCA) model for the implementation of environmental management in supply chains. The PDCA model is linked to the continuous improvement model which is outlined by Deming (1986) and represents a very useful framework for not only continually assessing which GSCPM variables to use, but evaluating the GSCPM variables and acting upon the results.

A final key observation to be made from RQ3 is that tools which are widely discussed in the academic literature such as the GRI, (2009), SCOR or Green SCOR are not extensively used in practice, or at least not in a UK context. ISO 14001 is the most popular and widely used tool behind own company in-house reporting. This is an important finding as integrating environmental performance into existing performance measurement systems (PMS) is easier when the organisation in question is familiar with an existing framework (Hubbard, 2007; Länsiluoto and Järvenpää, 2010).

A number of benefits have been attributed to embedding green practices into existing business strategy and operations (Porter and Van der Linde, 1995; Shrivastava, 1995; Zhu and Sarkis, 2004). With such diversification in existence with current SCPM reporting; it is evident from the results of this thesis, that industry is leading rather than following academia in supply chain reporting, and there is no one PMS solution which suits every business. It indicates a 'reporting revolution' is taking place in practice. This SCPM reporting tool proliferation makes proposing at least one tool for GSCPM integration very problematic and risks proposing a tool which is not widely used or accepted by the wider supply chain community. It is clear however, that guidance is needed, as a lack of it has resulted in industry creating, designing and implementing their own SCPM and GSCPM reporting tools, which may or may not be aligned to their overall business strategy or indeed government legislation. This reinforced the point made in Phase One (FG2) that *"it is the call to action what we are looking for"* from government (Participant 16).

The next section will now discuss the key empirical findings in relation to RQ4, which helped to understand the root causes behind GSCPM. Following this, Section 11.3 will draw together all of the key empirical findings and propose a reporting framework which incorporates a battery of GSCPM variables for the supply chain.

11.2.4 – *RQ4: What are the enablers and barriers for GSCPM? (Root cause analysis)*

Fourteen enablers and 15 barrier constructs were identified across all three phases of the research (Figure 11.7). The most significant enablers of GSCPM are for organisations to reduce cost, improve their operational efficiency and comply with government legislation. In contrast, the most significant barriers to GSCPM are the cost to invest in GSCPM, the complexity of the supply chain and data required to perform the measurement.

A key empirical finding for RQ4 is that cost is both a major enabler and barrier to measuring GSCPM. Figure 11.8 summarises the key enablers and barriers to measuring GSCPM and these in effect are the root causes behind GSCPM adoption. Similar themes have been identified in the literature with cost identified as a key driver of being companies being green (Green et al., 1996; Handfield et al., 1997; Carter and Dresner, 2001; Walker et al., 2008). Saha and Darnton (2005) also found that the principle reason for going green was not a genuine care for the environment, it was a reactive response to the pressures from government legislation, NGO's, customers, and stakeholders. It was also seen as a way to gain more business, save costs, and to enhance the company image. There is an opportunity to force a change in business behaviour by internalising the external environmental costs of logistics by taxing companies on such things as carbon emissions (Piecyk and McKinnon, 2007).

There are theories which explain why cost is so important to organisations; they are classified into two categories: the traditional economic theory which relates to improving operational efficiency, the other is institutional sociology which is based on the fact that an organisation's environmental management is not necessarily based purely on rational economic theory but other drivers such culture, ethics and a genuine care for the environment (Liu et al., 2010).

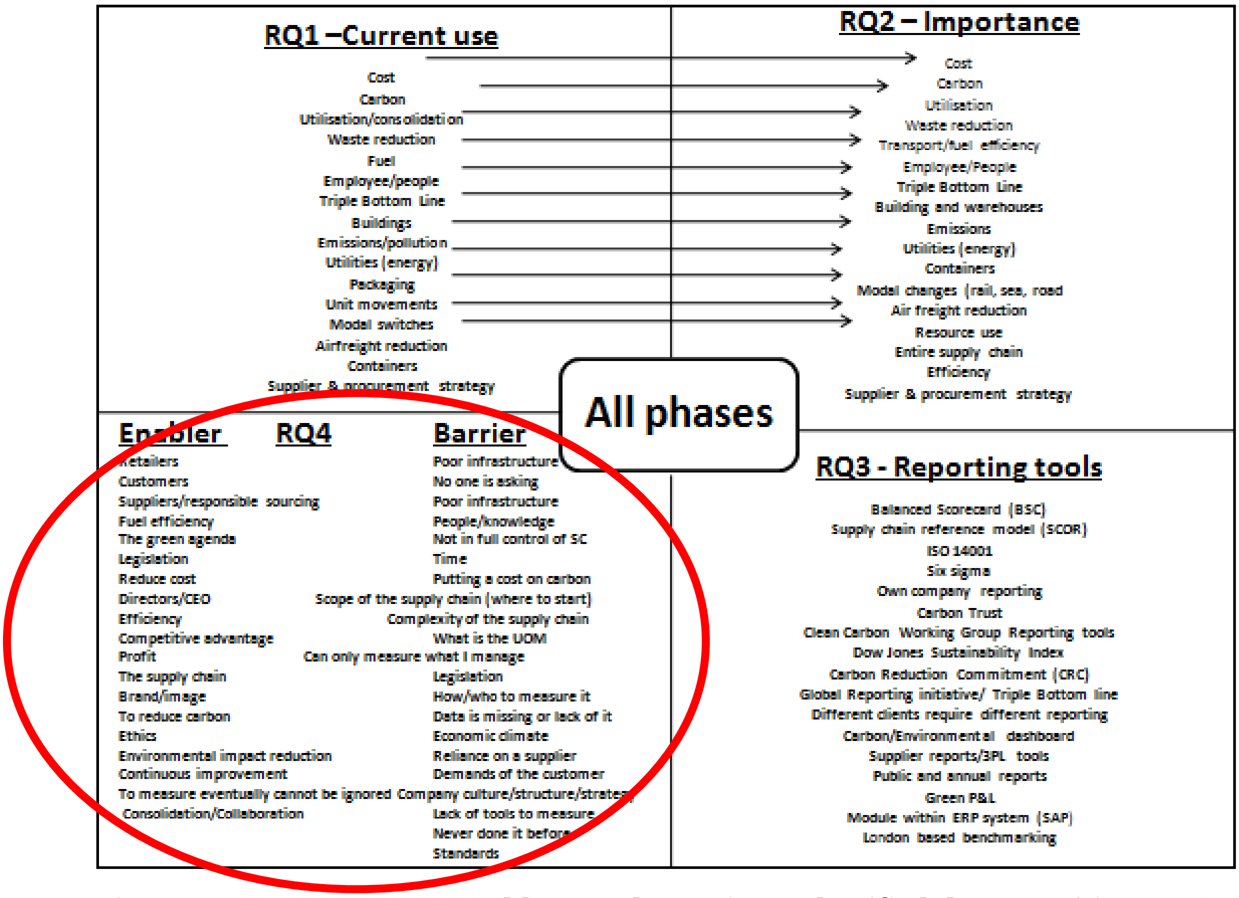


Figure 11.7 – GSCPM Enablers and Barriers Identified by Practitioners (A Summary of the Three Phases of the Research)

There are equal numbers of enabler and barrier variables for GSCPM. This balance between these driving and hindering forces are what creates a sense of inertia and lack of action around GSCPM in practice. There are also more internal barriers to the adoption of GSCPM than internal enablers (Figure 11.8). The Fishbone diagram in Figure 11.8 was created using the key enabler and barrier statements/themes which were identified in the Phase One and Phase Three focus group sessions. These internal barriers can be linked back to organisational theory in the extant GSCM literature, in particular, the RBV of a firm. Ownership and capabilities were big issues for the organisations participating in the focus group research; they struggled with the concepts of understanding: who should measure GSCPM, how it should be measured and exactly what should be measured. This created complexity and frustration. These hindering factors can be explained by the practitioner's internal capabilities and resources around people, systems and processes. External barriers included lack of government direction. In contrast, there were more external enablers driving organisations to measure GSCPM, for instance pressure from customers, suppliers and the government. These barriers can be linked back to the background literature on supply chain performance measurement in Chapter Five.

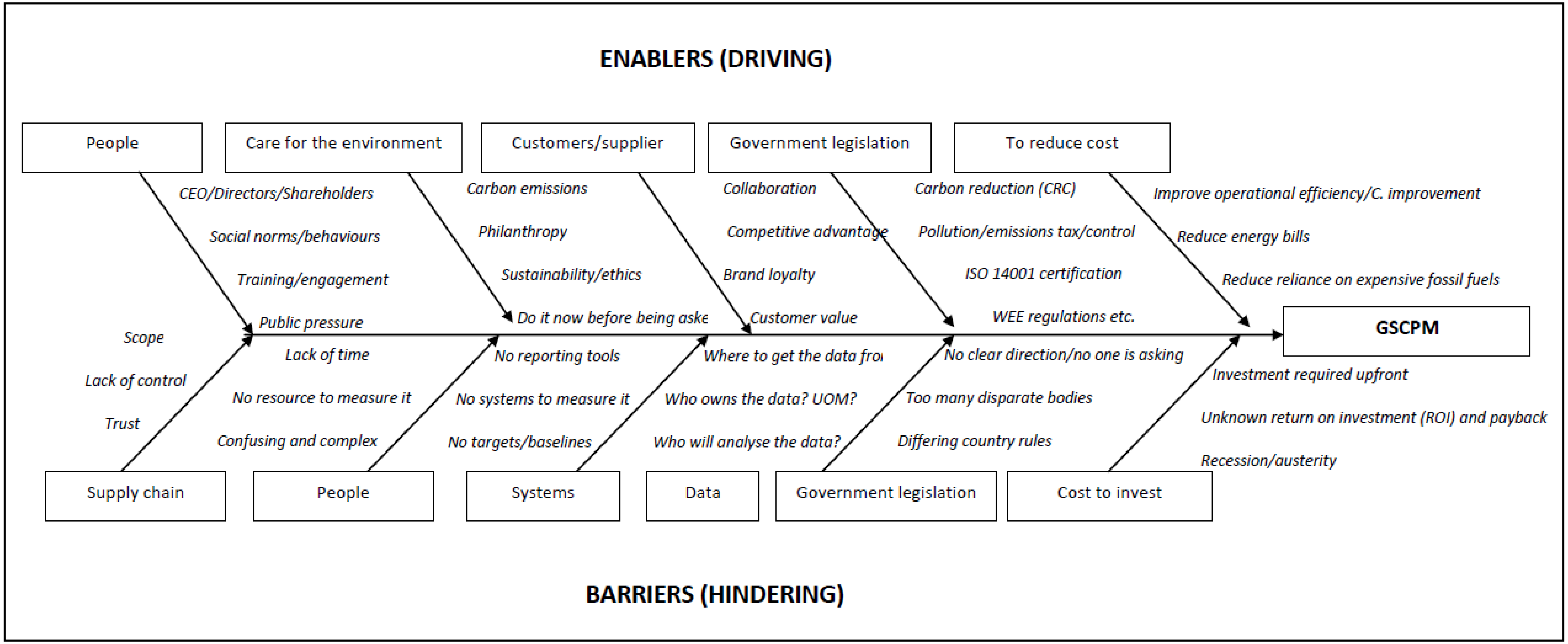


Figure 11.8 – Cause and Effect Fishbone Diagram for GSCPM

GSCPM Enablers and Barriers - Sector Differences

A second key empirical finding is that there are statistically significant sector differences in what motivate certain organisations to measure GSCPM, for instance, the survey results showed that the retail, manufacturing, transportation and warehousing sectors strongly agree, that to improve operational efficiency and continuous improvement, are key enablers to GSCPM. Furthermore, the transportation and warehousing sector respondents strongly agree, that reducing energy consumption and cost are key enablers to GSCPM. These sector differences are also evident in the barriers of GSCPM, for instance, the transportation and warehousing, manufacturing, professional, scientific and technical services sectors, all strongly agree, that resources, time, lack of data, the supply chain itself and that there are too many disparate government bodies are key barriers to measuring GSCPM. Zhu and Sarkis (2004) found that different industries in China had differing drivers and practices to GSCM. The automobile industry was also under the greatest pressure from import government regulations compared to the other sectors reviewed (Olugo et al., 2011). Walker et al. (2008) also found sector differences in their assessment of the public versus private sectors in relation to GSCMPs; thus reinforcing the findings in this thesis. No existing literature has been found thus far on sector differences specifically relating to GSCPM and is therefore a unique contribution of this thesis.

The third most significant finding is that government legislation, like cost is an enabler and barrier to measuring GSCPM. It was clear from the focus group research in Phases One and Three that legislation was important to practitioners and there was clear frustration about the lack of direction from government on what and how to measure. The respondents demanded a '*call to action'* (Participant 16) from government on this and in the absence of any direction they would continue to measure what their customer's required. Another view from Phase Three was that you can not put off the inevitable and participants recommended to measure now, rather than waiting to be asked to measure later. This reinforced the point that industry is leading rather following any particular guidelines from academia or indeed government.

The only existing literature which exists on drivers and barriers in relation to GSCPM is captured by Hervani et al. (2005) and Shaw et al. (2010). The remaining literature relates specifically to GSCMPs/GSCM. In an assessment of the drivers and barriers of GSCMPs in the private and public sectors, Walker et al. (2008) explore in some detail the factors that drive or hinder GSCMPs and which generate complexity in the private and public sectors. They categorise drivers and barriers into internal and external categories with most of the drivers of GSCM practices related to organisational factors. They also discuss the drivers of regulations, customers, competitors and society in general and identify the internal barriers as cost and poor supply chain partner co-operation. These constructs largely mirror those found in this thesis.

Holt and Ghobadian (2009) also identified that GSCM outputs are influenced by external and internal factors (Figure 11.8). They looked at the extent and nature of greening the supply chain in the UK Manufacturing sector and the factors which affect this. They found on average that manufacturers perceived the greatest pressure to improve GSCM practices through legislation and internal drivers, with the least influential pressures being societal and customers. They also found that manufacturers were more likely to focus on higher risk GSCMPs, that they had to implement, rather than engaging in more proactive, external engagement processes. Thus, reinforcing the finding discussed earlier that organisations are reactive rather than taking proactive steps in GSCPM.

Finally, Seuring and Müller (2008b) identified a number of supporters and barriers for creating sustainability in supply chains. They identified ISO 14001 as a major driver for the implementation of sustainable supply chains and also the training and education of employees. They also found higher costs, complexity, effort and missing communication as a key barrier. These mirror some of the enablers and barriers identified in this thesis. Hervani et al. (2005) also acknowledged that performance measurement in the supply chain is difficult because of the numerous tiers and that overcoming this barrier is not an insignificant challenge but a long-term goal. The same issue was identified in this thesis, with the supply chain itself being identified as a major barrier to GSCPM.

The enabler and barrier constructs identified in this research thesis largely mirror those found in the existing literature on GSCM. This, however, represents one of the first pieces of research to use focus group research to explore in-depth what is driving and preventing organisations measuring GSCPM. The results and findings therefore have a degree of granularity and depth around the issues experienced by practitioners which have not been identified in detail elsewhere, for example, data, systems and ownership were identified as barriers to GSCPM; they have not been identified anywhere else in the literature on GSCPM. Data/systems encompass some very specific issues which include aspects of 'what are the targets/baselines', 'what is the base UOM' and 'where is the data coming from', 'how do we measure and report'. This level of detail is not evident in the extant literature and therefore helps to contribute to the body of knowledge on GSCPM.

An additional question around GSCPM benefits was introduced into the research to understand if there were correlations between the perceived enablers and benefits of GSCPM. This extra insight was worthwhile as it identified that the top three benefits to measuring GSCPM are to reduce waste, to be more operationally efficient and to continuously improve and link closely to the construct of finance. The primary benefit to organisations is about reducing cost and to a lesser extent about the environment, collaboration with partners and creating customer value; thus the financial construct continues to underpin the GSCPM findings.

The foregoing sections of this chapter have integrated the key empirical findings of this research with the existing literature (RQ5). They have summarised and made a final assessment of the key gaps, disparities and similarities in the existing body of knowledge. The next section will now draw together these key empirical findings and propose a battery of GSCPM variables and reporting tools for supply chains, which will be a source of competitive advantage and will guide practitioners and government on future GSCPM decisions and actions.

11.3 – Proposed Universal Set of GSCPM Variables and Reporting Tools

A core contribution of this thesis is to draw together the key empirical findings from the research and propose a universal set of GSCPM variables and reporting tools which can be used by all organisations to measure and mitigate their impact on the natural environment. This will not only provide organisations with a source of competitive advantage but it will also help to guide future government policy decisions in this area. Additionally, it will also help to reduce the complexity, frustration and fragmentation which exists in industry and in the extant literature. The design of such a battery of GSCPM variables and reporting tools will take into consideration the key empirical findings of this thesis and the direct feedback/views of the respondents which took part in the focus groups. The findings serve as an indicator of the views of the wider supply chain and logistics population.

11.3.1 - A Recommended Universal Set of GSCPM Variables (What to measure)

A key finding from this research was that the GSCPM variables and reporting tools must follow a list of pre-requisites (Table 11.1) which were identified by the participants from Phases One and Three. These 15 pre-requisites are crucial in the development of GSCPM variables and reporting tools for organisations and for future research in this field.

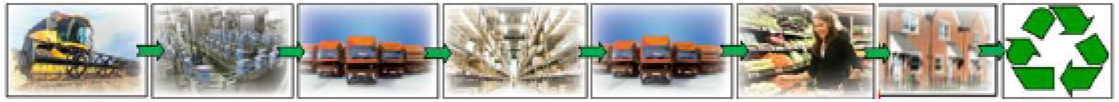
Table 11.1 – Fifteen Pre-requisites for a Proposed Set of GSCPM Variables and Reporting Tools

GSCPM variables/Reporting Tool Pre-requisites	
The GSCPM variables must be:	
1. Simple and easy to understand	✓
2. Standardised across industry types	✓
3. Transparent	✓
4. Include SMART targets and baselines	✓
5. Have agreed ownership and a governance process	✓
6. Require no complex equations/algorithms to calculate/measure it	✓
7. Be driven by government legislation	✓
8. The scope must be greater than carbon emissions and fuel consumption	✓
9. Have consequences for not hitting the targets	✓
10. Measure the end to end supply chain (including reverse logistics)	✓
11. Avoid duplication and double counting	✓
12. Cope with change (theme, context and challenge)	✓
13. Deal with the ‘so what’ and improvement	✓
14. Deal with mitigation and adaptation	✓
15. Generic or specific to certain industrial sectors	✓

Figure 11.9 provides a high-level guide for practitioners of the 12 overarching GSCPM constructs identified in this thesis and where they should be applied along a typical grocery supply chain. This GSCPM matrix is adapted from the sustainability matrix which was proposed by the food retail trade association in 2011 for assessing the sustainability issues along the supply chain. Those rows highlighted in yellow indicate that these constructs may be applied to all parts of the supply chain end to end. The purpose of this GSCPM matrix guide is to:

- Identify which GSCPM variables should be measured
- Where in the supply chain they must be measured
- Assess the environmental impact of each part of the supply chain
- Assess the environmental impact of the entire supply chain
- Allows practitioner to understand what they must do to mitigate the impact
- Identify opportunities and risks and how these help to support other initiatives

GSCPM Construct Matrix Guide

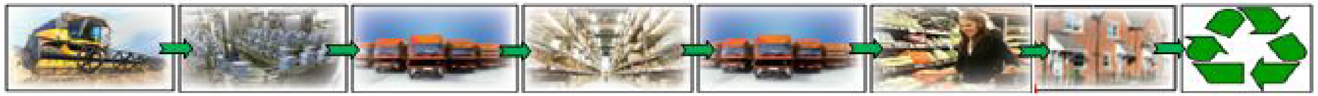


	Raw materials	Manufacturing	Inbound Transportation	Storage & Warehousing	Outbound Transportation	Wholesale & Retail	Customer	Recycling & Returns
1. Financial	✓	✓	✓	✓	✓	✓	✓	✓
2. Energy	✓	✓	✓	✓	✓	✓	✓	✓
3. Emissions	✓	✓	✓		✓			
4. Efficiency	✓	✓	✓	✓	✓	✓	✓	✓
5. Water	✓	✓		✓	✓	✓		✓
6. Triple Bottom Line/ Sustainability	✓	✓	✓	✓	✓	✓	✓	✓
7. People	✓	✓	✓	✓	✓	✓	✓	✓
8. Transport			✓		✓			✓
9. Systems	✓	✓	✓	✓	✓	✓		✓
10. Buildings	✓	✓		✓		✓		✓
11. Supplier	✓	✓	✓	✓	✓	✓		✓
12. Utilisation/Consolidation			✓	✓	✓	✓	✓	✓

Figure 11.9 – GSCPM Construct Matrix Guide (Adapted from Environmental Sustainability Matrix, IGD, 2011:2)

Figure 11.10 takes this one step further by reviewing the 29 variables and 12 constructs identified in this thesis and proposes a universal set of GSCPM variables which can be applied and used within or across nodes of the supply chain.

Recommended 12 x GSCPM Constructs



Raw materials	Manufacturing	Inbound Transportation	Storage & Warehousing	Outbound Transportation	Wholesale & Retail	Customer	Recycling & Returns

FINANCIAL	Supply chain costs/greening costs Cost measures (e.g. cost of running your warehouse, fleet etc)							
EMISSIONS	Carbon emissions of an activity (route/product) Carbon emissions per item/case/pallet delivered Overall company carbon footprint measures Overall supply chain carbon footprint Air, sea and land pollution GHG emissions (nitrous oxide/methane)							
UTILISATION	Container utilisation/consolidation Warehouse/pallet occupancy Vehicle fill/utilisation/backhaul Container size (20 or 40 ft)							
EFFICIENCY	Waste/packaging reduction/recycling Resource efficiency (raw materials, asset utilisation)	Waste/packaging reduction/recycling Resource efficiency (raw materials, asset utilisation)	Waste/packaging reduction/recycling Resource efficiency (raw materials, asset utilisation)	Waste/packaging reduction/recycling Resource efficiency (raw materials, asset utilisation)	Waste/packaging reduction/ recycling Resource efficiency (raw materials, asset utilisation)	Waste/packaging reduction/ recycling Resource efficiency (raw materials, asset utilisation)	Waste/packaging reduction/ recycling Resource efficiency (raw materials, asset utilisation)	Waste/packaging reduction/ recycling Resource efficiency (raw materials, asset utilisation)
TRANSPORT	No of pallet movements or touches per delivery	No of pallet movements or touches per delivery	Fuel use/ Efficiency(MPG)/mileage Air freight reduction No of pallet movements or touches per delivery No of container movements Modal Ratios	No of pallet movements or touches per delivery	Fuel use/ Efficiency(MPG)/ mileage Air freight reduction No of pallet movements or touches per delivery No of container movements Modal Ratios	No of pallet movements or touches per delivery	No of pallet movements or touches per delivery	No of pallet movements or touches per delivery No of container movements
ENERGY	Electricity consumption Gas consumption Energy used per case/item/pallet delivered to the customer							
PEOPLE	Environmental management training/education Employee travel Employee behaviours (driver behaviour) Customer buying behaviours							
BUILDINGS	Warehouse efficiency measures	Warehouse efficiency measures		Warehouse efficiency measures		Warehouse efficiency measures		Warehouse efficiency measures

SYSTEMS	Reporting Capabilities Systems infrastructure/Ability to measure							
WATER	Water consumption throughout the supply chain							
SUPPLIER	Supplier environmental performance/ compliance Procurement/sourcing Strategy	Supplier environmental performance/ compliance	Supplier environmental performance/ compliance	Supplier environmental performance/ compliance	Supplier environmental performance/ compliance	Supplier environmental performance/ compliance		Supplier environmental performance/ compliance
TBL/SUSTAINABILITY	← Economic, environmental and social measures → CSR Policy in place Community Awards							

Figure 11.10 – A Battery of 29 GSCPM Variables (Adapted from Environmental Sustainability Matrix, IGD, 2011:2)

GSCPM variables such as supply chain costs and carbon emissions can be measured within each node of the supply chain or measured for the end to end supply chain of a product or service. In contrast, GSCPM variables such as air freight reduction and fuel efficiency are only applicable to the transportation elements of the supply chain.

This by no means represents an entire list of GSCPM variables for the supply chain, but provides one of the first insights into a comprehensive list of GSCPM variables which can be used to assess the environmental impact of the supply chain. It highlights the diverse number of GSCPM variables available and how they can be applied to the entire supply chain. Clarke and Watkins (2003:17) recommend the next step is to rationalise the list of measures into "*core measures*" which are universally accepted by most organisations and then into the "*vital few*" which can be incorporated into an executive dashboard. Thus, the 'core' measures are those which were identified in Phase Two as generic and viewed in the same way. The author then focused on the most important 'core' GSCPM variables, which could be used to identify the vital few (Table 11.2). All of the proposed core GSCPM measures are underpinned by the constructs of energy, efficiency, transport, people, utilisation and emissions and will be important in the development of the vital few GSCPM variables. Further empirical testing is required to establish what these are. It is important to note there other GSCPM variables which are important (17 listed in Table 10.8, Chapter Ten), however, the eight GSCPM variables listed in Table 11.2 are both generic and important to all industries. These vital few GSCPM variables support the transition from performance proliferation to performance simplification (Morgan, 2007).

Table 11.2 – Proposed Core and Important GSCPM Variables

Proposed Core and Important GSCPM Variables ⇨	**Proposed 'Vital Few' Variables**
1. Electricity consumption **2. Gas consumption** **3. Water consumption** **4. Waste recycling** **5. Vehicle utilisation** **6. Employee training** **7. Employee travel** **8. Overall company carbon footprint**	? **Constructs:** *Energy* *Efficiency* *Transport* *People* *Emissions* *Utilisation*

Clarke and Watkins (2003) also recommend that each vital measure should have a detailed definition form created which covers the following criteria (Table 11.3).

Table 11.3 – The Chief Executive's Guide to Performance Measurement (Clarke and Watkins, 2003:18)

Definition	How the measure is calculated
Purpose	Why we measure this activity
Horizon	The time period of measurement
Source of Information	Where the data resides
Reporting	How the data is reported
Accountability	Who is accountable for generating the information
Process	The process followed to report, review performance and act upon the information

This addresses some of the root causes (barriers) which were identified in RQ4 around ownership, data and systems. The next step in the performance measurement process is to select a tool or PMS framework in which to present and report the GSCPM variables so that the information can be viewed strategically within an organisation and acted upon.

11.3.2 A Proposed GSCPM Tool

GSCPM Review and Improve (The So What?)

Following the development of GSCPM variables for supply chains, it is vital that there is an ongoing review process for developing new and emerging GSCPM variables in an organisation. ISO 14001 for PDCA which was recommended by Hervani et al. (2005) and Shaw et al. (2010) is an ideal framework in which to do this as it was identified as the second most used PMS by the practitioners in this thesis (Figure 11.11). This cycle will help organisations to continuously improve and mitigate their supply chain impact on the environment. Within this process, the GSCPM must be first developed, reported, analysed and reviewed. A key part of the process is that an ownership is applied to each of the GSCPM variables and a review process is set within the organisation in which to review and act upon the information. This reinforces the point in FG3 that "*It's what you do with the GSCPMs afterwards that are important.*"

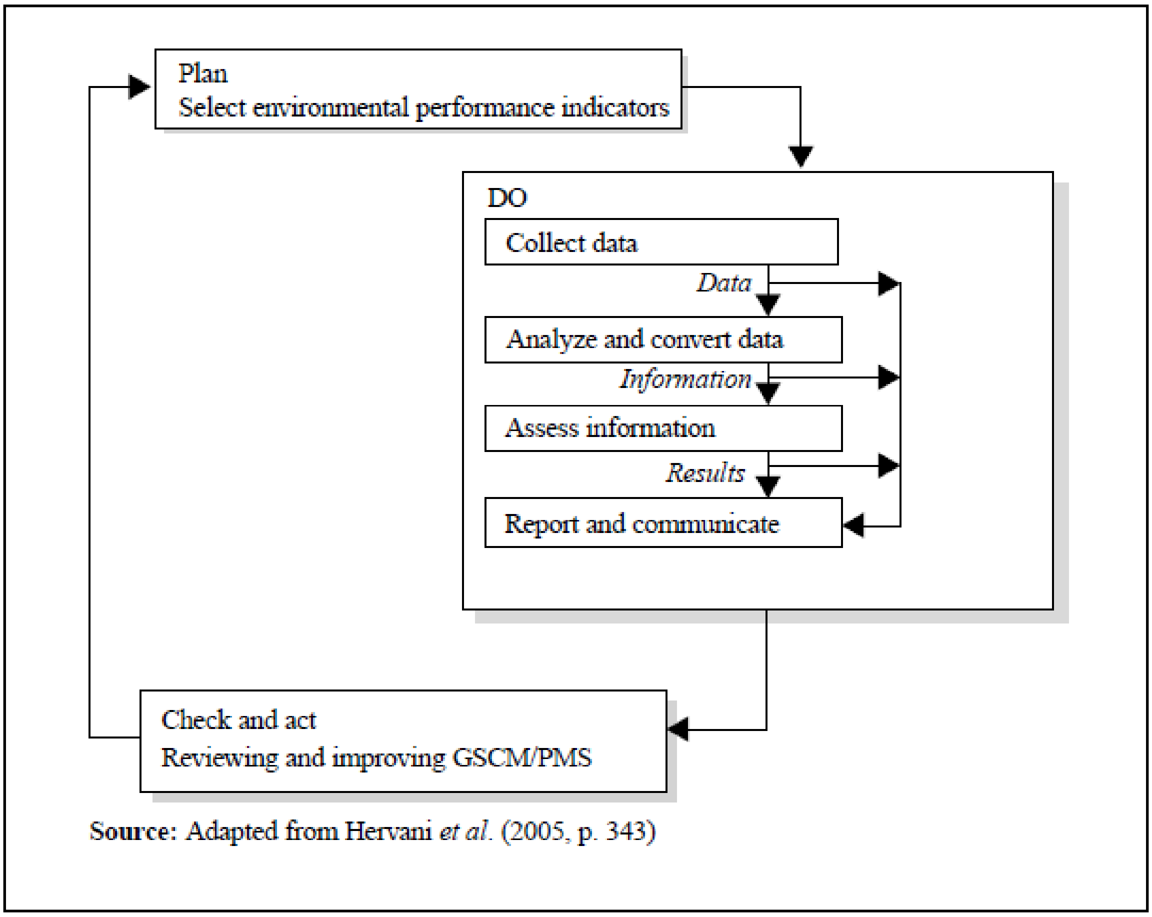


Figure 11.11 ISO 14001 PDCA Cycle (Shaw et al., 2010:327)

GSCPM Strategic (Executive) Reporting

The reporting element of this process can then be presented either in a company's own in-house report such as an environmental dashboard or via the third most commonly used supply chain strategic reporting tool in this thesis, the BSC. The use of the BSC for environmental reporting builds upon the work of Epstein and Wisner (2001), Hervani et al. (2005) and Shaw et al. (2010). Shaw et al. (2010) recommended that the most important GSCPM variables to practitioners can be incorporated and reported internally at a strategic level through one of the existing four perspectives or a fifth 'environmental' perspective within the BSC. Figure 11.12 illustrates this conceptually and identifies two dimensions within this fifth perspective accounting for the proposed GSCPM revolution:

1. What is our impact on the natural environment? (Mitigation)
2. How do/can we adapt to the changing natural environment? (Adaptation)

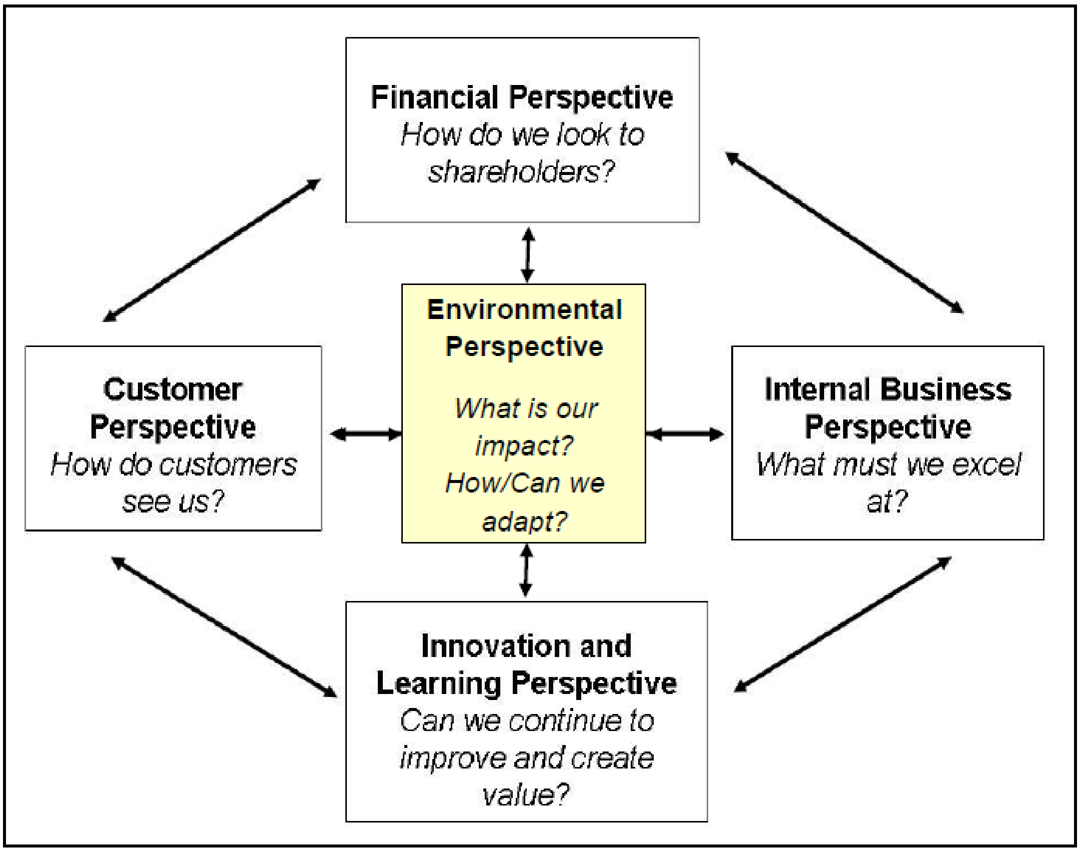


Figure 11.12: The Balanced Scorecard – A Fifth Perspective (Adapted from Kaplan and Norton, 1992:72 and Shaw et al., 2010: 335)

The BSC is a strategic performance reporting tool and provides a set of measures which allow senior managers to view their business performance at an executive level (Kaplan and Norton, 1992). It is a recommendation of this thesis that the vital few strategic GSCPM variables are viewed and reported through the fifth perspective in the BSC, however, operationally, the ISO 14001 PDCA cycle is used at an operational level as a tool to continuously improve and evaluate GSCPM in organisations. Thus, embracing the managerial taxonomy of strategic, tactical and operational proposed by Gunasekaran et al. (2001).

11.4 – Summary and Conclusions

This chapter has explored and summarised the key empirical findings from this research in a holistic and integrated way. It has compared and contrasted the key findings from each of the five primary research questions to the existing GSCPM literature and proposed conceptual model. This has enabled a final assessment of the key gaps, disparities and similarities in the existing body of knowledge and has drawn together the key findings across all the three phases of the research to propose a universal set of

GSCPM variables and reporting tools that organisations can use to manage their GSCPM.

The three-phased research approach (methodological triangulation) has enabled an extensive and in-depth view of the world of GSCPM development and enhanced the researcher's knowledge and confidence in the empirical findings, assertions and recommendations.

Chapter Twelve will now go onto summarise the main contributions of this thesis, the impact of these contributions on the existing body of knowledge and discuss the key implications for practitioners and academics.

CHAPTER TWELVE
CONCLUSIONS AND IMPLICATIONS

12.1 Thesis Summary

The purpose of this thesis has been to develop a universal set of GSCPM variables and reporting tools which organisations can use to mitigate their impact on the natural environment. This has been accomplished by exploring and testing which GSCPM variables and reporting tools are currently being used and viewed as important by practitioners, and what are the key enablers and barriers to GSCPM adoption in supply chains. This chapter concludes the thesis by summarising the main theoretical and practical contributions of this research along with an assessment of the managerial implications, research limitations and a guide for future research.

The thesis has extensively reviewed the field of logistics and supply chain management; providing a glimpse over the last century of how the discipline has evolved and adapted as new challenges have been met. The natural environment is probably one of the biggest challenges facing logistics and supply chain management today, as such this thesis has explored in detail the relationship between the two, both from a mitigation and adaptation perspective.

As a consequence of this growing environmental challenge, in the last eighteen years there has been an emergence and growth of work conducted in the field of green supply chain management (GSCM). GSCM continues to grow in interest amongst supply chain researchers and practitioners because of climate change issues, diminishing raw materials, excess waste production, increasing levels of pollution and because it is a source of competitive advantage. As a result, practitioners are facing increased pressure from their internal and external stakeholders to actively engage in GSCMPs to mitigate their impact on the natural environment. Practitioners therefore require robust ways of measuring and monitoring their environmental improvements, with cost continuing to be a primary consideration. Yet, there has been limited work conducted in developing and incorporating environmental or green measures into the existing bank of supply chain performance measures.

Despite the importance of this research agenda to supply chain practitioners, this thesis has identified that only 18 articles have been published in the last 18 years on developing GSCPM variables for supply chains, which is not a significant contribution. Very little research has been conducted on what GSCPM variables exist, how they are being applied and how they may vary by company or sector. Furthermore, over half these articles have been published in journals outside the field of logistics, showing a lack of maturity in the literature and research. The literature which exists both within and outside the scholarly academic journals is fragmented, complex and focuses on specific nodes or functions within the supply chain rather than the entire supply chain.

An in-depth assessment of the existing empirical research revealed a lack of theoretical rigour with the existing GSCPM studies mainly comprised of general reviews, literature reviews, single methodological approaches and small sample cases. Yet, there are demands for more rigorous research in logistics and supply chain management. Thus, there is a significant gap in the body of knowledge surrounding GSCPM adoption/ awareness and an understanding is required to bring order to the complexity and fragmentation which surrounds the current research. This thesis proposes a universal set of GSCPM variables and reporting tools that organisations can use to measure and mitigate their impact on the environment. GSCPM represents a new, topical and fertile ground for research and there is an opportunity to use combinatory research methods to build theory in this field to provide guidance to practitioners.

The literature review identified nine GSCPM constructs with cost and carbon the most dominantly cited measures. Drawing together all these constructs, issues and gaps in the literature, the author developed a conceptual model which underpinned and guided the research objectives and which helped to define the five primary research questions for this thesis: What GSCPM variables are organisations currently using? Which are important? Can GSCPM variables be integrated into an existing supply chain performance framework? What are the enablers and barriers to GSCPM? And do any of the constructs identified in the empirical research underlie those which have been found in the existing literature.

In order to assess the most important GSCPM variables for supply chains, it is vital to understand what is currently being used in practice and which are important to practitioners. Furthermore, it is imperative that an understanding be sought into what is driving and preventing organisations from measuring GSCPM in order that recommendations and actions can be taken to address these root causes.

To address the gaps in the existing research, this thesis built upon the work of Churchill (1979) and Dunn et al. (1994) by adopting a three phased methodology for scales and construct development to build theory in this relatively new research area. This is the first study of its kind in the field of GSCPM which has used this multi-method approach on a large study sample and has used the Churchill (1979) framework for variables and scales development. This has helped to increase the rigour and validity of this research and the resultant GSCPM and reporting tool constructs.

The empirical study comprised three phases: Phase One was an inductive phase, that involved conducting two focus groups with leading/supply chain managers and directors to generate GSCPM and reporting variables and constructs for testing; Phase Two was a deductive phase, that consisted of testing the adoption and importance of these emerging variables and constructs with logistics and supply chain professionals from the CILT and Phase Three was a inductive phase, that consisted of conducting a focus group with a different group of logistics/supply chain managers and directors to verify and validate the overall research findings. The application of methodological pluralism has enabled the researcher to alternate between inductive, deductive and inductive thought, thus generating an extensive and in-depth view of the world of GSCPM development; which up until 1998 was almost non-existent in the existing literature.

Phase One (literature review and focus groups) collectively identified 25 GSCPM variables and nine GSCPM reporting variables for further investigation and survey testing. Given the application and robust process applied to the two focus groups in Phase One, the results were considered substantive, internally valid and rigorous enough to proceed to the next phase for testing. The CILT was selected as a study sample in which to test the 25 and nine GSCPM reporting variables from Phase One.

Phase Two revealed that the three most widely adopted GSCPM variables were: 1) electricity consumption, 2) waste recycling, and 3) vehicle mileage. In contrast, the three most important GSCPM variables were: 1) vehicle mileage, 2) electricity consumption, and 3) fuel consumption. Thus, there is a relationship between GSCPM adoption and importance, with organisations utilising the GSCPM variables which they believe are important. Furthermore, the most commonly used supply chain performance reporting tools were: 1) own company reporting, 2) ISO 14001, and 3) the BSC. Finally, the survey results identified that the key root causes behind the implementation of GSCPM are cost, government legislation and the complexities associated with the supply chain itself. The perceived benefits however of measuring were: 1) waste reduction, 2) improving operational efficiency, and 3) continuous Improvement. Finance (cost) was identified as an overarching construct throughout all phases of the research and in the literature.

Factor analysis (PCA) was also conducted on the survey results (RQ2) to assess whether any of the 25 GSCPM variables where variables underlying any of the constructs identified in Phase One. The results revealed that these variables do underlie the constructs identified in the literature; however only one new construct emerged during this assessment (utilisation).

The purpose of Phase Three was to validate the overall research findings to ensure theory saturation had been met. Phase Three concluded that theory saturation had been met and revealed no new underlying GSCPM constructs. In summary, a total of 29 GSCPMs variables and 12 constructs were identified from this thesis, 25 GSCPM variables were empirically testing in Phase Two and a further four emerged during Phases Two and Three as part of this exploratory study. Seventeen of the 29 GSCPM variables are considered important to practitioners and eight are core and important to all practitioners regardless of sector or size.

12.2 Contribution to Theory and Methodology

RQ1 *- What GSCPMs are being used in practice today?*

Sixteen key GSCPM measurement areas were identified across all three phases of this thesis; ranging from carbon emissions through to employee training. Empirically, the most commonly used GSCPMs are: 1) electricity consumption, 2) waste recycling, and 3) vehicle mileage. Thus, the most commonly used GSCPM constructs are energy, efficiency and transport. Transport is a significant construct for RQ1, with four of the top 15 most used GSCPM variables being transport related. Empirically, the least-used GSCPM variables are: 1) energy used per item/case/pallet delivered, 2) carbon emissions per item/case/pallet delivered, and 3) fuel consumed per item/case/pallet delivered. Thus, the least-used GSCPM constructs are carbon, resource efficiency and also transport.

The most notable finding for RQ1 was that those GSCPM variables which organisations use, like usual performance measures, are primarily driven by cost and this underlies what is discussed in the existing supply chain performance literature. Cost is therefore a primary consideration in the development of GSCPM variables for the supply chain and it can be concluded that organisations are driven more by economic rather than altruistic reasons to mitigate their impact on the environment. Although a strong body of evidence exists in the academic literature of linkages between environmental management and perceived financial performance, much more is required to motivate organisations to measure GSCPM and thus mitigate their impact on the environment (Klassen and McLaughlin, 1996; Goldsby and Stank, 2000; Mollenkopf et al., 2010; Lee et al., 2012).

An unexpected and unique finding of this research is that GSCPM adoption is influenced by other factors such as company size and industrial sector, with different types of GSCPM being used by different companies. Very little explanation of the influence of industrial sector and company size on GSCPM adoption exists in the extant literature and this represents a large gap in the body of knowledge which requires further exploration. One explanation is that different companies and industries are exposed to different internal and external pressures which result in them adopting different GSCMPs and thus GSCPM variables (Zhu and Sarkis, 2004). Larger organisations also tend to have greater resources and capabilities to invest in GSCPM than smaller companies who are primarily focused on survival (Nawrocka et al., 2009).

Finally, it can be concluded from the RQ1 findings that are there Era's associated with the evolution of GSCPM and those measures which organisations use today (waste reduction – as is state) will be different to those which are adopted in the future (resource efficiency – to be state). Organisations will need to migrate from end-of-pipe solutions to preventing the environmental impact at source. This reinforced the concepts of environmental mitigation in supply chain but more importantly environmental adaptation (Abukhader and Jönson, 2004).

Despite the importance of this research problem to practitioners and academics, a lack of published empirical research exists in relation to GSCPM adoption and current use in organisations. Thus, this thesis represents one of only a few studies which have empirically tested in this field.

RQ2 *- Which GSCPMs are important to users, i.e. they are useful and provide an impact?*

Eighteen GSCPM measurement areas (17 individual GSCPM variables) were identified as important across all three phases of the research (Figure 11.5). The top three most useful GSCPM variables were: 1) fuel consumption, 2) waste recycling, and 3) electricity consumption measures. In contrast, the least useful GSCPM variables were 1) carbon emissions per item/case/pallet delivered, 2) number of container movements, and 3) energy used per item/case/pallet delivered.

A key contribution of this thesis is that GSCPM importance can be understood by assessing the relationship between GSCPM: 1) Adoption, 2) Usefulness, and 3) Ease of measurement (Figure 11.3, Chapter Eleven). The thesis has concluded that those GSCPM variables which organisations currently use are also seen as important and there is a relationship between these three dimensions which requires further research. Conversely, those GSCPM variables which are not viewed as important are not widely used. Stakeholder theory can be used to explain why organisations view certain GSCPM variables as important (Sarkis et al., 2011).

A key contribution is that those GSCPM variables which are easy to measure are more widely used and therefore seen as more important. The feedback from the focus group sessions corroborated this finding by stating the most important measures are those which people understand and are the easiest to calculate and measure. Thus, there is a relationship between the complexity of the GSCPM measurement and the perceived usefulness and importance, with practitioners finding the simple and least costly GSCPM variables the most important.

Carbon emissions on the other hand are very difficult to measure and therefore not widely used. This relationship between complexity and perceived importance has not be documented or discussed anywhere in the GSCPM literature and represents a unique contribution of this research and a major gap in the body of knowledge. Complexity theory can be used to conclude what is happening here. GSCM is a disorderly business system with significant heterogeneity. This complexity ultimately has an influence over human behaviour and learning. Complexity generates creativity enabling organisations to adapt and bring order to these complex situations (McElroy, 2000). Therefore, in the absence of direction from government, organisations are forging ahead and measuring those GSCPM variables which either they are being told to measure by their stakeholders or those which they find the most easy to measure. Further research is required to explore the relationship between complexity theory and its impact on GSCPM importance.

A major contribution of this thesis is that there are significant differences in the perceived importance of certain GSCPM variables and the organisation's industrial sector and size, thus reinforcing the impact of stakeholder theory/pressure on GSCPM in organisations. Furthermore, the thesis has concluded that there are 17 GSCPM variables which are important to organisation but eight 'core' GSCPM variables which are universally important (generic) to all organisations regardless of company sector/size; thus, they can be used to build a universal battery of GSCPM variables for the supply chain.

Finally, this thesis also represents the first piece of research to be conducted in the logistics and supply chain management discipline which uses the SIMCA-13 multivariate analysis software (Umetrics, 2012). Furthermore, it is also the first time the SIMCA-13 PCA analysis tool has been applied in a logistics and supply chain management context. The software is used extensively throughout the world in the biochemical and pharmaceutical industry and this is the very first time it has been applied to a logistics and SCM research. The use of SIMCA-13 adds further statistical rigour to the results and provides unique insights into GSCPM development which could not be replicated in traditional statistical software packages.

***RQ3** - Can GSCPMs be integrated within existing supply chain performance frameworks?*

A total of 17 reporting tools were identified by practitioners across all three phases of this research. The most commonly used supply chain performance measurement reporting tools are: 1) Own company reporting, 2) ISO 14001, and 3) The BSC.

A major contribution of this thesis is that there is ‘no one size fits all’ in terms of SCPM reporting and organisations are driving the reporting agenda by developing their own in-house company reporting which was an unexpected and unique finding.

Given the lack of guidance in this new complex, research area, it can be concluded that industry is leading rather than following academia on supply chain performance reporting. This presents challenges for standardising and benchmarking GSCPM reporting across different companies and industrial sectors. It can be concluded that alongside own company reporting, ISO 14001 and the BSC are the most appropriate and relevant tools for GSCPM integration as they are the most widely used and accepted in practice.

A further contribution of this research is that smaller organisations do not do any reporting at all and larger organisations report internally on GSCPM but not externally unless requested by the government/legislation. This supports the findings in the literature review that reporting and benchmarking of GSCPM are still very much in their infancy (Shaw et al., 2010) (Please see a copy of the author’s and co authors work in Appendix Six). This is because many organisations do not feel under any pressure to report on their GSCPM and are struggling with the initial concept of ‘what to measure’ and ‘how to measure it’.

The thesis concluded that practitioners do agree that GSCPM can be integrated within existing supply chain performance frameworks and they do indeed see a benefit of doing this. Although there is a desire and perceived benefit to integrate GSCPM into the existing bank of supply chain performance frameworks but there is clearly a lack of maturity and standardised SCPM reporting tools to do this and this presents challenges for GSCPM integration. A further issue relates to the fact that many small, medium and even large sized organisations do not yet report on their existing supply chain performance internally or externally (Keebler and Plank, 2009); which means organisations are some way off being able to measure at all.

A further contribution of this thesis is the lack of understanding and knowledge about environmental management practices amongst the logistics and supply chain community; the participants of this research were very unclear about what EMS and their company adopted. This is a major gap in the body of knowledge and suggests that logistics and supply chain practitioners need up-skilling and educating in this area if they are to successfully reduce their impact on the environment.

RQ4 *- What are the enablers and barriers in adopting and using GSCPM?*

The key root causes behind what is driving and preventing organisations from implementing GSCPM is directly linked to cost, government legislation and the complexities associated with the supply chain itself. Finance was identified as a primary construct throughout all phases of the research. This reinforced the economic theory that many organisations have an implicit or explicit financially-driven culture and an organisation's primary focus and frame of reference is about profit.

Fourteen enablers and 15 barrier constructs were identified across all three phase of the research. The most significant enablers of GSCPM are for organisations to reduce cost, improve their operational efficiency and comply with government legislation. In contrast, the most significant barriers to GSCPM are the cost to invest in GSCPM, the complexity of the supply chain and data required to perform the measurement.

There are theories which explain why cost is so important to organisations; they are classified into two categories: the traditional economic theory which relates to improving operational efficiency, the other is institutional sociology which is based on the fact that an organisation's environmental management is not necessarily based purely on rational economic theory but other drivers such as culture, ethics and a genuine care for the environment (Liu et al., 2010). The enabler constructs also directly correlate with the perceived benefits of measuring GSCPM, with finance emerging as an implicit construct throughout the top three statements (Figure 9.24, Chapter Nine).

A unique contribution of this thesis is there are significant differences in the way organisations views what are the enablers and barriers to measuring GSCPM. For instance the results showed that the retail, manufacturing and transportation/ warehousing sector respondents 'strongly agree' that to improve operational efficiency and continuous improvement are key enablers to GSCPM. These differences can be explained by stakeholder theory and the difference pressures which are exerted on particular industrial sectors (Zhu and Sarkis, 2004). Very little research exists on the enablers and barriers to GSCPM implementation in organisations and this represents one of only two studies which have identified sector differences in relation to GSCPM.

This is important as it can be used to explain why organisations are at different evolutionary stages in their environmental management process (Hervani et al., 2005) and that organisations are subject to varying degrees of stakeholder pressure, which in turn they respond to. Furthermore, the scope of GSCPM is considerable and therefore can imply different things to different people which in turn results in different approaches and outcomes (Saha and Darnton, 2005).

An overwhelming message which came out of all the focus groups, was the need for a 'call to action' by government to provide guidance and support on what to measure, and removal of barriers to measure and report. In the absence of any government direction/legislation, organisations will continue to measure what their customer's require.

RQ5 - *Do any emerging variables and constructs mirror those found in extant literature on GSCPM?*

The literature review identified nine GSCPM constructs with cost and carbon the most dominantly cited GSCPM variables. The research conducted in Phases One, Two and Three identified a further three constructs, they are: 1) Utilisation, 2) Buildings, and 3) Suppliers. Thus, it can be concluded, that those GSCPM constructs identified in the literature, do mirror those found in Phases Two and Three. Four new GSCPM variables were also identified in the research, these were: 1) air freight reduction, 2) supplier performance/procurement strategy, 3) CSR policy in place, and 4) pollution. This took the total number of GSCPM variables to 29 variables with 17 variables identified as important to practitioners (Table 10.8, Chapter Ten).

Limited research exists on horizontally-based GSCPM variables which will able organisations to measure their end-to-end supply chain (carbon used per case or item delivered to a customer) and very little literature exists on adaptation (future state) based GSCPM variables (resource efficiency). Yet, these will become increasingly important to organisations in terms of their long term survival and in a world where energy security and environmental adaptation will dominate the business landscape.

Very little rigorous empirical work has been conducted on GSCPM adoption, importance and how these differ by company size and industrial sector. This represents a significant gap in the body of knowledge and this thesis has served to bridge this gap and contribute to the body of GSCPM knowledge. The thesis has been conducted in a UK context where the majority of previous GSCPM empirical work has focused on Europe or the Far East. Thus, this thesis provides an alternative perspective to GSCPM adoption and importance, and addresses the issue of organisations ‘outsourcing or off-shoring’ their environmental impact to different countries like China.

A major contribution of this thesis is the proposal of a set of GSCPM variables (29) and reporting tools which organisations can now use to mitigate and report their impact of their supply chain on the natural environment. It will help to increase an organisation’s competitive advantage and guide future policy decisions; thus raising awareness amongst practitioners and academics of the importance of GSCPM. Furthermore, it is hoped it will now bring order and reduce the complexity and fragmentation which exists in the current research, enabling organisations to measure their entire supply chain. Finally, the use of methodological pluralism in this research has helped to provide a more complete picture of this phenomenon and represents one of only a few studies which have explored GSCPM in this way.

12.3 Managerial Implications

This thesis provides numerous implications for managers at all levels within the supply chain. The most notable are listed below.

What to Measure?

Firstly, this thesis has provided practitioners with a battery of GSCPM variables and reporting tools which will provide insights on measuring and mitigating their impact on the environment, and which can be used as a source of competitive advantage to help guide future policy decisions (Table 10.8, Chapter Ten). It will guide managers on what to measure, where these should be applied (Figure 11.10) and how these should be reviewed (Table 11.3, Chapter Eleven). This is by no means an exhaustive list of GSCPM variables but an initial guide to help bring order to the confusion which surrounds GSCPM variables in practice.

This thesis has also provided a useful set of 15 pre requisites which maybe applied by managers to continually assess the appropriateness of their GSCPM as it is a living and ever evolving process (Table 11.1). Caplice and Sheffi (1994) also recommended that supply chain metrics must be continually reviewed and judged against eight criteria:

validity, robustness, usefulness, integration, compatibility, economy, level of detail and behavioural soundness.

How to Report?

Based on the foregoing, this thesis has provided a guide to the process for continually reviewing and selecting GSCPM using the ISO 14001 evaluation (PDCA cycle) technique (Figure 11.11). The results showed that this tool is widely adopted in organisations and therefore managers will be familiar with the process and could therefore use this to continually review and develop their GSCPM variables (Hervani et al., 2005) at an operational level.

Executive View

The findings have shown that the BSC for supply chain reporting is still widely known and used amongst managers, particularly at a strategic level in the business and therefore could be adapted to incorporate and report on the vital few strategic GSCPM variables. Extensions to the BSC for incorporating environmental management in a general business context have been well documented in the literature and cases exist where this has been applied and tested (Epstein and Wisner, 2001; Länsiluoto and Järvenpää, 2010). The BSC therefore presents an excellent opportunity to pilot test GSCPM in a case study setting to determine the vital few strategic GSCPM variables required by organisations to integrate the environmental perspective into their existing business strategy. Integration of this kind, however, requires huge investment upfront to implement and embed within a company's existing culture, systems and processes.

What Does this Mean to the Bottom Line?

The findings confirm that the construct of finance (cost) is still of primary importance to practitioners in GSCPM and organisations are indeed driven by altruistic motives rather than through a genuine care for the environment. In the absence of guidance from academia or the government, managers will continue to report on the things which matter to their customers, stakeholders and which increase their profit.

There is a strong body of evidence in the academic literature of linkages between environmental management and perceived financial performance which support this emerging cost/green linkage theme (Klassen and McLaughlin, 1996; Goldsby and Stank, 2000; Mollenkopf et al., 2010; Lee et al., 2012). Much more academic research is required to make the direct link between GSCPM and financial performance/environmental impact in order that it is embraced by managers. From a managerial perspective, it is important that managers understand the financial benefits of measuring GSCPM in order that they can leverage and sell these positive outcomes to key stakeholders, particularly if their organisation has a financially driven culture.

What are the Root Causes behind GSCPM Implementation?

The key root causes behind what is driving and preventing organisations from implementing GSCPM are directly linked to cost, government legislation and the complexities associated with the supply chain itself. Finance was identified as a primary construct throughout all phases of this thesis and cannot be ignored. Some of these root causes are not within the control of managers which make it very difficult for organisations to overcome these barriers. This explains why there is a degree of inertia and creativity being applied to what is being measured and how it is being reported (own company reporting), reinforcing the need for a ‘call to action’ from government to legislate in this area to provide managerial guidance. From a managerial perspective, it is important that managers are aware of the root causes behind GSCPM adoption so that they can overcome these barriers and obstacles during GSCPM implementation.

How can a Firm Leverage its GSCPM Resources?

People and employees are absolutely vital to the successful implementation and adoption of GSCPM variables in organisations and are a key resource to organisations. A key finding from this thesis is that people, their social norms and their resultant behaviours have significant influence over the success of an organisation’s environmental practices. For example, supply chain managers are unfamiliar and ‘out of step’ with their existing environmental management systems and processes. From a managerial perspective, it is important that all managers are able to train and educate their teams, including themselves in the importance of GSCPM. This will help to overcome the divergent mindset which exists within organisations and reduces the risk of GSCPM disappearing down a divergent path (McIntyre, 1998b). Apsan (2000) identified that business people and environmentalists talk a different language and are therefore running in non-concentric circles; this is a real risk for companies.

Business Continuity and Environmental Adaptation?

A key finding of this thesis is that GSCPM variables are evolving and it is important that managers do not just focus on the 'here and now' but are planning ahead to the future. This means focusing not just on environmental mitigation but adaptation. Supply chain and energy security are the two out of four emerging issues that the World Economic Forum has identified as an area that will '*fundamentally shape'* our future and that are '*central to the functioning of the world economy and to the well-being of the global society*' (Halldórsson and Kovács, 2010:6). From a managerial perspective, it is important that the focus is not just on prevention and mitigation but more about whether their supply chain is sustainable and 'built to last' the changing natural environment. Managers need to be able to alternate between this short versus long term lens in order to survive and prosper.

What Impact do Demographics have on GSCPM?

Finally, this thesis has acknowledged that that smaller organisations (SME's) do not necessarily have the money, time or resources to measure and report GSCPM compared to larger organisations. Through their partners and customer's who occupy stronger more influential positions in the supply chain, smaller companies may collaborate and share these capabilities and resources. From a managerial perspective, demographics have a significant influence over the types of GSCPM variables used, which are important and how they may be reported. The thesis has demonstrated that there are not only sector differences but company size differences in GSCPM adoption, importance and reporting; and not every company will be at the same stage in the environmental management process. It is important that managers are aware of these limitations and variations when trying to implement GSCPM variables as there is no 'one size fits all'.

12.4 Limitations and Suggestions for Future Research

There are several limitations to this thesis which leave scope for future research. The most notable limitations are documented below:

Limitations

1. The literature on GSCPM is continuously being published and added to. Thus, there could be journals which may have been published in this field since the research was completed and thesis written-up.

2. While the thesis has focused on developing and testing GSCPM variables for supply chains (what to measure), it has not explored the 'how to measure' which is a key barrier to the implementation of GSCPM. The thesis also does not deal with some of the pre-requisite issues which practitioners have identified as being important in GSCPM development, such as; the review process, establishing a target/baseline and a definition form for each GSCPM.
3. The thesis sample was heavily represented by medium to large sized organisations which could mean the results and findings were biased towards to the views of larger organisations.
4. This thesis recommended the application of 29 GSCPM variables and 12 GSCPM constructs that organisations can use. This by no means represents an exhaustive list.
5. The thesis recommended the application of ISO 14001 for GSCPM evaluation and the BSC for strategic internal reporting. This is not to say that these tools would necessarily be successful and appropriate for all organisations.
6. The environmental impact of warehouses/buildings and people have been largely overlooked academically in relation to GSCPM, yet their environmental impact is significant.

To address these limitations, the following future research is recommended:

Directions for Future Research

1. There is a huge growth and interest in GSCPM which indicates the potential of this research area and there is opportunity to complete a full and up-to-date literature review of the key contributions since GSCPM emerged onto the logistics agenda in 1998.
2. There is an opportunity to explore the 'how to measure' GSCPM in more detail in a case study or cross case study setting to provide guidance for practitioners on GSCPM implementation. For instance, the application of the 29 GSCPMs, the targets/baselines, the 15 pre-requisites established in Chapter Eleven, the reporting tools and the review process itself.
3. There is an opportunity to explore using exactly the same research design, the development of GSCPM variables for SME's to gather a complete picture about

this phenomenon and identify any further GSCPM variables which maybe unique to SME's.

4. There is an opportunity to rationalise the list of 29 GSCPM variables and empirically test which are the '*vital few'* as the adage goes 'less is more' and there is a need to reduce this number to make implementation and review easier.
5. There is an opportunity to test the 29 GSCPM variables and proposed reporting tools in a case study or cross case study to assess their appropriateness and usefulness to a sample of companies.
6. There is an opportunity to focus on the warehouse/buildings aspect of the supply chain to assess GSCPM adoption and importance. Furthermore, there is also an opportunity to explore the relationship between organisational theory and GSCPM.
7. Finally, further research is required on the relationship between GSCPM and profit enhancement to convince organisations that this is the right thing to do both financially and ethically.

In spite of these limitations, this thesis makes several unique and significant contributions to the body of GSCPM knowledge.

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APPENDICES

Focus Group Session – Wednesday 25th January 2012 – Authors Notes & Audio Recording Transcripts

Text in black = field notes
Text in green = audio notes transcribed
Red – key themes and codes

Research Questions:

1. **What environmental supply chain measures does your organisation use and need?**

GL - We do not use any specifically or environmental. It's a relatively new area but we use a number of KPIs that measure the environmental impact. Things like 1) MPG on vehicles, 2) Vehicles fill ratio and 3) Empty running in vehicles. These are the three key ones in distribution.

Empty running on vehicles and **carbon footprint model**. Intermodal and **MPG to calculate carbon emissions** (RB)

RB – CILT, we do not measure our environmental impact. We are a member organisation and sell membership. We have a carbon footprint model that we use. For freight forwarding same as GL, we look at intermodal, switching from road to rail where we can for clients, empty running, MPG, containers movements and CO2

MPG (carbon dioxide), energy usage, asset utilisation (space used on vehicles) (KD)

KD - Similar stuff Ray, energy usage, MPG (but paradoxically bad), Asset utilisation, empty running and % of space left on vehicles and packaging

Record and report on fuel utilisation, Kilometres travelled by the fleet and utility usage for e.g. electricity used in our coldstores. Use the CRC – for government reporting – it is a requirement (NW)

NW - At the moment we record, measure and report on fuel utilisation (fuel used, kilometres travelled red and white diesel) For our cold storage we measure the electricity and gas usage. This is reported to the centre and then to CRC for the government. But mainly fuel used and utility usage.

Co2 emission reduction by using coastal feeder vessels from the major Southern ports to PD Ports in Teesport. Keeps the trucks off the road. We use biofuel for all our vehicles. All new machinery purchased is multi fuel for efficiency and reducing emissions (KC)

KC - We have developed a coastal feeder vessel to get trucks off the roads. You get less carbon emissions than you do with trucks. ASDA are main customer is saving 12 million road miles per year using this operation. We are also developing the rail service for Teesport to increase the utilisation and get trucks off the road. Trucks we operation use biofuel and all new machinery that we now purchase are all energy efficient.

Carbon reduction (fleet and buildings)
MPG
Vehicle fill and empty running (reducing it) (CW)

CW - We measure carbon for both fleet and building and energy consumption and MPG and I think (as we have a whole set of metrics which we report globally(, I think we measure vehicle fill. There are lots of other metrics but these are mainly service focused and not environmental.

Waste management
Reduction in packaging
Systems to reduce mileage
Single visit fix by engineers
Gas and electricity - using renewables
Trailer fill

MPG – Double deck trailers but do < MPG
Reduce what is going into landfill
Utilities (electricity and gas usage)
Measuring Cos, loading and eco transit website (PA)

PA - Distribution is a big focus for us, how product is packed onto a pallet and then onto a truck, there should be no room for my pen! It is very important to us that we have an aftercare business – 100 engineers. We have complex models that helps us to do as few miles as possible on the road. Upskilling our call centre operatives to be more helpful/ our key metric is 'single visit fix' to avoid doubling of the mileage. We also measure energy consumption (electricity and gas) also reducing packaging, less wasteful, we are green and into renewable.

CM – fleet wise pretty much what everyone else does MPG, trailer fill, empty running. The interesting thing over the last few years is the direct correlation of MPG to vehicles fill. Some units are running lower MPG because they are carrying 40% more stock on the back, therefore this is important. We generally track that and recycled waste via landfill and utilities (electricity and gas). This year we have opened a deep sea port consolidation centre in the North East to encourage people to use the feeder vessels from the south.

PA - I am representing the university but have been involved in a European funded research project looking at KPIs for benchmarking long distance freight operations. Using data from road and rail operators in the UK. We measure carbon emissions, loading out of vehicles. Eco transit website to define how green is your operation.

2. How do you measure and report them?

Using a Global Metric System that is used throughout DHL (CW)
This provide guidelines to DHL departments on what they need to measure and how they should be calculated. Also every business unit has its own targets on this system.

CW - We have a global metric system, so every operation in DHL's supply chain will have the same things to report on and the same explicit definitions of how to collect the data and what to feed into the system. This then is played back to enable benchmarking and comparison and every business unit has improvement targets to focus on. Sites are expected to make improvements year on year.

PD Ports (KC) – do not have much in direct reporting. They have done a study of the coastal feeder vessels and how much carbon it offsets compared to rail and road. Similar systems to DHL. Do you give this information to your customer? Yes, we try and link this to their own tailored supply chain (Tesco, ASDA etc) every customer supply chain is different and therefore their reporting needs are different.

KC - I do not think we do a lot of direct monitoring at the moment. We are a facilitator, taking the logical link of the coastal feeder vessel. We tend to take this information from our customers of how many road miles they have saved because we can only see from port to port and not from where the container has come from and where it is going to. So it's difficult to get an accurate value on that. But the likes of ASDA and other retailers do supply that information to us. But when we set up the coastal feeder vessel, we undertook someone to do a study of the carbon emission of the coastal feeder vessel. We do have all that information logged but it is a more of a fixed measurement. We can say for every ship feeder vessel it save carbon emission per X miles and X sea miles. Do the same by rail. For trucks we monitor this internally and with similar systems to DHL.
Ray – do you have to give your customers this information?

We say how many road miles it could save but you have to delve into what they actually want and what product they are bringing in from where and then they can give us all the figures and then we can do a study for them. For example how many road miles so carbon emissions. Each individual customer could have a different outcome depending on their supply chain. Different supply chains have different needs.

(NW) – we do not do any reporting internally, only for CRC (which is more like a questionnaire) for the government.

NW - We report on everything back within our organisation. Largely for the CRC as this is mandatory and required by law. It has also been captured for the European sites. But we are not doing any comparisons between markets or between distribution models or methods. I am here because we when you are serving the likes of M&S they are going to start knocking on your door soon to start providing this information. Fairly comfortable that we capture this data internally but we do not report externally or internally on it.

(KD) – Concern with reporting and KPIs – as over reporting can drive the wrong behaviour. Driving in the rear view mirror.

KD - I have worked for many clients, very similar to what Catherine was saying. But I have concerns over justifying a number that is retrospective, it means people take their eye off the ball and the day job. Concern about a metric driving the wrong behaviour for e.g. MPG, its like driving in the rear view mirror

(RB) – CILT – freight forwarding. Cost and Carbon are linked. Lo lo and Ro Ro. Cost driving green through collaboration. If you report on cost reduction it reduces the impact of your organisation on the environment.

RB – worked with clients a couple of shippers who wanted KPIs reporting. Report on cost but this drives also carbon emissions down. Ro ro, lo lo. Callaboration of two shippers which are competitors for one client to drive down the road miles but in doing so this drove down the road miles and carbon emissions. Cost is driving green. Cost is a big driver.

(GL) – Share customer base and vehicle fill – according to a plan. Measure the various to the plan. Measure the “Put to Put” (amount of times you touch a pallet). This drives efficiency. There is a correlation between the two things.. The retailer drives this whole agenda in our business. Demand this for the USP for their own customers.

GL- What is most relevant is that i have just joined PD Ports from a large global logistics provider and i worked in a particular sector. We had global metrics like DHL (global, regional and local), 3000 employees etc. What was key was that we were driven by a shared customer base, the retailers. The biggest benefit we were also to derive from a energy saving perspective was fill on a vehicle and adherence to a plan. Bus routes defined, plan written (nationally) the plan was then executed, driver briefed. Then the variance to the plan was measured, then you could work out where the costs had gone up or down and then derive cost or efficiency benefit. In warehousing ‘put to move’ ratio (no of times we have moved or touched a pallet before it is sold). Optimum is 1. Retailers are starting to ask for this. This drives the efficiency in the distribution and transport efficiency. This whole green agenda is going to be driven by what the retailers want. They want to preserve their USP for their own customers and push more onto suppliers.

(CM) – Share stats with retailers and they share stats with us. Data capture is on MPG. Idle time of vehicles in the yard (stop drivers from leaving their engines running). Telematics – this is a way of understanding drivers behaviours (lots of stopping and starting and breaking which can affect MPG.. We need to educate the drivers on the environmental impact of their driving behaviour. Compare the top 5 drivers against the worse 5 drivers. It is important to share best practice then you get a big pay back on..... ISO 14001, water and fuel usage and waste management.

We capture all our data and report it at group level and feed that all back up through the organisation. We share this with other sites and share best practice. More importantly because we have a wide variety of customer, the major retailers. We share our stats with them and they share their stats with us. You can then see what is best practice in the industry, you are then able to pick and choose best practice. Data capture e.g. MPG, telematics becomes real time, helps to provide corrective action to correct wrong behaviour – such as drivers idle time in the yard and what idle time there is before they move. Is this because they want their cabs warm etc. Great thing coming out around telematics and tracking is now drivers behaviour, harsh breaking or rapid acceleration which all impact on MPG > environmental impact. Educate the

drivers through training and development, to track and monitor, pick the top 5 good drivers and 5 worse drivers. Co ordinate the training and target areas as and when required e.g. trailer fill. We share best practice across the group.
Ray – what drives this sharing? Is it green?
A little bit. Synical view if you were going for ISO 9001 or ISO 14001 – where are you likely to get the biggest payback. Probably on ISO 14001 as you would tune everyone's behaviour to tracking MPG, fuel use, water, waste reduction. It touches everything. Engages everyone in peripheral activities.

(PB) We are led by our retailers
Cost is a big consideration
With supply chains looking to the east
More routine than green

PB – What I was going to say has already been said. GL has already indicated. We are led by the major retailers but cost is a main consideration. So ethically we are about cost rather than green. Interesting a trend in our sector and many others is our supply chains are looking to the East. No production of emission here as we have moved them to China for our castings.

3. **In your opinion, which are the most appropriate environmental supply chain measures used in your organisation?**

(CM) MPG is appropriate. You can attach a saving to this
It is customer driven

CM What i would probably say – it is the one which drives behaviour and cost. It is MPG. It is an appropriate measure, you can attach a cost to it and you can attach a saving to it

(NW) KM travelled per case delivered. You need to get more delivered per KM (e.g well travelled yoghurt pot)

NW – Kilos travelled per case delivered, scheduling of route efficiency. If I can get more cases delivered for every KM travelled. MPG is affected by so many things, driving, route, too many variable can impact on MPG. Make it difficult to manager or micro manage it.

(GL) Cases per drop
Fleet utilisation
The priority to the customer is have the product on time and the right price
Fuel consumed per case delivered

GL - MPG is a valid measure but it can drives the wrong behaviour. The key thing is to measure the cases per drop and then measure the fleet utilisation. MPG is erroneous. Green measure is not something which we measured by. It is a 'nice to have' the first priority is to have the customer's product on time and at the right price. Time deliveries are customer driven and not driven by distribution.

(CW) Because we have outsourced to China, more buildings are utilised - we extra storage
Forecast leadtimes are longer. We need to consider carbon to build extra storage and carbon to maintain this storage and old versus new buildings. If we did not source from the Far east, and if materials were made here we would not need the sheds. We have outsourced our carbon footprint to China. What carbon we used to emit, China now emit (but under no control – Kyoto).

CW – Fuel consumed per case delivered, that encourages fuel economy and reduces work
It is a measure which Tesco's have had for a few years (IS THIS A NEW THINKING RT)

KD – it is a measure which Tesco have had for a few years. It is a measure of activity against energy. It is bloody hard to measure because a) to identify within an industry/organisation, b) because someone else is pulling the strings, c) there are so many variables that affect it. So

you might go back to your customer with a plan, if you let me give you lots of benefits in pounds, shillings and pence....

CW – i guess the other thing it does not do is to take into account intermodal. Is it better to a shipping leg or a rail leg. The only other thing we need to look at is building utilisation with what is happening in the last few years with bringing things in from the Far East has meant that more and more companies have had to have extra storage here because of forecast lead times moving out and all these sheds take carbon to build and carbon to maintain

Transport (MPG)
Carbon versus cost – what is the trade off.

There is no complete measure it is 'siloed' by the supply chain Not every bit is measured, you can not always measure the bits you cannot control.

GL – Old buildings – is it better to have a new building that does not waster alot of energy in the form of lighting and electricity but then compare this to the amount of carbon to build it . Is that more efficient than an old building

CW – Also, if you could get your forecasting spot on you would not need a building, you could just predict what you needed and ship it (IS THIS JIT)

CW – It is, but if your customer pre ordered, then you would not need a shed. And if we made things here we would not need a big shed because you do not have to forecast things months in advance.

GL – That is the big thing in this whole debate – there is no correlation between semi manufactured products and their carbon carbon impact. We are just measuring individual elements. So if you take for example Paul's castings moving to the Far East for manufacture.

GL- The carbon impact of physically moving the manufacture from the UK to Far East is not captured. It could be that we are not comparing like for like carbon because carbon sources in China are dirty carbon in terms of production and completely inefficient factory processes and they are just throwing power at it to make it cheaper. We have moved the carbon but we are making it in a much dirtier way now.

CW - If you look at the government green plan for carbon – emissions have reduced and that is because we have exported it to China for the manufacture of products. All we measure it the carbon that is emitted from the UK and not the carbon we have purchased overseas. I think when you look at it for transport you forget about warehousing and vice versa. IS THERE A COMPLETE MEASURE? No

KC – It is measured in silos and not as a total measure

ARE WE ALL AGREED ON THIS? Yes

GL - Even worse not every element is being measured in the process. Only bits which the customer asks us to measure.

It is customers and legislation that drive this – there is no proactive way as an industry to measure it, no tool or technique
RB – 20 containers – drivers map their own route to avoid roundabouts and stopping and starting which is efficient and reduces carbon

Customer and legislation are the key drivers for measuring. But no proactive tool/ measurement available.

Allow drivers to make their own decision 'paragon versus telematics'

CW – Just going to it being measured in silos, it is probably not that difficult to measure as a whole thing. It is only the same as measuring the cost of things. We are all probably familiar with the terminology of tradeoffs between warehousing and transport and these tradeoffs change as fuel prices goes up. So why can you not have a trade off with the cost of carbon against your warehouse space then you could have a measure. If you are trying to deliver a cost/service trade off, then the customer will squeeze you on service and you will then be delivering half loads frequently and so forth

I do think it is possible to do, I just think we are not yet that sophisticated to do this.

4. **If you were given a free reign, what environmental supply chain measures would you propose and why? How would you measure these?**

PB – I cannot think of anything beyond what we are doing at the moment

Broaden it to all emissions and not just carbon (CW)
Emission per case/tonne delivered from production right through to consumption
There are also other measures such as packaging, waste and landfill, perishable 30% of food waste is wasted. We then try and minimise waste but over engineer the packaging, frequent deliveries, requirement for refrigeration

CW - i would say ALL emissions and not just carbon and this is off the top of my head

Emissions per X or case or tonne delivered

We need to look as the full end to end from production wherever that is all the way through to consumption. But I also think it would be important to look at other resources used along the way so we all know that fuel is important but there is also the amount of packaging used. So if you look at the supermarket supply chain. At the end of the year, they cut down their packaging to reduce overall waste in their supply chain. So from an environmental point of view it is in their interests in getting any perishable product to the customer to avoid any being thrown away. Perishables – 30% of food is wasted in developed countries between the farm and the consumer

All retailers drive the standards
British consortium (QMS)

GL - The interesting debate is that the whole supply chain is geared to minimising waste but then this results in over engineering of packaging or temporary control to extend shelf life. And this is not measured

CW – It is a cost trade off. We can use sophisticated refrigeration – as long as you do all of this and make a saving then this is fine.

GL – There is no measure across Europe for measuring any of this. It is all retailer driven. Standards can be signed up to but that is it.

5. **What are the drivers to measuring environmental performance measures in your supply chain?**

Customers, fuel efficiency, green agenda
(CW) DHL have a ‘go green’ strategy which started in 2007. 2010 10% improvements, 2020 30% improvements. This is driven by the board. CEO Frank Apple drives the green agenda and we have a department in europe which focus entirely on sustainability + director.
If we reduce the costs we will reduce the environmental impact (GL). Seeing the opportunity, Shipping world and growth in tonnage before the recession and then the decline and capacity left during the recession, saw alot of slow steaming as a result.

Perception is that rail is good and this is driving the green agenda. But the infrastructure is bad. Doubling mileage – you need to go North before you can go South.

GL - Cost (fuel efficiency)
Legislation
Customer – the customer wants you to demonstrate that you have mechanisms in place for being green.
NW - Drive for efficiency

NW – M&S had a green plan – if you wanted to be our supplier you are going to need a green agenda. Big customers are driving this.

CW- the driving force = "Going green" we have our initiative about improving our carbon efficiency. so if we doubled in size this is not about saying we will keep the carbon footprint the same but we will be more efficient about what we do and that was set in 2007 – with a target of 10% improvement by 2010 – which we achieved and a 30% reduction by 2030. This is being driven by the board. Our CEO is driving our go green plan – Frank Apple. Every departmental CEO has a responsibility for driving the green agenda in DHL. SO IT CAN BE DRIVEN BY THE SUPPLY CHAIN? So it is all about carbon at the moment but next is waste and shortly followed by water.

GL – I would agree with that – we had an initiative driven by the board. They had seen the benefit of this initiative with customers and contracts and took this ethos and embedded it into the rest of the organisation to get efficiencies. It is a differentiator and a good proposition. The other part worth mentioning there has been some environmental benefit made in shipping in the last ¾ years with huge growth caused by the recession in tonnage and lots of capacity afterwards. So shippers had to ostensibly 'slow steam' to reduce their carbon footprint – but it was more about cost really than the environment

KD – Legislation

KC – Principally rail is brilliant but the infrastructure is rubbish. The containers that we have are two high and wide to go through some tunnels. So this has created lots of investment in low lying wagons and where does all this money come from? Sometimes you have to go North to go South – doubling your mileage. So are we really getting a saving? Rail v Sea v C feeder v inland water barges. Probably better option than rail. The government bats on about rail but do not invest in it.

6. **What are the barriers to measuring environmental performance metrics in your supply chain?**

Difficulty in measuring
Most said not real barriers
Time and cost.
Nobody is asking for it!
Cost and the environment are the same barrier – it is all about the cost
No barriers – end to end supply chain. We are not in full control of the supply chain. Maybe a 4PL or 3PL would be better placed to do this as they control the full supply chain.
We need to make sure people understand why it is relevant.

CM – Interesting for us. Measuring what we want, we get the information. Its something as a business we want to put out there or a customer has requested it. The areas we have to meaure we are, there are no real barriers.
PB – Not really, just time, someone has to do it. The KPIs we tend to measure are those that drive the bottom line. There is no real barrier, just no one is asking for this information

NW – Cost are the environment are linked. You can dress it up as the environment but it is all about the cost. It is a drive for efficiency.

KC – I do not think there are any barriers other than what people have said. It is how involved in the supply chain you are, are you measuring the end to end supply chain or the middle bit.

So you can only measure this. The is barrier is you are not in control of the whole movement of the product.

CW – You can only measure what is in your control

KC – only 3 or 4 PLs could measure the whole thing

GL – there is a people thing, If people cannot see why it is relevant to measure it then what is the point. There is no physical barrier but getting people to measure and understand why it is important is the key thing and changing people's attitude towards measuring.

7. **Do you subscribe to an environmental measurement scheme, if yes, what?**

DHL purely internally report and are also in the Dow Jones Sustainability Index
PD Ports have ISO 14001 and use a EMS (GL)
About to implement 14001 (NW) Nothing beyond this.
(CM) ISO 9001 got this and 14001 still to get.
2012 18001 (H&S) TMS has this

CW – that is just internal – the global metric system for DHL. As far as I know we do not subscribe to anything else. We are in the Dow Jones Sustainability index

KC – We do ISO 14001 (got it). EMS just started to looking at this as part of CSI. We will be looking at energy usage, utilisation of vehicles, hearts and minds of people, because we are near a river there is also a statutory requirement that we must follow

NW – We are about to implement ISO 14001 in the UK and Ireland. No more reporting other than this

KD – No

CM – We have focused on ISO 9001. But looking to bolt on ISO 14001. There are other Clipper sites which have gone down the route of ISO 14001 but they are in different sectors. It is 2012 goal to bolt on 14001 and then ultimately ISO 18001 so we have a TMS)

PA – HGV – standards are Euro4 and 5 and then 6. Rail, the standards are stage 3a and then 3b

CW – Please can I draw everyone's attention to something which is coming up very soon - a piece of legislation it is called the Road map to Resource Efficiency. It looks at metals, minerals, fibres and water. It has gone out to all EU countries about resource security and making sure we have access to this stuff in the future.

8. **Organisations measure and report their supply chain performance through frameworks such as the 'Balanced Scorecard' or 'SCOR'. Which do you use?**

SCOR
Six sigma
NW – No
CW – Global Metric system (in house)
CM – Use a BSC approach

GL- Balanced Scorecard, SCOR, DEMAKE analysis (six sigma).

No, No, No,
CW – We have our internal global metric system

PB – We have standard KPI reporting, with an emphasis on customer facing, manufacturing efficiency all separately measured
CM – We use a Balanced Scorecard
No

9. **Which performance frameworks could be used for reporting environmental supply chain performance and how?**

No suggested framework –
CRC (NW)
Dow Jones Sustainability Index
EU Road Map
Packaging Waste regulations
Separate policy and legislation in the US
Operational best practice
Carbon Trust e.g. Walker's crisps
NW – I would struggle to benchmark (warehouse and transport) are in his control but other stuff is not (US regulation)

NW – We use CRC, which is government led. It is a tax return on energy usages. These things are so complex it is hard to understand. Maybe a true balanced scorecard might be the type of thing you would build. I would not know where to start with it unless you had a piece of software.

CW –Could CRC be extended?
NW – We have to be registered and certified for this energy efficiency scheme. Not sure what you do with it.
GL – Do you get a tax break on this?
NW – We have to submit everything to this and we get some form of break and tax allowance. Companies of a certain size have to be in it. CRC is a UK thing.

KC/GL – We operate a curb side collection service, we collect the waste and send to a primary recycler. The primary recycler then has to report back to the council on what cardboard they recycled and waste they still have.

GL – This whole thing about reporting tax capital gains and breaks could be what we need to drive it! There will be a whole debate about the source of energy in the future – is it renewable energy. Providing tax breaks to those companies who invest in this. Lower prices to those who source energy from a renewable source. There is an organisation called the carbon trust where you can get accreditation for your carbon.

NW – It's about reviewing your lean processes, how much carbon is used in the process and reducing it. E.g. Walker Crisps – they found that most of the carbon is used in the fertiliser of the potatoes.

Two things – what we can do now? What we can plan and develop for?
So now, we can look at transportation. But to develop for, I have a 30 yr old cold store. It will never be efficient, not until I switch it off. Opposed to measuring now we need to plan for the future. But i would not benchmark my supply chain against another because they are so different – for little return.

CW – Suppose it would be useful to look at the Dow Jones Sustainability Index to what questions/measures they ask. I do not know what measures are included but it might be worth a look.

10. **What are the direct benefits of incorporating supply chain environmental measures within a supply chain performance framework?**

(CW)Long term – make decisions that will ensure the organisation survives! (Sustainability)

(CM) Electricity usage saving = 47% (LEDS, PC swich off) Cultural- my staff took this home
Did lots of training on gas, electricity with staff and they took ownership and took this home.

(PA) Lighting improvement in schools reduced energy bill and improved child exam performance.

CW – It helps you make decisions which help the company to survive. If you are resource efficient then you are likely to survive because metals, minerals, fibres will get more and more expensive. The cost of resources are going up. It is not just about making sure you are cost efficient this year but that your supply chain is cost efficient for the next 10-15 years time. Anything that has an energy input will get more and more expensive

CM - One of the things we did in 2011 as a site. Utilities are getting more expensive year on year. Some areas have increased by 30%. It was an easy target area to turn around and engage the colleagues at a grass route level, provide training and development to take responsibility. We had electricity savings of as much as 47% last year and that was through no cash thrown at it. About somebody turning lights and equipment off Basic stuff. But we found what we got out of it was the guys took this home as a way of living too. One of our customers took it a step further. So with 4 of their sites they had 4 people and set up an energy challenge and awarded a prize. This cascaded through their organisation, took it home and took ownership of it.

CW – Yesterday, Philips made light improvements in a school in Germany. They changed the lighting and it saved energy, but it increased the kids attention and increased the exam results of this school. Better for the environment and more energy efficient. Win:Win situation.

11. **Given your position and experience, what do you think is important? Where are the gaps? What is missing?**

PA – social responsibility – making more efficient, sustainable, use less resource - cheaper

CM – Just to pick up on GL point.. less touches we make, the more revenue we can make. Sometimes this is driven by other things. So the flip side of this in 2010 was the cotton prices. They shot through the roof. The deconsolidation centre i look after in the NE. We found a client had bought a season and half ahead to alleviate costs ahead. Other impacts, we take goods from the Port, last year we saw a 20% drop in boxed goods coming in to the port. But overall the number of inbound units was the same. We found that our client buyers were buy from different countries to avoid tax and get tax breaks etc..This then compromised some packaging quality so the client changed their routing options into the UK. So this is driven by governments or the country infrastructure.

CW – One of the challenges of being efficient and efficient with resources and green is most of our supply chains are set up on a linear basis, so raw material, manufacture and consumption with some waste at the end. But this waste is expensive and difficult to deal with. This is because the product is not designed with recovery in mind. End disassembly. Pcs are built with this in mind and can be made into something else. China are already putting embargos on mineral exports. Some of these minerals are used in the Hi Tec industry in products and therefore countries like Japan have to manufacture in China because of this. So this is so important. Design so good disassembly is easy, cheap and energy efficient and reduced landfill.

KC – We are developing port centric logistics, most DCs are built on the M1 corridor. But the container come in through the ports. We are developing the build of more warehouses in the port to cut down on transport. It is not unique but we are going back to how we used to do this. Having a DC in the middle is not always the best.

NW – In some ways we need to increase the coverage. We need to look at employee travel to work and within work. We need to look at HR policies to minimise this. With the government, things are costing too much money – they halved the allowance for generating renewable energy – so I say plough your own furrow.

KD – got to measure the end to end supply chain

GL – Two quick things – Reverse logistics – is a really good way of improving sustainability in the supply chain. We are now on a journey where we are measuring environment and sustainability in supply chains. 30 years ago there were no KPIs measuring this. It used to be about 99% on time deliveries. This is now about green.

Watch out for the EU Road map to resource efficiency, th
ere maybe more measures (CM) It has gone out for consultation (minerals, fibre and water)
Rail standard, euro 4, 5 and 6
Port centric logistics
Challenges -sc are linear, waste recovery bit is expensive with disassembly in mind

(NW) we need to expand our view of being green
How far staff travel
Government cutting rebates for solar panels
We have got to measure the end to end supply chain – the whole thing

The ESCP is part of a bigger measurement = TBL

We need to change people's mindsets
Make the initiative win win (cost and green)
Distal supply chains (win win)
People - social norms it has to be a concerted effort. Knowledge has to be transformed into a concerted action. We can only act on information we are provided with.

People and companies are thinking short term, thinking competitively. Biggest supply chain nations (distal) are not compliant (Kyoto). This makes it very difficult and the EU uncompetitive.

SS question on TBL, mitigation etc

CW – CM example is a good example of TBL. It is an example of cost reduction, environmental and social because of the people saving at work and at home and work life.

WIN WIN CONNECTION RT

PB – We do things like video conferencing – but we do not measure it

NW – It will be ?? when we can say you cannot eat bananas in the UK because we do not grown them here

CW – People do not even consider not flying to go on holiday. We are in a society where the social norm is the resources are there, lets use them. We cannot keep chopping down rainforest to grow soya. But given that knowledge still has not translated into a concerted action. So from a TBL point of view, we have a long way to go. Awareness of stakeholders is important. I do not think many of us link work with the environment. E.g. washing powder and the chemical it releases to the environment. Manufacturers do not have to publish anything about this but yet we say wash at 30 degrees to save energy but release harmful chemicals at the same time to the environment. How as a consumer you would know whether to choose A or B?

KC – It takes 20 years for a plastic bag to degrade in landfill. But the supermarkets still dish them out, In Ireland everything is in paper bags.

CW – I did a green sermon to one of my account managers, I asked him afterwards if he would do anything differently. He said I will not do anything differently because I like my lifestyle, if it

was so important why are the government not doing anything about it. How do we get past this inertia?

GL – My initial observation. National companies versus global companies. 3 of the biggest economies do not sign the Kyoto landmark agreement. So we are doing this in the EU environment but they are not. Make us uncompetitive against these global economies

CW – The road map to resource efficiency felt that the objections to this were because of the impact on the competitiveness and impact on the EU economies. We will end up off shoring more and more.

Focus Group Session – Wednesday 26th January 2012 – My Notes

Research Questions

1. **What environmental supply chain measures does your organisation use and need?**

SR – Unfortunately, I am not aware of any that we use to measure the supply chain.
MB - We do not actually measure but we do record for our potential tenders and contracts whether the suppliers have an environmental management system in place or a carbon management system in place. But we do not have a metric.
RT – SO ONLY FOR SUPPLIERS WHICH ARE REQUESTING THIS THEN?

(MB) We request these measures from our suppliers in tenders and contracts but we do not do this ourselvees.
(NT) Not a direct measure, primarily a financial measure

NT – We do not have a direct measure. What we have is a measure about vehicle fill. In our world it is all about filling vehicles and being more efficient so by filling more the less delivery vehicles required. So we have that as a measure. It is primarily a financial measure because equally the saving is to the environment as it is for the financial. It is about driving the cost down but by driving the cost down you drives the environmental impact down. I have a wife that works in the environmental field so I brought this as an idea to our business one day, so we looked at converting everything we did for cost measures to environmental

(NG) we have a few measures we track = amount of packaging we use per annum. The energy consumption of our buildings and then we turn these into a carbon measure.

NG – We have got a few – we measure the amount of packaging we use in our product at line level. So we can report on it. We clearly measure energy consumption in all of our buildings we have got and as a company and then turn this into Co2 emissions. So we have that measure. Probably one of the biggest costs for us is freight distribution so the initial line haul taking freight from the distribution centre to the third party sortation. We can measure this element easily (cage fill, vehicle fill). The issue we have then is these parcels and pallets go on to a third party carrier. So how do we measure the impact of our parcel on a vehicle, because they are doing 120 parcel drops per day but 4 of our parcels are on it. So which element is related to us? That is something we would like to get to but even the carriers struggle with this as well.

(DR) We measure the carbon footprint of our employees travel (engineers car share. Bike to work scheme) Carbon emissions per load or case delivered.

DR - We have this from a couple of perspectives. One is as a software/hardware company. We measure predominantly the carbon footprint of our employees. Alot of our people are travelling alot of the time so we measure the carbon footprint of our employees in terms of mileage. Also in terms of hardware, we look at the power usage of our servers from a software point of view we take a slightly different perspective. They (customers) are looking at carbon and particulates and they'll look in terms of per mile, per load, per case and they are trying to measure their carbon footprint from a manufacturing and providing perspective. Most of my customers are in the transport so tend to be the main ones. We look at our how our engineers get to work, getting people to car share, use bicycles and working from home. It is also the power usage, building usage and water usage.

(LR) Petrochemical companies are doing 30% more by rail because of the green agenda. They are also doing more by pipeline opposed to road and rail. The key challenge is the last 5miles.

LR – In terms of my own individual company (SME)' no'. Other than from an economic point of view I try and reduce the amount of travel I do and reduce the amount of hotels I stay in. But i also work as a consultant to some of the much bigger organisations such as the petrochemical companies for example. And I know they have a myriad of environmental measures that they use. Again a lot of it is about vehicle utilisation, they look at what it costs them to run a vehicle, fleet efficiency. I know one of the big companies has made a move in the last 10 years – 30% of their product is moved rail from road and now via pipeline. They do alot more now via pipeline opposed to road and rail. So strategically if they are looking at moving fuel around the country, they have a kind of pipe first process, if they can move via the pipeline from Immingham they will, the next option is rail then to move by vehicles. The problem is that most companies have is in the last 5 miles, so to the fuelling station or to the customer. That is where the biggest cost is

(PR) Carbon emissions - environement, nitrous oxide – human health and Ballast water biodiversity (shipping). Shipping is governed by the IOM

PR - I know more about the case studies I have worked with. But just to answer the question. Most universities or public buildings now have labels of A, B, C, D or E just to say if the building is energy efficient or not. As well, fair trade supply but I am not sure if this is more sustainable than environmental. There are a lot of things going on in shipping and ports. For shipping basically it is about reducing emissions to the sea and air and so on. Also ballasts there are a few regulations (legislation) arriving for reducing air emissions. The three main areas for our emissions are carbon, nitrous oxides and sulphur. They all have different specifications. Carbon dioxide is more about global warming, nitrous oxides is more about human health. Then we have ballast water contamination of the vessels. Vessels when they travel from A to B they need to take on water to float. This water gets contaminate in the ship's tanks. This is regulated by the IMO (International Maritime Organisation) specifically for shipping. They are discussing ways to measure this.

(PB)Waste and waste packaging, warehouse carbon emissions
Choose shipping over air freight
Sky supply chain is 100% recycled (99.7%) This is driven by the client
There is a shared focus to drive improvements

QQ – In the company I worked for before we measure the performance of our suppliers in terms of environmental. However these measures were not designed by the company I worked for but by Boeing. The supplier Boeing was at the top of the supply chain and could control everything. All raw materials suppliers have to be certified to criteria. We then just implemented what they asked for. So some suppliers very strong at the top can set the measures

PB – Fundamentally we are an outsourced logistics business. So we have a number of measures with clients. So if I am working with the rail industry I have an infrastructure requirement. This is drive by the UK government. We also recondition engines so we would have everything you have talked about already. In terms of our own, definitively waste and waste/packaging and warehouse efficiency measures. So typically we are in control of our own warehouse that would be our focus – utilities/carbon emissions. In global transport and the use of global transport in supply chains, rather optimising and improving the mode of transport. For replenishment of our global DCs, over air freight, we use shipping as our primary mode of transport. So there is this environmental and cost consideration. . So we are always looking at the cost/service mgt equation but environmental is growing as part of this., Our project initiative with Sky's supply chain, they are a media/environmentally focused company and we have made a commitment to them to 100% recycle their waste. We achieve 99.7% for facilities for Sky. The overall impact for the client, the initial drive comes from us. There is a shared focus to drive environmental improvements off the back of CSR policies and cost/service

2. **How do you measure and report them?**

NT – We have measures which have an influence on environmentally like vehicle fill and KM/litre. We report these internally and weekly. The only other one which strikes me is waste recycling and waste coming back through reverse logistics processes. So retailers returning product back through – unwanted and at some point you need to find a home for them. Generally landfill. Generally the number of skips produced per week that we have to say bye to and these days it is about finding a home so food is consumed, primarily through charities so it has the benefit of removing cost for the customer.

(NT) KM/Week and ensuring we minimise waste

MB – in terms of resources and not supply chain. We do record quite a lot. All of our energy sources are recorded between half hourly to monthly. Utilities, this extends to water, DEX, EPES for a building. Our waste is recorded in line with our waste regulations. We record transport between inter sites and the distribution of our vehicles in mileage. We are fairly low on vehicle fleet numbers, so probably not as detailed as other companies. When it comes to external reporting, we do not send much out, but we do take a lot from people with regards supply chain issues in most instances it is the customer that says you can do this rather than us. I think this is changing. There is some work about to start within the NHS on carbon foot printing of suppliers within the medical and pharmaceutical sectors and how to we measure this?

For reporting metrics we either use the appropriate legislation such as the Environment Agency of the Department for Climate and Energy Change. If none of these we generally default to the Global Reporting initiative guidelines scope 1, 2 and 3. And use these as benchmarks to maintain consistency throughout the organisation. And it is mainly scope 3 that there is a differences lie for ourselves and other organisations as these are areas which are potentially out of our control. Scope 1 are direct measures such as a gas fired boiler, this is a direct emission within our control. Scope 2 are indirect emissions (electricity consumptions). Scope 3 transport in the supply chain. So we do try and measure our own but we do not have a huge supply chain. But there is quite a bit going on in the NHS as a customer and also within the commissioners of the key trusts we have our ultimate suppliers such as PCT etc and we have to write in to their contracts that we must have measures in place. These are changes we are starting to see. Large clusters are forming that will reflect any other metrics required.

SB – We categorise into two groups chemical and domestic waste. Currently achieving 85% recycling of our domestic waste. In 3 months we will achieve 100% away from landfill. On the chemical side is more difficult. We measure by tonnage, how much plastic and paper we produced. It is recorded on a monthly basis. So that is how we can identify exactly 85%. We also will not have any landfill in 3 months for domestic waste. We are working towards 75% of our clinical waste going to recycling. And things like measuring the carbon content of transporting waste – not at present but will, but future plans to measure it.

(MB) Consumption of resources. All energy resources are record half hourly and monthly
Waste is recorded
Fuel used in transporting between NHS sites
The use the GRI initiative to report on direct and indirect environmental metrics
Measure carbon emissions of waste transportation and measure variations month by month

Carbon Trust can help you to measure
Shipping IOM 2009 Gram of carbon/KM . this is the best measure available
Clean Cargo working group – emission factors for a TEU
Carbon/TEC/KM But this has limitations

Pipeline versus road and rail
% produced by each mode reported through management and operational meetings and down to a junior level
Emission limits/ targets reported and in the public domain.

(DR) Employee car travel mileage (this is capture on line, fuel used) and also capture heat and light energy usage
Energy mg/gb per CPU
Smartway Software (US) Environmental Protection Agency – Transportation
Dashboard metric provided to the customer
Oracle have a VP dedicated to CSR board level.
(NG) Monthly tonnes of woods, metal (waste streams)
Company car fuel usage (MPG)
Energy use (electricity, gas)
Amount of packaging used annually (% of volume despatched)
But very difficult to attribute green measures to the 3PL carrier who are doing multi drops
We have HR Director (CSR/Environment) Reviewed at board level
(MB) Floor area, waste (tonnes)
Electricity and energy consumption
Vehicle KM tracked
Carbon emissions impact per part moved
They have a flight deck (global control centre)Jaguar impact on the environment within a specific supply chain activity

QW – Big problems in measuring fuel consumption we like to benchmark the data. Measure the variations to keep data month by month, if it varies by certain levels we can see it as working consistently.

PR – Companies are using DEFRA guidelines on emissions and the environment agency to provide standards. Also the carbon Trust helps organisations. In shipping, they use DEFRA emission factors are carried by the IMO. Grams of carbon per tonne. But it is very inaccurate but all we have to go on so far. Other groups include the Green Cargo Working Group, they try to measure on emission factors/TEU, so factors being captured by industry but each have their own initiative so very early stage.

LR – We were talking about earlier for example about the desire for one of my companies to move fuel via a pipeline versus road or rail. These statistics are reported on a regular basis and are disseminates to the team meetings and brought up and discussed. Measure in % of volumes produced distributed by pipeline, by rail and by road. These are produced on a regular basis and reported through mgt meetings and notice boards and those involved in junior and operational levels. The guys which are involved in the refinery process they will see these figures. In addition to that there will be strict emission limits. If you are a Cos of Major accident controller they have emission targets and limits and these have to be reported and placed in the public domain. There are some strict criteria which must be complied with. For my major clients there are two major drivers: 1) cost and 2) legislation

RT - DO WE ALL AGREE WITH THIS?

Yes, mostly from everyone......
With metal recycling – you do not need legislation it makes good money on its own without any driver..

PB – I would say that this is true if it underpins your business brand but if your brand value is a value on something else then public perception and CSR might override those two.

So a third driver is what the brand needs and requires, cost and legislation. If your brand say Apple is governed by technology base then it is the quality of the product which is very important but if in making this product you kill the planet, then no one will buy the product. Another example is the body shop, an ethos that is built on a brand, but they were first to market with the product.

DR – I guess from our perspective we look at it from 2/3 points of view. In terms of our employees because everything is centralised in terms of travel we capture their travel and mileage and fuel usage. We directly capture this and input it into our system. In terms of light,

heat and power, it is captured and has a carbon figure attached to it. In terms of the product we produce we look at the energy in KB/GB used by our CPUs used to use as a comparative figure against other companies. In terms of the solutions we provide, take for example most of my work is in the transport sector. We capture at a granular level fuel used and emissions. The metric we use are defined by a system called SMARTWAY which is part of the Environmental Protection Agency used in the US. They define the emission used for different loads. We use that when we for example have a customer using the software to calculate their carbon footprint. Cost/carbon equation as a weight factor.

PB - Is your business governed by your US parent company?
DR – No, these drivers are coming out of Europe
The customers want to see the metric through a dashboard etc. In our company these metric are reported at a corporate and territory level

RT - WHO DOES THIS SIT WITH?

DR – VC looks after CSR, not the board but someone that reports into the board.

NG Two other measures are all waste streams are measured by monthly tonnage in terms of wood, metal and plastics. All energy sources are measured half hourly through to weekly. We can track our consumption. I mentioned we measured the amount of packaging used in our products. I think it is done annually as we have to capture the data from the core system and that is as a % of the volume of something. What is the packaging content of an item. We are trying to minimise this as far as possible. For fuel measures (fleet) we can measure very clearly what we are paying our third party carriers for in trunking and linehaul costs. But once that gets into a sortation hub how the hell do you capture this? At the moment we do not do this and the carriers struggle to do this as well. The carriers know what their overall cost is but how they then attribute that per customer is very difficult. We do not have a nominated direct director that looks after the environment. Our HR director has the CSR and environmental accountability. It is discussed at board level and down to the operational teams. It is about educating the people at the coal face which is where we get the biggest benefit

NT – Another influence which is the end customer e.g . Boeing – demands are driven through the supply chain. I guess its the customer or retailers driving it and creating the demand within the public. This then backfills into the supply chain.

PR – We are currently working with M&S and so it is definitely the retailers which are driving this

MB – All NHS organisations have to report their data which feed into the UK statistics. Have to report centrally for the NHS. Measures such as floor area of buildings, waste in tonnage, energy consumed (KW/sq metre) and heating volumes for a building. Reported back within the NHS.

3. **In your opinion, which are the most appropriate environmental supply chain measures used in your organisation?**

PB - Depends on the type and nature of the supply chain in question. I think the vehicle KM run for the transport and operations supply chain. In terms of global supply chains, it is the carbon emissions per part moved to satisfy a deman. We have a SAP based product that is business object driven so that we can see and control of the Jaguar global supply chain, I presented on this last year. Sap is a ERP system. It captures all the data then you can use an analysis tool at any level to identify environmental impact of any supply chain for the company to report on. We use that to identify areas for improvement and behavioural change, to cost improve to re focus. We now have a flight deck which has an environmental element built in our global supply chain centre and this is replicated in everyone of our global centres. We did this off our own back for Jaguar. We implemented this ourselves. It has now become a standard and last year we won an award for it from ASDA for environmental improvements within supply chain activities. ASDA sponsored

the award. What NG was saying is very important. It is about the whole team impact of environmental improvements and change. It is about making metric visible

NG – Certainly rather than answering the question specifically..... The most appropriate measures are the ones which are simple and that people understand. Because certainly with environmental mgt there are various bodies and you report so many areas and things. You then lose the whole point of what you are trying to achieve. I will say that Arco is not the best environmental company in the world but we are doing our bit. I personally believe we are doing it well as we have simple measures that people understand. And we equate that to turn the light off tonight and you will see a saving off X. These measures are then displayed for everyone to see.. It is the same suite of measures which are looked at from the MD down to grass roots levels. It is the simple ones e.g X tonner to landfill. Is its some complex equation then it starts to lose people there is no incentive then to change

RT - IF WE HAD A COMPLEX MEASURE THAT MEASURED ALL THE PARTS OF THE SUPPLY CHAIN, IT MIGHT BE TOO COMPLICATED?

NG – It depends on the influencing factors. It depends on what the measure is, how meaningful it is to everyone, not just to the science people, if it is a huge algorithm that says anything < 1 is great, but I need a PhD in maths to understand, then I do not get it. If it explains what 1 is -= X tonnes going to land fill it would be better. There are so many influencing factors

RT – DO WE NEED TO MEASURE IN SILOS OR JOINED UP?

PB – Isnt it a belief around what that measure is, if you take what NG has said. It is the call to action what we are looking for, so the government takes a measure, you are asked to measure and in 10 years the legislate that you need to hit 1 – this will drive a change in behaviour

DR – I guess for us as employees it tend to be carbon/employee. If we can understand it on a regional and individual basis. But for our customers it is different. It is the carbon/consumer portion. Consumer groups are interested in the carbon per squirt of ketchup, how much carbon is in that , that is a calculation which they do, they look to compare carbon per consumer portion across their entire range. For others in the transport and operations, it might be carbon/pallet or carbon/tonne/shipment/case/unit. The issue is the lack of commonality. Again for drivers per tonne of carbon, in Australia this is driven by the carbon tax. If you can put a value on carbon it will change people's behaviour.

LR – I would like to echo what NG has said about measure being simple. Simple measures are the ones which are the most effective and from my perspective i suppose the people I work with, the things that they look at is vehicle utilisation and how efficient they are on vehicles (air, road, rail, tank). If you can be more efficient and increase utilisation it is better ultimately for the planet. My philosophy is cost is the main driver and we talk about CSR, it is great because it gives a company a good public image so people will then buy your product and increase profits. Ultimately it is about the bottom line. The measure which affect the bottom line are the key measures. Legislation drives cost. Utilisation is the key measure. Going back to fuel distribution game, If you have a vehicle which is 90% or 88% full it is very difficult to tell but you can with a fuel tanker down to the 0.01% utilisation. So differences between transport types.]

NT – Is it difficult to get a back up or return load?

LR – Degree of this but now the refinerys are more concerned about waste product being returned to the refinery. This is driven by cost and legislation. There is a clear link.

PR – Best measures depends on the company. Take transport, I think it is the environmental impact of TEU/tonnes carried over a certain distance. Taking into account the amount of empty trailers, tonnes/KM – if it is empty on the return you still count the

fuel and KM. The KPIs must be simple but for transport we need to look to include social and environmental costs in the measure. There are studies to try and transform other social and environmental costs. Some pollution for example generates acid rain which then affects the agricultural sector. Road haulage has an impact on accidents on the road. We need to look at a strategic level and then make it simple on an operational level. Rail first, then sea, then road. It is about environmental and social elements.

In our company we are not free to switch supplier base. It is fixed by our customer Boeing. Boeing dictate the most appropriate measures, our job is to make them understandable to everyone.

SR – The key to getting this across is simplicity. My experience in the NHS in delivering this message is to keep it very simple and for people to understand and digest. If you make it complex then people do not understand. For the private sector I think morally I think we are all in agreement we should do it but it is all about the bottom line.

Private sector is bottem line driver
Public sector is budget constraints driver – very similar

MB – i would echo the same things. It needs to be simple. I have concerns over multiple emission factors and measures which make it hard to compare like for like. Consistent reporting tool that everyone can use that is transparent is top of my agenda. With regards the most appropriate measure: carbon emissions per widget/tonnage/KM/dressing/item For service contracts per mileage/visit/experience again mapping patient pathways. Makes it complex. Patient travel aspects and raw material aspects, follow up measure on a patient episode. These are complex measures and very difficult to measure. We need simple, transparent and consistent measures. Where do we draw the line. If everyone is measuring say carbon tax how do we prevent double counting carbon emissions five times? The UK has the CRC policy on carbon tax whic brings in £1B/year, which the NHS are now starting to pay.

NT – Alot of it has already been said. It is specific to a business or a business unit within a logistics field. You could not compare transport with warehousing – two different beasts. It needs to be simple. From my perspective 1) Vehicle efficiency (fill) and2) the efficiency of using those vehicles.

(NG)Need to capture and make the measures visible so people understand them. Simple measures required for e.g. tonnes to landfill is easy to understand. These are the best measures
(PB) There needs to be a call to action – legislation
(DR) Carbon per consumer portion per drop, per ship
The issue is the lack of commonality. Carbon tax?
Simple measures are the most effective such as vehicle utilisation (air, ship, truck etc)
Cost is the main driver = Bottem line
CSR is a good public image
Legislation will drive cost
Fuel vehicles are more accurate than FedEx lorries. But challenge with fuel is the no opportunity to back haul
Waste product back to the terminal is the focus
Tonne/KM of empty running
Got to think about the environmental and social issues with the environment (avoiding acid rain on agriculture, it can have social and economic impacts

Complex > Simple Strategic > Operational so understandable and measureable (simple)

Simplicity – all seem to agree with NG

It is all about the bottem line at the end of the day
(MB) Budget constraints are an issue in the public sector

4. **If you were given a free reign, what environmental supply chain measures would you propose and why? How would you measure these?**

   Carbon emission per widget/item. To get a complete measure is very difficult
   Needs to be simple, transparent and consistent. Avoid duplication and double counting.
   CRC Carbon tax = £1 bill/yr (government led)
   Measures can be specific to a business or a silo (warehousing or transportation)

5. **What are the drivers to measuring environmental performance measures in your supply chain?**

Cost, brand, legisation

(LR) Most would agree it is legisation and cost that are driving the measures
(PB) Apple – brand value is important – if it kills the planet people will not buy their product. Ethos and core values
Retailers are the driving force and the public

6. **What are the barriers to measuring environmental performance metrics in your supply chain?**

LR – When you make a measure, give a result and your customer does not then want it – customer can kick back

NG – Where do you start and stop in the supply chain. It goes back to the Ketchup example. If you go back to the raw materials being sourced in the far east, which transport mode, there are so many factors. The debate this afternoon has been – from my perspective, it is how do we get the data for that measure. It gets far more complicated going back up the supply chain because some areas of the world do not have these measures in place and it is difficult to get this data. Yet this is a huge part of the measure, we are only doing half of that measure. If data is missing, the data will lose its impact. What is the definition of the measure? Otherwise people will stop believing in it.

PB – In closed loop supply chains it is easier to measure
MB – It is where to you draw the boundaries

PB_ supply chain are driven by cost and service measures. It is collaborative in nature. In terms of return on assets, shared assets in collaborations:
1) **How bears this cost?**
2) **Where is the cost bourne?**
3) **How do you capture it**
4) **There are multiple measures**

You are in the most complex area. With the greatest respect to the petrochem industry it easy to pull it out of the ground, refine it and transport it.

PR – how much information can I share with my suppliers (logistics and product suppliers) is a barrier. What strategic information can I share outside my business?

NT – Also how complicated and laborious is the task of calculating the meaaure. If you have SAP and ERP system this is great. But if it takes a team of people five days per week then this is a cost barrier. Within closed loop – it is how much is within your control

LR – it is about the cost of carbon versus the cost of calculating the measure, if it is complex it drives the cost up.

NG – the issue is, what unit is it we are measuring? To be able to effectively benchmark. If DR and I benchmarked, I might be measuring KW/HR and he might be measuring grams of Carbon. This is an issue, what is the unit I am measuring?

MB – It is customer demand driven and if they do not ask for it, we do not measure it.

Where do you start and stop?
Sourcing to consumer?
Multi modal
Very difficult to measure parts of the supply chain upstream or outsourced activities. Very complex
Who bears the cost, where is it borne? Who measures?
Information sharing, lack of callaboration int he supply chain
Complicated and laborious to measure and calculate
Closed loop makes it easier
For commerical reasons people will not divulge this sort of information.
ROI Cst of gathering data versus the cost or value you of it in the end?
The measures need to be standardised.
Customer driven/demand is a barrier

7. **Do you subscribe to an environmental measurement scheme, if yes, what?**

NT – probably do but not aware
PB – i know we have these standards (ISO) We have IS0 14001 and have progressed to ISO 180001. WEE regulated. GRI I do not know. But this is not all implemented at every site only where required.

NG – Yes we do but not sure, possible carbon trust

DR - Ditto – we have a green centre intitiative so I am sure we do.

LR – Almost all of the big ones have it, ISO 14001 and ISO 180001 is pretty much universal

PR – ISO 14001
MB –this requirement goes into all our of tenders and contracts, if the do not have it they/we do not get it.

Not many of the respondent know whether they subscribe to a standard.
(PB) ISO 14001, 18001 wee regulated

GRI for the NHS and the Carbon Trust and ISO 14001 . This feeds into NHS contracts and tenders

Port sector ISO 14001 ISO 9001 EMAS

8. **Organisations measure and report their supply chain performance through frameworks such as the 'Balanced Scorecard' or 'SCOR'. Which do you use?**

MB – We use the balanced scorecard internally for reporting metrics and environmental metrics, we only measure and report on some environmental metrics

**** they use the GRI as an external reporting tool*** he mentioned this earlier**

Also we use other standards such as ISO 14001 to report on our environmental performance

NT – Probably, this is not my area of expertise

PB – We use the SAP/ERP system – every client has different methodologies needs. We are a lean organisation and use A3 reporting methods. We do not use BSC in the sense of the term but have similar ways of reporting to BSC. We have a SCOR methodology in our business and buy into what this reporting requires. We work with latest academic thinkers who want to come up with new models! And latest fads etc But the main aim of any tool is

to make complex data into simple data, which can then be actioned to create improvements.

NG – No BSC, in its purest form. We have measures displayed in variety of formats. Not linked to anyone report. They are all reported separately for specific measures

PR – Most customers have something along the lines of a BSC e.g. automotive. Whole bunch of metrics. It does depend on the customer's own requirements. Use the scorecard for sales only.

LR – Not a term I have heard of, but with big clients I see numerous data collected and reported on or data collection points.

PR – E,g, Port sector, not seen the BSC, Yet there are KPIS for emissions. ABP, or Port operators drive the shipping sector reporting, for e.g. Clean Carbon Working Group – is how some are communicated through. They are mainly communicated through groups like these

J – Not sure if we use the BSC – the buyers are really driving the reporting tools and metrics.
Only the GRI (NHS)
Arco – no particular framework
A3 reporting methodology
SCOR methodology – Oracle – sales use it but not supply chain.
Ports sector = ABP standardised reporting
Shipping sector – clean carbon working group (IMO)

9. **Which performance frameworks could be used for reporting environmental supply chain performance and how?**

?

10. **What are the direct benefits of incorporating supply chain environmental measures within a supply chain performance framework?**

?

11. **Given your position and experience, what do you think is important? Where are the gaps? What is missing?**

NG – i think this is then a summary for me, the measures that we have got in the room and from the supply chain backgrounds, we probably measure everything that is what we are good at. But what is missing is clear government guidelines and standardisation and simplicity. There are too many disparate bodies and legislation. Nothing really matches up. We need a clear message which could drive what we measure. A key strategic measures that we could plug all the smaller, simple ones into that would unify the UK and the globe in driving the success. In my own experience there is confusion out there and there is confusion I will do what my customers need but apart from that I will wait to see what happens.

MB – A unfied, transparent and simple....

Ultimately it will come from the government to standardise across industries and sectors and to get organisation in the UK and in the world to comply. It will be difficult to get a consistent approach

PR – It is a more sectoral approach, I suggest to develop a sector approach

MB – What happens if you have 10 different sectors, how do you unify?

NT – I agree with PR a sector approach is required. Those of us who are employed in storing and moving product are different from those which are moving people (NHS). What is the point in measuring and comparing a hospital with a DC?

PR – We need an international approach to targets and agreements. For measurement is has to be sectoral

DR – i do not see a problem with the measuring of things. But once we have measured, what are we going to do with it? Otherwise it just becomes a data capture exercise. Until we can put a financial value to it, it is a great academic exercise but it is not going to influence any behaviours. Put a value on the carbon. Legislation may pre empt this or legislation will follow. Everyone wants to save the planet but until we can say carbon is worth this value (£) then there is not point

NG – What is the unit of measure which would allow us to compare across functions and sectors? They are not currently comparable. The green measures must be comparable.

LR – A global standards, are we ready for this? No. The proof is Kyoto.

NT – Putting a financial cost on it. We are good at measuring those things which cost us money

SB – Cost is important. Department of Health are looking at putting energy efficiency ratings on appliances A, B, C etc. This is good for comparisons

MB – It has to stack up financially for it to work. The opportunities and requirements all individual and different measures to report. But if customers ask for it then we need a generic measure

PB – I do not agree with the sectoral approach that went around the table. Within supply chain, there are similar comparable types of activities. If an activity is consistent and standardised, it does not matter what sector it is in. Because a sector approach has no traction in terms of environmental measurement and improvement. I think there is a belief that a global standard is required but impossible to achieve in the political timeframes. Timeframes work against us. What we should not underestimate is our consumer mood is driven by the social media and will change over generations. Those people doing our job in 10-15 years time will be conditioned by legislation. Rarity of fossil fuels, survivability of the human race. These are big macro factors. But cost, service/CSR are the big three

NG – I agree with PB, unless you have a standard it is difficult to measure

DR Focus on KPIs very insular. But if you look at the supply chain that works across different companies. I believe supply chain is the least collaborative system. We become very company centric opposed to supply chain and environmentally centric

RT – WHAT WILL DRIVE THIS?

DR – the bottom line will drive collaboration but until the financial outweigh it, until the bottom line drives, they will not do it

LR – An international standard. Are we ready for it? No.

PR – We need an international standard for carbon emissions. Better collaboration is required

Suppliers need to responsible not only for their performance but their whole supply chain

MB – one last things. Cross sector reporting and standardisation is possible (CRC and Europenan union emissions trading standards. So there is an opportunity for standardisation

SS – WHAT IS THE RETAILERS REAL MOTIVATION? GREEN WASHING OR GENUINE CARE

People said mainly green bucks!, some said both.
PB – Driven by what their customers require
But if this makes them more competitive they will do it
The customer at the end of the day is in control, they pay.
Retailers are commercial organisation, it is about the green bucks
Both, both etc..

Close

We need clear government policy to drive a standardised measure
We measure everything
We are confused and therefore reactive
I will do what my customer tells me and no more or I will wait
Maybe a sector approach would help – but conflcit in the group about this. There is no point in comparing hospitals with logistics
We need a standard financial measure pre empt or follow
We need to put a value on carbon – is it worth £K? Until we do this no one will bother
What is the unit of measurement?
We need a global standard but even Kyoto did not work
It needs to stack up financially for it to work
You can standardise logistics activities across different sectors
SC are less collaborative and collaboration is the key to this
We are very insular
The bottem line will drive it

Focus Group Session – Wednesday 25th January 2012

Summary/ Abstracts and Themes – Data Reduction

Research Questions:

1. What environmental supply chain measures does your organisation use and need?

- Vehicles MPG
- MPG to calculate carbon
- Empty running
- Vehicle fill ratio
- Carbon emissions
- Carbon footprint model
- Intermodal switching (road to sea, road to rail)
- Asset utilisation
- % space left on vehicles
- Pallet utilisation
- Packaging reduction and optimisation
- Electricity consumption (utilities)
- Gas consumption (utilities)
- Fuel utilised (fuel consumed/KM travelled)
- < recycled waste to landfill
- Container movements
- Reduction in employee road miles (single visit fix)
- Direct correlation of MPG to vehicles fill
- Employee training and up skilling
- % of fleet using bio fuel
- Carbon dioxide reduction of buildings
- Carbon dioxide reduction of the fleet
- Correlation of MPG to vehicle fill
- Energy usage
- # of road miles
- # of times you move a pallet before it is sold (put to move)
- Water utilised

2. How do you measure and report them?

- DHL Global Metric System (in house company reports) which:
    - Sets targets
    - Defines what needs to be measured and what data to collect
    - What to feed back into the system
    - Drives improvement
    - Benchmark against different business units

- Not much in the way of direct reporting (PD Port)
- Reporting requirements are driven by the retailer or the customer base (consensus in the group)
- Different supply chains and products require different reporting requirements – these are tailored to a customer.

- Global, regional and local reporting system. Global metric system. Driven by a shared customer base (the retailers. About variance to a plan (GL)
- No benchmarking, we use CRC but do not do anything with the data internally or externally, it is mainly for the CRC and the government (IAWS Foods)
- We report on cost, but cost reduction also reducing carbon emission. Cost is driving green (RB)
- Metrics are retrospective and can drive the wrong behaviour (KD)
- Internal reporting system reporting at group level (Clipper Logistics)
- Telematic reports are used to track and improve driver behaviour, share best practice and share with customers and suppliers (MPG) (Clipper)
- ISO 14001 to internally report (Clipper)
- No reporting in Ideal Standard. Driven by cost, cost is the main consideration

3. In your opinion, which are the most appropriate environmental supply chain measures used in your organisation?

  - MPG (as you can attach a cost and saving to it)
  - Kilos travelled per case delivered
  - Scheduling of route efficiency
  - Cases per drop
  - Fleet utilisation
  - No 'green' generic measure as such, just lots of measures
  - On time at the right price is the priority
  - Fuel consumed per case delivered (encourages fuel economy)
  - KM travelled per case delivered
  - Building utilisation
  - Building (carbon to build and carbon to maintain)
  - Activity versus energy measure (theme)
  - Carbon cost of building a new warehouse
  - Carbon cost of maintaining a new warehouse versus old warehouse
  - Carbon cost of outsourcing to the far east (dirty production) and not just UK emissions
  - There is no single measure currently but in silos and some missed
  - Need to measure the entire end to end supply chain. Not impossible to do we are just not yet sophisticated to do this.
  - Carbon/cost tradeoffs

4. If you were given a free reign, what environmental supply chain measures would you propose and why? How would you measure these?

- Emissions per X or case or tonne delivered
- Measure all emissions and not just carbon
- Fuel
- Measure all resources used along the supply chain and not just fuel
- Waste reduction
- Packaging used
- Reduction in perishable products (e.g. food supply chain)
- It is all very much retailer driven

5. What are the drivers to measuring environmental performance measures in your supply chain?

- Customer (the retailers mainly is generally the consensus or big customers
- Fuel efficiency

- Green agenda in general
- Legislation (e.g. CRC for IAWS Foods)
- Cost is driving the green agenda – it is all about cost really
- Driven by the board of directors and CEOs
- Efficiencies (Going Green with DHL)
- Competitive Advantage (differentiator and good value proposition)
- The bottom line and other opportunities
- Capital gains and tax breaks (e.g. CRC Scheme)
- Rewarding buying renewable sources of energy
- The supply chain itself can drive this
- Cost (slow steaming)
- Cost and environment are linked so it can be dressed up as green but it is really about cost

6. What are the barriers to measuring environmental performance metrics in your supply chain?

- Poor rail infrastructure (go North to go South)
- Time
- Who should measure it in an organisation?
- People (education, attitude, what you are in control of, social norms)
- No one is asking for this information, it is a 'nice to have'
- Generally no real major barriers
- Not in full control of the end to end supply chain (you can only measure what is in your control)

7. Do you subscribe to an environmental measurement scheme, if yes, what?

- ISO 14001 (two of them aiming for)
- CRC Scheme
- ISO 18001
- ISO 9001
- EMS
- Statutory requirements
- DHL in house global metric system
- HGV standards (Euro 4,5 & 6)
- Rail standards (stages 3s and 3b)
- Road map to Resource Efficiency - new things to enter the EU stage

8. Organisations measure and report their supply chain performance through frameworks such as the 'Balanced Scorecard' or 'SCOR'. Which do you use?

- Balanced Scorecard
- SCOR
- DEMAKE (Six sigma)
- DHL In house global metrics system
- Set of standard KPIs (more customer facing, cost etc)
- No, no, no general consensus

9. Which performance frameworks could be used for reporting environmental supply chain performance and how?

- Something which looks at what we can do now and allows for planning and development for the future
- CRC – could it be extended?
- Perhaps a balanced scorecard
- Carbon Trust – Walker Crisps example
- Dow Jones Sustainability Index framework (which questions do they ask?)
- Reporting based on incentives to get tax breaks and capital returns for reporting

10. What are the direct benefits of incorporating supply chain environmental measures within a supply chain performance framework?

- It helps you make decisions which help the company to survive
- As a company you become more sustainable and resource efficient
- Getting the buy in from your team and changing attitudes and behaviours (social norms)
- TBL benefit – Clipper and electricity saving and Philips lighting in German schools
- Win win situations

11. Given your position and experience, what do you think is important? Where are the gaps? What is missing?

- We have to measure the end to end supply chain, we can do this, we just not yet that sophisticated .
- Other factors and not just fuel can affect the green agenda – so rising cotton prices can change how product is routed and how much stock we need in our sheds. It can also be driven by other company infrastructure and government legislation
- Chinese mineral embargos for example will affect where product is manufactured
- Reverse logistics will be key in improving sustainability in supply chains (linear to closed loop)
- KPIs have changed over the last 30 years – prior were more service focused (99% On time in full) now they are very environmentally focused
- We need to increase the scope of green, it is not just about fuel but employee behaviour and reducing employee mileage, chemical released into the environment etc..plastic bags, landfill
- We need to change people's mindset if we want to change
- The social norm is that resources are not finite.
- But we can only act on the information that we are provided us with as consumers
- Kyoto is important as three major economies have not signed – we need this.
- It will make EU countries uncompetitive (national versus global countries)

OTHER KEY THEMES

Cost is major driver
The balanced scorecard could be a potential framework
Cost is linked to green/environmental with similar trade offs
There is no complete one measure
It is siloed
You can only measure what you control
There are lots of things not being measured
Reverse logistics is important in sustainable supply chains
Retailers or Big customers are driving the measurement agenda
No one else is asking, therefore reactive
It is a nice to have

Some internal reporting but no external reporting
Mainly own in house reports
Collaboration helps in measuring the supply chain
People's behaviour is key in the process (driver training, telematics, social norms)
ISO 14001 is the main measurement framework but not yet widely implemented
Some large companies have their own in house metric system (but more customer facing)
Fuel (MPG) is a big measure but it is affected by so many variables
So are carbon emissions
Warehouse expansion is a key theme (old versus new) and carbon required to build and maintain
We offshore a lot of carbon to the Far East and only measure emissions in the UK

Group Session – Thursday 26th January 2012

Summary/ Abstracts and Themes – Data Reduced

Research Questions:

12. What environmental supply chain measures does your organisation use and need?

- Global reporting initiative (scope 1, 2 and 3)
- Vehicle fill x 2
- Cage fill on a vehicle (FedEx)
- The amount of packaging used at product level
- Waste/packaging measures
- Warehouse efficiency
- Carbon emissions
- Energy consumption of buildings
- Carbon produced per mile, per case and per load
- Water usage
- Power usage
- Building utilisation
- Employee travel mileage
- Fuel used
- Car share
- Cycle to work schemes
- Modal shift/ratios (pipeline/rail/sea versus road)
- Fleet efficiency
- Air emissions
- Shipping pollutants (ballast water contamination) and affect on biodiversity
- Nitrous oxides and sulphur (affect on human health)
- Carbon emissions (affect on global warming)
- Building rating (A,B,C,D or E) energy efficiency
- Cost of running a vehicle
- Waste produced (tonnage)
- KW/Square metre of building floor area (square metre)
- Heating volumes for building
- KM/litre of fuel
- # of skips filled and removed from site /week
- Vehicle mileage

13. How do you measure and report them?

- Global reporting initiative (scope 1 –direct , 2 indirect and 3 out of control)
- Carbon Trust is how it can measured (produce level)
- Green Cargo Working Group
- DEFRA guidelines on emission factors
- Strategic, middle, operational management levels reported at
- Grams of Carbon dioxide/container (TEU)
- Grams of Carbon dioxide/tonne for shipping
- Percentage of product produced distributed by mode
- International Maritime Organisation (IMO) for shipping
- Environmental Protection Agency
- NHS > UK statistics
- Waste is measured by tonnage (plastic and paper produced)/month

- Own system (Smartway e.g. Oracle) capture fuel used, emission produced etc Part of the Environmental Protection Agency used in the US
- Cost/carbon equation (weighted)
- Measure the variations to a plan
- Capturing and directly inputting employee travel (fuel used, mileage travelled)
- Reported at a corporate and regional level
- Reported at a corporate, operational and public level
  Product packaging produced annually at line level (70% of a product is packaging)
  Sensed some practitioner frustration at how they are supposed to capture certain environmental performance metrics e.g. parcel which goes to a third party carrier...

14. In your opinion, which are the most appropriate environmental supply chain measures used in your organisation?

The simple measures
No complex equations/algorithms
The measures which are clear, visible, simple, transparent and consistent
Carbon emission per part moved to satisfy a demand (global supply chains)
Vehicle KM run (transport and operation supply chains)
Vehicle efficiency (fill and utilisation)
Vehicle KM run
X tonnes to landfill
Turn the light off at the end of your shift
Carbon per employee
Carbon per consumer portion (Squirt of Ketchup)
Carbon per pallet/case/unit/tonne
Vehicle utilisation
Environmental impact of a TEU/tonne distance travelled
Empty running
The measure should include (social aspect, acid rain affecting agriculture)
Carbon emission per widget
Carbon emission per tonnage
Carbon emission per KM
Carbon emission per item

15. If you were given a free reign, what environmental supply chain measures would you propose and why? How would you measure these?

16. What are the drivers to measuring environmental performance measures in your supply chain?

- Cost
- Legislation
- Retailers (M&S)
- What the brand needs (apple)
- Big suppliers can drive this (Boeing)
- Customers drive this
- Bottom line

17. What are the barriers to measuring environmental performance metrics in your supply chain?

Cost of the carbon versus the cost of measuring it!
Where do you draw the boundary lines in the supply chain
What is the unit we should be measuring to enable benchmarking?
I can only measure parts of the supply chain I can control so only half the measure
Other countries do not have standards or need to measure (Far East)
If data is missing from the measure it will lose its impact
Who bears the cost of measuring?
Where is the cost borne in the supply chain?
How do we capture it?
Multiple measures and very complex so hard to measure
Where do you start and stop?
Supply chain is the most complex system to measure
How much strategic information can I share with my collaborative partners (suppliers)
It is laborious and expensive
Customer driven only

18. Do you subscribe to an environmental measurement scheme, if yes, what?

- Most of them did not know and were not sure
- Some putting ISO 14001 only at sites required
- Some already implemented
- Moving towards ISO 18001
- WEE regulations implemented
- Seemed a little vague about the standards

19. Organisations measure and report their supply chain performance through frameworks such as the 'Balanced Scorecard' or 'SCOR'. Which do you use?

- Global Reporting Initiative (GRI, scope 1,2 and 3) for the NHS
- BSC mainly used for non environmental reporting e.g. sales, but NHS do use it for some internal reporting
- ISO 14001 reporting tools used
- Clean Carbon Working Group Reporting tools
- No real framework in place, these metric are reporting separately in the business (Arco)
- SCOR model is used by Unipart
- A3 Reporting for lean models (Unipart)
- Generally with Unipart it is in house frameworks driven by the client.
- Different client, different reporting frameworks required

20. Which performance frameworks could be used for reporting environmental supply chain performance and how?

- Different client, different reporting frameworks required
- BSC. SCOR, internal reports etc

21. What are the direct benefits of incorporating supply chain environmental measures within a supply chain performance framework?

Not really discussed?

22. Given your position and experience, what do you think is important? Where are the gaps? What is missing?

- We need clear government guideline on what to measure
- There is confusion and the default is to meet your customer needs
- Too many disparate bodies and legislation
- It requires unifying, a key strategic measure for the others to plug into
- Transparency, simplicity, government led
- Sectoral approach to measuring? But challenged as SC has comparable activities
- It is OK with measuring, but what are we going to do with the results?
- We must put a financial value/cost (£) on carbon on the 'green' measurement.
- Driven by the bottom line
- It has to stack up financially for us to do it
- The measures must allow for comparisons between industry and sector
- There is a genuine care for the environment but the bottem line is paramount factor
- What is the unit of measure that would allow comparisons?
- Cost, service and CSR are the big three themes
- Political timeframes will work against us in this generation
- There is a belief we need a global measurement standard
- The next generation in the next 10-15 years will be very focused on rarity of fossil fuels, survivability and driven by legislation in this field. But we are restricted at present
- Collaboration is required to measure green performance
- Organisations have become very company centric and not environmentally centric
- Cross sector reporting is possible e.g. CRC and European Emissions Trading Standard reporting happens now

OTHER KEY THEMES

- Confusion and frustration
- Where do you draw the line on measuring and how can be sure we not double counting? (CRC Policy)
- Simple measures are the most effective measures
- We need government to drive this through legislation to drive a behavioural change. We need a 'call to action' to drive this
- If we can put a value on carbon it would change people's behaviour
- The issue is the lack of commonality between measure making like for like comparison difficult.
- You cannot compare warehousing with rail transport – two separate reporting elements
- No one measure for the supply chain there are too many influencing factors and variable
- The measure depends on the supply chain (global or local)
- The measure depends on the business and or the business unit
- Environmental improvements has to be a whole team impact
- SME – no measures (LRT)
- Generally no specific environmental supply chain performance measure
- Cost/service focus is the main driver
- Legislation is a driver
- Cost and legislation are linked
- Cost and environmental are linked. If you drive one down you will drive the other down.
- It is difficult to measure certain elements of the supply chain e.g. 3PL parcel deliveries (which is my parcel)?
- Large suppliers at the top of the supply chain can set the measures for others to conform to.
- There is a shared drive and focus by big companies to improve environmental performance as part of CSR policies e.g. Unipart and Sky.
- Big element is educating staff about environmental awareness and performance

- Large companies have a Director specifically looking after sustainability or the environment. In medium sized businesses it sometime sits with a HR director or a divisional director which reports in a board level. For SMEs there is not major ownership apart from the MD's own attitude and drive towards this.
- Reported internally mainly at a board, operational and rarely a public level or externally
- Public companies like the NHS seem to be more advanced in terms of reporting than private companies (GRI Initiative).
- Private companies – it is driven by the bottom line
- Public companies – similar but driven by budget constraints
- Appropriate measure set by a key supplier or customer in the supply chain (fixed and non negotiable)
- Keep it simple, if we make it too complex people will not measure or change their behaviour
- The measure depends on which supply chains you are looking at (e.g. global Jaguar supply chain or just national transport and operation supply chain).

Survey - Introduction & Background

Survey on green/environmental supply chain performance measures

Thank you for agreeing to complete our survey.

We are looking to enhance our knowledge about green/environmental supply chain performance measures and request you provide your opinions on this topic by completing the following survey, which will only take between 10 and 15 minutes of your time.

The purpose of the survey is to understand what green/environmental supply chain performance measures are currently being used in the sector, why they are being used, what the benefits are, and what are enablers and barriers to implementing them.

You are guaranteed complete confidentiality when completing this survey. No individual or company will be identified during the survey process or output.

As noted in our covering e-mail we are offering a new iPad as an incentive to participate. The new iPad will be awarded by random draw to survey participants. To enter this prize draw, please leave your contact details in the fields provided at the end of this survey.

This survey will close at midnight on Friday 22nd June, 2012.

Thank you for your participation and good luck in the prize draw!

Yours sincerely,
The CILT(UK) Team

Read the terms and conditions here - http://www.ciltuk.org.uk/pages/cabnews28

Section 1 - Green Supply Chain Performance Measures: CURRENT USE

***1. Which of the following green supply chain performance measures does your company use? Please tick as many as apply.**

	Please tick
Electricity consumption measures	◯
Driver behaviour	◯
Carbon emissions of an activity	◯
Carbon emissions per item/case/pallet delivered	◯
Overall company carbon footprint measures	◯
Vehicle mileage measures	◯
Packaging consumption measures	◯
Fuel consumption measures	◯
No of pallet movements or touches per delivery	◯
Warehouse utilisation measures (e.g. pallet occupancy)	◯
Fuel consumed per item/case/pallet delivered	◯
Vehicle running costs	◯
Waste recycling measures	◯
Warehouse efficiency measures	◯
Water consumption measures	◯
Gas consumption measures	◯
Overall supply chain carbon footprint measures	◯
Vehicle fill/utilisation measures (e.g. empty running)	◯
Energy used per item/case/pallet delivered	◯
Greenhouse gas emissions (nitrous oxide, methane etc)	◯
Cost measures (e.g. cost of running your warehouse, fleet etc)	◯
Employee training (environmental training)	◯
No of container unit movements (TEU)	◯
Employee travel	◯

Resource efficiency (raw materials, asset utilisation)

*2. Are there any other green supply chain performance measures which your company uses?

Yes

No

If you answered "Yes" then please specify these green supply chain performance measures in the text box provided below:

Section 2 - Green Supply Chain Performance Measures: USEFULNESS

***3. Please tick the button shown on the scale below which best indicates the 'usefulness' of each green supply chain performance measure to your company**

	No use whatsoever	Not very useful	Useful	Very useful	Exceptionally useful
Electricity consumption measures	◯	◯	◯	◯	◯
Driver behaviour	◯	◯	◯	◯	◯
Carbon emissions of an activity	◯	◯	◯	◯	◯
Carbon emissions per item/case/pallet delivered	◯	◯	◯	◯	◯
Overall company carbon footprint measures	◯	◯	◯	◯	◯
Vehicle mileage measures	◯	◯	◯	◯	◯
Packaging consumption measures	◯	◯	◯	◯	◯
Fuel consumption measures	◯	◯	◯	◯	◯
No of pallet movements or touches per delivery	◯	◯	◯	◯	◯
Warehouse utilisation measures (e.g. pallet occupancy)	◯	◯	◯	◯	◯
Fuel consumed per item/case/pallet delivered	◯	◯	◯	◯	◯
Vehicle running costs	◯	◯	◯	◯	◯
Waste recycling measures	◯	◯	◯	◯	◯
Warehouse efficiency measures	◯	◯	◯	◯	◯
Water consumption measures	◯	◯	◯	◯	◯
Gas consumption measures	◯	◯	◯	◯	◯
Overall supply chain carbon footprint measures	◯	◯	◯	◯	◯
Vehicle fill/utilisation measures (e.g. empty running)	◯	◯	◯	◯	◯
Energy used per item/case/pallet delivered	◯	◯	◯	◯	◯
Greenhouse gas emissions (nitrous oxide, methane etc)	◯	◯	◯	◯	◯
Cost measures (e.g. cost of running your warehouse, fleet etc)	◯	◯	◯	◯	◯
Employee training (environmental training)	◯	◯	◯	◯	◯
No of container unit movements (TEU)	◯	◯	◯	◯	◯
Employee travel	◯	◯	◯	◯	◯

Resource efficiency (raw materials, asset utilisation)	◯	◯	◯	◯	◯

Section 3 - Green Supply Chain Performance Measures: EASE OF MEASUREMENT

***4. Please tick the button shown on the scale below which best indicates how easy it is to measure each green supply chain performance measure in the context of your company?**

	Exceptionally difficult to measure	Difficult to measure	Straightforward to measure	Easy to measure	Exceptionally easy to measure
Electricity consumption measures	○	○	○	○	○
Driver behaviour	○	○	○	○	○
Carbon emissions of an activity	○	○	○	○	○
Carbon emissions per item/case/pallet delivered	○	○	○	○	○
Overall company carbon footprint measures	○	○	○	○	○
Vehicle mileage measures	○	○	○	○	○
Packaging consumption measures	○	○	○	○	○
Fuel consumption measures	○	○	○	○	○
No of pallet movements or touches per delivery	○	○	○	○	○
Warehouse utilisation measures (e.g. pallet occupancy)	○	○	○	○	○
Fuel consumed per item/case/pallet delivered	○	○	○	○	○
Vehicle running costs	○	○	○	○	○
Waste recycling measures	○	○	○	○	○
Warehouse efficiency measures	○	○	○	○	○
Water consumption measures	○	○	○	○	○
Gas consumption measures	○	○	○	○	○
Overall supply chain carbon footprint measures	○	○	○	○	○
Vehicle fill/utilisation measures (e.g. empty running)	○	○	○	○	○
Energy used per item/case/pallet delivered	○	○	○	○	○
Greenhouse gas emissions (nitrous oxide, methane etc)	○	○	○	○	○
Cost measures (e.g. cost of running your warehouse, fleet etc)	○	○	○	○	○
Employee training (environmental training)	○	○	○	○	○

No of container unit movements (TEU)	◯	◯	◯	◯	◯
Employee travel	◯	◯	◯	◯	◯
Resource efficiency (raw materials, asset utilisation)	◯	◯	◯	◯	◯

Section 4 - Green Supply Chain Performance Measures: ENABLERS

***5. The list of statements below focus on the various enablers with regard to measuring green performance in supply chains. Please tick the button on the scale below that best indicates the extent to which you agree or disagree with the following statements in the context of your company?**

	Strongly disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
Pressure from customers is an enabler	○	○	○	○	○
Government regulation and legislation are enablers	○	○	○	○	○
Suppliers are enablers	○	○	○	○	○
ISO 14001 certification is an enabler	○	○	○	○	○
A genuine care for the environment is an enabler	○	○	○	○	○
Public pressure is an enabler	○	○	○	○	○
The CEO/Board of Directors are an enabler	○	○	○	○	○
Product brand is an enabler	○	○	○	○	○
Reducing energy consumption is an enabler	○	○	○	○	○
Collaboration with suppliers is an enabler	○	○	○	○	○
Collaboration with customers is an enabler	○	○	○	○	○
Carbon emissions reduction is an enabler	○	○	○	○	○
Re-using, recycling materials and packaging is an enabler	○	○	○	○	○
Improving operational efficiency is an enabler	○	○	○	○	○
Pressure from retailers is an enabler	○	○	○	○	○
Desire to reduce cost is an enabler	○	○	○	○	○
Pressure from competitors is an enabler	○	○	○	○	○
Employee involvement is an enabler	○	○	○	○	○

Section 5 - Green Supply Chain Performance Measures: BARRIERS

***6. The list of statements below focus on the organisational barriers to measuring green performance in supply chains. Please tick the button on the scale below that best indicates the extent to which you agree or disagree with the following statements in the context of your company?**

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
Lack of time is a barrier	◯	◯	◯	◯	◯
Cost is a barrier	◯	◯	◯	◯	◯
Employee values and attitudes are a barrier	◯	◯	◯	◯	◯
The scope of the supply chain is a barrier	◯	◯	◯	◯	◯
The complexity of the supply chain is a barrier	◯	◯	◯	◯	◯
Trust in the supply chain is a barrier	◯	◯	◯	◯	◯
Obtaining data is a barrier	◯	◯	◯	◯	◯
Knowing who should measure it in the supply chain is a barrier	◯	◯	◯	◯	◯
Knowing what to measure in the supply chain is a barrier	◯	◯	◯	◯	◯
Lack of demand/requirement for measurement is a barrier	◯	◯	◯	◯	◯
The recession/austerity measures are a barrier	◯	◯	◯	◯	◯
Lack of employee training and commitment is a barrier	◯	◯	◯	◯	◯
Suppliers unwilling to exchange data is a barrier	◯	◯	◯	◯	◯
Different sectors have different challenges is a barrier	◯	◯	◯	◯	◯
Lack of legitimacy 'Greenwashing' is a barrier	◯	◯	◯	◯	◯
Too many disparate governing bodies & regulations is a barrier	◯	◯	◯	◯	◯
Lack of reporting/measurement tools is a barrier	◯	◯	◯	◯	◯

Section 6 - Green Supply Chain Performance Measures: BENEFITS

***7. The list of statements below focus on the organisational benefits of measuring green performance in supply chains. Please tick the button on the scale below that best indicates the extent to which you agree or disagree with the following statements in the context of your company?**

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
Measuring gives us competitive advantage	◯	◯	◯	◯	◯
Measuring gives us an improved image and reputation	◯	◯	◯	◯	◯
Measuring helps to improve profitability	◯	◯	◯	◯	◯
Measuring helps to reduce cost	◯	◯	◯	◯	◯
Measuring gives us improved customer loyalty	◯	◯	◯	◯	◯
Measuring reduces our risk of consumer/public critcism	◯	◯	◯	◯	◯
Measuring helps us to collaborate with our suppliers	◯	◯	◯	◯	◯
Measuring helps us to collaborate with our customers	◯	◯	◯	◯	◯
Measuring helps us to reduce waste	◯	◯	◯	◯	◯
Measuring helps us to innovate and continuously improve	◯	◯	◯	◯	◯
Measuring helps us to be more operationally efficient	◯	◯	◯	◯	◯

Section 7 - Green Supply Chain Performance Measures: REPORTING

***8. What supply chain performance measurement reporting tools does your company use? Please tick as many as apply:**

	Please Tick
The Balanced Scorecard (BSC)	◯
The Supply Chain Operations Model (SCOR)	◯
Six Sigma	◯
Own company reporting	◯
ISO 14001 (British Standards Institute)	◯
Carbon Reduction Commitment (CRC)	◯
Global Reporting Initiative (GRI)	◯
SAP reporting	◯
DEFRA reporting schemes	◯
We do not report at all	◯
Other	◯

If you have answered "other" then please specify your reporting tool in the text box provided below:

***9. What supply chain performance reporting tools would be appropriate to report your company green supply chain performance?**

	Very inappropriate	Inappropriate	Neither appropriate or inappropriate	Appropriate	Very appropriate
The Balanced Scorecard (BSC)	◯	◯	◯	◯	◯
The Supply Chain Operations Model (SCOR)	◯	◯	◯	◯	◯
Six Sigma	◯	◯	◯	◯	◯
Own company reports	◯	◯	◯	◯	◯
ISO 14001 (British Standards Institute)	◯	◯	◯	◯	◯
Carbon Reduction Commitment (CRC)	◯	◯	◯	◯	◯
Global Reporting Initiative (GRI)	◯	◯	◯	◯	◯
SAP reports	◯	◯	◯	◯	◯
DEFRA reports	◯	◯	◯	◯	◯

If there are any others (please specify and specify ranking)

***10. Please tick the button on the scale below that best indicates the extent to which you agree or disagree with the following statements in the context of your company?**

	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree
Green supply chain performance measures can be integrated within existing supply chain performance reporting tools (e.g. Balanced Scorecard)	○	○	○	○	○
There is a significant benefit to incorporating green supply chain performance measures into existing supply chain performance reporting tools	○	○	○	○	○

Section 8 - Respondent & Company Information

It is important that we capture your company profile to help us identify trends and interrelationships amongst the survey responses. Please respond by indicating the answer which best reflects your own perceptions of you and your company

11. What is your position within the company?

	Please Tick
CEO	◯
Managing Director	◯
Supply Chain Director	◯
Logistics Director	◯
Supply Chain Manager	◯
Logistics Manager	◯
Transport/Carrier Manager	◯
Environmental Manager	◯

Other (please specify)

*12. How many years have you been with your company?

*13. Please indicate your age category?

	Please Tick
Under 18	◯
18 – 25 years	◯
26 – 35 years	◯
36 – 45 years	◯
46 –55 years	◯
56 – 65 years	◯
66 and over	◯

*14. Please indicate your gender?

	Please Tick
Male	◯
Female	◯

*15. How many people are employed in your whole business – not just your site?

	Please Tick
1 to 9	◯
10 to 49	◯
50 to 199	◯
200+	◯

16. Which of the following best describes the industry you work in?

	Please Tick
Agriculture, Forestry, Fishing and Hunting	◯
Mining	◯
Utilities	◯
Construction	◯
Manufacturing	◯
Wholesale Trade	◯
Retail	◯
Transportation and Warehousing	◯
Information	◯
Finance and Insurance	◯
Real Estate and Rental and Leasing	◯
Professional, Scientific, and Technical Services	◯
Management of Companies and Enterprises	◯
Administrative and Support and Waste Management and Remediation Services	◯
Educational Services	◯
Healthcare and social assistance	◯
Arts, entertainment and recreation	◯
Accommodation and food	◯
Public administration	◯

Other (please specify)

Survey Complete

Thank you for taking the time to complete this survey.

17. If you would like to receive a summary of the results from this survey and be entered into our free prize draw to win a new iPad, then please leave your name, email address and telephone number in the text box below:

Name	
Email address	
Telephone number	

GSCPM & Reporting 30 minute Workshop

Location & Date	Room Details	Participants
Monday 8th October	The UCL Energy Institute is located on the 1st Floor of Central House, 14 Upper Woburn Place, London WC1H 0NN	SS & workshop participants (4 groups)
Purpose	**Objectives**	**Outcomes**
To identify GSCPM and reporting tools which could be used by organisations now and in the future	Participants to brainstorm the following questions using post its and flip chart paper: 1) Which GSCPM do you currently use - put these into themes? 2) Which are important (rank these on a matrix ease versus impact) 3) Are there any gaps? 4) Which reporting tools are used in supply chain management? 5) Can any of these be used to report GSCPM? 6) Which are the most appropriate?	The team will have a good understanding of what measures and reporting organisations currently use, the gaps and the desired future state. It will help to provide insight and guidance on what to measure and how to report this.

Start: 29/08/12 **12.45 hrs**

Session	Time	Duration (h:m)	Session overview	Lead	Outcome at the end of the session	Required Participants	Equipment & Preparation
Welcome	1/1.30/2.00 /2.30	2 minutes	Hello everyone, what is the workshop about? GSCPM & Reporting brainstorm session	SS	Everyone knows what the meeting is all about and the intended outcomes	All	Teas/coffees/biscuits
What GSCPM do you use? Are there any others?		5 minutes	Team to identify using post it notes and flip chart paper a list of GSCPM that they currently use and any others? Cluster these into similar ones	SS	Everyone knows which GSCPM are being used and the most popular as signified by the number of duplicate post its or clustered themes	All	Flip chart, flip chart paper, pens and post its
Consensus on which do you believe are important? (impact versus ease of measurement)		5 minutes	On a pre - prepared matrix on flip chart paper, rank these measures in terms of importance (ease of measurement and impact)	SS	Everyone knows which measures are the most useful (high impact) and those which are easy to measure. Does this reflect what organisations are measuring now? Is there a relationship	All	Flip chart, flip chart paper, pens and post its
What are the enablers and barriers to measuring GSCPM?		5 minutes	Team to identify 3 enablers and 3 barriers and place on the flip chart paper to discuss	SS	Identify the RCA behind GSCPM	All	Flip chart, flip chart paper, pens and post its
What reporting tools do you use for SCM? Which reporting tools could be used for GSCPM reporting?		5 minutes	Team to identify using post it notes and flip chart paper what supply chain reporting tools they use? E.g. Own company reporting, SCOR etc..Discussion on can the above reporting tools be used to measure GSCPM. Can they be integrated?	SS	Everyone knows which reporting tools are being used and the most popular as signified by the number of duplicate post its or clustered themes	All	Flip chart, flip chart paper, pens and post its
Close & the 'So What'? Share my research findings, compare and contrast		5 minutes	Table any concerns, reflections, question marks, gaps about GSCPM and reporting. Compare and contrast with my research findings, compare and contrast? Output of discussion to be shared	SS	Everyone has a chance to 'have their say' and table any concerns, gaps from the discussion.	All	Flip chart, flip chart paper, pens and post its

Moving Towards Sustainable Logistics

Feedback Overview

University College London
London, October 8th 2012

Dear customers and colleagues,

Thank you for attending Damco's 'Moving towards Sustainability' workshop. We hope that you found the event informative and worthwhile. Our primary goal was to increase your understanding of sustainability and its impact on logistics and supply chain management.

There were many topics covered during the workshop and the presenters, I think you will agree, did an outstanding job of sharing their expertise with you. If you would like to contact any presenter with questions, please see the attachment with the presentations and contact details.

You were a great group and your enthusiasm and positive spirit helped make our time together both productive and encouraging. Thank you for your comments and suggestions on the evaluations and I assure you that each will be given consideration so that future workshops will be even more of a success.

I hope you will join us in upcoming events in which Damco will cover other important topics affecting international supply chain management and development.

Yours faithfully,

Alan Kenning, Head of Key Account Management and Supply Chain Development

Agenda

Overview of Green Logistics – Sarah Flagg

Recent sustainability trends in logistics – Natalia Olynec

Low Carbon Shipping Project – Tristan Smith and John Mangan

Developing Green Supply Chain Measurements. Balanced Scorecards Sarah Shaw

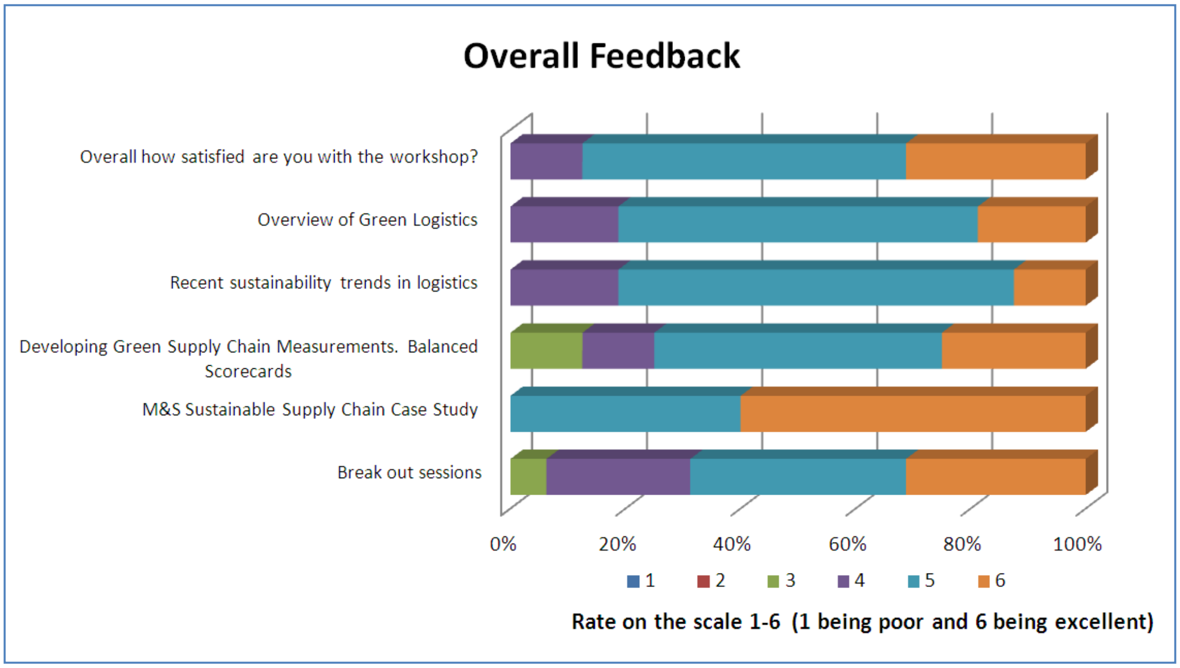
M&S Sustainable Supply Chain Case Study – Erin La Porte and Hugo Cabos

Break-out sessions:

- Sustainability as part of a balanced scorecard
- Logistics and Corporate Responsibility
- Low carbon shipping

Feedback survey result – what you said

The event was attended by 27 people – academia, logistics and corporate social responsibility practitioners – belonging to 4 different universities and 10 companies, which provided a mix of industries representing reefer, retail and industrial activities.



The results above show that 60% of respondents strongly agreed that they're objectives for the day had been met with an excellent session, with a further 30% very good session and 10% agreeing with a good session. Some delegates explained:

“Good interactive session, high level of knowledge and experience of session hosts. Good involvement with real applications at other customers. Well structured and balanced programme - theory and practical, as well as of academic and business people participation.”

“Very useful session for understanding the challenges faced when introducing green initiatives.”

In terms of relevance to the attendees and companies represented the session, participants found low carbon shipping information very interesting as well as the lack of a single measure of carbon impact on how companies measure or do not measure.

In terms of new workshop initiatives, participants showed genuine interest in attending future sessions around supply chain optimisation, freight network and trends, shipping information regarding reliability vs. costs and compliance with sourcing - factories and what they do, and issues within specific countries.

Breakout Sessions – Key Findings

GSCPM Session

What was the session about?

The session was about developing and selecting green performance measures for supply chains (GSCPM). There is a great deal of confusion over what to measure, how to measure and the benefits of measuring. The purpose of the session was to answer a series of questions which related to GSCPM and reporting.

How did it develop?

The session was facilitated by Sarah Shaw (Green Logistics PhD student from the University of Hull). Attendees were split into three groups and each group spent 30 minutes brainstorming the GSCPM questions. The key themes that emerged from these sessions are detailed below.

Summary of findings/Themes:

- Keep the measures simple
- Standardising is the way forward to enable benchmarking
- What does good look like?
- Be transparent in the reporting and measurement

1. What green supply chain performance measures are currently being used? Those in bold are the most useful.

Container/pallet movements	**Utilisation**
Supplier compliance measures	**Waste reduction and recycling**
Rail movements	Employee travel
Air freight reduction	Training
Carbon	Buildings efficiency
Utilities	Behaviour
Fuel efficiency costs	**Packaging**

2. Can green supply chain performance measures be integrated within existing supply chain performance frameworks?

   Yes and potential frameworks are:

   - Balanced Scorecard
   - DAMCO carbon dashboard
   - Other internal reports (green P&L, ERP system etc)

3. What are the enablers and barriers to measuring green supply chain performance?
   - The key drivers are cost, efficiency and reputation
   - The key barriers are cost, lack of knowledge and knowing where to start

Sustainability in your supply chain

What was the session about?

The session was about developing and understanding of the impact of sustainability in the supply chain on a broader manner. Integrate sustainability into strategic initiatives, is vital as this issues play out over long term, and will help in capturing value through three key areas – growth, risk management and returns on capital – can

How did it develop?

The session was facilitated by Natalia Olynec (Global Head of Sustainability at Damco). Attendees were split into three groups and each group spent 20 minutes discussion about sustainability issues and actions taken in their organisation, allocating them in a heat-map to identify impact of the initiative vs. its complexity, and evaluating their impact on the McKinsey value capturing model. The next 15 minutes of the session were dedicated to discuss finding with other groups.

Summary of findings/Themes:

- Common issues are: economic recession, climate change, fair trade, human right and child labour and transparency across supply chain.
- Initiatives taken are commonly described as With high significance to stakeholders and with high impact on business success.
- Common initiatives taken are more supply chain control on manufacturing side, audits, responsible procurement policies, water and waste management, responsible procurement and quality assurance.
- Initiatives often impact three key areas: growth, risk management and returns of capital, varying according to the industry and activity of the company. Across all groups, most significant areas influenced by the majority of the initiatives taken by companies are:
  - Returns on capital through Sustainable value chain
  - Risk management through Operational-risk management

Low Carbon Shipping Session

What was the session about?

The session was about discussing the carbon emissions impact in costs, lead time and e2e supply chains. Questions touch reliability and transparency of information (speed/reliability/price), and if cost of carbon should be absorbed or passed on the supply chain, deep sea vs short sea and reliability of shorter services, direct services vs transshipments and the perceived impact or of London Gateway project.

How did it develop?

The session was facilitated by John Mangan (Professor at Newcastle University) and Tristan Smith (Lecturer at University College of London), where attendees participated in a round table answering question and holding conversation around the topics above mentioned.

Summary of findings/Themes:

- Buyers, they need to be educated around the impact on logistics costs of their sourcing decisions
- Lack of transparency on pricing and the CO_2 impact
- Industries value costs and speed differently
- High scepticism about London Gateway
- Significant energy efficiency gain that's probably been achieved from rising fuel prices – passing cost onto customers is just not an option
- Failure in the container shipping industry around speed which is obstructing access to significant sustainability opportunities (carbon savings) in supply chains

This document is a summary of the findings, if you are more interested in knowing further details and findings of the sessions, do not hesitate to contact DAMCO for further information.

Contact details:

Hugo Cabos Larroya

Supply Chain Analyst
London, UK
Phone: +44 (0)208 559 5229
Mobile: +44 (0)7833 049630
Fax: +44 (0)208 559 5433
Email: hugo.cabos@damco.com
Web: www.damco.com

Richard L Hill

Supply Chain Development Manager
London, UK
Phone: +44 (0)208 559 5241
Mobile: +44 (0)7990 626827
Fax: +44 (0)208 559 5433
Email: Richard.L.Hill@damco.com
Web: www.damco.com

Developing environmental supply chain performance measures

Sarah Shaw and David B. Grant
Logistics Institute, University of Hull, Hull, UK, and
John Mangan
School of Marine Science and Technology, Newcastle University, Newcastle, UK

Abstract

Purpose – The purpose of this paper is to review extant literature and present a proposed research agenda to examine whether environmental, i.e. green performance measures, can be integrated within an existing supply chain performance framework, explore what a meaningful industry-recognised environmental measure should look like, and understand the direct benefits of incorporating environmental measures within a supply chain performance framework.

Design/methodology/approach – The paper is based on an extensive literature review in four key areas: performance management, supply chain performance management, environmental management and benchmarking.

Findings – The literature suggests there is an opportunity to explore the relationship between the environment and logistics and that environmental supply chain performance measurement (SCPM) should enable organisations to more effectively benchmark their supply chain environmental performance. A framework incorporating these notions and a research agenda for empirical study are also presented.

Practical implications – The paper provides direction for practitioners on measuring the environmental impact of their supply chains in the context of their overall business performance. The proposed research agenda integrates an environmental measure into an extant supply chain performance framework to provide practitioners with a more holistic view of their supply chain performance in relation to competitors.

Originality/value – There has been limited research conducted in this area. This paper provides insights into developing a green SCPM framework.

Keywords Supply chain management, Performance measures, Environmental management, Balanced scorecard, Benchmarking

Paper type Literature review

1. Introduction

Performance measurement systems are important in supply chain management (SCM). Over the last few decades there has been a transition from traditional, stand-alone performance measures to more sophisticated and balanced ways of measuring supply chain performance. This transition has been driven by increased complexity and supply chain globalisation and an attempt by supply chain managers and others to increase visibility over areas that are not directly within their control.

Supply chain performance measures have conventionally been orientated around cost, time and accuracy. However, organisations are now coming under increased scrutiny from customers and governments regarding their compliance with environmental and social responsibility. Notwithstanding these pressures there has only been limited research into incorporating an environmental measure or metric into the existing bank of supply chain performance measures. Thus, there is a danger that environmental and traditional supply chain measures will disappear along divergent paths.

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pp. 320-339

1463-5771
DOI 10.1108/14635771011049326

The purpose of this paper is to review the extant literature and set out a proposed research agenda to:

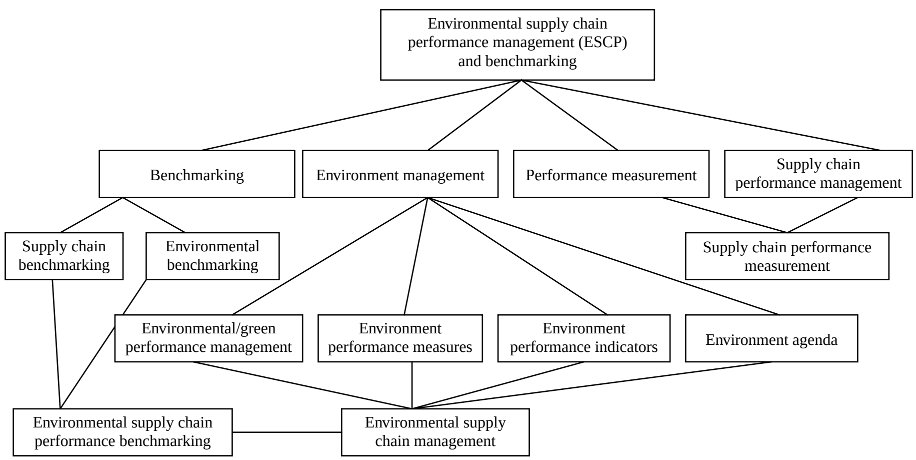
- investigate whether an environmental measure can be integrated within an existing supply chain performance (ESCP) framework;
- explore what an industry recognised environmental measure should look like; and
- understand the direct benefits of incorporating this measure within such a framework.

2. Methodology

This paper focuses on four key areas of literature: performance management, supply chain performance management, the environment and benchmarking. The objective was to review the literature within each area, identify any gaps among them, and evaluate whether there is an opportunity to integrate the four elements into a single framework. Although there is significant literature on environmental management within a general business context, there is limited research on integrating environmental or green supply chain performance measures within an ESCP framework.

The literature review was conducted in two phases. First, the contents of the five leading logistics journals (Menachof *et al.*, 2009): *International Journal of Logistics Management*, *International Journal of Physical Distribution & Logistics Management*, *International Journal of Logistics: Research and Applications*, *Supply Chain Management Review* and *Journal of Business Logistics* were examined for articles relating to the following five key word searches: performance management, supply chain performance management, green supply chain performance, environmental SCM and environmental management.

The key words were selected by constructing a relevance tree as shown in Figure 1 (Saunders *et al.*, 2007). The central theme was to "develop environmental supply chain performance measures", which was the key objective and main research question at the top level. The next step was to identify other key subject areas to begin the literature key word search; benchmarking, environmental management, performance management and supply chain performance measurement (SCPM).



Source: Adapted from Saunders *et al.* (2007, p. 75)

Figure 1. Relevance tree for the literature review and key word search

These four key subject areas were then further subdivided into sub-areas of relevance. The relevance tree provided a useful method of structuring the literature review search and ensured that all relevant parts of the literature were fully explored.

Second, a key word search of environmental performance management, environmental performance measures and environmental performance indicators was conducted on the ISI Web of Science database to specifically identify a list of key authors, journals and research work outside the field of logistics relating to environmental performance management.

The literature review method and proposal was presented to a leading panel of academic experts at the UK's Logistics Research Network Conference in 2008. The purpose of the presentation was to establish this as a credible area of research, to gain constructive feedback and to agree the research agenda. The conference provided valuable feedback in terms of the research scope and agenda and confirmed that this research area is relevant, topical and requires further investigation. Furthermore, the panel suggested the scope of the research requires clarity and focus because it is such a vast research area. Each key area is discussed in detail in the following sections.

3. Performance measurement

Traditionally, performance measures have been orientated around financial metrics such as return on capital employed or profit that record how an organisation has performed in the past but not necessarily how it will perform in the future. Traditional financial performance measures worked well previously, but are now out of step with the skills and competencies organisations are trying to master today (Kaplan and Norton, 1992).

There are a number of theories regarding how the concept of performance measurement was first developed. Morgan (2004) suggested that modern performance measurement originated in Venice during the fifteenth century with the invention of double book-keeping in accounting. In contrast, Johnson and Kaplan (1987) believed it originated during the industrial revolution. In any event, performance management emerged as a dominant field of research as early as the 1950s when academics and practitioners became interested in the need to measure and the unanticipated consequences of such measurement (Argyris, 1952; Ridgway, 1956).

Throughout the 1980s and early 1990s authors suggested various performance frameworks to manage firm performance; the performance measurement matrix (Keegan *et al.*, 1989), the performance pyramid (Lynch and Cross, 1991), the results-determinants framework (Fitzgerald *et al.*, 1991), the balanced scorecard (Kaplan and Norton, 1992), the Cambridge Performance Measurement Process (Neely *et al.*, 1995) and later the performance prism (Neely *et al.*, 2001, 2002). This led to the development of a dominant research question in the mid-1990s, particularly for the operations management discipline, of how these performance measurement systems are to be developed and deployed (Neely, 2005).

Performance measures are essential for managing and navigating organisations through turbulent and competitive global markets. They allow organisations to track progress against their strategy, identify areas of improvement and act as a good benchmark against competitors or industry leaders. The information provided by performance measures allows managers to make the right decisions at the right times (Gunasekaran *et al.*, 2004).

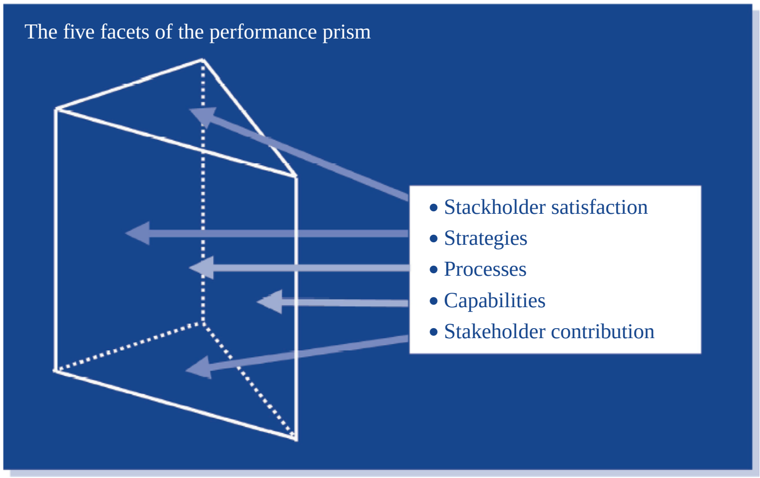
However, one of the most prevalent issues associated with performance measurement is having too many metrics. Some organisations are using hundreds of metrics which are often not aligned to the organisation's strategy (Hoffman, 2006). This leads to confusion, often results in "paralysis by analysis" and presents difficulties in conducting benchmarking exercises. Thus, there is a requirement for a meaningful and parsimonious set of measures and framework in an ESCP context. The balanced scorecard and performance prism frameworks appear promising to consider in the first instance and are further discussed next.

In an attempt to reduce confusion and increase clarity in the performance management process, Kaplan and Norton (1992) devised the balanced scorecard to provide managers with a fast but comprehensive view of their business through four key perspectives: financial, customer, internal business and innovation and learning. The balanced scorecard helps managers focus on a handful of critical measures that are aligned with the business strategy. These measures include both financial and non-financial information and Kaplan and Norton (1992, p. 71) describe it as like the "dials in an airplane cockpit". The balanced scorecard has now become widely accepted by many organisations. A Bain and Company survey of more than 708 companies on five continents found that the balanced scorecard was used by 62 per cent of responding organisations (Hendricks *et al.*, 2009).

The performance prism, shown in Figure 2 was developed more recently (Neely *et al.*, 2001) and addresses the needs and wants of all stakeholders, rather than a subset. The performance prism is defined as a second-generation performance measurement framework design, and could be used to enable organisations to select appropriate performance measurements. It serves to address shortcomings of other traditional performance frameworks, such as the balanced scorecard and consists of five facets: stakeholder satisfaction, strategies, processes, capabilities and stakeholder contribution. Its priority is to identify the stakeholders and assess their requirements before deciding on a strategy and a set of performance measures.

4. Supply chain performance measurement

SCPM has emerged as one of the major business areas where companies can obtain a competitive advantage (Lee, 2002). It is a key strategic factor for increasing organisational



Source: Neely *et al*. (2001, p. 12)

Figure 2.
The performance prism

effectiveness and for better realisation of organisational goals such as enhanced competitiveness, better customer care and profitability (Gunasekaran, 2001). A key feature in the business environment is that supply chains, not companies, compete with one another (Christopher, 2005).

Traditionally, logistics and supply chain performance measures have been quantitative and orientated around measuring cost, time and accuracy. For example, Gunasekaran *et al.* (2004) make reference to order lead-times, delivery performance, customer query time and total cash flow time within their framework of strategic, tactical and operational performance levels. However, Beamon (1999) believes such an approach makes supply chain measures inadequate as they rely too heavily on cost as a primary measure.

In a literature review of SCM performance measures and metrics between 1995 and 2004 Gunasekaran and Kobu (2007) identified almost 90 supply chain metrics, many of which overlap. The most widely used metrics identified were financial (38 per cent), but 60 per cent of all measures were functionally based. The proliferation of supply chain measures is a symptom of how supply chains have been managed. Supply chains are complex structures and as a consequence practitioners have created lots of metrics to manage them, often duplicating the same metrics within and across supply chain nodes or sites.

Lee and Billington (1992) observed that discrete sites in a supply chain do not maximise efficiency if each site pursues its own goals independently, the latter being usual practice. Further, Bhagwat and Sharma (2007) proposed the balanced scorecard as an appropriate framework from which to create a more balanced set of supply chain measures and to make a clear distinction between operational, tactical and strategic measures (Gunasekaran *et al.* (2004).

The key challenge for organisations is selecting the most appropriate and effective supply chain performance measures. As a guide Caplice and Sheffi (1995) recommended that managers should continually review and evaluate their supply chain performance metrics in order to make sense of the growing number of supply chain metrics and to ensure the metrics reflect the ever-evolving supply chain and business environment. They were not trying to propose new metrics but recognised that metrics needed to evolve with the changing external business environment. They also provided eight criteria on which to judge the quality of metrics: validity, robustness, usefulness, integration, compatibility, economy, level of detail and behavioural soundness. With organisations facing increased pressure from the government, customers and competition on their environmental and social performance, now is an appropriate time for this review process to take place and for organisations to begin quantifying their impact on the environment.

5. Environmental performance management

Environmental management research in a general business context is significantly well advanced. An ISI Web of Science database search of the keyword environmental management returned 22,012 articles for the period 1970-2009. Table I lists the top ten journal titles from this database search.

Additionally, a keyword search of environmental performance management and supply chain environmental performance between 1970-2009 returned 2,141 (10 per cent) and 112 (0.5 per cent) articles, respectively, which illustrates that environmental performance management in a supply chain context is very much in its infancy and a relatively new area of theory development. The *Journal of Cleaner Production* is the most frequently cited periodical source for supply chain environmental performance as shown in Table II.

In the 1970-1980s the environmental agenda was "non-existent" and seen by most organisations as a "fringe issue" (Beamon, 1999; Walton *et al.*, 1998). However, the business environment has changed and organisations are now coming under increasing pressure to provide evidence of their commitment to corporate social responsibility, particularly the environment.

For example, the 1997 Kyoto Agreement legally bound industrialised nations to reduce emissions of green house gases, particularly carbon dioxide by an average of 5.2 per cent below 1990 levels by 2012, with the UK committed to a reduction of 12.5 per cent by then. Additionally, the UK Department for Environment, Food and Rural Affairs (Defra) has set its own domestic target of reducing carbon emissions by 60 per cent by 2050 (Defra, 2007). The main objective of the Kyoto Agreement is to achieve a stabilisation and reduction of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the earth's climate system (Defra, 2009).

One of the key and fundamental aims of environmental management across all countries and industries is to reduce the emission of all these gases, particularly carbon dioxide. This is why organisations have become focused on measuring their carbon emissions or their "carbon footprint". Examples include IBM (2008) using the House of Carbon to communicate their green initiative across all areas of their business; WalMart using the Carbon Disclosure Project to manage the energy footprint of their

Journal title	Count	%
Environmental Management	500	2.27
Journal of Environmental Management	445	2.02
Journal of Cleaner Production	215	0.97
Agriculture Ecosystems & Environment	209	0.94
Forest Ecology and Management	203	0.92
Ecological Economics	200	0.90
Ecological Modelling	162	0.73
Ecological Applications	159	0.72
Resources Conservation and Recycling	154	0.69
Journal of Applied Ecology	152	0.69

Note: $\Sigma = 22{,}012$

Table I. The top ten journal titles from a word search of "environmental management" on ISI Web of Science database

Journal title	Count	%
Journal of Cleaner Production	14	12.50
International Journal of Production Research	11	9.82
International Journal of Production Economics	8	7.14
Journal of Operations Management	8	7.14
International Journal of Operations & Production Management	5	4.46
European Journal of Operational Research	4	3.57
Production and Operations Management	4	3.57
International Journal of Environmental Science and Technology	3	2.67
International Journal of Life Cycle Assessment	3	2.67
Journal of Environmental Management	3	2.67

Note: $\Sigma = 2{,}141$

Table II. The top ten journal titles from a word search of "environmental supply chain performance" on ISI Web of Science database suppliers (Carbon Commentary, 2008); and Tesco working with the Carbon Trust (2008) to put carbon labels on 70,000 products. Carbon emissions have become an industry-recognised measurement in the environmental management process and in the fight against climate change.

However, while greenhouse gas emissions are not the only area of focus in environmental management they have gained the most attention because of the observed impact they are having on the climate system. Defra (2006) has identified 22 environmental performance indicators in four key categories that are also considered to be significant to UK businesses:

(1) emission to air;

(2) emissions to water;

(3) emission to land; and

(4) resource use.

To help manage these four categories, some organisations have now adopted environmental management systems such as the International Organization for Standardization's (ISO) (2009) ISO 14001:2004 "Requirements with guidance for use" or the European Union's eco-management and audit scheme (EMAS, 2009) to provide guidance on mitigating their impact on the environment. ISO also developed ISO 14031:1999, an environmental performance evaluation tool, which is not a standard for certification but provides organisations with specific guidance on the design and use of environmental performance evaluation and on the identification and selection of environmental performance indicators. This allows any organisation regardless of size, complexity, location and type to measure their environmental performance on an on-going basis (ISO, 2009). ISO 14031 defines environmental performance indicators as "a specific expression that provides information about an organisation's environmental performance" and divides environmental performance indicators into three classifications:

(1) *Management performance indicators (MPI).* An indicator of an organisation's effort in influencing its environmental performance; for example environmental costs or budget (dollars per year), percentage of environmental targets achieved and time spent responding to environmental incidents (person-hours per year).

(2) *Operational performance indicators (OPI).* An indicator of an organisation's operational environmental performance; for example raw materials used per unit of product (kilograms per unit), hours of preventive maintenance (hours per year) and average fuel consumption of vehicle fleet (litres per 100 kilometres).

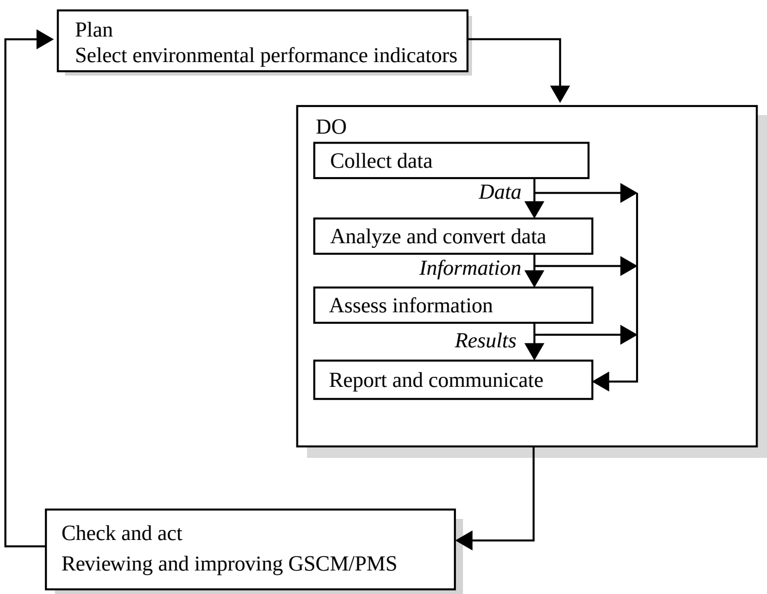
(3) *Environmental condition indicators (ECI).* An indicator of local, regional, national or global conditions of the environment and which are useful for measuring the impact of an organisation on the local environment; for example frequency of photochemical smog events (number per year), contaminant concentration in ground or surface water (milligrams per litre) and area of contaminated land rehabilitated (hectares per year).

This three-way taxonomy reflects the "pressure-state-response model" developed by the Organisation for Economic Cooperation and Development to assess the environmental performance of countries (Ditz and Ranganathan, 1997).

ISO 14031 is based on the plan-do-check-act (PDCA) continuous improvement model as shown in Figure 3 and focuses directly on environmental protection, cleaner production, sustainable development and communication of related achievements without burdening organisations with the demand for written reports and stringent system documentation (Jasch, 2000). The PDCA model forms the foundation of any green supply chain performance management system (Hervani *et al.*, 2005). The indicators used in the ISO 14031 process are variable within/across organisations and not for public disclosure. Until the end of December 2005 there were 111,162 ISO 14001:2004 certifications issued to 138 countries and economies (ISO, 2005).

In contrast, the global reporting initiative (GRI) which was established in 1997 by the Coalition for Environmentally Responsible Economies to provide a flexible framework to enable organisations to report on their economic, environmental and social performance (also known as the "triple bottom line" or "sustainability"). GRI is a voluntary initiative and provides a reliable and transparent way of exchanging and comparing corporate sustainability performance data. The GRI's vision is that sustainability reporting by organisations becomes as routine and comparable as financial reporting. Recently, over 1,500 companies from 60 countries have declared their voluntary adoption of the guidelines worldwide and the GRI has become the *de facto* global standard for sustainability reporting (GRI, 2009). The 2002 GRI guidelines identify two categories of performance indicators:

(1) Core indicators that are:
- relevant to most organisations; and
- of interest to most stakeholders.



Source: Adapted from Hervani *et al*. (2005, p. 343)

Figure 3.
The PDCA cycle for implementing an environmental management system

(2) Additional indicators that have one of the following characteristics:
   - they represent a leading practice in economic, environmental or social measurement, though currently used by few reporting organisations;
   - they provide information of interest to stakeholders who are particularly important to the reporting entity; and
   - they are deemed worthy of further testing for possible consideration as future core indicators.

GRI encourages the active disclosure of sustainability performance data and has the ability, like ISO 14031 to generate multiple environmental performance indicators. However, GRI is very stringent over the calculation and reporting of these indicators which helps to standardise the outputs for benchmarking. In October 2006, GRI launched their "third generation" (G3) reporting guidelines. These guidelines make GRI applicable to small companies, large multinational, public sector, non-governmental organisations and other types of organisations around the world. Table III presents a sample of GRI core and additional environmental performance indicators specifically associated with the logistics and supply chain sector.

Managing and reporting on environmental indicators can lead to significant cost savings and productivity gains. For example, the Environment Agency estimates British manufacturing would save £2-3 billion each year, equivalent to 7 per cent of profits by adopting best practice waste minimisation techniques, often with little or no investment (Defra, 2006). About three-quarters of the British population say more information on a company's social and ethical behaviour would influence their purchasing decisions (MORI, 2003). There is also a strong link between environmental management and perceived financial performance (Klassen and McLaughlin, 1996).

However, there is distinct lack of practice and theory in green logistics, specifically developing an ESCP measurement that can be used to assess the impact of supply chains on the environment. Organisations need more guidance on supply chain environmental performance management either through existing environmental management systems or government legislation. Initiatives such as the Green Logistics Project (Green Logistics, 2008) launched in 2006 and funded by the UK's Engineering and Physical Sciences Research Council are helping organisations to examine ways to reduce their impact on the environment and to make their logistics operations greener, particularly from a transport sector perspective.

The Carbon Trust (2008) has also been successful in raising the awareness of carbon dioxide emissions and energy use within the private and public sectors. It published an article which proposed a useful method of calculating the end-to-end supply chain carbon emissions (raw material production, distribution, manufacturing, product distribution, disposal and recycling). The Carbon Trust worked with Pepsico for two years and identified a saving of 18,000 tonnes of carbon per annum or equivalent to 8 per cent of the total emissions across their supply chain.

In summary, there is a need to develop a "common" ESCP measure that captures the impact of the entire supply chain relative to these foregoing issues. An ESCP measure should be incorporated into the organisation's overall business strategy so as to ensure that it does not disappear along a diverging path (McIntyre *et al.*, 1998). Incorporating this measure within an existing performance framework like the balanced scorecard will enable this integration and provide a standardised way to perform both internal

Category	Core indicator	Additional indicator
Materials	EN1. Total materials use other than water, by type	
Materials	EN2. Percentage of materials used that are wastes (processed or unprocessed) from sources external to the reporting organisation	
Energy	EN3. Direct energy use segmented by primary source	E17. Initiatives to use renewable energy sources and increase energy efficiency
Energy	EN4. Indirect energy use	
Water	EN5. Total water use	E20. Water sources and related ecosystems/habitats significantly affected by use of water
Biodiversity	EN6. Location and size of land owned, leased or managed in biodiversity-rich habitats	E23. Total amount of land owned, leased or managed for production activities or extractive use
Emissions, effluents and waste	EN8. Greenhouse gas emissions	E30. Other relevant indirect greenhouse gas emissions
Emissions, effluents and waste	EN9. Use and emissions of ozonedepleting substances	
Emissions, effluents and waste	EN10. Nitrogen oxides, sulplur oxides and other significant air emissions by type	E32. Water source and other ecosystem/habitats significantly affected by discharges of water and run off
Emissions, effluents and waste	EN11. Total amount of waste by type and destination	
Transport		E34. Significant environmental impacts of transportation used for logistical purposes
Suppliers		E33. Performance of suppliers relative to environmental components of programmes and procedures described in response to governance structure and management systems

Source: Adapted from GRI (2006)

Table III. Examples of GRI environmental performance indicators for the transport and logistics sector

and external benchmarking exercises. The challenge is to find an appropriate ESCP measure that organisations feel they can disclose and share in a benchmarking process. The measure must be comparable, robust, credible, valid and reliable and be applicable across all industries, sectors and countries.

6. Benchmarking environmental and supply chain performance

Corporate benchmarking is essential for continuous improvement. Organisations implement internal and external benchmarking activities to identify best practice and to gain competitive advantage. A number of benefits are derived from the benchmarking process: it enables best practices to be incorporated within the benchmark process or activity, it can provide stimulation and motivation to the professionals involved in the process, it provides a force for change within organisations and it may identify a technological breakthrough that would otherwise have gone undetected (Camp, 1989).

The key challenges of most benchmarking exercises are: what to measure, how to measure it, who should measure it, and the time and cost involved in the benchmarking process. Francis (2008) described the key challenges of benchmarking as scope selection, sponsorship, time and cost. Francis also suggests the biggest hurdle is coming up with standard ways to compare one company's operation with another in order to make like for like comparisons.

The majority of benchmarking activities are concerned with financial and management activities, however environmental benchmarking is becoming a major element in the environmental management of organisations. This is because organisations are coming under increasing pressure from governments, customers and the competition to improve environmental performance (Sarkis, 2003).

A database search of ISI Web of Science of environmental benchmarking between 1970 and 2009 revealed 118 articles, with 11 per cent found in the *Journal of Cleaner Production*. Furthermore, a word search of environmental supply chain benchmarking returned only five articles, the earliest dated back to 1997. This suggests that environmental supply chain benchmarking is also in its infancy and requires more academic research and investigation.

Previous research has focused mainly on internal environmental benchmarking (Boks and Stevels, 2003) or within a single industry (Rothenberg *et al.*, 2005). The quantity and availability of environmental data and the inconsistent use of key performance indicators makes the benchmarking process very difficult to execute (Hooper and Greenall, 2005). Even the commonly used ISO 14000 was not designed as a benchmarking tool and would need some modifications if it were to be used in the benchmarking process (Matthews, 2003).

Environmental benchmarking does depend on what stage an organisation is at in their environmental management lifecycle. Many organisations are still trying to establish how to measure their environmental performance and are therefore not in a position to conduct benchmarking activities. To provide practitioners with direction in the environmental supply chain benchmarking process, ESCP measures must be identified and a framework developed to enable organisations to quantify their environmental performance in relation to others.

7. Developing an ESCP framework

The primary goal of an ESCP framework should be to enable organisations to effectively monitor, evaluate and benchmark their entire ESCP. This framework should closely tie in with existing frameworks and environmental management systems. By using extant performance measures found in the literature the objective would be to build on existing research theory and practice and to develop a practical tool that can be used industry wide. The resultant framework would thus bring together the three key areas of research; SCPM, environmental performance measurement and benchmarking.

However, there are a number of questions that must be addressed by practitioners before a framework can be developed (Hervani *et al.*, 2005) and which are discussed further below:

Q1. What are the goals of the framework?

Q2. How does this framework fit within the strategy of the supply chain?

Q3. How should the framework be designed?

Q4. How should external stakeholders be integrated?

Q5. What are the most appropriate measures?

Q6. How should this be linked in with existing environmental management systems?

Selecting measures

The complex and vast nature of environmental management makes the process of selecting measures very difficult. Organisations attach varying degrees of importance to environmental performance indicators depending on their operation, industry, sector, country and region they are in. For example, Matthews (2003) describes how two processing plants of the same organisation, one in the east of the USA may determine that wastewater effluent is a top priority based on the existing regulatory pressure from local waterways, whereas in the west of the USA energy efficiency may be seen as more important given the demand for electricity in the area. This makes the process of benchmarking impossible.

Both Epstein and Weisner (2001) and Hervani *et al.* (2005) considered a balanced scorecard-type framework to implement and measure environmental and social performance within a case study organisation. This framework contains approximately 60 environmental performance indicators which are used in managing the organisation's existing policies, practices and enabling their workforce to achieve their targets. These indicators are however very specific to the organisation and may not be suitable for another organisation. There are also too many metrics to measure and compare, making environmental benchmarking difficult. Some of the metrics are shown in Table IV.

Table IV. Examples of balanced scorecard measures for sustainability

Financial	*Internal process*
Percentage of proactive vs reactive expenditures	Percentage of production and office materials recycled
Capital investments	Certified suppliers
Operating expenditures	Accidents and spills
Disposal costs	Internal audit scores
Recycling revenues	Energy consumption
Revenues from "green" products	Percentage of facilities certified
Fines and penalties	Percentage of product remanufactured
Cost avoidance from environmental actions	Energy use
	Greenhouse gas emissions
	Hazardous material output
Customer	*Learning and growth*
Green products	Percentage of employees trained
Product safety	Community complaints
Recalls	Percentage of renewable resource use
Customer returns	Violations reported by employees
Unfavourable press coverage	Employees with incentives related to environmental goals
Percentage of products reclaimed after use	Functions with environmental responsibilities
Functional product eco-efficiency	Emergency response programs

Source: Hervani *et al.* (2005, p. 346)

There is also the added complexity over what evolutionary stage an organisation is at in the environmental management process. Some organisations are reactive and focus on complying with existing legislation, others are proactive, demonstrating how they have greened their entire suppliers, products and processes (Hervani *et al.*, 2005).

There is a requirement to select a high-level, strategic or common measures which can be implemented by all organisations and that fits in with existing environmental management systems, but the main issue is how can such a vast management area be compressed into one measure? Brown (1996) suggests that various environmental performance indicators could be aggregated together to form an aggregated indicator. This simplifies the complex nature of such indicators however it may also reduce the visibility that organisations have over particular parts of their business.

Key stakeholders and carbon emissions

Before selecting a measure it is important to identify the key stakeholders in the environmental performance process. Neely *et al.*'s (2001) performance prism is a useful framework in identifying the key stakeholders. The performance prism consists of five interrelated facets. The first facet asks who the stakeholders are and what do they want and need. This is a fundamental issue when selecting a new performance measure or designing a new framework. This facet has a broader scope than the balanced scorecard view of stakeholders, which encompasses only shareholders and customers.

The UK Government is a major stakeholder in the environmental management process through which existing and future legislation will affect organisations. The UK Government has legally committed to reducing greenhouse gas emissions and has a duty to ensure the UK carbon account for the year 2050 is at least 80 per cent lower than the 1990 baseline (Climate Change Act, 2008). This is important in the context of environmental management because climate change is one of the biggest environmental management challenges facing the world today and the evidence suggests (Intergovernmental Panel on Climate Change (IPCC), 2007) that all countries must act now in unison to reduce greenhouse gas emissions to prevent catastrophic changes to the world's climate.

Given carbon dioxide's long-term impact on the environment, carbon emissions are one of the key strategic environmental measures for supply chains but not necessarily the only strategic measure that could be used for supply chain environmental benchmarking. Carbon emissions are measured in "million tonnes of carbon per annum" (Defra, 2007). At an organisational level they are measured in "kilograms" or "tonnes" of carbon dioxide per annum depending on the size or the scale of the activity being measured (Carbon Trust, 2008). Carbon dioxide emissions are therefore a useful measure as they can be calculated across all sites of the supply chain and across organisations (Carbon Trust, 2008; Braithwaite and Knivett, 2008).

In terms of ISO 14031's classification of environmental key performance indicators, carbon dioxide emissions are defined as an OPI, which is measuring a specific emission from an operation or organisation. However, it is almost impossible to measure the specific ECI associated with carbon emissions as the impact of anthropogenic carbon is not just local but global (IPCC, 2007). Carbon dioxide emissions could therefore be comparable across entire supply chains and be a useful "common" measure in conducting an environmental supply chain performance benchmarking activity. A limitation of this measure is that it does not take into account the size of the organisation and their growth factors, nor does it include the other three categories of emissions: water, land and resource use (Defra, 2006), which are important in the context of environmental SCM. But, by measuring and managing carbon emissions organisations may indirectly improve their energy and resource use.

However, there is a need for a more generic set of ESCP measures which closely tie in with existing environmental management systems. Carbon emissions only represent one measure within environmental performance management and the "environment" represents one dimension within sustainability reporting. So could these measures be made more generic? The GRI reports on all three dimensions of sustainable performance: environmental, economic and social and have also developed a logistics and transport sector supplement which enables organisations to report on their supply chain environmental, economic and social performance. This could represent a useful starting point in the development of a standard set of ESCP measures for benchmarking and would expand the scope of the measurement from purely environmental to sustainable. Furthermore, ISO 14031 also provides a useful way of dividing environmental performance indicators into the three categories of MPI, OPI and ECI. These categories could be used to develop specific ESCP measures within an "environmental" dimension.

Selecting a framework

As discussed in Section 3, several performance frameworks have been created and adapted to address the problem of performance measurement selection over the past few decades. However, many of them are insufficient for developing ESCP measures as they tend to be very prescriptive in their application to a particular industry or area of performance measurement. For example, Keegan *et al.*'s (1989) performance measurement matrix is very similar to the balanced scorecard in that it incorporates financial, non-financial, internal and external classes of business performance. But, it is not as well packaged as the balanced scorecard and does not make explicit the links between the different dimensions of business performance, which is one of the balanced scorecard's greatest strengths (Neely *et al.*, 2001).

Others include:

- Fitzgerald *et al.*'s (1991) results determinants framework in a study of the service industry identified two types of performance measures: results (competitiveness and financial performance) and determinants of the results (quality, flexibility, resource utilisation and innovation). The determinants are the leading measures and the results are the lagging measures.
- Azzone *et al.*'s (1991) framework which identifies the most appropriate measures for organisations that have chosen to pursue a time-based competition strategy.
- Lynch and Cross's (1991) performance pyramid which ties together the hierarchical and horizontal business process view of performance measurement.
- Brown's (1996) framework focuses on input, process, output and outcome measures, representing a horizontal view of performance measurement.

The balanced scorecard addresses both financial and non-financial performance measures and several studies have already attempted to adapt the balanced scorecard approach to SCM; see Brewer and Speh (2001) and Bhagwat and Sharma (2007). In addition, extensions to the balanced scorecard to incorporate environmental performance measures have also been advanced (Epstein and Weisner, 2001; Zingales *et al.*, 2002; Hervani *et al.*, 2005). However, although pioneering and popular, the balanced scorecard is now over 15 years old. Criticisms of the balanced scorecard and its applications include the exclusion of people, competitive environments, environmental and social aspects of industry (Paranjape *et al.*, 2006; Barber, 2008).

In contrast, the performance prism shown was developed more recently (Neely *et al.*, 2001) and addresses the needs and wants of all stakeholders, rather than a subset. It serves to address shortcomings of other traditional performance frameworks such as the balanced scorecard and consists of five facets: stakeholder satisfaction, strategies, processes, capabilities and stakeholder contribution. Its priority is to identify the stakeholders and assess their requirements before deciding on a strategy and a set of performance measures. The performance prism provides a very useful framework for developing ESCP measures by identifying and understanding the needs of the key stakeholders. The five components provide a logical guide for designing a new set of measures or when upgrading an existing framework (Neely *et al.*, 2001).

So which is the most appropriate framework? The balanced scorecard is the most widely accepted generic performance measurement framework, however it was not designed to be a supply chain environmental measurement tool. The balanced scorecard provides a high level strategic view of corporate performance and could be adapted to report on ESCP. In contrast, the GRI and existing environmental management system frameworks were designed specifically to manage and report on corporate environmental performance so there is an opportunity to combine the strengths of all three frameworks to develop a tool for ESCP benchmarking.

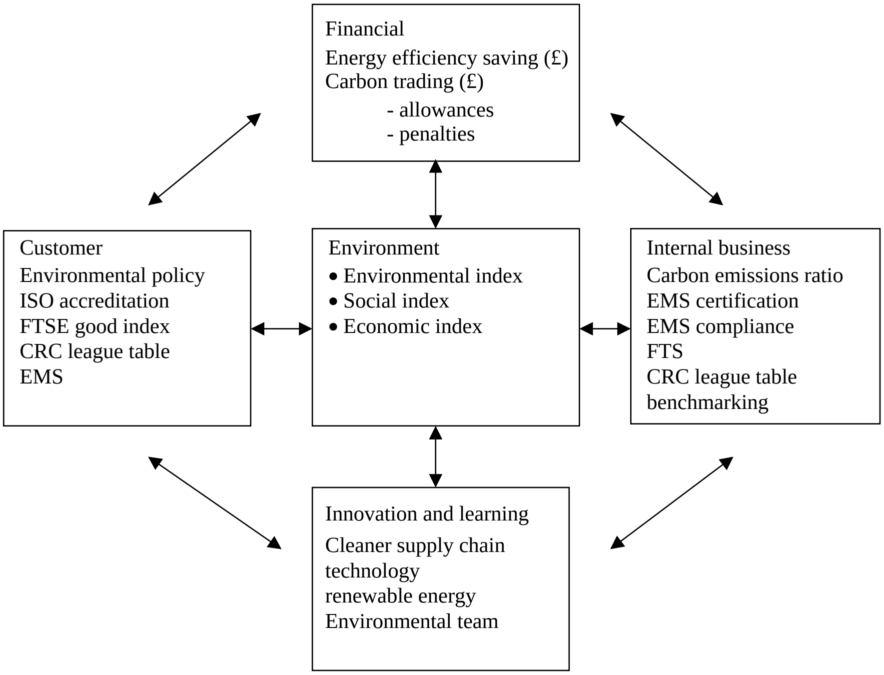
There are two potential ways in which corporate or ESCP could be expressed within the balanced scorecard:

(1) as a fifth "environmental" perspective; or

(2) as part of the four existing perspectives.

By incorporating an ESCP measure within the balanced scorecard framework as a fifth perspective or as part of the four existing perspectives, organisations are identifying that environmental management is one of their strategic focuses/goals as shown in Figure 4. It raises the profile and importance of environmental management and satisfies the stakeholders that it is being treated as a core value. Furthermore, it links in with Neely *et al.*'s (2001, p. 6) second facet "What are the strategies we require to ensure the wants and needs of our stakeholders are satisfied?" Johnson (1998) also posits that the scorecard could help the environmental department or function within the organisation to think about the value of their strategic activities. It would make the environmental agenda more visible and facilitate integration into the other organisational strategies. Epstein and Weisner (2001) argued that there is no rule for the right number of measures to include in a balanced scorecard, although including too many can distract from pursuing a focused strategy. A complete scorecard should contain approximately three to six measures in each perspective.

Kaplan and Norton (2001) also suggest that some environmental measures emerge as part of the scorecard's internal perspective. This provides an alternative view of how an environmental measure could be incorporated within a balanced scorecard framework. However, there is a risk that it will not be viewed strategically or as a perspective in its own right. Either way, by incorporating an environmental



Source: Adapted from Kaplan and Norton (1992, p. 72)

Figure 4. A fifth environmental perspective: the balanced scorecard

measure within an ESCP framework could help further develop and perhaps create a G3 of performance measurement frameworks.

Further research is required to clarify the exact measures within the fifth or internal perspective, however a supply chain balanced scorecard could report all three dimensions of sustainability: economic, environmental and social as shown in Figure 4. This would enable organisations to manage their ESCP and to report/disclose this in a benchmarking process.

There is also an opportunity to include some of the core GRI environmental performance indicators within the balanced scorecard as part of the fifth environmental dimension. This would help standardise the reporting for benchmarking, however consideration would need to be given to how this links in with the other perspectives of the balanced scorecard and how these measures could be used to provide a snapshot of an organisation's ESCP. Krajnc and Glavič (2005) present a model for designing a composite index for benchmarking sustainability. The index depicts the performance of companies across all three dimensions of sustainability reporting and could be used to provide a headline ESCP index for benchmarking.

8. Conclusions

SCPM is an important and well-established area of research in normal domain activities; however ESCP measurement is relatively under-researched in existing supply chain and environmental management literature. Yet it is a very topical subject. With a lack of direction and legislation on environmental management, it makes it very difficult for organisations to know exactly what they should measure and how to measure. More research is required in the field to provide direction for practitioners. This paper, therefore, recommends a framework and measure to enable organisations to effectively manage and benchmark (internally and externally) their environmental supply chain performance.

Previous research has identified multiple operational ESCP measures and has attempted to incorporate these within the balanced scorecard framework. However, because there are so many measures, it makes the process of benchmarking almost impossible. An aggregated, strategic ESCP index, incorporated within the balanced scorecard framework will provide organisations with a headline measure for benchmarking.

It is important to note that there is no ideal existing performance framework or ESCP measure; however what this paper attempts to do is to demonstrate that an ESCP measure can be incorporated within an existing framework and this could help facilitate the environmental supply chain benchmarking process. Neely *et al.*'s (2001) performance prism has provided a useful framework to identify an ESCP measure and to identify the key stakeholders in the environmental management process. Furthermore, Kaplan and Norton's (2001) balanced scorecard also represents a robust and well-established framework from which to incorporate this measure.

However, there are a number of limitations, which must be explored; the framework and ESCP measures have not been empirically tested. Furthermore, the environment only represents one dimension of sustainability reporting there are others that need investigating and incorporating. Finally, the method for calculating an ESCP index requires significant consideration to meet the requirements for benchmarking.

Finally, what should a future research agenda include? First, is the balanced scorecard the most appropriate framework? The ESCP index and balanced scorecard must be empirically tested. Further research is also needed to identify other strategic ESCP measures and the methodology for calculating these measures such as carbon dioxide emissions. Further, how can existing ISO 14031 and GRI environmental performance indicators be used in the framework? The challenge for the research community is to build on this framework to enable practitioners to not only measure their ESCP but also to benchmark this against other organisations. Integrating an ESCP within an ESCP framework will enable organisations to view the natural environment as a key part of their strategy.

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Corresponding author
Sarah Shaw can be contacted at: S.L.Shaw@2009.hull.ac.uk