

# **An investigation of green supply chain management in the construction industry in the UK**

**By**

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## **Abstract**

Environmental issues have been on the international agenda for several decades. More recently, the focus has expanded to broader topics such as sustainability and has forced industries to amplify their attention into their supply chain (customers and suppliers) (Hall, 2001).

The dissertation will address the theory and practices of Green Supply Chain Management (GSCM) in the construction industry in the UK focusing on large contractors and suppliers within the sector. Specifically on the power and drivers of big contractors to engage their supply chain, the practices they are requiring and the main barriers of their suppliers to implement them.

The methodology was originally based on sending questionnaires to contractors and suppliers in the construction industry in order to analyse the responses. However, there was a provision because of the potentially low response on the suppliers side (mainly SMEs) by arranging telephone interviews with two contractors.

The results showed that the respondents have the financial or market power to engage their supply chain. However, GSCM in the construction industry is still reaching a small percentage of the entire population. About the GSCM strategies that are being implemented, the findings illustrated that process-based practices are more common than product-based practices at this point. The results on the drivers confirmed that the two most important categories were sustainability and economic motivators. Nevertheless, legislation as a single driver was the most important for the majority of the companies. In terms of the barriers experienced, lack of resources was the most significant barrier for suppliers, followed by lack of skills or knowledge, internal barriers and finally the lack of government legal enforcement. The economic performance of GSCM in the construction industry is not yet detectable. However, negative economic impacts were perceived as more probable than positive economic impacts at this point.

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## Abbreviations

CIB	Construction Industry Board
CSR	Corporate Social Responsibility
EA	Environmental Assessment
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management Systems
EU	European Union
GSCM	Green Supply Chain Management
JIT	Just in Time
LCA	Life Cycle Assessment
NGO	Non Governmental Organisation
SCM	Supply Chain Management
SME	Small and Medium Enterprise

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# Introduction

Environmental issues have been on the international agenda for several decades, and both public and private sectors are concerned about the role they play in these matters. More recently, the focus has expanded to broader topics such as sustainability and has forced industries to amplify their attention into their supply chain (customers and suppliers) (Hall, 2001). Eventually, those suppliers must inevitably interact with lower tier suppliers if the whole supply chain wants to be integrated (Emiliani, 2000; Envirowise, 2001).

Green Supply Chain Management (GSCM) practices can contribute to an organization's environmental/sustainable policy by ensuring that the main suppliers and their products achieve better environmental performance as well as promoting sustainability awareness throughout the market and other supply chains (Brady, 2005). An effective supply chain management and purchasing process are crucial to the improvement of a company's environmental performance (Envirowise, 2001).

Therefore, the dissertation will address the theory and practices of GSCM in the construction industry in the UK focusing on large contractors and suppliers within the sector, and specifically on the drivers of big contractors to engage their supply chain, their financial or market power do it, the practices they are requiring and the main barriers of their suppliers to implement them.

## ***Role of Construction in the UK***

The construction industry is one of the most important in terms of turnover and human resources required, in the UK it contributes approximately 10% of gross domestic product and employs 1.4 million people for a total volume of work in 2000 of approximately £65 billion (Environment Agency, 2003).

## ***Environmental Impacts of construction***

Human development is based on construction of buildings and infrastructure. Unfortunately, construction is also responsible of significant impacts on the environment (Shen and Tam, 2002). Therefore, construction has been described as a major exploiter of natural resources, both physical and biological (Spence and Mulligan, 1995). It is also identified as a major



contributor to environmental pollution from both on-site and off-site activities. On-site activities relate with the construction of a physical facility, resulting in air pollution (including 50% of greenhouse emissions (Patermann, 1999)), water pollution, traffic, noise, dust, waste (responsible for generating 19% of total waste and 21% of the hazardous waste in the UK) and the conversion of 6,500 hectares of land per year from rural to urban (Environment Agency, 2003). While off-site activities relate to the mining, quarrying, manufacturing and transportation of different materials, representing 10% of national energy consumption in production and transportation of materials (Patermann, 1999).

In addition, the construction industry is a major user of non-renewable energy sources, minerals and metals (Spence and Mulligan, 1995), using over 420 million tonnes of material each year (Environment Agency, 2003). Finally, the construction industry in the UK is responsible for almost a third of all industry related pollution accidents and for almost 50% of all accidents at work (Patermann, 1999).

It is clear that the construction stage of any development can be particularly disruptive, and depending on the type of project (e.g. extractive or infrastructure projects) it can last up to ten years (Glasson *et al.*, 2005).

Based on these potentially significant impacts, Ofori *et al.* (2002) argues that major contractors should have the responsibility of environmental management of construction projects in order to minimise the environmental impacts on and off the site. In addition, Lamming and Hampson (1996) argue that the key for the wider spread of environmental management relies on the capacity of large companies to pass on best practice on environmental performance to their smaller counterparts (suppliers).

### ***Supply Chain Management (SCM)***

SCM was born in the manufacturing industry in the 1990's with the Just In Time (JIT) delivery system implemented in Toyota (Vrijhoef and Koskela, 1999), with the main aim of reducing inventories and regulating suppliers interaction with the production lines. Nevertheless, since its birth SCM has evolved into a full range of disciplines that involves closer customer-supplier relationships.

Handfield and Nichols (1999) defined SCM as:

*“The supply chain encompasses all activities associated with the flow and transformation of goods from raw materials (including extraction), through the end user, as well as information flows. Materials and information flows both up and down the supply chain”*

In other words SCM can be defined as the integration of suppliers and customers into the decision-making processes, focusing on the planning, implementation and control of the logistics operations to pull materials through the supply chain (Kannan and Tan, 2005).

However, there are some implications for customer firms that decide to work with their supply chain: understanding of the pressures they are experiencing as well as their capabilities, understanding of their suppliers activities and capabilities, and evaluation of whether or not they have the power over their suppliers (Hall, 2000).

The power matrix is a model that compares Buyer power VS Supplier power to assess the dominance situation. Figure 1 presents four possible scenarios.

BUYER POWER ATTRIBUTES RELATIVE TO SUPPLIER	HIGH	BUYER DOMINANCE  (>)	INTER- DEPENDENCE  (=)
	LOW	INDEPENDENCE  (0)	SUPPLIER DOMINANCE  (<)
		LOW	HIGH
		SUPPLIER POWER ATTRIBUTES RELATIVE TO BUYER	

Figure 1.- The power matrix (Cox and Ireland, 2002)

The features that define the different sections of the matrix are: balance between buyers and suppliers, buyer's expenditure to the supplier, number of alternatives, extent in which the product or service is commoditized or standardised and the level of information flowing from one part to the other (Cox and Ireland, 2002).

## Construction Supply Chains

The main stakeholders of the construction industry and those who interact with it are shown in Figure 2 to illustrate the complexity of the sector.

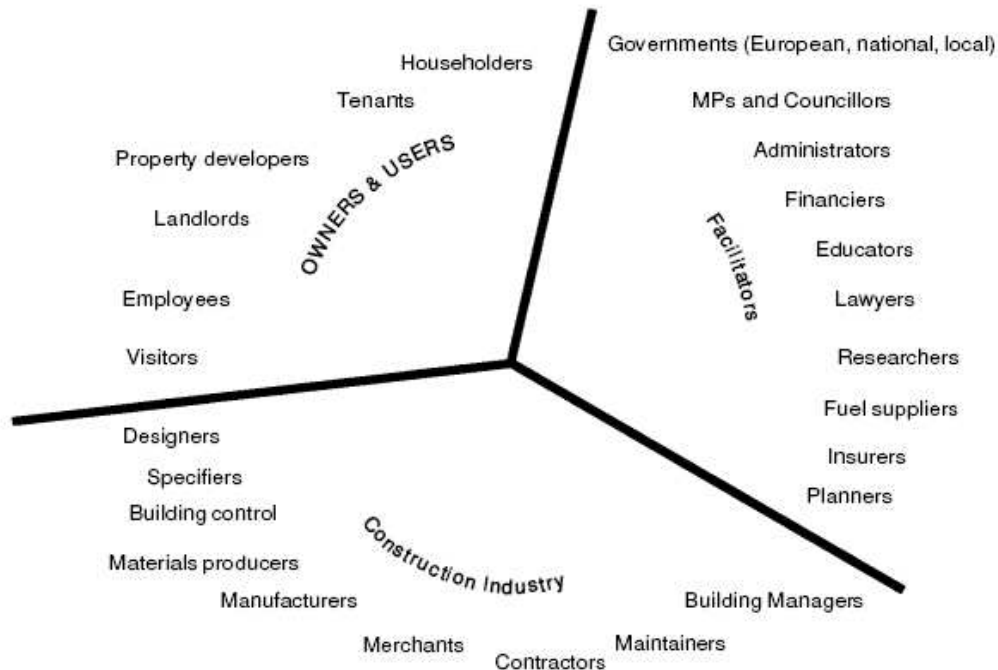


Figure 2.- Stakeholders of the construction and built environment (Courtney, 1999)

There is no such thing as a typical construction supply chain because of the variety of buildings, sizes, technologies and products that can be used (Akintoye *et al.*, 2000). Regardless, figure 3 exemplifies some of the most important elements:

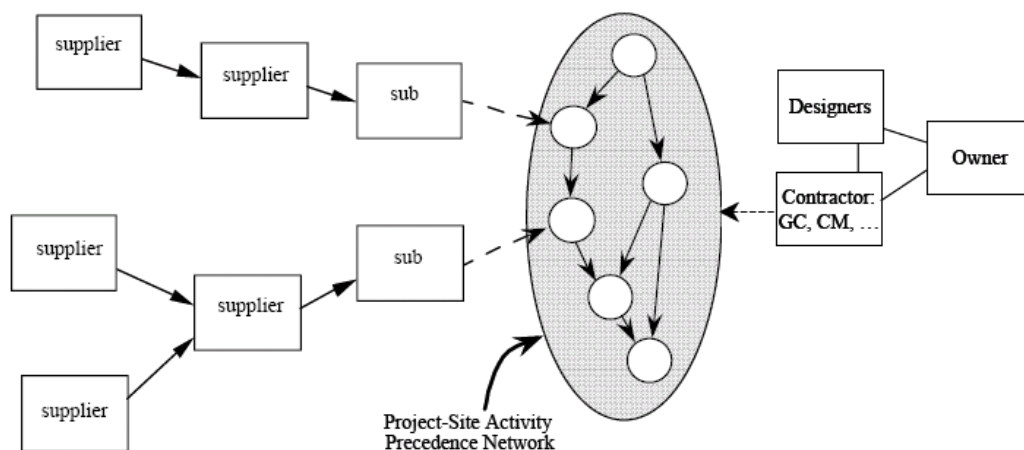


Figure 3.- Conceptual view of a construction project supply chain (O'Brian *et al.*, 2002)

Within a construction supply chain there are several supply chains, each one with different properties and circumstances. The main types of suppliers can be classified into materials, labour, equipment or machinery and professional services (Cox and Ireland, 2002). The role of contractors is usually the “integration” of all the actors mentioned.

To understand construction supply chains there are two main factors, 1) the behaviour of construction firms within markets and 2) the behaviour of individual supply chains (operational aspects) (O'Brian *et al.*, 2002).

In terms of the construction industry market, it can be described as fragmented and highly adversarial (Boardman, 2004) because of the conflicting nature of demand-supply (Cox and Ireland, 2002). It is characterised by traditional trading and non-cooperative relationships which result in a non-trusting climate and aggressive business mentality (Vrijhoef and Koskela, 1999), generating more focus on the clients than on the suppliers (Akintoye *et al.*, 2000).

About the operational aspects, the construction industry has a large amount of suppliers, mostly SMEs with less than 20 employees (Courtney, 1999; Sjoström and Bakens, 1999). In some cases, the customer selects the contractor and some of the suppliers (Akintoye *et al.*, 2000). In addition, lack of communication which generates large amounts of waste (Vrijhoef and Koskela, 1999).

### ***Environmental pressures through the Supply Chain***

Generally, suppliers are not exposed to the same kind of pressure from external stakeholders as their customers, so environmental pro-activity or innovation often comes from higher links in the supply chain (Hall, 2000). The main reasons why these pressures pass on to the supply chain are because stakeholders do not make a distinction between the environmental impacts of the company itself or their suppliers (Rao, 2005), and due to the large amount of clients or the size of their projects, big firms are the last and more visible link which makes them target for massive public attention and the media (Gonzalez-Benito and Gonzalez-Benito, 2006) (Epstein and Roy, 1998). For example, for NGOs it is more simple to focus on one particular organisation rather than the thousands of suppliers involved in a supply chain (Hall, 2001). And finally, legislation, that still is the most important pressure for the majority of companies. For example the duty of care in the UK in which any company related with the

production, handling or storage of controlled waste is responsible for its safe passage through the supply chain (Lamming and Hampson, 1996), and the tax system which encourages “beneficial” and discourages “harmful” impacts on the environment (Raynsford, 1999).

Thus, according to the pressures identified and the nature of construction supply chains, it is more likely that GSCM practices evolve better based on buyer dominance and inter-dependence where the influence can force the implementation of the strategies (Cox and Ireland, 2002). In the case of construction, only large contractors are expected to pressure their supply chain.

A key step is to prioritise the suppliers and commodities according to their importance in the supply chain, given that it would be impossible to attack all the supplies and suppliers at the same time (Envirowise, 2001; Hanfield *et al.*, 2005). According to Cousins *et al.* (2004), the degree of commitment of every company in greening the supply chain is defined by two characteristics, available resources VS perceived losses.

One way to identify critical suppliers is by assessing the risk attached within the supply chain. More specifically, performing a risk assessment to protect against corporate risk such as liabilities or loss (financial, performance, physical, social, psychological or time) (Envirowise, 2001). For example suppliers that handle hazardous materials (Lippmann, 1999) or when a company is over-reliant on a single or a limited number of suppliers for a product, technology or process (Cousins *et al.*, 2004).

### ***Sustainable Construction***

Several organisations such as the Construction Industry Board (CIB), the Environment Agency and the UK government have stated their concerns about the sustainability of the construction industry. CIB with an agenda 21 on sustainable construction, the Environment Agency with a position statement on sustainable construction (Environment Agency, 2003), and finally, the UK Government with the releases of two special reports, the Latham report (1994) and Egan report (1997) to address the barriers and promoting more effective EMS and SCM in the construction industry (Akintoye *et al.*, 2000).

Before defining sustainable construction, it is important to understand what a sustainable industry is.

*“...an industrial ecosystem where the consumption of energy and raw materials is optimised, waste generation is minimised, and the effluents of one process serve as the raw materials for another process”.* Theyel (2001)

Sustainable construction is a term that usually starts in the design phase and continues after the construction company has left the site. It should, by definition, encompass four attributes of sustainability; social, economic, biophysical and technical. The social pillar is based on the notion of equity and social justice, focusing in aspects such as promoting human health, enhancement of the disadvantaged people or equitable distribution of the social costs and benefits of construction. The biophysical refers to the improvement of the quality of human life within the carrying capacity of supporting ecosystems, reduce the use of energy, water, raw materials and land, increase the use of renewable resources and minimize pollution. The technical pillar is referred to a number of concepts about the quality and service life such as the durability, reliability and functionality of buildings. Finally, the economical pillar refers to several issues such as the promotion of employment, enhance competitiveness, choose environmentally friendly suppliers and contractors, and the financial affordability for the stakeholders (Hill and Bowen, 1997). It is important to acknowledge though, that whatever technology is used it is impossible to conceive a construction industry which does not result in some irreversible changes to the physical, social and economic environment (Spence and Mulligan, 1995).

Hill and Bowen (1997) propose a multi-stage framework based on environmental tools such as Environmental Assessment (EA) and Environmental Management Systems (EMS) to sustain the four pillars. EA during the planning and design stages of the construction projects with the aim of identifying the preferred options in terms of materials, sources of the materials, locations and design, as well as the mitigation measures. And EMS functioning with the objective of managing the significant environmental impacts during the construction phase, after the facility is delivered to the client and if possible during the decommissioning process. Figure 4 illustrates such framework.

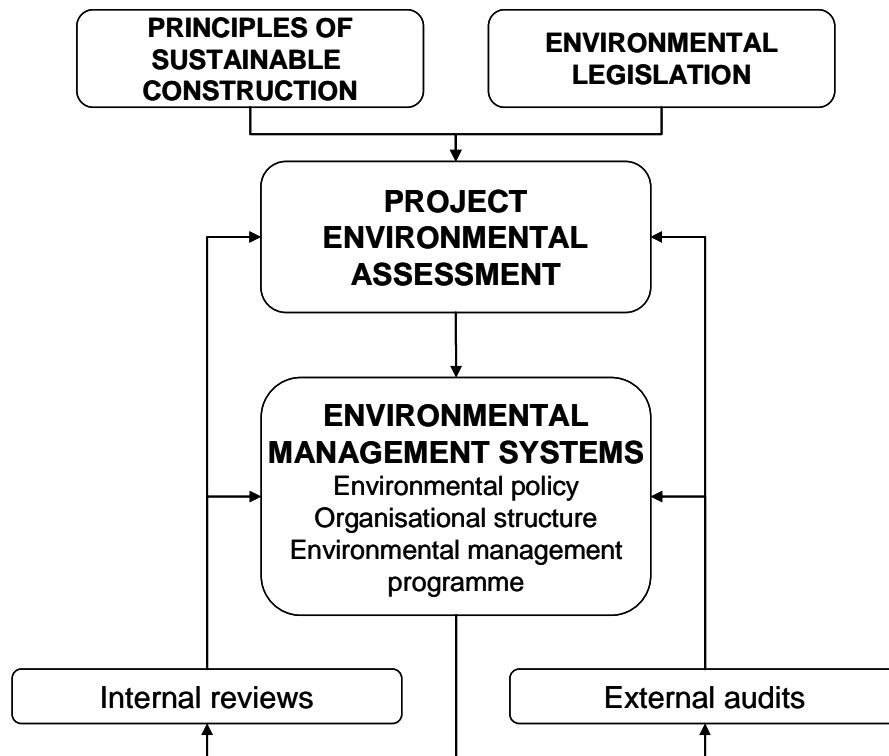


Figure 4.- Framework to achieve sustainable construction  
(adapted from Hill and Bowen (1997))

### **Main concepts of GSCM**

Green et al. (1996) defines GSCM as follows:

*“The way in which innovation in supply chain management and industrial purchasing may be considered in the context of the environment”*

GSCM is a broader term than sustainable procurement (Bowen *et al.*, 2001a). However, this concept is also related with GSCM practices and can be defined as:

*“The process whereby organisations meet their needs for goods, services, works and utilities in a way that achieves value for money on a whole-life basis in terms of generating benefits not only to the organisation, but also to society and the economy, whilst minimising damage to the environment”* (Purchasing and Supply Agency, 2006).

The supply chain processes influence the quantities and types of resources acquired and select the source of key products and suppliers; these activities are directly connected with the degree of negative impacts on the environment and indirectly connected with economic and

social growth within a community (Morton et al., 2002). In other words, GSCM is related with any attempt of improving the environmental performance of the purchased products/services or the suppliers that provide them (Bowen *et al.*, 2001a). The main aims of GSCM are to identify benefits, costs and risks associated with environmental performance (Hanfield *et al.*, 2005). A typical starting point in considering the inclusion of the supply chain is by implementing ISO 14001, which recommends the inclusion of policies to ensure the suppliers are aware of their environmental practices and liabilities (Rao, 2005).

Sarkis (2003) detailed the components of a supply chain and its environmental impacts (see Figure 5).

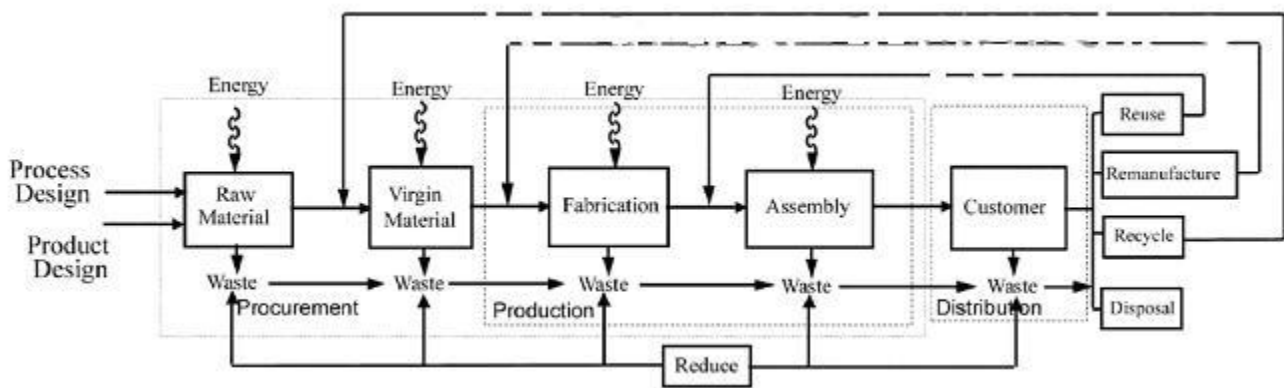


Figure 5.- Typical environmental impacts of a supply chain (Sarkis, 2003)

Environmental impacts and responsibilities within the supply chain can be classified as follows: direct impacts, depending entirely on the organisation and refers mainly to the construction of the building, shared impacts between the organisation and its suppliers, and indirect impacts that depend entirely on the suppliers activities (Hall, 2001). Nonetheless, when a company decides to purchase goods or products from a particular supplier, it inherently accepts the waste stream generated by its decision as well as the liability implications (Hanfield *et al.*, 2005).



Figure 6 provides a summary of the topics that will be explored on this dissertation.

## Construction Green Supply Chain Management

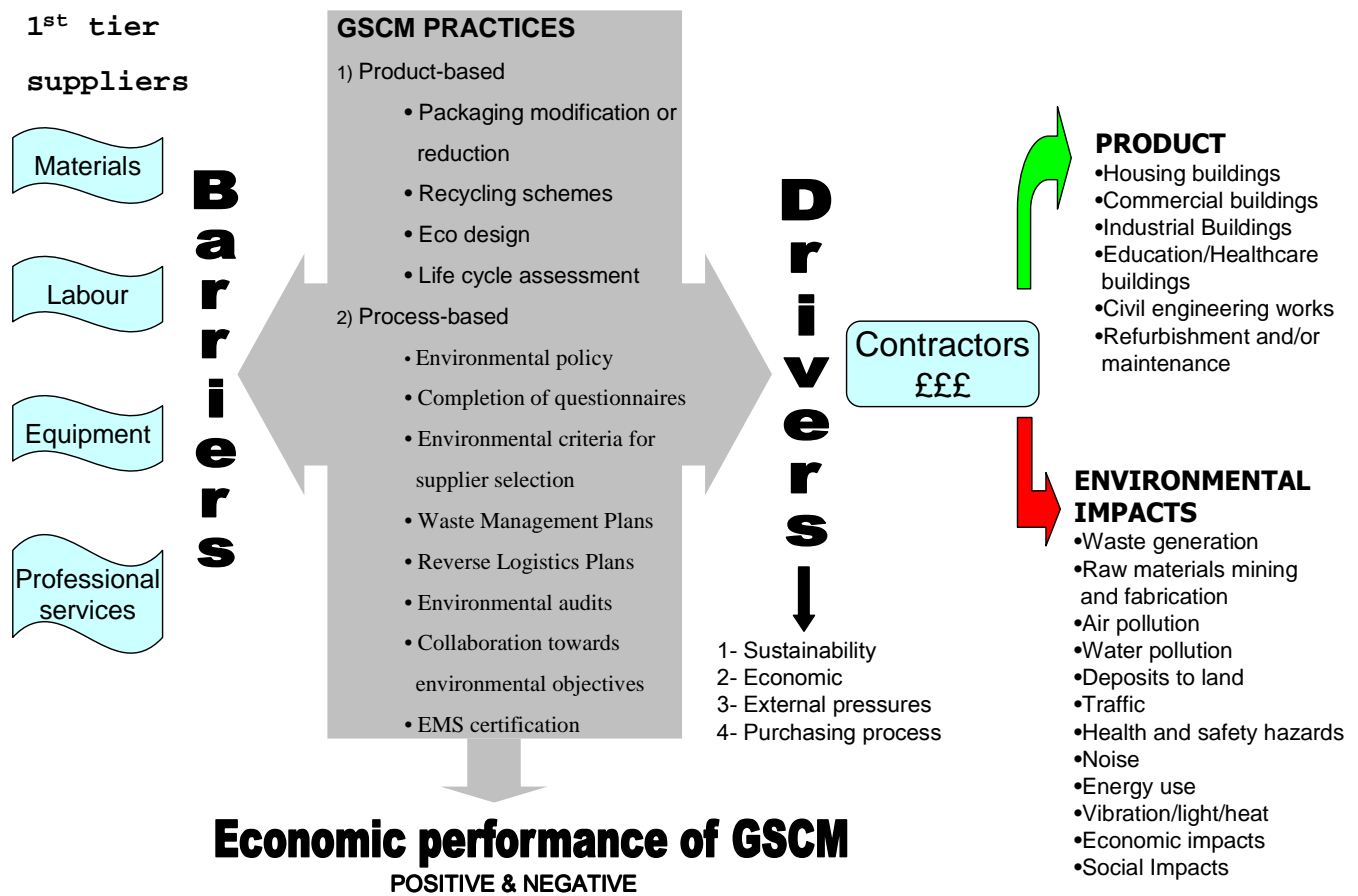


Figure 6.- Overview of main issues of Construction GSCM

### Classification of GSCM practices

There are many ways of classifying GSCM. For example, Theyel (2001) explains three types of environmental relationships, setting environmental requirements, sharing information and collaboration for improving products or processes. Bowen *et al.* (2001b) present a different classification: greening the supply process (that includes the incorporation of environmental practices into supplier's management), product-based green supply (that includes changes in the product supplied) and advanced green supply that introduces more proactive measures into the customer-supplier relationships such as the inclusion of environmental goals in supplier selection. Zhu and Sarkis (2004) identifies four types of GSCM, Internal Environmental Management, External GSCM practices, Investment recovery and Eco-design.

Finally, Srivastava (2007) and Bowen et al. (2001a) identify just two categories, product-based and process-based.

The following description of GSCM practices are based on the latter classification (see figure 6), and within every category the practices are the most common identified in the literature and are listed according to the level of complexity and resources needed to implement them. It is important to mention that these practices do not exclude each other and several practices can be performed together.

Product-based practices are those related with modifications to the product purchased or its by-products. One of the most common requirements is packaging reduction or modification, it refers to actions such as reducing the amount of packaging material, elimination of hazardous materials, facilitate dismantling or recycling (Envirowise, 2001). Another product-based practice is the implementation of recycling schemes, which involves the collaboration between supplier and customer for the collection, sorting and transportation when the recycling happens on a different link of the supply chain. Eco-design refers to the designing of products with certain environmental considerations (Srivastava, 2007). The main practices aim to material reduction, materials recovery (e.g. to facilitate dismantling or recycling), waste minimization or hazardous materials removal (Zhu and Sarkis, 2006). And finally, life cycle assessment (LCA), which can be considered as the most complex product-based practice because it requires knowledge about all the stages of a product. It is a technique used to track all materials and energy flows of a product associated with any activity over its entire life-cycle from raw material extraction, manufacturing, and use to ultimate disposal, it is also known as “cradle to grave” assessment (Vigon, 1994; Starkley, 2000).

On the other hand, process-based practices are those related with modifications to the supplier's management practices. One of the most common is the requirement of an environmental policy in order to improve the environmental performance. Nevertheless, an environmental policy has to be more than just a written exercise, it needs to reflect the realities of the wider environmental context in which the company operates (Sheldon and Yoxon, 2006). Another common practice is the completion of questionnaires to demonstrate to the customer commitment and performance. Some issues addressed are: regulatory compliance, environmental affects and measures, existing procedures and general commitment (Lamming and Hampson, 1996). Environmental criteria for supplier selection refer to the inclusion of environmental attributes or requirements in order to be approved as a supplier. Site Waste Management Plans is a process performed by customer and supplier involving the collection, transportation, incineration, composting or disposal of goods traded

between the two parties involved (Srivastava, 2007). A plan of this type should detail the amount and type of waste generated and how it will be reused, recycled or disposed (DEFRA, 2007). Reverse Logistics plans can be considered similar to a site waste management plan. However, it is about the collection, sorting and transportation of used materials specifically for remanufacturing. It needs the coordination between the return rate of materials and the actual demand (Srivastava, 2007), so to be effective it requires the close collaboration between the customer and the supplier. One more process-based practice is the implementation of environmental audits by the customer or by a third party on behalf of the customer. It consists on a systematic, periodic and documented evaluation of environmental performance of facility operations and practices (Glasson *et al.*, 2005). Finally, the requirement to design, implement and certify an EMS in order to maintain the relationship with a specific client. There are mainly two standards used in the industry, the development of EMAS in 1993 and the release of the ISO 14000 series in 1996 (Morrow and Rondinelli, 2002). A recent addition is the British Standard 8555 (Project Acorn) that breaks down the ISO 14001 or EMAS implementation into six stages, each stage with official recognition (DEFRA, 2005) (Gascoigne, 2002).

Collaboration towards shared environmental objectives was included on the questionnaire as a single process-based practice. It may include meetings, site visits, workshops, collaborative projects, discussions or networking (Envirowise, 2001). Nevertheless, collaboration can occur in any of the practices mentioned before and it refers to any kind of support provided by a big customer to its supply chain. It can be financial, training or provision of information (Lamming and Hampson, 1996). As an example some big contractors with the support of CIRIA have worked in recent years towards the implementation of EMS with their tier 1 suppliers (ENDS Report, 2001).

### ***Drivers and barriers to implement GSCM practices***

The classification of drivers is based on a survey carried out by Rao (2005), in which two main factors were identified as the most significant, sustainability motivators and economic motivators. In addition, additional research has commented on the influence of external pressures and the purchasing process itself (Hall, 2000; Morton *et al.*, 2002).

Sustainability motivators refer to the improvement in management practices to prevent significant environmental impacts as well as develop new environmental solutions (Rondinelli and Vastag, 2000). Economic Motivators refer to the reduction in energy use, raw materials,

increase market share or any strategy that could be translated into financial capital (Morrow and Rondinelli, 2002). External pressures refer to any external force capable to initiate these types of practices and finally the motivation of improving the purchasing process itself.

Usually the barriers for GSCM do not appear as isolated issues. Hence, the analysis on this section will be for groups of barriers that are linked because of their nature. The first group is formed by lack of resources, short term planning and lack of markets for recyclable materials. These are linked because they all deal with availability of resources (financial or human) for GSCM. Lack of resources is probably the most important barrier identified because the sources needed have to compete with other company's priorities (Stoesser, 1997). In addition, the costs and efforts involved in the design, development, documentation, implementation and certification of an EMS usually discourage smaller companies in which financial resources are restricted (Rondinelli and Vastag, 2000). Furthermore, costs have to be incurred on the short term whilst the benefits can take years and often can be difficult to associate with the measures taken (Freimann and Walther, 2001). Finally, lack of markets for recyclable materials can become a barrier for companies trying to implement product-based strategies (Rao, 2005).

The second group is formed by top management commitment, middle management commitment, inappropriate organisational structure and internal communication because they all deal with the internal aspects of a company. Top and middle management commitment are related and have to do with the company's capacity towards a successful GSCM. Top management particularly on SMEs, differs from the management behaviours found on large publicly owned businesses because they respond to different stakeholders and have different experiences and capabilities (Emiliani, 2000). Top-management commitment needs to understand the value, efforts and support required to implement GSCM strategies successfully (Lippmann, 1999). On the other hand, middle management commitment, knowledge and awareness towards legislation and environmental impacts are a crucial step towards the successful implementation of GSCM strategies (Bowen *et al.*, 2001a). Another barrier identified is the internal communication within a company. Organizations need to communicate effectively their environmental goals to their own personnel as well as their stakeholders and make clear how these goals relate with their regular functions (Lippmann, 1999). Lack of appropriate organisational structures and widespread ignorance of supply chain philosophy are also barriers identified for the implementation of GSCM (Akintoye *et al.*, 2000).

Another group is formed by lack of knowledge, lack of information and lack of support to implement such measures. These barriers deal with the expertise needed on issues such as environmental impacts, sustainability and supply chain processes. For SMEs, lack of knowledge about environmental impacts or underestimation of the environmental impacts is usual, one reason is that legal thresholds are usually bigger (Hillary, 2000). Lack of technical knowledge and skills on SMEs are also common. Usually these type of companies have less information and expertise available to them for dealing with environmental requirements from customers (Hillary, 2000; Ofori *et al.*, 2002). In the absence of other capabilities (such as quality control, inventory control management or pollution prevention) the concepts of continual improvement, lean production practices as well as avoiding the focus on “end of pipe technology” are more difficult to understand and achieve (Darnall and Edwards, 2006). Finally, the lack of government legal enforcement (Shen and Tam, 2002) or compliance with different types of legislation (local, national or even international legislation depending on the size) can be considered as a barrier to SMEs (Hillary, 2000).

### ***Performance of GSCM***

There are two major aspects related with performance, environmental and economic. In terms of environmental performance, Theyel (2001) identifies cleaner production, innovative approaches in design phase as well as environmental management and waste minimisation as the possible benefits. In terms of economic performance, Zhu and Sarkis (2004) distinguish between positive and negative economic impacts. Positive economic impacts such as decreased costs of purchasing materials, decrease in costs of energy consumption, decrease of waste treatment or decrease in fines for environmental accidents. Finally, negative economic impacts such as investment in technology or training, increase of operational cost or increase of costs for purchasing environmentally friendly products, given the availability and relatively cheap costs of virgin materials in the construction industry.

However, GSCM can be considered as a relatively new topic, so with current data sources and experiences it is difficult to assess if in practice GSCM is delivering better results to the companies involved (Zhu and Sarkis, 2004). The extent in which SMEs will respond to these requirements will depend on a case-by-case basis and the commercial benefit identified for these companies (Lamming and Hampson, 1996).

## **Objectives**

The research aims to investigate GSCM practices, drivers and challenges that the construction supply chain is experiencing in practice. Two different questionnaires were used to examine these issues, one for contractors and one for their suppliers. More specifically the research aimed to obtain information on:

- Perceptions on the significance of environmental impacts and requirements by contractors and suppliers
- Barriers and expectations about the economic impacts for implementing GSCM practices

Contractors:

- Identification of the main drivers to implement GSCM practices
- Assess if big contractors have the power to engage and support their suppliers and how they identify critical suppliers

Suppliers:

- Available resources to implement the GSCM practices required by customers
- What kind of support is available to implement such strategies

## Methodology

Selecting a suitable industry sector for the research meant looking for some characteristics, it should be recognised as environmentally significant, it should deal with a large quantity of suppliers, and it should have big firms on the end of the supply chain with the financial power to pull the rest of the supply chain links (Hall, 2001). Using these features, the construction industry was chosen for the dissertation. Another factor involved in the selection of the construction industry was that a consultant from White Young Green who has worked with construction firms and CIRIA in the design of an EMS specific for the construction industry was available for liaison.

The methodology was originally based on sending questionnaires to contractors and suppliers in the construction industry in order to analyse responses in terms of their perceptions about environmental impacts, GSCM practices, drivers and barriers. However, there was a provision because of the potentially low response on the suppliers (mainly SMEs), to focus more on the contractors side by arranging interviews to get more relevant information about the top link of the supply chain. A diagram with the complete methodology is presented. (see Figure 7)

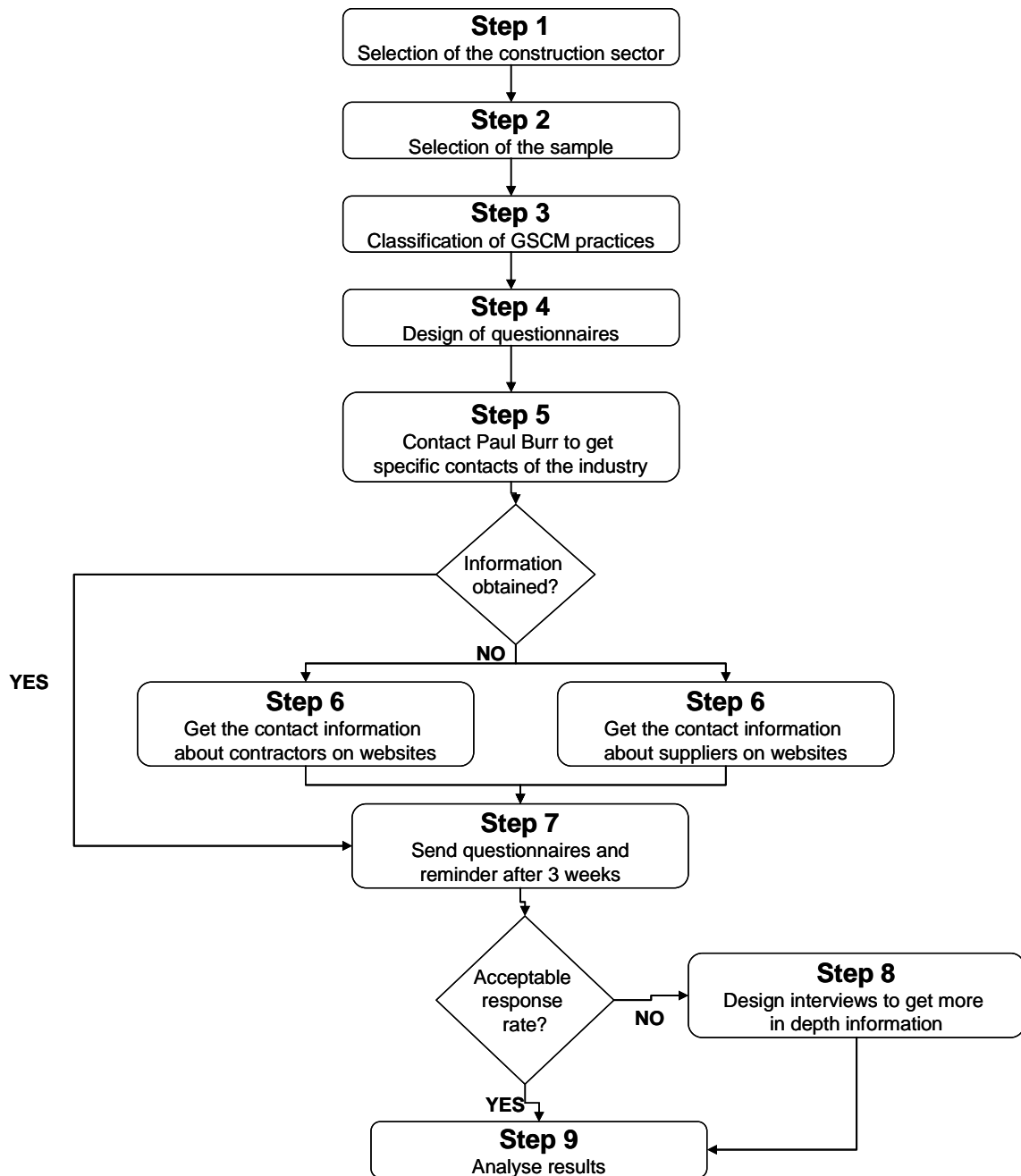


Figure 7.- Detailed methodology

## Population

The construction industry includes a wide range of companies including building contractors, quarrying firms, products producers, builder's merchants and professional services. It is estimated that the number of companies related with the construction industry in the UK is around 350,000 firms, from which 170,000 are building contractors (Jones *et al.*, 2006).

According to the European Union (EU) classification of size, 93% of construction firms are small with less than 14 employees, while 139 firms with over 600 employees accounting for



0.1% of all firms are responsible for more than 25% of all construction output in the UK (Jones *et al.*, 2006).

### ***Sampling***

Two different questionnaires were designed in order to assess both sides of the supply chain. For this reason, two types of samples were used, non-probability sample for the contractors and simple random sampling for the suppliers. A non-probability sample is a sample that has not been selected using a random method, thus the members of the population do not have the same probability, while simple random sampling is a selection at random from a list of the population (Bryman, 2004).

The selection of the contractors sample was based on size and turnover, with the objective of contacting the biggest contractors in the UK. The source of information was Construction News (2006), particularly the top 25 house builders in the UK in 2006 and Considerate Constructors Scheme (2007), which also lists top contractors that are dealing with the image improvement of the construction industry, and also recognise the inclusion of the supply chain as crucial to achieve this aim. A total of 35 questionnaires were sent between these two sources. The method to identify the respondents of each company was to search on their websites specific contacts related with EMS, Supply Chain or Corporate Social Responsibility (CSR). Because of the size of these companies it was common to find these types of contacts. The selection of the suppliers was a combination of two methods. First, 37 suppliers were identified from big contractor's websites, specifically on the supply chain section. Second, 45 suppliers were identified in the East of England on general construction databases such as EMAS ISO 14001 database (2007) of materials suppliers, the Norfolk Broads Building Services Supplies Norfolk & Suffolk UK (2007) and construction companies in the Norwich region from the Google construction directory. In the end, a total of 82 questionnaires were sent to these different sources and the method to find the respondent was to search on their websites to identify a department or person related with environmental issues or customer services. Because of the size of these companies, it was not possible to identify specific contacts, so the questionnaire had to be sent to a general customer services e-mail.

### ***Classification of GSCM practices***

As discussed, there has been several attempts to classify the different GSCM practices (see table 1 for some examples).

Table 1.- Classification of GSCM practices

Theyel (2001)	1. Setting environmental requirements 2. Sharing information 3. Collaboration
Bowen <i>et al.</i> (2001b)	1. Greening the supply process 2. Product green supply 3. Advanced supply chain
Zhu and Sarkis (2004)	1. Internal environmental management 2. External GSCM practices 3. Investment recovery 4. Eco-design
Srivastava (Srivastava, 2007) & Bowen <i>et al.</i> (2001a)	1. Product-based 2. Process-based

The classification used in this research was product-based and process-based practices.

The GSCM practices included on the questionnaire were identified on the literature and then included in one of the two categories mentioned before. See table 2 for a summary of the practices researched.

Table 2.- Summary of GSCM practices

**1.- Product-based practices**

Packaging modifications or modifications	(Envirowise, 2001; Zhu and Sarkis, 2006)
Recycling schemes	(Ofori <i>et al.</i> , 2002; Shen and Tam, 2002; Srivastava, 2007)
Eco-design	(Lamming and Hampson, 1996; Starkley, 2000; Morton <i>et al.</i> , 2002; Zhu and Sarkis, 2006; Srivastava, 2007)
Life cycle assessment	(Starkley, 2000; Envirowise, 2001; Morton <i>et al.</i> , 2002; Srivastava, 2007)

**2.- Process-based practices**

Environmental policy	(Starkley, 2000)
Completion of questionnaires	(Lamming and Hampson, 1996; Lippmann, 1999)
Environmental criteria for supplier selection	(Lamming and Hampson, 1996; Rao, 2005)
Waste management plans	(Lamming and Hampson, 1996; Envirowise, 2001; Morton <i>et al.</i> , 2002; Ofori <i>et al.</i> , 2002; Shen and Tam, 2002; Srivastava, 2007)
Reverse logistics plans	(Sarkis, 2003; Srivastava, 2007)
Environmental audits	(Starkley, 2000; Morton <i>et al.</i> , 2002; Rao, 2005; Zhu and Sarkis, 2006)
Collaboration towards shared environmental objectives	(Lippmann, 1999; Envirowise, 2001; Shen and Tam, 2002; Rao, 2005; Zhu and Sarkis, 2006)
EMS certification	(Starkley, 2000; Envirowise, 2001; Morton <i>et al.</i> , 2002; Shen and Tam, 2002; Zhu and Sarkis, 2006)

**Drivers and barriers**

In terms of the drivers and barriers for GSCM, the classification for the analysis was presented on the previous chapter. See table 3 for a summary of these two aspects.

Table 3.-Drivers VS barriers identified in the literature

<b>DRIVERS</b>	<b>BARRIERS</b>
<b>SUSTAINABILITY</b>	<b>RESOURCES</b>
Contribute to environmental protection (Rao, 2005; Zhu and Sarkis, 2006)	Lack of resources (financial/human) (Epstein and Roy, 1998; Rondinelli and Vastag, 2000; Ofori <i>et al.</i> , 2002)
Reduction of waste (Akintoye <i>et al.</i> , 2000; Envirowise, 2001)	Short term planning over long term (Freimann and Walther, 2001)
Reduction of environmental risks (Envirowise, 2001; Shen and Tam, 2002; Cousins <i>et al.</i> , 2004)	Lack of markets for recyclable materials (Rao, 2005)
<b>ECONOMIC</b>	<b>KNOWLEDGE/SKILLS</b>
Cost benefits (Envirowise, 2001; Rao, 2005; Zhu and Sarkis, 2006)	Lack of knowledge about environmental impacts (Hillary, 2000; Ofori <i>et al.</i> , 2002)
Avoid fines (Cousins <i>et al.</i> , 2004)	Lack of technical knowledge and skills (Hillary, 2000)
Image improvement (Morton <i>et al.</i> , 2002; Rao, 2005)	Lack of expertise from consultants or industry in a specific sector (Gerstenfeld and Roberts, 2000; Shen and Tam, 2002; Darnall and Edwards, 2006)
Meet market expectations (Shen and Tam, 2002)	Lack of information sharing between customer-supplier (Theyel, 2001)
<b>EXTERNAL PRESSURES</b>	<b>INTERNAL</b>
Regulations (Lamming and Hampson, 1996; Bowen <i>et al.</i> , 2001b)	Top management commitment (Lippmann, 1999; Akintoye <i>et al.</i> , 2000; Hillary, 2000)
Customer pressures (Hall, 2000; Morton <i>et al.</i> , 2002)	Middle management support (Lamming and Hampson, 1996; Stoesser, 1997; Hillary, 2000; Bowen <i>et al.</i> , 2001b)
Community/Environmental groups (Hall, 2000)	Effective communication (Lippmann, 1999)
Construction sector	Inappropriate organisational structure (Shen and Tam, 2002)
<b>PURCHASING PROCESS</b>	<b>LEGAL</b>
Develop relationships with suppliers (Emiliani, 2000; Morton <i>et al.</i> , 2002)	Lack of government legal enforcement (Shen and Tam, 2002)
Secure the supplies (Envirowise, 2001; Morton <i>et al.</i> , 2002)	

### ***Justification of method***

The data needed for this research was about environmental perceptions, strategies and practices in a particular sector and with a particular type of firms. Therefore, this type of purpose can be characterised as “descriptive”, which aims to portray a profile of events or situations and requires previous knowledge of the situation to be researched (Robson, 1993).

Robson (1993) describes three types of social research strategies, experiments, with the aim of measuring effects of manipulating one variable on another, case studies, with the aim of developing a detailed and intensive knowledge about a single case or a small number of cases, and surveys, which can be described as a collection of information in standardized form from individuals from known populations and usually deals with relatively small amount of data. According to the former description, the most suitable research strategy for the purpose of descriptive knowledge was the survey.

There are two main types of surveys, questionnaires and interviews. The method selected for this research was a combination of the two methods. The first step was to send the questionnaires to both contractors and suppliers and then arrange interviews with some of the contractors to get more detailed information.

Some of the advantages and disadvantages of questionnaires over the interviews are:

#### **Advantages**

Simple and straightforward approach to study attitudes, motives, beliefs or values, and may be adapted to collect general information. It is also considered as a low cost and less time consuming technique especially if there are time constraints, as well as anonymity if it is required (Robson, 1993).

#### **Disadvantages**

Typically low response rate, there could be misunderstandings or ambiguities during the completion and no chance to elaborate on an answer which could give additional or new information to the research (Bryman, 2004). And finally, the data may be affected by the respondent's characteristics such as lack of seriousness or responses based on desirability rather than real facts (Robson, 1993).

Normally, the most important characteristic of surveys is that they study the sample not in its own right but as a mean of understanding the population from which it is extracted. For this research, the contractors' sample could be a clear indicator of current practices while for the suppliers this is not the case. Nonetheless, it is important to acknowledge that the sample was not representative.

### ***Designing of the questionnaire***

The self-completion questionnaires were designed with a set of characteristics that usually helps the respondent and increases the response rate. Closed instead of open questions to reduce the variability of responses, facilitate the coding and interpretation, and avoid misunderstandings by clarifying the questions with a set of possible answers. Specific instead of general to provide more standardisation, inclusion of a "do not know" option, and a covering letter explaining the aim of the survey, confidentiality and the name of the sponsoring institution. Although, is not demonstrated if a cover letter increases the rate response (Bryman, 2004).

### ***Content of questionnaires***

The content of both questionnaires is similar; however, because of the different situation between contractors and suppliers there are some minor differences.

There are two main sections on the questionnaires, part A in which the baseline information is gathered, and part B with the aim of obtaining specific information about GSCM in the construction industry.

#### **Part A**

##### **Contractors**

The first three questions of this section aim to obtain information about the size, position of the respondent within the company and the type of construction.

Questions 4-5 are relevant to clarify if the contractors have implemented an EMS and what type of standard is the most popular. And finally, the last question of this section aims to identify what are the perceptions of these companies in terms of their environmental impacts, the scale used for this question is based on a Likert scale for attitudes measurement (Robson, 1993) that goes from negligible, minor and significant.

## **Suppliers**

The only difference with the contractor's questionnaire is that instead of asking the type of construction the focus is on the type of supplier (e.g. labour, materials).

## **Part B**

### **Contractors**

This section starts with two questions about general SCM, the first one to identify the size of their supply chain and the second one to assess what are the characteristics that big contractors consider to identify critical suppliers, this question presents several attributes such as cost, distance, quality, risk of loss and environmental performance.

The following questions can be considered as the core of the research because they deal with specific GSCM issues such as:

- Intentions to implement GSCM practices.
- Specific practices that are being implemented, classified by product-based or process-based and listed according to the degree of complexity and resources required.
- Perception about the power of big contractors to engage their suppliers.
- Strategies to support their supply chain on the implementation of GSCM with three possible answers: provision of information, training/guidance and financial support.
- Percentage of virgin vs recycled materials purchased by the company.
- Drivers of big contractors to implement GSCM practices.
- Perceptions about the barriers that their supply chain faces when implementing GSCM practices.
- Perception about the economic implications (positive and negative) of GSCM.

## **Suppliers**

The core of part B is essentially the same but focusing on the suppliers' perspective with the exclusion of two questions (the question related with the attributes to identify critical suppliers and the one related with the drivers to implement GSCM). Plus two additional questions (one related with the time required to implement the GSCM practices and the second one related with the support that is available for this type of organisations not only from their customers but from local government, government agencies, consultancies or the construction sector).

## ***Interviews***

As discussed, there was provision for interviews to be carried out (step 8 of figure 7). The main modification was that instead of comparing the results of the two questionnaires, the results were focused on the contractors' side as the size of the respondents was relevant in terms of turnover and power to engage their supply chain.

In order to get more depth about the drivers and practices being implemented, interviews were held with two contractors to clarify missing information such as the number of suppliers and their perceptions about the challenges and success of GSCM.

The interviews were designed as structured interviews to standardised the responses and be able to aggregate the results into the questionnaire analysis.



## Results and Discussion

### *Description of the respondents*

#### **Contractors**

From the 35 questionnaires sent to top contractors in the UK, nine responses were obtained for a 26% response rate. See Table 4 for a description of the sample.

Table 4.- Description of the contractors sample.  
Rank, turnover and employees from Construction News (2006)

Rank by Turnover (UK)	Company	Turnover £m	Employees	Size	Respondents
3	Amec	£3,065.90	21,610	Large	Safety and Environmental /Sustainability Advisor
4	Carillion	£2,284.20	15,628	Large	Supply Chain Director (PMI) and Supply Chain Lead for Sustainability
10	Amey uk plc	£1,208.80	6,493	Large	Health, Safety and Environmental Director
16	Miller	£892.80	1,616	Large	Sustainable Construction Manager
30	Willmott Dixon	£412.60	863	Large	Environmental manager
34	May Gurney	£364.90	3,238	Large	Lead environmental advisor
37	Keepmoat	£334.70	1,967	Large	Director
65	McNicholas Construction	£173.70	1,525	Large	Environmental manager
	CPPLC	£489.80		Large	Sustainability Specialist, BEST (Business Efficiency Support Team)
<b>Total</b>		<b>£9,227.40</b>	<b>52,940</b>		

Figure 8 shows the balance between the types of construction these companies performed. As the figure illustrates, these large contractors work with a wide range of construction types. All the respondents stated that their supplier base is over 50 for general operations. However, one interviewee stated that the number of suppliers can vary according to the type of construction, increasing the number if the construction is industrial or civil engineering works up to 150 suppliers. Another interviewee mentioned 436 subcontractors plus the materials and labour suppliers.

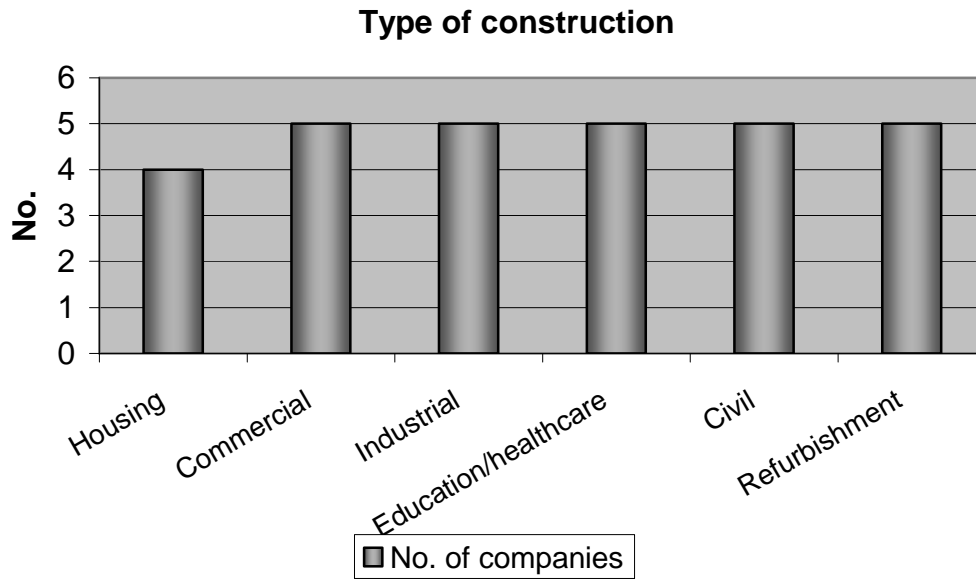


Figure 8.- Type of construction buildings

## Suppliers

From the 82 questionnaires sent to suppliers in the construction industry, only five responses were obtained, a response rate of 6%. Regardless of the low response rate, the suppliers perceptions are interesting for the general analysis and could help to the understanding of the current state of GSCM. The size of the sample was: one large, one small and three micro companies according to the EU classification.

## *Environmental Impacts*

It can be assumed that all the contractors are aware of at least most of their environmental impacts, given that all the companies have already implemented and certified an EMS with ISO 14001. Figure 9 illustrates the perceptions of these companies in terms of the significance of their impacts.

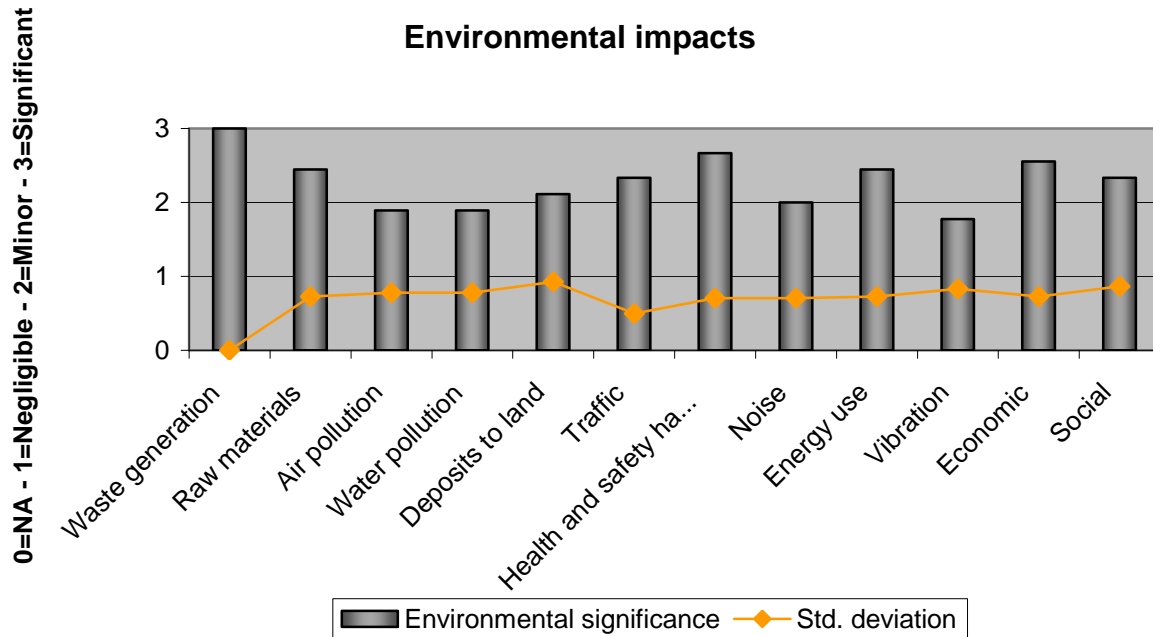


Figure 9.- Perceptions about the environmental impacts

Following figure 9, it is possible to identify the most significant environmental aspects as perceived by large contractors. Notably, the results correspond with the data presented by the Environment Agency (2003). Waste generation was considered by all to be the most significant impact. This is realistic, given that the sector accounts for 19% of the waste generated in the UK (Environment Agency, 2003). Health and safety hazards were also considered significant with an average of 2.6 on a scale from 0 to 3, which corresponds with the fact that almost a third of all industry related pollution accidents and almost 50% of all accidents at work are caused by this sector (Patermann, 1999). Raw materials and energy use were the next two in importance; this can be related with the fact that the construction industry requires extensive mining and quarrying of raw materials (over 420 million tonnes per year) as well as 10% of the national energy consumption for the production and transportation of such materials (Environment Agency, 2003). Finally, the socio-economic impacts that were also scored as significant, mainly because of the size of the labour force, the hazards linked with construction and the benefits obtained by the final product.

Remarkably, even when three respondents stated on the questionnaires that the companies are committed to mitigate the impacts, the general conclusion is that the construction industry has significant impacts on the environment and that large contractors are aware of this situation.

In the case of suppliers, it is worth mentioning that from all the attributes scored, six were below one and the other between one and two, meaning that the perceptions of these

respondents are much lower than the ones from the contractors. This result was expected given the size and environmental significance of their activities.

### **Identification of critical suppliers**

In terms of the attributes that large contractors evaluate to assess critical suppliers, figure 10 illustrate the results of a short list provided on the questionnaires.

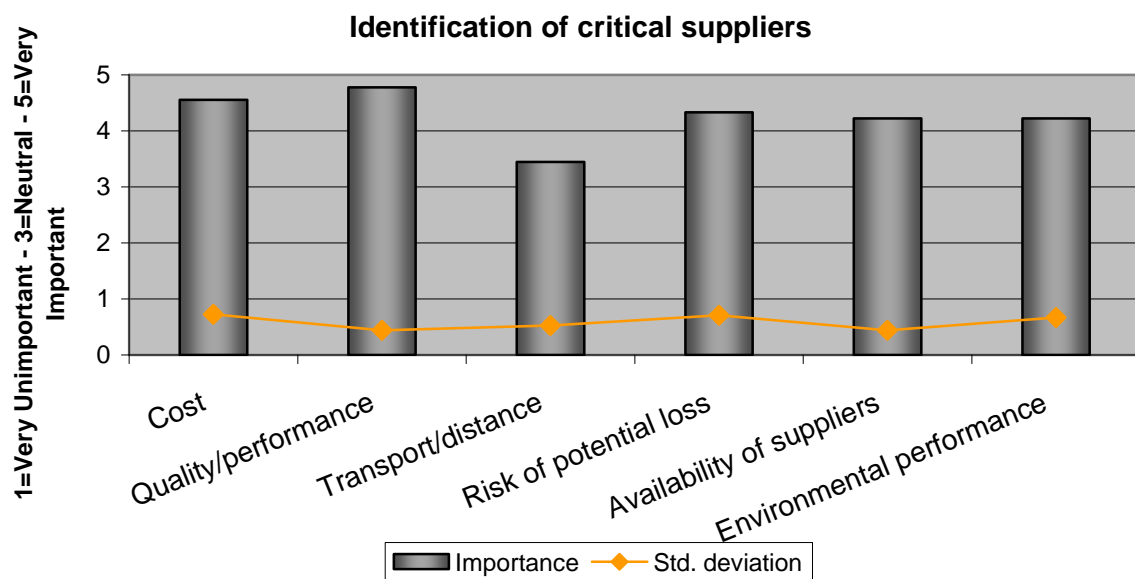


Figure 10.- Attributes to identify critical suppliers

It is interesting that all the attributes presented except *Transport/Distance* were above four which in the scale used means that are important to the companies.

The most important characteristic mentioned was *Quality/Performance*, which is consistent with the general aims of supply chain management (Kannan and Tan, 2005). The second attribute in importance was cost, this result does not necessarily support the inclusion of recycled materials into the supply chain provided that in some markets, recycled materials are still more expensive than virgin materials (Rao, 2005), and that virgin materials are readily available on the construction sector (Stewart, 2002). This topic could have been analysed in more depth because one of the questions was the proportion of recycled materials compared with virgin materials purchased by these companies. Unfortunately, none of the respondents knew the actual figures.

Risk of potential loss and Environmental performance were scored very similarly and with an average above four, which means that these large contractors are at least considering these attributes on their supplier's selection process.

The lowest attribute by consensus was *Transport/Distance* with an average of 3.44 (between neutral and important) and the lowest standard deviation. The implications of this statement is that transportation of construction materials cause significant environmental impacts in terms of greenhouse gases emissions (Patermann, 1999).

### ***Pressures over the supply chain***

All the contractors stated that had intentions, or had started already to pressure their supply chain on the implementation of environmental practices. About the power to engage their suppliers, the average was 4.11 with a relatively low standard deviation of 0.78. This result confirmed that large contractors agree on this fact.

From the five respondents on the suppliers' side, all stated that their customers have already started to engage them into environmental practices. This can not be conclusive but it supports the fact that the construction industry is interested in the growth of GSCM.

Figure 11 illustrates the type of available support for their suppliers.

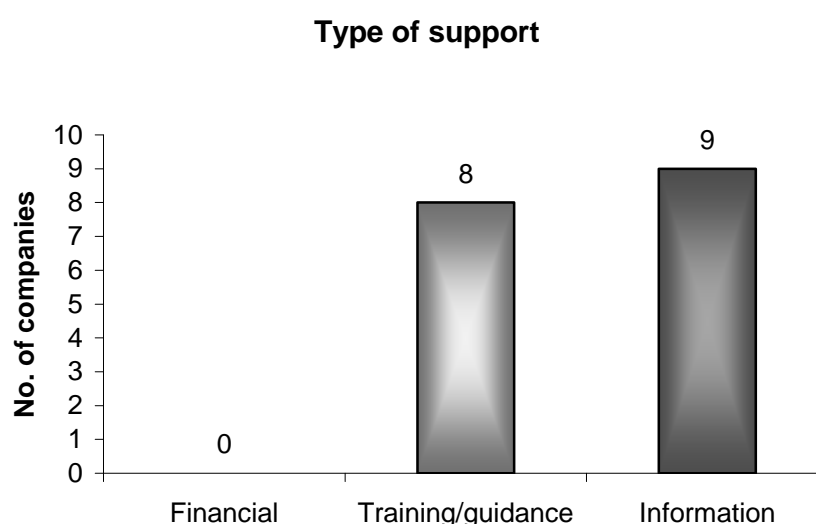


Figure 11.- Type of support available from the contractors

No company is giving financial support, although the support provided implied some financial resources from these companies. All provided information to their suppliers, and all

except one were more involved in the process by providing training or guidance to facilitate the implementation of GSCM. One interviewee stated that the training is mostly site-based, with meetings and discussions about issues such as excess packaging, waste management or general indications about their processes. Another interviewee mentioned that although training is available, their suppliers need to pay a fee to receive it. For this reason the respondent acknowledged that usually the most common practice is the provision of information about legislation and environmental awareness which has no cost implications.

From the suppliers' side, none of the five respondents mentioned to be receiving financial support from any source, and only one of them is receiving training or guidance from their customers. While the rest stated to be receiving only information from local government, government agencies or consultancies.

The fact that all the respondents appeared to be supporting their supply chain can be analysed from two points of view. On one hand, if this practice is extrapolated to other large contractors (considering their turnover and number of employees), it could create a multiplying effect in terms of the power these companies have and the spreading of environmental awareness in the sector (Lamming and Hampson, 1996).

On the other hand, it is important to acknowledge that even with that scenario; it would be a very small number of companies considering the size of the population. In addition, it is impossible for large contractors to deal with all their suppliers and usually they can only work with subcontractors and some materials suppliers, as confirmed by one of the interviewees. Another interviewee mentioned that usually the mechanical sector, which is more regulated and it is considered as highly technical, is more advanced in terms of environmental performance than other type of suppliers.

Finally, there were two comments on two of the questionnaires about these issues. First, that these efforts are not industry wide and because of the high number of potential clients, it is still possible for some suppliers to work with other companies and not worry about environmental issues. Second, that the size of the supplier also plays an important role in terms of the level of influence those customers may have over them.

### ***GSCM practices***

As discussed previously, GSCM practices were classified for this research in two categories, product-based and process-based, with the aim of improving the environmental performance of a purchased good or a supplier itself.

The results were obtained by the respondents selecting from a list of environmental strategies identified in the literature. The strategies were listed according to the level of complexity and resources needed for the implementation, hence it was expected that the first practices on the list were more popular (less complex). The nine respondents had 12 strategies to identify. Thus considering the number of strategies and the number of respondents there were a total of 108 options. Out of the 91 options that were chosen 24 were product-based (30%) while 67 process-based (70%). Moreover figure 12 and 13 demonstrate that after establishing these strategies it was necessary to identify whether the requirements were obligatory, optional or non existent.

Overall, both figures showed that process-based strategies appear to be more common than product-based for the construction industry. Noteworthy, optional and obligatory requirements from respondents showed that 89% of process-based were selected compared with 75% of product-based.

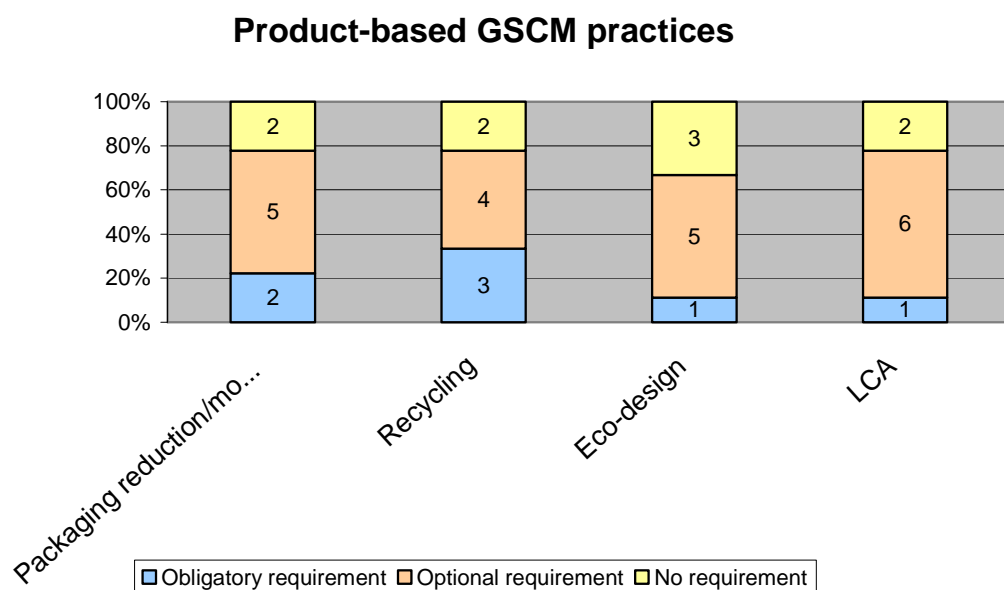


Figure 12.- Product-based practices

Following figure 12, product-based practices are not being enforced by large contractors. Therefore they can not be considered as pressures provided that most of them are still optional or non existent. The results proved that 19% of the practices were classified as compulsory requirement, while 56% as optional and 25% as no requirement.

Specifically to the case of Eco-design and LCA, only one respondent stated this as compulsory requirement for its suppliers. Besides, as discussed above, Eco-design and LCA

can be considered as more complex and demanding in terms of technical skills, where as packaging modifications and recycling schemes can be achievable in a shorter time and with fewer resources (Vigon, 1994; Srivastava, 2007). Consequently, it could be expected that the level of maturity of GSCM is linked to the complexity of the requirements imposed to the suppliers.

Further, only one respondent chose *no-requirement* for the four product-based practices. Clearly, the majority of the sample required at least one of the options presented.

It is important to mention that product-based practices are not independent of process-based practices. Figure 13 focused on the analysis of both figures bearing these relationships in mind.

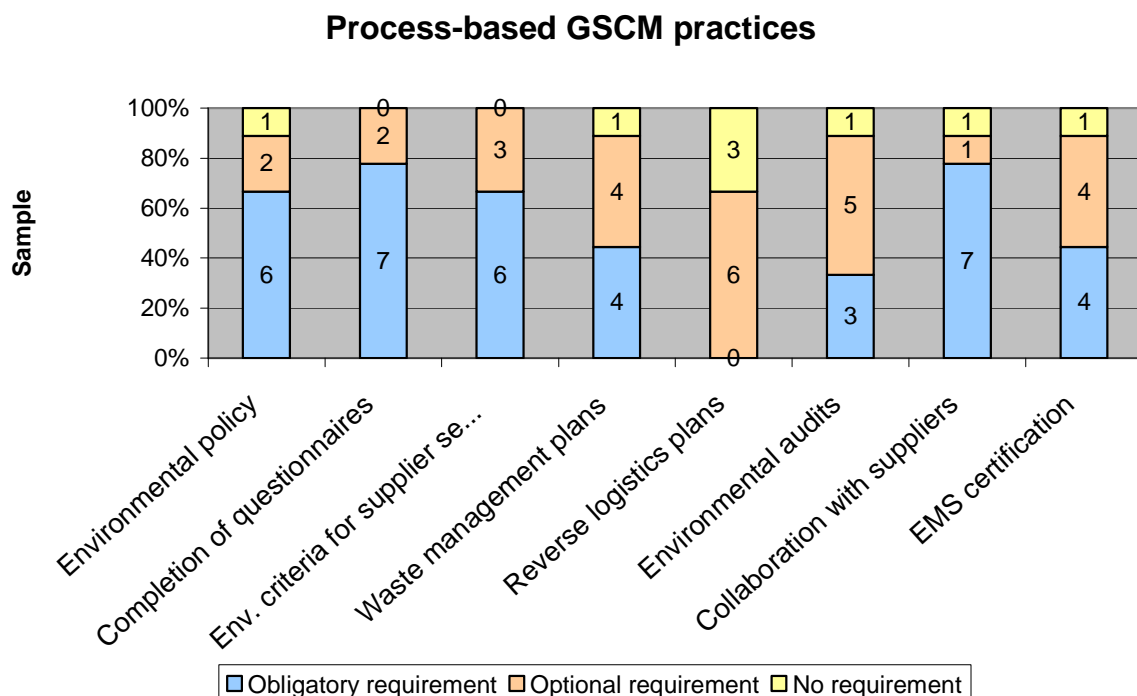


Figure 13.- Process-based practices

Figure 13 illustrates the degree of process-based requirements considered by large contractors. In fact, 51% of the requirements were classified as compulsory, 38% as optional and only 11% as no requirement. Noteworthy, the respondents whom stated the EMS certification as compulsory also marked at least 80% of the other practices as compulsory as well.

The highest practice was the completion of questionnaires with seven out of nine respondents stating it as a *compulsory* requirement and the two remaining as *optional*. This practice has



been classified as one of the basic ones to start with GSCM, given that it does not require much effort from the contractor's side (Lamming and Hampson, 1996).

One of the interviewees referred to issues addressed on these types of questionnaires as complying with environmental policy, information about risk assessments, environmental training, procedures for emergency situations, waste licences, an external certification or membership to environmental organisations. Remarkably, the second practice was collaboration with suppliers. This practice is also related to the size of these companies, which presumably have more resources available than their smaller counterparts. The third in importance was the inclusion of environmental criteria for supplier selection with six out of nine marking the requirement as *compulsory* and the rest as *optional*.

The implementation of an Environmental policy was the fourth most implemented practice by eight (six *compulsory* and two *optional*) out of nine respondents. This practice is frequent and one of the first steps toward environmental awareness. Although subjectively, the policy itself does not guarantee improvement on the environmental performance of a company (Gleckman and Krut, 1996). The following four options were in order site waste management plans, EMS certification, environmental audits and reverse logistics plans.

As discussed earlier, site waste management and reverse logistics plans are related because both deal with used materials. Nevertheless, the responses of the questionnaires reflected different patterns. Four companies scored waste management plans as compulsory, four as optional and only one as no required. While six respondents scored reverse logistics plans as optional and three as no required. Though these two options were at the bottom of the list, they might become more important in the future because of changes in legislation. The reason being is the consultation process that the UK government is carrying out with regards to the regulation of site waste management plans for construction projects. The main issues discussed are: the level of detail of such plans; the resources needed; the responsibilities; regulations and penalties (DEFRA, 2007). When the process finishes, it would become compulsory for all construction companies to create these plans and to collaborate with their suppliers to improve the performance of the supply chain in several ways (e.g. material reduction, re-use, recyclables or final disposal). Finally, the lowest required practice was EMS certification, scored equally as compulsory and optional by four respondents, and no requirement by one. It is worth mentioning, that despite of being on the bottom, it is still a high percentage considering the implications that an EMS has, especially for SMEs (Gerstenfeld and Roberts, 2000).

On the suppliers side it is not possible to draw conclusions because of the low response and different types of respondents. Interestingly, the one large company stated that is being forced by their customers to implement GSCM practices of some kind, in this case it was the completion of questionnaires and the inclusion of an environmental policy.

### ***Drivers for GSCM on the construction industry***

Figure 14 illustrates the drivers that large contractors are subject to in pursuing the process of greening their supply chain. The four main categories defined in the introduction are shown in the columns, while the individual drivers of each category are shown on the left of each column.

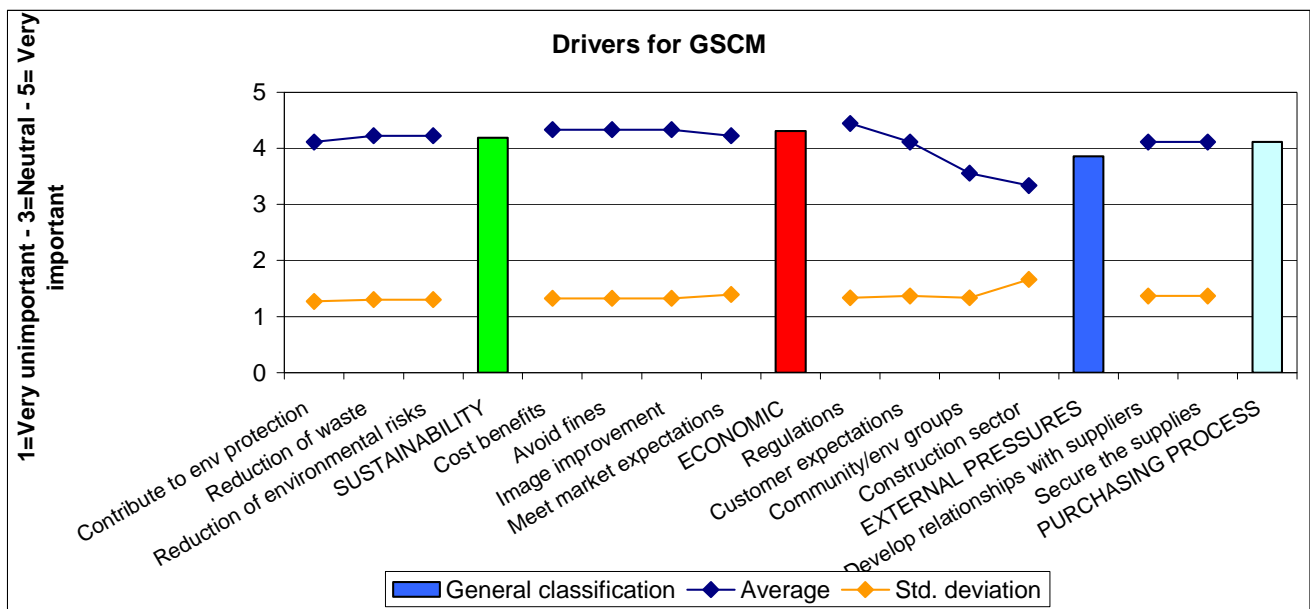


Figure 14.- Drivers for GSCM

Similar results were found in terms of average and standard deviation for almost all the drivers. For this reason during the interviews this topic was addressed to gain more information about the most significant motivators to implement GSCM practices. Nonetheless, the results on the figure showed that the four main categories were considered important with economic motivators in the first place, followed by sustainability motivators, the purchasing process and finally external pressures. This order corresponds to the findings of Rao (2005) in which the two most important drivers for top links in different supply chains were sustainability and economic.

Despite of external pressures situated below the other three main categories, the highest scored from the 13 evaluated was regulations as a single driver. In fact, this was corroborated by one of the interviewees which explained that legislation is in fact the most important driver for his company, confirming that for many companies it is still the most important reason to implement environmental measures (Lamming and Hampson, 1996; Rao, 2005). However, this was not the case for the two lowest scored drivers (community/environmental groups and construction sector pressures) which also belonged to the category of external pressures. This result could mean that at least for now, environmental pressures from NGOs are not as influential in the construction industry as they could be for other industries such as big retailers, paper or the oil industry (Hall, 2001).

Some comments from one of the interviewees were that the efficiency of their suppliers and subcontractors is an important driver, and that their environmental performance is linked to the company's efficiency. Further, their EMS (ISO 14001) has motivated them to be closer and to pull the rest of their supply chain.

### ***Barriers for the implementation of GSCM practices***

Figure 15 exemplifies the general average of how the respondents scored the barriers of their suppliers, while figure 16 illustrates the results for each barrier. In addition, an open question about general perceptions on the barriers was included on the contractors questionnaires (see table 5) to get more depth. Another source of information was the responses from the five suppliers.

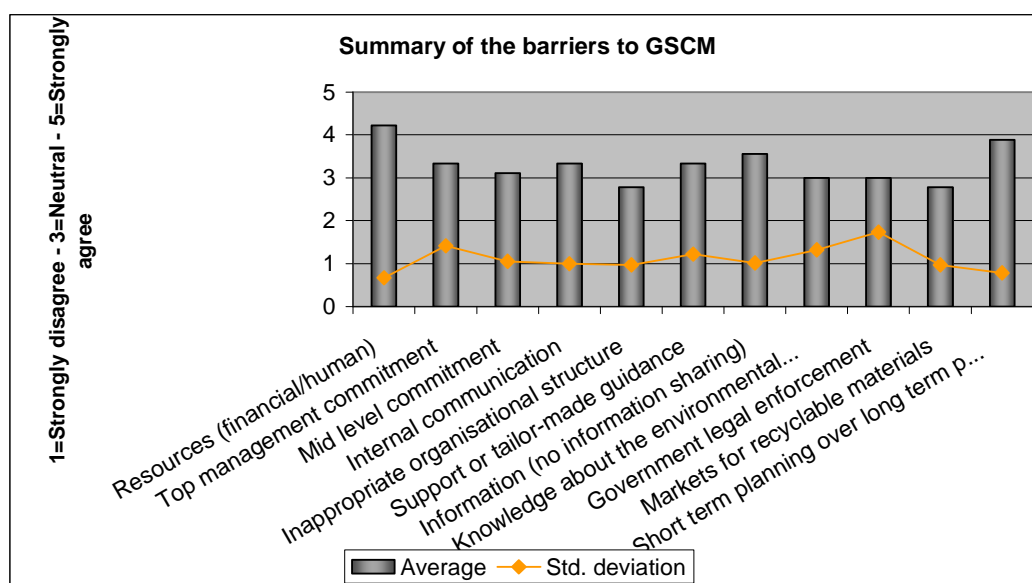


Figure 15.- General averages about perceptions on the barriers for GSCM

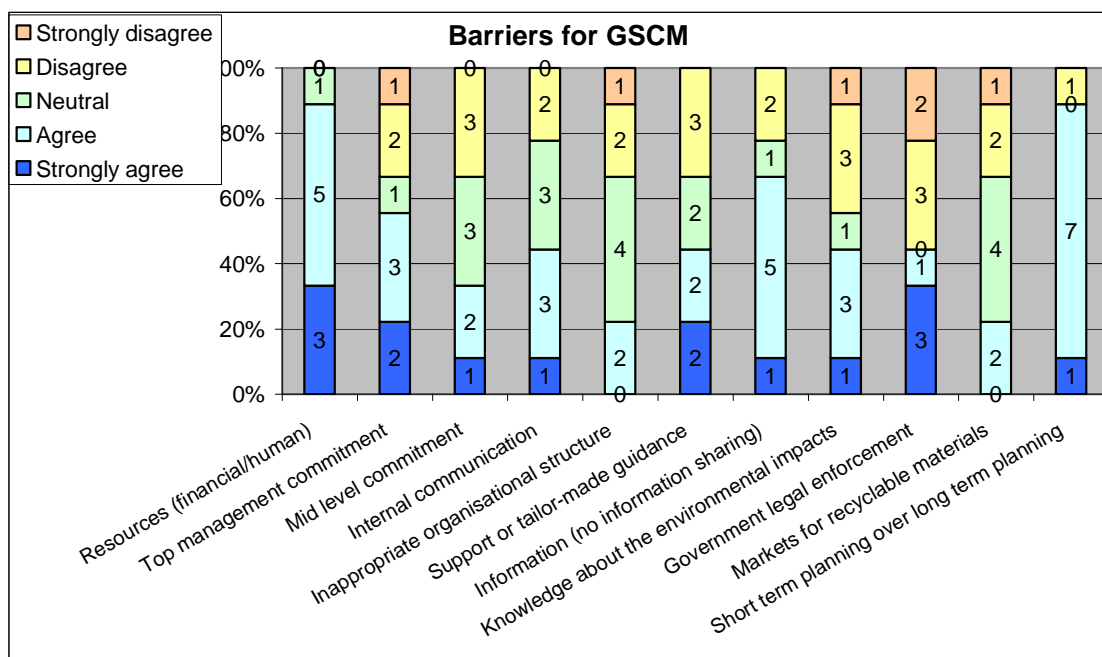


Figure 16.- Detailed results of barriers for GSCM

Table 5.- Barriers stated on the open question

Company	What are the main barriers to engage your suppliers?
AMEC	
AMEY	- Their knowledge and resources. - But this is a product/service specific comment. Some e.g. aggregate black top suppliers are well advanced.
Carillion	- Knowledge of the supply chain, in particular their understanding of the social and economic aspects of sustainability. - Complexity of life cycle models. - Potential cost increases.
CPPLC	- The size of the supplier and the number of clients they have (less likely to be influenced etc). - Lack of government regulation.
Keepmoat	
May Gurney	- Time, resources, large amount of rapidly changing environmental legislation.
McNicholas	
Miller	- Willingness to participate and a genuine understanding of the issues. Many suppliers already have excellent policies, whilst others have a long way to go.
Willmott Dixon	- Resistance due to fear of change amongst supply chain. - Efforts are not industry wide so we stand to lose good suppliers who can work for someone else and not have to worry about environmental issues. - Clients are not prepared to pay any extra to achieve a quality supply chain despite their rhetoric.

The first group of barriers is formed by *lack of resources*, *short term planning* and *lack of markets to recyclable materials*. The first two were the most relevant identified by large

contractors with an average of 4.22 and 3.88 respectively, and also had the lowest standard deviation, which means that there was agreement on the relevance of these two barriers. Lack of resources (financial or human) has been recognised before, especially for SMEs, as the most relevant for companies trying to implement environmental measures (Stoesser, 1997; Rondinelli and Vastag, 2000). Short term planning can be linked to the former because usually for SMEs the top priorities are more about survival and immediate solutions, while the benefits of environmental measures can take years to become visible and sometimes it is not possible to associate with the investment required (Freimann and Walther, 2001). The relevance of these barriers was confirmed by the suppliers' responses that stated short term planning as the most important constraint and lack of resources as the third most important.

A second group of barriers is formed by *lack of information* (average=3.55), *lack of knowledge* (average=3) and *lack of support or tailor-made guidance* (average=3.33). Although the averages do not show them as highly relevant for contractors, it is worth mentioning that on the open question (see table 5), four of the respondents stated that there is still poor understanding of at least some of the issues mentioned before. Darnall and Edwards (2006) emphasize the relevance of internal capabilities in order to succeed in implementing environmental management practices. The understanding of these types of barriers could explain why all the respondents are providing training or information to their supply chain in order to overcome them (see figure 9).

Another group of barriers is formed by *top management commitment* (average=3.33), *middle management commitment* (average=3.11), *internal communication* (average=3.33) and *inappropriate organisational structure* (average=2.77). The averages are situated close to the neutral band, meaning they are not considered as relevant as the barriers mentioned before. From the suppliers' side, all these barriers were scored even lower than contractors. This agreement between the two sides of the supply chain shows that the commitment in the supply chain towards GSCM implementation is not considered at the moment as relevant as the other barriers mentioned before.

Finally, *lack of government legal enforcement* (average=3, std. deviation=1.73) that was scored *neutral* on the general grade. However, this barrier had the highest standard deviation and figure 16 illustrates that almost half of the sample agreed while the other disagreed on this barrier. On the suppliers side, this barrier was the second most important.

## Perceptions about the economic performance of GSCM

When asked about economic implications because of GSCM, all the respondents expected to have some kind of economic impacts. In order to obtain information, a short list of positive and negative economic impacts were presented to score them in terms of their experience or perceptions. The results are shown on figure 17 and 18.

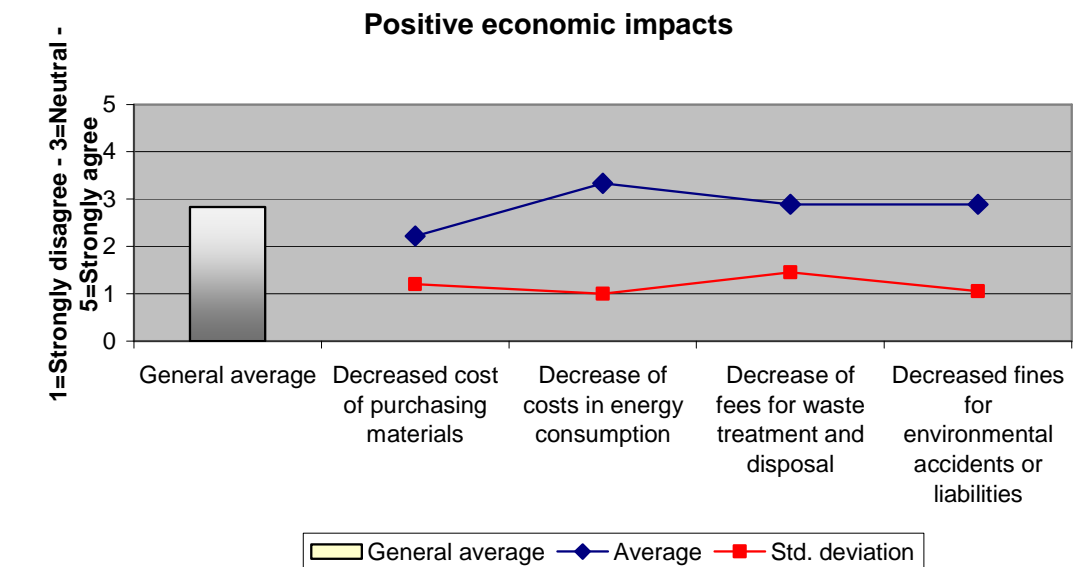


Figure 17.- Perceptions about the positive economic impacts

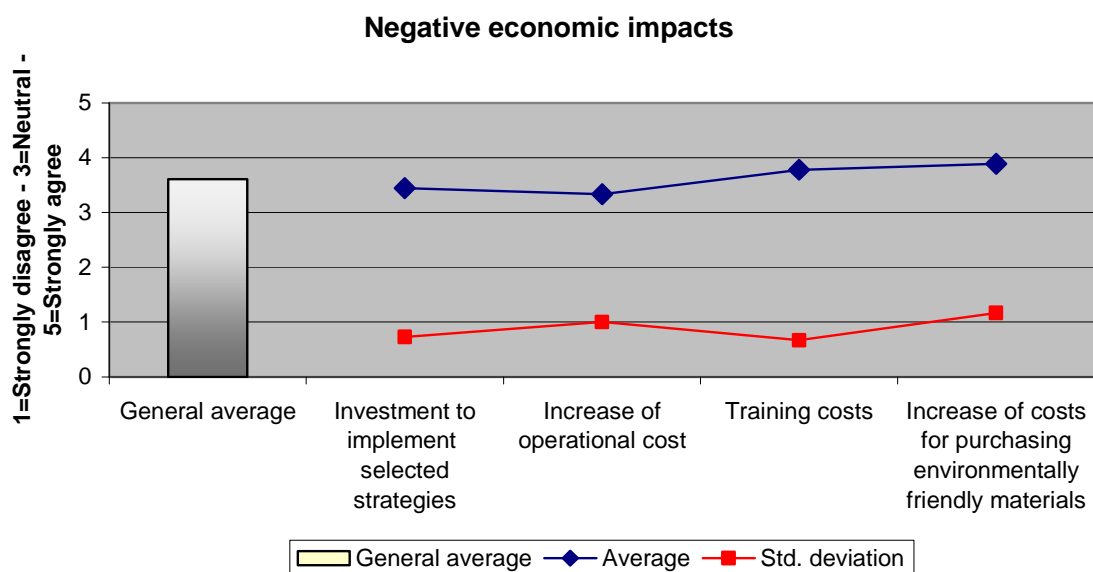


Figure 18.- Perceptions about the negative economic impacts

As discussed in the introduction, and confirmed on one of the telephone interviews, the economic performance of GSCM still remains to be seen. However, this question aimed to find out the perceptions of big contractors on this matter. It has to be considered that all these impacts are not isolated from each other and they could all happen at the same time in different fronts.

A general comment is that positive economic impacts were scored below the neutral band (general average=2.83) except for decrease in energy consumption, while negative impacts were all scored above (general average=3.61). Meaning that at least at this point of GSCM and with the results obtained so far, the expectations are more inclined to the costs and investments required to implement such measures than to the economic benefits. Furthermore, the standard deviations of the positive economic impacts were relatively higher than the negative impacts, so there was more agreement on what kind of negative impacts could be expected, while the positive impacts remained unclear. The explanation of this relationship could be that any type of management strategy usually requires investment to obtain profits. And in the case of GSCM this is the expected scenario, given the maturity and time that GSCM has been present on the construction industry. On the other hand, this result differs from the results of the drivers analysed before, in which the economic motivators had been identified as one of the major drivers for GSCM. The result on the suppliers responses was similar, the negative impacts had an average of four with a standard deviation below 0.6, while the positive impacts were scored below three (average=2.5) with higher standard deviations.

In terms of the positive impacts the highest score was for decrease in energy consumption. This statement is broad and with the available information it was not possible to get detailed expectations about this topic. Decrease of fees for waste treatment and decreased fines for environmental liabilities were scored similar and close to the neutral band. This illustrates again that still there has not been enough evidence of such savings. Although considering the amount of current and coming legislation (i.e. site waste management plans), it would be reasonable to expect these types of benefits in the future.

The lowest score was for decreased costs of purchasing materials, which corresponds with the highest score of the negative impacts (see figure 15 & 16). This confirms that the expectation for environmentally friendly products is that it rises the price of the purchased goods rather than decrease it (Rao, 2005).

The second negative economic impact was training, which corresponds with the fact that most of the respondents are dealing with this issue at the moment. The third negative impact scored was investment. On this matter, it would be expected that the biggest investment would come on the suppliers' side because they are the ones that need the modifications on their management practices or technology. And finally, increase of operational cost, which again depends more on the suppliers' side rather than on the customers, although, if this happens in reality, it could increase the operational cost also for the customers.



# Conclusions and recommendations

## *Conclusions*

The research aimed to identify several aspects related to GSCM in the construction industry in the UK by performing two different types of questionnaires to different links of the supply chain. However, the aim of the research had to be modified in order to focus only on the contractors' side considering the low response rate obtained on the suppliers' questionnaire.

Thus, the main objective of the dissertation was partially accomplished. Only one side of the supply chain was evaluated therefore further research about how suppliers are responding and how effective GSCM could be undertaken. In terms of large contractors, the information gathered on the interviews helped to the understanding of how the first link of the construction supply chain is dealing with environmental issues and more specifically with GSCM. The reason behind the low response rate on the suppliers' side might be the size of the companies sampled. In fact, most SMEs have fewer resources dedicated to these types of initiatives and are less pressurised by external forces to implement them.

In terms of the environmental impacts caused by construction, it can be concluded that large contractors have a good degree of awareness. The highest scores on this matter corresponded to most of the impacts identified as significant by the Environment Agency (2003). This included waste, health and safety hazards, use of raw materials and energy consumption, as well as socio-economic impacts.

The responses showed that cost and quality of goods are the most important in identifying a critical supplier, followed by other factors resulting from legislation pressures. Notably, distance was not considered as important regardless of its impacts on the environment.

Moreover, large contractors seem to have the financial and market power to implement GSCM. However, in the construction industry GSCM is still reaching a small percentage of the entire population because of the nature of the market.

One crucial aim of the dissertation was to find out what types of strategies large contractors are requiring from their supply chain. The findings confirmed that process-based strategies are more common than product-based strategies. In the case of product-based only 19% were compulsory, mainly caused by Eco-design and LCA. In contrast the process-based reached 51% as compulsory and was dominated by completion of questionnaires about environmental performance and collaboration with suppliers. Confirming the fact that large contractors are trying to support their supply chain on these issues. EMS, looked at the most complex

strategy of them all was elected by almost all respondents hence confirming its favourable implementation by most large contractors at some point.

In terms of the drivers for large contractors for implementing GSCM strategies, the results showed that the two most important categories were sustainability and economic motivators. However, legislation as a single driver was the most important for the majority of the companies, confirming that this is a major pressure on GSCM implementation. Unlike some sectors, large contractors do not perceived themselves as major targets for NGOs, so the construction industry is not felt as being under significant pressure.

In terms of the barriers that large contractors and suppliers are experiencing during the implementation of GSCM, the most significant were lack of resources and short term planning, followed by problems on access to information and expertise, together with lack of government pressure.

In the end, economic benefits are not yet proven to flow from improved environmental performance. Negative economic impacts from investment in training and environmentally friendly products have outweighed benefits. GSCM is still developing in the construction industry, as confirmed on the interviews.

### ***Recommendations for further research***

It would be worth to exploring in more detail the suppliers, specifically their attitudes and resources to implement GSCM practices, the knowledge and internal capabilities to respond to their customers' pressures, and finally the strategies they are using to overcome the barriers.

In terms of the construction supply chain efficiency and environmental performance, it would be interesting in the future to investigate if GSCM in the construction industry is generating benefits to the companies involved. In the end, the main purposes of GSCM are minimising the damage to the environment while generating positive economic impacts in order to achieve sustainable construction. Finally, it was not possible to estimate in this research the percentage of virgin materials compared to the percentage of recycled materials purchased by large contractors, so another issue would be to monitor the evolution of the markets of recyclable materials in the coming years as an interesting indicator for GSCM in the construction industry.

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## **Appendix 1. Contractors Questionnaire**





June 19<sup>th</sup>, 2007

Dear Sir/Madam:

I am currently undertaking an MSc in Environmental Assessment, Auditing and Management Systems at the University of East Anglia.

The topic I have chosen for my dissertation involves the research of Environmental Supply Chain pressures, barriers and strategies within the construction industry in the UK and the aim is to obtain information from construction firms as well as some suppliers of this sector.

Since your company is a part of the Construction Supply Chain I would be very appreciative if you would agree to participate in this research.

The information will be treated as strictly confidential and if you are interested in the results I will be pleased to send you a short summary when the research is completed.

If you have any questions or require further information please do not hesitate to contact me or my supervisor.

Thank you very much for your support.

Kind regards.

Octavio Barreiro (student)

[o.barreiro-trigos@uea.ac.uk](mailto:o.barreiro-trigos@uea.ac.uk)

Dr. Tracey Nitz (supervisor)

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School of Environmental Sciences

## Questionnaire contractors

Please mark boxes as follows: ☐

### SECTION A

1) What is the size of your company?

Micro	1-9 employees	
Small	10-49 employees	
Medium	50-249 employees	
Large	>250 employees	

2) What is your position in the company?

--

3) What type of construction buildings does your company provide?

Type		Comments
Housing buildings		
Commercial Buildings		
Industrial Buildings		
Education/Healthcare buildings		
Civil engineering works		
Refurbishment and/or maintenance		

4) Is there currently an Environmental Management System in place?

Yes	
No	
In progress	

5) If yes, is the company aiming for official certification?

ISO 14401	
EMAS	
BS8885	

6) What are your perceptions about the following impacts of your company?

	<i>Do not know</i>	<i>Not Applicable</i>	<i>Negligible</i>	<i>Minor</i>	<i>Significant</i>
Waste generation					
Raw materials mining or fabrication					
Air pollution					
Water pollution					
Deposits to land					
Traffic					
Health and safety hazards					
Noise					
Energy use					
Vibration/light/heat					
Economic (e.g. employment, expenditure and income effects, effects on the development potential of the area)					
Social (e.g. population and demographic structure, accommodation and housing)					

## SECTION B

7) How many suppliers does your company have for everyday operations? (Average)

Less than 10	
Between 11 & 30	
Between 31 and 50	
More than 50	

8) Of the next classification, how important are the following characteristics in your company's identification of critical suppliers?

	<i>Very Unimportant</i>	<i>Unimportant</i>	<i>Neutral</i>	<i>Important</i>	<i>Very Important</i>
Cost					
Quality/Performance					
Transport/Distance					
Risk of potential loss (financial, physical, social, other)					
Availability of suppliers					
Environmental performance					

9) Are there currently intentions or actions to include environmental issues on your supply chain management processes?

Yes	
No	
Do not know	

10) If yes, what type of strategies has your company adopted or would be interested in adopting to include environmental issues on your supply chain management processes?

		<i>No requirement</i>	<i>Optional requirement</i>	<i>Obligatory requirement</i>
<b>I</b>	<b>Product based.-</b>			
	Packaging reduction or modification			
	Recycling			
	Eco-design			
	Life cycle assessment			
<b>II</b>	<b>Process based</b>			
	Environmental policy			
	Completion of questionnaires			
	Environmental criteria for supplier selection			
	Waste Management Plans			
	Reverse Logistics Plans			
	Environmental audits			
	Collaboration towards environmental objectives			
	EMS certification			

11) Does your company have the power to engage suppliers into these strategies? (According to the market share or financial power)

<i>Strongly disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Strongly agree</i>

12) What are the main barriers to engage your suppliers?

--

13) Does your company support your suppliers on the implementation of these strategies?

Yes	
No	
Not applicable	

14) If yes, what kind of support is available for your suppliers?

<i>Financial</i>	<i>Training /Guidance</i>	<i>Information</i>

15) What percentage of virgin and recycled materials does your company purchase?

Virgin materials (%)	
Recycled materials (%)	
Do not know	

16) How important are the following drivers for your company to pursue these environmental strategies?

		<i>Very Unimportant</i>	<i>Unimportant</i>	<i>Neutral</i>	<i>Important</i>	<i>Very Important</i>
<b>I</b>	<b>Sustainability issues</b>					
	Contribute to environmental protection					
	Reduction of waste					
	Reduction of environmental risks					
<b>II</b>	<b>Economic issues</b>					
	Cost benefits					
	Avoid fines					

	Image improvement					
	Meet market expectations					
<b>III</b>	<b>External pressures</b>					
	Regulations					
	Customer expectations					
	Community/ Environmental groups					
	Construction sector					
<b>IV</b>	<b>Purchasing process</b>					
	Develop relationships with suppliers					
	Secure the supplies					

17) What are your perceptions about the main barriers of your suppliers to implementing these strategies?

	<i>Strongly disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Strongly agree</i>
Lack of resources (financial/human)					
Lack of top management commitment					
Lack of mid level commitment					
Lack of internal communication					
Inappropriate organisational structure					
Lack of support or tailor-made guidance					
Lack of information (no information sharing between customers/suppliers)					
Lack of knowledge about the environmental impacts of the company					
Lack of government legal enforcement					
Lack of markets for recyclable materials					
Short term planning over long term planning					

18) Has the company had or expect to have economic impacts because of these initiatives?

Yes	
No	
Do not know	

19) What kind of economic impacts has the company experienced or what kind do you expect to have in the future?

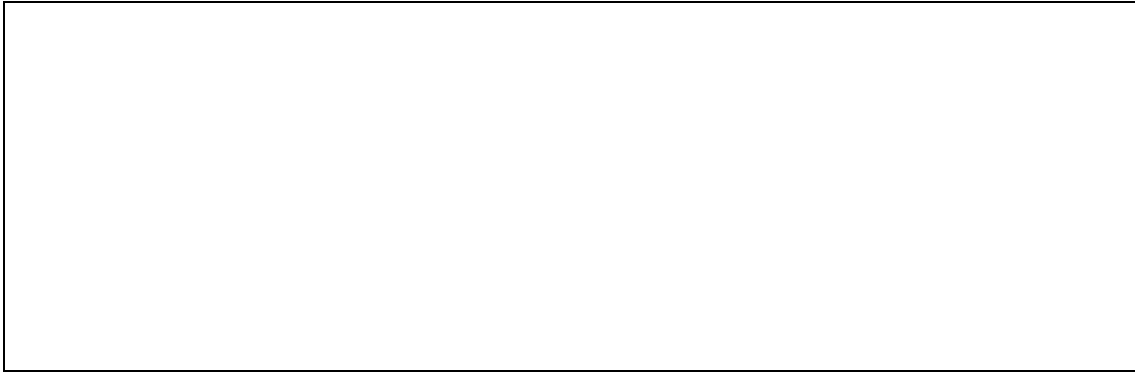
		<i>Strongly disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Strongly agree</i>
<b>I</b>	<b>Positive economic impacts</b>					
	Decreased cost of purchasing materials					
	Decrease of costs in energy consumption					
	Decrease of fees for waste treatment and disposal					
	Decreased fines for environmental accidents or liabilities					
<b>II</b>	<b>Negative economic impacts</b>					
	Investment to implement selected strategies					
	Increase of operational cost					
	Training costs					
	Increase of costs for purchasing environmentally friendly materials					

20) Would you like to receive a short summary of the dissertation?

Yes
No

***Thank you very much for completing this questionnaire***

If you have any comments about the questionnaire or issues involved please write them on the space below.



*Please send it back to [o.barreiro-trigos@uea.ac.uk](mailto:o.barreiro-trigos@uea.ac.uk) or  
[octaviobarreiro@hotmail.com](mailto:octaviobarreiro@hotmail.com)*



## **Appendix 2: Suppliers Questionnaire**



June 19<sup>th</sup>, 2007

Dear Sir/Madam:

I am currently undertaking an MSc in Environmental Assessment, Auditing and Management Systems at the University of East Anglia.

The topic I have chosen for my dissertation involves the research of Environmental Supply Chain pressures, barriers and strategies within the construction industry in the UK and the aim is to obtain information from construction firms as well as some suppliers of this sector.

Since your company is a part of the Construction Supply Chain I would be very appreciative if you would agree to participate in this research.

The information will be treated as strictly confidential and if you are interested in the results I will be pleased to send you a short summary when the research is completed.

If you have any questions or require further information please do not hesitate to contact me or my supervisor.

Thank you very much for your support.

Kind regards.

Octavio Barreiro (student)

[o.barreiro-trigos@uea.ac.uk](mailto:o.barreiro-trigos@uea.ac.uk)

Dr. Tracey Nitz (supervisor)

[t.nitz@uea.ac.uk](mailto:t.nitz@uea.ac.uk) (01603) 593130

School of Environmental Sciences

## Questionnaire suppliers

Please mark boxes as follows: ☐

### SECTION A

1) What is the size of your company?

Micro	1-9 employees	
Small	10-49 employees	
Medium	50-249 employees	
Large	>250 employees	

2) What is your position in the company?

--

3) What kind of services/products does your company provide to the construction sector?

Type		Specifications
Materials		
Labour		
Equipment		
Professional services		
Other		

4) Is there currently an Environmental Management System in place?

Yes	
No	
In progress	

5) If yes, is the company aiming for official certification?

ISO 14401	
EMAS	
BS8885	

6) What are your perceptions about the following impacts of your company?

	<i>Do not know</i>	<i>Not Applicable</i>	<i>Negligible</i>	<i>Minor</i>	<i>Significant</i>
Waste generation					
Raw materials mining or fabrication					
Air pollution					
Water pollution					
Deposits to land					
Traffic					
Health and safety hazards					
Noise					
Energy use					
Visual					
Vibration/light/heat					
Economic (e.g. Employment, expenditure and income effects, effects on the development potential of the area)					
Social (e.g. population and demographic structure, accommodation and housing)					

## SECTION B

7) How many customers does your company have? (Average)

Less than 10	
Between 11 & 30	
Between 31 and 50	
More than 50	

8) Are there currently intentions or actions from your customers to involve your company on environmental issues?

Yes	
No	
Do not know	

9) What type of strategies are your customers requiring to your company?

		<i>No requirement</i>	<i>Optional requirement</i>	<i>Obligatory requirement</i>
<b>I</b>	<b>Product based</b>			
	Packaging reduction or modification			
	Recycling			
	Eco-design			
	Life cycle assessment			
<b>II</b>	<b>Process based</b>			
	Environmental policy			
	Completion of questionnaires			
	Environmental criteria for supplier selection			
	Waste Management Plans			
	Reverse Logistics Plans			
	Environmental audits			
	Collaboration towards environmental objectives			
	EMS certification			

10) What is the percentage of virgin and recycled materials that your company purchases?

Virgin materials (%)	
Recycled materials (%)	
Do not know	

11) What is your perception about the time that your company will need to implement these strategies?

Less than 6 months	
Between 6 months and 1 year	
Between 1 and 2 years	
More than 2 years	

12) Are you receiving or do you expect to receive support to implement these requirements?

	<i>Financial</i>	<i>Training /Guidance</i>	<i>Information</i>
Customer			
Local government			
Government agency			
Private consultancy			
Construction sector			
Other			

13) What are the main barriers to implementing these strategies?

	<i>Strongly disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Strongly agree</i>
Lack of resources (financial/human)					
Lack of top management commitment					
Lack of mid level commitment					
Lack of internal communication					
Inappropriate organisational structure					
Lack of support or tailor- made guidance					
Lack of information (no information sharing between customers/suppliers)					
Lack of knowledge about the environmental impacts of the company					
Lack of government legal enforcement					
Lack of markets for recyclable materials					
Short term planning over long term planning					

14) Has the company had or expect to have economic impacts because of these initiatives?

Yes	
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No	
Do not know	

15) What kind of economic impacts has the company experienced or what kind do you expect to have in the future?

		<i>Strongly disagree</i>	<i>Disagree</i>	<i>Neutral</i>	<i>Agree</i>	<i>Strongly agree</i>
<b>I</b>	<b>Positive economic impacts</b>					
	Decreased cost of purchasing materials					
	Decrease of costs in energy consumption					
	Decrease of fees for waste treatment and disposal					
	Decreased fines for environmental accidents or liabilities					
<b>II</b>	<b>Negative economic impacts</b>					
	Investment to implement selected strategies					
	Increase of operational cost					
	Training costs					
	Increase of costs for purchasing environmentally friendly materials					

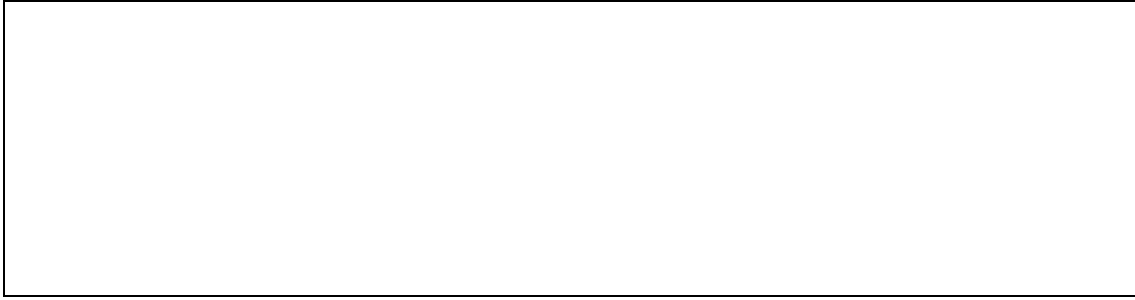
16) Would you like to receive a short summary of the dissertation?

Yes
No

*Thank you very much for completing this questionnaire*

If you have any comments about the questionnaire or issues involved write them on the space below.

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*Please send it back to [o.barreiro-trigos@uea.ac.uk](mailto:o.barreiro-trigos@uea.ac.uk) or  
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