Sustainable development for the logistics industry in the UK

Juan Mao

School of Architecture and the Built Environment

SUSTAINABLE DEVELOPMENT FOR THE LOGISTICS INDUSTRY IN THE UK

JUAN MAO

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Declaration

I certify that the thesis I have presented for examination for the MPhil/PhD degree of the University of Westminster is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

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Abstract

At a time when environmental mitigation is firmly at the centre of the agenda for sustainable development, there is no shortage of research in the field of green logistics. However, little has been done in an attempt to provide integrated solutions for industry, based on a practical assessment of the interrelationships between specific measures. This research investigates the current status of the British logistics industry in terms of its environmental sustainability, by examining 14 sustainable measures that feature strongly in contemporary logistics practice and policies, and determines the interrelationships among them. The primary data was collected using a combined approach involving a postal questionnaire survey and in-depth company interviews. The survey covered both logistics services providers (LSPs) and logistics service users (LSUs), together with the targeted inclusion of more specific actors within the logistics industry.

Through analysis of the sustainable practice and implementation process as seen in the experiences and judgments of key actors in the logistics industry, it is shown that the role of the actors as either logistics providers or users has a certain impact on their perceptions of, and behaviours in, sustainable logistics. Particular characteristics of the company and the sector it belongs to also exert influence, to various extents, on its response to sustainability. The findings also highlight cost-effectiveness as another critical factor determining companies' sustainability policies. On the basis of the assessment of the measures, in particular their effectiveness and cost efficiency, the thesis concludes with proposals for sustainable packages constructed from different perspectives, along with suggestions for their implementation. This evidence-based research thus informs policy-makers of appropriate and viable sustainable strategies with the right incentives in various circumstances, and the potential to bring about tangible improvements in environmental performance.

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

In the Climate Change Act (DECC, 2008), which established the world's first legally binding framework for environment mitigation, the UK Government has pledged to meet the ambitious long-term targets of at least an 80% reduction in greenhouse gas emissions by 2050, as well as an intermediate target of at least a 34% reduction by 2020, both against a 1990 baseline. As a signatory to the Kyoto Protocol, the UK is also committed to a 12.5% reduction in greenhouse gas emissions from 1990 levels in the period 2008 – 2012. Against this backdrop, the UK government has put a great amount of effort into seeking effective sustainable policies from an economy-wide perspective. As a result of many supportive studies conducted for this purpose, the transport sector, especially freight transport, has stood out with its significant potential for cost-effective carbon savings (CfIT, 2007).

As a major integrated function of logistics operations, freight transport cannot be isolated from the broader supply chain network in which it is embedded. In recent years an increasing number of researches exploring the scope of establishing sustainable logistics practices have been conducted in this area. However, as a discipline, the comprehensiveness of the logistics domain has inevitably led to the nature of the limited scope of such research; the vast majority of it focused on addressing specific problems associated with one of the many diverse branches from the logistics stem, such as supply chain design/restructuring, reverse logistics or urban logistics, to name a few. Consequently, the sustainable measures suggested in the literature are mostly subject to this limitation, either being the 'hard science' technological solutions like routeing and scheduling applications, optimisation modelling and alternative fuels and vehicles, or ‘soft science’ solutions such as policy-making, supply chain collaboration and driver training. It was thus considered a valuable contribution to the field to conduct research into integrated sustainable solution package(s) with a holistic and practical view of logistics as an industry.

This research intends to reveal the mechanism and effectiveness of the major sustainable measures recommended in previous literature through an empirical study. By bringing together the ‘isolated’ sustainable measures for specific logistics problems and investigating the interrelationships among them, this research adopts an original, integrative approach to environmental mitigation which is more realistically designed for extensive logistics networks.

1.2 Research Objectives

To address the main issues in reorienting fragmented sustainable logistics research and practices towards an integrated framework, this thesis has two main objectives. Firstly, ***to develop a greater understanding of the key sustainable logistics solutions and the critical factors influencing their actual or potential performance.*** To accomplish this objective, the major sustainable measures adopted in or proposed for logistics operations need to be identified and categorised, based on which the empirical study can then be carried out to evaluate their feasibility and effectiveness in mitigating the environmental footprint of the industry.

Following on from the first objective, the second one is ***to construct integrative, mutually supporting solution packages for key stakeholders of the industry, with recommendations on their implementation***. Meeting this objective requires analysis of the interconnections amongst individual sustainable solutions, associations between the critical factors and companies' behaviour patterns, along with the interactions between the key actors taking differing positions in the supply chain.

1.3 Thesis Structure

The thesis consists of seven chapters as follows:

Chapter Two starts with identification of major environmental challenges faced by the logistics industry, followed by the definition of sustainable logistics and a clarification of the concept of sustainable logistics solutions that have been adopted throughout this research. In the following section, an overview of the current logistics industry within the UK, including its structure and functioning, is provided, along with the highlights of some major trends significantly influencing the industry and its sustainability. Building upon the fundamentals, this chapter sees the rationalisation of a wide range of existing sustainable solutions into an organised typology framework of 14 thematic categories. Key research findings within each of the categories are then reviewed, with focuses being placed on the solutions' practical applications, critical factors influencing their actual or potential performance, and reported evidence of cost and benefit of their implementation.

The methodologies developed to serve the research objectives employ both quantitative and qualitative techniques. Starting with a brief overview of methodology applications in contemporary logistics research, the research process used in this thesis is defined in Chapter Three. Nine key research hypotheses are then constructed to satisfy the two objectives of the research. Finally, a complementary set of approaches, including an industry-wide two-stage questionnaire survey, a series of semi-structured in-depth company interviews and case studies, is outlined.

Chapter Four reports on the quantitative analysis of the present trends and patterns in companies' attitudes and behaviours, building upon the framework of 14 categories of sustainable solution established in Chapter Two, and on the collected evidence from the two questionnaires distributed to a sample of logistics service providers (LSPs) and logistics service users (LSUs) throughout Great Britain. Detailed analysis identifies the critical factors related to each of the individual sustainable solutions, mainly in terms of adoption, implementation and cost-effectiveness.

The preliminary findings from the survey analysis are strengthened and further developed in Chapter Five with the analysis of the qualitative evidence from the in-depth company interviews. This provides insights into the complex and dynamic logistics systems where interwoven factors are inseparably impacting on the prevailing views and practice of sustainability in the industry. The combination of both the quantitative and qualitative analysis enables the nine hypotheses established in Chapter Three to be tested.

Based on the analysis results and findings from Chapter Two, Four and Five, the solution packages are devised to achieve the overall research objectives, with suggestions for their implementations provided and implications addressed in Chapter Six.

Chapter Seven concludes the thesis with summary of the key findings of this research and looks into the areas which provide powerful pointers for future research and policy development.

1.4 Scope of Research

The scope of this research is confined to domestic logistics activities in the UK, in particular those associated with road haulage operations. This is partly due to the lack of an agreed convention for the definition and allocation of international freight transport's environmental externalities to individual countries. The fact that most government targets (e.g. the UK's Kyoto target), projections and modelling usually does not include emissions from international transport (CfIT, 2007) reflects the difficulty and ambiguity implicit in dealing with this issue. Retaining the consistent scope helps to enhance the applicability of this research and makes the project more manageable.

1.5 Summary

Providing a brief outline of the thesis, Chapter One has explained the initialisation of this research and specified the two research objectives, followed by the overall structure of the thesis. Finally, the scope of the research, along with its potential implications, was discussed.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Chapter One set out the objectives of the dissertation and provided a introduction to the problem to be tackled. In this chapter, a literature review is conducted to set out background information which forms the foundation of this research.

Firstly, sustainability issues facing logistics operations, primarily the environmental implications of freight transport, are examined from different perspectives in Section 2.2, followed by the definition of sustainable logistics in Section 2.3 and an overview of the contemporary logistics industry in Section 2.4. The current state and major trends of logistics practice is outlined, showing potential room for improvement in the sector's environmental performance.

Secondly, the literature on sustainable logistics solutions, either in practice or under development for future adoption, is reviewed in Section 2.5. Given the broad range of current solutions, one of the main purposes of this review is to encapsulate the concept and functionality of existing solutions, based on which a framework of 14 key sustainable solution categories is constructed. Previous research findings regarding the application and performance/feasibility of each solution, including cost and benefit studies, the approaches for adoption and implementation, as well as its implications, are summarised.

Finally, the chapter concludes with gaps identified during the literature review, which lead to the rationale of the applied methodologies in Chapter Three.

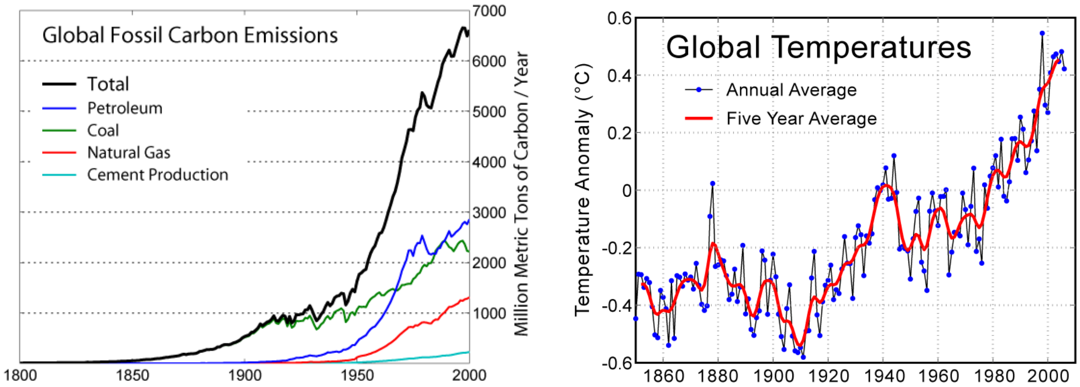
2.2 Environmental Issues of Logistics Operation

2.2.1 Environmental Externalities of Freight Transport

Among all logistics activities, transport is conspicuously the major contributor to the deterioration of natural environment. Broadly there are three primary sources for its environmental impact: construction of transport networks, operation of transport vehicles, and disposal of transportation vehicles and parts. Most of the literature addressing environmental issues of freight transport refers to the operation of transport vehicles only, with the other two polluting sources mainly regulated by land-use planning and waste policies respectively. Apart from external effects in economic and social domains (e.g. congestion, land use, vibration, noise, vision intrusion, public health and safety), the major environmental externalities of freight transport include emissions of greenhouse gas (GHG), toxic chemicals and other air pollutants from exhaust of vehicles, and resource depletion (e.g. fossil fuel consumption). Although the inherent social and economic implications of logistics operations lie well within the scope of sustainable development (see Section 2.3), this research prioritises addressing the environmental footprint of logistics industry.

Relying heavily on the usage of fossil fuel, which is the largest source of GHG emissions, transport directly contributes to climate change, particularly global warming, as illustrated in *Figure 2.1*. Some of the pollutants from transport have a direct effect on human health (Plowden and Buchan, 1995), such as carbon monoxide (CO) and particulate matter (PM); while others including lead and hydrocarbons (HC) are believed to have carcinogenic properties (DfT, 2004a). Emissions of nitrogen oxides (NO_x) and CO also contribute to the acidification of the environment. The result is damage to buildings and properties through acid rain, while woodland areas and some types of agricultural crops are adversely affected as well (DfT, 2004a).

Figure 2.1: Correlation between global fossil carbon emissions (left) and temperature record (right)



* The zero on the right hand figure is the mean temperature from 1961-1990.

Source: Marland et al. 2003; Rohde, 2005

Besides air pollution, noise pollution generated in logistics activities is mainly from vehicle movement, such as aircraft noise, especially during take-off and landing, rail train's horns, and truck movements. Unlike air pollution, which dissipates into the atmosphere, vehicle noise is a local phenomenon and will carry for only relatively short distances (DfT, 2004a).

A number of researches have specifically reported the more severe environmental impacts of logistics activities in urban areas with high population density. According to DETR (2000), up to 75% of NO_2 and 30-40% of PM are derived from road transport in busy urban areas. In London, transport accounted for 21% of the total carbon emissions in 2002, and road freight transport contributed more than a quarter of the CO_2 produced by transport (TfL, 2004). Road freight vehicles operating in an urban environment tend to emit a greater proportion of certain pollutants per unit of distance travelled than other motor vehicles such as cars and motorcycles, due to their higher fuel consumption rates per km and the widespread use of diesel (Browne et al., 2007). Moreover, the passage of a heavy truck may cause as much damage to the road surface as that of 2500 cars (Charles River Associates, 1969; cited in Browne et al., 2007). Hence road freight operations, predominantly involving HGVs, are attributable for most of the wear and tear on roads.

Also in urban areas, as goods vehicles contribute significantly to traffic noise, directly causing disturbance to residents and pedestrians on routes, their operations during evening or night hours are often restricted or prohibited, with local authorities often regulating loading and unloading of goods in certain areas. Finally, it is observed in many urban areas that road traffic grows at a faster rate than road capacity, where congestion, safety and unreliability of the network is worsening (FTA, 1996). The problem is greater particularly in older urban areas and city centres with narrow roads and shortage of parking space (Civic Trust et al., 1990; cited in Browne et al., 2007).

2.2.2 Interrelationships between Externalities

The aforementioned implications of the main logistics activities cannot be addressed in isolation, as there is significant interaction between them (Himanen et al., 2005). Measures that reduce one negative impact of logistics operations may well increase another. Take urban logistics as an example; banning HGVs from an urban area may be beneficial in terms of visual intrusion, physical intimidation and noise, but may lead to a greater total number of trips performed by smaller vehicles, and hence result in more fossil fuel use and pollutant emissions (Browne et al., 2007). Therefore, decisions should be made beyond the confined context of individual industries or fields, and integrative solutions designed, incorporating all the possible interactions.

Interconnections among the three dimensions of sustainability (i.e. environmental, economic and social dimensions) also play an important part. The Stern Review (Stern, 2007) examined the economic costs of climate change, concluding that the overall costs of strong and urgent action on climate change will be lower than the costs thereby avoided of the impacts of climate change under business as usual. Likewise, other environmental and social externalities have direct or indirect economic implications. Ogden (1992) examined the economic costs of accidents, for instance, which consist of delay costs, accident costs, increased vehicle operation costs generated by more congested traffic following the accidents, and clean-up costs. Ogden (1992) also estimated that the cost of excess truck noise is equivalent to 1% of total truck operating costs, with those for emissions being 0.2% of total costs.

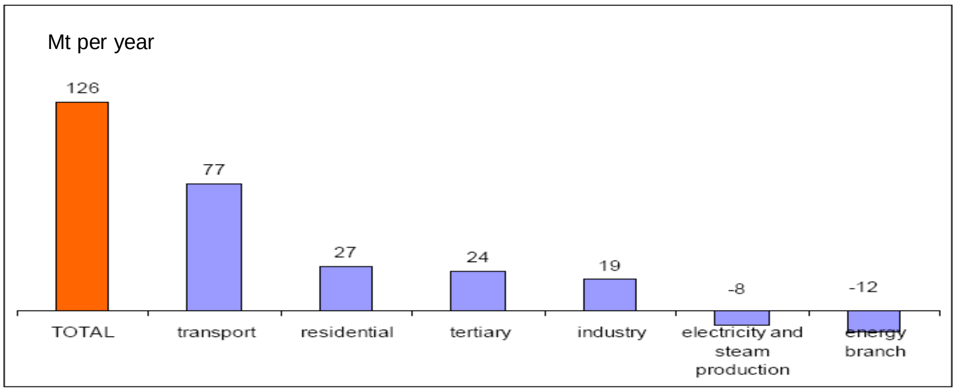
Although it is plausible to seek an ideal balance between economy, society and environment in achieving overall sustainability, when it comes to conflicting goals, trade-offs have to be made by priority. As the Stern Review (Stern, 2007) argued, climate change presents very serious global risks and should be given priority over other issues. Therefore improvements in all areas are desirable, but must be tested against their overall carbon implications. Take alternative transport as an example: there could be a negative net effect on the environmental if local air quality or noise impacts were reduced only at the cost of making rail travel uncompetitive and forcing freight or passenger traffic onto roads (DfT, 2007a).

From a different perspective, climate change may also have extremely adverse impacts on logistics operations. The increased frequency of severe weather conditions (e.g. heavy rains, high winds, etc) has been one of the main causes of disrupted transport service, and adds great uncertainty to its reliability. Network Rail is currently developing a climate change hazard map to identify weak links which are particularly vulnerable to risks, such as flooding or embankment landslip during extreme weather (Network Rail, 2010).

2.2.3 Growth Pattern of Freight Transport

Considered as the "single largest source of environmental hazards" (Wu and Dunn, 1995), the transport sector as a whole accounts for 26% of global CO_2 emissions. With its GHG emissions rising by 26% in the EU27 between 1990 and 2007 (EEA, 2009), it is also the sector with the fastest growth projection of GHG emissions in the EU by 2020 (Eurostat, 2004), see *Figure 2.2*.

Figure 2.2: Forecast changes in greenhouse gas emissions, EU 2005-2020



Source: Eurostat, 2004

Transport emissions growth in the UK shows a similar trend. Using the 'well to wheel method' [1], the transport sector is statistically the largest source of emissions in the country, and the only sector whose emissions grew significantly between 1990 and 2005 (11% excluding international movements), a period in which reductions in other sectors of the economy saw total UK carbon emissions fall by 5% (DEFRA,

[1] By using 'end-user' figures (also known as 'well to wheel' method, which allocates upstream emissions from power station and refineries to the sectors consuming electricity or fuel) and including international aviation and shipping, transport accounted for 32.4% of total UK carbon emissions in 2005. The figure becomes 27.4% when international aviation and shipping are excluded.

2007c). The upward trend continued until 2008, when GHG emissions in the sector decreased mainly as the result of the economic recession (DECC, 2010).

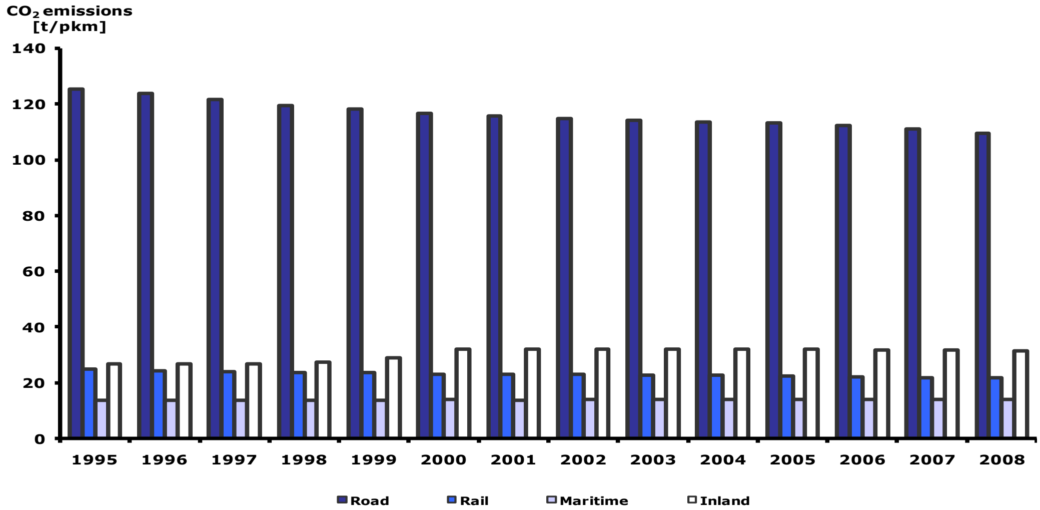
In contrast with the considerable attention given to emissions in the transport sector, little concern has been focussed specifically on the freight transport segment. In Europe, freight transport accounts for about one quarter of the transport sector, growing faster than any other sector in the economy, with road and air freight recording the largest increases in the EU-27 (43% and 35% in terms of tonne-kilometres, respectively) between 1997 and 2007 (EEA, 2010). During the same period, freight transport in the UK has increased by 9%, with road transport increasing by10% (DfT, 2009a).

Nevertheless, the relationship between the growth pattern of freight transport and its emissions is not clear in the absence of further breakdown analyses. Estimates of CO_2 emissions from freight transport vary widely, as a result of great discrepancies in available statistics, data collection and calculation methods, and in assumptions made by researchers. Take the UK domestic transport sector for instance. It is reported that vans and lorries accounted for 35% of total domestic transport carbon emissions in 2005 (DfT, 2006; DEFRA, 2007c), making it one of the fastest-growing sources of transport emissions along with air travel (CfIT, 2007). However, the share was estimated to be below 20% in McKinnon's (2007b) research for the same year. In a Government pocket book on 'Sustainable Development Indicators' (DEFRA, 2006b), CO_2 emissions from HGVs are claimed to have risen by 29% between 1990 and 2004, while the figure was estimated at only 5.4% between 1990 and 2005 by McKinnon (2007b). Possible reasons for such discrepancies were discussed in the literature, claiming a potential overestimation of emissions growth in the DEFRA document (McKinnon, 2007b; CfIT, 2007). To conclude, it seems that a robust, coherent and widely accepted methodology, allowing accurate estimates of emissions from freight transport, is urgently needed as the basis for strategy making.

2.2.4 Environmental Performance by Transport Mode

Energy efficiency and environmental impact varies greatly by transport mode in the freight sector. *Figure 2.3* illustrates the differences of CO_2 emissions per tonne-kilometre by transport mode between 1995 and 2008, when a modest improvement in road and rail freight was observed. Being the least energy efficient mode, road haulage has significantly higher carbon emissions than rail and waterway freight, placing modal shift from road to the alternatives, especially rail transport, high on the agenda of sustainable transport policy-making.

Figure 2.3: CO_2 emissions per tonne-kilometre and per mode of transport in Europe, 1995–2008

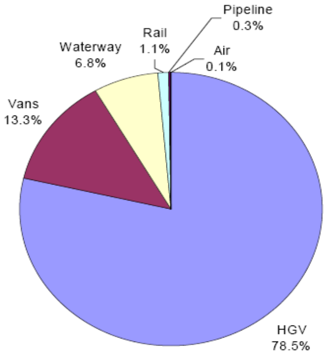


Source: EEA, 2010

It is worth noting that considerable discrepancies and disputations exist in measuring and comparing the environmental performance of various transport modes. Taking the CO_2 emission factor for rail freight for example; although a ratio of less than 25 g/tonne-km is adopted in *Figure 2.3*, the value varies considerably in different sources (e.g. 49 g/tonne-km by the National Atmospheric Emissions Inventory; 41 g/tonne-km by the Royal Commission on Environmental Pollution; 18 g/tonne-km by INFRAS; and 33 g/tonne-km by the University of Leuven). Likewise, for waterborne transport, the CO_2 emission factor largely depends on vessel type, ranging from 7 to 60 g/tonne-km, though the crude estimate of 30-40 g/tonne-km given by McKinnon (2007b) for domestic waterways (i.e. inland waterways and coastal shipping) accords with *Figure 2.3* above. Although not shown in this figure, the CO_2 emissions from domestic airfreight are estimated to be 1580 g/tonne-km by the Network for Transport and Environment and 1925 g/tonne-km by the World Business Council for Sustainable Development. McKinnon (2007b) summarised some reasons for such a discrepancy, mainly being; different assumptions about vehicle capacity utilisation (e.g. load factors) for certain modes, national variations, and calculation methods (e.g. input-based measures and output-based measures).

Besides emission factor, the carbon footprint of each transport mode is positively correlated with the amount of traffic it attracts. In a report prepared for the Commission for Integrated Transport (McKinnon, 2007b), best estimates of CO_2 emissions for each mode have been aggregated to illustrate the composition of domestic freight transport's overall emissions for the year 2004 (see *Figure 2.4*). Road haulage accounts for nearly 92% of the total emissions for freight, with HGVs contributing the most; while rail, air and waterborne transport together account for less than 8% of freight-related CO_2 emissions.

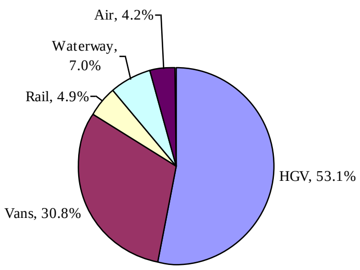
Figure 2.4: Modal share of CO_2 emissions from domestic freight transport, UK 2004



Source: McKinnon, 2007b

Generally, the data derived from McKinnon's (2007b) research is comparable with official statistics published by DfT (2006, see *Figure 2.5*), given that the latter did not differentiate figures for freight from those for passengers on rail, waterways and air transport. The only significant discrepancy between the two sources is the different contribution of vans and lorries in terms of CO_2 emission. McKinnon's result indicated a ratio of 86:14 between HGVs and vans, while DfT's figure 63:37 represents a greater environmental impact of light duty vehicles. The possible reason for this variation is the exclusion of non freight-carrying activities of vans in McKinnon's research, resulting in a lower reported impact by the van sector.

Figure 2.5: CO_2 emissions from transport sector by mode, UK 2004



	In MtC	As per cent of total domestic transport	As per cent of total UK CO_2 emissions
Road transport[a]	**32.6**	93.1	21.4
of which: Passenger cars	**19.4**	55.5	12.8
Light duty vehicles	**4.4**	12.4	2.9
Buses	**1.0**	2.8	0.6
HGVs	**7.6**	21.6	5.0
Mopeds & motorcycles	**0.1**	0.3	0.1
Railways	**0.7**	1.9	0.4
Civil aircraft	**0.6**	1.9	0.4
Shipping	**1.0**	2.9	0.7
All domestic transport[b]	**35.0**	100	23
Total UK emissions	**152.5**		**100**
Memo items:			
International aviation	**9.0**		5.5
International shipping	**1.6**		1.0
All transport emission (incl. International)	**45.7**		28.0
Total UK CO_2 emissions (inc. International)	**163.1**		**100**

Source: Netcen data published by DfT in Transport Statistics Great Britain, 2006.

a. Total road transport includes a small amount of emissions from LPG vehicles and from engines.

b. Total includes a small amount of emissions from other mobile sources and machinery.

Source: DfT, 2006

Of all transport modes, aviation has raised great concerns due to its significantly higher emission factor and growth rate. Having grown fastest of all transport modes, domestic aviation has seen its emissions doubled since 1990, while international air traffic emissions have increased by 123% (CfIT, 2007). However, aviation's wider impact on the environment is still uncertain. Besides the effects of CO_2 emissions, scientific studies have revealed the additional atmospheric effects of non-CO_2 emissions (e.g. NO_x, particles and water vapour) at high altitudes. Given the argument that the global warming impact of non-CO_2 emissions is much more short-term than that of CO_2 which remains for hundreds of years, the overall climate change impact of aviation is yet to be further assessed. Furthermore, approximately two-thirds of airfreight tonnage is carried in the cargo space of passenger aircraft. Dedicated freight aircraft represent only about 3% of total aircraft movements (CfIT, 2007). Given these factors and geographical constrains on the further development of inland waterway transport in Britain, the railways remain as a realistic alternative mode of sustainable transport in the future. Modal shift aiming at transferring more freight traffic from road onto rail will be addressed in detail later in this thesis.

2.3 Sustainable Logistics

Various definitions of sustainable development and sustainable logistics are reviewed in this section, in order of their applicable scope. While a generic definition with a broad scope may help reveal the essence or ultimate goal of sustainability, the ones with detailed, specific objectives, particularly blueprinted for logistics systems, are more practical for application.

The most widely quoted definition of sustainable development is "development that meets the needs of the present without compromising the potential of future generations to meet their own needs" (World Commission on Environment and Development, 1987). The broad scope of this definition was narrowed down to the one proposed by Himanen et al. (2005) for sustainable transport, which could also be adapted for a sustainable logistics system – a system that in itself is structurally viable in an economic, environmental, and social sense, and which also does not impede the achievement of overall sustainability of a society.

The Council of Transport Ministers of the European Union adopted a more in-depth definition of sustainable transport in 2001, which applies to both public and freight transport sectors (Rahman and van Grol, 2005). This approach, an adaptation of an earlier proposal by the Centre for Sustainable Transport in Toronto, defines sustainable transport as a system that:

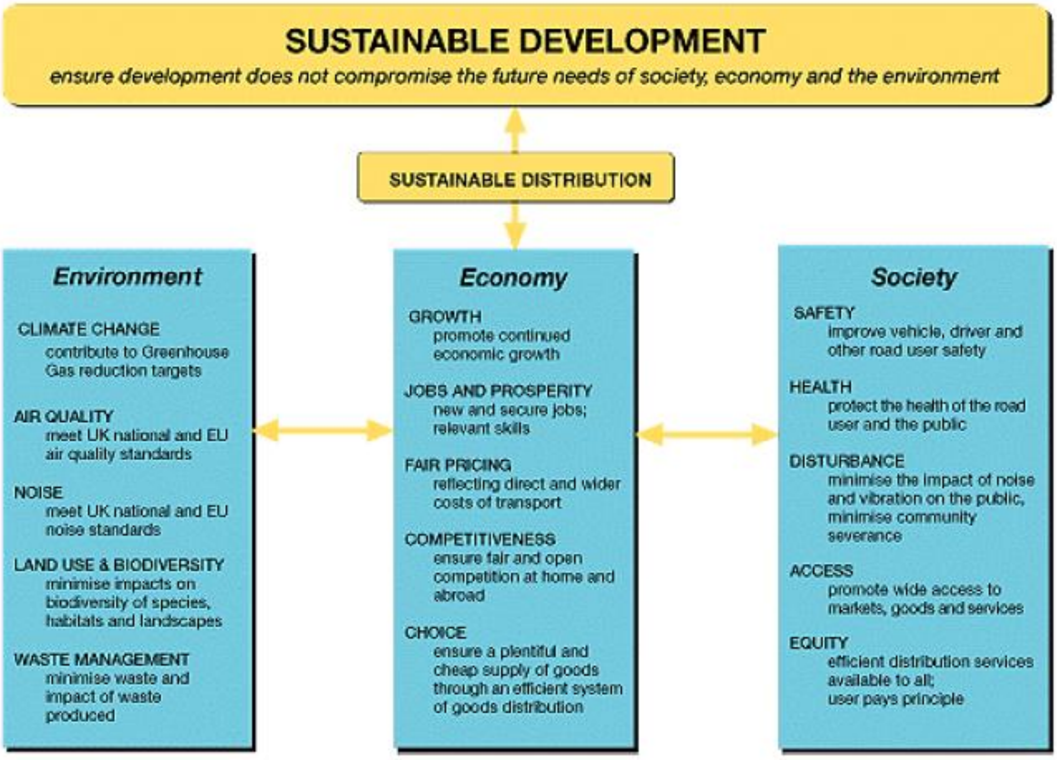
- allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promises equity within and between successive generations;

- is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development;

- limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable resources at or below the rates of development of renewable substitutes while minimizing the impact on land and the generation of noise.

However, it is the concept presented in the UK by DETR (1999) when proposing strategies for sustainable logistics which exceeds all others in its comprehensiveness and systemisation. Based on the definition of sustainable development as development which 'does not compromise the future needs of society, economy and the environment', DETR developed a concept of the 'Triple Bottom Line' which contains a series of performance indicators across the three parameters of society, economy and the environment respectively (see *Figure 2.6*).

Figure 2.6: Conceptual framework of sustainable distribution



Source: DETR, 1999

Different interpretations can be applied, based on this sustainability framework of the triple bottom line. For instance, the UK Round Table on sustainable development (1996; cited in Anderson et al., 2005) regarded ***economic impacts*** as (i) congestion, (ii) inefficiency and (iii) resource wastage; ***environmental impact*** as (i) pollutant emissions including the primary greenhouse gas carbon dioxide, (ii) the use of non-renewable fossil–fuels, land and aggregates, (iii) waste products such as tyres, oil and other materials and (iv) the loss of wildlife habitats and associated threats to wildlife species; and ***social impacts*** as (i) the physical consequences of pollutant emissions on public health, (ii) the injuries and death resulting from traffic accidents, (iii) noise, (iv) visual intrusion, (v) the difficulty of making essential journeys without a car or suitable public transport, and (vi) other quality of life issues (including the loss of green field sites and open spaces in urban areas as a result of transport infrastructure developments).

2.4 Logistics Industry Overview

This section provides the general outlook of the UK logistics industry, including the industry structure, functions and trends, as well as key issues associated with sustainable development of the industry in the future.

2.4.1 Industry Structure Overview

The UK's logistics market is regarded as one of the most mature in the world, with sophisticated operations developed over the last twenty years in line with the evolving needs of customers. The domestic market has become dominated by a handful of logistics giants, and consolidation is continuing, led by demand-side initiatives such as factory gate pricing (Transport Intelligence, 2005).

The logistics market is currently dominated by road transport. In 2008, road haulage accounted for 67% of tonnes moved, and 83% of tonnes lifted in Great Britain[2](DfT, 2009a). Rail freight has increased its share of goods moved in recent years, and is still the major mode for the movement of coal and coke; while waterborne transport continues to dominate the movement of petroleum products.

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[2] Aviation is excluded in the calculation.

As far as road freight is concerned, UK goods vehicles' activities totalled 163.5 billion tonne-km in 2008, when HGVs moved 157.1 billion tonne-km of goods. 68% of the market share is held by public haulage and 32% by own-account operation (DfT, 2009a). Statistics on types of goods carried by goods vehicles highlighted several sectors as major markets; including food, drink and tobacco; crude minerals; building materials; tools, machinery and equipment; paper, mail and parcels; and miscellaneous commodities (DfT, 2009a; DfT, 2007e; DfT, 2005e).

2.4.2 Functions and Dynamics within the Industry

The functioning of the logistics industry is highly subject to the implications of a set of critical factors and the role played by the government. Fuel cost, for instance, which constitutes about one third of HGV operating cost and is largely determined by world oil price and fuel duty, has substantial impacts on logistics operations. Although the fluctuation of oil prices reflects the macroeconomic environment and political status of critical regions, over which the industry has little control, fuel duty has been employed as a fiscal instrument by the government with direct impact on freight transport, in particular road sector.

As a sector with on average a low operating margin (around 4% as reported in Motor Transport Top 100 in 2010), road freight generally has its focus on cost reduction and efficiency improvement initiatives, and passes the rising operating costs on to its customers where possible. However, the strong bargaining position of many customers meant that the costs could not always be passed on in full (FTA, 2011). It is also reported that during the economic downturn, the business investment into new vehicles was largely scaled back, resulting in prolonged vehicle lives.

Interaction between the industry and the government has multiple dimensions. In addition to fuel duty, the industry relies heavily on the government's budget for the investment in transport infrastructure, including local roads and motorways, to address congestion and capacity issues (Eddington, 2006). The government also impacts on the logistics industry through policy making in areas such as road pricing (e.g. Lorry Road User Charging – LRUC proposed in the Coalition Agreement), aviation tax, and its prioritisation of low carbon transport projects.

2.4.3 Company Behaviour Patterns

Like studies in the public transport sector, where individual behaviour is a critical factor, requiring close examination in order to mobilise behaviour change, research into the logistics industry should have its focus on the behaviour pattern of its main actors – companies with logistics operations. It is revealed that a fundamental reason for the continuous occurrence of unintended effects and unattained environmental targets may be that little attention is given to behavioural aspects and social processes during sustainability policy making (Himanen et al., 2005).

Murphy and Poist (2003) carried out empirical research comparing US and non-US firms regarding environmental issues in logistics management. The non-US firms targeted in this survey are from Canada and Western Europe, so the comparison was made between highly industralised countries sharing many commonalities in business culture. Based on the chi-square test results for 6 selected propositions, the study reveals a fairly high degree of similarity between US and non-US firms with respect to their perspectives and practices in green logistics. It shows that most companies are still pursuing a reactive rather than proactive approach to green logistics and viewing it as a tactical rather than a strategic issue. This observation is reinforced by two other surveys among the UK companies (Ghobadian et al., 1995; Dahlmann et al., 2008) which also discovered that bottom line concerns appear to be paramount in guiding corporate behaviours.

Given that countries at different stages of economic development have different natures, representing the evolution of environmentalism, such a "comparative logistics" study can also be applied between developing and developed countries, or further explored with respect to various spatial, temporal/historical and sectoral aspects (Hartley, 1972). Thus, updated empirical studies would be desirable to identify changing company behaviour patterns and their links with geographical location, national characteristics or industry sectors.

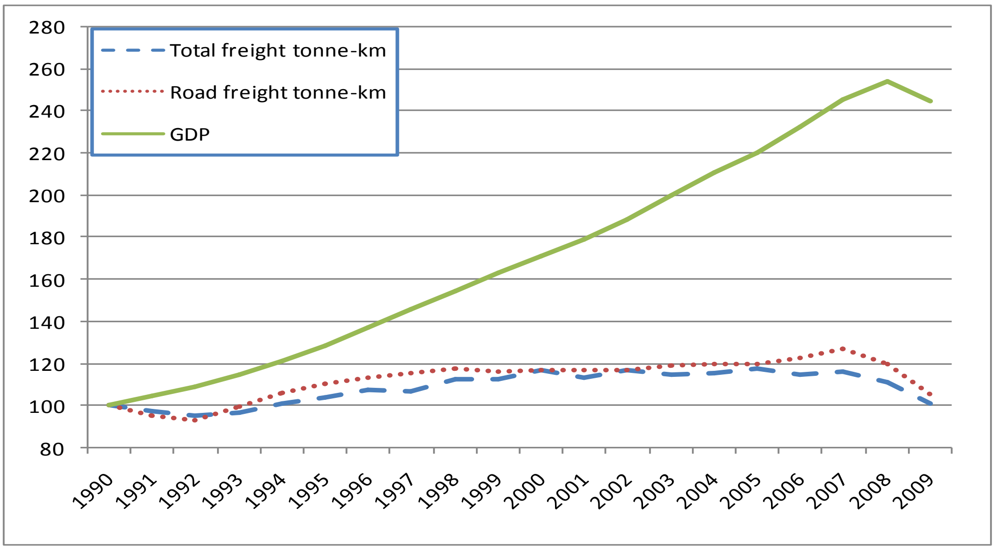
2.4.4 Major Logistics Trends

2.4.4.1 Economic Growth Patterns – Decoupling and Recoupling

In the past few decades, the growth of logistics activities has been seen as a highly correlated trend to the growth of the British economy (see *Figure 2.7*), demonstrating a high level of interdependence between them. Such a relationship had long been regarded as a virtuous circle, until the adverse environmental impact of logistics activities received unprecedented attention in recent years. In 1997, the decoupling point of road freight transport and domestic economic growth was first observed, and since then the link had been gradually weakening (DfT, 2004a), which seems indicate a movement towards sustainable logistics. However, there were few signs of a full breakdown in this unsustainable relationship (Schipper and Fulton, 2003). Furthermore, McKinnon (2007a) argued that the net environmental benefits are likely to be minor once the allowance is given to foreign trucks, vans lighter than 3.5

tonnes, and other transport modes which were excluded from the analysis. A recent update of the linkage revealed that GDP and freight tonne-km trends appear to have been “recoupling” since 2007.

Figure 2.7: Trends in GDP, domestic freight transport tonne-km and road freight tonne-km (index 1990=100): UK 1990-2009



Source: DfT, 2010

A backcasting study has been conducted by Akerman et al. (2006) trying to assess a potential pathway towards future sustainable transport in Sweden. Given the established target of stabilising the concentration of CO_2 in the atmosphere at 450 ppm (parts per million) by 2050, the present technological developments in improving fuel efficiency and reducing energy use in transport were summarised in the study. On this basis, assumptions were made that technical potential would be realised, and that energy intensity would be approximately halved by 2050. However, the study revealed that even with such substantial energy efficiency achieved, when combined with present transport volume and its growth forecast by 2050, it is not possible to reach a fully sustainable transport system. They concluded that only a combination of much improved technology and a transport volume similar to the level in 2000 would come close to reaching the target.

Although their research is based on the Swedish scenario, the same approach could be applied to any other country. With the larger transport volume and faster growth rate observed in UK, the scenario would only be more severe, and require a greater magnitude of institutional changes, rather than incremental ones. Therefore, putting a curb on the growth of transport, while seeking solutions for low-carbon operation at the same time, should remain firmly on the agenda of sustainable development.

2.4.4.2 Outsourcing

Externalisation of non-core business activities, so as to concentrate resources on more competitive operations, has been a significant trend since the 1980s. With logistics operations traditionally functioning as a supportive rather than a profit-generating part of a business, it is not surprising that 59% of the 300 companies surveyed by PE Consulting (1998) in 1996 did not regard it as a core activity. A more recent survey, conducted in 2005 among manufacturing and retail companies, reinforced the trend towards third party logistics (3PL) by revealing that 79% were currently using contractors for their logistics operations (EyeforTransport, 2005).

The upward trend of outsourcing is more evident in the UK. In financial terms, having the highest percentage (34%) of logistics expenditure contracted out in the EU in 1996, the UK was predicted to have 37% of its total logistics outsourced by 2002, compared with an average 28% in the EU (McKinnon, 1999). In terms of road freight lifted, the latest statistics published by DfT (2009a) indicate the share of 'hire and rewards' operation increased from 50% in 1980 to 57% in 2008. Especially regarding the transformation of contractors from providing basic logistics services like transportation and warehousing with a slim profit margin, to premium, value-added and integrated logistics services, a leading role that the 3PL/4PL providers are increasingly playing is reflected in ongoing structural changes since the last decade, such as the globalisation of logistics operation, wide application of information and communication technology (ICT) in supply chain management, and acquisitions and mergers being commonplace in the industry.

Generally, the trend of outsourcing is considered as being a move in the right direction towards sustainability. The connection is often ascribed to the competitive advantages of 3PL providers whose capacity is acquired from strategically bundled resources such as physical, technology, human and knowledge resources (Wong and Karia, 2009). These tend to allow more operationally and environmentally efficient opportunities to be exploited. As an industry, logistics was recognised as a service providing sector in the late 1980s, with the growing emergence of 3PLs (Sheffi, 1990). Consequently, the implications of logistics outsourcing, its impact on economic, operational and environmental performance, together with increasingly dynamic interactions between logistics service providers (LSPs) and users (LSUs) have since been explored in research (for recent studies see Marasco, 2008; Gadde and Hulthen, 2009; Hsiao et al, 2010).

2.5 Sustainable Solutions for Logistics

As key findings of the literature review, major sustainable measures adopted or proposed for the logistics industry are identified, grouped into broader categories, and classified into different levels in this section. In total, 14 categories are generated, each representing a specific field of research interest in sustainable logistics. For each category, the working mechanism, practical applications, cost and benefit, along with its actual or potential environmental performance, are reviewed respectively in Section 2.5.3, which will feed into the analysis and conclusion of this research.

2.5.1 Identification of Sustainable Measures

2.5.1.1 Sustainability through Technological Development

The Stern Review (Stern, 2007) concluded that policy to support innovation and the deployment of low carbon technologies is a key means of mitigating climate change. Although technological innovation is not regarded as the sole answer to the problem, it is believed to be a long-term solution to meet emissions reduction targets. Measures that have demonstrated potential in improving the logistics industry's sustainability through technological innovation include alternative fuels and vehicles, eco-friendly vehicle design, and information and communication technologies (ICT).

Developing alternative fuels and vehicles, to replace the heavy consumption of fossil fuels in the transport sector, is also one straightforward solution at a strategic level to mitigate climate change and atmospheric pollution. *Table 2.1* summarises the main fuels and vehicle types dominating or developing in the market, based on current technology. Presently, transport is still heavily dependent on petroleum-based fuels such as petrol (gasoline), diesel, natural gas and LPG, whilst the alternative renewable fuels highlighted in *Table 2.1* only account for negligible shares.

Table 2.1: Major transport fuels

Feedstock	Fuel		Vehicle
Petroleum	Petrol		Conventional or hybrid
Petroleum	Diesel		Conventional or hybrid
Natural gas	CNG		Conventional or hybrid
Natural gas	LNG		Conventional or hybrid
Electricity	Battery		Electric motor
Natural gas/Petroleum	Gaseous fuels	Autogas/LPG	Internal combustion engine vehicles (modified)
Biomass Biomass (fermentation) Biomass (fermentation) Natural gas/Biomass Biomass (fermentation)	Biofuel	Biodiesel Ethanol Butanol Methanol Propane	Internal combustion engine vehicles (modified) Conventional (modified) or OBR + fuel cell Conventional or hybrid Not economically viable
Natural gas/Electricity	Hydrogen	Compressed gaseous H2 Liquefied H2	Fuel cell (hybrid) Fuel cell (hybrid)

Conventional = traditional internal combustion engine vehicles; Hybrid = conventional combustion engine + electric motor

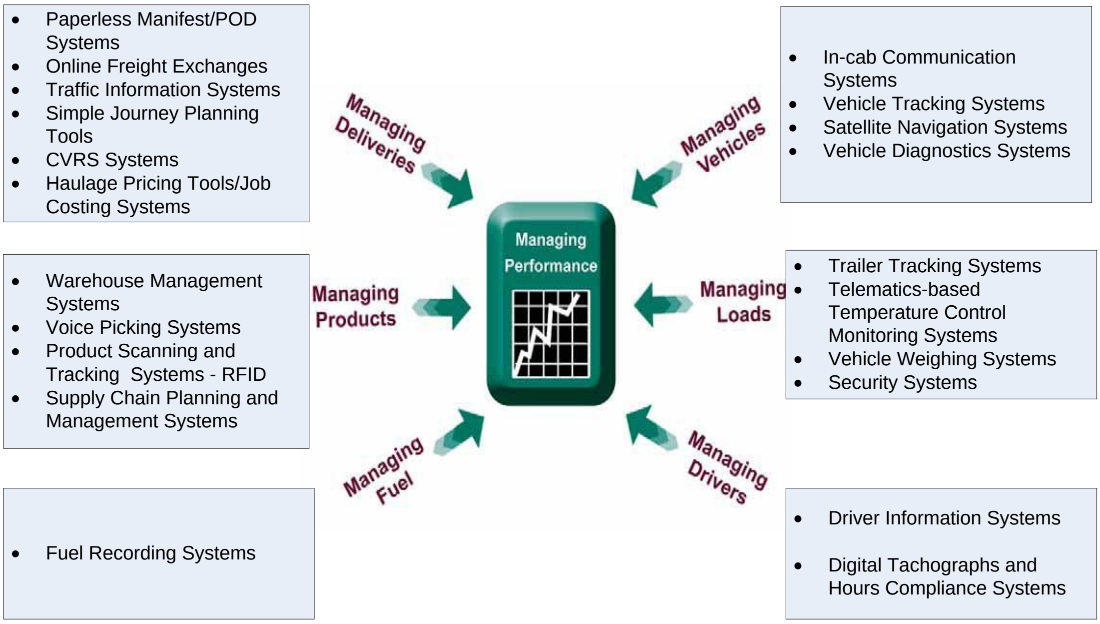
Source: compiled by author

Eco-friendly vehicle design has been stipulated by European emission regulations for new heavy-duty diesel engines, which are commonly referred to as 'Euro I - VI Standards', setting stringent specifications on exhaust pollutants such as CO, HC, NO_x, PM and smoke. First introduced in 1992 as Euro I, the standards have been tightened progressively. Euro V came into force in October 2008, and the latest, Euro VI, was introduced in 2009, and will come into effect from 2013 for approval of new engine types. Under this pressure, technological research and development in improving goods vehicles' overall environmental performance has been progressing over the years to make them safer, cleaner, quieter, and more fuel efficient (for a general overview of available diesel engine and vehicle applications in view of emission reduction, see Zelenka et al, 1996 and Knecht, 2008).

In addition to the development in engine technologies, a wide range of vehicle design technologies have been applied in practice, primarily helping to improve vehicle fuel efficiency. Aerodynamics, for instance, is the study of forces acting on objects moving through the air. Aerodynamic styling fitted to goods vehicles can help to reduce aerodynamic drag, thereby reducing fuel consumption and environmental impacts. This can be achieved by specifying a well-styled aerodynamic vehicle from new, or using a range of add-on retrofitting features (DfT, 2007b).

The application of ICT systems in logistics industry takes a variety of forms, offering great opportunities to improve efficiency in various functions of logistics operations. *Figure 2.8* summarises some major ones in the market and categorises them by their management focus into six key areas. All of these ICT systems come in different shapes and sizes and are believed to benefit both large and small companies by cutting their cost and increasing profitability (DfT, 2007c).

Figure 2.8: Information technologies for efficient logistics operation



Source: adapted from DfT, 2007c

There is further literature reviewing current ICT systems by different classifications. Helo and Szekely (2005), for instance, has divided logistics software applications into intra-firm and inter-firm applications; while Shapiro (2002) has classified them into transactional and analytical applications. The DfT's categorisation is adopted in this research, as it provides a more comprehensive framework which better reflects the practical operations, and is more straightforward for practitioners to follow.

2.5.1.2 Sustainability through Industry Optimisation

Although resorting to technological advances provides an obvious answer to the sustainability challenges, it may only have a minimal effect on carbon emissions compared with what can be achieved through a complete overhaul of supply chain networks – especially as 80% of carbon savings are only achievable at design stage (French, 2007). Based on this premise, another major strand of sustainable logistics research focuses on supply chain restructuring and optimisation, with carbon emissions incorporated into the traditional leverage of cost and service level during supply chain evaluation and design.

The literature of logistics network design mainly takes one of two approaches: cost minimisation (or profit maximisation) or environmental impact minimisation, while little has been done combining both formulations. Addressing the gap in this area, Quariguasi Frota Neto et al. (2008) developed a framework for the design and evaluation of sustainable logistics networks which balances profitability and environmental performance. Using a multi-objective programming approach, their model also allows evaluation of the efficiencies of the existing logistics network and of select legislation measures. For demonstration, the model was applied to the paper and pulp industry across Europe, revealing that strict mandatory legislation (e.g. 100% mandatory recycling legislation in Germany) might not necessarily lock out bad environmental solutions while deteriorating the efficiency of the sector. This suggests that there is space in the actual system for win-win solutions.

There is other research addressing more specific issues with a view of optimising the supply chain and logistics networks which, directly or indirectly, contribute to low-carbon operations. Suggested measures include:

- Backhauling: Backhauling is a key priority in reducing inefficiency in vehicle utilisation. A series of research studies have been conducted by McKinnon et al. (1996, 2003, 2004, 2006), identifying the opportunities for businesses to reduce empty-running and less-than-truckload operations.

- Local Sourcing: A move to locally or regionally sourced products will significantly reduce the distance travelled by goods vehicles, hence the related environmental externalities (Heriot-Watt University, 2007).

- Glocal Production: Akerman (2006) has observed a significant increase of "glocal production" since the turn of the century. Glocal production means that while company management and product development may be centralised, physical production may be decentralised and situated close to consumer markets. The reasons behind this turn include increased transport costs, an overall dematerialisation of society (e.g, through lighter and more durable products) and change in modal shift.

- Postponement: The postponement strategy aims at delaying some supply chain activities until customer demand is revealed in order to maintain both low system-wide cost and fast response. While *manufacturing postponement* delays customisation of products (van Hoek and van Dierdonck, 2000), *logistics postponement* often entails holding inventory at a central location until the demand can be confirmed (Pagh and Cooper, 1998). It is believed that waiting until the last moment to add packaging could have substantial benefits through reduced inventory and transportation costs (Twede et al, 2000).

- Primary Consolidation Centres (PCCs): Following the advent of regional distribution centres (RDCs), PCCs have been further developed since the 1990s. Not only could RDCs be supplied more easily, but PCCs ensure that only full loads of required products are delivered to RDCs, thus minimising vehicle movements (Christensen, 2002).

- Collaboration: Various forms of collaboration are in current practice or proposed, such as the online freight exchange market, where suppliers and hauliers are matched to reduce empty-running (Sarkis et al., 2000). Cross-industry collaboration through swaps, pooling and sharing resources, backloading and skill development, and horizontal collaboration among competing retailers to combine their independent but often parallel distribution networks, are other examples.

- Other proposed initiatives: Some changes in traditional supply chain processes may lead to significant improvements in logistics efficiency. *Nominated Day Delivery System (NDDS)*, for instance, is such a system, which incentivises customers to adhere to a fixed ordering and delivery timetable. On a 'nominated' day, a delivery vehicle is scheduled to visit a particular area and customers willing to receive a delivery on that day need to place their orders a minimum number of days in advance. Concentrating deliveries in particular areas on particular days result in higher levels of load consolidation, drop density and vehicle utilisation, thus leading to cost savings and reduced environmental footprint of the transport operation (McKinnon and Ge, 2006).

  Likewise, replacing the common practice of monthly payment with a *"rolling credit" system* is also proposed by McKinnon (2003a). Instead of invoicing the customers at the end of each month, which results in customers placing orders at the beginning of the month to take full advantage of the 30-day interest-free credit, the new payment approach would give customer the same payment terms – but from the date of order. The fluctuation of monthly delivery volumes can be distributed over the month, and better utilisation of transport capacity can be achieved.

  Another method to increase logistics efficiency is *unattended delivery*, allowing deliveries to be made when no one is there to receive them (McKinnon et al., 2003). Permitting out-of-hours delivery, it gives greater flexibility for logistics operations, as well as the opportunity for greater consolidation (Punakivi et al., 2001).

Apart from supply chain optimisation, there has been growing research interest in optimisation of logistics operations in congested urban areas since the late 1990s. As a result of population and economic growth in the past decades, which is projected to continue in the future, the demand for urban freight transport has been increasing significantly (Stratec S.A., 2005). The situation for the already stretched urban logistics operation is further complicated, in many cases worsened, by some major trends observed in land use planning (e.g. more restricted permission for out of town retail establishments), the demographic transition (toward an increasingly urbanised population in the UK), and changing legislation and regulation (e.g. congestion charging, weight and access time restrictions). The increasing prevalence of home shopping also adds to the mounting demand for not only efficient, but most of all sustainable, urban logistics operations, to cope with these long term changes, while extensions of the transport infrastructure within cities are limited and regarded as unsustainable (Hickford and Cherrett, 2007). To address the major issues confronted by urban logistics, and to inform local authorities in their policy-making, Muñuzuri et al. (2005) compiled a rather comprehensive list of solutions for urban logistics improvement.

Another area receiving great research interest is reverse logistics, covering a range of issues from waste management to reuse, recycling and disposal of end-of-life products. EU legislation plays an important role to see waste management practices developing in its member states over time. The main purpose is to reduce waste and its impact on the environment by setting mandatory recovery and recycling targets for member states. Under the principle of "polluter pays", the producer responsibility policy tool is usually employed to ensure that businesses who place certain products on the market take responsibility for them once they have reached the end of their life. The main European directives with direct impacts in this area are identified as:

- The EU Waste Framework Directive (WFD);
- The EU Landfill Directive;
- The EU Packaging and Packaging Waste Directive;
- The EU Waste Electrical and Electronic Equipment (WEEE) Directive;
- The EU Restriction of Hazardous Substances (RoHS) Directive.
- Other directives on waste oil, End-of-Life vehicles (ELVs), Batteries etc.

Transposition of these directives has been observed in the UK, while progress varies in different areas. However, as Lave et al. (1999) have pointed out, recycling is good policy only if the environmental discharges and resources used to collect, sort, and recycle a material are less than the environmental discharges and resources needed to provide an equivalent virgin material, plus the resources needed to dispose of the material safely. Therefore, life-cycle analysis should be given particular emphasis in reverse logistics policy evaluation. It is more of a challenge to establish an economically and environmentally viable framework for the backflow of products than to set targets for recycling and recovery.

2.5.1.3 Sustainability through Governance

The critical roles that supranational organisations, governments or local authorities can play in preserving the environment have been fully recognised in recent years.

With respect to sustainable logistics, there are three main roles that governments could play: regulator, facilitator, and buyer (Wu and Dunn, 1995).

The role of regulator mainly involves enacting and enforcing environmental laws, regulations and policies at different levels. Implementation of policy instruments is usually a choice between regulatory standards and market mechanism (Himanen et al., 2005). Road pricing, and taxation on fuels and aviation, are examples for the latter; while policies in waste and urban logistics management typify the former approach (see Section 2.5.1.2). Although some researchers believe regulatory standards as the chief policy instrument to mitigate environmental impacts (Greene, 2003), a balanced package of mutually reinforcing instruments is required for the complicated, layered structure of decision-making (Himanen et al., 2005).

The problem is raised that when policies are developed to mitigate negative impacts of transport in one domain, they may involve different institutional actors in another domain, and conflicting policies sometimes result. Efforts to overcome this in the domains of safety and environment are discussed in a report by OECD (1997). With respect to freight transport, more comprehensive sustainability policies easily get entangled in the often quite dominating policy views that exist in trade policy circles (Himanen et al., 2005). Based on the same concerns, Akerman and Hojer (2006) pointed out that the measures which imply synergies with areas outside the environmental domain may be comparatively easy to introduce at an early stage.

Despite interactions with external actors, policy-making is also highly inclined to biases towards economic interests of stakeholders, as well as to the belief that some environmental-friendly alternatives should be preferred (Quariguasi Frota Neto et al., 2008). For instance, Scandinavia advocates that the production of clean virgin pulp is both environmentally and economically preferable over recycling. France favours incineration, while Germany chooses recycling (Bloemhof et al., 1996; as cited in Quariguasi Frota Neto et al., 2008). To address this issue, non-articulated models, in which the user or decision maker does not interact with the model to find most preferable solutions, are recommended.

As previously mentioned in Section 2.4.2, the facilitator role of government in fostering a sustainable logistics industry can be carried out through investing in transport infrastructure development, initiating and supporting innovative R&D projects in sustainable technologies and offering regulatory/financial incentives to businesses to adopt new environmental initiatives. A 'carrot and stick' approach was suggested in FTA's Logistics Report (2011), which recognises and rewards businesses that make improvement in their carbon footprint a priority while makes it more difficult for those who don't. The importance of this role is further reinforced, regarding the areas involved are usually characterized by high inertia (e.g. urban structure planning), and will have profound impacts on the precondition of future sustainability 50 years or more from now (Akerman et al., 2006).

Another focused area in which the facilitation from the government may play an important part is modal shift. As discussed in Section 2.2.4, road freight contributes to nearly 92% of domestic freight-related emissions in the UK. Research also revealed that technological fixes alone are not sufficient for the sector to meet the 2050 CO_2 emission reduction obligations. Modal shift from roads onto alternative, more environmentally friendly transport modes, in particular rail transport, has therefore attracted increasing interest in policy-making and research. However, despite its absolute growth in recent years, rail freight remains a minority mode in the UK, accounting for around 5% of surface tonnes lifted and 8% of surface tonne kilometres moved (DfT, 2009a). The investment priority in rail freight sector is given by the government to increasing its capacity, which is regarded as ‘the biggest contribution of railway to tackling global warming’.

Since government is often the single largest buyer of goods and services in most countries, it can also use its power to buy “green”, thus providing monetary incentives for government contractors (Wu and Dunn, 1995). Edler and Georghiou (2007) have discussed public procurement as one of the key elements of a demand-driven policy that is effective in promoting innovation. Research conducted by Dalen et al. (2005) explored and demonstrated how the government’s choice of contract renewal policy in public procurement can be used as an incentive to achieve desired results, such as improved service quality and more sustainable operations. Taking an integrated life-cycle approach, Li and Geiser (2005) has established that government procurement is the driving force of integrating several key environmental product policy instruments, namely taxes and charges, producer responsibilities and eco-labelling. There are also empirical studies investigating how the green procurement is implemented by current government (see Michelsen and Boer, 2009).

2.5.2 Categorisation and Classification of Sustainable Measures

The major existing and potential sustainable logistics measures identified during the extensive literature review, as summarised in Section 2.5.1, are collated and categorised, with measures approaching certain types of problems or sharing similarities in tackling general environmental issues aggregated into common ‘themes’ as solutions. As shown in *Table 2.2*, altogether 14 solutions are formed based on which various classification methods can be applied.

Table 2.2: Breakdown list of major sustainable logistics solutions

1 Alternative Fuels	
1.1 Biofuels	1.2 Hydrogen
1.3 Other low emission fuels	
2 Diesel Fuel Taxation on Road Transport	
3 Driver Training	
4 Environmental Management Systems	
4.1 Environmental/carbon management and auditing systems	4.2 Corporate social responsibility (CSR)
5 Government Support	
5.1 Regulating	5.2 Procurement
5.3 Facilitating - funding and other support	
6 Inclusion of Transport in the EU Emission Trading Scheme	
7 Information and Communication Technology	
8 Modal Shift	
9 Product/Packaging Design	
10 Reverse Logistics	
10.1 Waste management	10.2 Other reverse logistics
11 Road Pricing	
11.1 Congestion charge scheme	11.2 Low Emission Zone
11.3 National road pricing ("pay-as-you-drive" scheme)	
12 Supply Chain Optimisation	
12.1 Green / local sourcing	12.2 Postponement
12.3 Logistics network restructuring	12.4 Other optimisation initiatives
13 Urban Logistics	
13.1 Urban transhipment/consolidation centre	13.2 Time / route / vehicle size/weight restriction
14 Vehicle Design Technology	
14.1 Engine Design	14.2 Aerodynamic design
14.3 Lower rolling-resistance tyres	14.4 Trailer modification
14.5 Tractor Design	14.6 Longer, heavier vehicles (LHVs)

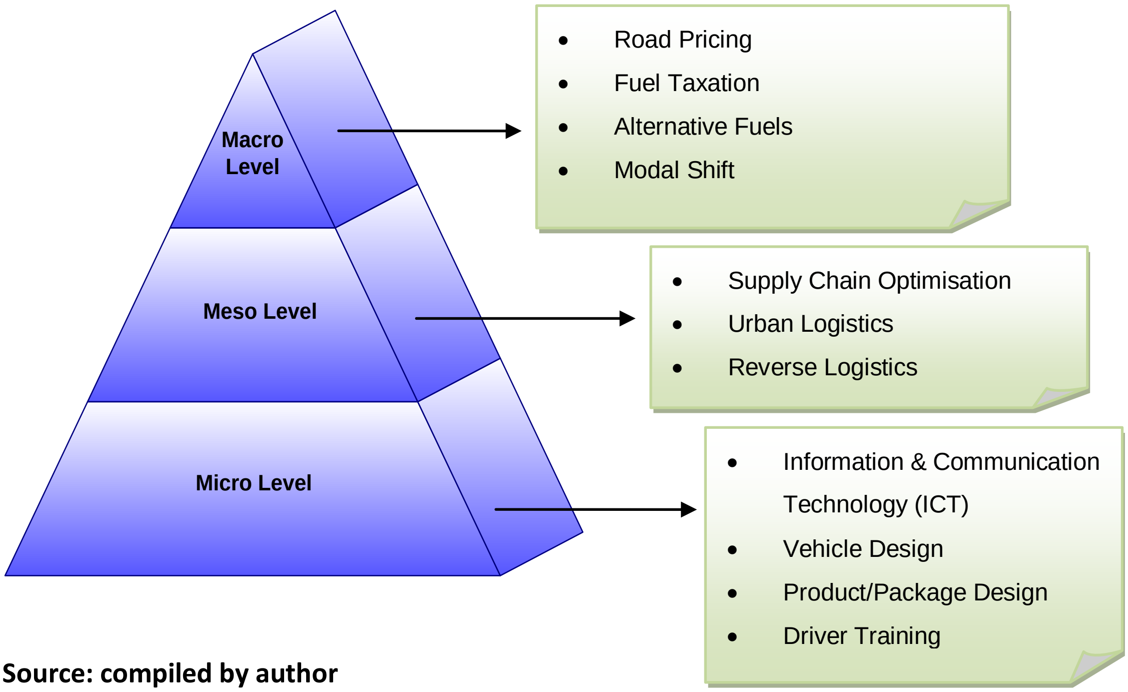
Source: compiled by author

One of the classification methods is to group the solutions into three strategies: the efficiency strategy, the substitution strategy and the reduction strategy (Holden and Hoyer, 2005). The solutions designed to improve the efficiency of logistics operation and maximise the utilisation of limited resources are regarded as the efficiency strategy; while the ones suggesting replacing – partially or completely – the current logistics practice with more environmentally friendly practice, fall into the domain of substitution strategy. Taking a different view, the reduction strategy includes solutions focusing on curtailing the level of demand for polluting logistics activities, especially freight transport.

Modal shift and alternative fuel, for instance, aimed at transferring a considerable part of demand for freight transport to more sustainable means, are typical substitution strategies. The efficiency strategy is employed in most of the other solutions; while the reduction strategy is much less widely applied, but is found in a few solutions such as road pricing, diesel fuel taxation and inclusion of transport into the Emission Trading Scheme (ETS). This highlights the relative difficulties facing the reduction strategy due to its implications on economic development.

While the classification by strategy is a good way to reveal the principle, purpose and working mechanism of different solutions, a classification by scale (see *Figure 2.9*) helps highlight the varying scopes of implementation and impact of the solutions.

Figure 2.9: Classification of sustainable solutions by scale



Source: compiled by author

Figure 2.9 represents a straightforward pyramid structure of 3 tiers, with established solutions being categorised into each tier according to the scale of their application. Solutions classified into macro level are strategic ones with a long-term perspective and top-down approach. They are often applied by supranational organisations, government or local authorities through legislation, fiscal or other policy instruments, which would have profound influences on the entire economy, environment and society in the nations or regions concerned. At meso-level, a systematic network perspective of logistics is presented. For urban logistics, reverse logistics or supply chain optimisation, multiple actors and stakeholders are actively involved and interacting in a system to achieve integral rather than local optimisation. In a similar vein, solutions at micro-level are initiatives that individual logistics companies can resort to, and have greater control over for sustainable operations. This classification will not only facilitate identifying and illustrating the linkages and interrelationships between solutions, but also will make it an easier task to explore the difficult issues related to cost, benefit and implementation.

The shortlisted solutions can also be differentiated by their maturity, i.e. those that have been applied in practice and those that have been proposed but not yet applied. There are some solutions in between, which have either been only ‘partially’ applied in a rather limited scope, or at an intermediate stage of a long-term, phased introduction period. For the solutions already applied, review and analysis of their current performance and the problems encountered during implementation will be conducted; while for the solutions which are still at an early proposal or trial stage, feasibility analysis is more appropriate. In either case, previous studies regarding critical issues for each sustainable solution category are reviewed respectively in Section 2.5.3 to follow.

2.5.3 The Potentials of Sustainable Solutions - Application and Implication

This section reviews key research findings in each of the 14 sustainable solutions. Worldwide examples of their practical applications in businesses and sectors are tabulated in *Appendix Ten*.

2.5.3.1 Alternative Fuels

As shown in *Table 2.1*, alternative fuels that have received great interest in research mainly include hydrogen, biofuels and other cleaner fuels such as natural gas, LPG and electricity. This subsection reviews the current state of the development of these fuels, their uptake in the industry, along with the instruments employed to materialise their environmental benefits.

Hydrogen as a renewable and sustainable solution for reducing fossil fuel consumption and combating global warming has been supported by research evidence (Midilli and Dincer, 2008). Despite its environmental merits, however, there are major obstacles to overcome before hydrogen becomes widespread in transport sector. Most of the hydrogen produced today is consumed on-site, and the cost of liquefying the hydrogen, storage and transporting it to the end user adds considerably to the production cost (Momirlan and Veziroglu, 2005). Meanwhile, taking an automotive manufacturer's perspective, a recent research examining the economic viability of hydrogen fuel cell vehicles suggested that the predictions of their major market penetration in the 2010–2035 time period are rather optimistic, given the current state of technology and inhibitors to further development (Frenette and Forthoffer, 2009). In conclusion, the magnitude of the technological, economic, and other challenges makes the outlook of widespread adoption of fuel cell in the near future unlikely without disruptive technological change. The work, as well as policy instruments, needed to introduce hydrogen infrastructure in the transport sector and to realise the transition from present fuel systems have been reviewed and summarised by Agnolucci (2007).

Natural gas as an alternative transport fuel has been proven to be cleaner and to generate lower carbon emissions than conventional fuels. Natural gas being a major feedstock for hydrogen, natural gas vehicles (NGVs) and infrastructures are often regarded as the transitional technology for moving towards a hydrogen economy. Another principal factor that motivates governments to promote the adoption of natural gas is the reduction of oil dependency, especially against the current context of peak oil and spiralling oil price worldwide. Statistics published by IANGV (2010) listed the leading countries in NGV adoption, with Pakistan, Iran, Argentina, Brazil, India and Italy running over 70% of NGVs in the world. There are also abundant empirical research providing evidence and analyses on the technology adoption processes under different market structures, the density of infrastructure required, as well as the regulations, policies and incentives aimed at promoting NGVs (for a multi-country analysis see Yeh, 2007).

In Europe, the adoption of natural gas for road haulage in different countries, measured by fuel consumption of medium duty (MD) and heavy duty (HD) NGVs, varies considerably, with Russia, Italy, Germany, Spain and France using over 1,000 million tonnes of oil equivalent (mtoe), while the others consuming less than 200 mtoe (NGVA Europe, 2011). With 150 mtoe consumption, UK is certainly not in the lead of NG adoption in Europe, and its position is further weakened when measured in relative terms, accounting for merely 0.015% of total NGVs in Europe.

Liquified petroleum gas (LPG), often referred to as Autogas when used as a transport fuel, is also considered ‘greener’ compared to conventional fuels, in terms of reductions in carbon and particle emissions. Generated as a by-product of oil refining process or natural gas production, the implications of LPG in energy security for the UK is particularly highlighted by Johnson (2003), given the surplus of LPG and the net exporter status of this country. However, like natural gas, the diffusion of LPG in

UK's transport sector has been slow, despite tax incentives and vehicle subsidies, and accounts for only 0.3% of total transport fuels use by mass (World LPGA, 2005). The incentive policies for promoting Autogas at various scales have been reviewed by World LPGA (2005) and AGEPL Europe (2009), ranging from fiscal instruments (e.g. duty exemption, tax credit, grants and rapid depreciation) to regulatory ones (e.g. mandatory sale/purchase requirements, standards for refuelling facilities and vehicle conversion, and exemption from city-driving restrictions).

Electric vehicles (EV), either battery-powered or plug-in hybrids, offer the potential for significant reductions in GHG emissions, despite the common argument that EVs are only as clean as the electricity used to power them, depending upon the carbon intensity of power generation in the country (Doucette and McCulloch, 2011). It is reported that with the current UK power generation mix, EVs could realise up to 40% CO_2 savings over the full life cycle. Apart from the cleanness of the national grid, research also found that substantial and immediate GHG reductions tend to be yielded from urban-type driving cycles, while inter-city haulage attains much lower carbon savings, highlighting the more important role of the technology in urban logistics (Smith, 2010). At present, a selection of supportive measures is in place for promoting EVs in the UK, including exemptions on Vehicle Excise Duty (VED), congestion charge and parking in certain regions/areas, recharging and infrastructure grants, and a low carbon van public procurement programme (details listed on DfT's website).

Whether in Europe or in the UK, strategies for alternative transport fuels seem to be converging in terms of priority, i.e. promoting electricity (either powered by battery or hydrogen/fuel cell) and biofuels (liquids) as the main options, natural gas and biomethane (upgraded from biogas) as complementary fuel options, and LPG as a supplement (European Expert Group on Future Transport Fuels, 2011). Compared to the more comprehensive and coherent set of European transport fuel policies, the main strategy adopted by the UK government for transport fuel has been carried out through the Renewable Transport Fuel Obligation (RTFO), which to a large extent has focused on biofuels, with policies addressing other alternative fuels often lost in discussions (RFA, 2011).

Biofuels are transport fuels made from organic material. To date, the focus of biofuels in Europe and the UK has been on the production of biodiesel and bioethanol (both liquid). Gaseous biofuels, in particular biomethane which can be upgraded from raw biogas generated through waste treatment, are technically feasible and financially competitive to CNG and liquid biofuels, while the diffusion of their application is largely affected by the actual value of Renewable Transport Fuel Certificates (RTFCs), by biogas upgrading technologies and by purchase and maintenance costs for biomethane fuelled vehicles (Patterson et al., 2011).

To promote the use of biofuels, the EU's Biofuels Directive (European Commission, 2003a) was adopted in 2003. Rather than being a legally binding legislation, the directive worked as guidance to EU member states, based on their voluntary commitments. Although the national indicative targets set in the directive for 2% biofuels as a proportion of all transport fuels by 2005 was not achieved, the market share of biofuels grew from a negligible 0.3% in EU in 2001 to 1% by 2005, with the doubling of the oil price since 2003 acting as the key motivation to address the energy security issues (Commissions of the European Communities, 2007). In 2009, the EC published the Renewable Energy Directive (European Commission, 2009), which replaced the cautious, progressive approach adopted in 2003 biofuels directives with a legal framework, with mandatory national targets requiring 10% of transport energy to be renewable by 2020.

In the UK, the RTFO was introduced in November 2005, and came into effect in April 2008, as the UK's primary mechanism to develop a healthy market for transport biofuels (DTI, 2007). For the fuel suppliers regulated by the RTFO, certificates can be claimed when renewable fuels are supplied. Certificates can be traded if obligated suppliers don't have enough certificates at the end of an obligation period. The target of the RTFO was initially set at 5% for renewable fuels as a proportion of total fuel sales by 2010/11, which was later amended to 3.25% by March 2010 (which was achieved), 3.5% for 2010/11 and 5% for 2013/14.

The RTFO had been implemented in conjunction with the 20p/litre fuel duty differential for biodiesel and bioethanol until the duty incentive was withdrawn in April 2010. Since then, it has become the only mechanism incentivising liquid biofuels production in the UK. In the year 2009/10, 3.3% of UK transport fuel was biofuel, of which 71% was biodiesel and 29% was bioethanol, while biogas accounted for less than 0.1% of biofuel supplied (DfT, 2011). On average, 51% GHG savings were achieved through biofuel supply during the same year. It is estimated that the UK could save up to a further million tonnes of carbon per year by 2020, should the Obligation be raised to 10% by 2015 (DTI, 2007).

Five business cases for the application of various alternative fuels, including the circumstances under which the transitions have been made by the companies, and the reported benefits and costs, are presented in *Appendix Ten*.

2.5.3.2 Fuel Taxation

Generally, fuel taxation is regarded as a fiscal instrument designed for two main purposes: changing behaviour (e.g. towards fuel efficiency operation) and raising revenue. Although the first objective was questionable given the low elasticity of demand for transport fuels (Leicester, 2005), this view of inelastic demand was challenged by Sterner (2007), arguing that it was only inelastic in the short run, which has important implications for policy makers, while in the long term, price elasticity is quite high, and has profound impacts on climate change. In regard to the second purpose, there is research revealing that fuel taxation in the UK is an effective revenue-generating regulatory tool which might have been less unpopular if it had been more explicitly linked to its environmental dimensions (Ekins et al, 2010).

In the UK, following strong protests, the Fuel Price Escalator, which had seen fuel duties increase by 3% above inflation to 6% between 1993 and 1999, was abandoned in 2000. Between 2000 and 2007, the fuel duty had not been increased ahead of inflation for several years, and consequently the tax rate (combined with VAT) in real terms (i.e. as a percentage of fuel price) had actually been falling due to the increasing oil price. However, since 2007, a series of above-inflation increases in fuel duty has been introduced and implemented every year, and was planned to rise further by 1p per litre above indexation in each year from 2010 to 2013 (Budget Notes, 2009).

Concerns over mounting operational costs faced by road freight operators have been frequently raised by the Road Haulage Association (RHA) and the Freight Transport Association (FTA), particularly regarding fuel taxation. RHA stated that Britain's diesel tax was more than twice that of the rest of the EU, which means an extra

£15,000 in fuel duty for a typical articulated truck doing 100,000 miles a year (Butcher et al. 2008). Based on its calculation, a 1p/litre duty increase costs an average haulier with an average truck £600 a year. Given the increasing number of foreign trucks operating in the country with cheaper fuels, it is warned that the fuel duty policy has largely impaired the industry's competitiveness. Suggestions were made to reduce or postpone the fuel duty increase while oil prices remain high; introduce a fuel duty rebate mechanism for hauliers and other essential vehicle operators; and introduce a database of foreign-registered goods vehicles entering the UK "to allow the effective enforcement of UK driving regulations and vehicle safety standards on visiting vehicles", or to impose extra duties on non-UK lorries that come into the country on business.

The mounting pressures of fuel duty are also expected to have a substantial influence on business decisions in seeking fuel efficiency (e.g. through more fuel efficient vehicles, supply chain/operation rationalisation, and accelerating the introduction of sustainable technology), or reducing their overall demand on traditional diesel fuel (e.g. switching to alternative fuels, vehicles and transport modes). For instance, there is empirical evidence from Hong Kong on the effectiveness of fuel taxation policies to promote the use of clean fuels (Hung, 2006). A positive correlation between average fuel efficiency across the entire UK truck fleet and fuel prices was also identified by McKinnon (2007c). However, a large survey conducted for the Burns Inquiry (2005) revealed that road hauliers of varying sizes were affected by fuel price increases to different extents, with large operators being more likely to recover from fuel price increases. This trend also seemed to strengthen over time, particular in the context of spiralling oil prices worldwide, leaving the vast majority of small operators struggling to pass on the increased cost to their customers and to protect their profit margins.

Finally, the Stern Review (2007) notes that a carbon price alone might not be enough to overcome the market failures in research and development, and therefore should be employed in conjunction with technology policy to ensure there is sufficient low carbon innovation for sustainable development in the transport sector.

2.5.3.3 Driver Training

Training and motivating drivers in fuel-efficient driving is one of the most cost-effective approaches to fuel saving. Positive impacts of eco-driving on emissions and fuel consumption has been examined by Swedish National Road Administration (Vägverket, 1999); while inappropriate driving has been proven to negate other fuel-saving measures and devices (DfT, 2002).

The EU has introduced compulsory initial qualification and periodic training, known as the Driver Certificate of Professional Competence (Driver CPC), which came into effect for HGVs drivers from September 2009 (European Commission, 2003c). This legislation applies to both existing and new drivers. Drivers who have obtained vocational driving licences by the implementation date will not have to undertake initial training, but periodic training (consisting of 35 hours over a five-year period) will be required for all drivers. All drivers must take a written or oral test following the training.

In the UK, the DfT launched the Safe and Fuel Efficient Drivers (SAFED) Scheme in 2006. It provided funding for low-cost van driver training and assessment which aimed to improve safe and fuel efficient driving techniques of commercial vehicle drivers, and to save operators money. Under the scheme, participant companies contribute to part of the training cost, with small and medium sized companies offered greater subsidies. Following a successful demonstration phase, which proved popular across a range of sectors, in particular the HGV sector, and with overall results of ‘greener’ and safer driving, the scheme was extended for another three years till 2010. It is reported that the SAFED has achieved an average 16% improvement in miles per gallon among trained drivers, giving a potential annual fuel saving of £3.3million and CO_2 emissions reduction of 9,350 tonnes, equivalent to an average of £425 and a reduction in CO_2 emissions of around 1.2 tonnes for each van driver (Lawson et al., 2008). As of 31 March 2010, funding was no longer available to support the training cost, and the training is provided on a commercial basis from the established trainer network.

With the intention to explore the common practice of driver training prevalent in the road haulage industry, the findings of a series of survey studies are summarised below, painting a less optimistic picture:

- A 1998 study found that only approximately 5% of HGV drivers had received advanced driving instruction (Social Issues Research Centre, 1998).

- A 2001 survey of HGV drivers found that 83% said they did not receive any driver training as part of their job (Lex, 2001).

- A UK skills survey revealed that 64% of respondents had been offered driver training. Training provision was directly linked to business size: for companies with 5 or fewer vehicles, only 40% of them offered training; while for hauliers operating 100 plus vehicles the percentage goes up to 90% (FTA, 2003b).

- A 2004 survey of HGV operators in the UK found that 48% of companies provided "some sort of training" to their drivers, the most commonly offered types of training were "defensive training", "in-house training", and "driver assessment" (Cooke, 2004).

- Survey work among HGV operators in the London boroughs of Southwark and Lewisham in 2004/5 showed that 58 out of 79 companies responding to the survey did not provide driver training. Approximately half of the respondents did have specific policies for dealing with instances of poor driving behaviour (Browne et al., 2005).

- A more recent study has carried out in-depth interviews with HGV drivers on their attitudes toward road safety. The results indicated that most were unaware or uncertain of the existence of a written safety policy in their company. Employed drivers from smaller companies tended to feel that "they were not up to date with current legislation and guidance on driving and were not provided with information by their managers" (Lang, 2006).

By looking at the survey results in order of time series, the provision of driver training appears to have improved over time, yet the trend seems to be vague and faltering. Furthermore, discrepancies can be observed between surveys among HGV drivers and those among operators, with the former revealing much less training received than what was claimed to be offered by operators.

It was argued that from businesses' perspective, one issue of concern in efficiency training is the high staff turnover in the freight industry, which could largely negate the incentives for companies to establish training programmes (Heriot-Watt

University, 2007). A suggestion to overcome this problem is made by Hagan (2005), that companies can issue employment contracts that bind drivers to working for them for at least three years.

Six business cases of driver training practice are detailed in *Appendix Ten*, providing specific measures undertaken, and highlighting the employment of other solutions in combination with driver training to achieve maximised benefits.

2.5.3.4 Environmental Management System (EMS)

Definitions of EMS take various forms in the literature while sharing the same core concept (e.g. Jiang and Bansal, 2003; Kolk, 2000; Holland and Foo, 2003). The broadly used one was given by the International Standards Organisation (ISO) as "the part of the overall management system that includes organisational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining…environmental policy" (cited in Martin, 1998). The most important international EMSs (also deemed in the form of external/ third party validation, standards, or schemes) are ISO 14001 and the EU Eco-Management and Audit Scheme (EMAS), while the British Standard Institute's BS7750 is the first national EMS standard of its kind.

A concept sharing some commonality with EMS is corporate social responsibility (CSR), which has gained increasing popularity in business practice over the last decade. Defined by the Commission of the European Communities (2001), CSR is "a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis". Although this definition enjoys a broad consensus in Europe, the precise nature and characteristics vary between different national and cultural contexts. Moreover, businesses vary substantially in their interpretation of and approaches to CSR as well as its reporting. A review of the UK's top ten retailers' CSR agendas conducted by Jones and Comfort (2005) evidenced the largely differing nature, approaches and extent of CSR, even among the companies of similar size in the same sector and country.

To date, little research has dealt with the overlapping and comparison between EMS and CSR (Walker et al., 2007). However, the respective discussions in both fields share great similarity, including the reporting and auditing process and their prevalence mainly among large multinational companies. The spectrum of CSR covers management of environmental impacts, natural resources and sustainable supply chain management, with the main distinctiveness of CSR being the incorporation of a social dimension in addition to environmental issues. As this research is conducted exclusively for the logistics industry, rather than explicitly distinguishing CSR from EMS, flexibility is allowed in applying both terms, with main focuses placed on their environmental dimensions.

Like CSR, the practice of EMS in the UK and the EMAS scheme in Europe are both voluntary. This voluntary nature has been in the centre of debate against a regulatory approach (i.e. 'command and control'), with different stakeholders holding different views. Enterprises and business associations, for instance, stress the importance of retaining the market-driven and voluntary nature of CSR. They argue that standardisation and legislation in this area would remove the competitive incentive driving forward CSR activities, constrain and stifle innovation for its development, and reduce CSR to a lowest common denominator (Commission of the European

Communities, 2002; CBI, 2008). The arguments for EMS take a similar vein, with the weakness of mandatory legislations being stressed (e.g. inherent inefficiency, rigidity, high economic cost, danger of corruption and inadequate capacity and resources for enforcement etc). Criticisms of economic instruments have also been used to highlight the potential benefits of EMS as an effective complementary approach to regulatory and fiscal instruments (Stewart, 2001; Watson, 2004).

Taking the opposite view, trade unions, civil society organisations and some researchers advocate a regulatory framework, establishing minimum standards and ensuring a level playing field, since voluntary initiatives are 'not sufficient' (Commission of the European Communities, 2002). It is claimed that social and environmental responsibilities are not reflected in the accountabilities and governance of companies with regard to UK company law, which only protects the interests of shareholders, instead of other stakeholders (Frankental, 2001). It is suggested that the credibility of CSR can only be secured as long as the involvement of all stakeholders, financial reward for CSR activity, and public scrutiny is in place, the implementation is benchmarked and audited, and a compliance mechanism is embedded across the organisation, horizontally and vertically. Similarly for EMS, several studies indicates a positive correlation between environmental regulations and EMSs, as rigorous EMSs are enforced with complicated environmental regulations in place in Germany and Austria, while less stringent environmental regimes have provided weaker incentives to introduce EMSs in Ireland (Malek, 2001; Wurzel et al, 2003; Flynn, 2003; Watson and Emery, 2004). Having less complex environmental laws compared with Germany and Austria, the UK regulatory bodies have a strong preference for voluntary agreements, hence compliance with environmental regulations is generally not given a high priority as a reason for companies to adopt EMS (Watson and Emery, 2004).

A 2008 survey reinforced the diverging paths taken by businesses in different countries for systematic environmental management; half of the UK companies surveyed had a dedicated department for environmental issues, while Japan topped the list with 95%. Large variations also exist by company size – the bigger companies tend to have a much higher degree of institutionalisation of environmental functions. Major difficulties encountered while establishing or implementing sustainable strategy turned out to be a lack of information, the complexity of implanting the strategy, and a lack of return on investment (BearingPoint, 2008).

Further in exploring individual businesses' behaviour patterns, two independent surveys on UK companies' environmental management practices (Ghobadian et al., 1995; Dahlmann et al., 2008) have both suggested that bottom line concerns are paramount in guiding corporate behaviours. Apart from cost reduction, other major motivators identified in the survey include improving public relations with stakeholders, risk reduction and legal reasons. It is then concluded that overall, the companies' strategies toward environmental management remain reactive and economic-oriented.

As to the momentum behind CSR, Ernst & Young (2002) identified five key drivers, namely greater stakeholder awareness of corporate ethical, social and environmental behaviour; direct stakeholder pressures; investor pressure; peer pressure and a heightened sense of social responsibility. Other incentives raised in the literature include: direct economic value; increasing awareness of responsibility when sourcing in developing countries as a result of globalisation; image and reputation; recruiting and retaining highly skilled personnel; environmental and social code of conduct and legal requirements; and marketing strategy to differentiate brands (Commission of the European Communities, 2001&2002; Girod and Bryane, 2003; Jones and Comfort, 2005).

Costs associated with EMS implementation depend on whether an in-house approach or external verification is adopted, as well as on company size. Generally such costs include set-up costs, certification costs, and annual operating costs. It is pointed out that data on both financial benefits and costs of EMS is usually unavailable or unreliable, since companies rarely measure the benefits or costs of their EMSs due to various reasons (Hamschmidt and Dyllick, 2001). Nevertheless, non-monetary benefits of EMS have been identified, such as compliance with regulation, risk minimisation, employee motivation, corporate image, and improved relationships with public authorities (Watson and Emery, 2004). Costs and benefits of CSR practice at macro and micro level have been summarised by the Commission of the European Communities (2006).

In both EMS and CSR development, increasing concerns have been given to small and medium-sized Enterprises (SMEs). There is concern among SMEs that the costs of acquiring a certified EMS such as ISO 14001 are beyond their reach. Even when financial barriers were not the main obstacle, problems still exist for SMEs due to the complexity and vagueness of the system (Biondi et al., 2000; cited in Watson and Emery, 2004), or lack of the internal expertise to establish environmental policies and effective management and auditing systems. Besides problems with SMEs, other challenges for further diffusion of CSR were identified by the Commission of the European Communities (2006) as “knowledge about the relationship between CSR and business performance; teaching and training about the role of CSR; transparency, which stems from the lack of generally accepted instruments to design, manage and communicate CSR policies; consumers' and investors' recognition and endorsement of CSR behaviours; and cohesion in public policies". To address these concerns prohibiting operators, especially SMEs, from implementing EMS, three case studies demonstrating best practices of logistics companies of various sizes are presented in *Appendix Ten*.

2.5.3.5 Government Support

Three major roles that governments can play in sustainable logistics (i.e. regulator, facilitator and buyer) have been discussed in Section 2.5.1.3. As the role of regulator is reviewed and assessed in this thesis through the key regulatory and policy instruments under relevant solution themes (e.g. road pricing, fuel taxation and urban logistics), this subsection focuses on the supporting roles of government beyond the traditional policy-making domain.

Based on the literature and government publications, the UK government has been providing a large variety of means of support for businesses to develop sustainable logistics practices. Funding, for example, is one of the most commonly adopted approaches. There are government funds used to support programmes and projects aimed at minimising the impact of freight on the environment, safety and congestion. One of the most important funds established in recent years is the Sustainable Distribution Fund (SDF, established 2005), which includes a mode shift programme and an efficiency programme covering a number of grants and support schemes. From April 2007, rail freight grants, water freight grants and road haulage schemes were brought together into a single pot (the SDF), with schemes that offer the best value for money prioritised for financial support (DTI, 2007).

Acting as a powerful buyer in the market, the DfT developed a new programme of public sector procurement, to promote and support low carbon vehicle development with initial funding of £20 million, including small fleet demonstrations to provide early markets for new innovative lower carbon vehicle technologies. The initial phase will be focused on the development of low carbon and fully electric vans, with other vehicle types being considered in subsequent phases (DTI, 2007).

Other major government supporting programmes with impacts on logistics industry include the Low Carbon Transport Innovation Strategy (LCTIS) aiming at accelerating the development and market penetration of new lower carbon technologies; the UK Climate Change Programme; Freight Quality Partnerships; Freight Best Practice programme and Freight Logistics Research Programme.

2.5.3.6 Inclusion of Transport into the EU Emission Trading Scheme (ETS)

To mitigate the environmental impacts of fast growing aviation, the EU has decided to place a cap on the carbon emissions from flights to and from EU airports by including the sector into the ETS scheme. Under the European Commission's legislation to include aviation in the existing EU ETS (2008/101/EC, 13 January 2009), for the period from 1 January 2012 to 31 December 2012, the aviation sector will be allocated 97% of the average annual emissions during 2004-2006 for free, with this figure dropping to 95% for 2013-2020. To complete the UK's transposition of the Aviation EU ETS Directive, the UK government brought the second stage Aviation EU ETS Regulations into force on 31 August 2010.

Meanwhile, the potential for inclusion of surface transport in the EU ETS was also given serious consideration (DTI, 2007). The UK Climate Change Programme 2006

(HM Government, 2006) committed the Government to considering possible inclusion of surface transport into the EU ETS or as a UK self-standing measure. It was later reaffirmed in the 2007 Energy white paper that an EU-wide approach was preferred in order to address emissions from surface transport.

As to specific regulating options to implement the scheme, there are three main mechanisms under consideration – the fuel producers option, the vehicle manufacturers option and the individual motorists and hauliers option. In the first scenario, fuel producers would need to hold an ETS CO_2 allowance to cover the total amount of CO_2 emissions resulting from the fuels they sell. This system could therefore be built upon the existing fuel duty records as a reliable basis for regulation. Since the majority of fuel sold in the UK has duty paid by oil companies rather than by fuel retailers, regulating 20 businesses would capture over 99% of fuel sales. In this case, the administrative cost would be the lowest, and most companies involved are already subject to the scheme and familiar with the ETS processes. In the cases of the vehicle manufacturers and individual motorist/hauliers, CO_2 allowances would be allocated to a myriad of different stakeholders, thus entailing big differences in administration and transaction costs and complexity of the whole system due to the number of entities involved.

Generally, emission trading is regarded as an effective quantity instrument to ensure the achievement of an overall environmental objective. In assessing the benefit of including aviation into the EU ETS, the annual EU-wide carbon savings were estimated to be 12–50 million tonnes by 2020, on the basis of aviation emissions stabilised at 2005 levels, compared to ‘business as usual’ emission levels (DTI, 2007). Analysis in the UK government’s Energy White paper also indicated a carbon saving of 1–2 million tonnes in 2020, if the cap was calculated on the basis of a 2–5% under-allocation to the road transport sector. However, the carbon benefits of ETS would be highly dependent on the number of allowances allocated to the transport sector; the tighter the cap on allowances, the greater the carbon savings, but also the higher the costs. The impacts would be further limited given some access to project credits (e.g. the Clean Development Mechanism, CDM). Therefore, it will be necessary for the Government to look at the implications of including surface transport in the EU ETS on carbon price, fuel price and industrial competitiveness, as well as the potential impact on other EU ETS sectors, before a more definitive view can be given as to its suitability (DEFRA, 2007a).

2.5.3.7 Information and Communication Technology (ICT)

In Section 2.5.1.1, a wide selection of ICT systems was categorised into six logistics functions, respectively; managing deliveries, vehicles, loads, drivers, fuels and products, as illustrated in *Figure 2.8*. This section reviews the major research findings on ICT in those functions which provide environmental benefits, directly or indirectly, with examples of their applications detailed in *Appendix Ten*.

ICT Systems by Logistics Function

ICT for delivery management ranges from paperless manifest systems, online freight exchanges, to traffic information systems and computerised vehicle routing and scheduling (CVRS) systems. *Online Freight Exchanges* function as electronic market places, where consignors post loads they need to move and hauliers with excess capacity seek loads or backloads. Both economic and environmental benefits can be realised through reduced empty-running and better utilisation of vehicle capacity. However, a distrust of such an e-market, due to the value proposition against hauliers, has been raised in the literature (Clements, 2001; Davis et al., 2007). *Traffic*

Information Systems provide live traffic information and advice, either via internet or GPS-based mobile communication devices, and this can help to minimise potential disruption by avoiding congestion (DfT, 2007c).

There is abundant literature about *CVRS Systems*. Sbihi and Eglese (2007) summarised the basic vehicle routing and scheduling problems, and many of their variants. To date, the vast majority of the established CVRS models are aimed at minimising the total cost (Hvattum et al., 2006), while little has been done in incorporating the environmental components. To address this issue, Palmer (2007) proposed a model specifically developed to assess CO_2 emissions from freight vehicles, which applies instantaneous fuel consumption formulae. The result shows that, with the cost of CO_2 emissions taken into account and the projection of increased congestion, the cleanest route would have the lowest overall cost in 2015, compared with the shortest and quickest routes. With the economic and environmental goals designed into the modelling, the employment of a CVRS system would see companies, especially large ones with complex delivery networks, benefit from reduced time and resources required for planning, fleet rationalisation, depot relocation or restructuring of distribution network.

ICT systems available for vehicle and load management (e.g. tracking and tracing) are often referred to collectively as telematics (DfT, 2007c), and vehicles armoured with such technology as 'intelligent vehicles' (Giannopoulos, 2004). *Vehicle/trailer Tracking Systems*, *in-cab communication systems* and *satellite global positioning system (GPS)* devices, together with *Satellite Navigation ('sat-nav') Systems*, enable managers to track, monitor vehicles and communicate with drivers in real time, and drivers to plan their journey en route. Appropriate use of telematics has been shown to significantly improve fleet productivity and efficiency, cut vehicle distances and fuel consumption, and is also believed to deliver road safety and environmental benefits (DfT, 2007c; McKinnon, 2003b).

Increasingly incorporating telematics, *temperature control monitoring systems* are used for monitoring the consistency of trailer temperature and alerting in real time when a problem is identified. Operations involving high-value perishable goods will benefit most from these systems regardless of their sizes (DfT, 2007c). *Vehicle Weighing Systems* provide an easy solution for enforcement of axle load limits. Operators usually benefit from enhanced road safety, prolonged vehicle life, and maximised payload while complying with legislations on overloading (DfT, 2007c). Based on developed weighing and satellite positioning technology, Dodoo and Thorpe (2005) described the development and on-road trials of a new road charging system for HGVs. Taking into account all major determining factors to pavement damage, their proposed charging system is believed to be more “fair and efficient” and consistent with the EC’s polluter pays principle.

In driver management, “black box” technology is employed, providing driver and vehicle performance data on a range of variables which can be used to monitor fuel consumption trends, compare fuel usage between drivers, monitor occurrences of idling, over-revving, speeding and harsh braking, and evaluate the impact of fuel-saving initiatives. One major technology for driver management is *digital tachographs*, which was introduced for all new HGVs in May 2006 as replacement of analogue tachographs (DfT, 2007c). Storing data on the drivers and vehicle in their own memory and separately on a driver’s smart card (VOSA, 2007), it can be accessed by operators, workshops (tachograph calibration centres) and enforcement officers (e.g. VOSA staff or Police) via different types of smartcards.

Fuel Recording Systems control diesel-fuel consumption and monitor movement parameters of vehicles. These systems can take many forms, including fuel cards, electronic keys, driver keys, PIN numbers and fingerprint identification (DfT, 2007c). Operation parameters associated with fuel consumption, such as distance travelled, fuelling volume and engine operating time, can be collected and stored automatically for analysis and monitoring, either in real time or at a later stage. Common practice in large companies sees fuel management systems incorporated as a function into an integrated solution package, often in line with telematics technologies like GPS.

Product management systems range from warehouse management systems, supply chain planning management systems, to Enterprise Resource Planning (ERP) and Electronic Data Interchange (EDI). Providing real time visibility and management of product flows within the warehouse, *Warehouse Management Systems (WMS)* are often regarded as the 'command centre' of a warehouse, and normally link different systems together (Helo and Szekely, 2005), such as material handling automation (e.g. *Voice Picking Systems*, *Product Scanning and Tracking Systems* and *Radio Frequency Identification*), and transportation systems (e.g. CVRS).

As an enabling technology for collaboration along supply chains (Hill and Scudder, 2002), *EDI* provides the infrastructure for information exchange between trading partners. It has been playing an important role in many, but particularly FMCG and retailing, sectors featured with supply chain initiatives such as Efficient Consumer Response, Continuous Replenishment Programme and Collaborative Planning, Forecasting and Replenishment (Pramatari, 2007). The impact of EDI on customer service and delivery performance was studied by Lim and Palvia (2001) and Ahmad and Schroeder (2001).

Diffusion within the Industry

In general, a trend of the diverse ICT systems to converge has been observed, and this trend is expected to intensify, leading to the integration of core business processes into one comprehensive information system, with cooperation among multiple stakeholders along the value chain, and hence a collaborative business environment (Helo and Szekely, 2005; Tarn et al, 2002; Green, 2001). On the other hand, closer examination highlights diverging paths taken by companies of various characteristics. POD and sat-nav systems, for instance, are ideal for multi-drop deliveries; while temperature control systems often benefit the distribution of high-value perishable products (DfT, 2007c).

A survey within the UK road haulage industry (Davis et al., 2007) assessing the impacts of ICT found that 85% of companies considered ICT important to their business. It was further revealed that the majority of companies were using 3 or 4 applications, with financial management and vehicle routing and planning as the most used functions. However, there is a strong positive correlation between company fleet size and perceived importance of ICT. Smaller operators, which account for 93% of the firms in the industry (Highways Agency, 2003), were missing out on the benefits from ICT adoption. A 2004 survey of HGV operators showed that only 31% of respondent companies had a strategy in place to reduce HGV mileage. The two most common approaches to achieving this were route planning and the use of telematics. Only 13% of the respondents used telematics in their HGVs, with higher penetration rates among larger fleet operators (Cooke, 2004). Likewise, under-usage of online freight exchanges was reported by Davis et al. (2007), revealing that only 32.6% of companies had used an online marketplace to access backloads and the telephone still remained the most common method in practice.

Cost and Benefit

The major and most often quoted benefits from employing ICT include improved financial efficiency (e.g. reduction in administration or transaction costs, fuel saving etc.) and customer service performance, enhanced operational efficiency (e.g. maximised vehicle utilisation, reduced empty-running, decrease in transport distance, business process automation, greater transparency and collaboration of the operational activities), and implied environmental impacts (McKinnon, 2003a&b; Léonardi & Baumgartner, 2004; Wang et al., 2007).

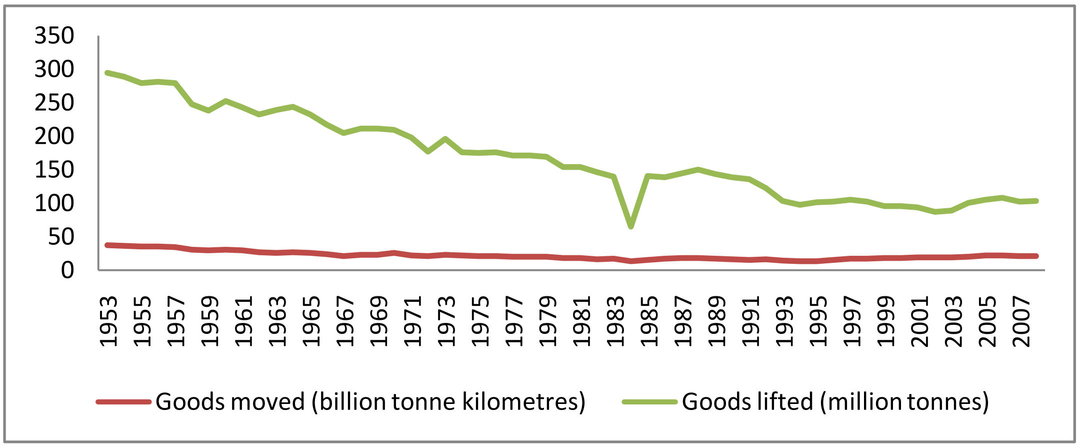
However, little work had been undertaken on measuring the transport efficiency and fuel savings that can be actually achieved from IT-based systems (Heriot-Watt University, 2007). Most existing CVRS systems, for instance, are designed to provide solutions that will minimise economic costs, through reduction of vehicle numbers, traveling distance, or delivery time. Such reductions may have direct positive environmental benefits mainly through fuel savings. To minimise total traveling time, vehicles tend to be directed to roads with less congestion so that they can travel at a faster speed, which generates less pollution, even where a greater total distance is entailed in some cases (Sbihi and Eglese, 2007). However, Sbihi and Eglese also pointed out that environmental benefits often occurred in an indirect way, and were generally not measured or emphasized. In addition, existing methods to measure the pollution levels of a set of vehicle routes may be unreliable, since the output of current CVRS models does not provide the necessary data as input to quantify the environmental benefits (Pronello and Andre, 2000).

Similarly, there is no universal approach for calculating costs (DfT, 2007c), although in general, the costs of introducing and implementing a particular ICT system are more tangible than its benefits. The costs of initial purchase, system setup, training, running and likely upgrading in the future can be provided by system suppliers and measured by company itself, and they are usually positively related to the sophistication of a system. A sophisticated, integrated system may cost as much as several million pounds, and hence requires elaborate planning and evaluation as well as the dedication of personnel resources throughout its implementation. Léonardi and Baumgartner (2004) discovered that most users and potential buyers see the highly diversified product range as a barrier to investment. According to Carey (2001; cited in Green, 2001), choosing the wrong system can cost five to ten times more than selecting the appropriate one in the first place. More and more companies are therefore resorting to consultant services prior to purchase, or during implementation. As a result, when total cost is evaluated, consideration should be given to all the factors involved, including costs associated with hardware, software, professional services, internal staff, installation and maintenance, and business changing (Payne, 2002).

2.5.3.8 Modal shift

Since 1955, when rail freight lost its leading position in market share to road for the first time, the sector had seen long term decline before the beginning of its revival in 1995. *Figure 2.10* shows the trend for rail freight market from 1953 to 2008. Rail freight had grown by 161%, from 13 billion in 1995 to 21 billion tonne-km in 2008. In the year 2005-06 alone, 6.74 million lorry journeys were saved, equivalent to 122 billion lorry kilometres over the year, which helped to alleviate road congestion and reduce overall CO_2 emissions (DfT, 2007a).

Figure 2.10: Domestic goods moved/lifted by rail, UK 1953-2008



Source: DfT, 2009a

Despite the growth of rail freight in absolute terms, its market share had only recovered to 8% in 2008 – the same level as in 1985, while waterborne traffic had decreased from 31% to 20% (DfT, 2009a). Meanwhile, the rapid demand growth could not be completely accommodated within the UK railway's capacity, due to underinvestment in the industry over years and the 'system failure' of privatisation.

To increase the market share of minority modes both at European Union and UK level, freight transport policies since the late 1990s have been encouraging the use of non-road modes (particularly rail) where practicable (Woodburn et al., 2007), backed by a series of government white papers, policy guidelines and projects (DETR, 1998, 1999, 2000; European Commission, 2001, 2004), and along with financial support in terms of grant funding (e.g. FFGs, TAGs, CNRS, Sustainable Distribution fund, and Transport Innovation Fund). Shifting from addressing issues of decline, the UK Government's focus for the railway industry were placed on accommodating growth for the first time since the 1950s. In the white paper published by DfT (2007a), investment priority for the rail sector is given to increase capacity in the 5-year period of funding plan from 2009 to 2014.

There are various projects at early or developing stages in the UK rail industry, such as the next generation of cab-based signalling, network-wide electrification, and gauge and capacity enhancement on key routes serving major ports in England. Next-generation signalling has been approved and investment made available by the Government; while gauge enhancement consists of a list of schemes under review for the Transport Innovation Fund (TIF). However, network-wide electrification is regarded as an "all or nothing" project, which is too risky to tackle at the moment with uncertainties in many aspects. Other options, such as maglevs and dedicated freight-lines on inter-urban routes are also unlikely now, regarded as too expensive or inflexible. Based on the literature review, *Table 2.3* summaries the major problems or challenges facing rail freight, and some solutions proposed.

Table 2.3: Problems/challenges faced by UK rail freight industry and proposed solutions

Problems/challenges	***Solutions***
Infrastructure bottle neck	*Modern radio-based signalling technology*
Demand growth	*Train Lengthening*
Compete with passenger service for space	*Dedicated freight lines on inter-urban routes*
Loading gauge (rolling stock/rail network)	*New, reliable freight engines*
Configuration of some terminals	*the Network Code 'use it or lose it'*
Weight/speed limit	*appropriate diversionary routes*
Maintenance closure	*European-sized rolling stock running directly to UK*
Higher expectation: 7-day year-round availability	*Network-wide electrification*
Reduce its own carbon footprint	*Lighter & more environmentally friendly trains/next generation of 'go-anywhere' trains*
High access cost	*gauge enhancement*
	Energy saving measures (on-train metres, driver training, regenerative braking, low-energy lighting)
	Biofuels/hybrid diesel-battery trains/self-powered fuel-cell trains (hydrogen)
	Sustainability KPIs development

Source: compiled by author

Infrastructure development and its financing, for instance, present a problematic area for intermodal transport. More than half of the freight moved by rail in the UK is travelling to or from a port. To secure as much freight traffic as possible by rail, connections with newly developed ports and landside access to the new facilities needs to be established. Current policy has required port developers to bear the costs of increasing the capacity of the rail network, which is claimed to be unfair and a distortion of the competitive market (Everitt, 2007).

While insufficient investment in infrastructure and equipment remains an unsettled issue over years, compounded by the practice of cross-subsidies from freight to passenger transport in some cases (Ruete, 2007), it is claimed that to date, pro-rail and pro-environment statements have not been backed up with sufficient financial support nor with sufficiently strong policy initiatives. The lack of confidence in future government support for the rail freight industry appears to be dissuading some companies from investing in rail since it is seen as being too high a risk, despite those companies having suitable flows that could switch from road.

In regard to costs, although rail or water is much cheaper compared with road haulage in tonne kilometre terms, the costs generated during transferring loads from one mode to another can be considerable (Garbutt, 2005). A growing proportion of international container traffic uses 9ft 6in boxes, for example, while much of the UK network does not have sufficient gauge or bridge height clearance to carry these on conventional wagons. This issue is regarded as a bottleneck for intermodal transport if it remains unsolved.

Adding to the issues listed in the table, Woodburn (2001) and FTA (2002) identified several key factors as major differences between road and rail haulage which make companies opt for road rather than rail, including trust, reliability, cost, business attitude, flexibility, cargo care, ease of doing business, incompatibility and lack of connection/infrastructure. In general, the service quality problems are identified as 'the single most significant reason for actual flows being lower than those anticipated' (Woodburn et al., 2007).

In an attempt to further explore what government, rail freight sector and companies can do to promote and facilitate modal shift, an overview of practical developments in this area, both in terms of technological and organisational innovation, with their implications is presented in *Appendix Ten*.

The Modal Shift section in *Appendix Ten* provides some examples of innovative technologies applied in intermodal transport with the common aims of reducing transhipment and handling cost and improving operational efficiencies, along with their advantages and disadvantages. Other transhipment innovations in intermodal transport include bimodal systems applying varying techniques in different European countries (e.g. "road railer" in France and UK, "Transtrailer" in Spain, and "Coda-E" in Netherlands, Denmark and Sweden), MB Kombi-Lifter and semi-trailer equipped with side loader. In bimodal systems, special trailers are transformed into railway vehicles for circulating on railways. To date in Europe, these are mainly at prototype and trial stage, and experience of regular services is in North America only.

There are also many examples of various forms of organisational innovations in multimodal and intermodal operations in *Appendix Ten*. The case of Cargo Domizil, for example, illustrated how the rail operator can fully exploit the advantages of rail over road, with suitable technologies and the substantial impact of road pricing. Mercadona represents an ideal case, where the logistics service user, as an influential party in its supply chain, has initiated a sustainable modal shift involving multiple stakeholders in the national logistics network (CLECAT, 2010). The environmental benefits, mainly measured in carbon reductions, are evidenced in most cases. The EU funded projects – Viacombi, BestLog and Promit – have compiled a comprehensive collection of 60 best practice business cases in intermodal logistics (EIA, 2011), providing more detailed information on the background, motivation, innovation and benefits of the initiatives.

2.5.3.9 Product/Packaging Design

According to the German Environmental Agency, 80% of a product's environmental impact is determined during its design phase. Taking a proactive approach, green design is aimed at minimising the environmental impact of a product or service throughout its life cycle at the design stage. Given the scope of this research, the focus of the review is mainly placed on green design approaches that interface with logistics operations, such as the design of a product's physical attributes (e.g. weight, volume and shape), especially packaging.

Limited research has been undertaken in the interface between product design and logistics (Heriot-Watt University, 2007; Dowlatshahi, 1999). Previously, designers tended to consider only marketing and manufacturing requirements in product development and packaging design (Vasquez et al., 2003), and latterly, the recyclability and recovery of the product. Nevertheless, logistics and product design are undeniably linked through the activities of handling, packaging, stacking and transporting (Heriot-Watt University, 2007). Packaging is even regarded as one of the most important activities in supply chains and distribution networks (Jahre and Hatteland, 2004; Gustaffson et al, 2006), so that a new sub-discipline of 'Packaging

Logistics' has been developed, which is defined as "the interaction between the logistics and the packaging system that improve 'add on' values to the whole supply chain from raw material producer to end-user, and the disposal of the empty package, e.g. by re-use, materials recycling, incineration or landfill" (Chan et al., 2006).

Despite marketers wishing to attract customers with variety and speciality in packaging styles, standardisation and conformity are the most desirable packaging attributes from logistics efficiency viewpoint (McKinnon and Forester, 2001). Unconventionally-shaped packaging causes problems all along the supply chain. The larger and more oddly-shaped the range of packaging sizes, the greater the handling and delivery complexity and consequently, the less efficient the transport operation will be. It is generally recognised that substantial savings in packaging, warehousing and transportation can be realised by changing the products' size, primary and secondary packaging and pallet patterns, exemplified by a case study by Delaney (1992; cited in Wu and Dunn, 1995). Under these considerations, it is already a common practice for the vast majority of products to be packaged in rectangular-shaped boxes (Hoare and Beasley, 2001). Also since tertiary packaging (e.g. from pallets to roll-cages) impacts on vehicle utilisation by reducing the available payload (ECR Europe, 2000), there is a trade-off problem between handling and damaging cost (i.e. less use of tertiary package) and transport cost (under-utilisation of vehicle load capacity).

In assessing the diffusion of 'green design' practice among the UK companies, a recent survey revealed that 45% of companies adopted a 'green design' approach. The vast majority took actions, either in compliance with legislation or in response to market demand, with operational costs being a concern for only 6% of the respondents (BearingPoint, 2008). Regulations playing important roles in product and packaging design include; the Waste Electrical and Electronic Equipment (WEEE) Directive, the Packaging and Packaging Waste Directive (2004/12/EC), the Restriction of Hazardous Substances (RoHS) regulations, the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulations, and recently, Eco Design directive (EEE), which focuses on the reduction of environmental impact of electrical and electronic equipment throughout the product lifecycle. Inevitably, these regulations and the general 'producer responsibility' principles behind them have more significant impact on certain industry sectors, such as electronics, automotive and packaging. However, by avoiding hazardous substances and incorporating as many less-polluting, or recyclable/renewable materials as possible in the product design, companies also have opportunities to make savings on the recovery, dismantling and recycling of products.

In addressing the interface between product design and logistics, focus in the literature has mostly been placed on either product design *process* (see the case of P&G in *Appendix Ten*) or on dynamics in supply chain management (e.g. avoiding mis-alignment between new product development and the supply chain in research by Fisher, 1997; also van Hoek and Chapman, 2006, 2007). In an attempt to fully explore the interrelationships between product or packaging design and logistics, eight practical cases have been compiled and presented in *Appendix Ten*.

2.5.3.10 <u>Reverse Logistics</u>

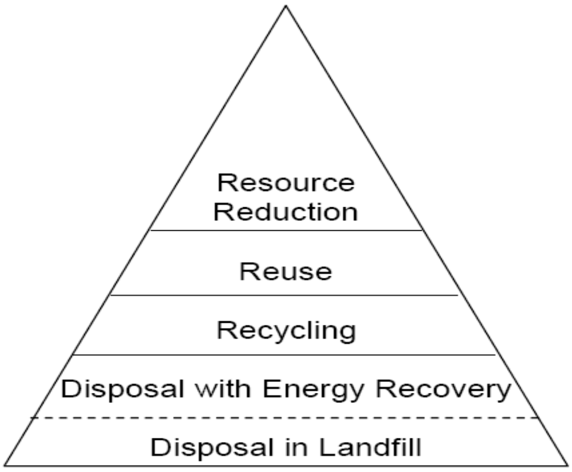
There are various definitions of reverse logistics in the literature. Stock's (1992) definition as "all issues relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials, and disposal" outlines the essence and the ultimate purpose of reverse logistics. Emphasizing backward flows, Roger and

Tibben-Lembke (1999) defined reverse logistics as "the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal." However, with the ever-increasing scope and complexity of the logistics network, products may not necessarily be returned to their point of origin, but to any point of recovery (De Brito and Dekker, 2003). Hence another much simpler and broader definition provided by Aberdeen Group (2006) was "the return, exchange, repair/refurbishment, remarketing, and disposition of products", highlighting the major activities involved in reverse logistics operations.

Waste Management

Lying firmly within the scope of reverse logistics by the definitions given above is waste management, along with all the other types of back flow of products and packaging. It is established on the basis of a waste hierarchy which, although takes various forms over the past decades (e.g. DfT, 2004b; DEFRA, 2007b), remains the cornerstone of waste strategies. *Figure 2.11* illustrates a classic waste hierarchy, placing waste management strategies in order of priority. With the highest priority in the hierarchy, *resource reduction,* which means preventing or minimising waste at the initial stages where it is generated, is the most favourable strategy with the greatest environmental benefit. Likewise, products should be reused and materials recycled as much as possible, so that value can be recovered and finite natural resources and energies can be saved from producing new products with virginal materials. For residual waste, composting and incineration with energy recovery are generally preferred to disposal into landfill, where the biodegradable part generates methane, a potent GHG which contributes negatively to climate change.

Figure 2.11: Waste hierarchy



Source: Carter et al., 1998

The main objectives of the government's waste management strategy are diverting waste from landfill, increasing recycling rates, while at the same time promoting waste prevention and re-use. Key waste materials and sectors identified as high priority, where diversion from landfill could realise significant environmental benefits, include paper, food, glass, aluminium, wood, plastic and textiles (DEFRA, 2007b). To achieve these sustainable targets, a mix of governance tools, such as pricing, regulation, voluntary agreements, and government procurement policies, has been exploited as an integrated waste strategy in England.

Firstly, the landfill tax escalator and the introduction of the Landfill Allowance Trading Scheme (LATS) have created sharp incentives for landfill diversion. The landfill tax escalator is set to increase by £8 per tonne from 2008 until at least 2014 (from £24 to £80 in 2014), providing greater financial incentives to businesses to reduce, re-use and recycle waste (HMRC, 2011). Funds are provided to local authorities and other organisations for investment in collection, recycling and recovery infrastructures; while allowance and government procurement policy is also in place to stimulate markets for recycled and recovered materials.

Secondly, there are delivery arrangements helping to drive the strategy, including the Waste Implementation Programme (WIP), the Waste and Resources Action Programme (WRAP) and the Business Resource Efficiency and Waste (BREW) programme (DEFRA, 2007b). The WIP aims to divert increasing volumes of biodegradable municipal waste away from landfill towards more sustainable waste treatment. The WRAP was established with the mission of developing recycling businesses and markets for recycled materials (priority materials include tyres, plasterboard and batteries). It works in partnership with local authorities and businesses providing advisory services. The BREW is a programme that works on a greater scale funding a number of projects to help business reduce waste at every stage of the business cycle and manage resources more efficiently. The programme itself is funded through landfill tax.

Thirdly, local authorities can set up their own trade waste collection schemes to improve local collection services, recycling rates and environmental performance of the collecting operations in their areas. Various case studies of such schemes have been reported to a limited extent in the literature (Enviros Consulting, 2002; Hickford and Cherrett, 2007).

Since the waste strategy in 2000, significant progress has been reported by the government. It was claimed that recycling and composting of waste was more than quadrupled from 1996/97 to 2008, achieving 37% in 2008, and the recycling of packaging waste increased from 27% to 56% over the same period. It was also reported that less waste was being sent to landfill, with an 8% decrease between 2000/01 and 2007/08 – believed to be largely a result of the landfill tax escalator. In 2007, a target of annual net reduction in global GHG emissions from waste management of at least 9.3 million tonnes of CO_2 equivalent was set for the UK

(DEFRA, 2007b & 2009).

However, compliance with the regulations and the pressure of pricing tools exert greater burdens on small and medium-sized businesses than large enterprises. The government sees such difficulties as the result of a lack of awareness, limited support and advice, and a lack of affordable services (DEFRA, 2007b). A business case for demonstrating waste transported on alternative modes with both financial and carbon savings is presented in *Appendix Ten*.

Other General Reverse Logistics

Apart from waste management, reverse logistics also deals with other sources of backflow. Rogers and Tibben-Lembke (1999) summarise sources for returns within a basic framework (see *Table 2.4*), which divides reverse flowing material into general product and packaging material, and divides returning points into end users and other agents along the distribution channel.

Table 2.4: Sources of reverse flow of products and packaging

	Supply Chain Partners	End users
Products	stock balancing returns marketing returns end of life / season transit damage	defective / unwanted products warranty returns recalls environmental disposal issues
Packaging	reusable totes multi-trip packaging disposal requirements	reuse recycling disposal restrictions

Source: Rogers and Tibben-Lembke, 1999

The reverse flow of unwanted products from end users, for instance, is regulated by the EC Directive on the Protection of Consumers in Respect of Distance Contracts (1997/7EC) (for UK the Consumer Protection Regulation 2000). The consumer is entitled to cancel any distance sale contract via distance communication within 7 working days. With the prosperity of e-commerce today, a dedicated reverse logistics process is required for handling the increasing volume of returned merchandise.

Packaging and packaging waste, on the other hand, is regulated by the Producer Responsibility Obligations (Packaging Waste) Regulations 2007. The principle of 'Collective Producer Responsibility' has been applied, requiring producers of packaging (including raw material manufacturers, converters, packer/fillers, sellers and importers of packaging) to take responsibility for their environmental impacts. The implementation is achieved through the Packaging Waste Recovery Note (PRN) System, where reprocessors are licensed to issue a PRN for each tonne of specific material they have recovered, and companies who are obligated under the Regulations must prove they have paid for the requisite amount of tonnes to be recovered each year. A market mechanism for PRNs has been created where the price is set by the reprocessors according to the availability of material being recycled.

The resources dedicated for reverse logistics operations and their environmental implications are becoming a major concern. In a report for DfT (2004b), the CO_2 emissions generated by product returns were estimated on a national basis for UK as 0.4 - 0.8% of total CO_2 emissions. From businesses' perspective, compliance with the legislations usually entails further transportation impacts, additional operations, and increased complexities of supply chain, which directly add to overall cost. Another report produced for DfT (Cranfield University et al., 2004) carried out a survey within the UK retail industry to investigate reverse logistics practices and the result indicated that the average percentage of logistics cost associated with handling returns is around 5% of total logistics cost, which is estimated to be £500 million for the sector.

Taking account of such impacts on sustainability, there is an urgent call for enhanced efficiency in reverse logistics. The existing literature's contribution to addressing the issue could be summarised as below:

- Outsourcing the management of returns. There are 3PLs specialised in reverse logistics, offering expertise, facilities and systems, and often alternative channels of disposition from the traditional ones available (Hickford and Cherrett, 2007).

- Data collection and flow. Rogers and Tibben-Lembke (1999) pointed out that a lack of information about the process is the biggest challenge in reverse logistics. Poor data collection leads to uncertainty about causes of return. Hence, in the long run, the most valuable outcome of sound reverse logistics management is the accumulation of data. This proposal was further developed in Parvenov's article (2005) which illustrates some best practices in return management. The application of radio frequency equipment (e.g. handheld scanners) was recommended for the returns process. In addition, any data collection and returns processing modules was suggested to be tightly integrated into the existing warehouse management and accounting systems, which allows for real-time inventory control, instant allocation, picking and cross-docking.

- Business Process Reengineering (BPR). There are some proposals in the literature for development of multiple stage frameworks in designing, planning and controlling of reverse logistics activities (Guide and Pentico, 2003; Beamon, 1999; Parvenov, 2005). A specialised return system, rather than a generic ERP package, is believed to be able to address some problematic issues in returns operations while support effective automation for greater efficiency.

- Alternative approaches to obtain used products from end users. Guide and Pentico (2003) in their research set out the 'Waste Stream Approach', the 'Market-Driven Approach' and the combination of both. While the Waste Stream approach relies on diverting discarded products from landfill by making producers responsible for the collection and reuse of their products, the Market-Driven Approach relies on end users returning their products to a firm specialising in their reuse, motivated by financial incentives such as deposit systems, credit towards a new unit, or cash paid for a specified level of quality.

- Standardisation for packaging. It is suggested that by using a common type, reusable packaging which could then be exchanged between several companies, the costs of separating, stock keeping and redistributing different types of packaging for reuse could be significantly reduced (Kroon and Vrijens, 1995; Golding, 1999; DfT, 2005a).

There are other measures which can also help to reduce reverse logistics costs and meet environmental targets, such as back-loading of returnable pallets, containers or other packaging and distribution materials. Again, it is important to stress that the whole process of returning and processing of reusable packaging materials should not be more environmentally harmful than the use of one-way packaging (Kroon and Vrijens, 1995). For instance, as Fernie and Hart (2001) noticed, while it works well for large retail chains to exploit backhauls of trays and other reusable materials from suppliers, wholesalers often find it impracticable to recover packaging waste from a large number of small shops.

2.5.3.11 Road Pricing

Road pricing is generally regarded as a promising instrument to reduce congestion and emissions, and improve air quality and road safety. With varying objectives and political and economic considerations, different forms of pricing schemes are devised and implemented on different scales. Austria and Switzerland, for instance, have introduced fees for HGVs, Germany the LKW-MAUT kilometre charge and Italy and France have toll roads (Noordegraaf and Riet, 2007). In the Netherlands a differentiated kilometre charge has also been proposed (VenW and VROM, 2006). Other commonly investigated alternatives include the congestion charge at busy times and places, rush-hour surcharges, tollbooth, and charges based on environmental characteristics of the vehicle. This section reviews the road pricing schemes that have been implemented or proposed for implementation in the UK, i.e. Congestion Charge, Low Emission Zone (LEZ) and national Road User Charging (RUC), focusing particularly on evidence of their impacts on the road freight sector, and the valuable lessons learned from other cities and countries.

Congestion Charge

London has been enforcing the congestion charge in the central area since 2003. The price was raised in 2005 and the zone was extended into parts of West London between 2007 and 2010. Although not the first in the UK (Durham in 2002), it has been one of the largest in the world since it was introduced. TfL is responsible for the charge and the system is run on a generally automatic basis using CCTV and Automatic Number Plate Recognition. According to its annual report (TfL, 2007), the initial setup costs of the scheme were £161.7m, with annual operation and administration costs around £90m. There were £123m net revenues reported in year

2006/07 and £137m in 2007/08. By law, all surpluses raised must be reinvested into London's transport infrastructure. During implementation, fee collection from foreign-registered vehicles appeared to be problematic.

The effects of the congestion charge in London have been controversial. On the one hand the TfL (2007) annual report regularly reviewing the impacts of the charge claimed that the level of traffic was 16% lower in 2006, while journey time (22% lower in 2006) and journey time variability have also decreased within the zone. The breakdown shows that the number of vans and lorries entering the zone had decreased by 13%. On the other hand, there are reports stated that after an initial improvement, rush-hour congestion has actually become worse than it was before the introduction.

Environmental issues, especially reducing GHG emissions and air pollution from vehicle exhausts, are not the primary aims of the congestion charge. However, TfL's Annual Monitoring Report (2007) stated that between 2003 and 2006, N_2O emissions fell by 17%, PM10 by 24% and CO_2 by 3%, with some being attributed to the effects of reduced levels of traffic, and the majority being as a result of improved vehicle technology. The report also acknowledged that only a one-off reduction of emissions could be expected from the introduction of the charge.

The daily charge for fleet vehicles registered with TfL is currently £8, which has been criticised for increasing the delivery costs for businesses. In an early stage impact study (Allen et al., 2003), the level of the charges was linked with the speed improvement. The findings indicated that for some companies, a 15% reduction in driving time in the congestion charging area would more than offset a daily charge of £5. Building on this result, another impact study conducted by the University of

Westminster (Anderson et al., 2005) demonstrated that the effect of the congestion charge would differ between companies depending on the level of the charge, the geographical area of the scheme and of the company's operation, and the speed improvement achieved by the scheme.

Low Emission Zone (LEZ)

Also broadly referred to as "Environmental zones", this approach has been implemented in many European cities, such as Copenhagen, Stockholm and Amsterdam, to restrict use of downtown loading zones by trucks over a certain age, or those that do not meet strict emissions standards. In 2002/03, Copenhagen experimented with an elaboration of this policy, with a pilot environmental pricing scheme called the 'City Goods Ordinance'. Under this program, use of the loading zones in the medieval city centre required payment of a daily charge. Longer-term, reduced-cost permits were available for vehicles that could meet certain age, size and capacity utilisation standards (Goldman and Gorham, 2006).

As a similar programme, the LEZ in London came into force in 2008, covering almost the whole Greater London area – the largest of its kind worldwide. It targets emissions of air pollutants from older diesel-engined lorries, buses, coaches, vans, minibuses and other heavy vehicles. Technically, it is enforced using fixed and mobile cameras which read vehicles' registration number plates and check them against a database. There is a phased introduction of the scheme from February 2008 through to January 2012, with different vehicles being affected over time by increasingly tougher emissions standards (TfL, 2007). At present the inclusion of larger vans and minibuses has been deferred from 2010 to 2012. Like the congestion charge, the LEZ applies to vehicles registered both in and outside Great Britain, which entails the same enforcement problems with foreign registered vehicles.

Unlike the congestion charge which focuses mainly on local traffic congestion, the objective of the LEZ is to improve air quality in London. It is applied 24 hours a day, every day of the year and applied to all vehicles in the target group, irrespective of whether they are used for commercial or private use. Nevertheless, the emphasis has been given to tackling local traffic pollution issues leading to poor health and quality of life in the city rather than broader climate change issues (TfL, 2008). So far there have been few studies to evaluate the impact of the scheme, partly because it is still at an early stage.

As far as logistics operators are concerned, any vehicle failing to meet Euro III standards for PM attracts a £200 daily charge, if driven within the zone. Options given to operators are replacing the engine or vehicle with a 'cleaner' one, or modifying the existing one by fitting pollution abatement equipment. Some preliminary impact studies (Allen et al., 2003; Anderson et al., 2005) revealed that three out of seven participant companies were expected to face a 5% operating cost increase due to the need to acquire compliant vehicles. It was concluded that LEZ would have the least impact on changing current distribution operations, compared with other policy measures, such as the congestion charge and time and weight restrictions in urban areas, but would have significant impact on pollutant levels.

'Pay as You Drive' – national Road User Charging (RUC)

In 2003, a comprehensive study into the feasibility of a new nationwide road pricing scheme (DfT, 2004) was set up by the UK Government. The main driver of the road charge system was to make better use of the road capacity and mitigate congestion.

Based on the principle of “polluter pays”, road users would be charged according to the time of day, distance, the road driven, and the type of vehicle. The system would be secured by a satellite tracking system and black boxes installed on vehicles. Although the initial idea is to replace road tax and fuel duty with the scheme across the country, the Government has been working closely with those interested local authorities developing their local road pricing schemes, while running a series of demonstrations to test possible future road pricing systems and technology. At this stage, future uptake of such scheme remains uncertain.

Despite the feasibility study concluding that a national scheme had the potential to cut congestion by about 40% with only 4% fewer vehicles using the roads, so far concerns have been raised on technology, implications for civil liberty, the enormous cost entailed in establishing and maintaining such a charge system, and the adverse impact on the sectors that rely heavily on car travel (e.g. tourism), with passenger transport receiving more attention than the freight sector. Against this backdrop, the case for the Dutch road pricing policy, which resembles the proposed RUC in the UK in many aspects, is reviewed in detail, offering a valuable reference for the future policy refinement.

As shown in *Table 2.5*, the Dutch road pricing policy comprises a kilometre charge that varies by time, place and the environmental characteristics of the vehicle. The charge will be higher in peak hours, congested areas, and for more polluting vehicles. The proposed technology is a satellite based (GPS) system with on-board units in all vehicles.

Table 2.5: Major components in the Dutch road pricing policy

Level of Congestion Reduction after Implementation	30% reduction in travel delays
Level of Charge	11 euro-cents per kilometer (during peak hours)
Time Dependency	Flat at first; variable later
Coverage	All roads in the Netherlands
Revenue Spending	To reduce/abolish vehicle taxes and fund road infrastructure
Type of Differentiation	Significant differences by time of day and location

Source: Noordegraaf and Riet, 2007

To evaluate the potential effectiveness of the proposed Dutch road pricing scheme in terms of changing firms' behaviours (e.g. reducing traffic, or shifting to less congested areas and off-peak hours), the behavioural responses of businesses to the policy have been examined by Noordegraaf and Riet (2007). 21 companies, shippers and carriers from five most-affected sectors in the Netherlands, were interviewed, and the evidence gathered revealed that although most companies perceived road pricing as a financial burden, the policy still would not hold sufficient incentives for significant behaviour change. Other implications of the road pricing policy include the possible redistribution of costs and benefits among actors in supply chains, and unequal effects on firms, with some facing a high impact and some not at all. In general, carriers tend to be relatively more impacted than shippers as they have little manoeuvring space when shippers are in control of the transport and logistics arrangements. Taking a similar approach, the impacts of road pricing on British companies will be examined in this thesis, and the results can be compared with observations in the Netherlands.

2.5.3.12 Supply Chain Optimisation

In practice, suppliers, subcontractors and 3PLs were identified as the stakeholders most likely to get involved in the establishment of a greener supply chain, which is in line with the BearingPoint (2008) finding that transportation and sourcing were cited by most companies as the two main functions involved in implementing environmental measures, comparing with less interest in eco-design or recycling activities. Reflecting this in the literature, the specific approaches proposed for achieving supply chain optimisation mainly focus on these two areas – sourcing and transport operations. As the major measures falling into this category have already been broadly conceptualised in Section 2.5.1.2, this section will review the practical applications and implications of them.

Green Sourcing: Green sourcing may be applied either in procurement, that is, in selectively choosing suppliers and products that meet certain environmental criteria, or in logistics, which emphasizes the critical role that location and distance of sourcing could play in a distribution network. In BearingPoint's (2008) survey, 67% of British companies claimed to have adopted green sourcing, although no distinction was drawn between these two forms. Meanwhile, it has been observed that modern logistics trends have been moving toward global sourcing and centralised production, warehousing and distribution (Wu and Dunn, 1995; McKinnon, 2003a), which raises the question of how companies balance their sourcing decisions between a wider geographical sourcing scope and low carbon operations.

The prevalent practice of green sourcing favours close relationship with suppliers. It is usually implemented through cooperation between two trade partners through new product design, mutual development of environmental projects, and environmental charter agreement, and is secured by auditing and KPIs for evaluation (BearingPoint, 2008). Difficulties of implementation were claimed to include a lack of information about risks and regulatory frameworks, and the complexity of overhauling the entire procurement policy and procedures, which usually requires systematic processes from material/product specification, identification of suppliers, to supplier assessment and monitoring.

Green sourcing does not often have the implication of reducing cost. In many cases, alternative products that are more environmentally friendly can be more expensive than conventional ones, and thus entail higher procurement cost. Likewise, local sourcing may see companies benefit from lower transport cost, while the acquisition cost is very likely to be higher than sourcing globally, particularly from remote regions with low labour cost. However, it is the total cost of a product over the full length of its life cycle that should be evaluated for the implementation of the solution. Apart from the purchase price of the product, the cost of use, maintenance, recycle, recovery or disposal as well as external ecological impacts should all be factored into analysis (Yang et al., 2004).

Distribution Network Restructuring: Although most environmental impacts are determined during the design phase of a logistics system, a periodical overhaul of an existing network may also have great potential in improving its overall environmental performance. The approaches may range from incremental changes in the material handling operation, warehouse layout and operating pattern (e.g. cross-docking), to structural changes of logistics systems towards efficient consumer response, and environmentally responsible practices that tend to favour fewer shipments, less handling, shorter movements, more direct routes and better space utilisation (Wu and Dunn, 1995). Three case studies were undertaken by Aronsson and Brodin (2006), elaborating structural changes in three firms' logistics systems and the resultant benefits. Higher resource efficiency, total cost saving and emissions reduction, for instance, were achieved, following a series of restructuring movements, including the establishment of an intermodal network, centralisation of the physical flows planning or warehouse (i.e. fewer, bigger warehouses), and standardisation of vehicles and load carriers. It was concluded that structural consolidation, standardisation within distribution systems, and mode selection are the important drivers of both efficiency and environmental performance.

Primary Consolidation Centres (PCCs): PCCs have seen rapid growth over the last decade and have become common practice. In the UK grocery supply chains alone, for instance, the number of PCCs increased from just 11 in 1998 to over 100 by 2003 (IGD, 2003). Examining the increasing use of PCCs, Potter et al. (2003) modelled a potential reduction of 28% in the mileage associated with transporting less-than-truckload consignments to RDCs. A case study of Procter & Gamble (Aron, 1994) demonstrated positive results from consolidation of its distribution centres.

Streamlining logistics operations: Reducing the environmental impact of transport mainly through improving vehicle utilisation and fleet efficiency was suggested by the European Commission (2001) in its White paper. Better transport planning and scheduling, higher fuel efficiency and lower consumption, greater consolidation of loads, and waste elimination throughout the distribution process are also methods frequently suggested. Nevertheless, a recent survey of companies in the UK, Germany, the Netherlands and Spain revealed that only 8% of respondents were either already involved in initiatives to make shipping and transport more efficient, or planning such measures within the next year (French, 2007).

Backhauling: When employed effectively, backloading can improve overall operational efficiency, reduce emissions and lower road congestion. In the UK, the proportion of kilometres run empty by HGVs over 3.5 tonnes has been steadily declining for over 30 years, yielding large economic and environmental benefits equivalent to £1.3 billion of road haulage cost and 1.1 million tonnes of CO_2 (McKinnon and Ge, 2006).

Successful case studies of backhauling were reported especially in the retail sector (Fernie et al., 2000; DETR, 1998), which benefited from reduced vehicle journeys and fuel savings. The problems associated with backhauling are generally viewed from the perspective of uncertainty and the complexities of scheduling arrangements (Heriot-Watt University, 2007). However, internet-based transport exchanges enabling hauliers to identify backload opportunities so that traffic flows and transport capacity can be matched nationwide more efficiently are proposed to tackle this issue (Sarkis et al., 2000; Mansell, 2001, 2006).

Postponement: Practical business applications of postponement have been exemplified by the widely quoted cases of Benetton (Dapiran, 1992), Gillette (Gander and Whitworth, 2000), Whirlpool (Waller et al., 2000), and Hewlett Packard (Twede et al., 2000; Feitzinger and Lee, 1997), to name a few. It has been recognised by researchers as having the potential to improve responsiveness while reducing inventory, transport, storage and obsolescence costs (Christopher et al., 2007). Previous research also identified an evident link between 3PLs and postponement activities built up over past years, seeing an increasing number of postponement services provided by or outsourced to 3PLs (Yang and Burns, 2003). Although growth of interest in and practice of postponement has been observed, and a variety of postponement techniques have been adopted by businesses, the impetus behind this comes down to a handful of factors such as the desire to control inventory risks, reduce logistics costs (Chiou et al., 2002; Rabinovich and Evers, 2003), shorten the product life cycle, grow product varieties and adopt e-business models (Yang et al., 2004), with environmental concerns rarely referred to as one of the major motivations.

Nominated Day Delivery System (NDDS): Introduction of NDDS is claimed to be against sales and marketing goals, due to the fears that the imposition of ordering constraints will result in loss of customers. However, the experience of companies operating NDDS contested this view (McKinnon, 2000). Furthermore, research conducted by Zografos and Giannouli (2001) has shown that a substantial increase in NDDS is expected in all sectors where this concept is applicable.

Rolling Credit System: There is little evidence in the existing literature on widespread implementation of Rolling Credit System, possibly as it entails close interaction with other functions within a business (e.g. sales, marketing, finance, and general management at higher level) as well as coordination across the whole supply chain (e.g. with customers and suppliers), which deters such methods from wide application. Also, the transport efficiency improvements attributable to 'rolling credit' system implementation require further investigation (McKinnon, 2003a).

Unattended delivery: Reception boxes are the main facilities designed for unattended delivery. A piece of research in Helsinki has suggested that the use of reception boxes can cut delivery distance and transport costs by as much as 40%. Attempts to sell reception boxes to domestic users have so far proved unsuccessful, causing their suppliers to re-orient their marketing from the B2C to the B2B sector. Unattended delivery of spare parts, sales catalogues and business parcels is reported to be increasing (Anon, 2006).

Collaboration: The main obstacle to horizontal collaboration is identified as the reluctance to discuss issues and problems in the supply chains with perceived competitors. It is also warned that care must be taken to ensure that competition laws are not infringed (Heriot-Watt University, 2007).

Altogether, six practical examples of supply chain optimisation with various approaches applied in businesses are included in *Appendix Ten* for further reference.

2.5.3.13 Urban Logistics

The dilemma of urban logistics is that on the one hand, the economic growth of towns and cities is interdependent with urban logistics activities, thus simply considering it as a problem and reducing the activity level would affect the development of cities and their inhabitants; while on the other hand, harmful environmental and social impacts of logistics operations would be further increased by growing logistics within already congested urban areas (Loffler, 1999). Therefore, seeking better sustainability and greater logistics efficiency based on existing urban infrastructure is the common objective of various urban logistics initiatives. There are broadly two categories of sustainable measures featured in urban logistics literature – consolidation/transhipment centre and other government led initiatives.

Consolidation/Transhipment Centre

The concept can be described of logistics hubs, located normally on the periphery of city centres, handling and transhipping freight destined for urban areas into small vans for final consolidated delivery. These vans would also undertake consignment collection from city centre premises. The potential benefits include enhanced vehicle productivity, reduced vehicle numbers and journeys, less congestion, lower emissions, noise and other environmental discharges by sharing the use of dedicated ‘city vans’, and the strategic advantage to exploit modal shift by locating the transhipment centre near railway or waterways (Browne et al., 2007).

However, there are many ‘technical’ issues that need to be addressed before the transhipment centre solution can even be piloted. For instance, the ownership of the facilities, whether the scheme should be operated on a compulsory or voluntary basis, the licensing system for operators in the area concerned, specification of the ‘city vans’, and the complementary policies, either as incentives promoting use, or as disincentives penalising lack of use, should all be decided before the idea can be realised (Browne et al., 2005).

Financial viability presents another issue for transportation projects of this kind. The additional cost of most urban shared-user transhipment platform projects in many European cities in the 1990s were evaluated as being too high for these experiments to continue (Dablanc, 2007). As Goldman and Gorham (2006) have pointed out, pursuing sustainable transport through major capital projects provides no guarantee of success, since the results of such projects are rarely correctly foreseen. For this reason, very few urban planning policies involve major transportation projects, or envision massive increases in transportation system capacity. Instead, they are often intended to be implemented quickly, incrementally, and at low cost.

Given all these considerations, it is suggested that this solution would achieve wider benefits if applied in conjunction with other complementary measures:

- <u>Locating strategy towards other modes</u>. Through locating transhipment centres at sites close to railway lines or waterways, modal shift towards more environmentally friendly freight transport would become more practical and financially attractive for operators.

- <u>Incentives and restrictions</u>. Various incentives may be employed to encourage the use of transhipment centres, while severe time-of-day or vehicle size restrictions within urban areas will put constraints on the operators outside the scheme. There are also proposals for compulsory use of such facilities, with all other lorries banned from designated areas.

- <u>Vehicle specification</u>. Dedicated fleets serving transhipment centres and within urban areas can be appropriately specified to achieve sustainable development. It is argued that the largest and heaviest lorries should be confined to a network of motorways and near-motorway standard trunk roads, while 'city lorries', which meet higher standards for lower emissions, noise and better safety, should be given priority over cars and other vehicles through the use of lorry lanes or shared bus/lorry lanes (Plowden and Buchan, 1995). However, there are many other factors impacting the decision-making on vehicle selection. Although, by and large, smaller vehicles may seem to be more environmentally friendly, financial performance tends to favour larger vehicles (Browne et al., 2007). The volatility of seasonality and uncertainty in the number of collections and deliveries one driver can achieve in a given time window also contribute to the difficulties on vehicle size selection. As a result, fleet mix may exist as a compromise across a range of requirements in the foreseeable future.

Projects of such shared distribution systems were carried out in Germany through private sector cooperation in the 1990s (known as 'city logistics'). However, it was considered as 'not compatible' with the prevailing UK model of retail distribution, where dedicated services were desired to maintain high level logistics control in the supply chain (Whiteing and Edwards, 1996). In UK there are successful case studies and reports demonstrating the potential and benefits of operating transhipment centres (for Heathrow airport consolidation centre, see Browne et al., 2007; for the case of Norwich, see Humphrey, 2008).

Other Government Led Initiatives

Since the late 1990s, a series of measures aiming to provide answers to sustainable urban logistics, with government playing a central role, have been proposed (BESTUFS, 2007; Browne et al, 2007; and Dablanc, 2007):

- Vehicle weight, size, access time and route regulations. Such are restrictions confining goods vehicles above a certain size or weight to certain routes (advisory or mandatory), or prohibiting them from entering, loading or unloading in all or part of an urban area during certain time. Compared with transhipment centres, which represent more of a long-term strategy requiring substantial analysis and high level capital investment, they can be applied in a short term with relatively low cost, and greater flexibility for future adaptation.

- Urban freight information and maps. This includes the production of lorry maps in paper form and online (showing appropriate routes, and information about access arrangements, loading/unloading regulations, and lorry parks), and provision of information about prevailing traffic conditions and relevant facilities.

- The establishment of "neighborhood drop-off points". These points can be as simple as a dedicated counter in a local shop, or as high-tech as 'Tower24' in Dortmund, Germany, a fully automatic storage facility where neighbours can collect their packages 24 hours a day (Goldman and Gorham, 2006). Both can significantly reduce trips associated with residential deliveries.

- Allowing night delivery operations. In contrast to the night curfew, this assisting policy, encouraging night deliveries, may help to alleviate congestion in urban areas, while quieter engines will be in demand along with it. Two survey studies conducted by the British Retail Consortium (2001; 2005) indicated that around 20-30% of the retail outlets were subject to delivery time restrictions (mostly at night time between 11pm and 7am). Jackson and Timson (2001) looked into details of how night time delivery restrictions impacted businesses and consequently imposed further pressure on the urban environment. They calculated that 600 vehicles, 687,000 vehicle trips and 106 million vehicle kilometres could be reduced by the four leading retailers in UK should the delivery restrictions be removed. Likewise, the FTA's survey (2003) result suggested that more than 50% of goods vehicle traffic growth could be reduced, were current night time delivery restrictions removed. Allen et al. (2003) also examined the impact of time restrictions and concluded that night time distribution could be beneficial from both economic and environmental perspectives, depending on the trade-off between higher night operation costs (e.g. higher wages for drivers and other staff, higher reception/despatch costs) and distribution cost savings (e.g. improved driving speed). Seeing many UK cities enforcing more restrictive time bans than their European counterparts, Browne et al. (2007) argued that easing such restrictions may be the case in some situations. They further suggested low speed limits, same access time for adjacent city centre streets, and coordinating restrictions in neighbouring towns as complementary measures to facilitate more efficient freight movements with minimum levels of disturbance.

- <u>Relaxing other urban freight restrictions and regulations</u>. Although most cities view goods vehicle traffic as something they should ban or at least strictly regulate instead of a service they should help organise in a more efficient manner (Dablanc, 2007), many studies have been devoted to the illustration of negative impacts of strict restrictions on urban freight operations. Allen et al. (2003) examined the impact of vehicle weight restrictions on operators. Their findings indicated that different companies are subjected to the effects of the policy according to their fleet composition. The operating cost of the worst affected company could increase as much as 30%, and the negative environmental impact would increase significantly as a result of increased vehicle trips and distances travelled. Based on similar considerations, Dablanc (2007) suggested that it is time for cities to abandon traditional access criteria based on goods vehicles' weight and size, and to adopt more relevant criteria based on their environmental and logistics performance. This practice has already been adopted in some northern European cities (e.g. Amsterdam, Copenhagen, Stockholm, Goteborg). As observed in a number of Dutch cities, for instance, licensing schemes were set up whereby participating firms receive certain privileges (e.g. longer delivery hours) in exchange for performance commitments (e.g. using only electric vehicles, and exceeding minimum loading standards). This may provide a workable solution to address the issues of restrictions (Goldman and Gorham, 2006).

- Sharing bus lanes with lorries in appropriate circumstances, examples of which exist in London and Newcastle.

- Encouraging the use of information systems and telematics applications with scope to improve logistics efficiency in urban areas.

- Low Emission Zone. It is a designated area that can only be entered by vehicles meeting certain emissions criteria. Such zones exist in several Swedish cities, Rome and London and are planned in Madrid, Paris, Copenhagen, and urban areas in Norway.

- Road pricing system. The research in off-hour deliveries (Holguin-Veras, 2008) evaluated the effectiveness of the freight pricing scheme and claimed that simply charging carriers may not be the most effective way to move freight traffic out of the congested hours, because (i) the carriers have great difficulties passing on toll costs to their customers; and (ii) in the few cases where toll costs could be passed on (e.g. in the industry sectors where carriers enjoy oligopoly power), the price signal reaching shippers is of no consequence compared to their additional costs for off-hour delivery. Hence freight road pricing during rush hours as a revenue generation mechanism was suggested to be combined with tax incentives to shippers who are willing to accept off-hour deliveries.

Regardless of the abundant research and alternative options in urban logistics, the inherent difficulties in the actual implementation remain an outstanding issue. In France, for example, while most transport plans have considered the issues and solutions discussed above, very few have led to effective action due to lack of budgets, the personnel, or the political authority to implement these types of policies (Deblanc, 2007). Given these concerns, it is suggested that these strategic policy visions might take different forms if applied in different cities, where local needs, levels of economic development, cultures, urban forms, economic structures, and transportation systems must be taken into account (Goldman and Gorham, 2006). The examples of five cases of best practice demonstrating the application of various forms are given in *Appendix Ten*.

2.5.3.14 Vehicle Design

Apart from the European emissions regulations for heavy-duty diesel engines discussed in Section 2.5.1.1, many governments now also regularly subsidise research into automobile technologies to improve fuel efficiency.

Lower rolling-resistance tyres, for instance, are stated to have the potential to save 7-13% on fuel consumption compared with standard tyres (DfT, 2004c). Although such energy-efficient tyres may need replacing more frequently than standard tyres owing to their reduced tread, using re-treads and remoulds that provide the same resistance as new tyres is suggested as a cost-effective alternative for businesses (DfT, 2005c).

Aerodynamic styling is given great importance in vehicle design, as it is estimated that 50-70% of a vehicle's power is used to overcome aerodynamic resistance, compared with around 20-30% for rolling resistance and 10-15% in the transmission system (Modi et al., 1995; cited in Heriot-Watt University, 2007). DfT (2004d) estimated that 6-12% fuel savings can be achieved through aerodynamic styling, along with other benefits such as CO_2 savings, a smoother ride and improved performance especially in head-wind conditions (DfT, 2006). A case study of BOC, the industrial gas company trialling an Air Flow Deflector Kit demonstrated 4% fuel savings which repaid the cost of the kit in five months (DfT, 2002; cited in Heriot-Watt University, 2007). More fuel savings from aerodynamic designs (over 7% for Somerfield, 15.8% for TNT Express, and 16.7% for Don-Bur) were also reported in various case studies (DfT, 2006; Don-Bur, 2006).

Double-deckers (DD): Two-tier vehicles have been promoted to offer considerable increases in the vehicle load factor without necessarily increasing the external dimensions of a truck (DfT, 2005d). The benefits offered by DD were well illustrated in some case studies (DfT, 2005d; DfT, 2006), such as reduced vehicle mileage, increased average vehicle utilisation, and resultant CO_2 emission reduction and financial savings. Nonetheless, concerns have also been raised regarding double-deckers (DfT, 2005d; DfT, 2006; Adams, 2006, cited in Heriot-Watt University, 2007). It was noted that fuel efficiency declined owing to the increased differential between cab and semi-trailer height. Meanwhile, the combined weight of the internal lifting mechanism and the moveable deck (up to 15 to 16 tonnes) not only reduces the payload capacity of the vehicle, but also contributes to more CO_2 emissions. The companies using double-deckers also face the common problem of not being able to maximise vehicle utilisation. Nevertheless, it is argued that by looking at fuel consumption per pallet-km, the efficiency is substantially improved, and the issue of extra weight can be addressed with advanced technologies (Swallow, 2005).

Longer, heavier vehicles (LHVs): In Section 2.5.3.13 (Urban Logistics) the issue of vehicle size in urban areas has been addressed, with smaller vehicles generally being favoured over larger ones. Nationwide, however, a strategy towards the ‘superlorry’ (sometimes referred to as ‘road train’) was proposed. Following a move from rigid to articulated vehicles in the British road haulage industry, the increase in vehicle weight restriction to 44 tonnes (and 54ft) was made in 2001, and a further extension of this to permit articulated trailers of up to 60 tonnes on certain trunk roads was considered (Davis et al., 2007). The economic and environmental benefits of raised weight restrictions in 2001 have been assessed by McKinnon (2005), primarily from reduced traffic level, road haulage costs and carbon emissions. A study commissioned by DfT on further increases in maximum lorry weight has also found that LHVs would deliver significant financial and environmental benefits without compromising road safety (The Times, 2007). Concerns about LHVs mainly concentrate on diversion of freight from rail, road safety and under-utilisation of vehicles (MTRU, 2007; McKinnon, 2005; The Times, 2007), which have been monitored and evaluated after a total trial period of ten years for LHVs (25.25m, 60t) in the Netherlands since 2001. With the research showing no negative impact on traffic safety and modal split shares, and the aim of increasing transport efficiency and reducing vehicle kilometres and emissions being achieved, LHVs have now been given a permanent status in the country (Rijkswaterstaat, 2011a, b & c).

At present, technologies for environmentally friendly engines or vehicles are relatively new, and the introduction of such technologies are held back by the highly competitive nature of the transport and logistics industry in the UK, given their high capital cost (Browne et al., 2007). As a result, it is often suggested that the regulatory framework of vehicle emission standards should be applied in combination with fiscal instruments, such as favourable taxation on cleaner or alternative fuels and vehicles, and financial incentives in the form of subsidies covering the additional cost of the technical solutions or retrofitting needed for compliance. In practice, disincentive policies to restrict the use of more polluting vehicles, including higher circulation taxes, penalty charges, or restriction of such vehicles in access to certain urban areas, are also implemented to achieve the desired environmental objective. Nine practical applications of vehicle design technology in businesses under different circumstances are presented in details in *Appendix Ten*.

2.5.4 Summary

It has been found that of the previous studies in the literature within the scope of sustainable logistics, a considerable number of them were devoted to examining the sustainability of freight transport, which is generally deemed as the biggest contributor in logistics to climate change. Most research explored the area with specific focuses, such as reverse logistics, road pricing, and those confined to certain technologies, geographical areas, transport modes, sectors or certain functions of supply chain. Such focuses have certainly helped researchers to exploit their specialised expertise and make a greater contribution to tackle the problems in question, but the narrow perspective also resulted in a lack of an integrated view of the whole picture. Interactions among solutions, for instance, were only patchily addressed in a limited part of the literature, yet neglecting this would greatly impact the effectiveness of their implementation and evaluation.

Another gap identified during the literature review is that, although existing research findings have provided a large variety of solutions for 'green' logistics, there are very few empirical studies revealing how the solutions could be widely implemented and to what extent they would impact on the industry and environment. For instance, despite abundant case studies illustrating specific applications of certain solutions within particular companies or sectors, data in this form cannot be generalised to represent the prevalent practice of the whole logistics industry. Most surveys conducted in recent years have failed to complement the case studies with a comprehensive view, as many of them have narrow focuses, are inconsistent in defining important terms, and are conducted using different approaches.

During the literature review process, it is also noted that cost-effectiveness often acts as an essential element in determining the scale of impact of a solution. In the market-based micro economic environment, logistics operators as individual entities are independent decision makers on whether or not to take on board any of the relevant green measures, which ones to take, and how to implement them. On a voluntary basis, such decisions should be largely based on cost-benefit attributes of the solutions, assuming that profit maximisation is the ultimate objective of businesses. This cost-effectiveness principle is also applicable at the macro level for evaluating the potential of sustainable policy instruments. In CfIT's (2007) report as advice to the Government, it is argued that over time, the contribution of some sectors towards overall emissions reduction may be potentially more significant than that of others due to their cost-effectiveness, hence it is inappropriate to assume automatically that all sectors should contribute equally towards the total reduction target, or even that the environmental contribution should be delivered proportionally by sectors according to their levels of emissions.

Unsurprisingly, comparability turns out to be a standing issue in regard to cost-effectiveness or any other evaluation of solutions. It was found to be extremely difficult to draw parallel comparison of the results from different studies, largely due to uncertainties of many critical factors and differences in methodology (Anable and Bristow, 2007). Differences in time series, geography, study purpose and focus, for instance, result in incomparability of the outputs. Discrepancy is also caused by different assumptions on degrees of implementation, impacts of certain solutions (e.g. demand elasticity of carbon pricing), future scenarios (e.g. technology development over time), definitions of costs and benefits included, and methods of calculation (e.g. discount rates, indicators for carbon emissions). Therefore, a robust methodology is required to provide a generic and objective approach to measuring, evaluating and comparing the existing sustainable solutions.

Given these considerations, and in an effort to bridge the gaps, a comprehensive and complementary repository of sustainable solutions representing the current practice has been pooled and research findings synthesised in the latter part of this chapter. A structured framework of 14 widely diversified sustainable logistics solutions was constructed and classified by different typologies, with various dimensions of each solution reviewed. The framework provides an integrated platform, allowing not only cost-effectiveness – hence the wider impacts of major solutions on the entire logistics industry and environment – but also other key attributes, to be compared, and for the interactions between solutions to be revealed. The methodology developed for these purposes is elaborated in the next chapter.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter elaborates the methodological approaches adopted in this thesis. Starting with a brief review of the trends in research methodology deployment observed in recent logistics research, it gives the reasons for adopting a combined approach for this study. After development of the main hypotheses to be tested against empirical evidence, the remainder of the chapter then describes the selection of various methods employed during the research in terms of their purpose, design and implementation.

3.2 Methodology Application in Contemporary Logistics Research

In general, business research methods, or social science research methods in a broader sense, have been 'borrowed' (Stock, 1997) and widely adopted in logistics and supply chain management research. However, as an emerging discipline, logistics is expanding the array of issues addressed, and the application of methodology is evolving and diversifying at a rapid pace. Consequently, much effort has been spent looking into the deployment patterns of research methods in this area.

A series of content analyses of previously published research in mainstream logistics journals leads to the conclusion that the predominant research approach appears to be deductive positivism (the definitions for deductive, inductive and abductive research processes are given in Section 3.3 and illustrated in *Figure 3.1*), with a strong emphasis on survey methods (Mentzer and Kahn, 1995; Ellram, 1996; Arlbjørn and Halldórsson, 2002; Näslund, 2002; Spens and Kovács, 2006). However, inductive and abductive approaches are emerging and increasing both in quantity and prominence, while evidence shows that the dominance of deductive approach is decreasing over time (Spens and Kovács, 2006).

Corroborating the findings of the earlier studies, Craighead et al. (2007) further revealed the popularity of survey-based research in examining 'attitudinal and behavioural aspects of logistics interactions'. They also discovered that considerable amounts of research were conducted using simulation and mathematical modelling, while case-study and action-research methods comprised a relatively small – but growing – proportion of published logistics research (for case studies in logistics, see Dinwoodie and Xu, 2008). The findings are collated and summarised in *Table 3.1*.

Table 3.1: Research methods applied in logistics in 1993 and 2003

Total number of journal articles reviewed: 157	*1993*	*2003*
conceptual / literature reviews/simulation/modelling	70.4%	45.0%
Survey/Interview	27.8%	38.8%
action/case-based research	1.8%	14.2%

Source: Adapted from Craighead et al., 2007

Another major pattern observed is the dominance of quantitative methodologies over qualitative ones in the majority of logistics research (Mentzer and Kahn, 1995; Näslund, 2002; Halldórsson and Aastrup, 2003; Larson and Poist, 2004). Mangan et al. (2004) argued that the combination of quantitative and qualitative methodologies provides greater multidimensional insight into many management research problems than a single research methodology does, and demonstrated the benefits via a 'real-world' logistics application. This opinion seems to be gaining recognition among logisticians, as is reflected in the trend towards the increasing employment of qualitative methods (Spens and Kovács, 2006).

Overall, research methodology deployment in logistics resembles the attributes of the discipline itself – it is typified by diversified, cross-functional and multi-disciplinary approaches. Flexible applications of traditional methods are commonplace in logistics research, which sees great adaptability of methods originally established for other disciplines (Stock, 1997). In solving logistics problems, a case study does not necessarily have to be qualitative (see Stassen and Waller, 2002 for a quantitative case study). Likewise survey methods, as well as data collection in a typical hypothetico-deductive process for a statistical-quantitative analysis, can also be deployed in inductive or abductive research processes with open-ended questions to collect qualitative data. As a result, the traditional links between inductive approach and qualitative methods, as well as those between deductive and quantitative methods, are less evident in logistics research than in other disciplines (see Quariguasi Frota Neto et al., 2008 for an example of a quantitative-inductive case research).

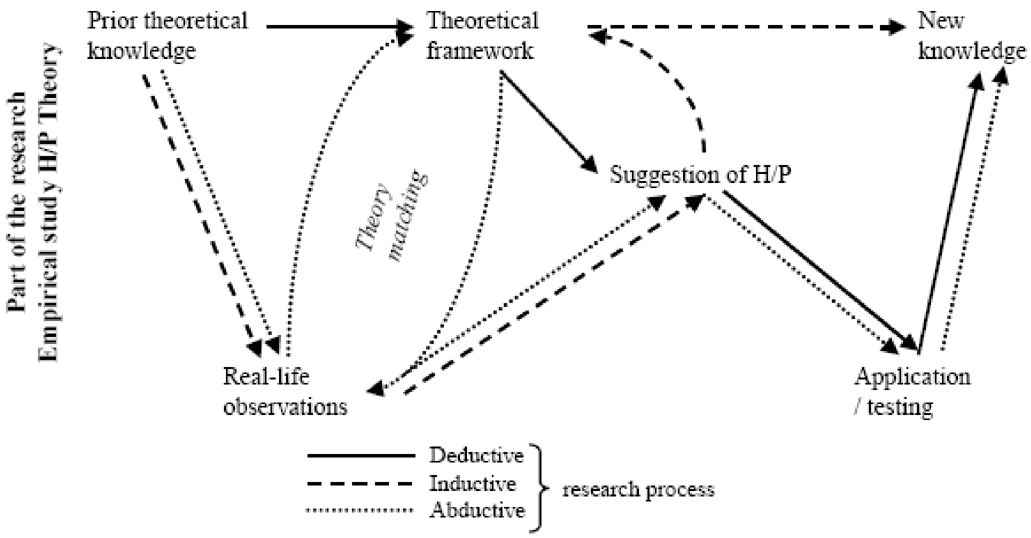
Nevertheless, there are areas identified during the research methodology review in logistics as having room for improvement. Most logistics articles, according to Spens and Kovács (2006), do not explicitly state the hypotheses under test, the research approaches used, or the research process adopted, although sometimes such implicit information can be inferred. Moreover, there are also times when an inductive or abductive research process is reported as deductive. The absence of a detailed methodology record consequently eliminates the possibility of periodically conducting replication studies in the future. More importantly, any vague or even wrong definition would jeopardise the methodology's vigour, something that has long been called for in logistics research (Mentzer and Kahn, 1995; Mentzer and Flint, 1997).

As a discipline that is still maturing, logistics is encouraged to be moving towards more theory-developing research (Spens and Kovács, 2006). Combining different research processes, approaches and methods has also been advocated in much of the literature (Mentzer and Flint, 1997; Näslund, 2002; Halldórsson and Aastrup, 2003; Mangan et al., 2004; Spens and Kovács, 2006).

3.3 Research Approach/Process

Based on the research process framework constructed by Kovács and Spens (2005), the deductive, inductive and abductive approaches follow separate paths of reasoning, with the common aim of acquiring new knowledge. *Figure 3.1* illustrates the framework, with three typical processes which these different approaches follow.

Figure3.1: Three research approaches/processes – deductive, inductive and abductive



Note: H/P stands for hypothesis or proposition

Source: Kovács and Spens, 2005

The inductive research approach is a theory-development process that normally involves generalisation of real-life observations and establishment of new theories as a result. The deductive approach follows the process of theory testing, on the other hand, applying the existing theoretical framework to specific instances (Hyde, 2000). Since many researches do not follow the pattern of either a purely inductive or deductive approach, but more a hybrid of these two kinds of process, in much the same way as the path which this thesis has taken, the abductive approach has come into being. Abduction is regarded as an appropriate process when reasoning from effect to causes or explanations (Lamma et al., 1999), and also works well when verifying problematic theories (Ribeiro et al., 1995).

To distinguish between these three research approaches, Spens and Kovács (2006) further developed three indicators which helped in determining the nature of the research approach adopted for this thesis:

(1) the starting point of the research process;

(2) the aim of the research; and

(3) the point in time at which hypotheses or propositions are developed and whether they are further applied.

This research started with screening and pooling major sustainable logistics solutions and constructing a categorised framework based on the results (see Chapter Two). This stage involved extensive literature review and information collection, mainly from secondary data sources such as White Papers, published reports, statistics and research, in order to paint a picture of the current state of sustainable logistics applications. Up to the stage of constructing the framework, it represents a typical theory-development process, where facts were aggregated and synthesised to establish general rules that could be applied to any specific situation or individual (in this case to individual logistics operation). Even though the facts, or real-life observations, are made through secondary sources, the argumentation line remains.

However, the developed theoretical framework was then empirically tested in order to:

(1) further reveal the possible interrelationships between major solutions;

(2) discover the attitudinal/behavioural patterns of different operation types; and

(3) explore the drivers or disincentives for each solution.

The first two objectives indicate a classic hypothetico-deductive research model, or theory-testing process, where ex ante hypotheses are tested empirically, and general conclusions are presented based on the corroboration or falsification of the hypotheses; while the third objective takes the process onto a diverging route. Instead of following a pure deduction or induction path, the objective is to discover the reasons, or causes, which explain the behaviour pattern of business towards certain solutions (i.e. the results of objective 2). As aforementioned, this is generally understood as the abductive approach, which normally involves 'reasoning from effect to causes or explanations' (Lamma et al., 1999). Based on the findings that result from pursuing these three objectives, the initial theoretical framework is restructured to represent a more realistic reflection of the most effective and practical solution packages.

Following the multi-task testing and exploring process, the final stage sees a couple of case studies compiled to illustrate the observed practice of the adjusted theoretical framework. It can be regarded either as a final testing/verification process of the new framework, or the application of the refined framework to an existing phenomenon.

Therefore, although throughout the research all three approaches – inductive, deductive and abductive – were adopted at different stages, and at a certain stage a combination of inductive and deductive approaches were applied, the argumentation of the entire research follows an abductive path.

3.4 Hypothesis Development

In order to verify and adjust the framework established in Chapter Two, nine hypotheses have been developed to address the overall research objective from three different perspectives – revealing associations, exploring interactions, and identifying linkages between effects and causes (see *Table 3.2*).

Table 3.2: Summary of nine hypotheses to be tested

	Hypothesis
Association	***Hypothesis One:*** *Sustainable logistics practices vary by business size.* ***Hypothesis Two:*** *Sustainable logistics practices vary by industry sector.* ***Hypothesis Three:*** *Sustainable logistics practices vary by the geographic scope of the operation.*
Interaction	***Hypothesis Four:*** *There are interactions between certain sustainable solutions.* ***Hypothesis Five:*** *Logistics service providers and logistics service users are similar in their sustainable strategies and practices.* ***Hypothesis Six:*** *There is interaction between logistics service providers and service users in sustainable practice.*
Cause & Effect	***Hypothesis Seven:*** *The perception of the importance of logistics sustainability is not always reflected in the actual practice of companies.* ***Hypothesis Eight:*** *The factors affecting the choice of sustainable measures are complex and depend upon the unique circumstances of each company.* ***Hypothesis Nine:*** *The choice of sustainable policies adopted by companies is highly related to the cost-effectiveness of the solutions.*

Source: compiled by author

The hypotheses on association deal mainly with the particular patterns or relationships that may exist between sustainable practice (as the dependent variable) and certain key factors (as independent variables), such as companies' attributes, industrial sectors and the geographic scope of the operations. Not only will the presence of the associations be tested, but the specific characteristics that such associations might hold are also projected to facilitate later analysis.

The hypotheses on interaction are developed to enable discovery of interrelationships that might exist among major actors within the industry and among certain sustainable solutions. With the intention of revealing the status quo of sustainable logistics practice (i.e. the perception or implementation of the sustainable solutions in question), and of identifying the explanatory factors (e.g. driving forces or disincentives), the hypotheses on cause and effect will play a critical part in enabling evaluation of the effectiveness of each sustainable solution within the established framework, and exploring the effective mechanism to strengthen its impact.

Altogether the testing of the nine hypotheses developed on the basis of the findings of the literature review and the sustainable framework will provide sufficient evidence to satisfy the key research objectives. The following section will address the research methods adopted for primary data collection, in order that the remainder of the thesis can deal with testing the hypotheses and restructuring the framework.

3.5 Research Methods – Purpose, Design and Implementation

As explained in Section 3.3, the deliberate choice of an abductive approach in conducting this research lends itself to a combination of various research methods in order to achieve the research objective. This section explains the selection of research methods which have been applied throughout the project, and details the purpose, design and implementation of each one of them.

3.5.1 Quantitative and Qualitative Research Methods

The selection and design of research method is greatly influenced by the research approach adopted. Although, as aforementioned, the traditional links of qualitative-inductive and quantitative-deductive are less evident in logistics research than in other disciplines, the general patterns still remain. *Table 3.3* gives an illustration of these patterns by summarising the key methods most commonly adopted for each approach. It should be noted that not all the methods fit solely within the boundary of different approaches due to the innovative application of methodology in contemporary logistics research. Hence the pattern shown in *Table 3.3* is an illustration of common practice rather than a rigid classification.

Table 3.3: Research methods normally applied for three research approaches

Deductive	
simulations model building (mathematical or computational) ***quantitative surveys*** ***structured interviews*** case studies	for testing hypotheses or theories
Inductive	
simulations model building (mathematical or computational) case studies	if built on the basis of empirical evidence for theory-developing
Abductive	
action research constructive research simulations model building (mathematical or computational) ***case studies***	often combined to complete an abductive reasoning process

Source: compiled by author

As highlighted in the table, empirical testing on the preconstructed sustainable framework was conducted by means of quantitative surveys and semi-structured interviews. Case study was chosen as a fit-for-purpose method at the final demonstration stage. Therefore, both quantitative and qualitative data were collected for analysis in reaching the conclusion of the research.

The benefits of such a flexible combination of both data collection methods are substantial – the advantages of each method are retained; while the different types of data complement each other, minimising the disadvantages of using either one of them in isolation and providing a comprehensive, yet also in-depth, perspective on the research questions under investigation. *Table 3.4* lists the strengths and weaknesses of both quantitative and qualitative research methods in a matrix, showing the complementary characteristics of each method.

Table 3.4: Strengths and weaknesses of quantitative and qualitative research methods

Quantitative Methods	Qualitative Methods
Strengths	***Weaknesses***
Efficient and low cost - large amount of information in limited time scale	Time-consuming; costly in terms of resources
Credibility - less bias	Bias (mainly from researchers)
Anonymity for respondents	Anonymity concerns (possible bias from respondents)
Greater accessibility	Access to subjects and information
Generalisable results from representative samples	Reflexivity; Selectivity
Objectivity and Transferability	Subjective and less transferable
Weaknesses	***Strengths***
Complexity of method; Artificial theoretical framework	Tailored method with flexible framework
Oversimplification of the real world problem	Open to incorporating new issues and critical factors
Risk of misinterpretation (by either respondents or researchers)	Reality; contexual, hence better comprehension
Past-, not future- oriented (Snapshots)	Insightful exploration
Limited depth of information	Targeted, detailed and in-depth information
Less control over / communication with the respondents	More control over / communication with the respondents
validity subject to researcher's understanding of the question	Self-correction and validation along the open process

Source: compiled by author

Traditionally, rigour as a critical quality criterion favours the quantitative method, leading to its dominance in logistics research over a long period. However, the arguably inherent lack of flexibility and sacrifice of relevance in the rigorous process of a quantitative method can be well complemented by the qualitative method, which is showing an increasing emergence in logistics.

In general, the quantitative method works well in measurement and analysis of a causal relationship between variables (Denzin and Lincoln, 2000), whereas qualitative research is normally applied in process examination, and phenomenon exploration and explanation. In simpler terms, quantitative research is good for testing hypotheses, and qualitative research for discovery (Bryman, 1988). The nine hypotheses developed in Section 3.4 represent a mixture of both types of question. The quantitative method is required in deciding whether a correlation or interconnection exists between certain factors (variables), whilst the qualitative method is necessary for characterising and interpreting the existing relationships. Therefore, it is believed that a hybrid approach is appropriate for the research.

3.5.2 Questionnaire Survey

A two-stage questionnaire survey was adopted in the early stages of the field work to collect statistical evidence in order to address the majority of the hypotheses, complemented by the in-depth interviews which were subsequently carried out. The survey aimed at a large sample of LSPs and LSUs operating in the UK. Information on sustainable logistics operations were collected from individual businesses across vertical sectors to give an overview of the main actors' attitudes and state of practice.

Questionnaire Design

The survey was designed to have two major phases with different data requirements. Accordingly, two questionnaires were developed (see *Appendix Two*) and distributed respectively at each phase.

Phase One: A single page, double-sided questionnaire (for the mail survey) containing nine questions was distributed to 600 LSPs and 700 LSUs. It was designed to be completed by all respondents, with the main purpose being to collect general information about the company, particularly in terms of its logistics operations, and its general attitude towards the 14 listed sustainable solutions.

In the questionnaire, data were gathered regarding basic attributes of the business in standardised formats, such as operational scale (measured by fleet size in the road haulage sector), geographic scope, freight transport mode in use, and vertical sectors which the business mainly serves or to which it belongs. The respondents were then requested to select and rank five out of the 14 sustainable solutions which have the greatest impacts on their logistics operations. These data were subsequently coded into SPSS (Statistical Package for the Social Sciences) to enable statistical testing for any potential relationships between these attributes and the companies' attitude/behaviour pattern in sustainability.

The questionnaire designed for this preliminary phase was kept as simple and straightforward as possible in order to obtain a desired response rate of at least 10%, which was deemed as achievable after examination of previous logistics research in the British industry. It mainly consisted of multiple-choice questions and should normally be completed within five minutes. It included the option for respondents to express their willingness to attend an interview in the near future, so that the accessibility problem of approaching suitable interviewees was largely tackled. There was also a question helping to screen out the potential candidates for a valuable case-study demonstration, which addressed the same issue of identification and availability. For further contact, demographic information such as name, job title, telephone number and email address were requested from respondents as well.

<u>Phase Two:</u> The questionnaire for this phase was designed to reveal the detailed attitude/behaviour patterns of the business regarding the five solutions they previously selected as the most influential ones in the phase one survey. The complete questionnaire is split into 14 sections, as can be seen in *Appendix Two*, each exploring one of the 14 sustainable solutions respectively. However, to avoid deterring potential respondents by the whole 16-page questionnaire, with many pages not requiring an answer, extra efforts were made to only include the relevant sections of the respondent's previous choices in the phase one survey. By doing so, the length of the questionnaire was much reduced, and the response rate was greatly boosted.

Although the questions for each section are not identical due to distinctive natures of each sustainable solution, all the sections were designed to cover the following major issues where applicable:

- the current sustainable practice in the logistics operation, including the specific measures adopted, to what extent and in which forms they are adopted;
- the main drivers or incentives for the business to employ the sustainable solutions;
- the main concerns about or disincentives to adopting the sustainable solutions;
- the strategies of the business in response to those solutions whose implementation are beyond its control, but have impacts on its operation and require its adaptation;
- respondent companies' evaluation of the overall cost-effectiveness and efficiency of the sustainable solutions;
- the interactions between key stakeholders and between certain solutions.

For the ease of completion, most questions were again multiple-choice questions, in combination with a small number of ranking and rating questions. The questionnaire also presented a mixture of closed- and open-ended questions, with the former making up the great majority. To keep the subjectivity from the author to a minimal level, a comment field was added to most closed-ended questions for respondents to give any other opinions if they were not covered by the options given. This also assures that the new issues which arose during the research were built in to the following analysis, rather than being eliminated simply because they lay outside the pre-determined research structure.

Survey Implementation

Prior to the full-scale distribution of the questionnaires to the target companies, a two-stage piloting was completed, providing indicative feedback that helped to guide and adjust future research activities.

In the first stage, the draft questionnaire was presented to seven experienced researchers and two consultants, asking for their opinions on the design of the questionnaire. Four researchers and both consultants made their comments on a range of issues such as the phrasing of certain questions, realigning the structure of the questionnaire, and the analysis method of the results to be collected. All issues raised were taken into account, and through continuous refinement, the questionnaire was finalised and an equivalent online survey was established on SurveyMonkey (a web-based tool that enables the creation of online surveys) to offer a fast and environmentally friendly way of completing it.

Based on the refined questionnaire design, a second-round pilot survey was then conducted, with 100 questionnaires distributed to LSPs, and nine completed and returned within a month of receipt. This result signified that a 10% response rate could be expected for the following full-scale survey. It was planned that in the event of a lower response rate, either a second-round phone call/email/mail reminder could be sent out to the targets, or the sample size could be expanded to ensure a minimum 120 valid responses for analysis.

Since there were no apparent problems with the way in which the returned pilot questionnaires had been completed, the full-scale survey was carried out after minor amendments. The sample frame is composed of two major interest groups in the industry: LSPs and LSUs. Samples from both groups were identified through FAME, an online database of company information in the UK and Ireland, and Applications & Decisions (A&Ds) published by the Vehicle and Operator Services Agency (VOSA). The number of companies to be contacted was initially set at 1200 in total, with 600 for each group. However, due to the lower response rate received from the LSUs group, an additional 100 questionnaires were circulated applying the same sampling techniques as with the first 600 LSUs.

For the phase one survey, stratified and cluster sampling techniques were adopted for each group respectively:

- **Stratification by logistics operation scale** was applied for LSPs group. The population of this group consists of all the logistics companies operating in the UK, with the sample frame being the companies/operations listed in the FAME database and the recently published A&Ds (those from the last quarter of 2008 and the first quarter of 2009), respectively representing large LSPs (FAME, with 93% companies exceeding £1m annual turnover) and small operators (VOSA, with the vast majority operating less than ten vehicles). From each source, 300 samples were randomly drawn. This sampling frame and stratification is not only a real reflection of the highly segmented logistics industry structure, but also enables further comparative analysis by operation scale at a later stage.

- For LSUs, **cluster sampling by vertical sector** was applied, identifying food, drink & tobacco; other FMCG (manufacture); industrial; retail; chemical and automotive as six focus sectors actively involved in logistics activities. This identification was based on the compilation of the industry sectors that the top 100 logistics companies in 2006 are mainly serving, which broadly indicates the sectors with the largest shares in the logistics market (see *Appendix Four*). The population for this group consists of all the large businesses trading in the UK from the six focus sectors; the companies listed in the FAME database within the six target sectors constitute the sample frame for the survey, from which a sample of 100 was drawn from each sector. As mentioned, most companies listed in FAME are large (LA) or very large (VL) companies. Through sorting the companies within each of the six sectors by annual turnover, the first 100 were targeted as leading companies of the sector, and in combination the 600 largest companies representing the majority of market share in the focus sectors constitute the initial set of target samples for LSUs. As a result of this sampling approach, the survey findings will be applicable to the large service users in the focus sectors who collectively have a dominant market share and greater influence in logistics practice.

The stratified or cluster sampling itself, no matter how rigorous the process it follows, does not guarantee that the desired responses will be received. However, the design of the questionnaire has incorporated elements to ensure the self-classification of the respondents (e.g. information on their operation scale and vertical sectors). The survey was also devised in such a way that it would identify any issues with sampling methods. For instance, in the responses to the phase one survey, if any other sectors were discovered with substantial influence on the logistics industry, the cluster sampling by sector could be rectified to include further investigation into these emerging sectors.

The distribution of the first questionnaires was primarily carried out via post to the registered addresses of the sample businesses. The mail was always addressed to the name of the senior logistics/distribution managers wherever possible, in order to ensure a good response rate and convenience of tracking. Freepost reply envelopes were enclosed with the questionnaire to reduce the time and effort required on the part of the respondents to complete and return their questionnaires. As an alternative, the recipients were invited in the mail to follow the link and complete the questionnaire online if they preferred.

During the second phase of the survey, the established online survey webpage played a greater part with the respondents' email addresses obtained from the first phase. Most recipients were sent an email with an embedded link which would lead them to the survey page with only the sections of relevance to them, based on their choices as given in the previous questionnaire.

Survey Results Overview and Analysis Method

After the pilot survey with 100 LSPs, the remaining 1100 questionnaires (500 to LSPs and 600 to LSUs) for the first phase of the survey were distributed between February and April 2009, with a request for recipients to complete and return them within one month of receipt. The return of completed questionnaires was reasonably quick, with most coming back within the first two weeks. However, there were many returned by Royal Mail due to the addressees no longer being in existence. This is mainly due to the outdated or incomplete information provided in the data sources used, especially from FAME.

By the end of May 2009, 57 completed questionnaires had been returned from LSPs group, including the nine responses from the pilot survey, giving a fairly satisfactory 9.5% response rate within the group. In contrast, however, the responses received from LSUs were much lower, with only 36 questionnaires completed and returned (representing a 6% response rate). In an attempt to boost the response rate, reminder letters with questionnaires or email invitations including the online survey link were sent to some of the companies which had not responded yet. Given the particularly low response rate from LSUs, an extra 100 LSU companies from the focus sectors were incorporated to the original sample in order to obtain the desired number of responses for analysis. These efforts achieved considerable success and generated another 11 responses from LSPs and 23 from LSUs, bringing the final response rates of the phase one survey to 11.3% and 8.3% for LSPs and LSUs group respectively.

The second-phase questionnaire was only distributed to the companies which responded to the first one, which came to 68 LSPs and 62 LSUs (including three logistics consultants). Out of the 130 questionnaires distributed during the second phase, 51 were completed by LSPs and 43 returned from LSUs. *Table 3.5* summarises the responses received by logistics group at both survey stages.

Table 3.5: Response rates of the survey by logistics group (two phases)

Interest Group	Number of Questionnaire	Phase 1 Reponses	Response Rate	Phase 2 Responses	Response Rate*
LSP	600	68	11.3%	51	75.0%
LSU	700	59	8.4%	40	67.8%
Total	1300	127	9.8%	91	71.7%

(* as a percentage of stage 1 responses)

Source: author's questionnaire survey, phase 1 & 2

The completed questionnaires were analysed by using SPSS. As the vast majority of questions were closed-ended ones with predetermined sets of options, it was possible for the large quantity of categorical data (both nominal and ordinal) collected in standard format to be easily coded and input into SPSS for further processing. Non-parametric test was the main method used for probing some of the hypotheses, while qualitative data acquired from interviews and case researches were also incorporated into the analysis. The comprehensive analysis of the questionnaire survey will be reported in detail in Chapter Four.

3.5.3 In-Depth Interviews

It was shown in Section 3.5.1 that a combined method encompassing both quantitative and qualitative analysis will facilitate the exploring of the research questions, providing a comprehensive coverage and an in-depth insight at the same time. Semi-structured interviews, as the method for collecting qualitative, insightful data in support of the survey findings, were carried out with logistics practitioners.

In-Depth Interview Purpose and Design

The general purpose of the interviews is to provide insightful information and develop better understanding in support of the survey findings. For this reason, all the interviewees had completed both parts of the questionnaire survey before the subsequent interview was arranged, depending on their availability and suitability. This arrangement benefited both interviewer and interviewee as regards gaining appreciation of the interview's agenda. For interviewer, particular behaviour and attitude patterns emerging during the survey from a specific respondent can be worked into the interview structure for further exploration. From the interviewees' perspective, participating in the questionnaire survey in advance enabled them to better comprehend the topics to be discussed in the interview and reduce the chance of confusion or misunderstanding during the course.

Bearing in mind the research objective and the consequent requirements on data collection, the sample of interviewees should ideally not only sufficiently represent both LSPs and LSUs groups, but also comprises an adequate number of companies from the major vertical sectors with a large market share and thus a major influence on logistics market. Also, to incorporate the non-standard, specialised logistics operations into the scope of the research, so that the analysis of and conclusions drawn from the evidence are effectively applicable to the whole industry, the interview sample should also include representatives for these segments which had to be left out of the questionnaire survey due to their distinct operational characteristics; examples include air freight, waterborne transport, mail and express operators.

However, the desired comprehensiveness of the research has to be compromised given the limited resources and the accessibility of the targeted companies. Given that 52% of questionnaire respondents agreed to a further in-depth interview on the subject, as shown in *Table 3.6*, approximately ten interviews on average could be achieved for each sector, with roughly half of them being with LSPs and another half with LSUs. As a result, a realistic target in the range of 70 to 80 interviews was decided on as sufficient for this thesis.

Table 3.6: Numbers of questionnaire respondents willing to be interviewed (by group)

Logistics Group	No. of respondents willing to be interviewed		% of respondents willing to be interviewed
	Face-to-face	Telephone	
LSP (n=68)	10	20	44.1%
LSU (n=59)	16	20	61.0%
Total	*26*	*40*	*52.0%*

Source: author's questionnaire survey, stage 1

In common with the sample frame of the questionnaire survey, the targeted interviewees were senior logistics managers from the businesses listed on the two databases – FAME, and the published A&Ds from VOSA. As previously mentioned, the vast majority of them were identified through the self-selecting module built into the first questionnaire, where their willingness to be interviewed and their preferred method of interview (i.e. phone or face-to-face) were asked for. Given the small sample size proposed for the interview, the self-selection sampling method is not deemed as a major issue.

The purpose of the interviews dictates the deployment of a flexible interview structure, which leaves scope for exploring particular issues that are relevant to the unique circumstances of the operation or supply chain under consideration. Meanwhile, consistency must be broadly maintained across the interviews so that the later comparative analysis is both feasible and meaningful. For these purposes, a series of questions was drawn up as a guiding schedule for the interviews (the full list of questions is presented in *Appendix Three*). The semi-structured nature of the interviews enabled the author to probe into the pertinent issues as they arose, while ensuring that all the main subjects were covered across the complete sample of the interviews. Since individual participant companies had differing views and distinct operational features, not all the questions were raised, as some were either irrelevant, not applicable or of little concern to them. Also certain solutions had to be altered or rephrased with explanations to suit the specific segment in question (e.g. 'road pricing' had to be referred to as 'toll charge' in the deep water shipping sector).

As can be seen in *Appendix Three*, to serve the overall objectives of the research, the questions developed for the interviews were organised into five themes:

- *Attributes of logistics operation*. Under this category, the detailed information that helps to enrich the understanding of the companies' logistics operation are requested, including cargo type, volume, vehicle type and fleet configuration, share of different transport modes, and specific logistics roles and activities of the company. This greatly supplements the limited and pre-formatted data provided in the questionnaire responses, and complete the constructed scenarios for particular businesses and sectors.

- *Structure of logistics network*. Questions under this theme aim to explore, on a broader scale, the attributes of the logistics network that the companies are operating in. The companies' positions within the supply chain, and the type, number and location of the 'nodes' within the distribution network, the average length of haulage, and geographical presence are all examined with the interviewees.

- *Interrelationship within the supply chain*. From the survey results it was only possible to look into the potential interactions and linkages between various parties in the logistics industry through a subset of respondent companies (45 out of 130) who selected supply chain optimisation as being of great impact on their operations. The questions in this category were designed to search for qualitative evidence for this kind of relationship in greater depth from a less selective sample, and where possible, to define how such interactions are affecting sustainable practice in today's logistics operations.

- *Attitude and practice on sustainable logistics operations* (company- and sector-specific). In order to bring out the most crucial and imminent environmental issues in logistics operations faced by the companies and sector without any effect of distortion deriving from preconceived ideas or opinions, the interviewees were encouraged to suggest any particular issues within their company and the sector, before the five solutions of their choices were discussed towards the end of the interviews. This was, therefore, the most flexible part of the interview schedule and there were considerable variations in the focus of the discussions.

- *Rationale of the survey responses*. Being built mainly upon the survey evidence, this batch of questions aim to identify the reasons and explanations behind the observed response patterns and to further develop the main issues surrounding each of the 14 sustainable solutions which were difficult to investigate through the questionnaire survey. At this stage the discussion focused mainly on the choice of the five sustainable solutions made by the interviewees in the earlier questionnaire, the reasons for not choosing the other solutions also being probed where appropriate.

Throughout, the major aspects of sustainable strategy, practice and the rationale behind the pattern were addressed in relation to the unique circumstances of the individual companies, the sectors and different logistics roles. In order to reflect the larger economic environment as a substantial factor impacting on the companies' sustainable behaviour, changes in companies' sustainable strategy as a result of the economic downturn during the period of this research were also incorporated into the scope of the interviews. The result will be indicative for future trend projection, given certain economic climate scenarios.

Implementation of the In-Depth Interviews

Six initial interviews were carried out in September 2008 prior to the main batch, in order to identify and rectify any potential problems in designing, planning and conducting such interviews. Time control turned out to be a major concern arising from these trial interviews, as most of them lasted around two hours, which is considerably longer than the 30 to 45 minutes planned – a duration that these interviewees deemed manageable and practical. This was partly due to the lack of previous experience in conducting interviews with practitioners in a formal environment, but more importantly resulted from the attempt to cover all the 14 sustainable solutions during the interviews. It then became apparent that not only was it inefficient to try to go through each solution with interviewees in the hope of obtaining as much information as possible, but also that the risks increased of the issues of real importance being masked in the course of having to deal with such an overwhelming volume of information, of which much was not directly relevant. Most of the valuable, quality and revealing information emerged at a fairly early stage of the interviews, and the interviewees tended to make more general comments about the issues that they regarded as non-critical, or with which they were not familiar. The feedback on the structure and content of the interviews provided by the interviewees reflected the same problem – some of the sustainable solutions are not actually applicable to them, or have little impact on them in practice. Based on the feedback, it was decided to place the focus on the five solutions which had the greatest impact on the interviewees' operations, instead of interrogating all the 14 solutions. This amended schedule was effective in reducing the interview duration, with the average coming down to a far more manageable 40 to 45 minutes.

Following the completion of the two-stage questionnaire survey, the main batch of the interviews was carried out between August and December 2009, allowing time for the compiling and preliminary analysis of the survey responses to be accomplished in the intervening period as part of the preparation for the interviews.

There were difficulties in arranging as many interviews as desired, due to the lack of availability of some interviewees. This problem was more severe with specialist operators, particularly air, rail and waterway operators. Given the low response rate across the entire survey sample, it is not surprising that no response was received from alternative mode freight operators. Fortunately, it was still possible to gain a reasonably good comprehension of these areas through interviews with users of such services, whose perceptions and experiences largely influence the potential future market shares of these segments.

The intention was to conduct face-to-face interviews wherever possible, although this was subject to restrictions of time and finance. As shown in *Table 3.7,* of all the respondents willing to be interviewed, over 60% (40 out of 66) specified a telephone interview rather than a face-to-face one. As a result, around one third of the interviews were carried out face-to-face, with the rest conducted over telephone. It proved productive to choose whichever approach was more suitable for the interviewees, and the information collected by the two methods was comparable for later analysis.

Table 3.7: Numbers of interviews by logistics group

Logistics Group	**No. of interviews**		***Total***
	Face-to-face	**Telephone**	
LSP	6	17	23
LSU	13	20	33
Total	*19*	*37*	*56*

Source: author's interviews

Altogether 56 interviews were carried out with LSPs and LSUs operating in different vertical sectors. *Table 3.8* breaks down the sample of interviews by sector. Since many LSPs and some of the LSUs were operating in multiple sectors, in which case the interviews covered those sectors in which their major logistics activities take place, the sum of the numbers of interviews in individual sectors exceeds the total number of interviews. For the same reason, although the overall total of completed interviews fell relatively short of the target, the multiple cases presented by a considerable proportion of the interviews ensured a satisfactory coverage of the target logistics operations. As the depth of the interviews was sufficient to allow the detailed examination of the hypotheses, the number of interviews is deemed as justifiable and adequate to meet the requirements of the research.

Table 3.8: Numbers of interviews by vertical sector

Industrial Sector	LSP (n=23)	LSU (n=33)	Total (N=56)
Food, drink and tobacco	12	5	17
Other FMCG (manufacture)	8	6	14
Retail	5	7	12
Chemical	5	6	11
Automotive	5	4	9
Other industrial (manufacture)	9	5	14
Courier	3	—	3
Container	2	—	2
Healthcare	2	2	4
IT	1	2	3
Construction	0	1	1
Publishing (newspaper)	0	1	1

Source: author's interviews

<u>Analysis Method of the Interviews</u>

The common purpose of both survey and interview methods is to identify and collect sufficient evidence to serve the research objective, which will be achieved through testing the hypotheses developed in Section 3.4. On the one hand, large amounts of structured, quantitative data provided scope for quantification and statistical testing to reveal general patterns and potential associations; on the other hand, content analysis can be carried out on the in-depth qualitative data obtained from the interviews for the same purpose. Since the survey respondents and interviewees are virtually from the same sample frame, the results of the content analysis could be calibrated with the survey findings, which could then be reinforced or adjusted.

In addition, the nature of interview as a research method provides a valuable opportunity for rationalising the findings that came from previous surveys and those which emerged simultaneously during the interviews. The observed patterns, associations or interrelationships could be explained by interviewees, exemplified and demonstrated through the individual cases, and enriched with detailed information on the business circumstances.

The analysis was carried out based on the interview transcripts drawn up from the notes taken during the interviews. This method had proved to be satisfactory and efficient during the pilot interviews, and was therefore retained in the later main interview phase. It also, to some extent, relieved the interviewees from the concerns of commercial confidentiality, although in a few cases there was still reluctance to disclose certain types of data that related to the details of their operations.

Apart from the content analysis which was employed throughout the analysis of the transcribed interviews, a matrix of critical issues examined during the interviews was also constructed (see *Appendix Eight*), with the complete sample of interviewee companies labelled by their industry sectors and logistics roles. This provides an effective form of summarising, identifying and highlighting the patterns and trends that emerged during the course of the interviews, as well as a platform which facilitates comparison between various groups in focus.

3.5.4 Case Study

As reported in Section 3.2, there has been an evident tendency in logistics research towards deployment of case study as a research method, reflecting the increasing pragmatism that can be observed in business research design (Saunders et al., 2007). Having taken a closer look into the case researches in the logistics domain, Dinwoodie and Xu (2008) further discovered a recent trend diverting from single case towards comparison of multiple cases, as well as an apparent pattern of the case study being deployed increasingly in combination with other associated research methods.

A multiple case research method has been adopted as the final stage in completing this thesis. Prior to the case studies, quantitative survey and semi-structured interview were carried out to test the initial sustainability framework and the nine hypotheses derived from it. The framework was then subject to substantial reconstruction according to the test results. As for the new framework, the types of "what, where, how and why" research questions – i.e. what sustainable measures are being implemented by logistics operators; under what circumstances are they being implemented; how, and why are they being implemented in this way – can then be addressed by the in-depth case research.

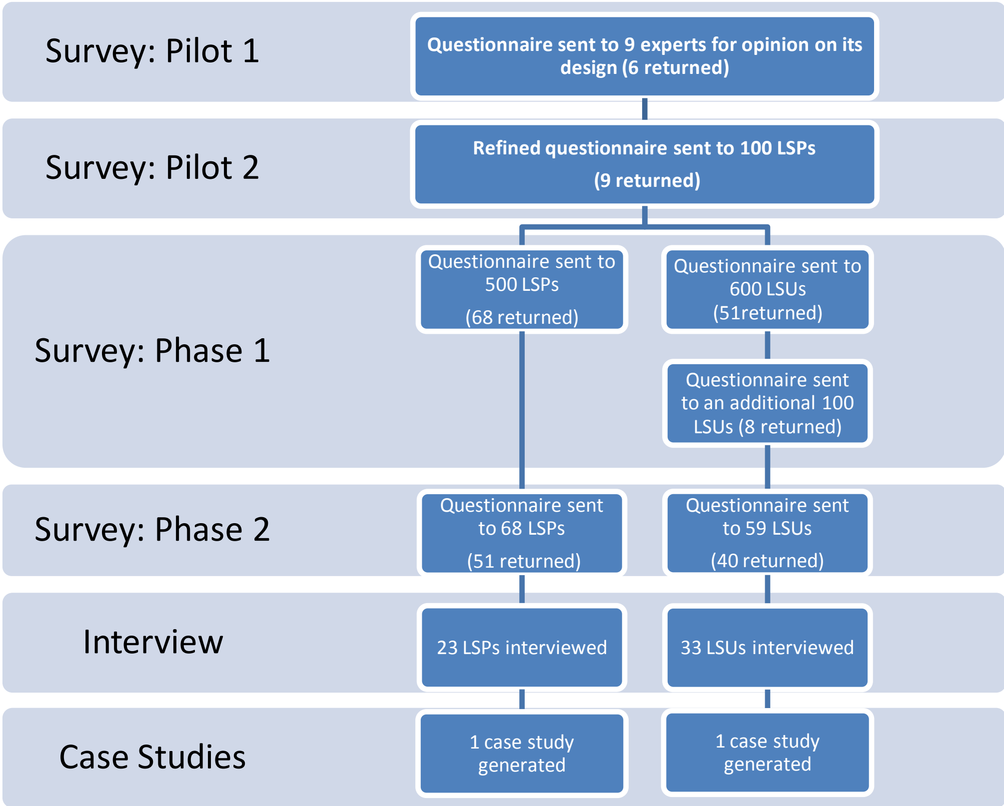
Investigation into the cases also presents an exploratory study of particular processes involved in adopting sustainable practices in logistics operations, specific to the context. Not only do new insights into the actions being taken in sustainable logistics enrich existing knowledge and understandings of the mechanism of the proposed framework, but the gathered in-depth evidence will also help to corroborate and demonstrate the relationships and interactions between key variables.

In addition to the cases incorporated as anecdotal evidence in the interview analysis (see Chapter Five), two multinational companies stood out from the interviewee companies in terms of the scope, institutionalisation and representativeness of their sustainability practices for their specific vertical sectors, which led to two case studies. Both case studies were constructed utilising primary information sources from interviews and secondary sources from publications, company documents and websites. The findings of the two case studies are attached in *Appendix Five* as a supplementary method which provides on practical applications of the sustainable logistics framework proposed in this research (see Chapter Six).

3.6 Summary

Undertaking a comprehensive approach to data collection, questionnaire survey and interview, as two primary research methods deployed for this thesis, complement each other and formulate the evidence base needed for hypothesis testing, which is fully reported in Chapter Five. Further developed from interview evidence, two case studies provide for a demonstration of the sustainable framework in practice. The entire process undertaken for the data collection and the achieved results have been mapped out in a flow chart in *Figure 3.2*. The analyses of the questionnaire survey and the interviews, although with differing emphases and methods, are combined to provide a more thorough and comprehensive understanding of businesses' attitudes and behaviour patterns in sustainable logistics operation, and will be elaborated in Chapters Four and Five respectively.

Figure 3.2: Flow-chart of the data collection process and achieved results



Source: compiled by author

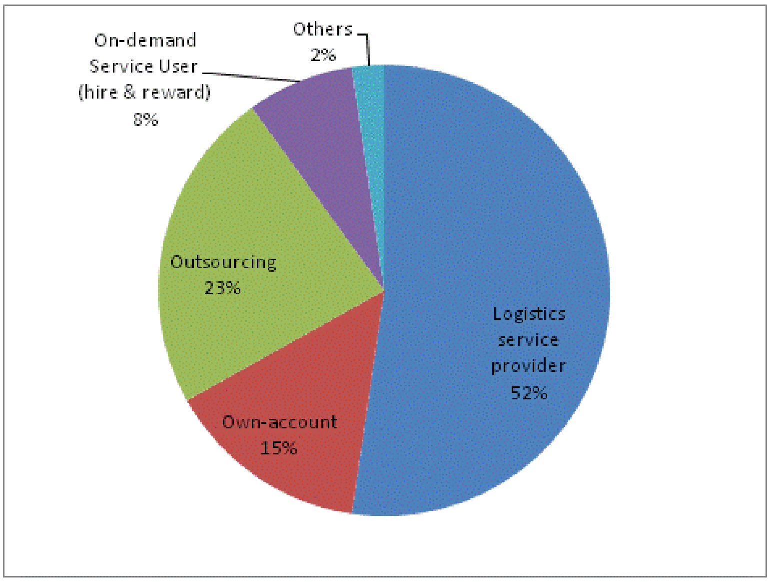
CHAPTER FOUR: SUSTAINABLE LOGISTICS PRACTICE – PATTERNS AND TRENDS

4.1 Introduction

Based on the questionnaire survey findings, this chapter reveals the common sustainable practices adopted by the UK's logistics industry at the time of the survey in 2009. The methodological issues surrounding the design and implementation of the survey were discussed in Section 3.5.2. A quantitative approach is adopted throughout the chapter so as to present a statistical overview and analysis of the existing situation, identifying potential association, interaction and causation within the industry.

The first section provides the background information about the companies that participated in the survey, with a particular focus on the critical characteristics of their logistics operations. *Figure 4.1* shows the breakdown of the 130 respondents based upon the specific role that the businesses involved were playing in their logistics functions. The pie chart indicates that a desirable balance was achieved, in that an almost equal number of responses were obtained from the supply side of the industry (52% coming from logistics service providers / LSPs) and the demand side (46% from logistics service users / LSUs). The three respondents (2%) classified as 'others' are specialist logistics consultancies providing supply chain management services, mainly for LSUs but sometimes for LSPs as well. Further interrogation was carried out in a few cases where multiple-choice responses were received, so that all respondents could be classified into a single category representing their major logistics roles.

Figure 4.1: Breakdown of questionnaire respondents by logistics role



Source: author's questionnaire survey, stage 1; total number of respondents N=130

The LSUs can be further divided into three categories, as shown in *Figure 4.1*, in terms of their relationship with LSPs:

i) *On-demand service users*, who employ logistics services from the hire and reward marketplace as and when needed, and hence do not have a long-term established relationship with service providers; these account for a mere 17% of the total LSUs.

ii) *Companies who outsource their logistics functions* to third-party logistics providers, and normally have strategic partnership and fixed-term contracts with them; these account for over half of the LSUs, evidencing the prevalence of the outsourcing practice in large businesses.

iii) *Own-account management*, representing 32% of the LSUs, refers to companies who have their logistics operations managed in house. One could arguably classify the companies falling into this category as service providers, since compared with the two categories above, they provide their own logistics services. However, the main purpose of this type of logistics operations is to exclusively serve the core business of their companies, and they are hence mostly influenced by, and reflect the company's logistics demand. It is the role of supportive function to a particular business that differentiates the in-house logistics operations from independent LSPs, whose revenue are generated from their logistics activities. As own-account logistics clearly represents the interests of the business it is serving, they are suitable for incorporation into the LSUs group when studying their behaviours and attitudes towards sustainability.

This categorisation not only allows the exploration of the attitudes and behaviour patterns of the key players from both sides of the logistics market, but, more importantly, enables comparative studies to identify the interrelationships that may exist between them. Furthermore, at aggregate level, where only the two main groups – LSPs and LSUs – are considered, the sample sizes for each group are sufficiently large to support meaningful statistical analysis. When complemented by the in-depth, qualitative information from the interviews, it forms a solid basis for testing the nine hypotheses established in Chapter Three.

The following sections concentrate on the analysis of the questionnaire responses, mainly in terms of revealing the sustainable solutions with major impacts on the key players, and the critical factors influencing their decision-making processes.

4.2 General Statistical Overview of Questionnaire Respondents

This section, which precedes the in-depth analysis of the questionnaire responses, reveals the general characteristics of the respondents' companies in terms of their logistics operations. Similar to *Figure 4.1*, *Table 4.1* presents in more detail the results from the stratified sampling applied during the survey, with response rates of the first round survey calculated for each logistics group.

Table 4.1: Composition and response rates of the first stage survey by logistics role

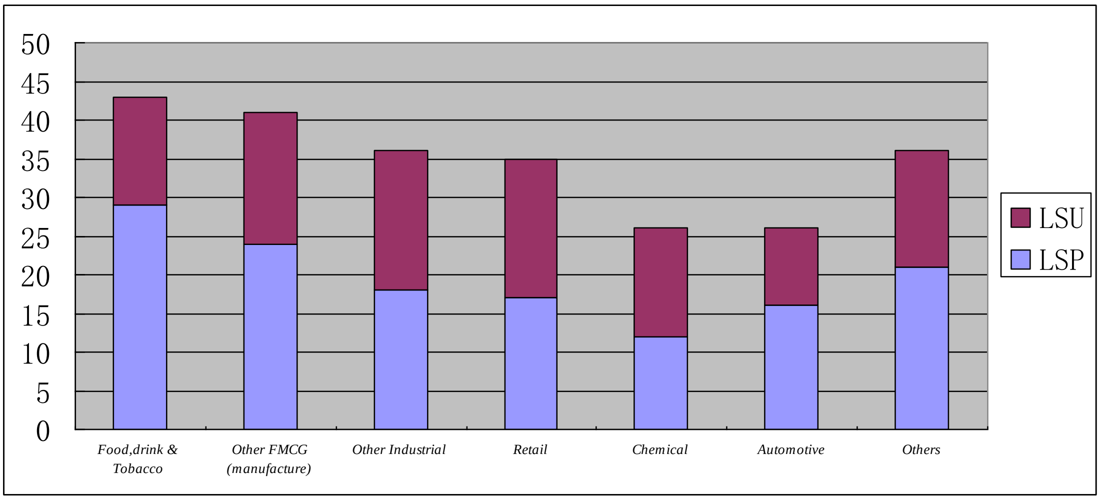
Logistics Roles		Frequency	Percentage	Response Rate
Logistics service provider	Logistics service provider	68	52.3%	11.3%
Logistics service user	Own-account	19	14.6%	8.4%
	Outsourcing	30	23.1%	
	On-demand Service User (hire & reward)	10	7.7%	
	Others	3	2.3%	—
Total		***130***	***100%***	

Source: author's questionnaire survey, stage 1; total number of respondents N=130

It shows that the overall response rate for the LSPs (11.3%) is considerably higher than that for the LSUs (8.4%). This can be attributed to the differing sampling techniques employed for the two groups during the survey. LSPs of all sizes were covered in the sample frame, and the contacts were normally the middle or top managers of the companies. Since their core business is providing specialist logistics services, the chances are greater of the contacts who had received the survey regarding it as a relevant and valuable experience, hence the higher response rate. On the other hand, only the largest companies in a few selected vertical sectors were targeted for the LSUs group. The fact that logistics is not the core businesses for these companies might greatly diminish the perceived importance for them of participation in the survey. It is also more difficult to target the right person within a large organisation who is in charge of the logistics function, and the case was further complicated when their logistics operations were outsourced, or conducted within different divisions on a hire and reward basis. For these reasons, the variation in response rate from the two groups was regarded as justifiable.

Participants in the survey from both groups were asked to identify the vertical sectors where their main logistics activities were carried out. *Figure 4.2* presents the results by using a stacked bar chart, showing the total number of companies within each sector, and also the numbers from each group. The sectors are presented in descending order to highlight their relative importance in the logistics industry. All respondents provided information on this, hence there was no missing data. The total exceeds 130 due to the multiple selection given by many respondents – especially LSPs, who often serve multiple sectors.

Figure 4.2: Breakdown of questionnaire respondents by vertical sector and group



Source: author's questionnaire survey, stage 1; total number of respondents N=130 (multiple response)

Overall, food, drink & tobacco, other FMCG manufacture and other industrial turn out to be the three sectors generating the most responses, with retail (generating 35 in total responses) following very closely behind the industrial sector (36 in total). However, the pattern varies slightly between LSPs and LSUs. Within the LSPs group, it is still the same three sectors that yielded the most responses, while the automotive sector generated almost as many responses as retail, emphasising its relatively strong presence and consequently great influence in the logistics market. On the other hand, among the LSUs, the food, drink & tobacco sector is outnumbered by retail, and coordinated with the chemical sector, indicating the active involvement of the latter sectors in logistics practice.

Although the ‘others’ category has a substantial share in the number of companies which chose and specified their main sectors because they were not listed in the six sectors given, it does not appear to be a major issue after being broken down and examined. Within both groups where altogether 32 respondents chose ‘others’, the specified sectors are highly diversified, as shown in *Table 4.2*.

Table 4.2: Breakdown of ‘others’ specified by the respondents on their sectors

LSP (n=19)		LSU (n=13)	
Container	6	Construction	3
Courier	4	Pharmaceutical	3
General haulage	3	Textiles	2
Healthcare/medical	2	Newspapers	1
Oil, biofuel, petroleum	2	Telecommunication	1
IT	2	Petroleum	1
Farm machinery & plant	1	Civil engineering	1
Packaging	1	Real estate	1
Furniture & removal (domestic & commercial)	1		
Timber, steel, marble, art	1		
Set, staging, PA, lighting, AV, instruments, costumes, props	1		

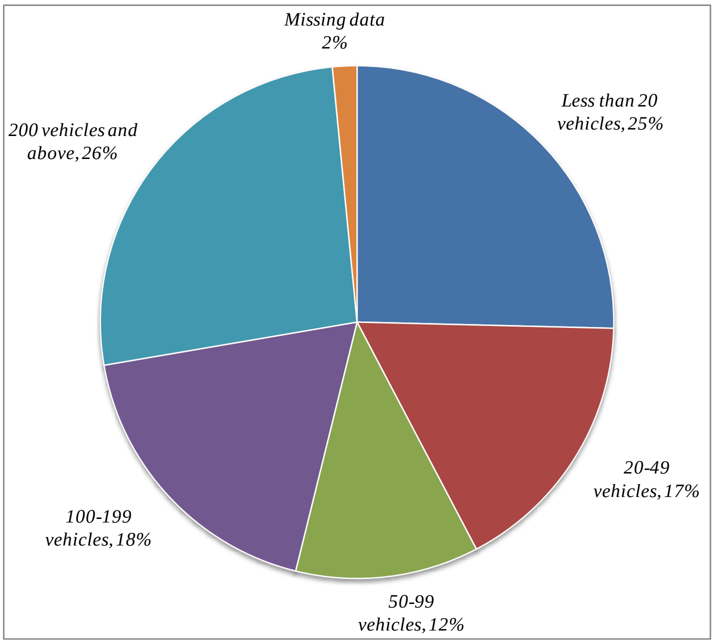
Source: author’s questionnaire survey, stage 1

Among the 19 LSPs who selected ‘others’, six of them have their major logistics activities in container haulage, four in express and three in ‘general haulage’ (or “various”, “anything”, “miscellaneous”, to quote some of their own words). The rest have less than three counts, ranging from healthcare and packaging to the information technology, energy and recreation sectors. As for the 13 LSUs, the construction and pharmaceutical each have three responses and the remainder specified a diversity of sectors ranging from media and telecommunication services to real estate and civil engineering. In order to ensure that the respondents were not mistaken as a legitimate sample from the target sectors, each case was further investigated by either contacting the respondents or obtaining data from the published company reports. This revealed that the reason for the LSUs choosing ‘others’ is that their companies/groups conduct business in multiple sectors which all involve logistics operations. Nevertheless, the rigour of the sampling procedure is not compromised since all the 13 respondents are mainly responsible for the logistics operations within the targeted sectors.

This further examination of the constituent sectors for the ‘others’ justifies the selection of the six sectors, since none of the specified ones received nearly as many responses as the predetermined major six. Although it could be argued that the respondents might tend to follow the listed options for convenience, this factor has been greatly diminished by the self-validation process built in follow-up interviews.

When it comes to the number of goods vehicles either being operated by the company (in the case of LSPs or own-account operations), or being used to serve business needs (for other LSUs), the integrated picture presents a fairly even distribution in fleet size. As shown in *Figure 4.3*, the fleet sizes of the respondents’ companies tend to be slightly converging towards both ends, which represent, respectively, very small logistics operations with less than 20 goods vehicles, and very large-scale operations with more than 200 vehicles. Companies falling into these two categories account for over half of the total sample. The number of companies with relatively small-scale logistics operations (i.e. 20-49 vehicles) is more or less the same as those with relatively large operations (100-199 vehicles); while the ones in the middle (with 50-99 vehicles) have the smallest share of the total responses, which is reinforced given the unequal intervals in fleet-size groupings. In general, the variation among categories does not seem to be huge. Although it may look like an ideal composition for a sample in terms of operational scale, since each category is represented equally within a symmetric distribution, it is less meaningful until one looks further into the subgroups.

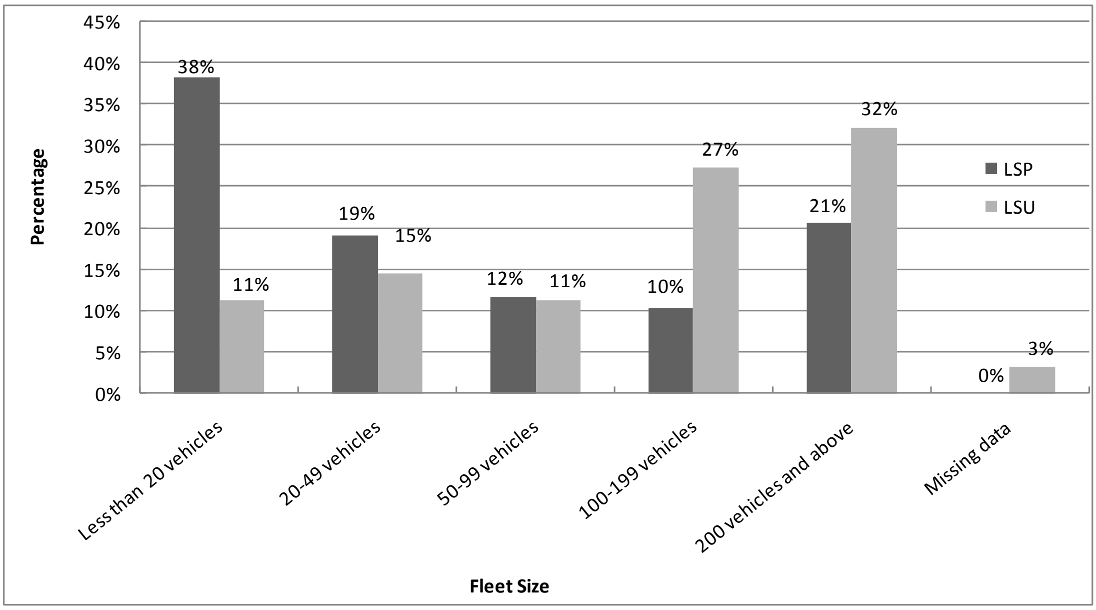
Figure 4.3: Breakdown of questionnaire respondents by fleet size



Source: author's questionnaire survey, stage 1; total number of responses N=127

In fact, the picture looks quite different when the data are broken down into the supply and demand sides. The clustered bar chart in *Figure 4.4* reveals the contrasting patterns existing in the LSPs and LSUs groups. The polarisation of the fleet size across the LSPs is evident, while the LSUs group has more responses from large operations than small ones. Given that the single-mode skewed distribution of LSU fleet size is largely due to the sampling technique applied, which included only the largest companies in the target sectors, it is the distribution pattern of the LSPs that reflects the current state of the supply side of the UK's logistics industry. In a market that consists of the 'vital few' and the 'trivial many' as two typical types of actors, the sustainable solution packages, being one of the main outputs of this research, should be able to effectively address the various issues faced by each type.

Figure 4.4: Breakdown of questionnaire respondents by fleet size and group



Source: author's questionnaire survey, stage 1; total number of respondents N=127, number of LSPs n_1=68; number of LSUs n_2=59

The data obtained from the survey are more revealing when calibrated against statistics for the whole population. *Table 4.3* summarises the latest data regarding road freight operator fleet size from VOSA (DfT, 2009b). Some categories were combined to be consistent with the categorisation applied in the survey, so the only disparity left is in the dividing boundary of each interval (e.g. in the survey, the small operator is defined as having 0 to 19 goods vehicles, instead of the 0 to 20 definition used in VOSA's publication), which is not considered a major factor contributing to the remarkable variance between the sample (*Figure 4.4*) and population (*Table 4.3*).

Table 4.3: The distribution of road freight operator fleet size, Great Britain 2008/09

Fleet Size	No. of Operators (Thousands)	Percentage
0-20 vehicles	92.3	97.3%
21-50 vehicles	1.8	1.9%
51-100 vehicles	0.5	0.5%
101 vehicles and above	0.3	0.3%
Total	94.9	100%

Source: VOSA, published in DfT,2009b

Table 4.3 illustrates a highly fragmented industry, with 97.3% of the operators operating 20 or fewer goods vehicles, while only 0.3% operates a fleet of more than 100 vehicles. The average fleet size in Britain 2008/09 is 3.8, stressing the dominance of small operators in terms of quantity. Against this backdrop, the responses received from the survey have clearly shown a disproportionate congregation of larger operators in the sample, particularly the very big ones with over 100 vehicles. Bearing in mind that the LSPs participants were randomly drawn from the exact database (VOSA) based on which the statistics of the population were produced, which minimises any possible discrepancy resulting from sampling error and variety of data sources, this observed pattern provides great insight when interpreting operators' behaviour by operational scale. It would appear that bigger operators tend to be more interested in / obliged to sustainable logistics practice than are their smaller counterparts.

Other factors that might have also contributed to the variation between the sample and the population include the following:

i) The VOSA statistics comprise all license holders, including the restricted license which is mainly granted for private use or in-house operation. This type of license makes a substantial proportion of the total licenses, but was excluded from the sampling since it does not represent the LSPs as defined for this research.

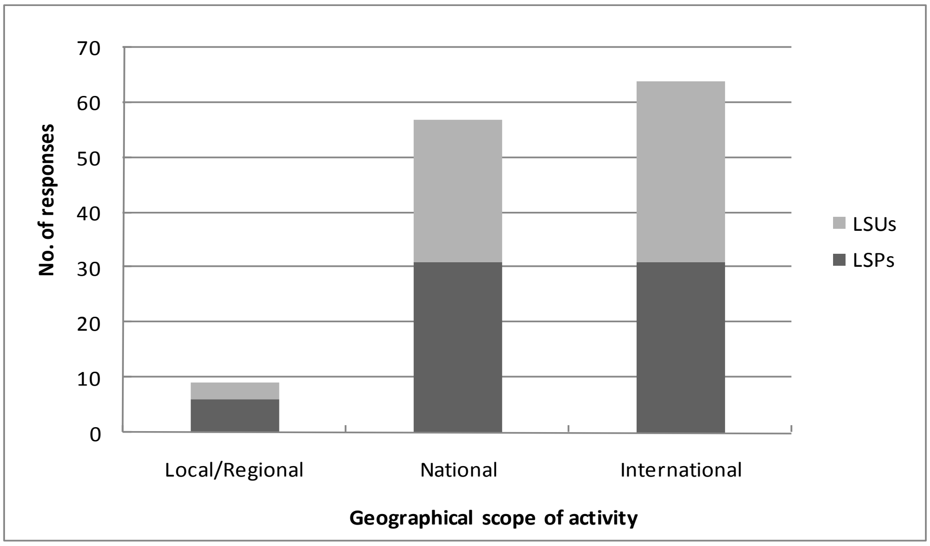
ii) It is common for large logistics operators to hold multiple licenses at various locations or for subsidiary operations, which consequently results in the dilution of their presence in the statistics.

iii) Partly owing to the multiple licensing, the directors registered for a particular operating centre are often not only responsible for the operation in question, but also in charge of other operations at a higher level and a larger scale; in these cases their input to the survey would have reflected their entire management sphere rather than the particular operating centre through which they were originally identified.

It can be inferred that the sample constitution of LSPs in terms of fleet size is not necessarily representative of the industry structure, but more a reflection of the different perceptions of operators on sustainability. Although there are no published statistics available that differentiate specialist ‘public’ logistics operators from the private and own-account operators, it is highly likely that the real distribution of LSPs by operational scale lies somewhere in-between the VOSA statistics and the survey sample. This inference can be further cross-checked and adjusted accordingly with the results using other statistical indicators such as annual turnover and employment level (see *Appendix Six*), both indicating the same type of Pareto distribution, with the vast majority of operators at the small business end but less variance across the range as a whole. Given the sizeable market share held by the minority of the operators of a large operational scale, and another substantial slice shared by numerous small operators, these two categories certainly lend themselves to the centre of study where their collective would have a great influence on the whole industry.

Another indicator relevant to the nature and scale of logistics operation is geographical sphere. *Figure 4.5* shows that the vast majority of the responding companies are involved in either national (44%) or international operations (49%), whilst the companies operating on a local or regional scale account for only 7% of the total respondents.

Figure 4.5: Breakdown of questionnaire respondents by geographical scope and group

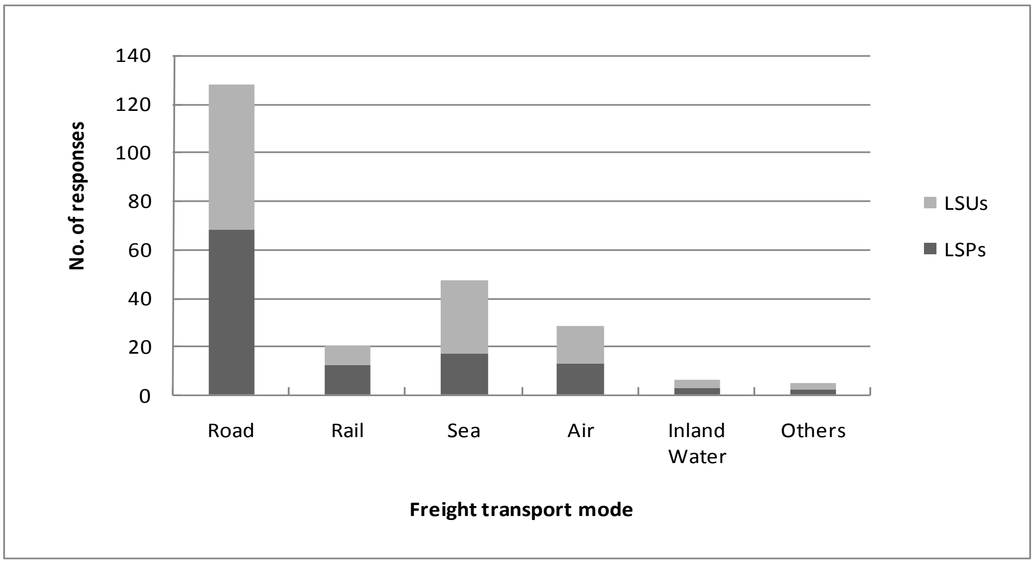


Source: author's questionnaire survey, stage 1; N=130

The distribution patterns within the LSPs and LSUs groups are highly consistent in terms of the geographical spread of their logistics operations, although the tendency towards broader scope activities is more explicit for LSUs possibly as the result of the sampling method. However, this is not the factor that might possibly have influenced the result from LSPs. Therefore the strong correlations between LSPs and LSUs in this case might imply underlying interactions between the two stakeholders.

With modal shift being a high-profile sustainable transport solution, the freight transport modes in use were also explored during the survey. A total of 129 responses were received, and the results are summarised in *Figure 4.6*. All the LSPs, and 98% of LSUs, are using road haulage, evidencing road transport dominance in the current logistics market. Of the respondents, 36% are using deep sea shipping, while rail freight and air cargo account for 22% and 16% respectively. Only 4% selected inland water as one of their transport modes, and a negligible number of companies identified other transport modes being used, primarily cross-country pipelines.

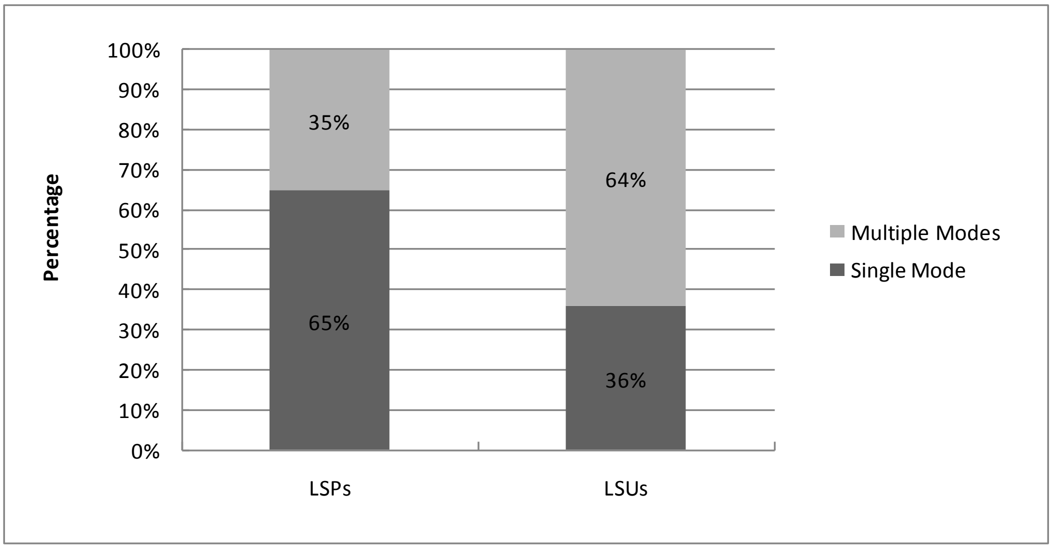
Figure 4.6: Breakdown of questionnaire respondents by freight transport mode and group



Source: author's questionnaire survey, stage 1; N=129 (multiple response)

Considering the fact that intermodal transport has increased significantly in recent years, and that more and more companies are using multiple transport modes for their freight shipment, the data collected on this issue can also usefully be presented in a manner that reveals the number of modes being used by the businesses. A quick overview at aggregate level shows that the companies using a single mode of transport for goods distribution (51%), and those operating multiple modes (49%), are almost even in number. However, as depicted in *Figure 4.7*, the overall balance between different mode choices turns out to be a result of the counteraction of the opposite patterns observed within the LSPs and LSUs groups. Of the LSPs responding to the survey, 65% operate in a single transport mode, namely road freight; whilst among LSUs, the companies that use only one transport mode make up a minority share of 36%, with road freight being the major mode for all but one, which uses dry bulk deep sea shipping as its main mode. Of all the companies using multiple transport modes, only three explicitly stated that the deep sea shipping is the mode with the greatest freight volume in their supply chains, and one chose airfreight as the major one for its business.

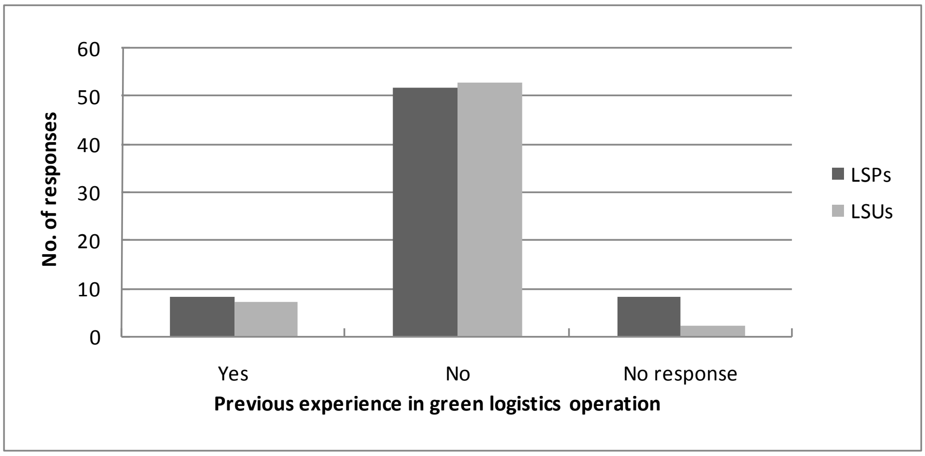
Figure 4.7: Breakdown of questionnaire respondents by transport mode choice and group



Source: author's questionnaire survey, stage 1; N=129

The final general question relates to whether or not the company has relevant experience in 'greening' their logistics operations that could possibly be presented as a case study. The purpose of this question is to discover the actual actions being taken by companies in sustainable logistics, regardless of the specific solutions applied, by carefully phrasing the question in a less obvious way to avoid leading respondents to a predictable (most likely positive) answer. Meanwhile, potential candidates for case studies can be identified. In contrast to the great importance placed on sustainable logistics, over three quarters of the respondent companies have no previous experience in greening their logistics operations. Only 12% of the companies have actively taken sufficient steps with results substantial enough to be presented as a case study, whereas 8% did not give any information in response to this question. Although the mention of a case study might raise concerns about commercial confidence, this should have been eliminated, or kept to a minimal level, by making it clear in the covering letter accompanying the survey that the participants will be anonymised in the research report unless they agree to be named. Also, given that showing the willingness and capability to conduct business in an environmentally responsible way has become a competitive advantage for businesses, the adverse effect of confidentiality concerns should be offset, and hence the result, disappointing as *Figure 4.8* is, can be regarded as close to the situation in the real world.

Figure 4.8: Breakdown of questionnaire respondents by whether they have previous experience in green logistics and by group



Source: author’s questionnaire survey, stage 1; N=130

Overall, the analysis of the general features of the respondents’ logistics operations reveals that the survey was conducted among a variety of key stakeholders within the UK’s logistics industry. Not only is the composition of the respondents reasonably representative of the key players from the supply side of the current logistics industry, but the built-in self-verification process has also worked well to ensure that the six predetermined target sectors are the ones with the greatest implications for logistics, and are hence the ones to be looked into first when sustainable logistics solutions are applied. The categorisation of respondents by different characteristics forms a sound basis for further statistical analysis of the patterns of practice within the industry, and in particular the factors affecting the adoption of sustainable solutions in logistics activities.

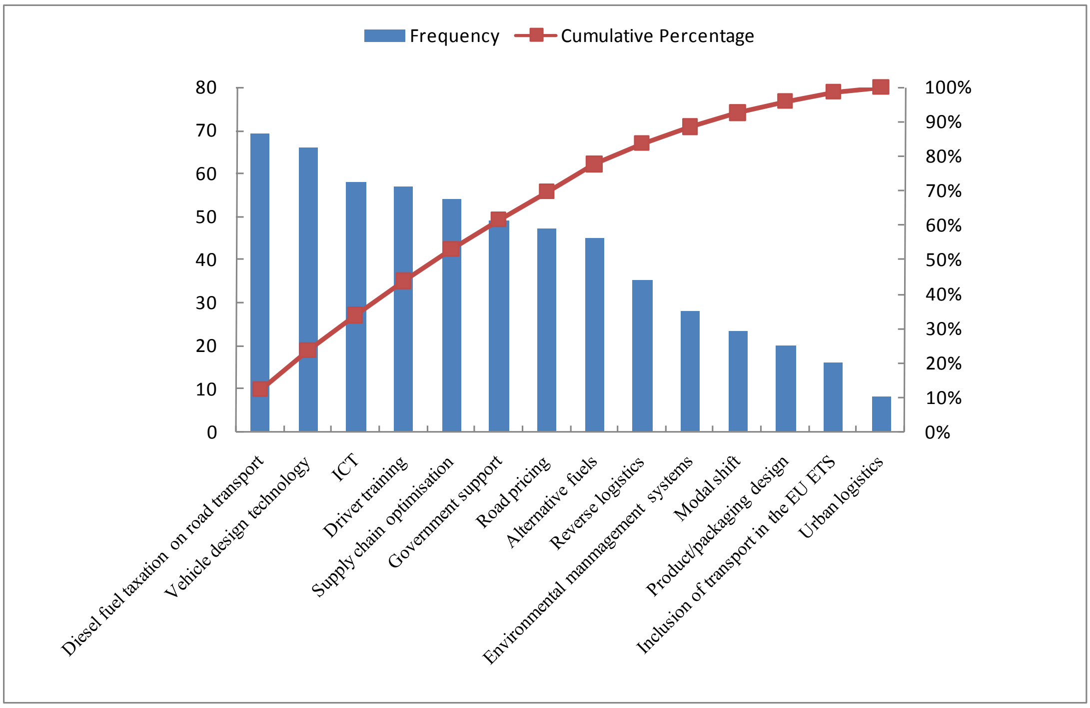
4.3 Sustainable Logistics Practice: Current Status

The effectiveness of most voluntary sustainable solutions for the logistics industry relies greatly on their acceptance among the practitioners. Hence the issues of fundamental importance in evaluating the potential of these solutions in practice are the attitudinal/behavioural patterns of the companies. Even for the sustainable solutions designed to be implemented mandatorily, their impacts on the companies involved will largely determine their performance once enforced. This section deals with these issues by revealing the survey results on the evaluation of the pre-established sustainable framework consisting of 14 solutions by the respondents.

Out of the 14 categories of sustainable solutions, the participants of the survey were asked to choose and rank the five of them which have the most appreciable impacts on their logistics operations. The consequently generated ordinal data set contains richer and more informative contents than the results of a multiple-choice question. However, the respondents were not required to rank the entire list of 14 solutions, since some previous studies show that the ranking data beyond the fourth-ranked option tend to be unreliable due to increasing difficulty in management of the task (Bradley and Daly, 1994).

The Pareto diagram of *Figure 4.9* provides an overall perspective of the way the pre-constructed framework is perceived by the respondents. Of all the 130 respondents, 15 failed to give valid answers to the question. This is mainly attributable to the nature of the forced ranking questions of this kind being prone to respondent error. However, since the invalid/missing data only constitutes a minor part of the entire sample, this is not considered a major concern in the study.

Figure 4.9: 14 Sustainable solutions by their perceived impacts on respondents

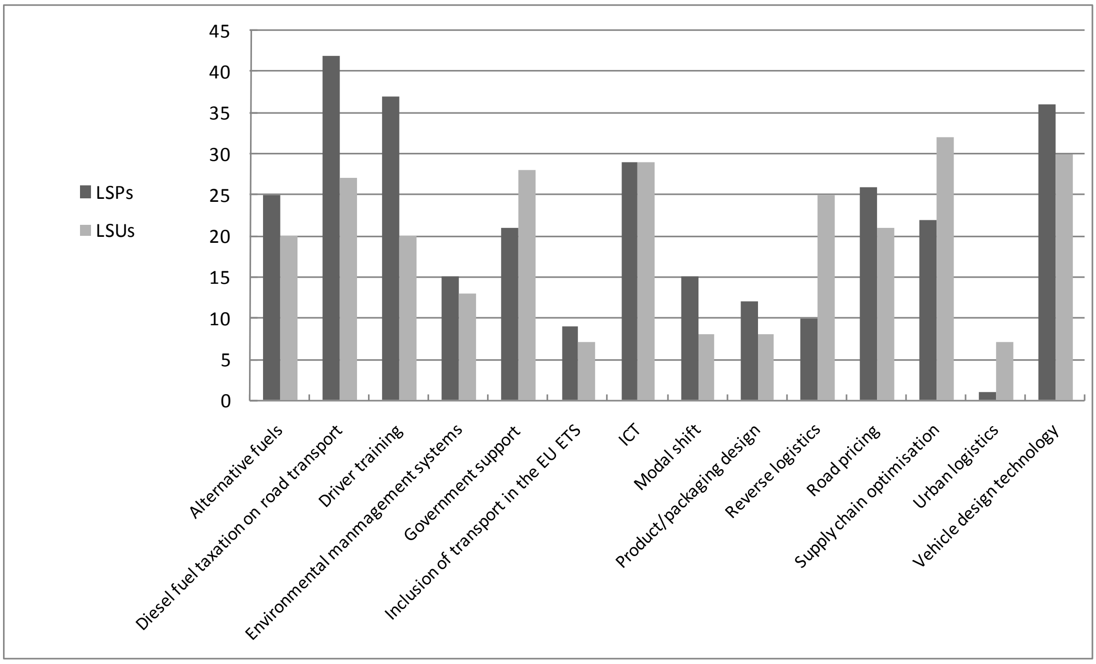


Source: author's questionnaire survey, stage 1; N =115 (multiple response)

By treating each entry of the data as nominal, the scenario is simplified to a basic choice model where the perceived importance of the candidate solutions can be ranked by the number of times they were selected (i.e. frequency). In descending order by number of votes received, the five most influential categories are: *diesel fuel taxation on road transport*, *vehicle design technology*, *information and communication technology (ICT)*, *driver training*, and *supply chain optimisation*. Altogether, these five solutions have taken more than half of the votes, indicating their great implications for shaping sustainable practices in the industry.

However, the priorities appear to shift across the sustainable solutions in terms of their impacts when the LSPs and LSUs groups are examined individually. In total, 60 valid responses were received from the LSPs group, and 55 from LSUs. *Figure 4.10* highlights the variations between their choices.

Figure 4.10: 14 sustainable solutions by their perceived impacts on respondents



Source: author's questionnaire survey, stage 1; N=115 (multiple response)

Measured by the absolute number of times that each solution was chosen by the respondents, three solutions from the top five (as ranked when the two groups are combined together) still made it into the top five within both groups, although in different orders. They are *diesel fuel taxation on road transport*, *ICT*, and *vehicle design technology*. For LSPs *driver training* and *road pricing* made the other two positions; whilst *government support* and *supply chain optimisation* complete the top five in the LSUs group. *Table 4.4* provides the results from both groups, listing the six most selected measures by each group. The sixth was included for the reason that the frequencies of each of them are very close to those of the fifth in both groups.

Table 4.4: Six most selected sustainable solutions by group

Rank by Frequency	LSPs	Frequency	LSUs	Frequency
1	Diesel fuel taxation on road transport	42	Supply chain optimisation	32
2	Driver training	37	Vehicle design technology	30
3	Vehicle design technology	36	ICT	29
4	ICT	29	Government support	28
5	Road pricing	26	Diesel fuel taxation on road transport	27
6	Alternative fuels	25	Reverse logistics	25

Source: author's questionnaire survey, stage 1; N =115 (multiple response)

In order to incorporate the ordered nature of the data provided by respondents when valuing and comparing the five most influential measures in question (the partial ranking), a simple technique of weighted frequency can be applied, where the first priority is given the weight of 5, the second of 4, and so on. By multiplying the weight of each priority given to a certain solution by the number of times it was selected, the respective weight of a priority for each solution can be calculated. The sum of the weights for all the five priorities gives a total score for every solution. *Table 4.5* summarises the results obtained by applying this technique.

Table 4.5: The weighted ranking of 14 sustainable solutions by LSPs, by LSUs, and combined

Ranking	*N=115*	*LSPs (n=60)*	*LSUs (n=55)*
1	Diesel Fuel Taxation	Diesel Fuel Taxation	Supply Chain Optimisation
2	Driver Training	Driver Training	Diesel Fuel Taxation
3	Vehicle Design Technology	Road Pricing	ICT
4	Supply Chain Optimisation	Vehicle Design Technology	Vehicle Design Technology
5	ICT	Alternative Fuels	Government Support
6	Road Pricing	ICT	Road Pricing
7	Alternative Fuels	Supply Chain Optimisation	Alternative Fuels
8	Government Support	Government Support	Driver Training
9	Environmental Management and Auditing	Environmental Management and Auditing	Reverse Logistics
10	Reverse Logistics	Modal Shift	Environmental Management and Auditing
11	Modal Shift	Product/Packaging Design	Modal Shift
12	Product/Packaging Design	Reverse Logistics	Urban Logistics
13	Inclusion of Transport in the EU ETS	Inclusion of Transport in the EU ETS	Inclusion of Transport in the EU ETS
14	Urban Logistics	Urban Logistics	Product/Packaging Design

Source: author's questionnaire survey, stage 1; total number of respondents for each group in column headings

Comparing the weighted ranking results to the ones derived from absolute frequencies, the top six sustainable solutions remain very much the same for each group, as well as for both combined, although the rank within the six does change considerably due to the distribution of the priorities. For instance, regarding the top six solutions, the only discrepancy resulting from applying the weighted ranking technique is *reverse logistics* being replaced by *road pricing* in the LSUs group. This is because although the former had more 'votes' from the responding LSUs, many (11 out of 25) of them gave it the lowest priority; while road pricing is outnumbered by reverse logistics by four votes, yet a large proportion of the votes had higher ranks, hence causing it to overtake reverse logistics with a higher overall weighted score.

4.4 Statistical Testing – Exploring Associations and Interactions

Building on the survey results reported in Sections 4.2 and 4.3, this section is dedicated to identifying the possible existence of association and interrelationship between the LSPs and LSUs groups, and linkage between certain logistics operations' attributes and their sustainable practices through statistical testing. The majority of the data collected in the survey are categorical, of which most are nominal and a minority ordinal; hence non-parametric statistical methods have formed the main part of the analysis in this section.

4.4.1 Sustainable Practices of Different Stakeholders

Starting with an analysis of the top solution selected by the respondents – *diesel fuel taxation on road transport* ('*fuel taxation'* in the following text), this section summarises the Pearson's chi-square test results for each of the solutions by logistics role that the respondents are playing in the industry (i.e. LSPs or LSUs).

Fuel taxation stood out as the sustainable solution with the greatest impact on the respondent companies' logistics operations. This is a result from both number of times it was selected as one of the top five influential measures, and the relatively high ranking it was assigned by the respondents. According to the result of weighted impact score shown in *Table 4.5*, fuel taxation consistently achieved the top rank within each group, and the variation in preference was unapparent. However, the difference was more evident in terms of frequency when the measure topped the rank in the LSPs group but only came fifth in the LSUs group (see *Table 4.4*). In order to further examine the significance of this variation, *Table 4.6* was compiled to give an overview of the distribution of responses within each group.

Table 4.6: Summary of ranking responses on impact of diesel fuel taxation by group

Fuel Taxation	*1*	*2*	*3*	*4*	*5*	*Total*	*Weighted Impact*
LSPs (n=60)	24	8	3	3	4	42	171
LSUs (n=55)	6	12	3	3	3	27	96
Combined	31	22	9	10	12	69	267

Source: author's questionnaire survey, stage 1; total number of respondents N=115

Of the LSP respondents, 70% identified fuel taxation as one of the top five solutions in terms of impact on business, while nearly half of the LSUs did so. Of those who selected the solution, over three quarters of the LSPs gave it the first or second priority, and two thirds of the LSUs did the same. By combining the lower three ranks (i.e. 3, 4 and 5) into one category, a chi-square test was then conducted, and the contingency table with observed and expected cell values, along with the test results, is shown in *Table 4.7*.

Table 4.7: SPSS Chi-square test results for diesel fuel taxation by group

Part (a): Diesel fuel taxation cross-tabulation by group

			Impact Ranking of Diesel Fuel Taxation				Total
			1	2	3*	4**	
Group	LSP	Count	24	8	10	18	60
		Expected Count	15.7	10.4	9.9	24.0	60.0
	LSU	Count	6	12	9	28	55
		Expected Count	14.3	9.6	9.1	22.0	55.0
Total		Count	30	20	19	46	115
		Expected Count	30.0	20.0	19.0	46.0	115.0

* 3 is the category combining the respondents who assigned the lower three ranks (i.e. 3, 4 or 5) to fuel taxation.

** 4 is the category for unselected options, where the respondents did not select fuel taxation as one of the five solutions with most impact (hence no ranking).

Part (b):Chi-square test for rankings by LSP and LSU groups on diesel fuel taxation

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.635(a)	3	.003

(0 cells (.0%) have expected count less than 5. The minimum expected count is 9.09.)

Source: author's questionnaire survey, stage 1; total number of respondents N=115

The p-value gained from the two-sided Pearson's chi-square test is 0.003, indicating that the probability of having the observed difference by chance is less than 0.3%. There is, therefore, a statistically highly significant difference between the LSPs and LSUs groups in their perceptions of fuel taxation. The major factor that contributed to this difference lies in the extent to which fuel taxation impacts on the logistics operation. For LSPs, most votes on this solution were given the first rank, indicating that the service providers are most concerned and affected by the implementation of, or changes in, diesel fuel tax. While it is still perceived as a major concern for LSUs, it is so only to a lesser extent. As service users are generally involved in logistics operations in a less direct manner, particularly in the case of those outsourcing their logistics functions or simply hiring services on demand, the cost implication of fuel taxation may not be as visible and critical as it is for the logistics operators.

Applying the same analysis to the remaining sustainable solutions individually, the test results are collectively summarised into *Table 4.8*. (Note: Using the same re-coding methods, the grouping of different ranks varies for various solutions according to the specific distribution of the assigned priorities.)

Table 4.8: Summary of Chi-square test results for rankings on sustainable solutions by group

Ranking	*N=115*	*Degree of Freedom**	*Test Statistics Value*	*p-Value*
1	Diesel Fuel Taxation	3	13.635	*0.003***
2	Driver Training	3	7.942	*0.047**
3	Vehicle Design Technology	3	3.886	0.274
4	Supply Chain Optimisation	3	8.171	*0.043**
5	ICT	3	3.047	0.384
6	Road Pricing	2	0.341	0.843
7	Alternative Fuels	3	1.227	0.747
8	Government Support	3	3.226	0.358
9	Environmental Management Systems	2	0.646	0.724
10	Reverse Logistics	2	12.174	*0.002***
11	Modal Shift	2	2.431	0.297
12	Product/Packaging Design	—	—	—
13	Inclusion of Transport in the EU ETS	—	—	—
14	Urban Logistics	—	—	—

* Degree of freedom is 2 or 3 depending on the grouping of different ranks.

Source: author's questionnaire survey, stage 1; total number of respondents N=115

As highlighted in the table, the LSPs and LSUs groups have shown significant differences in their perceived importance of four sustainable solutions. *Diesel fuel taxation* and *reverse logistics* are significant at the 1% level; while *driver training* and *supply chain optimisation* are significant at the 5% level. The bottom three sustainable solutions have not been tested by this approach due to the small number of responses received within each category. The results obtained would be invalid, as there would be a large proportion of cells with an expected value of less than 5. For these three cases it is better to examine any variation by simply comparing the data.

As analysed before, the perceived difference in the *fuel taxation* solution can be interpreted by the various core businesses conducted by LSPs and LSUs. And probably for the same reason, *reverse logistics* has shown considerably contrasting patterns between the two groups (see *Table 4.9*). Nearly half of the LSUs regarded reverse logistics as of great impact on their logistics operations, even though most of them gave it relatively lower ranks among their top five. On the contrary, only 17% of LSPs selected it, and the ranks are distributed quite evenly. This may largely be a result of the very nature of the businesses concerned: whereas LSUs are committed to and managing reverse logistics as a sometimes obligatory and integrated part of the business, for LSPs it is a business segment which generates revenues and has a positive effect on their balance sheets. Moreover, as is the case for some LSUs, the importance of reverse logistics is often stipulated by regulations and attached to the return flow of the products, where the complexity and cost-effectiveness of this operation disproportionately affects bottom-line performance; on the other hand, when it comes to specialised LSPs, efficiently managing the flow of goods in both directions and eliminating waste are more a part of normal practice and do not constitute so much of a pressing issue of concern.

Table 4.9: Summary of ranking responses on impact of reverse logistics by group

Reverse Logistics	*1*	*2*	*3*	*4*	*5*	*Total*	*Weighted Impact*
LSPs (n=60)	2	2	2	1	3	10	29
LSUs (n=55)	1	3	6	4	11	25	54
Combined	4	7	11	9	19	35	83

Source: author's questionnaire survey, stage 1; total number of respondents N=115

Likewise, *driver training* and *supply chain optimisation* have received different levels of attention from LSPs and LSUs, mainly due to the nature of their core business. In general, driver training is deemed to be of greater influence on logistics operation by LSPs, while supply chain optimisation is so highly valued by LSUs that it tops the rank, both in absolute and weighted frequencies. Based on the contrasting results from the LSPs and LSUs groups, it seems that LSUs are taking the more proactive and leading role in supply chain optimisation, implying a recognition of the need for collaborating and interacting with other parties within the logistics network, and a willingness to do so. Surprisingly, this is not so much the case for LSPs, whose overall rank for supply chain optimisation was only 7th, suggesting that they attached less importance to interaction with other parties along the supply chain. That said, how strong and active the interactions are between LSPs and LSUs, and the nature of their influence on each other with regard to sustainable practice, were both still quite vague at this stage; the issue will be further explored in more detail in Section 4.5.4.

For the remainder of the seven solutions, the results from chi-square test do not show sufficient evidence to reject the initial hypotheses – in other words, no significant difference can be detected between the LSPs and LSUs groups. This implies that these sustainable measures would have similar impacts on the businesses of both LSPs and LSUs, and therefore do not require adaptation to the parties involved.

Since the chi-square test is not suitable for the three sustainable categories with lowest ranks, the distributions of frequencies have been listed in *Table 4.10* by group for comparison. There is no evident distinction between the two groups for the categories *product/packaging design* and *inclusion of transport in the EU ETS*. However, the *urban logistics* category does signal an unequivocal distinction between them. Out of all respondent LSPs, only one identified urban logistics as an influential solution, and even then this was with the lowest rank; while the percentage is considerably higher among LSUs, with priorities spread more or less evenly across the five ranks. However, it is worth noting that the lowest rank of urban logistics among the 14 solutions might be a result of the vagueness of the term used in the survey. As reviewed in Section 2.5.3.13, ‘urban logistics’ covers a comprehensive range of sustainable policies and practices, which might have led to confusion or misinterpretation by the respondents. Given this consideration, the survey results regarding urban logistics have not been read too much into the final conclusion in this research.

Table 4.10: Summary of responses on the three lowest-ranked measures by group

		1	2	3	4	5	Total	Weighted Impact
Product & Packaging Design	*LSPs (n=60)*	0	2	6	2	2	12	32
	LSUs (n=55)	1	1	1	2	3	8	19
	Combined	2	5	10	8	10	20	51
		1	*2*	*3*	*4*	*5*	*Total*	*Weighted Impact*
Inclusion of Transport in the EU ETS	*LSPs (n=60)*	0	1	1	3	4	9	17
	LSUs (n=55)	1	2	1	1	2	7	20
	Combined	2	5	5	8	11	16	37
		1	*2*	*3*	*4*	*5*	*Total*	*Weighted Impact*
Urban Logistics	*LSPs (n=60)*	0	0	0	0	1	1	1
	LSUs (n=55)	1	2	1	2	1	7	21
	Combined	2	4	4	6	7	8	22

Source: author's questionnaire survey, stage 1; total number of respondents N=115

4.4.2 Sustainable Practices Related to Other Operational Characteristics

The same statistical testing method has been employed to find out whether the attributes of logistics operations, such as geographic scope and fleet size, have significant impacts on their sustainable practice. At aggregate level, none of the 14 sustainable solutions turned out to be evaluated differently by the respondents with different geographic scopes or operational scales. The attempt to explore the interrelationship within each logistics group produces the same result for LSUs, while the LSPs group shows some minor divisions for three solutions. *Supply chain optimisation* and *alternative fuels* are significant at the 5% and 10% level respectively by geographic scope, and *reverse logistics* is significant at the 5% level by fleet size. The patterns observed indicate that logistics operators operating at local or national level place a higher priority on supply chain optimisation; while the international operators seem to pay more attention to alternative fuels. As far as fleet size is concerned, larger operators tend to evaluate reverse logistics as of more influence than is the case with their smaller competitors.

Based on the survey data and the testing results, the observed discrepancies are not significant enough compared with the overall consistent patterns which appeared in operators with different sizes and geographic scopes, not to mention the fact that the credibility of the test is impaired by the small sample size when the data set was broken into LSPs and LSUs groups. For the reasons given above, it appears that the companies' attributes such as operational scale and geographic scope are not critical factors that significantly influence their strategy and practice in sustainable logistics.

4.5 Critical Factors Influencing Sustainable Practice

As detailed in Chapter Three, the questionnaire survey involved two phases, and all the respondents from the first phase were invited to take part in the second phase, which was designed for further investigation into the five most highly ranked sustainable categories of their choices. *Table 4.11* summarises the second-phase survey responses received on each of the 14 solutions by logistics group in the order of their perceived impact ranking.

Table 4.11: Number of responses from the second-stage survey by group

Ranking	*N=115*	*LSPs (n=51)*	*LSUs (n=43)*	*Total (N=94)*
1	Diesel Fuel Taxation	33	21	*54*
2	Driver Training	31	18	*49*
3	Vehicle Design Technology	28	21	*49*
4	Supply Chain Optimisation	18	27	*45*
5	ICT	23	21	*44*
6	Road Pricing	20	16	*36*
7	Alternative Fuels	19	15	*34*
8	Government Support	14	20	*34*
9	Environmental Management Systems	10	9	*19*
10	Reverse Logistics	6	17	*23*
11	Modal Shift	11	4	*15*
12	Product/Packaging Design	7	5	*12*
13	Inclusion of Transport in the EU ETS	5	4	*9*
14	Urban Logistics	1	5	*6*

Source: author's questionnaire survey, stage 2; N=94 (multiple response)

Following the same order, the subsequent subsections reveal the results collected from the second-stage survey, addressing the critical issues related to each solution, such as implementation, motivation, disincentive, cost-effectiveness, and strategies. Due to the small sample sizes of the bottom five solutions and the relatively low impacts of them on the businesses, the survey findings in those solutions are attached in *Appendix Seven* for further reference.

4.5.1 Diesel Fuel Taxation on Road Transport

As shown in *Table 4.4*, altogether 69 out of 115 respondents (60%) identified fuel taxation as one of the top five sustainable solutions with the greatest impact on their logistics operations. Moreover, of these respondents, a large proportion gave it the first or second rank, indicating not only that this solution has implications on a broad sphere of the stakeholders, but also that the influence it has on them is profound. A total of 54 of the respondents (78%) carried out the second phase of the survey for this particular category. Interestingly, when they were asked to rate the policy instrument in terms of its effectiveness in sustainability from 1 (not effective) to 5 (very effective), as shown in *Table 4.12*, the average rate given was below the median rating of 3, suggesting a fairly negative view of its effectiveness. Contrasting with this figure, the average rating derived from the converted ranks given to fuel taxation (i.e. the 1st priority was converted to an equivalent rating 5 as very effective, and the 5th rank to rating 1 as being not effective) during the first phase survey has a value of 3.9, showing the level of great impact that this solution is having on businesses.

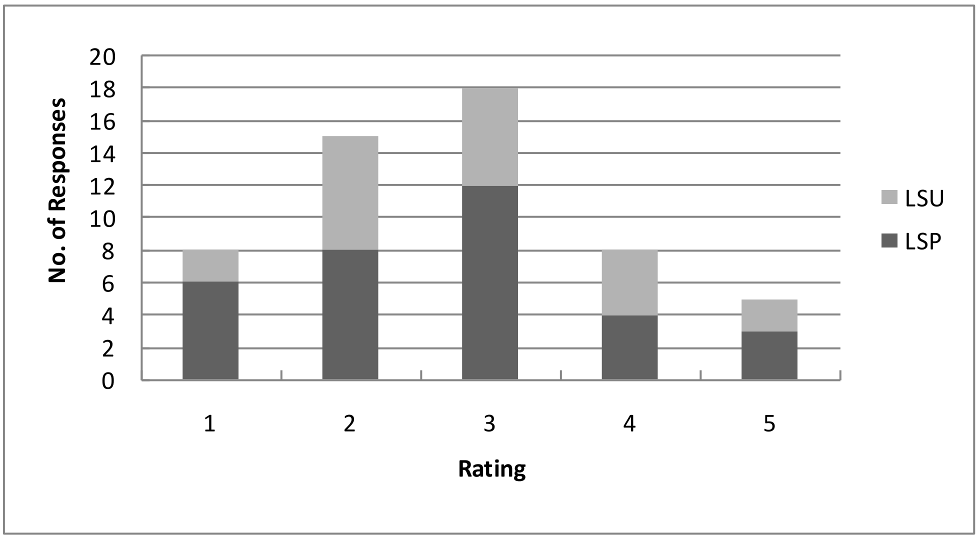
Table 4.12: Respondents' rating on effectiveness of diesel fuel taxation by group

	No. of Responses	Mean	Standard Deviation
LSPs	33	2.70	1.19
LSUs	21	2.86	1.18
Combined	54	2.80	1.19

Source: author's questionnaire survey, stage 2; N=54

The means of the rating and the standard deviations calculated from both groups do not differ very much, and the distribution of the rating is depicted in *Figure 4.11*. Regardless of the logistics role, most respondents rated the effectiveness of fuel taxation as 2 or 3, while only five of them thought the measure to be very effective as a stimulus for sustainable transport.

Figure 4.11: Rating distribution on the effectiveness of diesel fuel taxation



Source: author's questionnaire survey, stage 2; total number of respondents N=54

Although the results obtained from the two phases of the survey seem contradictory at first sight, this might reflect the difference between a projection of the actual performance that the policy could achieve and the stakeholders' attitude towards it. On one hand, the businesses involved agreed on the great impact of fuel taxation, which signifies the effectiveness of the solution. On the other hand, they appeared to be resistant to the enforcement of or increase in fuel taxation.

The strategies that the companies are adopting, or would adopt, in response to the increasing diesel fuel taxation can be an indication of the working mechanism of fuel taxation as a sustainable solution. It also provides a perspective on how effective the measure is going to be in practice. The data is analysed by applying the same techniques used for ranking the 14 sustainable categories – total number of votes for each option and sum of its weighted frequencies (see *Table 4.13*).

Table 4.13: Strategies in response to diesel fuel taxation by group

Strategies	Sum of Frequencies			Sum of Weighted Frequencies		
	LSP	*LSU*	*Combined*	*LSP*	*LSU*	*Combined*
Enhancing fuel efficiency	30	14	44	67	29	96
Passing the cost on to customers	22	6	28	41	9	50
Overhaul and reorganise operation	9	13	22	19	27	46
Alternative fuel	14	12	26	25	20	45
Modal shift	4	12	16	8	23	31
Absorbing cost internally	11	3	14	19	5	24
Fleet upgrading	7	3	10	12	4	16
Others	2	0	2	3	0	3

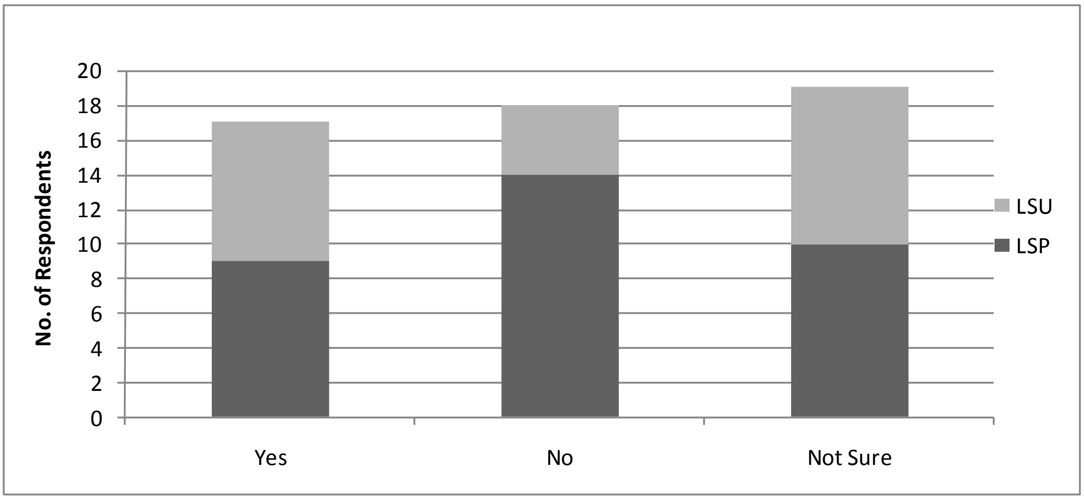
Source: author's questionnaire survey, stage 2; total number of respondents N=54 (multiple response)

It appears that LSPs and LSUs opt for a variety of strategies in response to fuel taxation. Most of the respondents from both groups agreed on the first priority as being fuel efficiency improvement, reaffirming the positive influence of taxation on the rational consumption of fossil fuels. However, two thirds of the LSPs chose to pass the additional cost incurred as a result of increased fuel tax on to customers, indicating that it is almost a standard practice in the industry to incorporate fuel tax into the pricing strategy. Alternative fuel is also favoured by many LSPs as a strategy in reaction to increased diesel fuel price, even though its overall ranks are considerably lower than those of the first two strategies. This, from a different point of view, also reveals the potential linkage between fuel taxation and alternative fuels as two major sustainable categories. Based on the observations from the survey, the extent to which fuel taxation as a fiscal instrument is going to be imposed on logistics operators will have a noticeable impact on their choice of fuel.

Although LSUs also regarded fuel efficiency as the most important strategy, they opted for overhauling and reorganising their operations along with modal shift as the other two main strategies in response to fuel taxation, which clearly differs from their service providers' reactions. Both strategies adopt proactive approaches, showing the greater manoeuvring space for the LSUs to accommodate external tax pressures.

To businesses, sustainable practices often come at a price, especially when it comes to a fiscal policy instrument such as fuel taxation. A question was then put to the respondents asking their opinions as to whether the overall cost incurred by fuel taxes can be justified by the resultant benefits; the responses are illustrated in *Figure 4.12*. There is more or less same number of responses in each category, presenting diversified views on this matter. In general there are more LSPs (14) who do not believe the cost can be justified by the benefits, or who are not sure (ten), while ten expressed positive opinions. LSUs certainly have relatively higher opinions on the benefits of fuel taxation: the number of respondents with positive answers (eight) is twice as many as those giving negative ones (four), although nine are 'not sure'. The reasons behind the divided viewpoints and the sizeable proportion of 'not sure' answers are further interrogated in the next chapter.

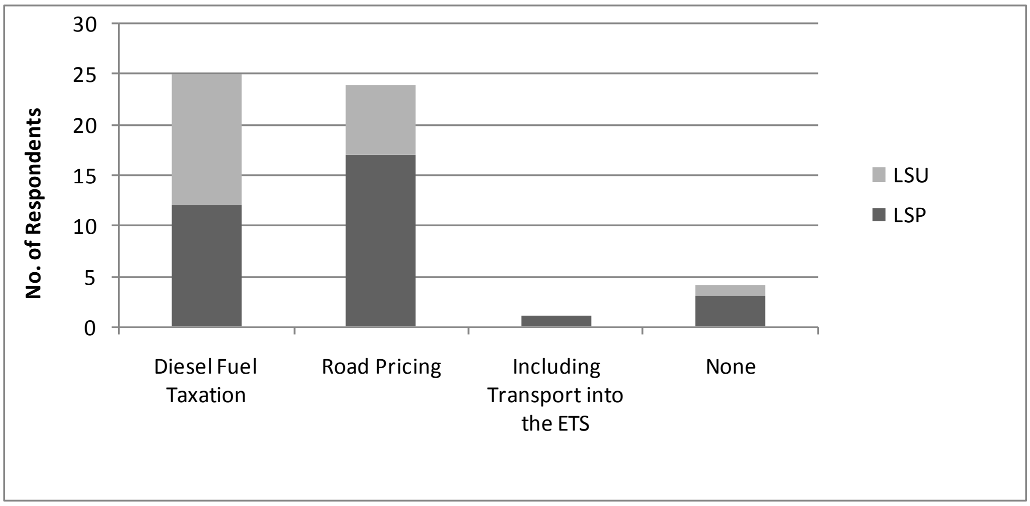
Figure 4.12: Do overall benefits of diesel fuel taxation outweigh the cost?



Source: author's questionnaire survey, stage 2; total number of respondents N=54

Amongst the initiatives for sustainable transport, three fiscal policy instruments – diesel fuel taxation, road pricing and the inclusion of transport into the ETS – were compared by respondents in terms of their perceived environmental performance. As presented in *Figure 4.13*, the most accepted substitute for diesel fuel taxation is road pricing, with a larger proportion of respondents from LSPs than from the LSUs group opting for it. Including the transport sector into the ETS, on the contrary, received only one response from the sample, showing the lack of recognition given to the proposed scheme. Three LSPs and one LSU explicitly stated that none of these policies would work for sustainable transport, but they only constitute a minority (7%) of the sample and this is thus not considered to be a commonly shared opinion.

Figure 4.13: Which measure works better for sustainable transport?

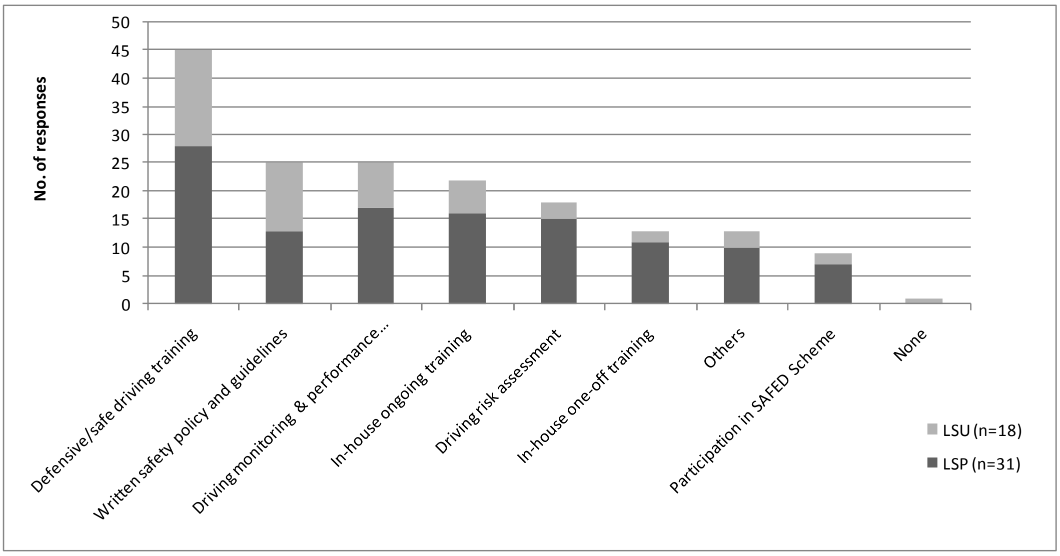


Source: author's questionnaire survey, stage 2; total number of respondents N=54

4.5.2 Driver Training

Out of the 57 respondents selecting driver training as one of the top five sustainable solutions having the greatest impact on their logistics operations, 49 completed the second part of the questionnaire. *Figure 4.14* shows in descending order the specific training programmes provided to drivers by the respondent companies. All but one respondent selected more than one programme, showing their openness to seeking a variety of initiatives for improving drivers' performance.

Figure 4.14: Types of driver training programmes by group



Source: author's questionnaire survey, stage 2; N=49 (multiple response)

Defensive / safe driving training was the most commonly selected by both LSPs and LSUs, implying that the first priority of most companies is given to ensuring the competence of the driver, as well as health and safety issues. In compliance with the Driver Certificate of Professional Competence (CPC), the road haulage sector has seemingly made moves in response by committing themselves to training practices. Coming second is *written safety policies and guidelines*, obtaining a high ranking mainly as a result of the LSUs' choices. Two thirds of LSUs have their driver training requirements and procedures documented as part of the company' policy, while 42% of LSPs have formal files and documentation in support of their training programme. However, this variation cannot be simply generalised as the result of different logistics roles, given that the LSUs are the leading companies within their industry sectors. Instead, it is more likely a result of business scale, with larger companies tending to have comprehensive, established policies regardless of their logistics roles.

Receiving same number of responses as written safety policy and guidelines, *driving behaviour monitoring and performance assessment* saw stronger support from the

LSPs' side. In all, 55% of LSPs have relevant programmes in place, compared with 44% among LSUs. The difference would be even more evident if the business scale factor was taken into account. This, to a great extent, reflects the stronger financial motivation behind the LSPs' behaviour. Fuel typically accounts for between a quarter and a third of the total costs of operating a truck (McKinnon, 2007c). Driving behaviour monitoring and performance assessment normally leads to improvement in fuel efficiency, and hence has direct implications for fuel saving and cost reduction.

In-house ongoing training, *driving risk assessment*, and *in-house one-off training*, were also selected by at least one quarter of the respondents, mainly from the LSPs group. For the companies with in-house training facilities, driver training can be arranged and carried out in a flexible manner to suit business demand and cause minimal disruption to daily operations. Out of the 35 respondents having in-house driver training in their organisations, six of them specified employment of third-party training courses as complementary to their in-house training. Altogether 13 respondents indicated driver training course provided by a specialist institution as their major training programme.

In a similar manner to the analysis of strategies formulated in response to fuel taxation, the main reasons for providing driver training have been extracted from the questionnaire responses and the results summarised in *Table 4.14*.

Table 4.14: Motivations for driver training

Motivations	Sum of Frequencies			Sum of Weighted Frequencies		
	LSP	*LSU*	*Combined*	*LSP*	*LSU*	*Combined*
Health and safety	24	19	43	65	46	111
Compliance to regulations	23	18	41	52	38	90
Improve fuel efficiency	22	10	32	40	15	55
Environmental benefits	7	5	12	7	5	12
Deployment of new technology	9	1	10	10	1	11
Better customer service	7	1	8	8	3	11
Improve operational efficiency	2	0	2	5	0	5
Others	0	0	0	0	0	0
Corporate image	0	0	0	0	0	0

Source: author's questionnaire survey, stage 2; N=49 (multiple response)

Health and safety, and compliance to regulations are the main reasons for driver training practice. Not only does the prevention and reduction of road accidents benefit businesses with smooth running of operations and lower maintenance costs, but drivers equipped with safe-driving techniques and better expertise in manual handling of heavy loads are less likely to suffer from fatigue, tiredness or injury at work. This also shows the level of influence that a well-designed and enforced regulation can have in shaping an industry's practice. Fuel economy is cited as the third reason that encouraged companies to train their drivers, followed by environmental benefits, which is directly associated with fuel consumption in terms of CO_2 emissions. Ten respondents cited the reason as deployment of new technology. For instance, upgrade of fleet normally requires extra trainings to be provided to drivers. Better customer service was selected by eight respondents with relatively low ranks, of which seven were from the LSPs group, indicating the relatively high level of commitment that LSPs have to LSUs.

The major obstacles that businesses are most likely to face in providing driver training are ranked in *Table 4.15*. The lack of required resources – such as qualified instructors, available drivers' time, and money in the budget for training courses – can put restraints on provision of more training where it is needed. Lack of information or expertise also appeared to be a major concern of many respondents. Although there are many specialist institutes offering all forms of training courses to those businesses without in-house expertise, deciding on the most suitable training for their drivers could be challenging, especially considering the complexity of supply chains and specialised logistics activities for different sectors that LSPs are serving at the same time.

Table 4.15: Major concerns in providing driver training

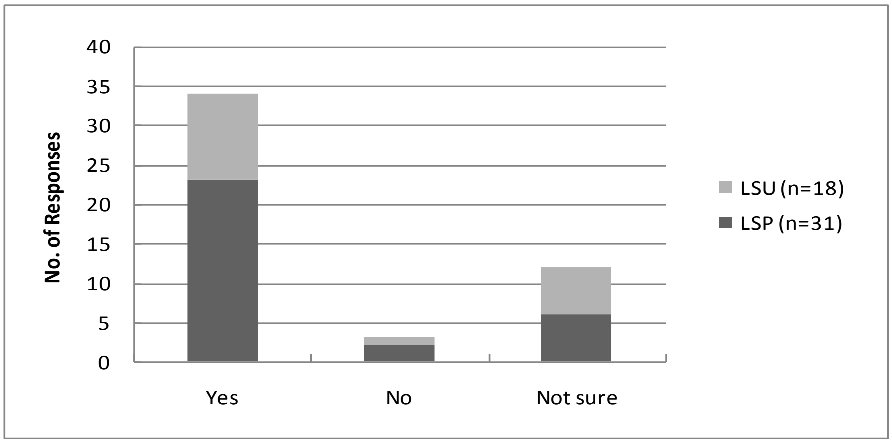
Concern	Sum of Frequencies			Sum of Weighted Frequencies		
	LSP	*LSU*	*Combined*	*LSP*	*LSU*	*Combined*
Lack of resources	20	13	33	45	30	75
Lack of information/expertise	15	16	31	34	34	68
Complexity of implementation	14	7	21	31	16	47
High cost	13	6	19	31	11	42
High staff turnover	11	6	17	17	9	26
Lack of return on investment	9	3	12	13	7	20
Others	2	0	2	6	0	6

Source: author's questionnaire survey, stage 2; N=49 (multiple response)

Other barriers, in descending order by their importance, include high cost, high staff turnover and lack of return on investment. It would appear that, overall, the economic factors are not as highly ranked as they normally would be in most business decisions. Training cost, return on investment, and staff turnover, are all related to the financial output of the programme, yet were all less commonly selected and lower ranked by respondents from both groups. This clearly points to the direction for future improvements in strategies for engaging more companies in driving training, with the focus being put on provision of tailored training programmes for different types of businesses and industrial sectors.

The general attitudes of respondents towards driver training are sought through their evaluation of its cost-effectiveness (see *Figure 4.15*). In total, 34 out of 59 respondents gave positive opinions on it, while 12 stated that they were not sure whether benefits definitely outweigh the total cost. Only three respondents expressed negative views on driver training, which is in line with the previous inference that the financial disincentives is not of great concern in implementing driver training.

Figure 4.15: Do the overall benefits of driver training outweigh the cost?



Source: author's questionnaire survey, stage 2; N=49

4.5.3 Vehicle Design Technology

Among the 36 LSPs and 30 LSUs who identified vehicle design technology as one of the five most influential sustainable solutions for their businesses, 28 LSPs and 21 LSUs continued with the second phase survey regarding details of its implementation. *Table 4.16* illustrates the level of adoption of and interest in a few specified technologies by the respondent companies.

Table 4.16: Adoption of / interest in particular vehicle design technologies by group

Vehicle Design Technology	LSP (n=28)		LSU (n=21)	
	In place	*Interested*	*In place*	*Interested*
Low rolling-resistance tyres	17	8	9	10
Longer, heavier vehicles	11	12	13	7
Aerodynamic styling	9	7	2	15
Alternative-fuel vehicles	8	5	4	7
Fuel-efficient engines	6	15	6	13
Double-deckers	6	9	7	11

Source: author's questionnaire survey, stage 2; N=49 (multiple response)

It would appear that of all the specified vehicle techniques/options, *low rolling-resistance tyres* and *longer, heavier vehicles* were those most commonly adopted by practitioners. The prevalence of the former may be largely attributed to the cost-effectiveness of the measure, while the popularity of and considerable amount of interest in the latter somehow indicates the preference of the industry on the matter of vehicle size. However, as revealed in the follow-up interviews, the connection between current interest and future adoption is, to a large extent, affected by the taxation on goods vehicles by category and other charge schemes which have substantial economic implications for LGVs.

A contrasting pattern appears in the responses concerning *fuel-efficient engine*, showing a relatively low level of adoption despite a high level of interest. This reveals a trend within the industry of factoring fuel efficiency into operators' decision-making on fleet upgrading. Similarly, *double-decker* does not seem to be widely in use at present, while its deployment in the near future seems promising going by the level of interest shown by both LSPs and LSUs.

*Aerodynamic*c *styling* and *alternative-fuel vehicles* are the two vehicle technologies seemingly employed more by LSPs in practice than by LSUs; the LSUs' interests in these measures are relatively higher, especially in aerodynamics styling. Both involving substantial modification or upgrading of the vehicle fleet, these two technologies entail commitment to the continuous improvement of the fleet performance, which may explain the behavioural variation between the two groups.

As fleet management policy is formulated as a combined result of both internal factors, such as fixed and variable costs, and external factors such as environmental regulations and various charge schemes based on the category of the vehicles, several such major regulations and schemes, either enforced or proposed in the UK, were listed in parallel for respondents to evaluate their respective impacts on their fleet operations (rating from 1-5: 1 for very limited impact and 5 for greatest impact). The results are summarised in *Table 4.17*.

Table 4.17: Rating results on potential impacts of external factors on fleet operation

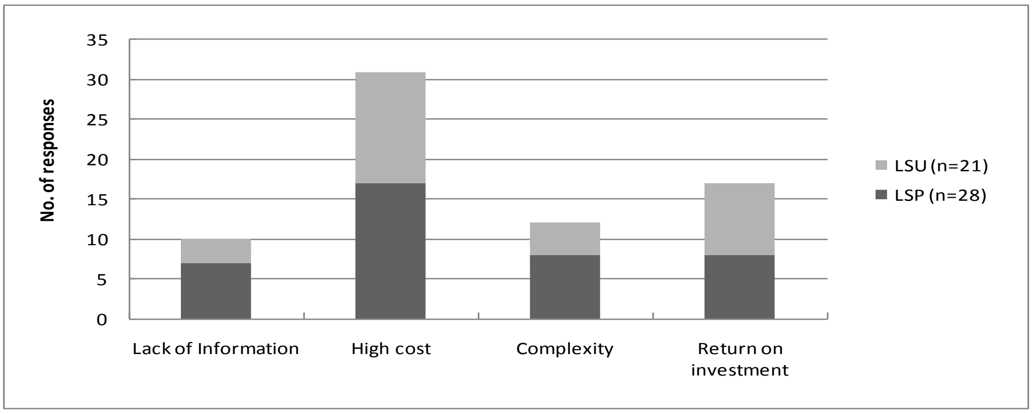
Policy/Charge Scheme	LSP (n=28)		LSU (n=21)	
	Mean	*SD*	*Mean*	*SD*
Fuel Tax	3.87	0.93	3.67	1.18
Lorry Road User Charge	3.59	1.17	3.12	1.07
Low Emission Zone	2.46	1.23	2.81	1.11
Inclusion of road transport into the EU ETS	2.11	1.34	1.98	1.03

Source: author's questionnaire survey, stage 2; N=49

It seems that *fuel taxation* and *road user charge scheme* would have the greatest impact on the companies' fleet operations, regardless of their logistics roles, which is likely driven by their knock-on effect on operating cost. Increased diesel fuel price, largely resulting from fuel duties and taxes, may induce operators to seek more fuel-efficient goods vehicles or switch to alternative fuels; while a national road user charge programme would have a similar mechanism of increasing the marginal, activity-based cost of the fleet operation, urging companies to look at compliance engines and vehicles with minimal running cost. Having scored around 2.5 on average, *low emission zone* appeared to have much less impact on commercial fleets. The locality of the already in-place scheme, limited to the Greater London area, is likely to have influenced the rating depending on whether or not their operations cover the particular area. *Inclusion of road transport into the EU ETS* scored the lowest among all measures, showing the lack of attention given to or knowledge of it, among both LSPs and LSUs.

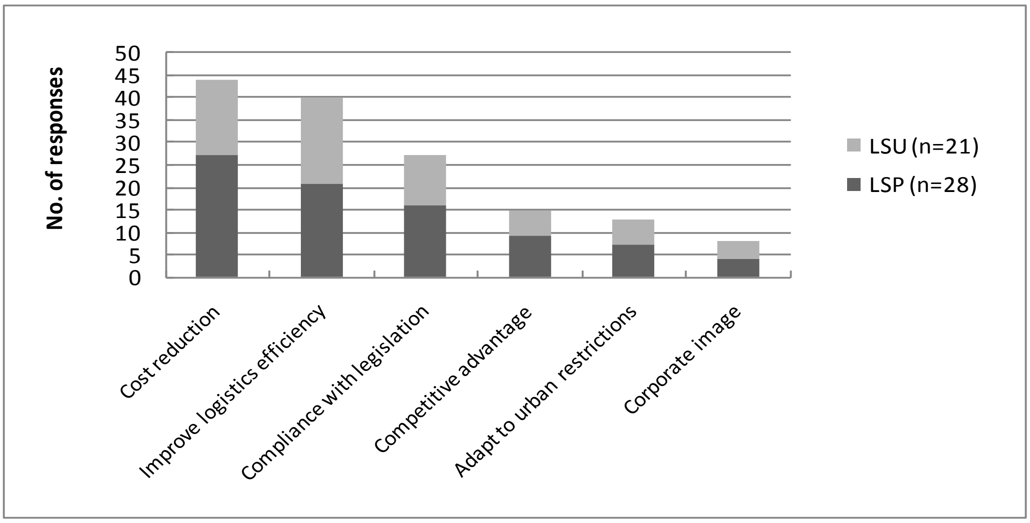
Incentives for and disincentives to implementing vehicle design technologies have also been explored in the survey, and the results are depicted in *Figure 4.16* and *Figure 4.17* respectively. The financial implications of the solution are highlighted by both graphs. On one hand, the high cost and low return on investment (or the long pay-back time) of vehicle technology constitute the main concerns regarding its adoption; on the other hand, cost reduction as a result of adoption stood out as the most selected incentive. Conflicting though it seems, primarily due to the generalised term ‘vehicle design technology’ being used for both questions, the survey result suggests that the most important determinant of market penetration is the cost-effectiveness of the technology.

Figure 4.16: Major disincentives to adopting vehicle design technology



Source: author’s questionnaire survey, stage 2; N=49 (multiple response)

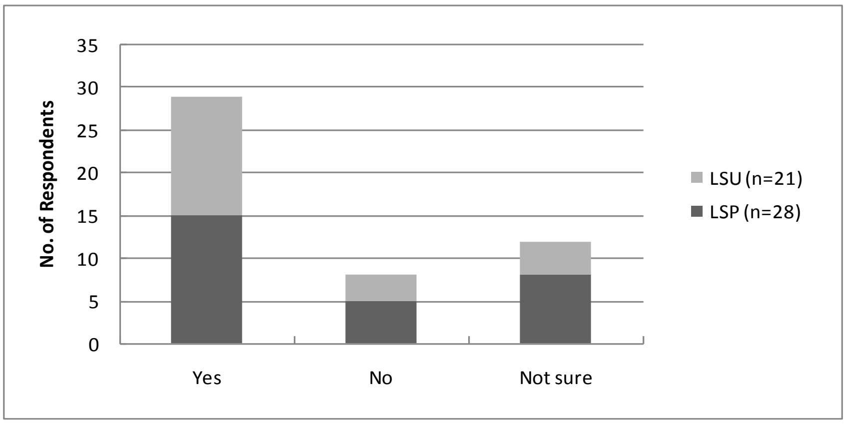
Figure 4.17: Major incentives for adopting vehicle design technology



Source: author’s questionnaire survey, stage 2; N=49 (multiple response)

Overall, as shown in *Figure 4.18*, positive opinions are presented in terms of the benefits received from applying the solution against total cost. 24% of the respondents were not sure on the issue, indicating that a considerable number of stakeholders are still postponing their actions, waiting for fuel efficiency and other tangible benefits of such technologies to be evidenced in practice.

Figure 4.18: Do the overall benefits of vehicle design technology outweigh the cost?



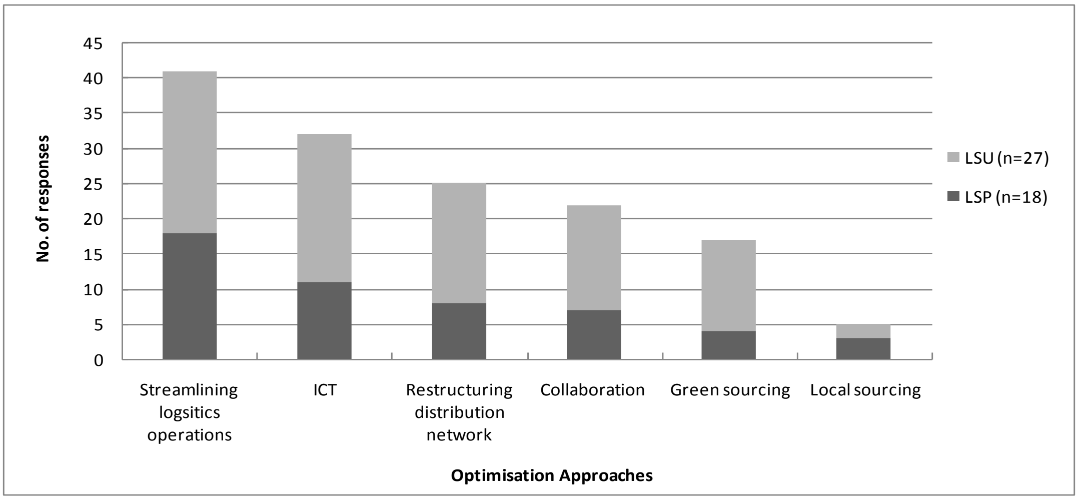
Source: author's questionnaire survey, stage 2; N=49

4.5.4 Supply Chain Optimisation

As revealed in previous analysis, supply chain management is an area where contrasting patterns are evident between the LSUs and LSPs groups in terms of its perceived impact on logistics operation. A higher proportion of LSUs (58%) identified the solution as having profound implications for their logistics operations than that of LSP respondents (37%). The variation is more apparent in terms of weighted frequency which also takes the assigned rankings into account: supply chain optimisation does not even make it into the top five in the LSPs group, despite its position at the very top of LSUs' sustainable agendas. There are, consequently, more LSUs than LSPs responding to this part of the questionnaire. Altogether 27 LSUs and 18 LSPs completed the second stage of the survey regarding supply chain management issues, which aimed to explore their current practice, their interactions with other stakeholders within and beyond the logistics network, major problematic areas in supply chain optimisation, and the main drivers and disincentives, as well as cost-benefit evaluation.

Figure 4.19 summarises the common approaches to optimising supply chain operations and their popularity among LSPs and LSUs. *Streamlining logistics operations*, *ICT*, and *restructuring distribution network* appeared to be the three most commonly adopted approaches among practitioners. Streamlining logistics operations focuses mainly on improving operational efficiency through incremental changes and rearrangement of routine working processes, and hence entails relatively low costs for its implementation. Compared with ICT and logistics network restructuring, it is often under the control of the executing company, yielding more predictable and quantifiable benefits and offering more flexibility in adjustment when the situation is changed or when expected improvement is not achieved. Similarly, although ICT and network restructuring may yield substantial financial and operational benefits once they are successfully implemented, they also inevitably entail a larger amount of initial investment of money and resources, and are more likely to involve other parties alongside the supply chain. Therefore, the preference order of the three approaches is likely to be the result of a mix of factors including implementing cost, scope and depth of the approach, involvement of outside parties, and complexity and flexibility of the implementation.

Figure 4.19: Supply chain optimisation approaches adopted by LSPs and LSUs



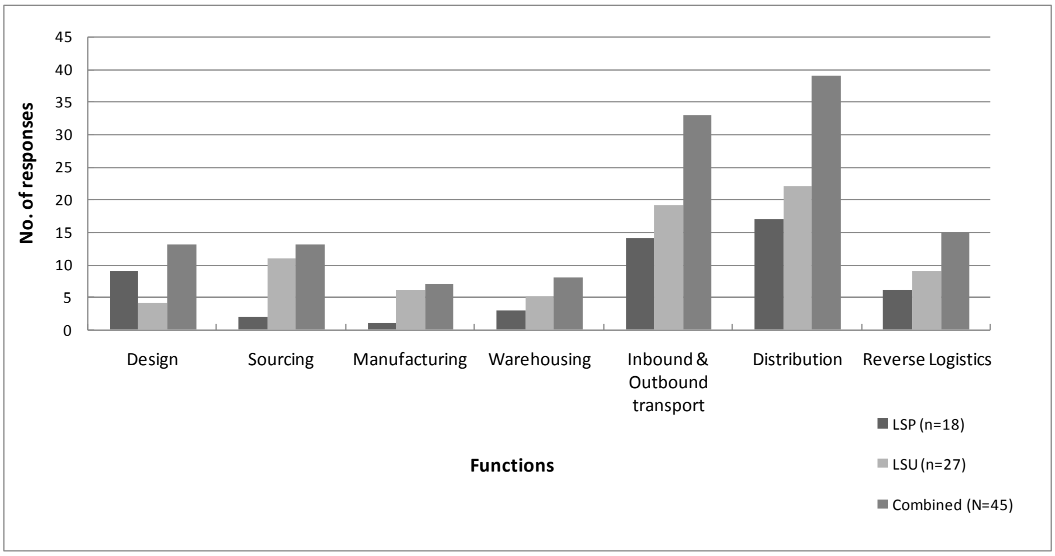
Source: author's questionnaire survey, stage 2; N=45 (multiple response)

Nearly half of the respondents (49%) have also adopted a *collaborative* approach in optimising their supply chains. Often taking the forms of shared database, vehicles, distribution facilities and skills, this approach is designed to release the full capacity of existing resources with minimal additional input. The concept of sharing resources has received increasing interest during tough economic times when increasing numbers of logistics operators have allied, or are considering establishing such partnership to enhance efficiency and reduce cost to a level that is otherwise impossible to achieve.

Combining green sourcing and local sourcing into one category, *sustainable sourcing* is adopted by the same number of respondents as is the collaborative approach. However, the breakdown shown in the figure indicates the single major contributor as *green sourcing* applied by LSUs. Among 22 companies who have adopted sustainable sourcing, 17 of them (77%) employed green sourcing, while only five (23%) of them implemented local sourcing. This observation implies that through local sourcing, the benefits from decreased transport costs might not be sufficient to justify the opportunity costs such as the forgoing of more efficient production, lower labour cost, and hence cheaper products from overseas. It may also be a result of the fact that, using life cycle analysis, the environmental credential of local sourcing is not always plausible, and is thus less convincing for companies compared with green sourcing, which primarily involves a vendor/supplier selection and monitoring procedure to ensure that products are sourced from those with less environmental impact.

Although discovering the approaches employed by companies in optimising their supply chains helps to draw a sketch of the present practice in the industry, it may not be comprehensive in covering every aspect of the supply chain. Taking a different perspective, the survey asked the participants to highlight the functions/stages along a typical supply chain which are most involved in delivering an environmentally sustainable supply chain; the results are shown in *Figure 4.20.*

Figure 4.20: Functions most involved in sustainable supply chain



Source: author's questionnaire survey, stage 2; N=45 (multiple response)

Goods distribution (for wholesaler and retailer), closely followed by inbound and outbound transport (for manufacturer and supplier), is the function most selected by both groups, reinforcing the key role that freight transport is playing in sustainable logistics. Among other logistics activities within the supply chain, design, sourcing and reverse logistics were more or less equally selected as potential areas. Product and package design is seemingly being neglected by those product-based businesses, i.e. LSUs, with only 15% of them identifying this area. Although having a considerably higher proportion (50%) taking action at this stage, LSPs as service-based businesses, might have taken completely different views of the definition of product design, which often means the design of a logistics solution package for their clients. For logistics companies, especially the big players in the industry, the design of the service portfolio is often customised to suit the client's needs, and is one of the most critical factors in winning a contract with new clients and retaining established relationship with exiting ones, which may explain the momentum observed at this stage among LSPs.

Overall, the survey findings on this matter reveal the stages/functions within a supply chain where companies are working hard to improve. It also highlights the stages that are currently being overlooked and thus have great potential for the embracing of sustainable technologies and measures, including warehousing, product/package design and manufacturing (mainly for LSUs). In conjunction with the findings on supply chain approaches, the interconnections that exist between certain sustainable solutions have also emerged – for example ICT and supply chain optimisation, and reverse logistics and supply chain optimisation.

To further reveal how the stakeholders interact with each other, respondents were asked to identify the parties involved in or influencing their supply chain optimisation. The results are shown in *Table 4.18*. Due to LSPs' and LSUs' different roles in the supply chain, the combined frequency in this case becomes less interpretable, and it is more appropriate to examine their responses separately.

Table 4.18: Parties involved in or influencing supply chain optimisation

Parties	LSP (n=18)	LSU (n=27)	Combined (N=45)
Clients (B2B)	11	21	32
Suppliers	8	17	25
3PLs	5	15	20
Subcontractors	9	11	20
Consumers (B2C)	3	9	12
Government authorities	4	6	10
Others	1	5	6
NGOs/Associations	2	2	4
Environmental think-tanks	1	2	3
None	0	0	0

Source: author's questionnaire survey, stage 2; N=45 (multiple response)

In general, the supply chain optimisation processes adopted by individual businesses would appear to be always interwoven with interactions with a wide variety of outside parties, ranging from business partners, clients and consumers, to government authorities and NGOs. Quite as anticipated, the direct business partners, and the immediate actors upstream and downstream in the supply chain, seemed to have closest interrelationships with the company in question, with clients being the most selected parties by both groups. None of the respondents claimed that their supply chain optimisation was carried out without the involvement or influence of other parties, implying that such optimisation can present a potential challeng of co-ordination between various parties.

For LSPs, *business clients*, *subcontractors* and *suppliers* appeared to be the parties most frequently involved in or influencing the optimisation process. Noticing that these three parties are all direct business partners of the logistics companies along supply chain, the inference can be made at this stage that commercial interest and benefits might be the key element in bringing these parties together for the purpose of optimising the supply chain, which is not necessarily a negative sign from the viewpoint of sustainability, as long as the operational improvement also leads to environmental efficiencies. A similar pattern is disclosed within the LSUs group, with their *business clients*, *suppliers*, *3PLs* and *subcontractors* being the most selected as active participants in improving supply chain performance. One third of the LSUs also identified *individual consumers* as an influential group, which is likely to be driven by the rapid growth of B2C e-commerce in recent years.

Apart from trade partners who are linked closely by direct business interests, the role that other stakeholders are playing in companies' supply chain management seems quite limited. Among all the parties outside the value chains, *government authorities* appeared to have the most influence on companies' strategy formulation, with ten responses from both groups. However, the interactions between logistics actors and other stakeholders are negligible, according to the survey results. Combined together, NGOs, industry associations and academia received only seven responses from both groups, while logistics consultants alone were mentioned by six respondents, which again indicates a business bond between the key actors.

Developing an informed strategy with the aim of steering business behaviour towards long-term sustainability requires a fuller understanding of the businesses' own concerns. *Table 4.19* and *Table 4.20* summarise respectively the major inefficiencies within the businesses' supply chain, and the main causes of these inefficiencies.

Table 4.19: Major inefficiencies within supply chain

Ineffiencies	LSP (n=18)	LSU (n=27)	Combined
Low loading factor	12	9	21
Fuel consumption/efficiency	11	9	20
Empty running	7	11	18
Increasing lead time	9	6	15
Communication and coordination	6	8	14
Overcapacity/Undercapacity	5	7	12
Order processing/fulfillment	3	9	12
Warehousing operations	3	5	8
Inventory management	0	3	3

Source: author's questionnaire survey, stage 2; N=45 (multiple response)

Table 4.20: Causes of inefficiencies within supply chain

Causes of Inefficiencies	LSP (n=18)	LSU (n=27)	Combined
Lack of communication and collaboration along supply chain	11	16	27
Demand fluctuation	13	11	24
Congestion	9	12	21
Product/package design	5	7	12
Warehousing configuration	7	5	12
Non-strategic roles of logistics within the company	3	5	8
Government regulations	3	3	6
Fleet configuration	3	2	5
Low inventory policy / JIT delivery	2	2	4
Priority to outbound distribution	0	1	1
Growth of ecommerce and home delivery	0	0	0
Postponement	0	0	0

Source: author's questionnaire survey, stage 2; N=45 (multiple response)

As *Table 4.19* suggests, the inefficiencies of major concern – in other words the obstacles or bottlenecks in the supply chains – range widely from fuel efficiency, low loading factors, and overcapacity to long lead time, poor communication and low efficient order processing. The less problematic areas are warehousing and inventory management, receiving only eight and three responses respectively.

Although the vast majority of the respondents made multiple choices on both issues, making it difficult to relate the causes to specific inefficiencies, the survey result does highlight certain common reasons. *Lack of communication and collaboration along supply chain*, for instance, has been selected by 60% of the respondents as the cause of their supply chain inefficiencies. Communication problems could be largely solved or reduced by resorting to ICT, if it is the inefficiency in data capturing, processing and transmitting that leads to poor visibility in the supply chain. Nevertheless, in many cases it is the businesses and people involved who have the problem communicating in an effective and efficient manner, which is a much more complicated issue to address than any technical ones. *Demand fluctuation* and *congestion* have also been identified by around half of the respondents, showing that a substantial part of the inefficiencies that the businesses are facing is inherent in the wider industry and society settings. Other frequently quoted causes include *product/package design*, *warehouse configuration* and *non-strategic roles of logistics within the company*. Contrasting with the limited role that product and packaging design seems to be playing in logistics operations, it would appear that businesses have come to realise the inconvenience and associated cost of the lack of good product design for logistics operations, which might in turn lead to increasing action in this area. Likewise, warehouse configuration is within the scope of the businesses' strategy-making, and once reaching the trigger point, it is only a matter of time before a business will act on it. The non-strategic roles of logistics, however, might take a longer time to be addressed in the absence of external pressures or profound changes in the business culture.

Common logistics strategies and practice – such as postponement, a low inventory policy, just-in-time delivery (JIT) and giving priority to outbound distributions – did not appear to be regarded as principal contributors to logistics inefficiencies. The growth of e-commerce and home delivery, resulting in large numbers of small yet frequent deliveries, seemed to be embraced by both LSPs and LSUs as more of an opportunity, as none of them regarded it as the cause of inefficiency.

Reasons for establishing or not establishing a greener supply chain were also sought from participants of the survey; *Table 4.21* and *Table 4.22* list the results by group. In descending order, the most common disincentives that put businesses off setting up a greener supply chain appeared to be: *difficulties in co-ordinating with other parties within supply chain*, *the complexity of implementation*, *lack of information or knowledge*, and *lack of required resources*. As discussed earlier, co-ordination among parties within a supply chain adds to the complexity of restructuring efforts; while the lack of information, knowledge and required resources coincides with the absence of influence from supportive associations and academia (see *Table 4.18*). These issues combine to present an area which has great potential for improvement.

Table 4.21: Disincentives to establishing a green supply chain

Disincentives	LSP (n=18)	LSU (n=27)	Combined
Difficulty in coordinating with other parties within supply chain	16	20	36
The complexity of implementing	12	19	31
Lack of information/communication	9	6	15
Lack of resources needed	6	9	15
Lack of consumer recognition	1	5	6
Lack of return on investment	1	3	4
High costs	1	0	1

Source: author's questionnaire survey, stage 2; N=45 (multiple response)

Table 4.22: Drivers of establishing a green supply chain

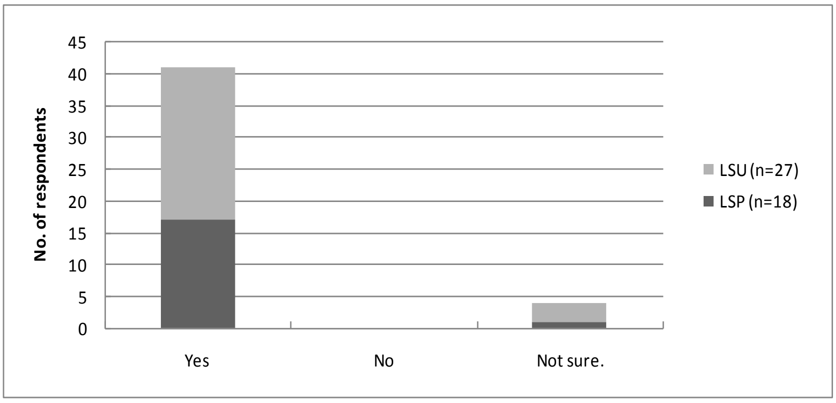
Drivers	LSP (n=18)	LSU (n=27)	Combined
Reduce logistics costs	14	23	37
Improve operational efficiency	17	19	36
Satisfy customer requirements	12	11	23
Establish a competitive advantage	4	12	16
Expand to new markets	6	3	9
Improve corporate image	0	5	5
Differentiate from competitors	1	4	5
Optimise manufacturing	0	2	2

Source: author's questionnaire survey, stage 2; N=45 (multiple response)

As far as the incentives that encourage companies to take on a green supply chain approach are concerned, *cost* and *efficiency* implications have been revealed as the most quoted drivers by both groups. Achieving a high level of *customer satisfaction* came third in total, followed by *gaining a competitive advantage*, with responses coming mainly from LSUs. The divided opinions on the competitive advantages of operating a green supply chain could be a result of the different sampling frames of the two groups, seeing leading companies voicing on behalf of LSUs in this survey.

In evaluating the overall benefits of operating a green supply chain against the costs incurred, both groups appeared to have reached consensus on the justifiable costs compared with greater benefits, as shown in *Figure 4.21*. More than 90% of respondents believe that the benefits outweigh the additional costs, while the rest hold a sceptical view rather than being totally negative, which again indicates the great acceptability and practicability of the solution among industry members.

Figure 4.21: Do overall benefits of a green supply chain outweigh the cost?



Source: author's questionnaire survey, stage 2; N=45

4.5.5 Information and Communication Technology (ICT)

The survey result from stage one has seen same number of responses (29) in ICT from the LSPs and LSUs groups, making it the fifth solution in terms of impact on today's logistics operation. Taking account of the slightly different sample sizes of the two groups, and the varied rankings of ICT, LSUs seemed to regard it as of greater influence. The second-stage survey on the topic of ICT was carried out to provide more insight into some primary facets, including the specific ICT systems that the businesses are using or expecting to employ, the scope of the systems in use, their environmental contribution, the major drivers of and disincentives to new ICT implementation, and the perceived cost-effectiveness of ICT. Altogether 23 LSPs and 21 LSUs completed this part of the survey.

Looking into the particular ICT systems currently being deployed within the respondents' logistics operations helps in providing an overview of the functions within the supply chain that tend to lend themselves to ICT applications. As shown in *Table 4.23*, *product scanning and tracking systems*, *supply chain planning & management systems*, and *computerised vehicle routeing and scheduling (CVRS) systems* (including the simpler journey planners) are widely in use among both LSPs and LSUs. *Paperless manifest/POD (proof of delivery) systems* and *telematics* and *vehicle tracking system*s, although not as commonly in use as those applications mentioned above, are being used by nearly half of the respondents. In contrast, *traffic information*, *fuel recording*, *online freight exchanges* and *vehicle diagnostics systems* appeared to be less commonly deployed at present.

Table 4.23: Type of ICT systems in place or interested by group

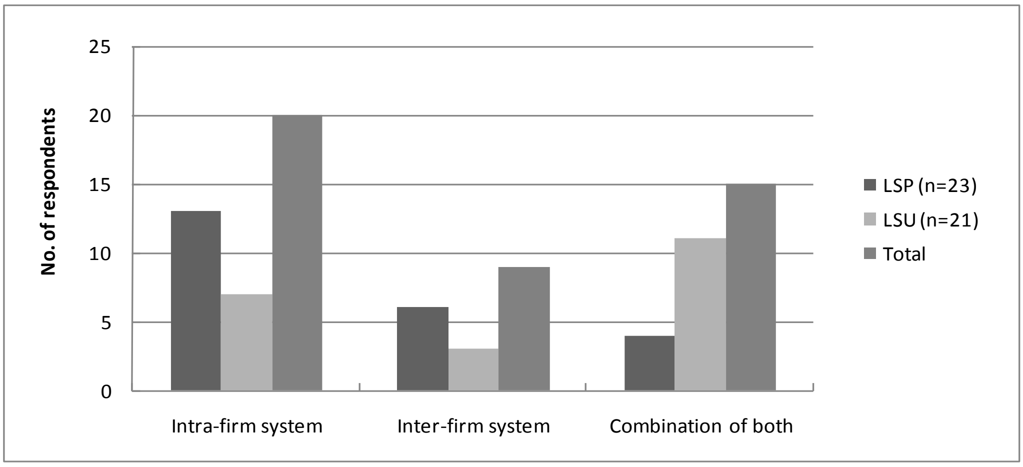
ICT Systems	In Place			Interested		
	LSP (n=23)	LSU (n=21)	Combined	LSP (n=23)	LSU (n=21)	Combined
Product scanning & tracking systems	14	19	33	6	1	7
Supply chain planning & management systems	13	19	32	8	2	10
CVRS systems / simple journey planning tools	13	15	28	5	8	13
Paperless manifest / POD systems	9	13	22	7	2	9
Telematics	11	10	21	9	9	18
Vehicle tracking systems	8	8	16	12	10	22
Online freight exchanges	4	3	7	5	4	9
Vehicle diagnostics systems	3	4	7	8	5	13
Fuel recording systems	4	2	6	10	6	16
Traffic information systems	3	0	3	7	9	16

Source: author's questionnaire survey, stage 2; N=44 (multiple response)

The types of ICT systems in which the businesses showed interest indicate the areas of growth in the future, as well as the developing trend of ICT in the logistics industry. The collected data revealed that *vehicle tracking systems*, followed by *telematics*, *traffic information* and *fuel recording systems*, represent the direction that many businesses are moving towards. Noticing that the first three applications all share the logistics objectives of streamlining fleet operations, facilitating communication, and improving visibility and responsiveness of the supply chain, while fuel recording systems are intended for fuel saving, it is clear that the focus of the businesses in exploiting ICT will continue to be placed on operational efficiency and cost reduction. CVRS, supply chain management, product scanning & tracking, and paperless manifest/POD systems, which have already seen broad employment in the industry, topped the agenda of those who do not have them at the moment. Online freight exchange, which is not being deployed widely among businesses, seemed to have received more interest compared with the number of current users, suggesting a likely doubling in the user base in the near future if all the interested companies subsequently become practical users.

Most ICT systems operate in a network environment, thus the connectivity of the systems across the supply chain is a critical indicator of the breadth and depth in which the information systems are functioning. To gain a general picture on this matter, respondents were requested to classify their ICT systems by the scope of their connectivity, i.e. whether the system is confined to an intranet that is shared only within the organisation, or one that is at least partially connected and integrated with other parties along the supply chain, or whether both types of systems co-exist in the business. *Figure 4.22* depicts the result for each group, and for the totals.

Figure 4.22: Connectivity of the ICT systems in use by group

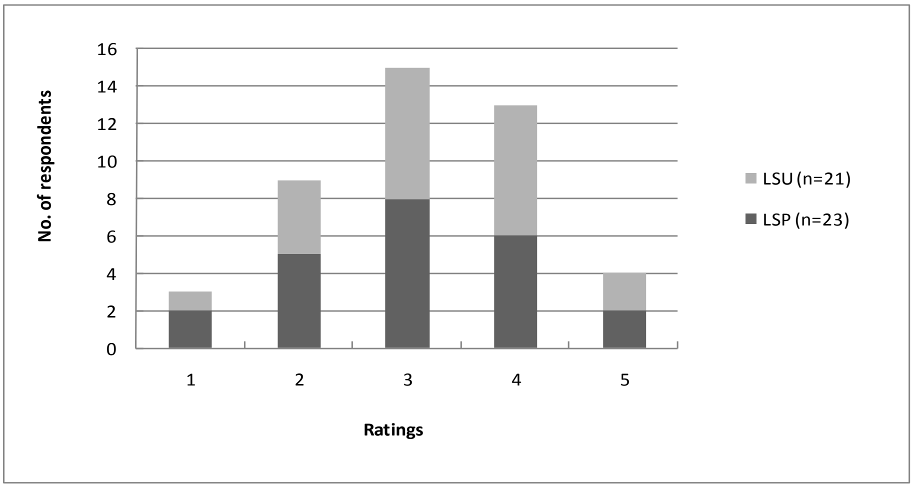


Source: author's questionnaire survey, stage 2; N=44

It can be seen from the figure that LSPs tend to have more stand-alone ICT systems in place, while LSUs appeared to have more sophisticated systems covering both internal operations and external data exchanges. However, bearing in mind both the small sample sizes and different sample frames used for different groups, caution should be taken in generalising this pattern. In general, intra-firm systems have the largest share in the sample, which is likely to be even more true for the entire population, indicating that there is substantial room for ICT to play an increasing part in linking up the various parties along the supply chain.

Regardless of the variety of functions and connectivity of the ICT systems being employed, their contribution to environmental mitigation has been evaluated by the respondents. Ratings were given on the ICT applications implemented in their companies from 0 (no environmental contribution) to 5 (very substantial environmental contribution) and the results are summarised in *Figure 4.23*.

Figure 4.23: Ratings on contribution of ICT systems to environmental sustainability



Source: author's questionnaire survey, stage 2; N=44

As shown in the figure, no respondents claimed that their ICT systems had no environmental credentials at all. Ratings made by both groups, while slightly skewed towards the upper end, are centred around 3, suggesting a fairly pronounced effect of ICT on the environment. The average rating of the 23 LSPs is 3.04, with the standard deviation being 1.11; this compares with a mean and standard deviation for the LSUs groups of 3.24 and 1.04 respectively. Undertaking a two-sample t-test with the data gives a test statistics of 0.617, which is smaller than the critical value of 1.96 at 5% significance level, indicating that there is no significant difference in the evaluation of ICT's environmental performance between the two groups.

In deciding whether to introduce a new ICT system into existing network, evaluation is often made between the overall benefits that the new system can bring to the business and the potential problems that come along with the implementation of it. The benefits related to ICT applications, i.e. the main reasons that encourage companies to adopt ICT, are listed in *Table 4.24*, while the disincentives are presented in *Table 4.25*.

Table 4.24: Main reasons of implementing ICT systems by group

Drivers	LSP (n=23)	LSU (n=21)	Combined
Improve operational efficiency	21	16	37
Improve customer service	17	14	31
Cost reduction	9	14	23
Improve environmental performance	10	6	16
Market expension	2	7	9
Legislative requirement	2	3	5
Asset security	3	2	5

Source: author's questionnaire survey, stage 2; N=44 (multiple response)

The reasons most frequently cited for implementing ICT are *operational efficiency improvement* and *customer service enhancement*, followed by *cost reduction*, as can be seen in *Table 4.24*. Of note is that the financial benefits of ICT were not as highly valued as were its implications for operations and service level, indicating a performance-oriented decision-making process on this matter. Among other factors of less importance, over one third of the respondents cited environmental performance, showing another positive sign of the confidence that they have in ICT as a means of reducing their environmental footprint. Market expansion, cited mainly by LSUs, might be associated with the opportunities present in today's ever-increasing e-commerce market. Asset security, ensured by the technology monitoring the location and status of the stock, particularly for high-value and perishable goods, received five responses due to its application in specialised supply chains.

Table 4.25: Main disincentives to employing new ICT systems by group

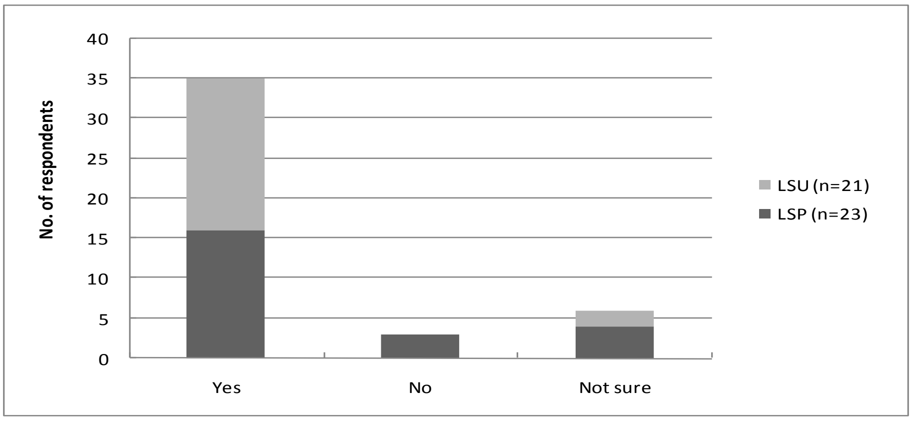
Disincentives	LSP (n=23)	LSU (n=21)	Combined
High complexity	17	11	28
High cost	12	15	27
Lack of resources	14	12	26
Non-compatibility with current system	4	10	14
Long implementation period	5	7	12
Too much information sharing	0	3	3

Source: author's questionnaire survey, stage 2; N=44 (multiple response)

The reasons cited by the respondents as main disincentives to employing new ICT systems have been classified under the broad categories listed in *Table 4.25*. The factor of most importance appeared to be the *complexity* of introducing a new system or technology, as it may involve many functions within the businesses as well as outside parties along the supply chain, and often requires extensive changes to be made in existing operational processes, and training to be conducted among staff. Of nearly equal importance are the *high cost* that ICT normally entails, and a *lack of resources* – financial, human resource, time or expertise – which can also broadly be regarded as part of the cost of implementing an ICT system. Thus, for businesses, although cost saving is not the most valued attribute of ICT application, the direct and hidden costs of it can be prohibitive. *Non-compatibility with existing systems*, cited mainly by LSUs, is a common problem for businesses applying multiple systems. Integrating such 'silo' systems into one consistent system presents a great challenge, especially when the existing systems have been used for a long time. Over a quarter of respondents specified *long implementation time for ICT projects* as a deterrent, again reflecting the complexity of and the high demands placed on limited business resources.

Similarly to the general viewpoint on supply chain optimisation, the attitude of respondents towards ICT as a sustainable solution appeared to be positive overall, as illustrated in *Figure 4.24*. 80% of respondents think that the overall benefits of ICT can justify the additional cost. Given the high cost of ICT being cited as one of the most important factors prohibiting companies from implementing it, this result shows an apparent acceptance of the solution among practitioners. Six respondents are not sure about ICT's cost-effectiveness; while three respondents, all LSPs, do not believe that the benefits can justify the total cost; the reasons behind this will be investigated in the analysis of the interviews.

Figure 4.24: Do the overall benefits of ICT justify the additional cost occurred?



Source: author's questionnaire survey, stage 2; N=44

4.5.6 Road Pricing

As with the analysis of diesel fuel taxation, the study into road pricing as a policy imposed on businesses, rather than a voluntary solution whose implementation can be decided by individual companies, should be focused on aspects such as the policy's impact on logistics operations and businesses' behavioural responses towards it. Of the 26 LSPs and 21 LSUs who identified road pricing as one of the five sustainable measures having the most impact on their logistics operations, 20 and 16 from each group respectively completed the second part of the survey.

Two local charging schemes, the congestion charge and the low emission zone, which have been in force in London since 2003 and 2008 respectively, were put along with a proposed national road charging scheme, for respondents to compare their actually or likely impacts on their businesses. Participants were asked to rank the three charging schemes from 1 to 3, with 1 being the policy most affecting the business and 3 being that having the least impact. The results are compiled in *Table 4.26*.

Table 4.26: Ranking results for various road pricing schemes in the UK

Ranking	LSP (n=20)				LSU (n=16)			
	1	*2*	*3*	*Weighted Total*	*1*	*2*	*3*	*Weighted Total*
Time-distance-place national road users	11	7	2	***49***	12	3	1	***43***
Urban congestion charge	7	7	6	***41***	2	9	5	***29***
Low emission zone	2	6	12	***30***	2	4	10	***24***

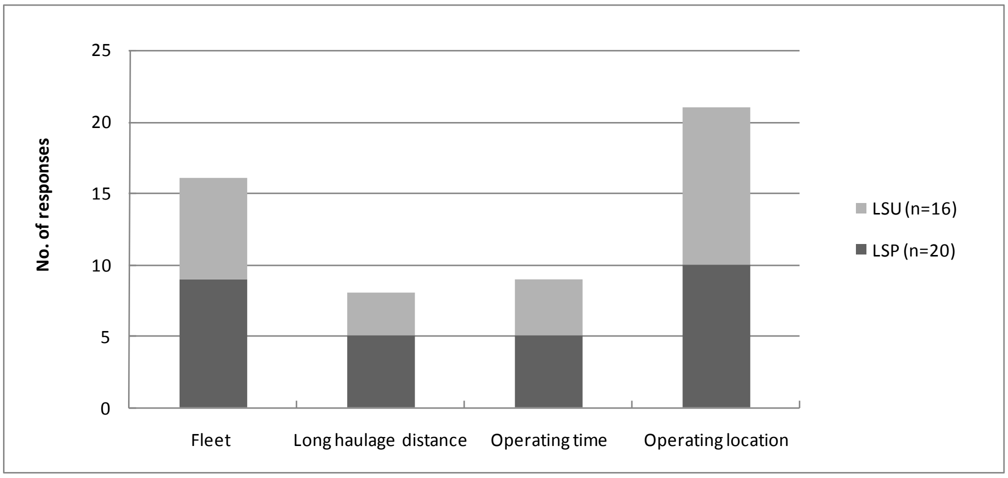
Source: author's questionnaire survey, stage 2; N=36

By assigning weights to different ranks (i.e. 3 to the first rank, 2 to the second and 1 to the third), weighted frequencies were summed to give the total scores that represent the relative importance of the charging schemes perceived by the respondents. The responses from the LSPs and LSUs groups seemed to be generally agreed on the different impacts of the three road pricing policies. The national road user scheme, raised as a hypothetical one being imposed on businesses, was regarded as the one with more impact compared with the local schemes. Between the two local charging schemes, urban congestion charges appeared to have greater impact than emission charges.

Bearing in mind that the comparison has been carried out among charging schemes with greatly different purposes, working mechanisms, operation scales and enforcement measures, some may argue that it is not on the basis of a like-to-like comparison. However, in spite of varying in many major aspects, these pricing policies would all have impacts on logistics firms' bottom line which might lead to changes in their behaviours. The impacts on individual companies targeted by a policy, considered collectively, reflect the effectiveness of the policy in achieving its objective. Therefore, the focus on individual logistics operations has provided a level platform where impacts of various policies on the same individual firms, no matter how much those policies differ from each other, can be compared. It may be simply in accord with common sense to expect that a national pricing scheme would affect more businesses and hence have a greater total impact, and the findings of this survey further suggest that for individual companies which are targeted by all forms of road pricing schemes, the national scheme – based on travel distance, locations, environmental characteristics of the vehicle and time of the day – would also have more profound effects than a congestion charge or low emission charges.

Participants were then asked to identify the features of their logistics operations that are most affected by road pricing. As can be seen from *Figure 4.25*, the most cited category turned out to be the location or scope of the operation, suggesting that the businesses tend to concentrate and react exclusively on the pricing schemes in place. For the same reason, fleet configuration constituted the second 'problematic' area subject to penalty fees charged by road pricing schemes; whilst long haulage distance appeared to be of least concern to logistics operators, as none of the current road pricing schemes in force is related to the distance travelled.

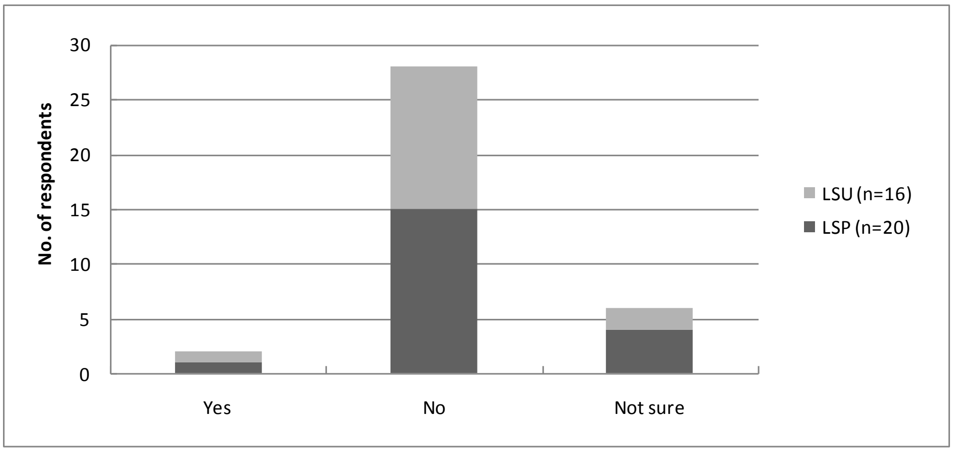
Figure 4.25: Logistics factors most affected by road pricing



Source: author's questionnaire survey, stage 2; N=36 (multiple response)

Apart from the financial implications of road pricing, which result directly in increased transport cost, it may on the other hand benefit shippers and carriers with greater reliability and reductions in journey times in the event that congestion is substantially reduced, which would eventually drive the transport cost down. The companies would only react and change their behaviours when the imbalance of these two forces had reached a certain level that could no longer be accommodated by existing operations. *Figure 4.26* reveals the result of the question seeking businesses' opinions on the balance between benefits and costs of road pricing. Clearly, the vast majority of the responding companies (94%) do not believe, or are not convinced, that the benefits that they are getting from road pricing can justify the burden of the additional cost, indicating the possibility that cost claim winning over benefit claim might be translated into freight transport price in the near future.

Figure 4.26: Do overall benefits from road pricing justify the cost?



Source: author's questionnaire survey, stage 2; N=36

In evaluating how likely the cost claim from road pricing is going to occur in reality, and in which way road pricing is going to change logistics stakeholders' behaviours, the major strategies taken by the respondent companies in response to road pricing have been listed in *Table 4.27*.

Table 4.27: Main strategies in response to road pricing by group

Responding Strategies	LSP (n=20)	LSU (n=16)	Combined
Passing the cost on to customers	9	8	17
Absorbing cost internally	8	5	13
Fleet upgrading	7	5	12
Distribution network restructuring	5	7	12
Improve fuel efficiency	5	4	9
Modal shift	2	4	6
Retiming the trips	1	2	3

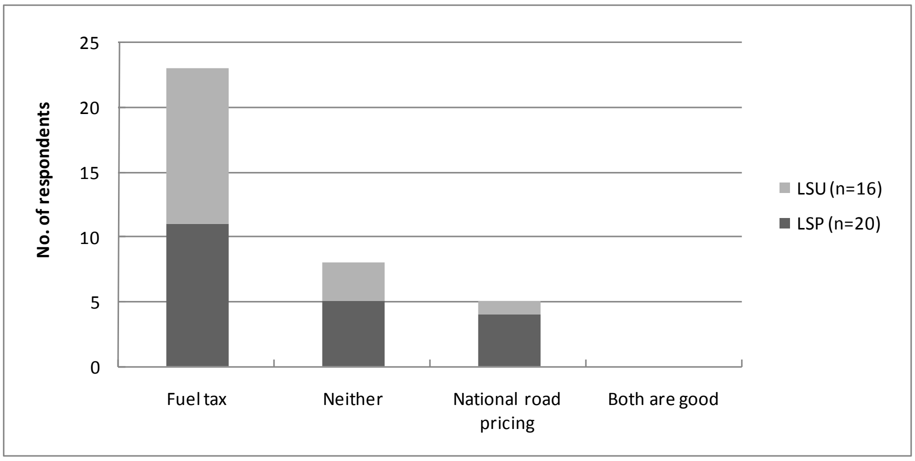
Source: author's questionnaire survey, stage 2; N=36 (multiple response)

Nearly half (47%) of the respondents from both groups said they would pass the costs on to customers, which may have certain effects on freight transport rates in the market. It is beyond the scope of this research to quantify to what extent the impacts of the current road pricing schemes have been reflected in the changes in freight rates, and how much this has changed the total demand for freight traffic. It could be estimated, though, that such changes in road freight rates would be marginal, with a very limited effect on reducing the demand for road freight services, as over one third (36%) of the respondents claimed that they would find ways to absorb the additional cost internally. Fleet upgrading and distribution network restructuring strategies, both opted for by one third of the respondents, indicates the type of logistics strategy-making in which the road pricing is largely factored. It is also noticeable that 17% of the survey sample cited modal shift as one of the strategies that they might take, presenting a promising prospect for alternative transport modes.

As proposed, the national road pricing was designed in place of the fuel duty currently charged at the point of purchase as part of the fuel price, and it was widely expected that it would also replace the vehicle excise duty (VED) if enforced. The implementation of the proposed scheme was suspended at the time of conducting the survey due to technical and administration difficulties. Nevertheless, in the long term it is still necessary to take this option into consideration in policy-making. Both based on the 'polluters pay' principle, national road pricing and fuel taxation were evaluated by the respondents.

As can be seen in *Figure 4.27*, participants in the survey were asked to choose from the policies, or the combination of them, the one that they think is best for developing a sustainable road freight market. The finding reveals that 64% of total respondents consider current fuel taxation policy to be more effective than a new national road pricing scheme, while 22% of them do not support either policy, showing a rather negative attitude and a resistance to fiscal measures in general. The remaining 14% opted for the national road pricing scheme, and no respondent thought the combination of policies to be a good idea.

Figure 4.27: Which policy works better for sustainable transport?



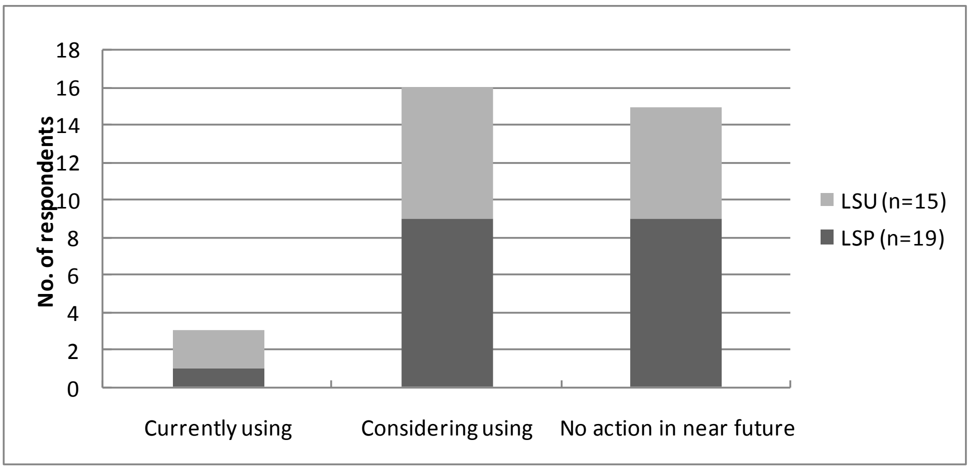
Source: author's questionnaire survey, stage 2; N=36

4.5.7 Alternative Fuels

Among the 25 LSPs and 20 LSUs who had claimed alternative fuels as one of the five most influential sustainable solutions for their logistics operations, 19 and 15 of them, respectively, responded to the second-stage survey. This subsection discusses the issues covered during the survey, primarily about current use and planned future adoption of alternative fuels, proportions of the actual or planned usage, major drivers for and concerns about adopting alternative-fuel-related technology, and general attitudes towards the solution's cost-effectiveness.

Although LSPs had generally shown greater enthusiasm about alternative fuels than the LSUs according to the first-stage survey result (see *Table 4.5*), in practice they seemed to be lagging behind in terms of the percentage of businesses having it in operation - see *Figure 4.28*. Merely one LSP (5%) is currently using alternative fuels as part of their freight transport operations, while 13% of LSUs are taking part in the initiative. This result, however, is subject to a great probability of sampling error due to small sample sizes and the leading status of LSUs in their industries. The number of companies that are not using any alternative fuels at the moment, but are considering switching part of their fuel consumption to alternative ones, is slightly larger than the number of those which do not have plans for adoption in the near future. On the one hand, this signified a potential healthy growth of the emerging technology, although the extent to which it will expand may not be as extensive as it is seen in the figure, given that the whole sample was taken from those who are interested in the technology. On the other hand, whilst acknowledging the great impact of alternative fuel, 44% of the businesses still have no action plan for it, suggesting that the drawbacks of adoption are probably as noteworthy as the advantages.

Figure 4.28: Current practices in alternative fuel by group



Source: author's questionnaire survey, stage 2; N=34

In order to further discover the types of alternative fuels that the businesses' interests lie in and the prospects of their market immersion, the respondents with experiences of using, or plans to use, alternative fuels were asked to specify the particular alternative fuels that they are using or are intending to use, and the percentage of their usage, measured by the percentage of alternative fuel vehicles in the total fleet.

The results are summarised in *Table 4.28*.

Table 4.28: Types and usages of alternative fuels in use / planned to be used

Alternative Fuel	In use (n=3)	In plan (n=16)	Percentage of usage
Biodiesel	2	5	<5%
Natural Gas	0	1	<5%
LPG	1	4	<5%
Electricity - batteries	1	2	<5%
Biogas	1	2	<5%
Pure plant oil	2	4	<5%
Not sure yet	—	6	<5%

Source: author's questionnaire survey, stage 2; N=19 (multiple response)

As can be seen from the table, among the three current users of alternative fuels, a diversified range of fuels are being adopted on a small scale, including biodiesel, LPG (liquefied petroleum gas), electricity (powered by on-board batteries), biogas and PPO (pure plant oil). Two out of three are trying more than one alternative fuel at the same time, with biodiesel and PPO being adopted in both operations. For those who are interested in introducing alternative fuels in the near future, again the interests seemed to spread across the whole range of available choices. Biodiesel and PPO, along with LPG, appeared to be the most popular options compared to the others, indicating a somewhat conservative approach to new technologies. With certain modifications to the existing fleet, these fuels can be used on the vehicles, providing environmental benefits such as reduced CO_2 emissions from well to wheel, less pollution when spilt (biodiesel and PPO), eliminated particulate emissions and reduced nitrous oxide emission (LPG), at relatively low initial and maintenance costs. In contrast, requiring bigger modifications or purpose-built vehicles, the initial investment in adaptation to natural gas, biogas or electricity is much higher. The low public availability of the fuels also adds to the limitation of operation, which might have contributed to their lower acceptance as observed from this survey.

Without exception, all the current and planned future adoptions of alternative fuels are small-scale trials which account for less than 5% of total fuel consumption.

Apparently, the increasing application in the future will largely depend on the results of these trials, especially in terms of their financial and environmental performance, as well as the development of fuel-related technologies and infrastructures.

Nearly every alternative fuel available for commercial vehicles has its pros and cons, which are largely factored into businesses' decisions on its application. *Table 4.29* and *Table 4.30* summarise the results of the survey questions exploring the main factors that encourage the businesses to adopt / consider adopting alternative fuels, and the major concerns of those who would rather wait for further development before committed to it.

Table 4.29: Main drivers of adoption of alternative fuels by group

Drivers	LSP (n=19)	LSU (n=15)	Combined
Environmental benefits	15	12	27
Increasing diesel fuel cost	11	6	17
Road pricing	7	7	14
Fuel duty incentives	8	6	14
Lower operating cost	8	5	13
Corporate image	7	4	11
Regulations	4	1	5

Source: author's questionnaire survey, stage 2; N=34 (multiple response)

As shown in *Table 4.29*, the environmental credentials of alternative fuels appeared to be the most cited reasons from both groups. Compared with the incentives for adoption of other solutions, there is a more apparent linkage here between companies' behaviours and the rationales based on environmental performance. However, by no means can it be regarded as the only determinant factor in the success of alternative fuels, given that the following four most frequently quoted reasons are all cost related. The ever-increasing price of diesel fuel has been cited by half of the respondents as one of the main reasons for seeking alternative fuels. Although the production costs of many alternative fuels are not necessarily lower than those for diesel fuel at present, cost savings can be achieved through *tax incentives* (i.e. reduction on fuel duty and VED) and *exemption from local road pricing schemes*, which are both quoted by 41% of respondents. Lower operating costs, including lower vehicle maintenance cost and running cost (e.g. electric vans), cited by 38% of respondents, also add to the financial benefits of switching to sustainable fuels. Nearly one third of the respondents believed that through demonstrating their commitment to renewable and environmentally friendly fuels and technologies, their corporate images would also benefit from good publicity. Regulations, primarily RTFO (the Renewable Transport Fuel Obligation), appeared to have limited impact on businesses' decisions on alternative fuels.

Table 4.30: Main disincentives to using alternative fuels by group

Disincentives	LSP (n=19)	LSU (n=15)	Combined
Availability	11	12	23
Vehicle modification / fleet upgrading	10	5	15
Maintenance cost	8	7	15
Inconvenience	7	7	14
Vehicle performance	7	6	13
Higher fuel consumption	6	5	11
High alternative fuel price	5	3	8

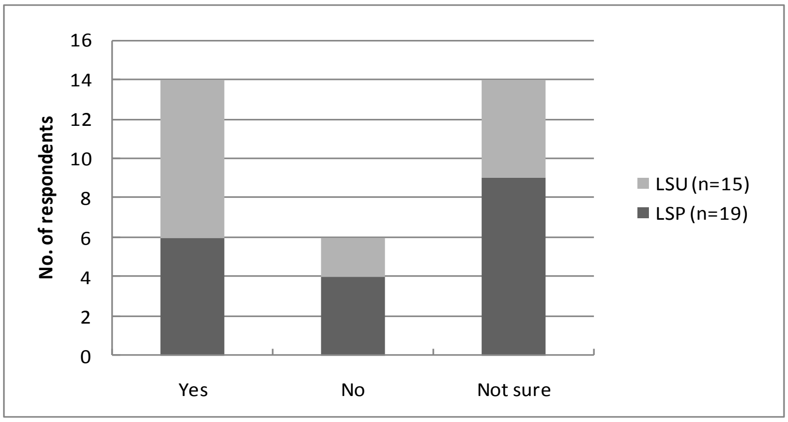
Source: author's questionnaire survey, stage 2; N=34 (multiple response)

Looking into the main reasons that put companies off from adopting alternative fuels, *availability* seemed to be the most common obstacle for both LSPs and LSUs. Bearing in mind that there are various forms of alternative fuels under discussion, the problems in availability cover the availability of alternative fuels, the infrastructure (e.g. battery charging points and fuel refilling networks), and alternative fuel vehicles. The initial set-up costs, resulting mainly from essential vehicle modifications or the purchase of purpose-built vehicles, together with maintenance costs, turned out to be another major deterrent for businesses. Responses on the remaining disincentives are fairly evenly distributed, including the inconvenience of operating an alternative fleet (e.g. limited travelling distance and 'return-to-base' for refill), vehicle performance (e.g. lower payload, range and speed), higher fuel consumption and higher fuel price.

In summary, operational and financial viability constitute the major concerns of businesses regarding converting to alternative fuels.

In evaluating the cost-effectiveness of alternative fuels, a mix of opinions, as can be seen in *Figure 4.29*, were collected from the respondents, showing a lack of agreement in general attitude. Equal numbers of respondents (41%) expressed opposite views on alternative fuels' cost-effectiveness, with the remaining 18% taking a neutral position. The high level of disagreement on this matter, while possibly a combined result arising partly from the questionable environmental benefits of certain alternative fuels and partly from the slow progress and limited scope of commercially viable development in fuel technologies and infrastructures, certainly indicates the amount of effort needed to promote the solution among logistics operations.

Figure 4.29: Do the overall benefits of alternative fuel outweigh its cost?



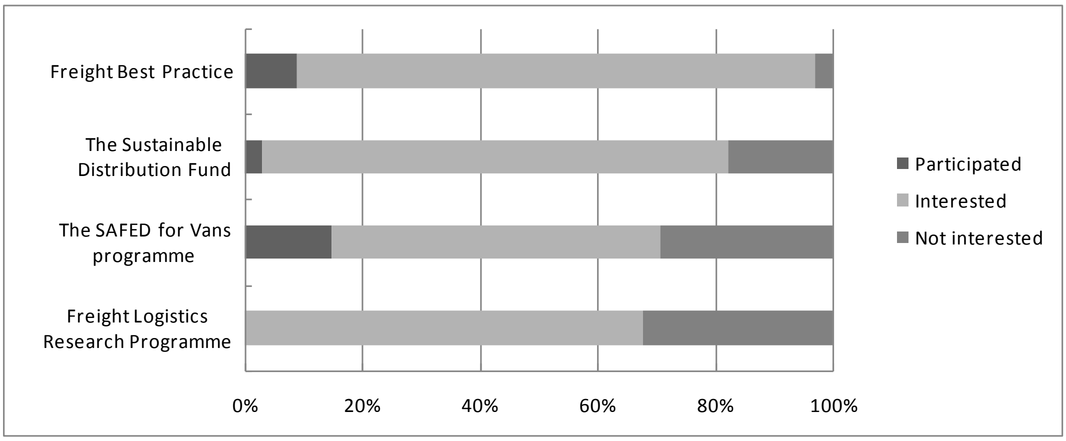
Source: author's questionnaire survey, stage 2; N=34

4.5.8 Government Support

The first-stage survey findings revealed that in total, 43% of the respondents identified government support as one of the five sustainable solutions with the greatest impact on their logistics operations. The proportion from the LSUs group

(51%) is considerably higher than that from the LSPs group (35%), suggesting potentially more active interconnections between large stakeholders in the industry and government authorities. Of these respondents, 14 LSPs and 20 LSUs took part in the second stage of the survey, which focused mainly on the specific forms of government support, the major benefits that businesses are expecting from such programmes, and obstacles that are holding them back from getting involved. The general attitudes of businesses towards government support – including current provision of the support, effectiveness, and expectations of and interest in the type and level of support – were also sought at the stage. *Figure 4.30* shows the responses received regarding a selection of wide-scale sustainable logistics programmes rolled out in recent years, specifying whether the businesses have participated, are interested in, or are not particularly interested in the type of programmes in question.

Figure 4.30: Participation and interest in government-initiated programmes for sustainable logistics operation



Source: author's questionnaire survey, stage 2; N=34

Generally, it would appear that the businesses which have actually participated in any form of government supportive schemes remain a minority, which is in clear contrast with the level of interest shown in these programmes. The list of four government-initiated programmes in support of sustainable logistics represents different roles that the government could play, including guidance and advice

(Freight Best Practice), training skills and sharing expertise (the 'SAFED for Vans' programme), funding and establishing other finance mechanism (the Sustainable Distribution Fund), and development and research in sustainable operations, technologies and infrastructures (the freight logistics research programme). The survey results indicate a relatively higher level of interest in the advice and guidance services provided by government authorities, followed closely by funding and granting facilities. Training and research, although less popular with businesses, also received more responses of interest than not – a by-and-large welcome gesture from the industry in response to a diverse range of government support.

To further investigate the most valued aspects of government support by industrial members, the question was raised to respondents about the benefits they are anticipating from government support programmes. The responses are summarised in *Table 4.31*.

Table 4.31: Expected benefits from government support programmes by group

Expected Benefit	LSP (n=14)	LSU (n=20)	Combined
Financial support	9	15	24
Information and advice	10	13	23
Infrastucture development & improvement	6	11	17
Operation efficiency improvement	8	7	15
Partnership with authorities	4	8	12
Cost reduction	5	6	11
New market opportunity	3	3	6
Corporate image/certificate	2	3	5
Technical support	1	2	3

Source: author's questionnaire survey, stage 2; N=34 (multiple response)

Reaffirming the results from interested programmes, financial support (with 71% of respondents citing it) and information and advice services (68%) topped the rank. Infrastructure development and improvement, along with operational efficiency enhancement, were cited by around half of the respondents, reflecting the expectations of both better external operational environments (e.g. greater capacity of various freight transport modes) and improved internal operational performances. The third batch of frequently quoted benefits, including partnership with local governments, cost reduction and new market opportunities, has a common implication for profitability. Businesses may benefit from partnership with local authorities in different ways, ranging from access to certain urban areas and delivery facilities to influencing the review of operating restrictions and related policies. More importantly, well-established partnership implies business opportunities, as local authorities are increasingly outsourcing freight-related services to professional operators in private sectors. Improvements in corporate image and technical support, only raised by a few respondents as expected benefits, are thus not considered to be major value-adding facets of government support.

Disregarding all the potential benefits of government support, the fact is that the vast majority of companies are still left out of the programmes that are aimed at promoting sustainable logistics practices, which has substantially hampered the overall effectiveness of such initiatives industry-wide. To tackle the problem it is essential to identify the main obstacles which prevent businesses from participating in the support schemes provided by government; the results from the survey are shown in *Table 4.32*.

Table 4.32: Obstacles to participating in government support programmes by group

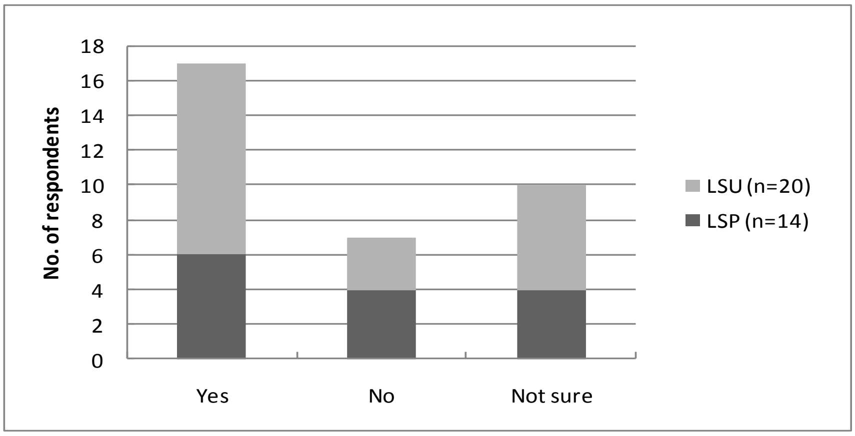
Obstacle	LSP (n=14)	LSU (n=20)	Combined
Lack of prospective returns	8	12	20
Lack of information	9	7	16
Limited resources	6	7	13
Extra cost	6	3	9
Complexity of application procedures	5	3	8
Transparency of decision making	2	4	6
None	1	1	2

Source: author's questionnaire survey, stage 2; N=34 (multiple response)

Interestingly, lack of prospective returns was cited by most respondents as the reason that restrained them from taking part in government support programmes, which seems to conflict with the great interest that they had shown in the concept earlier. A plausible explanation could be the disparate views of businesses between what is expected from government support and what is perceived to be actually achieved by current programmes. Lack of information about the available support and services offered by governments, lack of resources enabling them to get involved and take full advantage of the programmes, and the extra costs entailed were also frequently quoted by the respondents as other main barriers to involvement. The framework and processes of the support schemes constitute another obstacle, with 24% of respondents quoting complexity of application procedures, and 18% complaining about transparency of decision making on the granting of support. Only one LSP and one LSU claimed that they had not found that the above problems hindered their participation in the programmes, either as current or former participators.

To measure the actual or perceived benefits that business could obtain from government support against all the cost, resources and commitment required from participation, respondents were asked to evaluate the worthiness of taking part in the government support programmes. As can be seen from *Figure 4.31*, 50% of the respondents held positive views on the issue, believing that their businesses would be better off participating in government sustainability projects. Possibly due to the variety of programmes available at present, over a quarter of respondents found difficulties in making a judgement on the cost/benefit comparison; while seven respondents reckoned that the cost might not be justified if they took part in the current projects.

Figure 4.31: Do overall benefits from participating in a government support programme outweigh the cost?



Source: author's questionnaire survey, stage 2; N=34

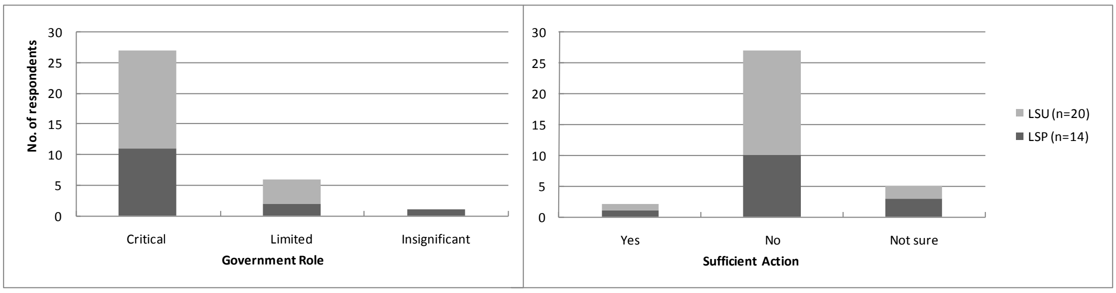
Complementary to the previous questions posed about specific aspects of government support, both on the forms of the support and the particular benefits of and obstacles to taking part, the survey went on to gain further insight into companies' opinions on:

a) How important a role should government play in sustainable logistics?

b) Is government (central and local) doing enough to support sustainable logistics?

It should be noted that the results from the questions above may not be independent, since, for example, the respondents who believe that the government should play only a limited role in sustainable practices of the industry would tend to think that the governments have acted sufficiently, or even more than enough, in their roles of intervention. Based on this consideration, the results from both questions are placed in parallel for comparison – see *Figure 4.32*.

Figure 4.32: Government roles vs adequacy of actions in sustainable logistics by group



Source: author's questionnaire survey, stage 2; N=34

It is apparent that most businesses (nearly 80%) agreed on a critical role that governments should play in sustainable logistics. Another 18% thought a limited role more appropriate, with the remaining 3% preferring an insignificant role. Accordingly, from the second chart, 79% of the respondents did not think that governments have taken sufficient actions in their roles in sustainability, whereas 6% held the opposite opinion, leaving 15% 'not sure' about the adequacy of the government interventions.

To conclude, the survey results on government support revealed that the businesses are generally of the opinion that governments should take the lead in sustainable practice in the logistics industry. The main approaches which received a large amount of interest are information and advice provision, funding schemes, training services, and technology and infrastructure development. Although a lack of assurance about the returns from taking part in the government programmes, together with complexity, uncertainty and ambiguity as commonly perceived characteristics of the procedures, constitute the main obstructions that discourage businesses from participating, overall the benefits of government support are still perceived to outweigh the costs. Apart from increasing publicity and transparency of the government-initiated programmes and simplifying the procedures, the emphasis of improvement should also be placed on broadening the scope of the existing programmes to accommodate the needs of more companies who are interested in taking part, as well as devising more programmes tailored for different businesses' needs.

4.5.9 Environmental Management Systems (EMS)

Out of the 14 sustainable solutions proposed for consideration, environmental management systems (EMS) was ranked the ninth and tenth respectively by LSPs and LSUs in terms of the impact on their logistics operations (see *Table 4.5*). Of the 15 LSPs and 13 LSUs who identified EMS as a solution of great impact, ten LSPs and nine LSUs responded to the second-stage survey which aims to characterise the state of corporate environmental management practice.

As managerial structure and process are indicative of the state of business environmental strategy and activity, evidence was collected from the respondent companies concerning how they are managing their environmental impacts. *Table 4.33* reveals the prevalence and nature of systems and processes that companies have adopted in managing environmental issues.

Table 4.33: Environmental management practices by group

Environmental Management Practice	LSP (n=10)	LSU (n=9)	Combined
ISO 14001	3	6	9
The EU Eco-Management and Audit Scheme (EMAS)	0	2	2
Formal sustainable/environment policy	2	2	4
Informal sustainable/environment policy	2	0	2
Internal Environmental Auditing	1	1	2
External Environmental Auditing	0	0	0
None	2	0	2

Source: author's questionnaire survey, stage 2; N=19 (multiple response)

Looking across the sample, 58% of the respondents have formalised, systematic environmental management policies and procedures in place, such as ISO 14001 or EMAS (the EU's Eco-Management and Audit Scheme), audited and certified by independent accreditation bodies. To a lesser extent of commitment and engagement, around 21% of sample companies have formal environment policies, while another 11% have informal ones as general guidance for their operations in environmental aspects. In broad terms, these figures present a fairly encouraging state of businesses' environmental management practices, with most participating companies seemingly fully aware of and responsive to addressing their environmental impacts. However, a closer examination into the substantial variations between the LSPs and LSUs groups reveals that this behaviour pattern is mainly attributable to the much higher proportion of uptake among LSUs. Nearly 90% of responding LSUs have either certified EMSs or formal environmental policies in place, while the proportion for the

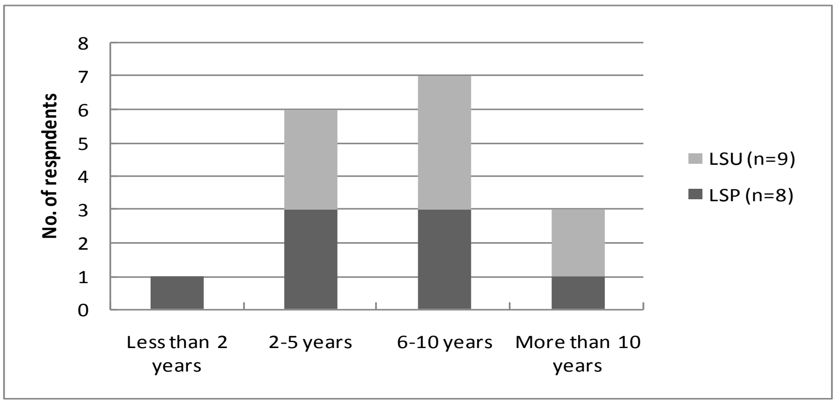
LSPs group is merely 50%.

The difference between logistics groups is also evident in environmental auditing procedures. Apart from those companies with ISO 14001 certifications or EMAS registrations which entail external auditing processes, one third of the LSUs have internal auditing procedures for monitoring the environmental performance of their operations, while only 14% of the LSPs have engaged in such processes. Overall, that leaves 60% of LSPs and 22% of LSUs with no environmental auditing of any sort in their operations. Incorporating the evidence from above, it seems that LSPs are lagging behind LSUs in environmental management practice.

However, the observed divide between the groups is likely a result of a mixture of factors including firm size and industry sector. All LSU respondents, for instance, are operating a fleet of over 200 vehicles, representing large businesses in the selected vertical sectors; the fleet sizes of respondent LSPs, on the other hand, vary from 50 to above 200, hence representing a more diversified sample in terms of operational scale. The findings suggest an increasing tendency for larger companies to undertake environmental management activities.

The extent and state of the businesses' environmental management practice can also be reflected by indicators other than the types and nature of procedures being adopted, such as the time horizons of the environmental management, and the number of staff dedicated to environmental management. *Figure 4.33* demonstrates the responses received regarding the length of their environmental management practices. Two LSPs with no environmental management activities have been excluded from the result.

Figure 4.33: Time length of environmental management practice by group

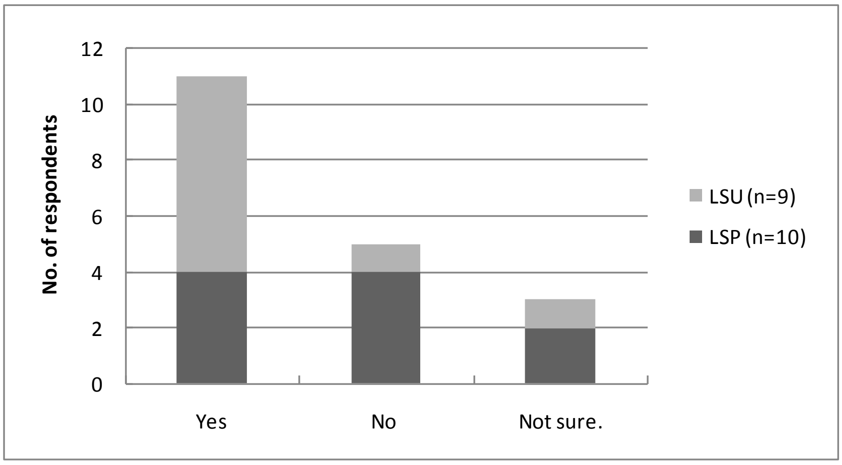


Source: author’s questionnaire survey, stage 2; N=17

As shown in the figure, 41% of respondent companies have had their environmental management strategies and activities in place for between six and ten years, while 35% have had such an establishment for between two and five years. Those who have been undertaking efforts in the area for more than ten years represent 18% of respondents; while the company who has taken action in the past two years only accounts for 6% of the sample. Although it appeared that the LSUs tend to have longer period of engagement in environmental management, this variation detected between groups from the small samples is by no means sufficiently substantial to enable the drawing of generalised conclusions.

In attempt to keep the questionnaire manageable as a task for respondents to complete and minimise the inaccuracy incurred by estimation, lack of information or obscure role specification, participants were asked to provide information on whether or not their companies have dedicated personnel in the role of environmental management or equivalent, rather than on the actual number of staff in such roles. *Figure 4.34* reveals the pattern of the environmental commitment in terms of designated human resources.

Figure 4.34: Dedicated personnel in environmental management by group



Source: author's questionnaire survey, stage 2; N=19

The observations seem encouraging considering that more respondents (58%) claimed to have employees dedicated to the environmental management role within the businesses than those without (26%). The remainder (16%) claimed no knowledge on the issue, to some extent suggesting a diluted presence of the environmental managing activities, at least in the respondents' operations.

Table 4.34 reports the main reasons cited by respondents as motivations for undertaking environmental management practices. Apart from the obvious *environmental benefit* which is set as the direct objective of most EMSs, the most cited drivers of businesses' environmental responsiveness fall into the broad category of economically driven motivation. This group of responses is mainly associated with cost reduction, gaining a competitive advantage and achieving operational efficiency. *Cost reduction*, cited by 53% of respondents and achieved primarily through minimising of waste and energy consumption, has increasingly important economic implications in a context where energy costs, especially fuel prices and carbon prices, have been continuously rising. Selected by 47% of respondents, *competitive advantages* can be achieved through benchmarking with competitors' actions and gaining leadership in innovation, relationship with society and sustainable development. Of the respondents, 42% identified *operational efficiency*, which is generally realised through input reduction and enhanced resource utilisation. Directly or indirectly, all the three most frequently cited drivers can be translated into businesses' bottom-line performance, indicating that most surveyed companies are still operating with a primarily economic mindset.

Table 4.34: Motivations for environmental management by group

Motivations	LSP (n=10)	LSU (n=9)	Combined
Cost reduction	7	3	10
Environmental benefit	5	5	10
Competitive advantage	4	5	9
Operational efficiency	5	3	8
Risk reduction	4	4	8
Improve corporate image	3	4	7
Commercial opportunities/incentives	4	2	6
Public relationship with stakeholder	2	3	5
Comply with environmental regulations	2	3	5

Source: author's questionnaire survey, stage 2; N=19 (multiple response)

As another economic driver for EMS, c*ommercial opportunities or incentives* received responses from nearly one third of the respondents, being ranked only slightly higher than stakeholder pressures and compliance with laws. This suggests that the businesses have less vision of increasing profitability from environmental management, either through revenue opportunities such as competitive products and services and increased market shares, or economic incentives such as tax breaks, interest-free loans and emissions trading schemes.

Other commonly cited motivations include risk reduction (quoted by 42% of respondents), corporate image improvement (37%), public relationship with stakeholders (26%) and compliance with environmental regulations (26%). It would appear that socially driven forces have greater weight in businesses' environmental responsiveness than legislative instruments, reflecting the voluntary-based market-driven approaches adopted by British government and regulatory bodies rather than a more stringent 'command and control' approach (see Section 2.5.3.4).

Of same importance in exploring major factors that motivate businesses to commit to environmental management is the gaining of better understanding of the practical difficulties encountered by the businesses in establishing and developing an effective EMS. This helps to identify the reasons that EMSs are generally not prevalent among logistics operations, so that policies can be devised to promote the uptake of them when needed. *Table 4.35* describes the survey results for this issue.

Table 4.35: Difficulties in establishing environmental management systems by group

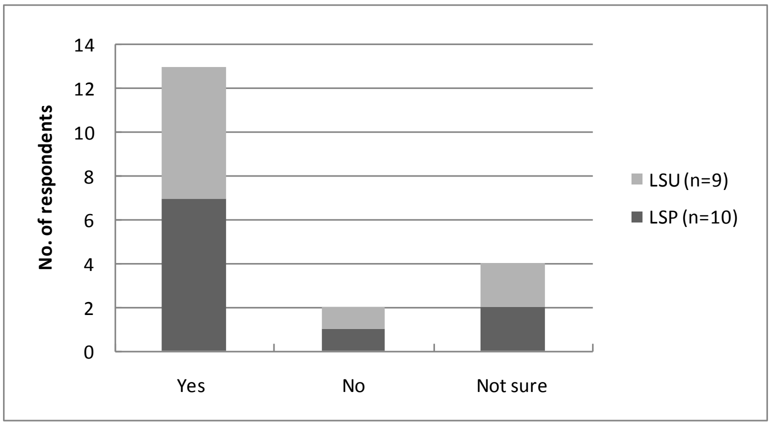
Disincentives	LSP (n=10)	LSU (n=9)	Combined
Complexity of implementation	6	8	14
Lack of return on investment	5	7	12
High cost	6	5	11
Lack of information/expertise	5	5	10
Lack of resources	6	2	8
Lack of consumer' recognition	2	0	2

Source: author's questionnaire survey, stage 2; N=19 (multiple response)

As shown in the table above, the responses from the LSPs are distributed fairly evenly across the range of disincentives except *lack of consumers' acknowledgement*, which received no responses from the LSUs group. It seems that for businesses, customers' recognition of the company's environmental commitment functions more as a market incentive than an issue of concern when absent. Compared with LSPs, LSUs appeared to have fewer problems with limitation of available resources for establishing EMS, while they are more concerned with the complexity of implementation and lack of returns from such systems. The complexity of implementing an EMS across an organisation varies depending on whether an in-house approach is adopted or external validation is required, and so do the total costs incurred. In the case of ISO 14001 certification or EMAS registration, conformance and compliance to a series of exhaustive, detailed and complex formal standards involves a large amount of administration, consulting and auditing activities, and is not only apt to give the impression of bureaucracy to businesses but also exerts extra burdens on limited business resources.

To justify the difficulties associated with the complicated proceduralisation processes of EMS, businesses need to see an economic rate of return, either financially or yielded through efficiency gains and waste reduction, which can be intangible and hard to measure. Providing insight into businesses' attitudes towards EMS based on their judgements as to its cost-effectiveness, *Figure 4.35* illustrates the distribution of responses on whether the benefits of EMS can justify the overall costs.

Figure 4.35: Do the overall benefits of EMS outweigh its cost?



Source: author's questionnaire survey, stage 2; N=19

In all, 68% of respondents had positive views on the cost-effectiveness of EMS, while only 11% gave negative opinions. Much as this may seem to be an encouraging indication, when one bears in mind the fact that the sample was drawn from the businesses who had evaluated EMS highly among other sustainable solutions at the first stage, it becomes clear that the true picture for the whole population in the industry is likely to be much less optimistic. Noting that a considerable proportion (21%) of respondents from the sample could not give an explicit answer comparing the benefits and costs of EMS, much work still needs to be done in order to engage more of the hesitating businesses in environmental management.

4.6 Summary

This chapter has presented and analysed the results of the two-stage questionnaire survey, revealing the perceived impacts of the 14 pre-established sustainable logistics solutions by logistics operators and users. Key issues surrounding each of the first nine solutions with greatest impacts on the respondents, including driving forces moving businesses to engage in the sustainable practice in question and the main barriers dissuading them; their current practice and future plans for adoption; the cost-effectiveness of the solution; and strategies in response to the enforcement of certain sustainable policies and regulations, have then been explored and discussed. The survey results and analyses for the remaining five solutions of less priority are presented in *Appendix Seven* for further reference.

Overall, the LSPs and LSUs appeared to have similar opinions regarding the impacts of most sustainable solutions. However, their attitudes and behaviours varied considerably when it came to certain solutions; this calls for further investigation in the rationale behind the observations, along with other issues that could not be addressed solely through quantitative methods. The abundant evidence collected in this phase, therefore, is built upon throughout the discussions in the remaining chapters, and further developed with other qualitative evidence gathered during the in-depth interviews and illustrative case studies. The next chapter will focus on the testing of the nine hypotheses established in Chapter Three, thus helping to achieve the key objective of this research.

CHAPTER FIVE: DECODING THE PHENOMENON – CAUSATION AND IMPLEMENTATION

5.1 Introduction

The previous chapter presented the analysis of the questionnaire survey and the findings concerning general attitude, behaviour patterns and trends within the logistics industry. Building upon the quantitative evidence, the intention of this chapter is to address the overall objective of this research through testing the nine hypotheses developed in Chapter Three. Qualitative evidence from the interviews undertaken with a sample of 56 companies is incorporated and combined with the survey findings to provide a more thorough and comprehensive view of the phenomenon under examination within each hypothesis.

Starting with an overview of the company interview results, the chapter carries on following the framework of research hypotheses in three themes, with the focus being on association, interactions, and cause and effect respectively. Specialised logistics segments are dealt with separately in Section 5.4 before the conclusion of this chapter. Throughout the hypothesis testing, reference is made to the relevant sections in the previous chapters to avoid repetition.

5.2 Overview of In-Depth Company Interviews

The methodological approach of the in-depth interview was discussed in Section 3.5.3. This section provides an overview of the constitution and classification of the interviewee companies, along with the key outcomes of the interview process.

Out of the nine hypotheses under examination, three of them are concerned with identifying major attributes of logistics operation which are likely to be factored into companies' sustainable behaviours. Testing these hypotheses requires comparative analyses to be conducted between various groups, which in turn necessitates appropriate categorisation. Based on the hypotheses of association, the main attributes of the businesses – including operational scale, industrial sector and geographic sphere – suggest themselves as suitable criteria for classification.

Table 3.8 in Chapter Three summarised the numbers of the interviewee companies by vertical industrial sector, with breakdown details by interviewee incorporated in *Appendix Eight*. It can be seen from the table that food, drink & tobacco appeared to be the sector with the biggest number of interviewee companies in the sample, followed by the sectors FMCG and industrial. The uneven distribution of the number of companies across sectors seemed to be mainly attributable to the large variation within LSPs group, with the numbers of LSU interviews varying little between different sectors. Although it was anticipated that the LSPs would show more diversity in the industry sectors in which they are operating, due to the nature of their business and the sampling technique employed, the outcome still explicitly highlights the sectors with greater implications in the overall logistics market in terms of the number of specialist logistics operators involved.

As to operational scale, the size of the goods vehicle fleet serving the company's logistics needs has been identified as the closest approximation to its measurement, and utilised throughout the survey. Consistency has been maintained by applying the same grouping standards when differentiating the interviewee companies. The response patterns from the interviews, presented as percentages, are compiled in *Table 5.1* in parallel with those from the previous survey, for comparison purposes.

Table 5.1: Sample classification by fleet size – interview versus survey results

	Fleet size	LSP (n=23)	LSU (n=33)	Total (N=56)
Interview	**Less than 20 vehicles**	35%	15%	*23%*
	20 ~ 49 vehicles	9%	12%	*11%*
	50 ~ 99 vehicles	13%	9%	*11%*
	100 ~ 199 vehicles	13%	27%	*21%*
	200 vehicles and above	30%	36%	*34%*
Survey	**Fleet size**	**LSP (n=68)**	**LSU (n=60)**	**Total (N=128)**
	Less than 20 vehicles	38%	11%	*26%*
	20 ~ 49 vehicles	19%	15%	*17%*
	50 ~ 99 vehicles	12%	11%	*12%*
	100 ~ 199 vehicles	10%	27%	*19%*
	200 vehicles and above	21%	32%	*27%*

Source: author's interviews and questionnaire survey (stage 1)

Overall, the constitution of interviewee companies in terms of business scale did not display distinct variations from that of the questionnaire survey, although the share of the companies in the middle range with 20 to 99 vehicles in operation seemed to have slightly decreased in the interviews. Similar patterns were observed in both LSPs and LSUs groups, with a tendency towards a convergence of companies on both ends of the operational scale when the presence of the medium-sized businesses was marginally diluted in the interview sample. Since this shift between groups of various fleet sizes was on a statistically insignificant scale, and was in the direction that in essence reinforces the industry structure in reality, with an overwhelming majority of operators being very small and a few big players having a substantial market share, the outcome is deemed to be satisfactory and in support of the further analysis of the interview evidences.

In the same fashion, the categorisation by geographic scope of the interviewee companies is presented in *Table 5.2* alongside a comparison with the survey results. Again, in a manner resembling the patterns observed in the previous survey, the distribution of the interviewees with various geographic spreads has concentrated on the national and international categories. Companies operating at the local/regional scale appeared to be under-represented in the sample of interviewees in both LSPs and LSUs groups compared with the proportions in the survey sample, signifying the lower willingness of smaller companies to take part in the interviews. However, the variation is not significant; moreover, it is not regarded as a major issue, since a considerable number of companies operating in a broader scope also undertake their logistics activities in local areas.

Table 5.2: Sample classification by geographic scope – interview versus survey results

	Geographic Scope	LSP (n=23)	LSU (n=33)	Total (N=56)
Interview	**Local/Regional**	4%	0%	2%
	National	43%	42%	43%
	International	52%	58%	55%
Survey	**Geographic Scope**	**LSP (n=68)**	**LSU (n=62)**	**Total (N=130)**
	Local/Regional	9%	5%	7%
	National	46%	42%	44%
	International	46%	53%	49%

Source: author's interviews and questionnaire survey (stage 1)

The constitution of the interviewee companies with at least part of their logistics operations carried out within the alternative/specialised logistics segments is mapped in *Table 5.3*. This provides an overview of the usage of alternative transport modes across the sample of interviewees. Although, as observed from the survey outcomes, it would appear that deep sea shipping and air freight are being more widely adopted by the interviewees, it was revealed during the interviews that the vast majority of the freight moved by these two modes was for international shipment. When the domestic market is examined, intermodal together with rail freight turned out to be the leading alternative modes with the largest user bases. Nevertheless, it was also discovered in the interviews that when the domestic market is considered in isolation, most companies involved in alternative freight modes are only using them for a negligible proportion of their total freight volumes. This is particularly the case for intermodal, where the estimates of the percentage of freight moved given by the interviewees are below 10%, without exception. This coincides with the latest figures published by DfT (2009a) which show that rail freight was commanding 10.67% of the land-based freight market in goods moved, and 5.68% in goods lifted.

Table 5.3: Coverage of specialist logistics service sectors in interviews

Logistics Segment	LSP (n=11)	LSU (n=16)	Total (N=27)
Rail	4	3	7
Shipping	8	11	19
Air	6	7	13
Inlandwater	2	0	2
Intermodal	3	5	8
Courier	3	3	6

Source: author's interviews (multiple response)

Issues of express service as a specialist logistics operation, together with the sustainable practices distinctively related to alternative freight activities, as listed in *Table 5.3*, will be specifically addressed under Section 5.4. The discussion is kept brief due to their minor market shares and the limited scope of their sustainable experiences, but it certainly helps to provide a comprehensive view into the current state of the overall logistics industry. Trivial though they may be in terms of freight volumes at present, they may have a far more important role to play in the future in decarbonising the logistics industry as a whole.

During the interview process, it was also found feasible to group certain companies with comparable features pertaining to some attributes of their business and supply chain for further interrogation into their attitudes and behaviour patterns. On the basis of the interview transcripts, the interviewee companies were identified and matched with each other when operating in the same industrial sector with the same logistics roles (i.e. LSPs or LSUs), and conducting similar logistics functions within the supply chains at equivalent operational scales. *Table 5.4* summarises 18 such groups identified in a selection of sectors. Due to the anonymity promised to the interviewees, the companies are coded by their logistics roles (the code being P for LSPs or U for LSUs, followed by a unique number within the group).

Table 5.4: Matched interviewee companies by industrial sector

Industrial Sector	LSPs		LSUs	
FDT	P1,P7,P12	P4,P5	U10,U13,U19	
Retail	P2,P8,P9		U6,U14,U21	U17,U19
Chemical	P1,P10,P12		U22,U25	U7,U11,U24
Automobile	P13,P16		U26,U28	
FMCG	P2,P3,P21	P12,P16	U2,U6,U12,U14	
Industrial	P12,P16	P10,P20	U1,U29	U4,U30

Source: author's interviews

As can be seen from the table, altogether 45 instances with 18 groupings were identified as being clustered with other companies in the sample. These small groups have up to four peer operations in the sector engaged in similar logistics activities, providing a great scope for probing into the similarities or variations in their sustainable behaviours. All the six focus sectors have been covered with the groupings, while the interviewees in other sectors such as IT, healthcare and courier have their unique characteristics, and hence are not able to form any cluster in this sense. Given the limited number of companies in those sectors, however, it is probably best to have a diverse sample representing different types of business so that critical issues of concern within each can be highlighted, rather than having a group of the same sort providing information which could not be generalised anyway. As will become clear in Section 5.3.3 when Hypothesis Eight is examined, these groups/clusters play an important role in illustrating the complexity faced by companies in making sustainable strategies and movements.

In addition to the overviews provided in this section, a comprehensive matrix was compiled from the transcribed interviews, presenting a summary of the information provided by each of the interviewees. This is attached as *Appendix Eight* to this thesis. Highlighting the key points raised in the interviews, the matrix also functions as a reference to enable a quick grasp of the main features and key issues relating to the companies and their positions in sustainable logistics. The additional qualitative, insightful details provided by some interviewees that were impossible to show in the matrix will be incorporated throughout the hypothesis analysis in the next section.

5.3 Hypothesis Testing and Analysis

This section is dedicated to testing the nine hypotheses constructed in Chapter Three, and is divided into three subsections, each addressing three of the hypotheses. The first set of hypotheses is concerned with the potential associations that might exist between certain features of logistics operations and sustainable logistics practice. Hypotheses Four to Six are dealt with in Section 5.3.2 and focus mainly on revealing the interrelationships amongst particular sustainable solutions and between key actors within the industry. The last series of hypotheses concentrates primarily on discovering the explanatory factors for the observed attitude and behaviour patterns that are more complex in nature and are subject to the unique circumstances of individual companies or sectors; this series therefore relies heavily upon the in-depth evidence acquired from the interviews. In combination, testing the nine hypotheses provides the evidence needed to satisfy the research objectives, which aim at identifying the most effective sustainable packages for British logistics industry and the most efficient way to implement them.

5.3.1 Sustainable Conduct and the Role Players: Associations

Hypotheses One to Three are examined in turn in this subsection in an attempt to gain a better knowledge of associations between key operational features and sustainable conduct, in particular whether the companies with different attributes, i.e. operational scale, vertical sector and geographic scope of logistics operation, are behaving differently. When a linkage is identified, how and to what extent it tends to affect the businesses is further explored.

Hypothesis One: Sustainable logistics practices vary by business size.

The constitution of the survey respondent companies by goods vehicle fleet size has been analysed in Section 4.2, with the overview of the interviewee companies presented in Section 5.2. As already argued, there is little point directly comparing the LSPs and LSUs groups in terms of their response patterns to sustainability issues on the basis of either the survey or interview outcomes, due to the different sampling techniques applied to each group. However, it is possible to interpret their responses separately by business scale within the group, and conduct a comparative analysis on the response patterns that emerged in the earlier survey and subsequent interviews. This method of analysis not only screens out the interference arising from different logistics roles, as one of the potential contributory factors affecting businesses' responses, but also allows variations between industry sectors to be highlighted, which provides the foundation for testing Hypothesis Two.

On the supply side, as displayed in *Figure 4.4*, 57% of the survey respondents who were LSPs were small operators with less than 50 goods vehicles in service, while big operators running at least 100 vehicles accounted for 31% of the group. Since there are no official statistics available on the constitution of specialist logistics service providers in the UK by operational scale, VOSA has been identified as a source of reliable data providing information closest to what is required in this research. At aggregate level, without differentiating operations run for private or in-house purposes from those for commercial purposes, over 99% of the operators in the UK were reportedly managing no more than 50 vehicles in the year 2008/09 (see *Table 4.3*). Given all the factors discussed in Section 4.2 that might have contributed to the gap between the survey sample obtained and the population figure approximated by VOSA statistics, the magnitude of the disparity still indicates that there might be other major influences that have resulted in the apparent congregation of large operators that appeared in the survey sample.

To maximise the utilisation of limited space in the survey questionnaire, care was taken to avoid adopting obvious questions that would lead to predictable answers; for instance, asking the respondents whether they perceive sustainable logistics as a matter of importance. Nevertheless, the importance of sustainability as valued by the recipients of the survey questionnaire would certainly have affected to a great extent their decisions as to whether to participate in this research or not. Even after taking into account factors that might have played a critical part in the recipients' decisions on participation for individual cases (such as unsuitability of the recipient, a busy work schedule or a company policy of ignoring surveys), the decision to respond to a survey on sustainability can generally be regarded as a reflection of a certain degree of interest in the subject, such that the time and effort required by participating is regarded as justifiable. It was based on this premise, along with the survey data and population statistics, that a preliminary conclusion was drawn that larger logistics operators tend to perceive sustainability as an issue of more importance than do their smaller counterparts.

This pattern indicating a linkage between the business size of an LSP and its attitude to sustainability was strengthened by a further convergence trend towards large logistics companies that arose during the interviews. The presence of small operators with less than 50 vehicles shrank from 57% in the survey sample to 44% in the interview sample; while the shares of all the other larger operator categories increased to a greater or lesser degree, with the proportion of the largest operators group (those operating 200 vehicles or more) increasing by 9% to 30% of the sample. Looking at it from the participants' point of view, agreeing to an in-depth interview with the researcher, having already completed the questionnaire survey, suggests more commitment – and the willingness to dedicate the extra resources required by the nature of interview – and hence can, to a certain extent, be said to relate to the level of importance that sustainability has in the perception of the respondents. Since the interviewees had all participated in the previous survey, the effects of other random factors such as unsuitability of recipients, a company policy of not responding to surveys, and commercial confidentiality were minimised at this stage, thus giving more conclusive evidence in support of Hypothesis One.

On the demand side, where the response patterns of LSUs were looked into, 59% of survey respondents were served by a fleet of at least 200 goods vehicles. However, as this is more the result of a sampling technique which only targets the largest companies in each focus sector, no conclusion can be drawn about the large proportion of large-scale companies obtained for the survey sample. Applying the same assumption about response rate as a primary indicator of companies' perception of the importance of sustainability, it would appear that LSUs tend to regard sustainable logistics as being of a lower priority than do LSPs. Although the consideration of less targeted sampling was raised in Section 4.1 as a potential cause of the lower response rate from LSUs group, it should have been offset by the adverse effect of the greater commitment to sustainability of larger businesses, should the same rule for LSPs be applied to LSUs. Moreover, the fact that during the questionnaire survey, the LSU respondents were addressed by their names and positions in the companies should also have minimised the issue of less targeting sampling for the LSUs group. Therefore, the inference made about their response pattern is regarded as sound in serving the objectives of this research.

Further efforts were made through conducting statistical tests to examine whether logistics operations of differing sizes have different focuses when it comes to specific sustainable solutions. Based on the 115 valid survey responses regarding ranks of the top five solutions in terms of their impact on the businesses, the chi-square test has been run for the LSPs and LSUs groups both combined and separately (see Section 4.4.2). According to the test results, by and large the evidence was not significant enough to support the proposition that business scale is an influencing force in businesses' choices of sustainable solutions. Reverse logistics turned out to be the only category amongst the 14 sustainable solutions evaluated by the respondent LSPs which had different impacts on companies of different sizes, with larger operators seemingly more affected by it.

Section 5.2 has revealed that the pattern of responses by operational scale in the interviews was not significantly different from that of the survey sample, reinforcing the results of the above analysis based on survey outcomes. Nevertheless, given that the interview sample is a subset of survey respondents, a similar constitution of various business sizes is very much to be expected in normal circumstances, which limits the significance of this observation. Even though it does show a consistent pattern in support of the previous findings, it provides little scope for developing the level of understanding of this issue. Qualitative information from the interview transcripts is utilised to solve this problem.

As can be seen from the interview schedule in *Appendix Three,* a series of questions had been designed centring around the current sustainable practices of the interviewee companies' logistics activities. The interviewees were asked to identify the relevant actions taken by the companies in logistics operations which had implications, in particular positive ones, for their environmental footprint. Once these actions had been identified, the extent to which they were taken, the critical issues that arose during their implementation, and the main reasons for taking these initiatives in the first place were then explored. Analysis of the interview transcripts regarding the sustainable practice section indicates that although not statistically evident in the survey responses, the qualitative evidence clearly supports a profound linkage between some sustainable practices and business scale.

Information and communication technology (ICT), for instance, has turned out to be a sustainable solution much more heavily and widely applied amongst the big logistics operations, both in terms of technology diffusion (i.e. scale of application of ICT in various functions and logistics activities, and integration with other ICT systems within the company or along supply chain) and infusion (i.e. the sophistication/level of the technology employed, as well as the extent to which ICT permeates the functions involved) than that it is amongst the small operations. All seven LSPs operating a fleet size of over 200 goods vehicles have a well-established ICT infrastructure and in-house systems covering goods distribution, freight tracking and tracing, vehicle scheduling and routeing, and warehouse management functions. This is also the case with the 12 LSUs having over 200 vehicles in operation, either in-house or outsourced to 3PLs. In many cases of contract logistics, according to both LSP and LSU interviewees, the LSPs' ICT capability had been valued as their core competence and played a critical role in securing the deals between both parties.

The importance of ICT was not only reflected in the investment of the large LSPs in continuously developing their ICT systems and introducing new technologies into logistics operations, but also highlighted by the trend emerging in the retail sector which sees big retailers, normally with their own national distribution networks, often opting to outsource their online ordering operations to the specialist e-fulfilment solution providers. U6 for instance, one of the leading supermarket retailers in the UK, has recently decided to take more of its outsourced distribution operation in-house following a supply chain review. However, over the same period it also outsourced its non-food sectors and online shopping and returns services to a few specialist LSPs with expertise in e-tailing and the ability to operate an agile supply chain within highly demanding timescales, which are, without exception, backed by their sophisticated ICT systems. P14, one of the world's leading express service and logistics provider, with a global ICT network providing great visibility, is currently looking into improving their communication links by equipping their drivers with new-generation handheld computers featuring cellular technology.

Regarding the primary motivations for and major benefits of improving ICT capability, environmental mitigation appeared, unsurprisingly, to be only a 'by-product' or 'extra bonus' that comes with gains in operational efficiency and cost savings. When asked to illustrate the links between environmental benefits and the application of ICT, most interviewees mentioned points such as reduced empty-running and reduced numbers of vehicles on the road, which mitigates road congestion and reduces carbon emissions; the reduction in stock level and in handling in the warehouse, which is energy efficient; and fuel efficiency, achieved mainly by monitoring, planning and routeing systems. Acknowledging the low priority given to sustainability when decisions were being made on the establishment of ICT, all the big LSPs and LSUs interviewed were positive about its substantial positive implications for the environment, though none of them was able to provide facts and figures relating to measured carbon savings as a result of using ICT.

Apart from ICT, environmental management system (EMS) is another sustainable solution which seemed to be closely related to business scale, according to the interview evidence. Out of the 19 interviewee companies with a fleet of over 200 vehicles, 11 (i.e. 57.9%) had their logistics operations covered under the umbrella of an enterprise EMS, while another five (26.3%) had formal procedures certified by at least one accreditation organisation, though logistics activities were not particularly integrated into them. Four leading LSPs also had a dedicated department or division responsible for environmental compliance. In contrast, out of the 19 small operators with less than 50 goods vehicles, only five (26%) of them had formalised environmental policies relating to logistics functions, and four turned out to be LSPs. The variations in behaviour amongst companies of various sizes do not only exist in terms of the proportion which adopt, but also in their level of engagement. A few large operators claimed to have achieved a high level of transparency and disclosure of environmental performance through comprehensive carbon monitoring, reporting and management systems, and dedicated personnel; the small operators, on the other hand, were usually focusing on improving fuel efficiency with emission reduction being achieved almost unintentionally. Two small LSPs explicitly stated that the environmentally sustainable strategies taken by their key clients had acted as catalyst for them to look into their own carbon footprint, revealing the influence of large businesses on their LSPs when it comes to sustainable practices.

Similarly, companies of differing sizes would appear to differ correspondingly in their practices relating to alternative fuels, as the anecdotal evidence from the interviews came solely from large-scale operations. U19, a large high-street retailer in the UK, has recently undertaken a trial running converted HGVs on pure plant oil, though no further decision had been made on the future adoption or the possible scale of such an operation by the time of the interview. The interviewee highlighted the difficulties encountered in sourcing the fuel, as well as the additional cost occurred during the implementation. Another interviewed company with a vision for alternative fuel turned out to be a leading figure in the retail sector as well. U14 was planning to start operating five HGVs in its fleet using LBM (liquid biomethane), which is a direct substitute for natural gas and has a noticeably lower carbon intensity than biodiesel. Again, the prospects for this biofuels operation were not clear, as the interviewee was only at the stage of experimenting and evaluating the initiative. However, given the extent of adaptation required for both the vehicles and operation schedules, it was sensed that there was still a long way to go before a large-scale application could be realised, despite the 30% reduction in CO_2 emissions estimated by the company.

Taking an overview of the interview evidence on sustainable practices, it is evident that the large logistics operations in the sample are taking more initiatives which have positive environmental implications than the smaller ones; in this regard, the conclusion drawn is far clearer than could be deduced from the analysis results based on survey data. In terms of implementation, the anecdotal information also suggests that more far-reaching approaches are taken by the companies of bigger size, with greater engagement. This is mainly a consequence of the limited resources of smaller operators, especially in the difficult economic environment prevailing during the time of the research. As one interviewee commented, “the time is tougher for smaller operators than their bigger rivals in the recession, and their first priority is definitely going to be survival in the short term rather than sustainability in the long term.”

Overall, the evidence from both the survey and interviews has been shown to support the varying degree of importance placed on sustainability issues by businesses of various sizes, as well as differing practices taken in certain sustainable areas. Larger operators appear to generally attach more importance to sustainable issues than their smaller competitors, with a greater proportion of them relative to the population responding to both the survey and interview invitations. The uptake of particular solutions, such as ICT, EMS and alternative fuels, has revealed substantial gaps between large and small operations, both in terms of the prevalence of adoption and the depth of penetration. Therefore, overall, Hypothesis One is held to be true. However, when the particular sustainable solutions identified by the respondents as being of great impact were examined, the statistical test results are not significant, which suggests that although businesses of varying sizes may have different perceptions on the importance of sustainability, amongst those who do think it is important, they do not act distinctively differently in assessing specific sustainable solutions. It also emerges that LSUs seemed to place a lower priority on sustainable logistics as compared with LSPs, which is plausible given that logistics is not the core business of these companies.

Hypothesis Two: Sustainable logistics practices vary by industry sector.

Since the vast majority of LSPs in the survey sample are operating in multiple sectors, while most LSUs have identified one or two sectors where their main logistics activities are carried out, it is more feasible to use quantitative methods to study the potential variations in sustainable practice by vertical sectors in LSUs group, which helps to create a level platform for comparative analysis across sectors without substantial interference arising from the logistics role and business scale factors as identified in Hypothesis One.

The initial analysis of the achieved sample structure for the survey and interviews by vertical sector has been dealt with in Sections 4.2 and 3.5.3 respectively. However, when it comes to investigating whether various sectors have different views on logistics sustainability, it is the response rates of the industrial sectors, rather than the proportions of them in the samples, that accurately reveals the importance with which they perceived the issue. To illustrate this, *Table 5.5* shows the response rates attained for the six focus sectors *(a)* during the questionnaire survey and *(b)* during the interviews, in descending order. The relative shares of each sector in the overall samples are also incorporated, in order to exemplify how this might have influenced the conclusions to be made if it were used for the analysis.

Table 5.5: LSU response patterns in survey and interviews by industrial sector

(a) Survey responses overview

Industrial Sector	No. of Responses	% of Sample	Response Rate
Other Industrial	18	20%	*15%*
Retail	18	20%	*15%*
Other FMCG (manufacture)	17	19%	*15%*
Food,drink & Tobacco	14	15%	*12%*
Chemical	14	15%	*12%*
Automotive	10	11%	*9%*
Total / Average	91	100%	*13%*

(b) Interview responses overview

Industrial Sector	No. of Responses	% of Sample	Response Rate*
Chemical	6	18%	*43%*
Automotive	4	12%	*40%*
Retail	7	21%	*39%*
Food, drink & tobacco	5	15%	*36%*
Other FMCG (manufacture)	6	18%	*35%*
Other Industrial	5	15%	*28%*
Total / Average	33	100%	36%

** Interview response rate = (number of interviews ÷ number of survey responses in the same sector) × 100%*

Source: author's survey and interviews

As can be seen, the figures presented in the table paint quite a mixed picture regarding the response patterns by sector. Whether looking at the sample of the survey or of the interviews, the response rates of sectors appear to be comparable with one another, whilst across the whole spectrum the disparity between the highest response rate and the lowest seems to be considerable. Furthermore, through comparing the response rates of the survey with those of the interviews, the vertical sectors under consideration showed contrasting patterns. Based on this observation, the six focus sectors can be crudely divided into three groups. Other industrial and FMCG can be classified into one group, which had the highest response rate during the survey, yet the lowest in the interview sample; retail and food, drink & tobacco, as the second group, had relatively steady response rates close to the average rates in both samples; while chemical and automotive form the third group, which had the lowest response rates during the survey but relatively higher ones in the interviews compared with other sectors.

Regardless of other factors that might have contributed to the observed patterns, the response rates from the questionnaire survey were obtained from the 117 leading companies within each of the six focus sectors, and can hence be inferred as indicators of the general importance of sustainable logistics as perceived by these sectors. As argued in Hypothesis One, the response rates from interviews were derived from those who responded to the previous survey, and thus reflect more on the level of importance that the companies attached to sustainable logistics, or the extent of their commitment to it. In light of this reasoning, the four sectors FMCG, retail, other industrial, and food, drink & tobacco would appear to more widely view sustainable logistics as an issue of importance; whilst among the companies who signified this viewpoint by responding to the survey, it is those in the automotive and chemical sectors who demonstrated more interest and commitment through their further involvement in the in-depth interviews.

Bearing in mind that this provisional conclusion has been deduced from quantification of both survey and interview data, with the latter being subject to small sample sizes for the sectors, caution should be taken in the interpretation of the observations, as any marginal changes in the number of interviewees may have a great impact on the corresponding response rates of the sectors, which would in turn lead to different conclusions. Moreover, other factors, such as the geographic sphere of the supply chain (tested in Hypothesis Three), the accuracy in identifying suitable recipients for the questionnaire, and business size (still an issue, but to a lesser extent, within the LSUs group), might all have contributed to the patterns as observed.

Although the overall survey sample is sufficient for some statistical analysis, as reported in Chapter Four, given the number of the focus sectors (six) and sustainable solutions (14), as well as the limited sample sizes for the LSUs group, especially of interviews, there is little scope for further quantitative methods being applied in testing Hypothesis Two. Building upon the general patterns which emerged in the perceived importance of sustainability by sector, the following analysis concentrates on revealing the distinctive focuses of the target sectors in their sustainable logistics practices, i.e. which sector is more likely to employ certain sustainable solution(s) – or from another perspective, which solution tends to have greater implications in certain sector(s), primarily with the support of interview evidence.

As discussed in the analysis of Hypothesis One, alternative fuel happened to be an issue that was experimented with mainly by larger retailers amongst the interview sample, sparking further examination into the justification for this linkage. Although broadly, alternative fuel may take various forms with distinctive natures and environmental performances, the two forms adopted by the interviewees, i.e. biogas and pure plant oil, were both used for local/regional deliveries rather than long-distance haulage. This was, according to the interviewees, due mainly to the availability and storage of the fuel, yet as U14 pointed out, the alternative fuel was also more suitable for urban distribution where its environmental credentials (e.g. contribution to air quality) can be maximised. In exploration of the motivation behind the alternative fuel initiatives, both interviewees emphasised the great level of responsibility that their company has taken in social and environmental aspects as long-term strategies, partly as the awareness increases among the public and consumers about the adverse impact of the products they provide. The evidence suggested that the sectors that were exposed to a larger extent to public scrutiny or consumer pressure are more likely to be actively seeking ways to operate in an environmentally friendly way, with the cases of retail sector experimenting with alternative fuels being a good example of this.

Likewise, the FMCG and the food, drink & tobacco sectors are subject to a similar level of attention and concern from their large customer bases and the general public, with a greater part of this attention being focused on the logistics activities than is the case with other sectors. As P1 – a major logistics and supply chain solution provider with its core businesses in the food and drinks sector as well as in the construction sector – asserted, "food, drinks and other fast consumer goods sectors, compared with industrial sectors, has been an easy target of public debates and researches in terms of their carbon footprint, because of their proximity to the end market or supply chain, but the sometimes disproportionate attention received by these sectors does not necessarily reflect the amount of pollutants they produce compared to other sectors." This coincides with the statement of U14, which adopted alternative fuel, that the overall environmental benefits of using alternative fuel at the current trial scale was by no means substantial compared with that of the other sustainable initiatives taken by the company outside its logistics operations. Whether the assertion is true or not, it certainly sheds light on the potential interrelationship between the nature of a sector and its sustainable behaviours.

During the interviews, environmental issues associated with food miles were especially referred to by all the five LSUs, and half of the 12 LSPs, in the food sector. Although the LSPs' focus seems to be on reducing total transport mileage through efficiency management, it is the LSU interviewees who appear to be taking a more critical view on this matter. U5, U13 and U19, for instance, had all, to various extents, voiced their concerns over the 'false' conception by consumers of local food being more environmentally sustainable. Agreeing on a life-cycle assessment approach rather than over-simplified calculations centred around food miles, they believed that local food is not necessarily a more sustainable solution. Interestingly, this opposing view contrasts with the high-profile practice of U19, a large supermarket chain, in localising the sourcing and production of one category of its everyday food product. Although the interviewee could not disclose the economic implications of such initiatives, it pledged that this movement had certainly gained recognition among its consumers according to its own customer survey, and also played a critical role in supporting local food producers and subsequently the local economy. The split in attitudes and behaviours again underlines the stronger tendency to market-orientation by the latter.

According to many LSP interviewees, certain solutions, such as ICT and supply chain optimisation, play a far more strategic role in those sectors with demanding logistics needs, such as the pharmaceutical and medical equipment, high-tech, spare parts and automotive sectors. The globalised nature of production and distribution also adds to the challenge of enhancing real-time visibility and control over inventories along supply chains. P1, P7, P11, P13, P14 and P20 have all given examples of providing bespoke, real-time responsive services to customers' needs, with the latest ICT technology forming the core of the network planning and supply chain optimisation capability of these LSPs. P6, a logistics provider active in the healthcare sector, detailed the challenging logistics requirements of its customers. Operating the global distribution network for a large healthcare product supplier with its production centralised in north England, P6 is responsible for the delivery to its European customers. Not only are the products temperature-sensitive, but all the orders have to be delivered within a 48-hour time window. To maintain a high service fulfilment, regional distribution centres across Europe are replenished every week, yet the inventory management is centralised to minimise the overall stock level and optimise product allocation. Consequently, the time-critical and complex distribution network features of these sectors were reflected in the prevalence of outsourcing logistics functions, where interactions between LSPs and LSUs tend to be more intense. As U22, a pharmaceutical and medical device manufacturer, pointed out, by leveraging the LSP's capability in consolidation, temperature compliance storage and inventory management, the normally required dedicated logistics service can be operated on a multiple-user basis by the independent LSPs specialised in the sector, hence maximising the cost-efficiency in logistics for the business without compromising quality of service.

Likewise, the retail sector is also one which appeared to have a particular emphasis on supply chain optimisation, at least in part due to its complex distribution networks.

As can be seen from *Appendix Eight*, all of the seven LSU interviewees in this sector either view supply chain optimisation as a solution which have great impact, or have prior experiences or current practices in the area. Since most LSPs usually operate in a diversity of sectors, this pattern is less evident among them, with only one out of six showing both in their perception and by their practices that supply chain management was of great importance to them, while another four had experience in optimising or restructuring their supply chain, but without regarding it as having particularly great implications for their operations. U21 elaborated the recent logistics overhaul conducted in collaboration with its lead logistics provider. This supply chain scrutiny was driven mainly by the economic slowdown, which has led to many retailers switching from expanding strategies to looking into internal cost reduction and efficiency enhancement in every facet of their operation. During the logistics review, it was identified that a large amount of deliveries to stores were still made by the suppliers directly, which was a key area of inefficiency arising from excessive transport and handling activities. By centralising the supplier deliveries into one of its LSPs' fulfilment centres, not only were costs reduced at store level, but the retailer also benefited from increased purchase power as well as reduced carbon footprint as a result of consolidated deliveries. Interviewee companies in the FMCG sector, which is characterised by seasonality, global sourcing and substantial return flows of merchandise, e.g. U6, U19, U21 in the fashion industry and U20 as a consumer electronics manufacturer, also displayed a comparable level of focus on supply chain management, in particular working closely with their logistics partners as well as integrating reverse logistics functions with distribution networks.

As far as the chemical sector is concerned, although interviewee companies within the sector are operating a widely diversified selection of products, ranging from plastics, oil and fuels to gypsum and resins, most of them had identified that the key environmental concern facing the industry is the issue of hazardous substances in various forms, which require stringent handling and transport processes along the supply chain. As a result, driver training was highlighted as a critical solution commonly adopted for the sector. P7 and P10 for instance, both providing fuel tanker services to their clients, have in-house training for drivers to acquire petroleum load and discharge competence. In coping with regulations and legislation for the industry that are ever-changing, specifically tightening, P12 has a dedicated team for keeping updated, ensuring compliance, and providing internal training for chemical logistics operations, which is an integral part of its accredited environmental management system. Also, as a result of the product attributes of the sector, with many operations involving transportation of liquid or dry bulk goods, five out of six LSU interviewees in the sector had prior experience of, or were currently using, alternative transport modes in parallel with road haulage, primarily waterborne transport and rail freight. For similar reasons related to the less time-sensitive and bulky freight operations in industrial sectors, three large LSUs (out of six in the interview sample) in the industrial sector are leveraging alternative modes where possible, although mainly out of concerns over cost.

Combining the quantitative and qualitative evidence generated from both the survey and the interviews, it is clear that different sectors vary in the priority that they give to issues of sustainability, and the distinctive features of their logistics operations are also reflected in the adoption of corresponding sustainable solutions. Although during this part of the analysis the evidence obtained by interview is largely anecdotal, and the sample sizes of the focus vertical sectors are by no means sufficient to allow greater generalisation, the credibility of this analysis is in part ensured by the specific part of the discussion with each interviewee which centred around the key sustainable issues facing their sectors in question as a whole (see the interview schedule in *Appendix Three*), and is in part reaffirmed by the explicitly differing patterns exemplified by the interview cases. To conclude, by vertical sector there were perceptible variations among the participant companies' views on the importance of sustainable logistics, but not to such an extent that they would still remain when all the other potential influencing factors were taken into the equation. Nevertheless, since the qualitative evidence has all pointed to various, yet explicit, forms of links between different sectors' unique logistics attributes and the (relatively) common attitudes and sustainable practices observed in those sectors, Hypothesis Two can be generally accepted with reasonable certainty.

Hypothesis Three: Sustainable logistics practices vary by the geographic scope of the operation.

The analysis of this hypothesis can be conducted from two perspectives. Firstly, evidence can be examined to identify whether logistics operations which operate within different geographic scopes places a different priority on sustainable issues. For instance, do international operations attach more importance to sustainability compared to national and local operations, because their activities cover a physically broader sphere? Secondly, when the specific sustainable behaviours are examined, questions should also be addressed on whether or not logistics operations of varying geographic coverage are adopting differing strategies and measures. The first perspective is approached largely on the basis of quantification from both survey and interviews outcomes, while the second is explored with qualitative information on interviewees' sustainable practices.

The distribution of survey respondents and interviewees by geographic sphere is summarised in *Figure 4.5* and *Table 5.2* respectively and briefly discussed after each. In the survey sample, both LSPs and LSUs groups had the vast majority of companies operating on either a national (44%) or international (49%) scope, with logistics operations that were carried out only within local or regional areas accounting for a negligible proportion (7%). This unequivocal tendency towards a geographically broad coverage emerging from the survey results was reinforced by interview outcomes, with the presence of the local logistics operations being further squeezed to 2%, which suggests a positive correlation between geographic scale and their response patterns regarding sustainability, unless the uneven distribution by geographic scope in the sample was actually a real reflection of the population.

Unfortunately there are no publicly available statistics on the constitution of the British logistics operations by geographic spread, which makes it a challenging task to directly interpret the data collected. Statistics on various types of goods vehicle operator's licence, for instance, would be a valuable benchmark for the analysis, since it would not only enable one to differentiate own-account operators (Restricted licence holders) from 3PLs (i.e. LSPs in this research), but would also allow LSPs to be split into national and international operations. In the search for substitute sources of information which could be used as a reference baseline against which to gauge the observations, domestic road freight by length of haul of HGVs, together with the statistics on international road haulage, were identified as indirect surrogate measures for revealing the geographic attributes of logistics operations.

Statistics published by the DfT (2009a) on road freight transport allowed the parallel comparison between domestic and international road haulage for the year 2007, as well as domestic road freight movements within 100 kilometres (inclusive) and over

100 kilometres over the last ten years (the relevant statistics were extracted and summarised in *Appendix Nine*). As can be seen, for road haulage made by UK-registered HGVs over 3.5 tonnes, international freight turned out to be merely a small fraction of domestic volumes, whether measured by goods lifted (tonne) or goods moved (tonne-km). A look into the domestic haulage statistics reveals that consistently over the ten-year period from 1998 to 2008, long-distance haulage (over 100 kilometres) accounts for around 30% of the total goods lifted, and 73% on average of the goods moved. Given that the freight traffic volumes by haulage length is relatively more proximate to the numbers of goods vehicles operating within various geographic scopes, it can be inferred that there may be a larger proportion of road haulage activities carried out at local/regional level than national ones.

It is against this backdrop that the survey and interview outcomes appeared to be strikingly in contrast to what is the crudely approximated case in the population, suggesting the need for a deeper probe into the underlying causes. Firstly, the classification of the participating businesses by geographic sphere was simplified to represent only the broadest scope of their logistics activities, which might have led to the under-representation of local and national operations. Going back to the original data form, the unadjusted survey responses, including those multiple choice ones, are compiled in *Table 5.6*.

Table 5.6: Survey response patterns by geographic scope

Geographic Scope	No. of LSPs	%	No. of LSUs	%
Local/Regional	15	17%	14	16%
National	42	48%	39	45%
International	31	35%	33	38%
Total	88	100%	86	100%

Source: author's survey (multiple response)

As shown in the table, the proportion of local/regional operations in the entire survey sample has more than doubled due to the multiple selection of some responses, while the share of national operations also increased moderately, yet enough to overtake international operations as the category (both for LSPs and LSUs) with the largest number of responses. Altogether 10 LSPs and 11 LSUs identified logistics activities at all three levels, which is the principal contributor to the changes. As with the interview outcomes, most of the interviewees classified as national or international had clarified that as an integrated part of their operations, a certain proportion of their logistics activities was conducted within local/regional spheres, in particular for the final legs of the distributions to end customers in local markets, as commonly observed in many typical hub-and-spoke logistics structures, although difficulties were experienced by most of them in measuring the proportion of activities carried out at various geographic scales, due to the complexity of their logistics operations and the lack of standard, appropriate criteria for such measurement.

Even with the unadjusted response data, which turned out to be relatively more in line with the population distribution, there is still an evident, disproportionally strong presence of international operations in both the survey and interview samples, suggesting that operating over a broader geographic sphere might be linked with more awareness of and responsive strategies concerning sustainability. However, it is worth noting that a considerable proportion of international freight is likely to be transported via alternative non-road modes, whilst the parallel statistics on international road haulage did not include the entirety of international freight, which might have led to an underestimated proportion of international logistics operations in the population. As a result of extremely limited statistics available on logistics scale, it is therefore not feasible to draw a firm conclusion on the linkage between geographic scope of logistics operations and perceived importance of sustainability.

As far as the 14 sustainable solutions are concerned, statistical tests were conducted on the survey data to determine whether respondent companies of various geographic spreads had shown different preferences for particular solutions – the results were reported in Section 4.4.2. They show that overall there was no significant difference among the sample businesses in response to the sustainable solution package provided. When LSPs and LSUs groups were examined separately, divergent views emerged amongst companies within the LSPs group regarding alternative fuels and supply chain optimisation, with international operators attaching more importance to the former, and local and national operators to the latter. However, the validity of the test results, and hence of any generalisation of them, is restricted due to the limited sample size. For this reason, further qualitative evidence either in support of or opposing the preliminary conclusions were sought from the interviews.

Amongst the 25 (out of 60) LSP survey respondents who perceived alternative fuel as having a great impact on their logistics operations, 14 of them were international operators, with nine operating nationally and two on a local/regional level. In contrast, of the entire interview sample of 23 LSPs, only one of them had previous experience in adopting alternative fuels; this LSP turned out to be an international supply chain solution provider, P1, who merely employed one electric vehicle for its local delivery to a customer with great environmental concerns. Although the practice seems to be opposite to the importance of alternative fuel as perceived by LSPs, this was reaffirmed by the survey result shown in *Figure 4.28*, where only one out of 19 LSP participants was currently using alternative fuels. The interview with P1 showed no apparent connection between its adoption of an electric vehicle and its international coverage. The fact that the interviewee did not consider alternative fuel as a solution of any great impact, and that the only alternative fuel vehicle usage was for local delivery, also inclines towards rejecting the existence of any link. Finally, the transcripts for the nine interviews in which alternative fuel was discussed due to a high level of perceived impact were reviewed, and again presented no evidence for such a relationship. It would appear that the high importance attached to alternative fuel by most logistics operators was on the basis of a long-term perspective in a hypothetical context where alternative fuel would roll out on a large scale. It has little to do with the current practice of the participant operators, let alone their geographic attributes, but more with the optimistic views of the interviewees regarding the outlook. As a result of the above analysis, the difference observed in LSPs' opinions on alternative fuels by their geographic scope is more likely to be an outcome in accordance with the general geographic constitution of the survey sample, rather than an effect of it.

Since the statistical test had revealed that supply chain optimisation appeared to be more highly valued, in terms of its impact, by local and national LSPs than international ones, an investigation was also conducted into the potential connection between geographic factors and supply chain management practice. A further look into the data showed that out of the 22 survey respondents who selected supply chain optimisation as one of the top five influential solutions, 14 (64%) of them were national operators, compared with 45% of them in the entire sample, which makes this a major factor contributing to the variation. In the interview sample, altogether six of 23 LSPs had attached great importance to this solution, with half being international operators and half national ones. Although the proportion of international LSPs (at 52%) in the entire interview sample was slightly bigger than that of national ones (43%), the small sample size does not enable any conclusive conclusion to be drawn from this. Nevertheless, when the practice of the interviewees in supply chain optimisation was examined, all four instances (P1, P7, P11, P15) were carried out on the national scale, with P1 the only international operator being involved in multiple cases of nationwide distribution network restructuring for its customers. The interviewees from P10 and P23 believed that supply chain optimisation, implemented at national level, can yield maximum benefit in cost saving, operational efficiency and service improvement without being overly compromised by drawbacks such as the lengthy implementation period, the huge initial cost and the risk of business loss that a strategic overhaul of the international supply chain normally entails. For this reason, although none of them had taken far-reaching actions in optimising their supply chains, they both envisioned its future adoption at national level. Therefore, concurring with each other, both survey and interview evidence have indicated a clear correlation between supply chain optimisation and national operations.

In addition to alternative fuels and supply chain optimisation, urban logistics and modal shift are the two solutions that are most likely to interrelate with the geographical sphere of logistics operations. For international operators, it is not only more viable and economic to explore alternative transport modes such as rail, shipping and airfreight due to the greatly increased length of haulage, but in many cases intermodal transport is the only way to get goods delivered between certain destinations. Likewise, it is also self-evident to presume that urban logistics will for the most part concern those operations that take place in urban areas with stringent restrictions. As a result, further efforts were made in seeking evidence relevant to these inferences.

Among the few interviewees who had prior experience in sustainable urban logistics practice, P10, as a specialist distribution operator of general palletised goods with a substantial part of its activities being conducted in urban areas, shared its views on this subject. To tackle the increasing congestion problems in urban areas, the company had devised an overnight consolidation solution which applied the concepts of a consolidation/transhipment centre on the outskirts of major towns and cities and night-time delivery, as reviewed in Chapter Two. The interview with the company particularly highlighted the strengthened benefits which urban logistics approaches could realise with the support of local government. In one city located in eastern England, the city council had made an experimental traffic order which allowed the company's fleet serving the consolidation centre to use the bus lane on designated roads. According to the interviewee, a close relationship with city and county council, in its experience, had been a key element in the success of this solution. Agreeing with other interviewee companies with urban logistics operations, it claimed that, as most of its customers were located in busy town centres, it was inevitably affected by the restrictions imposed in these areas, but that such impacts could be contained by compliance actions, and that since all operators in the same area were equally subject to the same constraints, there was no hindrance to fair competition and no drastic action was needed in this regard.

As was the case with urban logistics, although modal shift was not commonly observed in practice amongst the sample of interviewees, the anecdotal evidence provided by those who had experience in using alternative modes for freight transport appeared to support geographic location as being a critical factor behind the modal choice decision. U28 for instance, a manufacturer in the automotive sector and a regular rail freight user, had recently switched the transport of cars produced in one of its factories in England from road to rail. The action was taken following the re-development of a local rail terminal directly linked to the factory facility, benefiting not only the business – with a reduction in delivery lead-time and in traffic on the production site – but more importantly the environment, with a halving of CO_2 emissions as a result of taking a considerable number of heavy duty car transporters off the road. The interviewee also disclosed an important role that the government had played in this project, mainly in terms of financial investment and support through sustainable funds. Adding to the case of U28, four of the seven interviewees who had identified modal shift as of great impact regarded the accessibility or proximity to the alternative transport network (e.g. railheads, ports) as one of the primary reasons that encouraged them to evaluate its feasibility in the first place, which emphasises the importance of infrastructure development in promoting alternative modes in place of road haulage.

In summary, the quantitative analysis has indicated a plausible linkage between geographic sphere and perceived importance of sustainability, in that the broader the geographic coverage of the operations, the higher priority the operators are likely to give to sustainable issues. However, this finding is inconclusive due to the lack of official statistics able to explicitly differentiate logistics operations by geographic scale. Upon a closer examination of the attitudes and behaviours of the participant companies in sustainable logistics, the qualitative analysis does not support the preliminary testing result that international LSPs attach more importance to alternative fuels; nevertheless, the relationship between supply chain optimisation and geographic scope has been borne out, indeed further developed, by the interview evidence, this relationship being that the supply chain solution is employed most commonly, and believed to work the best, at the national scale. Other anecdotal evidence also verified the positive relationship between businesses' geographic attributes and urban logistics, as well as modal shift. Therefore, the assertion in

Hypothesis Three can be at least partially accepted in regard to the specific sustainable solutions addressed, though some degree of uncertainty remains when it comes to the generalisation of the geographic sphere as one of the critical factors in sustainable logistics.

5.3.2 Working Mechanism in Sustainability: Interactions

Building upon the analysis in Chapter Four and the previous subsection, this subsection focuses on the interactions between the two major influencing groups within the logistics industry – LSPs and LSUs – as well as the interrelationship between certain sustainable solutions. This set of hypotheses is of particular significance not only in discovering an effective working mechanism for increasing the uptake of various sustainable solutions among the key actors of the industry, but also in identifying the most effective and efficient combination of these sustainable solutions – if the assumed synergies of certain solutions are borne out by the evidence from the survey and interviews.

Hypothesis Four: There are interrelationships among certain sustainable solutions.

Regarding the 14 sustainable logistics measures under consideration, the interrelationships amongst them, if any, would be in the form of a multidimensional interwoven network which cannot be deconstructed by simply analysing each of the solutions in isolation. Building upon the kind of isolated analysis conducted in Chapter Four, this part of the analysis places the emphasis on exploring the interrelationship(s) from three different angles and for various purposes, as follows.

Businesses 'preferences' analysis. The great diversity in the theoretical and practical nature of the initial solution framework lends itself to a variety of categorisations, each highlighting the features of individual solutions by a pre-established criterion, and grouping the solutions accordingly. By applying some major categorisation to the solutions, it is feasible to examine whether the businesses had a tendency to attach more importance to certain groups of solutions, hence 'preferences' of sustainable solutions types, even if such 'preferences' were a result of external forces.

Synergy analysis. As the name suggests, this type of analysis aims at searching for the existence of synergies with certain combination of some solutions.

Substitute analysis. Converse of synergy analysis, the intention of this analysis is to find out whether the application of a given solution would have an impact, in particular an adverse or offsetting one, on the likelihood of adopting other solutions.

In combination, the three analyses, which focus on different critical facets of the complex interrelationship amongst the sustainable solutions, will address the needs of testing Hypothesis Four. Wherever an interrelationship is identified, further investigation on the type of interrelationship is carried out and detailed throughout the analysis. The three types of analysis are now dealt with one at a time.

<u>Business Preference/Attitude Analysis</u>

In Section 2.5.2 of Chapter Two, various classification methods were employed to categorise the 14 sustainable solutions; these were: by strategy, by scale, and by maturity. Building upon the survey results on solution rankings by perceived importance, *Table 5.7* presents an overview of the preference patterns by each classification.

Table 5.7: Business preference patterns by various solution classifications

Ranking	*Ranking of Sustainable Solution*	*By Strategy*			*By Scale*			*By Maturity*	
		Efficiency	*Substitution*	*Reduction*	*Macro*	*Meso*	*Micro*	*Established*	*In Development*
1	Diesel fuel taxation	√		√	√			√	
2	Driver training	√					√	√	
3	Vehicle design technology	√	√				√	√	√
4	Supply chain optimisation	√				√		√	
5	ICT	√					√	√	
6	Road pricing		√	√	√			√	√
7	Alternative fuels		√		√				√
8	Government support	√	√	√	√			√	
9	Environmental management systems	√					√	√	√
10	Reverse logistics	√		√		√		√	
11	Modal shift		√		√			√	√
12	Product/packaging design	√					√	√	
13	Inclusion of transport into the EU ETS			√	√				√
14	Urban logistics	√	√			√		√	√

Source: author's survey

As shown in the table, when classified by strategy, the top five sustainable solutions all, at least in part, fall into the category of efficiency strategy, which, as the name suggests, serves the purpose of operational efficiency improvement. Taking the other two classification methods into account, these solutions with the highest ranks also appear to be established ones (all five) implemented at micro level (three out of the five). Overall, the substitution strategy was appraised by the respondents as having fairly substantial importance, although this varied considerably across the set of solutions in this category. Vehicle design, road pricing and alternative fuels, together with the government's facilitating roles in these areas, for instance, turned out to have much attention paid to it, whilst modal shift and urban logistics seemed to be largely neglected according to the results (note: results on urban logistics are subject to misinterpretation by respondents, see Section 7.3). Similarly, solutions applying reduction strategies represented a mixed picture, with fuel taxation being of the greatest impact on logistics businesses, but inclusion of transport into the EU ETS being low down the league in terms of importance.

In a similar fashion, there is no explicit pattern identifiable by comparing solutions functioning at macro- and meso-levels. By and large the macro sustainable solutions may seem to outstrip the meso ones, as the table shows, but this is due mainly to the much smaller number of solutions falling into the meso level. When classification by maturity is examined, a problem arises in that certain solutions comprise various measures, with some of these being still under development, and some being completely mature and established in practice. Although it is not possible to distinguish the exact elements of a solution perceived by different respondents that might belong to different categories, the table reveals that vehicle technology, road pricing and alternative fuels appear, of all the solutions under development, to have greatest potential in contributing to environmental sustainability through their substantial logistics impacts as evaluated by the business respondents.

Synergy Analysis

The first aspect of synergy to be examined is vehicle technology and alternative fuels. Most alternative fuels need to be run on purpose-built or modified vehicles, meaning that the two solutions are closely related to, and strengthen, each other. It is thus not surprising, given this interdependency, to have observed the common co-existence of both solutions in logistics operations. In practice ICT and driver training were also applied along with vehicle technology, in maximising the benefits from each of these solutions. P1, as an example of making full use of the combined solution set, has installed the latest GPS technology across its fleet based at one key account customer's national fulfilment centre in the Midlands. The on-vehicle communication technology not only enables visibility and real-time planning, scheduling and tracking, but also collects information on drivers' activities and vehicle movements to enable fuel consumption and fleet monitoring and control.

The most commonly observed synergetic link is between ICT and supply chain management. As reported in Chapter Four, both solutions were ranked as top five measures in terms of impact on the business, with supply chain optimisation ranked the fourth and ICT the fifth. During the second stage of the survey when specific approaches to optimising the supply chain were explored, 71% of the respondents selected ICT as one of their main means of improving their supply chain performance. The existence of such synergy was further confirmed by the second-stage survey evidence from the ICT section, in that 73% of the respondents had supply chain management information infrastructure and systems in place, illustrating that supply chain optimisation is one of the ultimate goals that ICT serves in the logistics industry. Qualitative evidence from interviews, as discussed in previous analysis of hypotheses, also supports the close relationship between these two solutions. In practice they are often implemented together to realise improved operational efficiency and enhanced customer service levels, with supply chain optimisation activities planned and executed on the platform of powerful IT backbone systems (as in the cases of P1, P7, P11 and U5).

Other complementary sustainable solutions that emerged from the interview evidence include eco-friendly product/packaging design, supply chain optimisation and reverse logistics. U32, a leading electronics product manufacturer, exemplified this, explaining how it had taken all the components of various sustainable implications into the equation to formulate and implement its eco-design guidance. In respect of reverse logistics, the ‘reduce, reuse and recycle’ principle is incorporated into its product/packaging design, which aims to use the minimal amount of materials, in particular minimising the use of those with greater environmental impact, to produce products that are easy to be reused, upgraded or recycled at the end of their working life. And since changes to the designs of product/packaging often have broad logistics implications, trade-offs need to be made to generate optimised outcomes across the entire supply chain. For instance, light packaging materials like expanded polystyrene are efficient in fuel consumption but less so in space utilisation, and their recycling relies more heavily on available infrastructures. Moulded pulp made from recycled paper, on the other hand, is more environmentally friendly while putting more weight on vehicles. Taking the load factor into account, the company has focused on the energy efficiency by unit of product, and meanwhile use less packaging material which increased their loading factor by 30%. Likewise U18, in the food sector, had adopted a series of redesigned food containers shortly prior to the interview, which benefits their logistics operations with improved pallet and warehouse utilisation and reduced internal handlings, as on average each pallet can now carry 60% more containers than before.

Some of the anecdotal evidence from the analysis of associations between businesses' geographical attributes and their sustainable behaviours in Hypothesis Three also points to the critical role the government has played in the practice of urban logistics (e.g. P10) and of modal shift (e.g. U28). Both cases have demonstrated that, implemented in tandem with government support (of a different from in each case), urban logistics and modal shift will be able to reap greater benefits than they would by counting on the businesses' voluntary actions alone.

<u>Substitute Analysis</u>

Although all using their own mechanisms, some solutions have similar implications, especially economic ones, on businesses within the logistics industry, hence often giving rise to debate as to whether one should be implemented to replace another. Diesel fuel taxation, road pricing, and inclusion of transport into the ETS constitute such a group of arguably substitutable solutions at macro level. As analysed in Section 4.5.1, the survey results revealed that road pricing and diesel fuel taxation were most commonly regarded to be replaceable by each other, with the former slightly more popular with the LSPs and the latter amongst the LSUs. Taking a different angle, as reported in Section 4.5.3, the impacts of several solutions (i.e. fuel taxation, lorry road user charge, the LEZ, and the ETS) on fleet management decisions were examined, with the highest rating given to the same two solutions – diesel fuel taxation and road pricing. Although it was not possible to tell which solution was of greater effect in these analyses due to their similar response frequencies, in Section 4.5.6 the pattern revealed clearly suggests that fuel taxation was perceived to be a much more effective approach by the respondents, with 64% of them selecting it and 14% the national road pricing scheme. A similar pattern was obtained from the analysis of the survey results regarding ETS (see *Appendix Seven*), with fuel taxation receiving more responses than road pricing and the ETS. Although the extremely small sample size (nine) in this part has greatly limited the scope for generalisation, as complementary evidence in support of the previous findings, extrapolation can be made from the general survey outcomes that most respondents view diesel fuel taxation as a more effective policy in achieving long-term sustainable objectives than the proposed national road-user charging scheme.

Concurring with the survey analysis results, the vast majority of the interviewees who commented on road pricing and fuel taxation as sustainable policy instruments expressed more concerns about fuel taxation than a proposed national road user charging scheme, largely because of the premature status of the latter. Most interviewees were not convinced that a comprehensive road pricing scheme would be implemented in the foreseeable future, given the highly complex procedures and potentially high cost involved, and hence they tended to believe that few actions need to be taken in reaction to the hypothetical scenario. A similarly sceptical view on the inclusion of the transport sector into the ETS, regardless of the various forms of suggested implementation, was also shared amongst most interviewees. Of the entire sample, only three of them were currently included in the EU ETS. Although generally being positive about the scheme, U27, a big car manufacturer, was uncertain about singling out transport as an individual targeted sector for the ETS. From its point of view, freight transport constitutes a rather small fraction of total carbon emissions compared to the heavily polluting sectors addressed by the EU ETS at present, and the overall environmental benefits obtained by including transport into the ETS might not justify the administrative burden and large cost of implementation that it would entail.

To summarise, the analyses conducted from different angles exploring the interrelationships within the initial sustainable solution framework have all been shown to support the statement set out in Hypothesis Four, hence it can be accepted with a considerable degree of confidence. In total, five sets of solutions with synergy have been identified from research participants' sustainable logistics practice; furthermore, understanding of the substitutable solutions and the attitude patterns by various categorisations of solution has been furthered by means of a combination of survey and interview evidence. Overall, the analysis for this hypothesis will provide a sound basis for devising sustainable packages in Chapter Six.

Hypothesis Five: Logistics service providers and logistics service users are similar in their sustainable strategies and practices.

An alternative way of expressing the statement in Hypothesis Five is that LSPs and

LSUs do not behave in an appreciably different manner in sustainable logistics. To provide an overview concerning this assertion at aggregate level, in Section 4.4.1 the chi-square test was employed to 11 solutions individually by logistics group, based on their responses in the questionnaire survey, and complemented by the analysis built upon the quantification of the remaining three solutions whose sample sizes were not adequate for any statistical test. The results were summarised in *Table 4.8*. Only four solutions out of the 11 tested showed statistically significant variations in responses from LSPs and LSUs groups, namely diesel fuel taxation, driver training, supply chain optimisation and reverse logistics; while among the other three low response solutions, urban logistics also displayed a distinctly differing pattern between the two groups. A preliminary analysis was then made of the likely causes for the observed split between the groups.

Looking at the results from quantitative survey analysis, five out of the 14 solutions seemed to be evaluated differently by the LSPs and LSUs, which indicates a certain level of heterogeneity between the two groups, although probably not to a large extent. More in-depth evidence was hence needed in order to determine, through examination of the magnitude of the discrepancies and their causes, whether the preliminary results could be validated or dismissed. Building upon the analysis in Section 4.4.1, the five solutions most likely to be viewed or adopted differently by LSPs and LSUs are examined first, followed by a comprehensive review of the survey and interview evidence for areas where variations are present. Anecdotal cases are also utilised where available.

As revealed in Chapter Four, diesel fuel taxation and reverse logistics are the two solutions which had highly statistically significant variations in the appraisal of their importance by LSPs and LSUs. Major differences exist between these groups, in that

LSPs appeared to be more affected by fuel taxation, whilst more LSUs regarded reverse logistics as an area of great impact. The preliminary analysis had attributed this to the distinctive nature and differing focuses of the core business of the groups, which was reinforced by the results from the second-stage survey. Although the LSPs and LSUs had generated fairly different response patterns regarding their strategies in response to fuel taxation, the cost-effectiveness of it, and substitute solutions for it (see Section 4.5.1), a large part of the variation can be explained as a result of the higher level of exposure of LSPs to the fiscal measure because of their cost structures, in which transport costs formed a sizeable part of total operational cost. According to the interview transcripts, this imbalance in the economic implications of fuel taxation not only results, inevitably, in greater concerns on the part of LSPs, but also has a more profound impact on small and medium-sized operations, which are often operating a lower-margin transport service than the large ones, which can alleviated the fuel cost implications, partly due to economy of scale and their diversified, value-adding logistics portfolios.

As can be seen from the results in Section 4.5.10, the primary source of the difference between LSPs and LSUs in reverse logistics was the number of responses received on this solution from each group, rather than any considerably differing patterns in their attitudes or behaviours. Not only were their responses on the main issues covered in the second-stage survey generally consistent, but the evidence from the interviews also showed no clear sign of differences in their practice. The fact that many LSU interviewees have their reverse supply chain outsourced and managed by LSPs further suppresses the scope for widely differentiating between the behaviour patterns of these groups.

Likewise, a close examination of the main causes of the different opinions on driver training, as established in Section 4.4.1, also points to the very nature of the businesses. As would be expected, the LSPs appeared to attach relatively more importance to driver training than the LSUs do, and this difference lay largely in the greater proportion of responses from the LSPs group. The responses to the issues raised in the second-stage survey from both groups turned out to be fairly similar, with the only divergence of views identified being in motivations for driver training, with LSPs citing fuel efficiency twice as frequently as LSUs.

Supply chain optimisation and urban logistics, on the basis of the survey analysis, would appear to be valued much more highly by LSUs than by LSPs, as the responses received from LSUs group outstripped that from LSPs both in numbers and in ranking. However, the probe into the detailed survey responses on supply chain optimisation presented a mixed picture without explicit patterns on the principle issues, while the extremely small sample on urban logistics limited the scope for comparative analysis between the groups. An overview of the general practices of the interviewee companies as presented in *Appendix Eight* has displayed sufficient evidence from both sides, of the efforts dedicated to optimising supply chain structures and operations, whilst the cases where LSPs were actively involved in sustainable urban logistics operations actually outnumbered those involving LSUs. Based on these observations, although it is obvious that LSUs have attached more importance to supply chain optimisation and urban logistics from the survey results, it is not clear whether this was due to other factors such as business size, industry sector, geographic sphere or sampling techniques applied. Taking the interview evidence into account, there is no conclusive evidence as yet for different behaviours between the two groups.

In an effort to exclude as many other influencing factors as possible when analysing the level of distinction (or consistency) between the LSPs' and LSUs' sustainable behaviours, the approach has been taken of examining and comparing the opinions and practices of 'matched' LSPs and LSUs, i.e. ones with similar operational scales and industry backgrounds. As summarised in *Table 5.4,* the interviewee companies were already clustered into 18 groups for this purpose by sector and logistics role, which facilitated the matching process between the LSPs and LSUs. As all except one of the LSUs clusters were large operations operating fleets of over 100 vehicles, the subsequent comparisons are thus only available between the LSUs and LSPs of this operational scale. Altogether seven LSPs (three of these, since they were serving multiple sectors at large scale, were included in different sector groups) and 12 LSUs, in four industry sectors (namely food, drink & tobacco; chemical; automobile; industrial), were identified as having comparable attributes, enabling investigations to be conducted in these four matched groups. Nevertheless, it turned out that whether one compares their opinions on external sustainable measures imposed on the businesses (such as fuel taxation, road pricing and the ETS), or the practical steps they have taken to mitigate the environmental externalities of the logistics activities (e.g. supply chain optimisation, ICT, alternative fuel and modal shift), neither LSP nor LSU interviewees produced patterns consistent with their peers with the same logistics role, let alone any strategies or behaviours which were discernibly comparable between the two roles. It appears that the attitudes and strategies towards sustainable logistics operations reflect to a large extent the individual company's ethos and values, which are also greatly influenced by the organisation's culture, management structure and key decision-makers' preferences on the specific approaches to tackling environmental issues. More importantly, even with similar attributes at the basic level, the broadly diversified behaviours of the interviewee companies in pursuing sustainability seemed to be more a result of their unique operating requirements and circumstances, rather than of their different logistics roles as LSPs or LSUs. The extremely complex mechanism of sustainable decisions and behaviours determined by the specific logistics structures and conditions will be fully scrutinised in Hypothesis Eight. Therefore, as far as Hypothesis Five is concerned, this part of the analysis is not able to provide evidence for consistent behaviours of LSPs and LSUs in sustainable operations, although it does not, either, support the adoption of markedly different approaches by LSUs and LSPs as a result of their different roles.

Based on the evidences extracted from both the survey and interviews, and the analyses of them, it would appear that with quantitative methods, certain degrees of variations emerged between the two groups in their perceptions on the relative importance of various sustainable solutions. When combined with the qualitative information and comparative analysis, only diesel fuel taxation and driver training illustrated distinguishable variation between the LSUs and LSPs groups, which was likely to have resulted from their different roles in logistics operations. Other observations produced a mixed picture, with no conclusive conviction able to be made regarding the statement in Hypothesis Five. Instead, most of them pointed to a more complex attitude-forming, behaviour-shaping mechanism encompassing potential interactions between the two parties and the unique set of circumstances of individual companies which will be examined in the following Hypotheses Six and Eight respectively. On this basis, even without sufficient evidence to reject Hypothesis Five, it cannot be accepted either due to the absence or deficiency of conclusive evidence in its support. The inconclusive result from this part of the analysis, however, does suggest that logistics role might not be a key factor with material implications in the effectiveness of sustainable solutions.

<u>Hypothesis Six:</u> There is interaction between logistics service providers and service users in sustainable practice.

In a simplified scenario, it can be argued that Hypothesis Five is a result, or reflection, of Hypothesis Six, in that the more active and strong the interactions between LSPs and LSUs in their sustainable practice, the more likely that they would have comparable sustainable strategies and behaviours. Although the possibility of the existence of such a relationship can not be discounted, the actual circumstance was anticipated to be far more complex than a straightforward linear relationship, not to mention the fact that the interactions may take a whole variety of forms, and the intensity or activity level of them is not quantifiable. Therefore, building upon the analysis in Hypothesis Five, this part of the analysis focuses on identifying and illustrating, from various angles, a diversity of interactions between LSPs and LSUs with the support of the evidence collected from both the survey and interviews.

Firstly, the responses to detailed survey questions concerning supply chain optimisation (Section 4.5.4) signify a certain level of potential interaction between the two parties. In identifying the parties involved in, or influencing, supply chain optimisation, 11 out of the 18 LSPs (61%) cited business clients, whereas 15 out of the 27 LSUs (56%) chose 3PLs. Also on the basis of survey evidence, it appears that goods distribution and inbound/outbound transport are the major functions in the centre of supply chain management for both parties, being the areas in which most LSPs' expertise and core competence lie. The most commonly adopted optimisation approaches by both groups showed a large degree of agreement, with streamlining logistics operations, ICT, restructuring of the distribution network, and collaboration being cited by a majority of respondents, implying the possible forms/means that the interactions between LSPs and LSUs might take in practice. Looking at the responses received on ICT implementation, specifically its connectivity (shown in *Figure 4.22*), over half of the companies have inter-firm ICT systems in place, again signifying an active interrelationship amongst the major parties across the supply chain. Even when most of the survey evidence obtained in relation to interactions between LSPs and LSUs could not be shown to point unequivocally to the existence of such a connection (although it could be inferred from the response patterns), the information collected during the interviews is unambiguous in interpreting the formation and characteristics of the interrelationship, which is presented in the following analyses.

On the one hand, in a typical supply and demand relationship between LSPs and LSUs, the environmental awareness of the LSUs has turned out to be subsequently reflected in the LSPs' definition and measurement of the standard and quality of the service provision. With one of its retailer customers renowned for innovation and environmental commitment, P1, for instance, had initiated and driven a series of sustainable measures across its supply chain, including a shared-user service centre, reusable tote cases for the package to minimise package waste, and an electric vehicle in central London which also benefited from congestion charge exemption.

There is a fairly evident tendency on the part of at least large LSUs towards an established, long-term, strategic partnership with one or a few lead logistics providers which are normally leading companies in the logistics industry. A total of 11 out of the 23 LSPs (48%), and 21 of 33 LSUs (64%), were actively involved in such partnerships, with five LSUs currently considering further consolidating their logistics service vendor base. U32 commented that co-operation with fewer trustworthy logistics providers noticeably reduced co-ordination requirements and management issues as communication was made in a more effective and efficient manner. Furthermore, the one-stop-shop solution provided by the leading LSPs enables LSUs to concentrate on their core competence, while still being able to monitor the whole logistics processes with real-time visibility and key performance indicators, backed by the key LSP partners. As will be addressed further in the following analysis, this tendency, observed mainly amongst large businesses, is likely to become more widespread within the context of the economic downturn, which has seen a large scale of consolidation in the highly segmented logistics industry. Compared with the conventional trading relationship based on fix-term or one-off contracts, strategic partnership normally encourages initiatives in developing the companies' competitive advantage in all aspects, instead of merely confining this to short-term economic results, and hence presents more scope for conducting sustainable practice.

On the other hand, in many cases LSPs – with their expertise in best practice, economies of scale, capital-intense assets such as fleet and warehousing facilities, and well established ICT systems – also appear to have offered new scope to LSUs for sustainability that would otherwise have been infeasible for LSUs alone to achieve. For instance, as far as the supply chain and logistics network is concerned, quite a few LSP and LSU interviewees (e.g. P7, P11, U5, U29 and U32) had in recent years, along with their logistics partners, gone through supply chain reviews which led to restructuring or other substantial changes in the distribution network, where the targeted or materialised outcomes of such moves were enhanced operational efficiencies, reduced mileage (and hence reduced carbon emissions) and cost saving. P7, for instance, had acquired and developed a purpose-built warehouse in North England under a contract with one customer in the food sector, located next to its production site. The manufacturer then consolidated all its food warehousing into the new distribution centre in place of the old one which was 30 miles away and required shuttle services between the production site and warehouse. The shuttle transport alone, it was estimated by the interviewee, used to generate about 160,000 kg of CO_2 every year. As a result, the co-operation between the LSP and LSU not only yields cost and efficiency benefits, but also mitigates the environmental impacts. According to the company files provided by P7 on relevant cases with their customers, it has also helped a large glass manufacturer to centralise its nationwide distribution, which had been carried out from each distribution centre individually, resulting in many duplicated routes and much overcapacity. Through co-ordinating the sites it was estimated that the fleet size could be reduced by 20% and the total transportation cost by 25%. The customer is also said to be pleased with P7's negotiating power which leads to better deals in vehicle leasing that would not be achievable given its own operational scale.

As presented in the analysis of Hypothesis One, the ICT infrastructure and expertise of LSPs were often highly valued and leveraged by LSUs in seeking logistics efficiencies. In the same case of P7, its proprietary, integrated transport management systems proved to be adding great value to their customers through optimised route planning and vehicle loading, minimised empty running, and real-time visibility.

For many LSUs, greater cost savings and further efficiency enhancements were also achieved by leveraging LSPs' multiple-user operations, which ensure the maximised resource utilisation and flexibility, benefiting both parties and consequently the environment with minimisation of energy consumption and unnecessary logistics activities. U25 presents a typical example of the LSPs' critical role in enabling and facilitating such interactions with LSUs, and between various LSUs. As a global supplier of polymers and heavy metals, U25 has a long-term contractual relationship with its key LSP, which operates its national distribution centre and manages its primary and secondary distribution across the UK. Through the LSP's own online freight exchange system, spare capacity on the distribution return legs was fully utilised via back-loading, while U25's own fleet and distribution centres were also used for third party storage and delivery. As U25 stated, its LSP provided a platform for independent LSUs from various industry sectors to share spare capacity seamlessly and without compromising quality of service. Since LSPs normally take the lead and play the central co-ordination role in this sort of interrelationship, the economic and environmental credit should without question be granted to them, which seemed to be highly valued by their clientele LSUs as well.

It is also worth mentioning that apart from facilitating the indirect interaction between LSUs through resource sharing, a few large LSPs are also playing a critical part in co-ordinating the smaller operators' activities. In the interview sample this was the case for P1, P12 and P15, who act as lead logistics providers (LLPs), or 4PLs, for some of their customers, which involves managing other LSPs and their service quality on behalf of the LSUs. P15 stated that because of their knowledge of the local and regional market, their customers benefit from their competency in procuring the most appropriate carriers at the most competitive rates. Thus, the interactions amongst LSPs appear to be led and largely influenced by the large operators in the industry, bridging the demands of big LSUs and the supply of small LSPs in the logistics market by selective consolidation of services. From another perspective, this also supports the assertion made in Hypothesis One, in that LSPs of various sizes appeared to be playing different roles in sustainable logistics practice.

Although the vast majority of anecdotal evidence from the interviews supported mutually strengthening interactions of various kinds between the groups, a few interviewees voiced less positive views on the interrelationship. U12 in FMCG, U19 in retail and U32 in the IT sector all expressed their concerns over the performance and commitment of their LSPs. All these three LSUs have their logistics functions partially outsourced to multiple LSPs, where added value was felt to be not always observable compared to in-house operations. The open-book contract, which was highly praised as an effective endorsement for sustainable initiatives by some interviewees (e.g. P1, P7, P13 and U19), in particular LSPs, was a cause for concern from the viewpoint of some LSUs, who perceived it as diverting the focus of LSPs from cost reduction and innovation when adopting more environmentally sustainable approaches. U32 claimed that there were increasing costs arising from its contractors and subcontractors, with unsatisfying levels of service, mainly due to the substandard vehicles and transport equipment of some small LSPs. It was considering taking the transportation function fully in-house to tackle the problem, and it also believed that own-account operation would offer more scope for, and control over, greener practice. As this issue is eventually down to the ability of LSPs to provide value-creating services to the LSUs with cost-effectiveness and mutual trust between the parties, it should not be deemed as counter-evidence for the facilitating role that a healthy interrelationship between LSPs and LSUs can have in a broad sense. Instead, it is more a potential problem that may occur due to mismatched logistics requirements and capabilities during the interactions between LSUs and LSPs, and is hence a factor to be taken into the equation while fostering or maintaining a good relationship between the two parties.

Another external factor that has emerged as having implications for the level of interactions between LSPs and LSUs is the macro-economic environment. During a recessionary period, such as prevailed the research was conducted, contract logistics businesses in most vertical sectors suffered, some more severely than others; this period has seen many LSUs and LSPs (e.g. P1, P13, U3, U10, U19, U21 and U28) reduce contract and subcontract capacities, meaning a decreased level of interaction between LSPs and LSUs. Nevertheless, as P13 and U10 also pointed out, their partnership with key LSPs has been taken to a new level, with both parties working closely together for operational cost-efficiency and tailored, flexible service solutions aligned to the businesses' ever-changing needs. In addition, following restructuring reviews driven by cost reduction motivations in the wake of the economic downturn, several LSUs had actually decided to outsource a greater part of their logistics function, as LSPs were believed, or had proved, to be able to achieve this goal more effectively and efficiently, resulting in increased and intensified interactions between LSPs and LSUs. Overall, although the evidence of the recession's implications for interactions between LSPs and LSUs is largely qualitative, and varies case by case, it is evident that a variety of interactions do exist between the two major parties in logistics industry, and the level and forms of such interaction are constantly changing as a result of a combination of internal and external factors.

To summarise, there is evidence that both sides of the logistics market exert influence on each other in terms of sustainable logistics. The interactions between the two parties take on a diversity of forms and may lead to quite different results in attitude and practice. A great amount of the evidence pointed to economic implications as the major driver behind most interactions, although often with environmental impacts entailed indirectly. Generally, it appears that the LSUs can easily convey their environmental ethos to their LSPs through the trading bond; while there is also abundant evidence to show that in many cases the LSPs were able to take the initiative in impacting sustainable logistics practice positively. Therefore Hypothesis Six can with confidence be accepted. Given that such interactions appeared to be particularly dynamic when substantial economic gains were present, it is highly likely that the cost-effectiveness of a sustainable solution may have a central role in determining its success in practice in logistics operations – a possibility which will be tested in Hypothesis Nine.

5.3.3 Influencing Factors on Decision-Making: Cause and Effect

The focus of this subsection is on finding out the causation of the observed sustainable attitude and behaviour patterns among logistics operations. This builds upon the analysis in Chapter Four and the previous two subsections, particularly Section 5.3.1. In realising and proving the complexity of interwoven factors that determine businesses' decision-making and behaviours in sustainability, this part of the analysis sees the in-depth, qualitative evidence gathered through the interviews being fully used for what it is best at – interpreting observations, identifying the key influencing factors, and explaining cause and effect. Combined with the conclusions of the previous six hypotheses, the analysis in this subsection will complete the picture of how businesses are acting and reacting to their sustainability obligations in the real world, and will hence help to decide what is the best way of influencing their behaviours in the desired direction.

Hypothesis Seven: The perception of the importance of logistics sustainability is not always reflected in the actual practice of companies.

The difference between the perceptions and practices of businesses in sustainable logistics can be explored from two perspectives:

a) whether the perceived importance attached to sustainability is accordingly reflected in the priority given to logistics strategies and operations; and

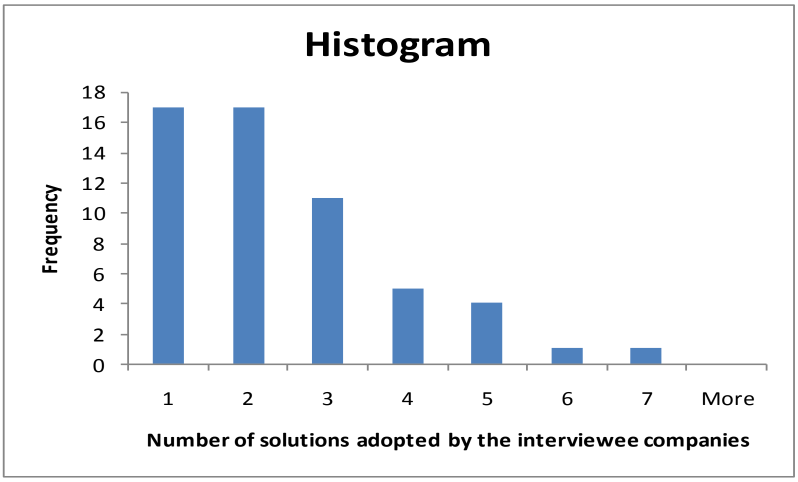
b) whether the perceived impacts of specific sustainable solutions by individual businesses are guiding their practices correspondingly.

As the whole point of testing this hypothesis is to gauge the businesses' actual behaviours in relation to their claimed standpoints, the key in this part of the analysis is to make objective observations (as much as the circumstances permit). Although a better approach for obtaining reliable information on businesses practices is through visits to and observations at the operational fields, this was unfortunately not feasible given the time and resource limits as well as the sample size (i.e. 56 companies) of interview. As an alternative, the interviewee companies were requested to provide information on the sustainable practices they had engaged or still were engaging in, supported by as much detailed figures and facts for the cases as was available. By no means would this method (or even on-site observation) produce an exhaustive evidence-base of all sustainable actions taken by the interviewee companies, but by identifying those areas where the management was aware of, and committed to mitigating the environmental impact of its logistics activities, the objective of testing the assertion in the hypothesis can nevertheless still be attained. The following analysis will take the two perspectives one at a time.

Firstly, as established in the previous analysis for Hypothesis One, although a question about the importance of sustainability was not included in the survey questionnaire due to concerns over respondents being prone to give certain obvious answers, their very participation in the two-stage survey – and particularly the subsequent interviews – indicates to some extent the level of importance that the participant companies attached to the issue. Even keeping in mind all the other factors that could have also contributed to the sample companies' decision to participate, the fact that none of the interviewees thought that sustainability in itself was not a critical issue to be immediately dealt with reinforces the validity of the conclusion that they perceive the issue as being of great significance.

However, the consensus on the high importance of the sustainability issue appeared to be influenced by many other factors, and this led to a variety of forms of behaviours in the companies' logistics operations in practice. As shown in *Figure 5.1*, the sustainable logistics measures taken by the interviewee companies in practice were recorded and subsequently categorised under the framework defined in this research (detailed in *Appendix Eight*), so that the number of solutions employed by the companies can be counted. As a crude indicator, the number of solutions does not give any detail as to the extent to which the companies were committed to specific sustainable practices (i.e. infusion), but from another point of view, it reflects the innovation of and the initiatives taken by the companies in the range of areas that they looked into when seeking environmental performance improvement (diffusion).

Figure 5.1: Distribution of the interviewee companies by number of sustainable solutions adopted in practice



Source: author's interviews

The figure reveals that the Pareto principle applies to our sample in that 61% (34 out of 56) interviewees were taking a maximum of two solutions and 80% (45 out of 56) were employing three or under. In other words, although all the companies in the sample agreed on the great importance of sustainability in logistics operations, the vast majority of them were doing relatively less in exploring the potentials in various areas across the supply chain than the others, in terms of the number of solutions adopted in practice. If the importance and priority they claimed that sustainability had to them had actually been placed on sustainability in their operations, most of the companies would have looked into a variety of areas in order to improve their environmental credentials and would have been able to demonstrate corresponding actions. Therefore, the evidence so far supports the assertion made in Hypothesis Seven from the first perspective, in that the perceived importance of sustainability is not reflected in their behaviours.

Taking the second perspective in further examining the specific actions of individual companies against their perceptions, not only will the statement in Hypothesis Seven be tested, but a more important question will be answered – if the views appear inconsistent with the behaviours, how are they different from each other and what caused this variation? In addressing these issues, motivations or disincentives to take / not take certain sustainable solutions will be investigated, which lays a sound foundation for testing Hypotheses Eight and Nine.

As established in Chapter Four, the perceptions of the importance of logistics sustainability issues by the respondents have been collected through the questionnaire survey, and their actual practice has been explored during the follow-up interviews; the combined evidence provides solid grounding for testing the statement in Hypothesis Seven. The matrix in *Appendix Eight* contains information regarding the perception and practice on the 14 sustainable solutions, with each of the interviewee companies' choice of the top five most important solutions highlighted in yellow, and the actions actually taken marked with dots, so that any discrepancies can be easily identified. *Table 5.8* summarises the frequencies of each solution selected by the interviewee companies as one of the five most influential ones out of the 14 given solutions during the survey, as well as the number of times it was observed in their practices. As the frequencies from both the survey and the interviews were generated from the same sample (i.e. the sample of interviewees), any discrepancy between them would suggest a certain degree of deviation, and the direction of this deviation.

Table 5.8: Comparisons between perceived importance/impact of, and practical actions taken in, sustainable solutions

Ranking	*Solutions*	*LSPs (n=23)*		*LSUs (n=33)*		*Total (N=56)*	
		Perception	*Practice*	*Perception*	*Practice*	*Perception*	*Practice*
1	Diesel fuel taxation	15	***n/a***	14	***n/a***	29	***n/a***
2	Driver training	14	***8***	12	***9***	26	***17***
3	Vehicle design technology	14	***5***	19	***7***	33	***12***
4	Supply chain optimisation	6	***11***	24	***19***	30	***30***
5	ICT	9	***10***	19	***12***	28	***22***
6	Road pricing	9	***n/a***	11	***n/a***	20	***n/a***
7	Alternative fuels	9	***1***	13	***2***	22	***3***
8	Government support	9	***1***	15	***2***	24	***3***
9	Environmental management systems	5	***5***	6	***11***	11	***16***
10	Reverse logistics	6	***4***	14	***8***	20	***12***
11	Modal shift	5	***1***	6	***6***	11	***7***
12	Product/packaging design	8	***4***	7	***4***	15	***8***
13	Inclusion of transport in the EU ETS	1	***n/a***	3	***n/a***	4	***n/a***
14	Urban logistics	0	***2***	2	***3***	2	*5*

Source: author's survey (stage 1) and interviews

As the table shows, most (eight out of 11) solutions were observed with practical implementation by fewer of the sample logistics operators than the number of them who gave it an 'importance vote' in the survey. Of the remaining three solutions, supply chain optimisation managed to merely even out between the frequency of perceived importance and that of the companies having supply chain optimisation processes in place, and this resulted mainly from the LSPs group, with more of them taking actions even while not regarding it a critical area that impacted substantially on their logistics operations, thus offsetting the adverse pattern in the LSUs group.

Environmental management systems (EMS) and urban logistics are the only two solutions which were practised by more participant companies than the number of those who deemed them as of great impact. In the case of EMS, this was mainly a result of the fact that a considerable number of interviewee companies, especially the large ones, have established formal environmental management systems, ranging from company strategies and policies in environmentally responsible logistics operations to accredited certificates such as ISO 14001 and the EU's EMAS. The validation was carried out during the interviews to ensure that the EMS claimed as a sustainable solution actually covered and applied to the logistics operations, and that it was not counted as one if it was merely a more general organisation-wide management tool. Out of the 16 companies with EMS in place, only four of them regarded it as a solution of great impact on their logistics operations, which also means that a majority of the survey respondents (seven out of 11) who attached great importance to the solution were not practising it in reality. In this sense, although EMS was relatively more commonly adopted by the interviewee companies, as a solution ranked lowly in its appreciable impact on logistics operations by the same sample, it indicates that not only might the actual benefits which can be derived from its adoption be very limited, in a logistics function at least, but also that its implementation could also be a challenge for those interested. Either way, the inconsistency between the perceptions and actions regarding this solution is fairly apparent.

As for urban logistics, the extremely small numbers of the samples obtained from both the survey and the interviews, potentially caused by the vagueness of the terminology used in the questionnaire, mean that it is unlikely to make any valid inferences or interpret any patterns as observed, not to mention that case by case there was little similarity in the forms of actual practice in this area, which is a broad field with a diversity of applications.

It is worth noting that the above comparative analysis is only applicable for the 11 solutions within the businesses' control. External influences exerted on the businesses by the other three solutions – namely diesel fuel taxation, road pricing, and inclusion of the transport sector within the ETS – need to be addressed differently and interpreted with caution. Fuel taxation for instance, as discussed in Section 4.5.1, showed some seemingly contradicting responses on attitudes towards the solution, which was likely to be a reflection of the contrast between the actual effectiveness of the solution at macro level and negative/resistant reactions at micro level. Since altogether 29 interviews companies had identified diesel fuel taxation during the first-stage survey as a solution of great impact and 20 had so identified road pricing, discussions were held with these interviewees regarding the solution(s) of their choice. In response to the present diesel fuel taxation, the strategies and actions taken by the interviewee companies largely concurred with those presented in *Table 4.13* on the basis of survey outcomes, with over two thirds of them (21 out of 29) opting for improving fuel efficiencies, driver training and monitoring, and passing on the cost to customers. More profound changes, such as alternative fuel, modal shift and supply chain restructuring were far less commonly employed as responsive strategies to current fuel taxation. This seemed to be especially the case for domestic operations, where the fuel duty is imposed on all operators indiscriminately; a few interviewees did express their concerns over the spiralling fuel price gap between the domestic market and mainland Europe, which exists largely as a result of fuel duty and has greater implications in 'fair competition' under the context of relaxing cabotage regulations within EU. Although the transcripts show that only a minority of interviewees were ready to take more drastic action to improve their productivity and competitiveness in preparing for tougher competition in a free market, overall the evidence pointed to a commonly adopted reactive approach to fuel taxation by most interviewee companies, with prevailing practices such as fuel surcharges and fuel efficiency management remaining unchanged as the main resorts.

In respect of a hypothetical national road pricing scheme and inclusion of the transport sector into the EU ETS, the very existence of a responsive strategy in the businesses is in doubt. Most interviewees who believed that the solutions would be of substantial impact on their operations at the same time failed to see their implementation in the foreseeable future, which greatly decreased their motivation to be proactive. As one interviewee (an LSP) stated, "Quite frankly, businesses are always most concerned about their bottom-line performances, which means survival before sustainability, especially during a recession like this. There are enough problems for them to worry about which are happening now rather than sometime in the future." Although a rather different tone from the voices of the big players with long-term, strategic views in regard to sustainability, this standpoint appeared to be shared amongst other operators who felt the pinch most during the economic downturn.

Also, the evidence revealed that the lack of awareness and knowledge of the ETS was another major issue with the solution. Three out of the four interviewees who regarded it as an influential solution were already covered within the scheme in other industry sectors, and thus had a better understanding of the functionality of the scheme. In spite of that, concerning the inclusion of the transport sector into the scheme, they took various views on its effectiveness, with some thinking it 'absolutely unnecessary' to extend the scheme to include transport, as it was not the major source of environmental impact, being less than that attributable to their core businesses, and others believing that a full scale application covering both freight and passenger transport operations would be appropriate. However, as stressed earlier, with solutions like the ETS which are down at the bottom of the ranking league of importance, the major issue for analysis is the insufficient number of samples to justify the discerning of any patterns or trends from the evidence collected on them. Hence the only conclusive evidence is that there is certainly a lack of impact of the ETS on the practice of businesses' logistics operations thus far.

In summary, the analyses from two perspectives each showed a certain level of disparity between the businesses' perceptions and actual practices in sustainable logistics. On the one hand, the high priority of environmental sustainability as perceived by the participant companies was not matched with a correspondingly high level of movement towards achieving sustainable goals. On the other hand, the importance and impact attached to specific sustainable solutions in various areas was not always reflected in their adoption in operations. Therefore, the evidence supports the acceptance of Hypothesis Seven, with the causes of the difference between attitudes and behaviours being further explored in the two remaining hypotheses.

Hypothesis Eight: The factors affecting the choice of sustainable measures are complex and depend upon the unique circumstances of each company.

In Section 5.3.1, three attributes of logistics operations were examined for their impact on businesses' sustainable practices: business size, industry sector and geographic sphere; these were tested in Hypotheses One to Three respectively. The hypotheses were accepted to varying degrees, indicating that all three elements had to some extent contributed to the behaviour patterns observed within the sample companies. Hypothesis Five tested logistics role as another potential factor, with no definite conclusion being drawn. However, throughout the analysis thus far, the pictures revealed often contained mixed information suggesting the existence of many more factors to be taken into consideration. The necessity of conducting an interrogation specifically addressing this issue was especially highlighted in Hypothesis Five, when a comparative study was carried out between the LSPs and LSUs groups in the matched clusters, identifying great disparities not only between the two groups, but also among companies within the same group.

Given the complexity of the interwoven factors affecting companies' sustainable logistics behaviours, an effective approach to detecting and illustrating the intertwined elements, as well as their combined influence on individual companies and supply chains, is a comparison analysis between closely matched companies which have similar business attributes at the basic level. To serve this purpose, *Tables 5.9* to *5.14* show a detailed comparison within five groups of companies in various focus industry sectors respectively, covering key attributes and logistics features that may have an impact on their sustainable strategies and practices. Instead of attempting a fully comprehensive analysis, this section aims to provide sufficient evidence to test the statement set out in the hypothesis whilst identifying some of the major causes of differing patterns other than those already discussed. As this part of the analysis requires a detailed understanding of the specific circumstances of the particular company and the supply chain in which it is involved, it is primarily based on the information collected from the interviews.

Table 5.9: Comparative analysis for Group One (LSUs – Retail – fleet size over 1000)

	Company U6	Company U14
Product/service	Supermarket chain	Supermarket chain
Operational scale	Around 2000 goods vehicles	Around 1200 goods vehicles
Logistics network	27 DCs (most in-house)	21 DCs (5 in-house, 16 outsourced)
Sustainable strategies	Strategic plan with long-term vision (40-year perspective)	Short-/medium-term objective (five-year perspective)
Sustainable solutions of great impact	Supply chain optimisation EMS Road pricing Reverse logistics ICT	Diesel fuel taxation Supply chain optimisation EMS Alternative fuel Driver training
Sustainable practice	SC optimisation: backload through partnership Vehicle: fleet upgrade from single decker to double decker RL: reduce, reuse, and recycling Modal shift: rail, waterways (canals) ICT: carbon auditing system; electronic trading system Energy-saving techniques; renewable energy AF: electric and hybrid vans	SC optimisation; relocate DCs; sustainable supplier programmes Fuel efficiency device on existing fleet RL: divert waste to biomass plant Modal shift: road to rail Reduce and redesign packing ICT infrastructure development; MIS system renewal AF: electric vans (recently expanded); LBM(trial)

Source: author's interviews

As leading high-street supermarket chains in the domestic market, U6 and U14 turned out to have quite different logistics attributes, both in terms of operational scale and distribution management. U6's goods vehicle fleet size is almost double that of U14's. While U14 had most of its distribution centres (DCs), as well as its online business operations, outsourced to logistics providers, U6 was keeping most of its logistics functions in-house and only outsourcing certain non-food segments (e.g. clothing) and online ordering fulfilment to a few logistics specialists. Just before the interview, U6 had taken a substantial proportion of its outsourced activities back in-house following a supply chain review. The two companies also have differing views on their sustainable strategies, with U6 appearing to have a more far-reaching blueprint, leading into 2050. Bearing all the variations in mind, however, as *Table 5.9* shows, the two companies display a high degree of similarity in regard to their perceptions and adoption of sustainable measures. It would appear that apart from the intensive exposure of the retail sector to general public scrutiny, peer pressure from competitors had also acted as an effective catalyst for innovative sustainable initiatives. And this mechanism seemed to have performed well in helping companies to benchmark their environmental conduct against the best practice in the sector.

Table 5.10: Comparative analysis for Group Two (LSUs – Chemical – fleet size around 100)

	Company P1	Company P10
Product/service	Petroleum products and industrial gas	Oil and biofuel
Logistics network	13 DCs; over 200 deliveries/day; 90 tanker vehicles	3 storage facility; over 400 filling stations; >100
Operational characteristics	Stable volume across the full range of products (over half being bulk distribution)	Demand fluctuation by promotional activities and seasons
Logistics arrangement	LSP's own fleet	LSU's leased fleet, LSP's drivers; with additional LSP's vehicles to cope with volatile demand
Operational priorities	Cost leadership and operational efficiency	Demand forecasting and inventory management
Sustainable strategies	Emphasis on health and safety issues for the sector	
Sustainable solutions of great impact	ICT Diesel fuel taxation Driver training SC optimisation Road pricing	Diesel fuel taxation Alternative fuels Vehicle design Modal shift SC optimisation
Sustainable practice	ICT: on-board communication systems Continuous driver training and qualifying programme Environmental auditing and action plan Electric vehicle (small-scale, not in chemical sector) Trailer design with increased capacity	Modal shift: rail tank & barge In-house driver training (specialised in petroleum operation) & incentive schemes SC optimisation: vehicle routeing & scheduling

Source: author's interviews

It was revealed from the survey data that the two LSPs P1 and P10 were both operating distributions of petroleum-related products for their customers in the chemical sector. Although the overall business scale of P1 is considerably larger than that of P10, in the oil segment they had comparable sizes in terms of the goods vehicle fleet in operation. *Table 5.10* shows that although these two companies were well matched at a basic level, under closer examination they presented very different network structures, logistics characteristics and distribution requirements, which, at least in part, resulted in their differing assessment of the sustainable solution set and behaviours in practice. It is noticeable that in spite of differing in most aspects, both companies had in common the priority for their sustainable strategy, namely the health and safety issues applying throughout the whole supply chain, including handling, storing and transporting processes. It again reinforces the conclusion for Hypothesis Two, in that industry sector is one of the factors impacting on businesses' sustainable practice.

Table 5.11: Comparative analysis for Group Three (LSPs – Express – fleet size over 1000)

	Company P14	Company P15
Product/service	Domestic and international parcel deliveries	B2B, B2C express services & supply chain solutions
Logistics network	About 180 depots across UK	Over 200 depots across UK
Position in SC	Downstream	Upstream & downstream
Sustainable strategies	Responsible corporate citizen	Market leader; long-term corporate governance
Sustainable solutions of great impact	SC optimisation Diesel fuel taxation ICT Government support EMS	Vehicle design Road pricing Government support Diesel fuel taxation Alternative fuel
Sustainable practice	ICT: global network, handheld computer with cellular technology EMS: short- to medium-term strategies and goals SC optimisation: capacity adjustment; reposition; collaboration Packaging: recycled/recyclable packaging in place of plastic ones	RL: reduce waste EMS: well-established long-term (10-year) goals SC optimisation: organisational restructuring; global alliance UL: city consolidation centre Vehicle: quiet, fuel-efficient model / fleet upgrade

Source: author's interviews

P14 and 15, as two large competing international express and logistics providers operating more than 1000 goods vehicles in the UK, had both undergone severe volume contractions during the recession, particularly in air cargo relative to the road segment. Both companies had taken steps to rationalise their air freight capacities, with P14 switching to promoting low-cost, time-insensitive road services amongst its customers to "better adapt to the market demand". Although the environmental implications of this trend during economic downturn are not straightforward, and depend on the scope of the resulting modal shift across the whole industry, it clearly signifies the economic environment as an influencing factor on the industry's sustainable performance.

Even with comparable operational attributes and common market conditions, as shown in *Table 5.11*, P14 and P15 had employed quite differing sustainable strategies and measures in their operations. Having had a history of adopting climate-change-related strategies over years, and with a vision of taking the lead in environmental management, P15 was convinced that good corporate governance in respect of carbon emissions would help the company to stay in a better position to meet the challenge of increasing carbon prices. Through setting its own CO_2 efficiency goals for the next ten years across the entire company, including its subcontractors, P15 was initiating the establishment of a comprehensive carbon monitoring and reporting system to maintain the momentum of its sustainable development. Taking a different approach, P14 tended to set more specific objectives achievable in the short- or medium-term, such as cutting their emissions by a certain amount by 2010 through eliminating printing and posting paper invoices; and using recycled or recyclable packaging materials instead of virgin plastics to reduce waste, energy consumption in producing the packaging, and the environmental impact. The differences in strategies and approaches between the two operators seemed to be influenced most by group culture and policies, with varying definitions of the roles the companies were expected to take in sustainability (i.e. a leading role with competitive advantage, or a compliance role of 'responsible corporate citizen').

Table 5.12: Comparative analysis for Group Four (LSUs – FDT – fleet size over 1000)

	Company U10	Company U13	Company U19
Product/service	Frozen food & ready meal	Bread, cake, dessert & food ingredients	Groceries
Logistics network	Large vendor base; nearly 2000 daily delive	Over 20 production sites and 60 distribution	Over 2000 daily deliveries directly to stores
Transport equipment (UK distribution)	Outsourced to multiple LSPs	In-house operations	60% in-house; 40% Dedicated haulier
Position in supply chain	Upstream and downstream	Upstream, mainly distributed to retailers' central DCs	Upstream and downstream
Sustainable strategies	Short-term (3-year) target and assessment with carbon emission measured in both absolute and relative terms	Short-term targets relating to food miles; more focused on marketplace measures and community initiatives	Five-year plan for carbon neutral operations including its customers and suppliers
Sustainable solutions of great impact	Vehicle design	EMS (to be implemented)	Supply chain optimisation
	Diesel fuel taxation	Vehicle design	Road pricing
	Government support	ICT	Supply chain optimisation
	Product/packaging design	Modal shift	Alternative fuel
	Alternative fuel	Driver training	Driver training
Sustainable practice	Energy-efficiency improvement: energy-intensive refrigeration equipment	SC optimisation: consolidating supply chains into three key divisions based on their	Information and awareness compaign
	Collaboration with external partners such as WRAP, Carbon Trust etc.	Government support: food waste reduction campaign funded by WRAP programme	EMS: ISO 14001 for environment and OHSAS18001 for health and safety
	Sustainable sourcing: suppliers specification (e.g. EMS for farms)	Sustainable procurement from certified suppliers, local sourcing, product labelling for	Modal shift & RL: waterway (canal) for waste, refuse and recyclables;
	Vehicles fitted with Microprocessor control system & hush kit	ICT: vehicles fitted with telematics to monitor the vehicle's engine performance, fuel consumption and driver behaviour.	SC optimisation: local sourcing & production, reduce air freight
		National in-house driver training programme	Alternative fuel: trial on pure plant oil

Source: author's interviews

Three large LSU companies, being U10, U13 and U19, were identified in the food, drink & tobacco (FDT) sector as having similar operational scope (i.e. operating more than 100 goods vehicles for distribution) and geographic sphere (i.e. logistics activities being primarily at a national scale, with a minority being international –

import/export). Again, the detailed information in respect to other major business attributes, along with the similarities and disparities in their perceptions and behaviours in sustainable operations, have been highlighted in *Table 5.12* for comparison purposes.

It is clear from the table that the three companies, although all big players in the food sector, varied considerably in their product and service portfolios. U13, for instance, has a comprehensive distribution network established mainly for servicing multiple retailers' central distribution centres; while U10 and U19 both have a large number of consignments delivered directly to stores and restaurants. This variation in most of the attributes is reflected in their broadly differing perceptions and practices in sustainability, although consistency can be identified in certain areas. All three companies have relatively short-term carbon-saving targets (three to five years) specified, with measurable indicators set against a baseline year. And there is consistent prevalence of consumer- and community-oriented initiatives across the three companies, reinforcing the associations between sectors and sustainable behaviours tested in Hypothesis Two (Section 5.3.1). Supplier verification appeared to be another common approach by which the companies committed themselves to sustainability, with all the companies having it in place. However, as a frozen food and ready meal producer with energy-intensive operations, it is noteworthy that U10 has invested considerably in energy-efficiency improvement by using the latest technologies and equipment. U13 has been leveraging the complete control that it has over its own logistics operations, with fundamental restructuring and consolidation of its multiple parallel supply chains, and national in-house driver training programmes backed by telematics fitted on vehicles. Taking the opportunities presented by miscellaneous grocery products and the flexibilities in its partially outsourced distribution network, U19 has been actively seeking alternative solutions for more sustainable transport. Having completed trials using various alternative fuels, it is experimenting on an inland waterway for its reverse logistics operation while cutting the amount of food transported by air.

Table 5.13: Comparative analysis for Group Five (LSPs – FMCG – fleet size over 500)

	Company P12	Company P16
Product range	High-street fashion and clothing (men and women)	High-street and designer women's clothing,
Capacity	3 million garments per month	Over 4 million garments per month
Storage	50% hanging garment storage, 50% carton storage	70 % hanging; 30% carton
Position in supply chain	Upstream and downstream	Upstream and downstream
Sustainable solutions of great impact	Diesel fuel taxation Road pricing Vehicle design technology Modal shift Inclusion of transport in the EU ETS	Diesel fuel taxation Alternative fuel Government support Driver training Vehicle design technology
Sustainable practice	Cardboard and polythene recycling Reverse logistics process revamped and IT system upgraded Back-hauling of returned goods & packaging ICT: RFID, automated warehousing	Recycling hangers, totes and packaging materials Shared-user distribution network & facilities Trial on electric vehicles successfully completed ICT: voice-picking, WMS system EMS: ISO 14001

Source: author's interviews

P12 and P16, as two logistics providers active in the fashion industry, have great commonality in many aspects, as illustrated in *Table 5.13*. Both LSPs provide a comprehensive range of services, from pre-retailing services, warehousing and quality control to inspection, pick and pack, and distribution. Delivering consignments to both major retailers / department stores and individual consumers via hub-and-spoke networks, the two companies operate their fleets with specialist garment carrier trailers and on-vehicle satellite tracking, providing real-time visibility. Although displaying widely differing assessments of the sustainable solutions' impacts, which is likely to be a reflection of the general opinions held on multiple sector logistics operations rather than that specifically addressing the fashion industry, there is more consistency in their sustainable practices that are undertaken particularly for the sector. (In validating the comparative analysis, only the sustainable measures adopted by the two LSPs for the sector are listed in *Table 5.13*.) ICT and automation have emerged as one key element across both forward and reverse fashion supply chains, which normally feature global sourcing, a high turnover rate, seasonality and time-critical distribution. As a result, the information systems and automation technologies have been widely applied in the sector to meet the demanding needs of accurate inventory management, efficient and cost-effective warehousing, short lead-time order fulfilment, and fully capitalised capacity. Apart from operating dedicated central DCs on behalf of some customers, both companies were exploiting the opportunities and efficiencies of multi-user consolidation centres across various customers, and were able to share with them the benefits reaped.

Overall, the evidence from this comparative analysis of the five groups of logistics operations covering LSP and LSU companies in the retail, chemical, express, food and FMCG (fashion) sectors can be summarised by four major observations:

1) There were consistent attitudes and practices in sustainability across some logistics operations which had great variation in most of the attributes. The two LSUs in the retail sector displayed considerable differences in logistics operations, whilst their assessment of the sustainable solutions, and the measures that they took in practice, turned out to be highly comparable.

2) The differing characteristics of supply chains did appear to result in variations in sustainable opinions and behaviours. The seemingly ‘matched’ LSPs group in the chemical sector actually varied in most aspects of their logistics operations, and unsurprisingly had quite differing opinions about and behaviours in sustainability. In a similar vein, the three LSUs in the food sector, which had crucial differences in their logistics operations, also displayed a variety of sustainable practices, although a certain degree of similarity could be seen in their market-oriented strategies.

3) Logistics operations which resemble each other in many respects may adopt

similar sustainable strategies and take similar actions, as is the case with the group of two LSPs in the fashion industry.

4) Most importantly, the logistics operations with commonality in many respects may differ widely in both views and conduct regarding sustainability. The two LSPs providing express services were similar in many logistics features, yet their strategies and practices in sustainable logistics had noticeable differences.

Combining the four observations above provides sufficient evidence in support of Hypothesis Eight, suggesting that the critical factors impacting on businesses' sustainable decisions and behaviours should not be applied in isolation. The formation of sustainable strategies at company level is determined by a set of unique circumstances and conditions, and is subject to change when the circumstances change. Therefore, Hypothesis Eight holds on the basis of the evidence.

Hypothesis Nine: The choice of sustainable policies adopted by companies is highly related to the cost-effectiveness of the solutions.

Amongst all the factors that were proved to have impacts on businesses' sustainable decisions and actions throughout the analysis in this research, the statement in this hypothesis singles out cost-effectiveness as one of the most critical determinants in decision-making process. This analysis consolidates much of the quantitative evidence from the questionnaire survey, which was discussed in depth in Chapter Four, in addition to the qualitative analysis of the interview transcripts with reference to the supportive evidence from previous hypotheses.

Building upon the ranking results of the 14 sustainable solutions by their impact on logistics operation, Hypothesis Four examined the patterns using various classification approaches. It was highlighted that the solutions with direct cost implications or substantial efficiency improvement benefits were highly appraised by the respondent companies. Of the top six solutions regarded as being of greatest impact on the businesses, four aim primarily at enhancing operational or fuel efficiencies (i.e. driver training, vehicle design technology, supply chain optimisation and ICT), which subsequently have a positive effect on economic performance as a result of increased productivity or reduced cost. With the other two solutions, namely diesel fuel taxation and road pricing, both having an immediate impact on businesses' bottom lines, the overall pattern clearly supports the primary significance of cost-effectiveness of sustainable solutions on businesses' strategies and behaviours.

Adding to the general views on sustainable solutions revealed by the information collected in stage 1 of the survey, the questionnaire for stage 2 focused specifically on exploring the respondents' perceptions of those solutions based on their choices, their attitudes towards them, and their actual practice in those areas (see Section 4.5). For each of the solutions, the issue of cost-effectiveness was addressed where possible, providing a reliable and comprehensive source for evidence needed in testing this hypothesis. For most solutions, respondents were asked to assess the overall benefits to their businesses derived from implementing the solution, against the cost of implementation. Although only a crude indicator, given that certain solutions are actually thematic categories themselves consisting of various specific measures with varying attributes and performance (whether environmental or economic), the main purpose of this question is to provide a consistent measure for comparing the perceived cost-effectiveness of various sustainable solutions considered in their broadest sense. As summarised in *Table 5.14*, the proportion of the respondents (in the LSPs and LSUs groups individually, and combined) who believe that the overall benefits outweigh the cost incurred by each solution was calculated, along with other evidence that emerged from the second-stage survey which pointed to the critical part played by cost-effectiveness concerns in the companies' decisions regarding particular solutions. On the basis of all the survey evidence, the last column lists the conclusions made for each of the 14 solutions in regard to the assertion in Hypothesis Nine (H9 in the table).

Table 5.14: Overview of cost-effective evaluation on the 14 solutions by survey respondents

	Sustainable Solution	Cost-effectiveness			Other survey evidence for the importance of cost-effectiveness (* for positive, # for negative)	Conclusion for H9
		LSPs	LSUs	Combined		
1	**Fuel taxation**	30.3%	38.1%	33.3%	** (section 5.5.3 & 5.5.6)	Accept
2	**Driver training**	74.2%	61.1%	69.4%	* (section 5.5.2)	Accept
3	**Vehicle design**	N/A	N/A	N/A	*, # (section 5.5.3)	Accept
4	**SC optimisation**	94.4%	88.9%	91.1%	* (section 5.5.4)	Accept
5	**ICT**	69.6%	90.5%	79.5%	*, # (section 5.5.5)	Accept
6	**Road pricing**	5.0%	6.3%	5.6%	—	Accept
7	**Alternative fuels**	31.6%	53.3%	41.2%	* (section 5.5.6)	Accept
8	**Government support**	42.9%	55.0%	50.0%	*, # (section 5.5.8)	Accept
9	**EMS**	70.0%	66.7%	68.4%	*, # (section 5.5.9)	Accept
10	**Reverse logistics**	100.0%	64.7%	73.9%	*, # (section 5.5.10)	Accept
11	**Modal shift**	N/A	N/A	N/A	**, # (section 5.5.11)	Accept
12	**Product/packaging desig**	71.4%	60.0%	66.7%	—	Accept
13	**ETS**	N/A	N/A	N/A	—	Inconclusive
14	**Urban logistics**	N/A	N/A	N/A	## (section 5.5.11)	Accept

Source: author's questionnaire survey, stage 2

As can be seen from the table, eight out of the ten sustainable solutions with proportion figures available could be deemed as cost-effective to various degrees, with the percentages of respondents holding this view greater than one third. (In replying to the cost-effective question, the respondents had three options to choose from: overall benefit outweighs cost, overall cost outweighs benefit, or not sure.) These results were further supported by the evidence that emerged from other questions in the second-stage survey, such as cost implications being one of the top drivers (i.e. positive cost-effectiveness) or disincentives (i.e. negative cost-effectiveness) for adopting the solutions. Combining the direct and indirect survey evidence, the eight solutions – together with vehicle design, modal shift and urban logistics, which provided only indirect but nevertheless considerable and clear evidence for the great impact of cost-effectiveness – have all been shown to support Hypothesis Nine.

It is worth addressing diesel fuel taxation and road pricing as two special cases, as unlike the other solutions, they were both perceived by respondents as having fairly low cost-effectiveness. In Chapter Four, this was extrapolated to be a reflection of the resistant attitudes towards such fiscal instruments that exert financial pressure on businesses, rather than the true cost-effectiveness of the macro measures. The fact that both solutions were highly ranked amongst the 14 solutions evidently indicates their great effectiveness. With the cost-effectiveness of both solutions being high or low, the companies in the logistics industry certainly have been or would be impacted profoundly, which justifies the acceptance of Hypothesis Nine.

Sufficient evidence to support Hypothesis Nine was also identified in interview transcripts. During the analysis for Hypothesis One, sustainable logistics practices appeared to vary by business scale, partly due to the cost implications of certain solutions, such as ICT, environmental management systems and alternative fuels. It was also revealed that environmental credits often came second in terms of their importance to cost and efficiency benefits to most companies, in particular for small and medium-sized businesses. The analysis of Hypothesis Two highlighted the link between the strong market-orientation feature of certain sectors and the high-profile sustainable conduct observed in those sectors, implying sustainable practices driven by economic performance. Similarly, the linkage discovered between supply chain optimisation and national operations when examining Hypothesis Three turned out to be largely a result of maximum cost reduction and service improvement, again reinforcing the impact of cost-effectiveness that cannot be underestimated.

Looking at the LSPs and LSUs groups, not only did they present fairly comparable outcomes in evaluating individual sustainable solutions' cost-effectiveness according to *Table 5.14*, but the evidence from the interviews (see Hypothesis Five) only reinforced the conclusion, in that even for the few solutions for which there were varying patterns between the two groups, such as diesel fuel taxation and driver training, the major reason behind the divergence in their views and actions was the difference in logistics roles, specifically cost structures, with logistics-related cost constituting a far more substantial part of the overall cost for LSPs than for LSUs. The testing of Hypothesis Six provided more anecdotal evidence of how LSPs and LSUs are interacting with each other in the areas that yield most cost benefits and gains in sustainability, exemplifying the top priority given to cost-effectiveness by many interview companies. The comment by one LSP's quoted in Hypothesis Seven explicitly confirmed the prioritisation of the cost initiatives over sustainability by many companies in the logistics industry, again emphasising the central role of cost-effectiveness.

In summary, there is abundant evidence to show the paramount influence that cost-effectiveness as a critical factor is having on businesses' sustainable strategies and practices. The analysis also revealed that the cost-effectiveness of specific sustainable solutions or measures would have a great impact on their adoption and prevalence amongst operators. Therefore Hypothesis Nine can be accepted with a considerable degree of confidence.

5.4 Specialised Logistics Sectors

The constitution of specialist logistics services in the interview sample was summarised above in *Table 5.3* (Section 5.2). The term 'specialist logistics services' covers all alternative freight transport services, i.e. other than standard road haulage, in addition to the express sector, which has its own distinctive logistics attributes with a relatively high proportion of operations in B2C (business-to-consumer) and C2C (consumer-to-consumer) trading, involving the distribution of a large quantity of geographically dispersed, time-definite, relatively small orders via comprehensive networks of multiple-transport modes. Primarily due to the very limited samples obtained for each specialist sector, it is not the intention of this section to draw generalised conclusions about sustainable logistics attitudes or practices from the evidence base, but rather to provide some valuable insights into the current status, along with some experiences in and challenges facing these sectors.

According to the transcripts of the interviews with the three express service providers and the three companies that are using courier services on a large scale (all distributing over 50% of their freight volumes via one or more couriers), the operators from this sector were experiencing the pinch during the economic downturn like other LSPs, which consequently "forced" them (as one of them put it) to place cost reduction before sustainability during this period. Although most of the cost-cutting measures taken by the couriers were aimed at "matching their resources/capacities to economic conditions", hence reducing logistics activities, this is more of a reflection of the coupling relationship between logistics and the economy rather than evidence for a sustained trend towards sustainable operation. However, certain cost-control measures that they have adopted do present long-term environmental benefits; these include streamlining the logistics structure; seeking closer partnerships or alliances with other operators; retiring old goods vehicles, ships or aircraft with high maintenance costs, lower fuel efficiency and poor environmental performance; and further development of multi-user network solutions to replace dedicated services. It would appear that, compared with other standard LSPs, various forms of co-operation are more common amongst express operators at both small and large scale, which provides a platform for them to "exchange volumes" on a greatly extended network. The preliminary findings pointed to the direction for future research and case studies on the express sector in an effort to increase the awareness and application of the successful co-operative operation models amongst other LSPs within the industry.

The shipping sector, with eight service providers and 11 users in the interview sample, has also seen cost-saving measures and geographical restructuring of its activities (e.g. network optimisation, suspension of certain line services, revised port rotations) being widely adopted during the economic downturn in response to the sharp reduction in freight rates and volumes. A number of operators mentioned that the severity of declined volume in the shipping market had resulted in many vessels (normally the older ones) being taken out of service in an effort to restore the shipping rate, which led to the overall reduced level of activities. However, none of them believed that the reduced supply would be sustained, especially at the cost of service level and quality. Other observed practices that may have long-lasting effects on environmental sustainability include a pronounced trend towards fuel consumption reduction and fuel efficiency improvement (e.g. reducing vessel speeds, or 'slow steaming', which also substantially reduces CO_2 and NOx emissions), further consolidation (or alliance) of the carriers, higher utilisation factors through active capacity rationalisation (e.g. using fewer ships and instituting additional ports-of-call) and EMS standards (e.g. an ISO-certified vessel fleet). Low-carbon ship design technologies were regarded as the key solution to future sustainability by eight interviewees, while infrastructure development was cited by another five. It might be worth noting that with the ongoing development of port infrastructures – whether redevelopment and construction of new terminals at existing ports, or building up new container ports – the current issue of concern with ‘overcapacity’ might present real opportunities for shipping to play an increasing role in modal shift in the long term.

Collectively eight interviewees, as either service providers or users of intermodal services, provided limited information regarding sustainable practices in this type of operations. Apart from the issues with alternative modes involved in intermodal transport that were discussed earlier, the major high-priority issue would appear to be increasing the prevalence and market share of intermodal services, as the few LSUs (15% of the interview sample) were only using the service for less than 10% of their total cargo volumes. Three service users (out of five) stressed during the interviews that they would consider switching more traffic to intermodal transport if the service could be provided seamlessly end-to-end, with a service level and cost performance at least comparable to road haulage, suggesting that the major obstacle contributing to the unpopularity of intermodal transport is interconnectivity (and related factors).

To summarise, cost management / productivity improvement has been the theme for most companies in specialist logistics sectors when considering weathering the downturn. Environmental benefits were yielded partly as a result of the ongoing network rationalisation, capacity adjustment, optimised asset utilisation and closer co-operation, with some of these measures more positive in term of sustainability than the others.

5.5 Summary

This chapter has analysed and tested each of the nine hypotheses in turn, incorporating the in-depth information gathered from the interviews with the questionnaire survey results. *Table 5.15* summarises the outcomes of the testing of each hypothesis.

Table 5.15: Summary of hypothesis testing results

	Hypothesis	Testing Results		Conclusion
		Quantitative Analysis	Qualitative Analysis	
Association	***Hypothesis One*** : Sustainable logistics practices vary by business size.	Accepted	Partially accepted	Accepted
	Hypothesis Two : Sustainable logistics practices vary by industry sector.	Inconclusive	Accepted	Accepted
	Hypothesis Three: Sustainable logistics practices vary by the geographic scope of the operation.	Inconclusive	Accepted	Partially
Interrelation	***Hypothesis Four:*** There are interrelationships among certain sustainable solutions.	Partially accepted	Accepted	Accepted
	Hypothesis Five: Logistics service providers and logistics service users are similar in their sustainable strategies and practices.	Partially accepted	Inconclusive	Inconclusive
	Hypothesis Six: There is interaction between logistics service providers and service users in sustainable practice.	Partially accepted	Accepted	Accepted
Causation & Implementation	***Hypothesis Seven:*** The perception of the importance of logistics sustainability is not always reflected in the actual practice of companies.	Accepted	Accepted	Accepted
	Hypothesis Eight: The factors affecting the choice of sustainable measures are complex and depend upon the unique circumstances of each company.	N/A	Accepted	Accepted
	Hypothesis Nine: The choice of sustainable policies adopted by companies is highly related to the cost-effectiveness of the solutions.	Accepted	Accepted	Accepted

Source: compiled by the author

Building upon the analysis in Chapter Four and the hypotheses testing in this chapter, together with the findings from the literature review, the main research objective can now be fulfilled through the construction of effective sustainable solution packages. This will be addressed in the next chapter.

CHAPTER SIX: CONSTRUCTION OF SUSTAINABLE SOLUTION PACKAGES

6.1 Introduction

The analysis in Chapters Four and Five not only revealed the attitude and behaviour patterns of logistics operations in sustainability, and the factors which have caused or contributed to the observed patterns, but more importantly, through testing the nine pre-constructed hypotheses, enabled a better understanding to be developed regarding the initial framework of the 14 sustainable logistics solutions. Drawing upon previous analysis and hypotheses-testing results, together with the findings from literature review, this chapter further develops the initial framework into various custom solution packages for different scenarios and operation types with enhanced effectiveness, practical feasibility and efficiency.

6.2 Construction of the Solution Packages

The analysis results and the conclusions drawn in Chapter Four and Five related to the actual or potential performances of the solutions have been summarised in *Table 6.1*. Each column following the solutions presents one key performance indicator (KPI) that has been evaluated, including effectiveness, cost-efficiency and level of engagement with each solution by logistics operators. The definitions and evaluation applied to these indicators are now dealt with one by one.

Table 6.1: Summary of key performance indicators of the initial 14 solutions (business perspective)

Rank	*Solutions*	*Effectiveness*	*Cost-Efficiency*	*Practicability (business perspective)*
1	Diesel fuel taxation	Very high	Negative	*(Reactive)*
2	Driver training	Very high with LSPs	Positive	Underperforming
3	Vehicle design technology	Very high	Mixture	Underperforming
4	Supply chain optimisation	Very high with LSUs	Positive	Well-performing
5	ICT	High	Positive	Underperforming
6	Road pricing	High	Negative	*(Passively reactive)*
7	Alternative fuels	High	Mixture	Extremely underperforming
8	Government support	High	Mixture	Extremely underperforming
9	EMS	Medium	Positive	Well-performing
10	Reverse logistics	Medium with LSUs	Positive	Underperforming
11	Modal shift	Medium-Low	Mixture	Underperforming
12	Product/packaging design	Low	Positive	Underperforming
13	ETS	Low	Negative	*(Passively reactive)*
14	Urban logistics	Low	Negative	Well-performing

Source: author's survey (stage 1 and 2) and interviews

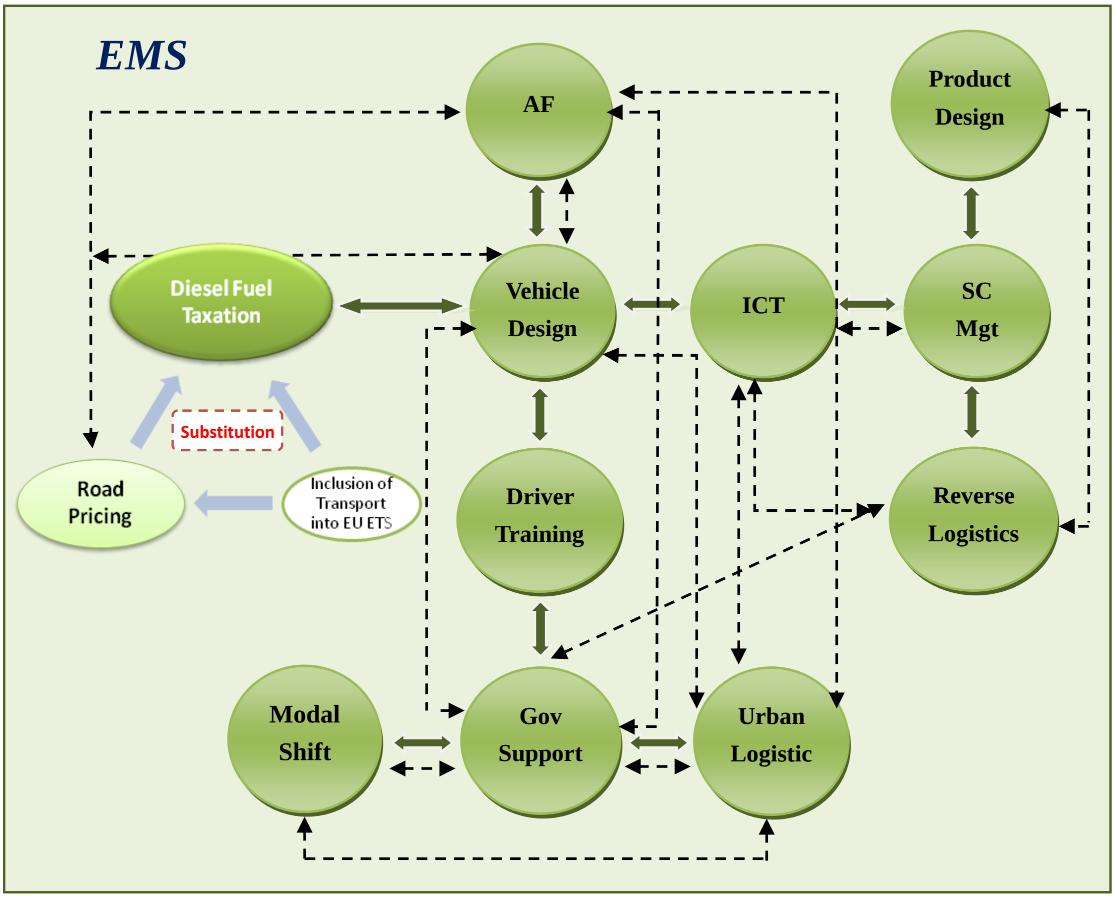
Firstly, the evaluation of the effectiveness of the solutions, as summarised in the table, was derived from the perceived impacts of individual solutions on the participant companies' logistics operations (detailed in Section 4.3). The evaluation follows the logic that the greater impact a solution has on logistics operations, the more effectively it is able to improve environmental sustainability through altering operators' behaviours. Since the sum of weighted frequencies was employed as an appropriate measurement for this indicator, the evaluation reflects both the comprehensiveness of the solutions' spheres of influence (i.e. the proportion of respondent companies selecting the solution) and the relative magnitude of their effects on businesses (i.e. the ranking of the solution in terms of their impacts by the respondents). Therefore, in a broad sense, the results provide valuable insights for estimating and comparing the actual environmental benefits able to be achieved by individual solutions in practice.

Secondly, during the testing of Hypothesis Nine, 13 of the 14 sustainable solutions had considerable survey evidence in support of the theory that their cost implications were a critical factor in their adoption and implementation, which necessitates the gauging of the cost-efficiency of individual solutions in order to provide for the construction of the solution packages and their effective implementation (see *Table 5.14)*. Combined with the interview evidence, the assessment of the sustainable solutions' cost-effectiveness can be conducted in a qualitative manner, i.e. by identifying whether they are generally positive in terms of cost-effectiveness or not. The survey evidence on this issue was identified through the responses to the survey question as to whether overall benefits of each solution outweigh the total cost, with the results being reported in Section 4.5 (see *Figure 4.12,15,18,21,24,26,29,31&35* for the first nine solutions and *Appendix Seven* for the remaining five). Further evidence from interviews was addressed throughout Section 5.3, in particular where Hypothesis Nine was tested. It is worth noting that the conclusion was primarily drawn from the attitudes and opinions held by the participant companies in this research, and hence was a reflection of cost-effectiveness from businesses' perspective at micro level, rather than an overall appraisal at a larger scale.

In a similar vein, the examination of Hypothesis Seven has built an understanding of the sustainable actions taken by the participant companies in their logistics operations, in comparison with their perceptions on the impacts or importance of the solutions, from which the measurement regarding practicability of the solutions came into shape. A high degree of inconsistency was discovered through this analysis, insofar as certain solutions were much more readily employed by companies despite their relatively lower impact levels, whilst the implementation of others appeared to fall far short of the great influence that businesses perceived them to have (see *Table 5.8* for a summary of analysis results). As a result, practicability, in the sense of extent of adoption, was identified as another key indicator in evaluating the performance of sustainable solutions. For instance, extra attention should be given to those solutions which score highly in effectiveness and cost-efficiency and yet have low practicability. The latter, indicating obstacles, bottlenecks or substantially problematic aspects in their functioning mechanism, once tackled, would offer great potential for real sustainable benefits. In the table, 'underperforming' or 'well-performing' signifies whether the solution in question was adopted by as many participant companies as those identifying it as one of the most influential solutions. The solutions highlighted as 'extremely underperforming' indicate a stark contrast between the effectiveness and the relative practicability, requiring further exploration of the causes. There are three solutions functioning at the macro level whose practicability could not be evaluated with the same approach, i.e. diesel fuel taxation, road pricing, and the inclusion of transport into the EU ETS, for which the businesses' strategies in response to these solutions were presented as a substitute indicator. As can be seen in the table, these solutions appeared to be playing a limited part in sustainable logistics, as most companies were responding only reactively.

In addition to the KPIs that are essential for constructing sustainable solution packages, the complex – yet important – interrelationships among the solutions should also be incorporated into the formula. *Figure 6.1*, developed mainly on the basis of the analysis in Hypothesis Four and the findings from literature review, illustrates the key interconnections identified between certain solutions, with focuses being placed on substitute – and particularly synergistic – relationships among the solutions.

Figure 6.1: Interrelationships among the 14 sustainable solutions



Note: dashed-line arrows indicate interrelationships identified from literature review; solid-line arrows indicate interrelationships from survey and interview evidence.

Source: author's survey (stage 1 and 2) and interviews

As shown in the figure, diesel fuel taxation – when compared to the other two substitutable solutions (road pricing and the inclusion of transport into the EU ETS) – was regarded as having more positive impact by the participant companies (see *Figure 4.13&27*), and therefore, it was thought should be given more priority in shaping and enacting short-term sustainable policies in order to secure maximal carbon benefits, while keeping resistance from the industry, systematic risks and market instability all at minimal level. The synergies illustrated by solid-line arrows among the other ten solutions are built upon interview evidence which has been discussed in Section 5.3.2; while the dashed-line arrows indicate synergies identified during the literature review (Chapter Two). EMS, in the broadest sense of the term, may include various forms and combinations of elements from the other sustainable solutions, and was thus placed in the background of the whole basket of solutions.

Building on the picture of the interrelationships between the major sustainable solutions, the critical factors that influence the attitudes towards their uptake, and the KPIs gauging their likely performance in practice, it becomes clear that any solution package for sustainable logistics should take on various forms and perspectives to adapt to the ever-changing environment and circumstances of individual businesses (see Hypothesis Eight). Broadly speaking, depending on the strategic vision that is integrated into the sustainable objectives, and the extent to which profound institutional changes are required, solution packages should be devised to serve both short-term mitigation objectives and long-term transformation goals towards a low-carbon economy.

Moreover, as testing the hypotheses has proven that businesses sustainable behaviours are associated with their operational attributes, including the operational scale (Hypothesis One), industrial sector (Hypothesis Two), and geographic sphere (Hypothesis Three), solution packages should accommodate suitable and practical measures for different types of operations. That said, it is also important to keep solution packages as generic as possible, to serve as a pertinent and effective guidance for most businesses in the logistics industry; they should hence not be overly specific to local circumstances. As a result, it was decided to develop the solution packages for the two types of companies which had displayed distinctive sustainable behaviour patterns in the research, yet which when combined together represent the overwhelming majority of the logistics market share – the small fleet operators and the large logistics operators (see Hypothesis One). As Hypothesis Five was not accepted due to the absence of conclusive evidence, no differentiation is made between the LSPs and LSUs groups with respect to the application of proposed solution packages.

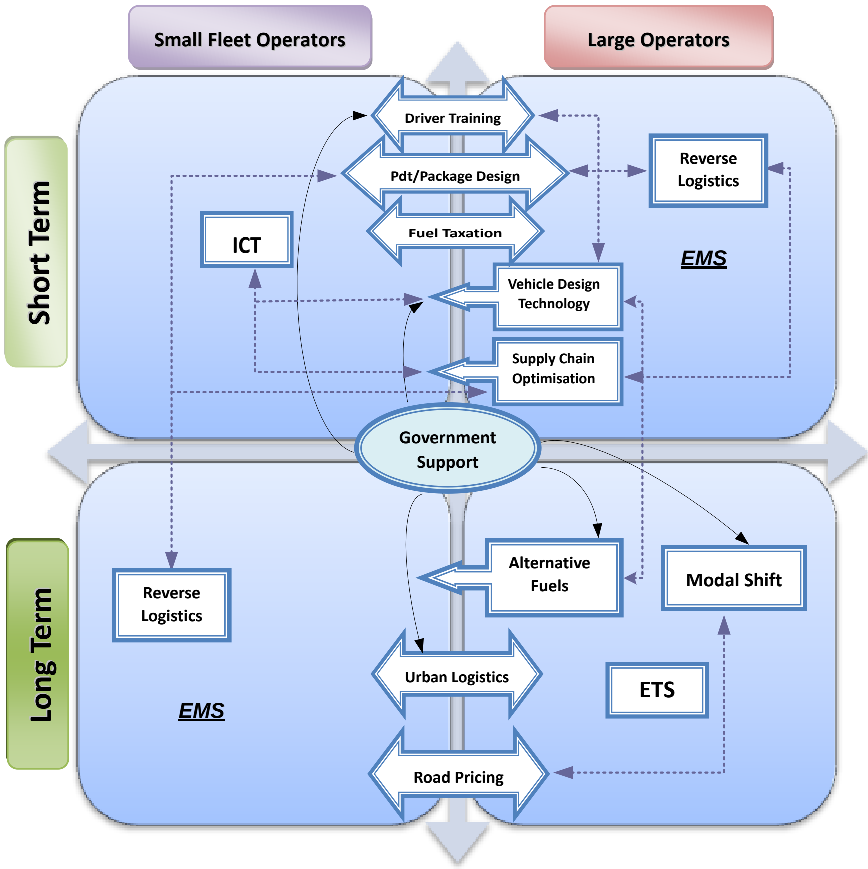
A matrix framework has therefore been devised to illustrate the four solution packages subsequently designed, with both short-term and long-term visions for each of the two types of companies. In general, the allocation of the solutions into different packages follows principles based on the KPIs for the solutions:

(i) Cost-efficiency is the key indicator which determines whether a solution is suitable for small operators to implement, or more viable for large operators. Solutions with positive and high cost-efficiency have the greatest potential to prevail amongst logistics companies, in particular small companies, which account for a vast majority of the entire industry. It is also one of the KPIs for strategic vision – solutions with higher cost-efficiency should be aimed at in the short-term, and vice versa.

(ii) Effectiveness and practicality, from different perspectives, indicate the vision for a solution. The effectiveness of a solution signifies its potential impacts on the sustainability of the industry, regardless of its cost-efficiency; while practicality implies room for improvement or existing obstacles/bottlenecks. Therefore, short-term priority should be given to solutions with high effectiveness and practicality, with the commitment to increasing certain solutions' relatively low effectiveness and practicality through the long-term sustainable agenda.

These principles act as general guide for allocation of the solutions into the packages, yet the combination of different evaluations for multiple KPIs creates much more complex cases than a single KPI does. Hence for individual solutions, it is still necessary to examine their suitability for each package, case by case. *Figure 6.2* displays the solutions included in each package; the dynamics among them (i.e. the synergies between solutions, as in *Figure 6.1*); and, where possible, some suggested working mechanisms for certain solutions.

Figure 6.2: A matrix of four proposed sustainable solution packages



Source: compiled by the author

As can be seen from *Figure 6.2*, many sustainable solutions can be adopted by, or applied to, both small fleet operators and large logistics operations, which are hence positioned at the centre of the vertical axis within double-arrowheaded boxes. Other solutions, such as supply chain optimisation, vehicle design technology and alternative fuels, although they can be employed by both small and large operators, imply the need for greater resources and capability. Their implementation hence requires large companies to take the lead and to proliferate best practices among smaller companies through various forms of interaction with them (see the examples in Hypothesis Six). Indicating the critical initiative-taking role that is best played by large enterprises, these solutions were placed in the boxes which are placed on the large operators' side but close to the vertical axis, with a left-pointing arrow extending across to the small fleet operator's segment.

Government support was shown at the very centre of the matrix, indicating the crucial, strategic leadership role that government has to play in whichever scenario is being considered. The facilitating and supporting functions of local governments, featured in the anecdotal evidence of the previous analysis, as well as in the survey and literature, were depicted with solid black lines linked to related solutions. Taking into account the government's role as the ultimate decision-maker on sustainable regulations and policies – decisions that have profound and far-reaching impacts on the entire industry and the nation, such as changes in diesel fuel taxation, national road pricing and carbon trading programmes – the major influence that government bodies can have in the agenda of sustainability development, whether in the short term or the long term, cannot be overstated.

The four proposed solution packages will be addressed in turn in the following subsections, where further justification will be given for the selection of individual solutions for each package, along with suggestions for their implementation and the specific role that government could play in each scenario.

6.2.1 Short-Term Solution Package for Small Logistics Operations

For the small and medium-sized logistics operations, the research has revealed that although there were no significant differences between their sustainable thinking and that of their larger counterparts, they did appear to be much less active in pursuing sustainable practices, mainly as a result of the economic implications (see Hypothesis One in Section 5.3.1). Seen in this light, a solution package for them in the short term would best focus on the solutions which were proven to be cost-efficient to implement, with tangible financial returns or efficiency gains on investment. Driver training and ICT were thus identified for inclusion in this package, as measures with positive cost-effectiveness and a relatively low threshold of initial investment (at least for the lower-end technologies across the full spectrum of ICT solutions). It should be noted that both the solutions are classified as underperforming (i.e. more interest received in the solutions than actual adoption in practice) in *Table 6.1*, indicating that the logistics operators are already aware of their potentials, and will therefore be more prepared to adopt them.

Taking driver training for example, it was revealed through the literature review that the training provision is directly linked to business size, with smaller companies lagging behind current legislation and guidance on driving (Section 2.5.3.3). To address the issue of high staff turnover as the potential cause of this problem, employment contracts were suggested to bind trained drivers for a certain period of time (Hagan, 2005). From the practical applications reviewed in the research, driver assessment and incentive programs rewarding above-average drivers are often introduced along with the facilitation of analytic software, vehicle telematics and fuel monitoring equipment, to achieve positive results in fuel cost and carbon savings (*Appendix Ten*).

Apart from the elements that can be incorporated into driver training, ICT is a solution that comes in different shapes and sizes, to benefit both large and small companies (DfT, 2007c). However, evidence from both the literature and the interviews shows a strong correlation between its adoption and company size, with small operators still missing out on the benefits that ICT can provide. Taking into account the investment cost, which is positively related to the sophistication of the system and the highly diversified product range as two disincentive factors, online freight exchange and simple vehicle routing and planning programmes are suggested as the ICT systems that can be fully exploited by small operators (Section 2.5.3.7.2).

Although vehicle design technology and supply chain optimisation tend to lend themselves to larger operations, mainly due to the effects of economies of scale, the benefits that they provide can also be realised in small operations via diverse interactions with large companies (Hypothesis One, Section 5.3.1). Certain vehicle designs, such as low-resistance tyres and aerodynamic styling, particularly those which can be retrofitted to vehicles at an economically viable cost, can be applied to rigid goods vehicles, or to tractor units if the operators do not run their own trailers, enabling smaller operators to benefit from immediate fuel savings. Likewise, supply chain optimisation can be sought by small-scale operations, via routeing and journey planning, backhauling or collaboration with other parties along the supply chain. In particular, opportunities should be investigated where certain ICT systems and technologies can be utilised to support supply chain optimising initiatives as well as new vehicle designs. As illustrated in the interview evidence and case studies, synergies between these solutions often provide greater environmental and economic benefits than stand-alone solutions, and should hence be an area of priority during the decision-making process, when existing sustainable solutions are reviewed and the scope for employing new solutions is evaluated.

In the short-term sustainable strategy for small logistics operations, the role that governments could play is mainly facilitating. To promote driver training and ICT application, partially funding and supporting programmes (e.g. SAFED, which has received positive feedback from participant companies and yielded real benefits), along with consulting and advisory services can be provided by government for small operators at lower cost, so that the barriers – of lack of information, limited resources and the complexity of choice – can all be addressed. For product and package design, as regulations are already playing an important role in shaping compliance behaviour, the government could concentrate more on researching and disseminating examples of inspiring, good product design practice which demonstrate substantial logistics and environmental benefits.

6.2.2 Short-Term Solution Package for Large Logistics Operations

The short-term solution package envisaged for large enterprises encompasses almost all the sustainable solutions recommended for small and medium-sized enterprises, except for ICT, which was observed as the norm among large logistics operations both in terms of diffusion and infusion (as discovered in the analysis of Hypothesis One, Section 5.3.1). Nevertheless, with evolving technologies and changing logistics network structures and practices, larger operators should be encouraged to take greater initiative in experimenting with new technologies and innovative solutions, whether in the spectrum of vehicle design, product/package design, or supply chain optimisation. Such initiative, if offering strategic transformation or revolutionary progress in low-carbon operations, yet requiring substantial resources and collaboration amongst businesses and concerned institutions or organisations, should be led, co-ordinated and supported by government, which could also facilitate the promotion of good practice through public procurement (Section 2.5.3.5).

The linkage identified between reverse logistics and large-scale logistics operations (Hypothesis One) suggests that the solution not only relates mainly to big operators, but, more importantly, may be far more effective in fulfilling environmental mitigation targets in the short term when implemented by large operators in the logistics industry. In addition, good practice appearing from the evidence base of this research pointed to a systematic approach which incorporates reverse logistics principles and measures into the supply chain optimisation process and sustainable product/package design, with efficiency gains and waste reductions being achieved in multiple stages across both the forward and the reverse supply chain (see Hypotheses Two and Four). In line with the conclusion that sustainable logistics practice varies by vertical industry sector (Hypothesis Two), existing research suggested the sectors of priority in waste management, in terms of environmental benefits, including paper, food, glass, aluminium and textiles (Section 2.5.3.10).

Another area exemplifying this synergy is product/package design and supply chain optimisation. Apart from the anecdotal evidence from the interviews (see Hypothesis Four), the multiple cases presented in *Appendix Ten* for best practices in product/package design also demonstrate a clear linkage between these two solutions. On the one hand, reviewing and redesigning the product sizes and package configurations can greatly reduce the complexity of logistics operations and increase supply chain efficiencies. On the other hand, such initiatives often entail a cross-functional project involving manufacturing, marketing, commercial, procurement departments and fundamental changes in current logistics operations. In many cases, the resultant logistics changes have further impacts on other stakeholders along supply chain, requiring greater collaboration among the parties concerned. Hence it is suggested that product/package design is incorporated as an initial, formal decision-making process during supply chain optimisation, initiated by large operators, in order to achieve maximum benefits effectively.

It is worth mentioning that both reverse logistics and product/package design scored relatively low in effectiveness and practicability, in spite of their positive cost-effectiveness, indicating that raising awareness, sharing experiences and promoting practical sustainable measures in these fields should be the main priorities in realising their desired environmental implications.

EMS appeared to perform well within the participant companies in relation to its perceived impact, particularly among large operators, reflecting a satisfactory level of prevalence at present. However, the practicability indicator was mainly derived from the quantification of survey and interview results, and thus does not provide insights into the extent to which EMS was implemented within individual companies, nor into the specific procedures involved. In fact, the qualitative evidence revealed that only a handful of large companies, being market leaders in their respective industries, had extensive EMS covering major aspects of their supply chains, whilst most companies with various forms of EMS in place had much more limited applications in their logistics functions. As highlighted in Hypothesis Seven (Section 5.3.3), the picture was less promising than it had initially seemed, as most operators with EMS in place did not see it as a solution with great impact, whilst most operators who did regard it as such did not adopt it for various reasons. Therefore, it is clear that large companies, as frontrunners when it comes to EMS, should concentrate on identifying and establishing clear links between applications of EMS and the consequent financial and environmental benefits in the short term, which would inspire smaller-scale logistics operations and promote best practice in the long run. Generally, based on the current status of the majority of large logistics operations, EMS as a sustainable solution applied in the logistics domain is in need of further specification in processes, procedures and explicit approaches of management, in particular regarding the monitoring, auditing and reporting of environmental performance.

Government's role in regulating EMS has been much debated in the literature, with opposing views on whether the market-driven and voluntary nature of EMS should be retained, or whether a mandatory legislation framework should be established (Section 2.5.3.4). With positive correlation between environmental regulations and EMS practice observed in countries such as Germany, Austria and Ireland, it is recommendable that the UK government review the EMS implementation in the industry, starting with establishing minimal standards for large companies to ensure a level playing field, involving stakeholders and increasing public scrutiny in the short and mid term. In contrast, the government's role as regulator has already been extensively enforced in reverse logistics, with combined government tools of regulation, pricing, voluntary agreements and government procurement policies (Section 2.5.3.10). The importance of life-cycle analysis is emphasised in reverse logistics policy evaluation; establishing an economically and environmentally viable framework is more valuable than setting targets for recycling and recovery (Lave et al., 1999).

Finally, fuel taxation, as a regulatory tool applied by government to the industry regardless of business size, should be carefully assessed to effectively drive behaviour changes in logistics operations. Empirical evidence on the effectiveness of fuel taxation policies to promote clean fuels in Hong Kong (Hung, 2006), and to improve fuel efficiency in UK's freight transport (McKinnon, 2007c) has been identified in existing literature (Section 2.5.3.2). The profound impacts of fuel taxation on logistics operations is further reaffirmed by the survey results, with the solution being selected by most of the respondents with the highest rank (Section 4.5.1), indicating the great potential of the solution in the short term. Consideration should also be given to fuel taxation decision-making, as operators of various sizes appeared to be impacted by fuel price increases to different degrees, with large operators more likely to recover the cost, while small operators struggle to pass on the increased cost to their customers (Burns Inquiry, 2005).

6.2.3 Long-Term Solution Package for Small Logistics Operations

Regarding the long-term vision for sustainable development in the logistics industry, more drastic action is required if further progress towards low-carbon operations is to be made. Following the lead from the large operators' good practice in reverse logistics, alternative fuels and EMS, small and medium-size fleet operators will have to either adopt measures in these areas themselves, or join the existing environmental management systems, and thus become an integrated part of the wider, optimised logistics networks, so that the operational efficiency and environmental performance of the industry as a whole can be further improved.

Although perceived as being of great influence on logistics operations, the current road pricing schemes have a limited effect on changing road freight rates and reducing the demand for road freight services, according to approaches taken by the participant companies in response to road pricing (see *Table 4.27*). Likewise, the interview evidence indicates that there is a lack of responsive strategy among logistics operators for the proposed national road pricing scheme. Both the interview evidence (Hypothesis Seven) and the literature review findings (see Noordegraaf and Riet, 2007) highlighted the unequal effects of such a road pricing scheme on firms with different attributes, with small operators being more vulnerable to the policy. Therefore, taking a long term perspective, examination of the possible redistribution of costs and benefits among various actors within logistics networks should be conducted prior to the introduction of the charging system on a wide scale.

Also in the long-term vision, urban logistics, although having the lowest effectiveness and cost-efficiency rankings in the survey, possibly due to the terminology used in the survey, should be given more thought, along the lines of improving its working mechanism through better design and planning in conjunction with other urban policies. As a solution targeted to reduce the overall carbon footprint of logistics activities in local or regional areas, it does not necessarily imply poorer cost-effectiveness from a societal perspective. Moreover, the interview evidence already showed that companies were ready to take up opportunities in urban logistics where they were present, typically with the backup of the local government authorities (Hypothesis Three, Section 5.3.2), signifying the great potential of this solution and the synergies between it and government support.

The pivotal roles that government can play in urban logistics have been highlighted in the literature review (Section 2.5.3.13). Firstly, given the objective of decarbonisation, it is feasible for government to finance sustainable development projects (e.g. transhipment centres) through policy instruments and fiscal measures exerted on businesses which monetise their environmental impacts. Secondly, a series of complementary, government-led initiatives, such as urban freight management and regulations, information maps, nearby delivery areas and sharing of bus lanes with lorries, is suggested for implementation. Finally, many researches in this area call for a reassessment of the current urban freight restrictions and regulations, with a view of relaxing the strict policy restrictions with negative operational and environmental impacts. For instance, considerable economic and environmental benefits from easing night time delivery restrictions have been estimated; whilst traditional access criteria based on goods vehicles' weight and size is suggested to be abandoned for more relevant ones on their environmental and logistics performance. To avoid repetition, road pricing and inclusion of transport in the ETS – which also requires a central role of government and which applies to both small and large operations – will be addressed in the next subsection.

6.2.4 Long-Term Solution Package for Large Logistics Operations

As far as large enterprises are concerned with the long-term perspective, they should be expected to take the opportunities presented by modal shift and alternative fuels, both of which have been observed as having low practicability amongst operators at present.

The critical part that innovation and low carbon technologies should play in climate mitigation was stressed in the Stern Review (Stern, 2007), and alternative fuels and vehicles provide one such long-term solution for the logistics industry. The development and uptake of major alternative fuels has been reviewed in Section 2.5.3.1, with electricity (either powered by battery or hydrogen fuel cell) and biofuels identified as the main options for the future. The evidence from the interviews shows that large-scale operations are more active in trialling and deploying alternative fuels (Hypothesis One), justifying the application of this solution to the scenario. Both existing literature and anecdotal evidence in this research specifically indicated that alternative fuels may be employed in urban areas, where greater economic and environmental benefits can be yielded, implying the facilitating role of government in promoting alternative fuels through urban logistics policy-making. Nevertheless, it takes more than facilitation from government to realise the potential of the solution in the long term. The future outlook for research and development for commercially viable alternative fuels, and the construction of the required infrastructures, for instance, would be on a far more secure basis with central supervision and coordination by government bodies, along with financial support where necessary. Other approaches, including differentiated fuel duty, public procurement (i.e. buyer's role), and certificate trading schemes (e.g. RTFO) have been employed in practice, where application and impacts in combination can be further assessed with a long term perspective.

Compared to alternative fuels, modal shift was perceived by most participant companies as a solution with low impact, emphasising the lack of confidence or awareness as a pressing issue to be addressed, which is of equal priority to the government's current focus on increasing capacity. Although at both European and UK levels, this focus has been supported by a series of government white papers, policy guidelines, projects and funding, the importance of having government support for modal shift, and the perception of insufficient provision of the support are still reflected in both the literature and the interview evidence (Hypothesis Three). It is claimed that to date, pro-rail statements have not been backed up with strong financial support and policy initiatives (Ruete, 2007). To restore the confidence in future government support for the rail freight industry, a few areas need to be further investigated, such as underinvestment in infrastructure and equipment, and cross-subsidies from freight to passenger transport. In addition, as revealed from the survey results, governments play a crucial role in promoting non-road modes through policy instruments on fuel tax and road pricing (*Appendix Seven*). Other critical issues and challenges that the rail freight industry is facing, and the measures suggested for tacking these problems, have been summarised in *Table 2.3* in Section 2.5.3.8.

Finally, as previously mentioned, another essential role for government is to continuously model and plan for the implementation of policies that are alternatives to diesel fuel taxation, which is envisaged to remain as the main policy for the logistics industry in the near term. In the long term, the potential impacts (including their environmental, economic and societal implications) of the alternative regulatory instruments – such as road pricing and inclusion of transport into the EU ETS – need to be carefully evaluated against diesel fuel taxation, so that decisions can be made appropriately when the time and conditions are right for the switch. As the vast majority of the participant companies are taking reactive approaches to the policies under proposal in this research, it follows that even in the short term, when no step changes are made in regard to switching from one policy to another, there is still scope for incremental adjustment in the present fuel taxation regime.

6.3 Implementation of the Proposed Solution Packages

In combination, the four sustainable solution packages, constructed for the two main types of logistics operation in the industry, with a vision for the short and the long term respectively, provide a logical and feasible framework for sustainable development. With problematic areas and also synergies amongst the solutions being highlighted in the previous section, the packages proposed form a systematic approach which has the aim of effectively bringing the sector into line with the UK's sustainability targets.

Having devised the solution packages, the next critical issue to be tackled is associated with effective implementation of them – should some of the packages be given higher priority than others? Or are the four packages, which target different segments, of equal importance and thus all to be implemented, with resources allocated evenly between them? It is the author's belief that although the four dimensions addressed by the proposed solution packages might not have equivalent environmental and economic implications, they are all crucial in shaping a sustainable logistics industry, and the materialisation of such an objective would not be achieved with any of them individually failing to deliver. Ideally, therefore, each package should receive sufficient investment, resources, and government and social support. Unfortunately, there might not be a case for satisfying these requirements in all respects, especially given the present macroeconomic and political status of the nation; hence, trade-offs will have to be made when conflicts present themselves.

Regarding the two target groups of companies within the industry, it was highlighted in Chapter Four (see *Table 4.3*) that the logistics industry was highly fragmented, with small-scale operators dominating the market in terms of the number of companies. However, further examination of turnover and employment levels reveals that it is very likely that a small minority of large-scale operators constitute the backbone of the industry, with 10% of the total number of establishments accounting for around 80% of the market share (estimated from UK Road Haulage Industrial Report, Mintel, 2009; calculation included in *Appendix Six*). With this in mind, it is considered that the solution packages developed for large operators might have greater aggregated implications for carbon reduction by market share than those for smaller operators. Furthermore, the outline of *Figure 6.2* clearly carries more weight in the right half of the diagram, which presents the solutions for large operations, reinforcing the strategic role played by large, leading companies in sustainable logistics. As discussed in the previous section, the exemplar effect of large operators, and the innovative initiatives taken by them, along with the interplay between the two groups (Hypothesis Six), will facilitate the positive implications of the solution packages to be conveyed from the vital few to the secondary many.

Although a trade-off between short-term mitigation goals and long-term decarbonising objectives is even less negotiable, there are certain solutions in the proposed packages that should be focused upon. As suggested in Section 6.2, vehicle design technologies in the short term – as well as alternative fuels and modal shift in the long term – present strategic opportunities for carbon-neutral logistics operations in the future, yet in the meantime they call for substantial investment, infrastructure development, close partnership amongst industry members, and support from government and the general public. In addition, government should assume responsibility for continuously assessing the development, refinement and employment of alternative policy and regulatory instruments, such as a national road pricing scheme, ETS and urban logistics planning and regulation, in order to secure systemic optimisation at a larger scale, which is not achievable through other market-oriented, local optimisation solutions alone.

6.4 Summary

Building upon the analysis in Chapter Four and the testing of hypotheses in Chapter Five, four sustainable solution packages have been devised, being one short-term vision and one long-term vision package for each of the two largest groups (as defined both in terms of market share and representativeness) of major actors in the UK domestic logistics industry. A matrix framework was constructed to illustrate the dynamics between the four proposed packages, and the suggestions on the implementation and overall implications of the packages were further addressed. The conclusion of this research is made in Chapter Seven, which is concerned with relating them to the fundamental objective upon which this thesis is based.

CHAPTER SEVEN: CONCLUSION

7.1 Introduction

In Chapters Four and Five, both the quantitative evidence, gathered mainly from the two-stage questionnaire survey, and the qualitative evidence, derived from the subsequent in-depth interviews, have been analysed; this has enabled the nine hypotheses to be tested and sustainable solution packages to be devised in Chapter Six. To illustrate the ways in which the two research objectives have been addressed, this final chapter highlights the research findings, with reference to the hypothesis testing results and the proposed sustainable framework with four solution packages as the overall conclusion. Finally, the limitations of this study and its implications for future research are addressed, identifying ways in which the subject area might be further investigated.

7.2 Research Findings and Conclusions

7.2.1 Prerequisite: Identification and Classification of Key Sustainable Logistics Solutions

In order to achieve the first prime research objective, which was "to develop greater understanding of the key sustainable logistics solutions and the critical factors affecting their actual or potential performance", the prevailing key sustainable logistics solutions had first to be identified, along with the possible factors which would crucially affect their performance. This goal was accomplished through an extensive literature review in Chapter Two.

In Chapter Two, major existing contemporary sustainable solutions were identified from the literature in the main strands of the logistics research domain, encompassing a wide range of measures and approaches which focus on varying functions of logistics. These solutions are attempts to tackle the environmental implications of logistics operations, especially freight transport, by means of technological development (e.g. alternative fuels, green vehicle design, ICT systems), network optimisations (e.g. supply chain optimisaion, urban logistics, reverse logistics), and governance (e.g. government support, fuel taxation, road pricing). Taking an integrated approach, the major solutions identified from the preliminary literature review were then categorised into a framework of 14 sustainable solutions, upon which is built a more focused literature review of the critical factors related to each of the solutions and their applications.

The findings from the literature review not only provide a comprehensive understanding about prevailing sustainable logistics solutions, their working mechanism and environmental implications, but they also highlight the fields which need to be further developed or exploited through research. The isolation of individual solutions observed in the existing literature, for instance, is addressed with the integrative framework, and further tackled through examining the interconnections between the solutions. Secondly, in spite of the abundance of case studies demonstrating companies' practices with different solutions, no generalisation or comparison could be made on the solutions' effectiveness. Given that the effectiveness of each solution is directly linked with its impact on logistics operations, a ranking system is specially designed to overcome the comparability issue presented by the great diversity between the solutions. Lastly, cost-effectiveness emerged as a critical factor impacting the effectiveness of a solution.

As a result, Hypothesis Nine is established to test this theory. With this hypothesis being accepted after testing, cost-effectiveness is then used as one of the key indicators for evaluating the 14 solutions, which contributed to the construction of the final four solution packages.

7.2.2 The First Research Objective: Empirical Study on the Sustainability of the British Logistics Industry

The framework of 14 sustainable solutions was subject to investigation through a two-stage questionnaire survey, followed by in-depth interviews with a feasibly sized sample of logistics service providers and users, covering six major vertical sectors of great importance within logistics. This empirical part of the research revolved around the two research objectives. Designed to provide greater understanding of businesses' attitude and behaviour patterns towards sustainability, the survey questionnaire gathered information regarding the perceived impact of the sustainable solutions, the current practices of businesses and the cost-effectiveness of the solutions, as well as the key factors affecting their prevalence in the industry. The detailed survey findings were reported for each of the ten solutions in Chapter Four (with the analysis of the remaining four solutions attached in *Appendix Seven*), based upon which an overview of sustainability within UK's logistics industry is outlined, and the first research objective largely fulfilled.

Being complementary to the survey outcomes, the evidence from interviews has greatly helped to explain the patterns and trends observed from the survey. Insightful information about sustainable applications and practices, interactions between different stakeholders in the industry, and the interwoven relationships between certain sustainable solutions was also gathered from interviews, which greatly facilitated the testing of the nine hypotheses. With the testing results summarised in *Table 5.15*, it is revealed that sustainable logistics practices vary significantly by business size and industry sector; whilst the variance is less evident by geographic scope or logistics roles (i.e. between LSPs and LSUs), which helps to explain the design of solution packages catering for logistics operations of different sizes. Close interrelationships amongst sustainable solutions identified during the literature review have also been borne out and strengthened with empirical data and analyses, which were depicted in *Figure 6.1* and fed into the device and implementation suggestion of the solution packages (See *Figure 6.2)*.

7.2.3 The Second Research Objective: The Proposal of Sustainable Solution Packages

The second and ultimate research objective was satisfied following the quantitative analysis of survey results, qualitative analysis of interview transcripts, and hypothesis testing. The research findings from those analyses enabled the initial 14 sustainable solutions to be evaluated in terms of various performance indicators regarding their effectiveness (ranking results from survey), cost-efficiency (Hypothesis Nine) and practicability (Hypothesis Seven). Also taken into consideration were: the major interrelationships that were revealed between solutions (synergetic or substitutionary); the interactions between groups of industrial members (in particular between large-scale operators and small and medium-size operators); the main business attributes that influence their sustainable behaviours; and other critical factors, which, from both literature and empirical evidence, appeared to have great impact on individual sustainable solutions or combinations of them.

In light of these considerations, four solution packages were devised in a two-dimensional framework, with two adapted to large logistics operations with short-term and long-term visions respectively, and two catering for small and medium-sized operators (Section 6.2). To maximise the environmental benefits in the short term, small operators should apply cost-efficient solutions such as driver training and product/packaging design, with large operators exploiting advances in vehicle design technologies, supply chain management, and reverse logistics. In the long term, with strong government support, large operators should look into opportunities presented in areas including modal shift and alternative fuels; while sustainable practices in urban logistics and reverse logistics could be taken up by smaller operations through large operators' impacts upon them. Government plays a pivotal role through the entire process, not only through decision-making about policy instruments such as road pricing, fuel taxation and ETS, but also through the facilitation and support it provides to the industry in various forms. Recommendations on implementation of each solution package were given in Chapter Six, along with the evaluation of their implications and suggestions on prioritisation where appropriate (Section 6.3).

7.3 Limitations of this Research

Towards the end of this research project it was recognised that the broad heading of 'Urban Logistics' applied in the questionnaire survey as a sustainable solution might not have been interpreted correctly by the respondents. Although the term is widely used and understood in academic research, it might not be the case for business practitioners. In light of the anecdotal evidence obtained from the in-depth interviews, it seems highly likely that the solution's effectiveness was under-evaluated in the survey results and consequently in the solution packages, with urban logistics given the lowest rank out of the 14 solution categories (Section 4.3). This factor accordingly brings into question the analysis of behaviour difference between LSPs and LSUs in urban logistics, based on the survey outcomes (Section 4.4.1). However, this part of discussion was made brief, and given the inconclusive testing result for Hypothesis Five (see *Table 5.15*), it does not impede the soundness of the research and the conclusions made. Additionally, as the anecdotal interview evidence adds to the understanding of current urban logistics practice, its contribution to the research, although limited, still remains valid.

7.4 Implications for Future Research

Given the limited resources and time-scale, this research has concentrated on revealing the perceptions that businesses have of the cost, benefit and effectiveness of each sustainable solution. The results of this focus have been used to select measures which can be expected to obtain higher acceptability/popularity among various industry members, and which are therefore more likely to realise the maximum benefits of sustainable logistics.

However, the nature of the survey method employed leaves room for follow-up researches which would further investigate ways of linking real outcomes of carbon reduction (e.g. actual cost and carbon savings in quantified terms) to a range of solutions, disregarding practitioners' preference for some of them. Research looking into the actual and accurate measurements of solutions is often needed after the pilot stage of specific measures, and will provide objective and indicative potential performance assessments of the measures in question. This type of evaluation is extremely helpful in the decision-making process by pointing in the directions of the strategy options that will have the greatest potential for sustainability. Together with this research, future research in those areas will frame a sound structure which can inform policymakers not only of the appropriate strategies to take in various circumstances, but also of the amount of effort or cost that various alternatives would entail, were they to undergo full-scale, industry-wide implementation.

Bibliography

Aberdeen Group (2006), *Revisiting Reverse Logistics in the Customer-Centric Service Chain*, Aberdeen Group Benchmark Report.

AGEPL Europe (2009), *Autogas in Europe, the Sustainable Alternative*, AGEPL, Brussels.

Agnolucci, P. (2007), Hydrogen infrastructure for the transport sector, *International Journal of Hydrogen Energy*, 32 (2007), pp 3526-3544.

Ahmad, S. and R.G. Schroeder (2001), The impact of electronic data interchange on delivery performance, *Production and Operations Management*, 10 (1), pp16–30.

Akerman, J. and M. Hojer (2006), How much transport can the climate stand? – Sweden on a sustainable path in 2050, *Energy Policy*, 34, pp1944-1957.

Allen, J., G. Tanne, M. Browne, S. Anderson, G. Christodoulou and P. Jones (2003), *Modelling Policy Measures and Company Initiatives for Sustainable Urban Distribution, Final Technical Report*, London, 2003.

Anable, J. and A.L. Bristow (2007), *Transport and Climate Change: Supporting Document*, London: CfIT.

Anderson, R.J. (1998), *On the Security of Digital Tachographs*, Proceedings of the 5th European Symposium on Research in Computer Security, pp111-125.

Anderson, S., J. Allen and M. Browne (2005), Urban logistics – how can it meet policy makers' sustainability objectives?, *Journal of Transport Geography*, 13(1), pp71-81.

Anon (2006), Box clever: transforming home grocery shopping, *Strategic Direction*, 22 (9), pp32-33.

Arlbjørn, J.S. and A. Halldórsson (2002), Logistics knowledge creation: reflections on content, context and processes, *International Journal of Physical Distribution & Logistics Management*, 32(1), pp22-40.

Aron, L.J. (1994), P&G's logistics strategy: simplify and standardize, *Inbound Logistics*, April 1994, pp24-29.

Aronsson, H. and M.H. Brodin (2006), The environmental impact of changing logistics structures, *The International Journal of Logistics Management*, 17(3), pp394-415.

Beamon, B.M. (1999), Designing the green supply chain, *Logistics Information Management*, 12(4), pp332-342.

BearingPoint (2008), *Supply Chain Monitor 'How mature is the Green Supply Chain?'*, Corporate Insight, White Papers.

BESTUFS (2007), *BESTUFS Good Practice Guide on Urban Freight Transport* (written by Allen, J., Browne, M. and Thorne, G., Best Urban Freight Sultions, available at: www.bestufs,net.

Bettac, E., Maas, K., Beullens, P., Bopp, R. (1999), *RELOOP: Reverse optimisation in a multi-user trading environment*, Proceedings of International Symposium on Electronics and the Environment.

Biondi, V., Frey, M. and Iraldo, F. (2000), Environmental management systems and SMEs: motivations, opportunities and barriers related to EMAs and ISO 14001 implementation, *Greener Management International*, No. 29, pp55-69.

Blumenfeld, D.E. (1987), Reducing logistics costs at General Motors, *Interfaces*, 17(1), pp26-47.

Bradley, M. and A. Daly (1994), Use of the logit scaling approach to test for rank-order and fatigue effects in stated preference data, *Transportation*, 21(2), pp167-184.

Bridgwater, E., Anderson, A. (2003), *CA Site WEEE Capacity in the UK: an Assessment of the Capacity of Civic Amenity Sites in the United Kingdom to Separately Collect WEEE*, Report prepared for Defra by Network Recycling.

British Retail Consortium (2005), *Delivery Curfew 2004 Survey*, BRC.

British Retail Consortium (2001), *Delivery Curfew Survey Results*, BRC.

Browne, M., M. Piotrowska, A. Woodburn and J. Allen (2007), *Urban Freight Transport – Literature Review*, Carried out as part of Work Module 1 of EPSRC Green Logistics Project.

Browne, M., J. Allen and S. Anderson (2005), Low emission zones: the likely effect on the freight transport sector, *International Journal of Logistics: Research and Applications*, 8(4), pp269-281.

Bryman, A. (1988), *Quantity and Quality in Social Research*, London: Unwin Hyman.

BSI (1994), *BS7750: Specification for Environmental Management Systems*, British Standards Institute, London.

Budget Notes (2009), Budget 2009, HM Revenue & Customs, available at: http://www.hmrc.gov.uk/budget2009/notes-pdf.htm

Burns Inquiry (2005), *The Burns Report*, Freight Transport Association / Road Haulage Association, Weybridge.

Butcher, L., A. Seely, P. Bolton and E. Beale (2008), *The Road Haulage Industry: Cost and Taxes*, Research Paper 08/68, 31 July 2008, House of Commons Library. Avaiable at: www.parliament.uk/briefing-papers/RP08-68.pdf

CfIT (2007), *Transport and Climate Change – Advice to Government from the Commission for Integrated Transport*, London: CfIT.

Carter, C.R., Ellram, L.M. (1998), Reverse logistics: a review of the literature and framework for future investigation, *Journal of Business Logistics*, 19(1), pp85-102.

CBI (2008), *Corporate Social Responsibility*, the Confederation of British Industry's website, http://www.cbi.org.uk/ndbs/content.nsf/802737AED3E3420580256706005390AE/9D502144AC9F644380256F58005BD16C

DfIT (2007), *Transport and Climate Change*, Advice to Government from the Commission for Integrated Transport.

Chan, F.T.S, H.K. Chan and K.L. Choy (2006), A systematic approach to manufacturing packaging logistics, *The International Journal of Advanced Manufacturing Technology*, 29(9-10), pp1088-1101.

Chiou, J-S., L-Y. Wu and J. Hsu (2002), The adoption of form postponement strategy in a global logistics system: the case of Taiwanese information technology industry, *Journal of Business Logistics*, 2(1), pp107-24.

Christensen, L. (2002), The environment and its impact on the supply chain, *International Journal of Retail & Distribution Management*, 30(11), pp571 – 572.

Christopher, A.B., W.C. Christopher and B.H. Joe (2007), Postponement: an evolving supply chain concept, *International Journal of Physical Distribution & Logistics Management*, 37(8), pp594-611.

Civic Trust, County Surveyors Association, and Department of Transport (1990), *Lorries in the Community*, HMSO, London.

CLECAT (2010), *Logistics Best Practice Guide 2nd Edition*, European Association for Forwarding, Transport, Logistics and Customer Service, Brussels.

CLECAT (2009), *Logistics Best Practice Guide*, European Organisation for Forwarding and Logistics, Brussels.

Clements, B. (2001), The mapping of communication channels between transportations and logistics service providers to examine how they are affected by the increase of e-commerce, *Logistics Research Network 2001 Conference Proceedings*, Institute of Logistics and Transport, London, pp106-110.

Commissions of the European Communities (2007), *Biofuels Progress Report: Report on the progress made in the use of biofuels and other renewable fuels in the Member States of the European Union*, Brussels.

Commission of the European Communities (2006), *Implementing the Partnership for Growth and Jobs: Making Europe a Pole of Excellence on Corporate Social Responsibility*, Brussels, COM(2006) 136 final.

Commission of the European Communities (2002), *Corporate Social Responsibility: A Business Contribution to Sustainable Development*, Communication from the Commission, Brussels, COM(2002) 347 final.

Commission of the European Communities (2001), *Promoting a European framework for Corporate Social Responsibility*, Green Paper, Brussels, COM(2001) 366 final.

Cooke, P. (2004), *Light Commercial Vehicle Trends: 2004*, Centre for Automotive Industries Management, Nottingham Trent University.

Craighead, C.W., J.B.Hanna, B.J. Gibson and J.R. Meredith (2007), Research approaches in logistics – Trends and alternative future directions, *The International Journal of Logistics Management*, 18(1), pp22-40.

Cranfield University, Sheffield Hallam University and CILT (2004), *The Efficiency of Reverse Logistics*, Department for Transport. Available for downloading from http://www.ciltuk.org.uk/pages/revlog

Dablanc, L. (2007), Goods transport in large European cities: difficult to organize, difficult to modernize, *Transport Research Part A*, 41 (2007), pp280-285.

Dahlmann, F., S. Brammer and A. Millington (2008), Environmental management in the United Kingdom: new survey evidence, *Management Decision*, 46(2), pp264-283.

Dalen, D.M., E.R. Moen and C. Riis (2005), Contract renewal and incentives in public procurement, *International Journal of Industrial Organization*, 24(2), pp269-285.

Dapiran, P. (1992), Benetton – global logistics in action, *International Journal of Physical Distribution & Logistics Management*, 22 (6), pp1-5.

Davis, I., R. Mason and C. Lalwani (2007), Assessing the impact of ICT on UK general haulage companies, *International Journal of Production Economics*, 106(2007), pp12-27.

De Brito, M.P. and R. Dekker (2003), *A Framework for Reverse Logistics*, Erasmus Research Institute of Management Report Series Research in Management.

DECC (2010), *Provisional 2009 Results for UK Greenhouse Gas Emissions and Progress towards Targets*, published 25 March 2010, available at: http://www.decc.gov.uk/en/content/cms/statistics/climate_change/gg_emissions/uk_emissions/2009_prov/2009_prov.aspx

DECC (2008), *Climate Change Act 2008*, available at http://www.statutelaw.gov.uk/legResults.aspx?LegType=All+Legislation&title=climate+change&Year=2008&searchEnacted=0&extentMatchOnly=0&confersPower=0&blanketAmendment=0&TYPE=QS&NavFrom=0&activeTextDocId=3539938&PageNumber=1&SortAlpha=0

DEFRA (2009), *Waste Strategy – Annual Progress Report 2008/09*, Department for Environment, Food and Rural Affairs, London: The Stationery Office.

DEFRA (2007a), *Draft Climate Change Bill*, Department for Environment, Food and Rural Affairs, London: The Stationery Office.

DEFRA (2007b), *Waste Strategy for England 2007*, Department for Environment, Food and Rural Affairs, London: The Stationery Office.

DEFRA (2007c), Table 5 Estimated emissions of carbon dioxide (CO_2 expressed as Carbon) by *IPCC source category, type of fuel and end user: 1970 – 2005* available at Defra e-digest environmental statistics website: www.defra.gov.uk/environment/statistics/globatmos/download/xls/gatb05.xls (accessed 09 April 2008).

DEFRA (2006), *The Environment in Your Pocket*, 10th Edition, Department for Environment, Food and Rural Affairs, London.

DEFRA (2006b), *Sustainable Development Indicators in Your Pocket*, Department for Environment, Food and Rural Affairs, London.

Delaney, R.V. (1992), *Achieving Excellence in Packaging – an overlooked opportunity*, The Council of Logistics Management Annual Meeting, San Antonio, TX.

Demirbas, A. (2007), Importance of biodiesel as transportation fuel, *Energy Policy*, doi:10.1016/j.enpol.2007.04.003.

Denzin, N. and Y. Lincoln (2000), *Handbook of Qualitative Research*, 2nd ed., Sage Publications, London.

DETR (2000), *Guidance on Full Local Transport Plans*, Department of the Environment, Transport and the Regions, London.

DETR (1999), *Sustainable Distribution: A Strategy*, Integrated Transport White Paper daughter document, Department for the Environment, Transport and the Regions.

DETR (1998), *Energy Savings from Integrated Logistics Management: Tesco plc, Best Practice Programme, Good Practice Case Study 364*, Department of the Environment, Transport and the Regions.

DfT (2011), *Biofuel Supply Summary*, statistics available at: http://dft.gov.uk/pgr/sustainable/biofuels/

DfT (2010), *Transport Statistics Great Britain:2010*, Department for transport, London: TSO.

DfT (2009a), *Transport Statistics Great Britain, 2009 Edition*, Department for transport, London: TSO.

DfT (2009b), *Transport Statistics Bulletin, Road Freight Statistics 2009*, Department for transport, London: TSO.

DfT (2008), *Road Transport and the EU Emissions Trading Scheme*, Department for transport, London.

DfT (2007a), *Delivering a Sustainable Railway*, White Paper CM7176, Department for transport, London.

DfT (2007b), Aerodynamics for efficient road freight operations, *Freight Best Practice*, Department for transport, London.

DfT (2007c), Information technology for efficient road freight operations, *Freight Best Practice*, Department for transport, London.

DfT (2007d), *Transport Trends: 2007 edition*, Department for transport, London.

DfT (2007e), *Transport Statistics Great Britain: 2007 edition*, Department for transport, London.

DfT (2006), Smoothing the flow at TNT Express and Somerfield using truck dynamic styling, *Freight Best Practice Programme*, HMSO: London.

DfT (2005a), Make back-loading work for you, *Freight Best Practice Programme*, Department for Transport, HMSO: London.

DfT (2005b), Efficient public sector fleet operations, *Freight Best Practice Programme*, HMSO: London.

DfT (2005c), In-fleet trials of fuel saving interventions for trucks, *Freight Best Practice Programme*, HMSO: London.

DfT (2005d), Focus on double decks, *Freight Best Practice Programme*, HMSO: London.

DfT (2005e), *Transport Statistics Bulletin: Survey of Van Activity: 2004*, HMSO: London.

DfT (2004a), *The Future of Transport, A Network For 2030*, Department for transport.

DfT (2004b), *The Efficiency of Reverse Logistics*, Report prepared for the Department for Transport by Cranfield University School of Management, Sheffield Hallam University, and The Chartered Institute of Logistics and Transport (UK).

DfT (2004c), Save fuel with lower rolling resistance tyres, *Best Practice Programme*, Department for Transport: London.

DfT (2004d), The streamlined guide to truck aerodynamic styling, *Transport Energy Best Practice Programme*, Department for Transport: London.

DfT (2002), Fuel champion saves equivalent of 50 trailers loads of carbon dioxide a year, Good Practice Case Study 398, *Best Practice Programme*, Department for Transport: London.

Dinwoodie, J. and J. Xu (2008), Case studies in logistics: a review and tentative taxonomy, *International Journal of Logistics Research and Applications*, 11(5), pp393-408.

DTI (2007), *Meeting the Energy Challenge, A White Paper on Energy, May 2007*, Department of Trade and Industry, London: The Stationery Office.

Dodoo, N.A. and N. Thorpe (2005), A new approach for allocating pavement damage between heavy goods vehicles for road-user charging, *Transport Policy*, 12, pp419-430.

DON-BUR (2006), *Eco-Stream – Aerodynamic Sloping Roof Profile*, available at: www.donbur.co.uk/DON-BUR_News.htm, accessed 29th November 2006.

Doucette, R.T. and M.D. McCulloch (2011), Modeling the CO_2 emissions from battery electric vehicles given the power generation mixes of different countries, *Applied Energy*, 88(7), pp2315-2323.

Dowlatshahi, S. (1999), A modelling approach to logistics in concurrent engineering, *European Journal of Operational Research*, 115, pp59-76.

EBB (2007), *EBB Annual Biodiesel Production Statistics*, European Biodiesel Board press release, available at: http://www.ebb-eu.org/EBBpressreleases/EBB%20press%20release%202006%20stats%202007%20cap%20Final.pdf

ECR Europe (2000), *The Transport Optimisation Report*, University of St. Gallen, Efficient Consumer Response Europe.

Eddington, Sir Rod (2006), *The Eddington transport study: the case for action: Sir Rod Eddington's advice to Government*, Social Research in Transport (SORT) Clearinghouse. Paper 343.

Edler, J. and L. Georghiou (2007), Public procurement and innovation - resurrecting the demand side, *Research Policy*, 36 (7), pp949-963.

EEA (2010), *Towards a Resource-Efficient Transport System – TERM 2009: Indicators Tracking Transport and Environment in the European Union*, EEA Report, No 2/2010, European Environment Agency.

EEA (2009), *Greenhouse gas emission trends and projections in Europe 2009*, EEA Report, No 9/2009, European Environment Agency.

EEA (2007), *Annual European Community greenhouse gas inventory 1990–2005 and inventory report 2007*, European Environment Agency.

EEA, (2003), *Overall energy efficiency and specific* CO_2 *emissions for passenger and freight transport, Indicator Factsheet*, Term 2003 27 EEA 31.

EIA (2011), *Intermodal Freight Transport & Logistics Best Practice*, European Intermodal Association, Available at: http://www.eia-ngo.com/category/best-practices

Ekins, P., H. Kleinman, S. Bell and A. Venn (2010), Two unannounced environmental tax reforms in the UK: the Fuel Duty Escalator and income tax in the 1990s, *Ecological Economics*, 69(7), pp1561-1568.

Ellram, L.M. (1996), The use of the case study method in logistics research, *Journal of Business Logistics*, 17(2), pp93-137.

Emery, B. (2007), 2007- a critical year for the rail industry, *Rail Freight Handbook 2007*, Rail Freight Group, pp57-58.

Enviros Consulting (2002), *Potential Markets for Electronic and Electrical Equipment*, Project funded by the Environment Agency, available at: http://www.londonremade.com/download_files/weee.doc (accessed 25 November 2006)

Ernst & Young (2002), *Corporate Social Responsibility*, available at: www.ey.nl/download/publicatie/doemload/corporate_social_responsibility.pdf

EST (2005), *Ecodriving, Smart Efficient Driving Techniques*, Energy Saving Trust.

Europa (2006), *Waste Electronic and Electrical Equipment*, on the Portal site of the

European Union (http://ec.europa.eu/environment/waste/weee_index.htm).

European Commission (2010), *EU Energy and Transport in Figures, Statistical Pocketbook 2010*, Brussels.

European Commission (2009), 2009/28/EC of the European parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, *Official Journal of the European Union*, European Parliament and the Council.

European Commission (2004), *Towards the rail transport European integration*, Press release IP/04/516, European Commission.

European Commission (2003a), Directive 2003/30/EC of the European parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport, *Official Journal of the European Union*, European Parliament and the Council.

European Commission (2003b), *Energy & Transport in figures 2003*, Directorate-General for Energy and Transport.

European Commission (2003c), Directive 2003/59/EC of the European parliament and of the Council of 15 July 2003 on the initial qualification and periodic training of drivers of certain road vehicles for the carriage of goods or passengers, amending Council Regulation (EEC) No 3820/85 and Council Directive 91/439/EEC and repealing Council Directive 76/914/EEC, *Official Journal of the European Union*, European Parliament and the Council.

European Commission (2001), *White Paper on European transport policy up to 2010: Time to Decide*, Brussels.

European Expert Group on Future Transport Fuels (2011), *Future Transport Fuels – Report of the European Expert Group on Future Transport Fuels*, January 2011, Brussels.

Eurostat (2004), *Energy, Transport & Environment Indicators – Data 1991-2001*, European Communities, Luxembourg.

Everitt, R. (2007), Rail Access to Ports: Who Pays?, *Rail Freight Handbook 2007*, RFG.

EyeforTransport (2005), *Outsourcing Logistics – The latest trends in using 3PL providers January*, available at: www.eyefortransport.com

Feitzinger, E. and H.L. Lee (1997), Mass customization at Hewlett Packard: The power of postponement, *Harvard Business Review*, 75(1), pp116-121.

Fernie, J. and C. Hart (2001), UK packaging waste legislation; implications for food retailers, *British Food Journal*, 108(3), pp187-197.

Fernie, J., F. Pfab and C. Marchant (2000), Retail grocery logistics in the UK, *International Journal of Logistics Management*, 11 (2), pp83-90.

Fisher, M. (1997), What is the right supply chain for your product?, *Harvard Business Review*, 75(2), pp105-16.

Flynn, B. (2003), Much talk but little action? 'New' environmental policy instruments in Ireland, *Environmental Politics*, 12(1), pp137-56.

Frankental, P. (2001), Corporate social responsibility – a PR invention?, *Corporate Communication: An International Journal*, 6(1), pp18-23.

French, E.MILT (2007), Green by design, *Logistics & Transport Focus*, 9(5), pp42-45.

Frenette, G. and Forthoffer, D. (2009), Economic & commercial viability of hydrogen fuel cell vehicles from an automotive manufacturer perspective, *International Journal of Hydrogen Energy*, 34(9), pp 3578-3588.

FTA (2011), *The Logistics Report 2011*, Freight Transport Association.

FTA (2003), *Relaxing Delivery Restrictions could Reduce HGV Traffic Growth by more than 50% says FTA*, FTA press release, 6 November 2003.

FTA (2003b), *Solving the Skills Shortage 2003*, Conference Report, 27th October 2003, Freight Transport Association.

FTA (2002), *Business Options: The Perception of Rail Freight*, Freight Transport Association.

FTA (1996), Lorries in Urban Areas - Delivering the Goods and Serving the Community, *Freight Matters*, 96(5), Freight Transport Association.

Gadde, L.E. and K. Hulthen (2009), Improving logistics outsourcing through increasing buyer-provider interaction, *Industrial Marketing Management,* 38(6), pp633-640.

Gander, P. and M. Whitworth (2000), Don't put it on, put it off, *Food Manufacture*, 75, pp39-40.

Garbutt, R. (2005), Sea and Water conference, *Logistics and Transport Focus*, 7(4), pp50-52.

García-Arca J., J.C. Prado-Prado & A. García-Lorenzo (2006), Logistics improvement through packaging rationalization: a practical experience, *Packaging Technology & Science,* (in press).

Garnett, T. (2003), *Wise Moves: Exploring the Relationship between Food, Transport and* CO_2, London: Transport 2000.

Ghobadian, A., H. Viney, P. James and J. Liu (1995), The influence of environmental issues in strategic analysis and choice, *Management Decision*, 33(10), pp46–58.

Giannopoulos, G.A. (2004), The application of information and communication technologies in transport, *European Journal of Operational Research*, 152, pp302-320.

Girod, S. and M. Bryane (2003), Branding in European retailing: a corporate social responsibility perspective, *European Retail Digest*, 38, pp1-6.

Golding, A. (1999), *Reuse of Primary Packaging – Final Report*, Prepared for European Commission.

Goldman, T. and R. Gorham (2006), Sustainable urban transport: four innovative directions, *Technology in Society*, 28, pp261-273.

Green, F.B. (2001), Managing the unmanageable: integrating the supply chain with new developments in software, *Supply Chain Management: A International Journal*, 6(5), pp208-211.

Greene, D.L. (2003), *Obstacles to Policy Implementation: Fuel Economy Standards, the Rebound Effect and Safety,* paper presented in STELLA FG4 meeting in Quebec on 26–27 May 2003.

Guide, V.D.R. and D.W. Jr. Pentico (2003), A hierarchical decision model for remanufacturing and re-use, *International Journal of Logistics: Research and Applications*, 6(1-2), pp29-35.

Gustaffson, K., G. Jonson, D. Smith and L. Sparks (2006), *Retail Logistics & Fresh Food Packaging*, Kogan Page, London.

Hagan, P. (2005), Skills for life, *Commercial Motor, 15th December*, pp36-37.

Halldórsson, A. and J. Aastrup (2003), Quality criteria for qualitative inquiries in logistics, *European Journal of Operational Research*, 144, pp321-332.

Hamschmidt, J. and T. Dyllick (2001), ISO 14001: profitable? Yes! But is it eco-effective?,*Greener Management International*, 36, pp43-54.

Hartley, R. (1972), *Marketing Management and Social Change*, Intext Educational Publishers, Scranton, PA.

Helo, P. and B. Szekely (2005), Logistics information systems – an analysis of software solutions for supply chain co-ordination, *Industrial Management & Data Systems*, 105 (1), pp5-18.

Heriot-Watt University (2007), *Transport Management – A Literature Review*, Green Logistics Project Work Module 1.

Hickford, A.J. and T.J. Cherrett (2007), *Developing Innovative and More Sustainable Approaches to Reverse Logistics and the Collection, Recycling and Disposal of Waste Products from Urban Centres – Literature Review*, Working Paper for EPSRC Project.

Highways Agency (2003), *Highways Agency Guide to Freight*, February.

Hill, C.A. and G.D. Scudder (2002), The use of electronic data interchange for supply chain coordination in the food industry, *Journal of Operations Management*, 20, pp375-387.

Hillary, R. (1994), *The Eco-Management and Audit Scheme, A practical guide Business and the Environment - Practitioners Series*, Stanley Thornes, Cheltenham.

Himanen, V., M. Lee-Gosselin and A. Perrels (2005), Sustainability and the interactions between external effects of transport, *Journal of Transport Geography*, 13, pp23-28.

HM Government (2006), *Climate Change: The UK Program 2006*, CM6764, SE/2006/43.

HMRC (2011), *Notice LFT1 - A General Guide to Landfill Tax*, April 2011, HM Revenue & Customs.

Hoare, N.P. and J.E. Beasley (2001), Placing boxes on shelves: a case study, *Journal of Operational Research Society*, 52, pp605-614.

Holden, E. and K.G. Hoyer (2005), The ecological footprints of fuels, *Transportation Research Part D*, 10, pp395-403.

Holguin-Veras, J. (2008), Necessary conditions for off-hour deliveries and the effectiveness of urban freight road pricing and alternative financial policies in competitive markets, *Transportation Research Part A: Policy and Practice*, 42(2), pp392-413.

Holland, L. and Y.B. Foo (2003), Differences in environmental reporting practices in the UK and the USA: the legal and regulatory context, *British Accounting Review*, 35, pp1-18.

Hsiao, H.I., R.G.M. Kemp, J.G.A.J. van der Vorst and S.W.F. Omta (2010), A classification of logistic outsourcing levels and their impact on service performance: evidence from the food processing industry, *International Journal of Production Economics*, 124(1), pp75-86.

Humphrey, C. (2008), *Full Evaluation Report – Urban Transhipment Centre*, available at: http://www.eltis.org/docs/studies/10-3%2010-4%2010-5cNorwich.pdf (accessed 21 November, 2009).

Hung, W.T. (2006), Taxation on vehicle fuels: its impact on switching to cleaner fuels, *Energy Policy*, 34(16), pp2566-2571.

Hvattum, L.M., A. L-kketangen and G. Laporte, (2006), Solving a dynamic and stochastic vehicle routing problem with a sample scenario hedging heuristic, *Transportation Science*, 40(4), pp421-438.

Hyde, K.F. (2000), Recognising deductive processes in qualitative research, *Qualitative Market Research: An International Journal*, 3(2), pp82-90.

IANGV (2010), Natural gas vehicle statistics: summary data 2010, available at http://www.iangv.org/tools-resources/statistics.html (accessed 20 April, 2010)

IEA (2010), *Roadmap Background Informtation: Biofuels for Transport*, International Energy Agency.

IGD (2003), *Transport Optimisation: Sharing Best Practice in Distribution Management*, IGD: Watford.

IRU (2002), *Report on Road Transport – Best Industry Practices*, International Road Transport Union, available at http://www.iru.org/en_bookshop_item?_rewrite_sticky=bookshop-display-action&id=10

Jackson, M. and D. Timson (2001), The supply chain implications of 24h economy for large retailers in the UK, *Proceedings of 24 h Economy 24 h Transport: Nightmare or Solution?*, Distrution Forum in Vaveno, Italy, 10-11 September, pp11-22.

Jacoby, D.H. & Ellerman, A.D. (2004), The safety valve and climate policy, *Energy Policy*, 32 (2004), pp481–491.

Jahre, M. and C. J. Hatteland (2004), Packages and physical distribution: implications for integration and standardisation, *International Journal of Physical Distribution and Logistics Management*, 34(2), pp123-139.

Jiang, R.J. and P. Bansal (2003), Seeing the need for ISO 14001, *Journal of Management Studies*, 40(4), pp1047-1067.

Johnson, E. (2003), LPG: a secure, cleaner transport fuel? A policy recommendation for Europe, *Energy Policy*, 31(15), pp1573-1577.

Jones, P. and D. Comfort (2005), Corporate social responsibility and the UK's top ten retailers, *International Journal of Retail & Distribution Management*, 33(12), pp882-892.

Hill, J. (2009), *Greener Products – Mapping the Environmental Policy Drivers on Products and Production Processes*, Green Alliance, September 2009

Khan, O. and Creazza, A. (2009), Managing the product design-supply chain interface Towards a roadmap to the "design centric business", *International Journal of Physical Distribution & Logistics Management*, 39 (4), pp301-319.

Keenan, M. (2008), *Study of Costs and Impact upon CO_2 and Primary NO_2 Emissions of a Range of Limits for Emissions of NO_x and PM in the Timescale 2014*, Ricardo UK Ltd.

Knecht, W. (2008), Diesel engine development in view of reduced emission standards, *Energy*, 33, pp264-271.

Kolk, A. (2000), *Economics of Environmental Management*, Financial Times/Prentice-Hall, London.

Kovács, G. and K.M. Spens (2005), Abductive reasoning in logistics research, *International Journal of Physical Distribution & Logistics Management*, 35(2), pp132-144.

Kroon, L. and G. Vrijens (1995), Returnable containers: an example of reverse logistics, *International Journal of Physical Distribution and Logistics Management*, 25(2), pp56-68.

Lamma, E., P. Mello, M. Milano and F. Riguzzi (1999), Integrating induction and abduction in logic programming, *Information Sciences*, 116, pp25-54.

Lang, B. (2006), *In-depth interviews with van drivers and managers of van drivers*, Published Project Report PPR 106 Order 88, for AA Motoring Trust, TRL Limited.

Larson, P.D. and R.F. Poist (2004), Improving response rates to mail surveys: a research note, *Transportation Journal*, 43(4), pp67-74.

Lave, L.B., C.T. Hendrickson, N.M. Conway-Schempf, and F.C. McMichael (1999), Municipal solid waste recycling issues, *Journal of Environmental Engineering*, 125(10), pp944-949.

Lawson, K., C. Michaelis and D. Waldron (2008), *SAFED impact assessment 2007 – Final Report, Databuild Research & Solutions*, available at: http://www2.dft.gov.uk/pgr/freight/research/safedimpactassessment/safed.pdf

Leicester, A. (2005), Fuel taxation, Institute for Fiscal Studies, *Briefing Note No. 55*.

Léonardi, J. and M. Baumgartner (2004), CO_2 efficiency in road freight transportation: status quo, measures and potential, *Transportation Research Part D*, 9, pp451-464.

Lex (2001), *The Lex Vehicle Leasing 2001 Report on Company Motoring*, Lex Vehicle Leasing.

Li, L. and K. Geiser (2005), Environmentally responsible public procurement (ERPP) and its implications for integrated product policy (IPP), *Journal of Cleaner Production*, 13(7), pp705-715.

Lim, D. and P.C. Palvia (2001), EDI in strategic supply chain: impact on customer service, *International Journal of Information Management*, 21(3), pp193–211.

Loffler, P. (1999), City Logistics: A contribution to sustainable development? – A contribution to the discussion on solutions to freight transport problems in urban areas, *World Transport Policy and Practice*, 5(2), pp4-10.

Lourenço, H.R., Soto, J.P. (2002), *A Recoverable Production Planning Model*, Working Paper, Grup de Recerca en Logistica Empresarial, Barcelona.

Lowe, D. (2007), *The Transport Manager's and Operator's Handbook 2007*, Kogan Page: London.

Malek, T. (2001), *The development of environmental policy in Germany*, in Heinelt, H.

Malek, T., Smith, R. and Toller, A.E. (2001), *European Union Environmental Policy and New Forms of Governance*, Ashgate, Aldershot, pp56-60.

Maltby, J. (1995), Environmental audit: theory and practices, *Managerial Auditing Journal*, 10(8), pp15-26.

Mangan, J., C. Lalwani and B. Gardner (2004), Combining quantitative and qualitative methodologies in logistics research, *International Journal of Physical Distribution & Logistics Management*, 34(7), pp565-578.

Mansell, G. (2006), Transport tendering comes of age, *Logistics & Transport Focus*, May 2006.

Mansell, G. (2001), The development of online freight markets, *Logistics & Transport Focus*, 3(7), pp18-21.

Marasco, A. (2008), Third-party logistics: a literature review, *International Journal of Production Economics*, 113(1), pp127-147.

Marketline International (1997), *EU Logistics*, London.

Marland, G., T.A. Boden, and Andres, R. J. (2003), Global, Regional, and National CO2 Emissions, *Trends: A Compendium of Data on Global Chang*, available at: http://cdiac.esd.ornl.gov/trends/emis/tre_glob.htm

Martin, R. (1998), *ISO14001 Guidance Manual, National Center for Enviornmental Decision-Making Research, Technical Report NCEDR/98-06*, available at: http://www.usistf.org/download/ISMS_Downloads/ISO14001.pdf

Mason, R., Simons, D., Peckham, C., Wakeman, T. (2002), *Life-Cycle Modelling CO_2 Emissions for Lettuces, Apples and Cherries*, available at the Department for Transport website:http://www.dft.gov.uk/stellent/groups/dft_freight/documents/page/dft_freight_508272.hcsp

McKinnon, A.C. (2007a), Decoupling of road freight transport and economic growth trends in the UK: an exploratory analysis, *Transport Reviews*, 27(1), pp37–64.

McKinnon, A.C. (2007b), *CO_2 Emissions from Freight Transport in the UK*, UK Commission for Integrated Transport, London.

McKinnon, A.C. (2007c), Increasing fuel prices and market distortion in a domestic road haulage market: the case of the United Kingdom, *European Transport*, 35(2007), pp5-26.

McKinnon, A.C. (2005), The economic and environmental benefits of increasing maximum truck weight: the British experience, *Transportation Research Part D*, 10, pp77-95.

McKinnon, A.C. (2003a), Logistics and the environment, Chapter 37 in Hensher, D.A. & K.J. Button (eds.), *Handbook of Transport & the Environment*, Elsevier: Amsterdam.

McKinnon, A.C. (2003b), The effects of ICT and e-commerce on logistics: a review of the policy issues, *BPR Logistics: EU Thematic Network, Position Paper No. 3*, February 2003.

McKinnon, A.C. (2000), Sustainable distribution: opportunities to improve vehicle loading, *UNEP Industry and Environment*, 23(4), pp26-30.

McKinnon, A.C. (1999), Outsourcing of logistical activities (revised and updated version), *Global Logistics and Distribution Planning*, Kogan Page, London.

McKinnon, A.C. (1996), The empty running and return loading of road goods vehicles, *Transport Logistics*, 1(1), pp1-19.

McKinnon, A.C., M.I. Piecyk and A. Somerville, (2008), Decoupling, recoupling and the future growth of road freight, *Logistics and Transport Focus*, 10(12), pp40-46.

McKinnon, A.C. and Y. Ge (2006), The potential for reducing empty running by trucks: a retrospective analysis, *International Journal of Physical Distribution & Logistics Management*, 36(5), pp391-410.

McKinnon, A.C. and Y. Ge (2004), Use of a synchronised vehicle audit to determine the opportunities for improving transport efficiency in a supply chain, *International Journal of Logistics: Research and Applications*, 7(3), pp219-238.

McKinnon, A.C., Y. Ge and D. Leuchars (2003), Analysis of transport efficiency in the UK food supply chain, *Full Report of the 2002 Key Performance Indicator Survey*.

McKinnon, A.C. & D. Tallam (2003), Unattended delivery to the home: an assessment of the security implications, *International Journal of Retail & Distribution Management*, 31(1), pp30-41.

McKinnon, A. and M. Forester (2001), Effects of product design and packaging on freight vehicle utilisation, *Proceedings of the 6th Logistics Research Network Conference, Edinburgh, UK, 12-14th September 2001*.

Mentzer, J.T. and D.J. Flint (1997), Validity in logistics research, *Journal of Business Logistics*, 18(1), pp199-266.

Mentzer, J.T. and K.B. Kahn (1995), A framework of logistics research, *Journal of Business Logistics*, 16(1), pp231-50.

Michelsen, O. and L. Boer (2009), Green procurement in Norway; a survey of practices at the municipal and county level, *Journal of Environmental Management*, 91(1), pp160-167.

Midilli, A. and I. Dincer (2008), Hydrogen as a renewable and sustainable solution in reducing global fossil fuel consumption, *International Journal of Hydrogen Energy*, 33(16), pp 4209-4222.

Mintel (2009), *Freight Forwarding (Industrial Report)*, UK, May.

Momirlan, M. and Veziroglu, T.N. (2005), The properties of hydrogen as fuel tomorrow in sustainable energy system for a cleaner planet, *International Journal of Hydrogen Energy*, 30(7), pp 795-802.

MTRU (2007), *Heavier Lorries and Their Impacts on the Economy and the Environment*, for Freight on Rail, October, available at:
http://www.freightonrail.org.uk/PDF/heavier%20lorries%20and%20their%20impacts%20on%20the%20economy.pdf (accessed 22 March, 2008)

Muñuzuri, J., J. Larrañeta, L. Onieva and P. Cortés (2005), Solutions applicable by local administrations for urban logistics improvement, *Cities*, 22(1), pp15-28.

Murphy P.R., Poist R.F. (2003), Green perspectives and practices: a "comparative logistics" study, *Supply Chain Management: An International Journal*, 8(2), pp122-131.

Näslund, D. (2002), Logistics needs qualitative research – especially action research, *International Journal of Physical Distribution & Logistics Management*, 32(5), pp321-38.

Network Rail (2010), Network Rail Interim Climate Change Adaptation Report, 30 September 2010, available at: http://archive.defra.gov.uk/environment/climate/documents/interim2/network-rail-101210.pdf

NGVA Europe (2011), *European NGV Statistics – NGVs and fuel consumption in Europe 2010*, Natural and Bio-Gas Vehicle Association Europe, available at: http://www.ngvaeurope.eu/european-ngv-statistics

Noordegraaf, D.M.V. and O.A.W.T. Riet (2007), *The Impact of Road Pricing on Shippers and Freight Carriers: the Distribution of Costs and Benefits*, Bijdrage aan het European Transport Conference 2007, Noordwijkerhout.

Ogden, K.W. (1992), *Urban Goods Movement, A Guide to Policy and Planning*, Aldershot: Ashgate.

OECD (1997), Integrated environment/safety strategies – expert group report, *Road Transport Research Programme*, Paris.

ORR (2006), *National Rail Trends Yearbook 2005-06*, Office of Rail Regulation.

Pagh J. D. and M.C. Cooper (1998), Supply chain postponement and speculation strategies: how to choose the right strategy, *Journal of Business Logistics*, 19(2), pp13-32.

Palmer, A. (2007), An integrated routing model to estimate carbon dioxide emission from freight vehicles, *Logistics Research Network 2007 Conference Proceedings*.

Parvenov, A. (2005), Reverse logistics: best practices in warehouse returns, *Supply Chain Digest*, 2005.

Patterson, T., S. Esteves, R. Dinsdale and A. Guwy (2011), An evaluation of the policy and techno-economic factors affecting the potential for biogas upgrading for transport fuel use in the UK, *Energy Policy*, 39 (2011), pp1806-1816.

Payne, W. (2002), The time for ERP?, *Work Study*, 51(2), pp91-93.

PE Consulting (1998), *The Changing Role of Third-Party Logistics – Can the Customer Ever be Satisfied, Survey into the Expectations of Outsourced Distribution Services*, Egham, P.E. Consultancy.

Phillips, J.H. (1996), Legal alert – environmental audits, *Metal Finishing*, January, pp49-51.

Plowden, S. and K. Buchan (1995), *A New Framework for Freight Transport*, London: Civic Trust.

Potter, A., C. Lalwani, S. Disney and H. Velho (2003), Modelling the impact of factory gate pricing on transport & logistics, *Proceedings of the 8th International Symposium on Logistics*, pp625-630.

Pramatari, K. (2007), Collaborative supply chain practices and evolving technological approaches, *Supply Chain Management: An International Journal*, 12(3), pp210-220.

Pronello, C. and Andr ́e, M. (2000), *Pollutant Emissions Estimation in Road Transport Models*, Report INRETS-LTE, vol 2007.

Punakivi M., H. Yrjola and J. Holmstrom (2001), Solving the last mile issue: reception box or delivery box?, *International Journal of Physical Distribution and Logistics*, 31(6), pp427-439.

Quariguasi Frota Neto, J., J.M. Bloemhof-Ruwaard, J.A.E.E. van Nunen and E. van Heck (2008), Designing and evaluating sustainable logistics networks, *International Journal of Production Economics*, 111(2), pp195-208.

Rabinovich, E. and P. Evers (2003), Postponement effects on inventory performance and the impact of information systems, *International Journal of Logistics Management*, 14(1), pp33-48.

Rahman A, van Grol R. (2005), SUMMA final publishable report v. 2.0. Available at: http://www.summa-eu.org/control/reports/SUMMA-D8.pdf

RCEP (2000), *Energy: The Changing Climate*, *22nd report*, Royal Commission on Environmental Pollution, London: The Stationery Office.

RFA (2011), *Year Two of the RTFO – Renewable Fuels Agency Report on the Renewable Transport Fuel Obligation 2009/10*, London: The Stationery Office.

Ribeiro, R.A., P.L. Powell and J.F. Baldwin (1995), Uncertainty in decision-making: an abductive perspective, *Decision Support Systems*, 13, pp183-93.

Rijkswaterstaat (2011a), *Longer and Heavier Vehicles in Practice: Economic, Logistical and Social Effects*, July 2011, Directorate General for Public Works and Water Management (Rijkswaterstaat), Traffic and Shipping Department.

Rijkswaterstaat (2011b), *Monitoring Traffic Safety: Longer and Heavier Vehicles*, July 2011, Directorate General for Public Works and Water Management (Rijkswaterstaat), Traffic and Shipping Department.

Rijkswaterstaat (2011c), *Monitoring Modal Shift: Longer and heavier vehicles, the Follow-up Measurement (2011)*, Directorate General for Public Works and Water Management (Rijkswaterstaat), Traffic and Shipping Department.

Rohde, R. A. (2005), *GeoWhen Database*, retrieved in September 2007 at: http://www.stratigraphy.org/geowhen/index.html

Robinson, M. and Mortimer, P. (2004), Urban freight and rail, the state of the art, *Logistics & Transport Focus*, 6(1), pp46-51.

Rogers, D.S., Tibben-Lembke, R.S. (2001), An examination of reverse logistics practices, *Journal of Business Logistics*, 22(2), pp129-148.

Rogers, D.S. and R.S. Tibben-Lembke (1999), *Going Backward: Reverse Logistics Trends and Practices*. Reverse Logistics Executive Council, Pittsburg, PA.

Rothery (1993), *BS7750: Implementing the Environment Management Standard*, Gower Publishing Ltd.

Shapiro, F.J. (2002), Business process expansion to exploit optimization models for supply chain planning: the role of optimization in supply chain management, IMA Workshop, *Slim Technologies*, Wellesley, MA, available at: www.ima.umn.edu/talks/workshops/9-23-27.2002/shapiro/shapiro.pdf (accessed March 2008).

Sarkis, J., L.M. Meade and S. Talluri (2000), E-logistics and the natural environment, *Supply Chain Management: An International Journal*, 9(4), pp303-321.

Saunders, C., A. Barber, G. Taylor (2006), Food miles – comparative energy/emissions performance of New Zealand's agriculture industry, *Research Report*, 285, July, Lincoln University, New Zealand.

Saunders, M., P. Lewis and A. Thornhill (2007), *Research methods for business students*, 4th Edition, Financial Times/Prentice Hall.

Sbihi, A. and R.W. Eglese (2007), *The Relationship between Vehicle Routing & Scheduling and Green Logistics – A Literature Survey*, Lancaster University.

Schipper, L.J. and L. Fulton (2003), Carbon Dioxide Emissions from Transportation: Trends, Driving Factors and Forces for Change, in D.A. Hensher and K.J. Button (eds) *Handbook of Transport and the Environment*, vol. 4, Amsterdam: Elsevier.

Sheffi, Y. (1990), Third party logistics: present and future prospects, *Journal of Business Logistics*, 11(2), pp27–39.

Smith, W.J. (2010), Can EV address Ireland's CO_2 emissions from transport?, *Energy*, 35(12), pp4514-4521.

Social Issues Research Centre (1998), Renault master white van man study, *Van Man Study*, SIRC, Oxford, 1998.

Soh, C., Kien, S. and Tay-Yap, J. (2000), Cultural fits and misfits: is ERP a universal solution?, *Communications of the ACM*, 43(4), pp47-51.

Spens, K.M. and G. Kovács (2006), A content analysis of research approaches in logistics research, *International Journal of Physical Distribution & Logistics Management*, 36(5), pp374-390.

Stassen, R.E. and M.A. Waller (2002), Logistics and assortment depth in the retail supply chain: evidence from grocery categories, *Journal of Business Logistics*, 23(1), pp125-143.

Stern, N. (2007), *The Economics of Climate Change: The Stern Review*, Cambridge University Press.

Sterner, T. (2007), Fuel taxes: an important instrument for climate policy, *Energy Policy*, 35(6), pp3194-3202.

Stewart, R.B. (2001), A new generation of environmental regulation, *Capital University Law Review*, 29, pp21-182.

Stock, J.R. (1997), Applying theories from other disciplines to logistics, *International Journal of Physical Distribution & Logistics Management*, 27(9/10), pp515-39.

Stock, J.R. (1992), *Reverse Logistics, A White Paper Prepared for the Council of Logistics Management*, Oak Brook, IL.

Stratec, S.A. (2005), City freight: inter- and intra-city freight distribution networks, *European Commission Fifth Framework Programme*, Energy, Environment and Sustainable Development, Final Report.

STRAW (2006), Sustainable transport resources and waste, Report by Envirocentre, as part of the *Biffaward Programme* on Sustainable Resource Use.

Swallow, K. (2005), Double dutch, *Commercial Motor*, 21 July, pp62-63.

Tarn, J.M., D.C. Yen and M. Beaumont (2002), Exploring the rationales for ERP and SCM integration, *Industrial Management & Data Systems*, 102(1), pp26-34.

TfL (2008), *London Low Emission Zone, Impacts Monitoring Baseline Report*, July 2008, Transport for London.

TfL (2007), *Proposed Emissions Related Congestion Chargin: Public and Stakeholder Consultation & Detailed Scheme Description and Supplementary Information*, August 2007, Transport for London.

TfL (2007), *Central London Congestion Charging: Impacts monitoring, Fifth Annual Report*, July 2007, Transport for London.

TfL (2004), *London Travel Report 2004*, Transport for London.

The Times (2007), Bigger, longer, cheaper, greener: superlorry is coming your way, *The Times*, November 26, 2007.

Transport Intelligence (2005), *UK Logistics Market Report - The essential reference guide to the UK Logistics industry*, January 2005.

Trends (2003), *Calculation of Indicators of Environmental Pressure Caused by Transport*, Main report, European Commission, Office for Official Publications of the European Communities, Luxembourg.

Twede D., R.H. Clarke and J.A. Tait (2000), Packaging postponement: a global packaging strategy, *Packaging Technology & Science*, 13, pp103-115.

Vägverket (1999), *Impact of EcoDriving on Emissions and Fuel Consumption: A Pre-Study*, SNRA Publication 1999:165E

van Hoek, R. I. and R. van Dierdonck (2000), Postponed manufacturing supplementary to transportation services?, *Transportation Research Part E*, 36, pp205-217.

van Hoek, R.I. and Chapman, P. (2006), From tinkering around the edge to enhancing revenue growth: supply chain-new product development, *Supply Chain Management: An International Journal*, 11(5), pp385-9.

van Hoek, R.I. and Chapman, P. (2007), How to move supply chain beyond cleaning up after new product development, *Supply Chain Management: An International Journal*, 12(4), pp239-44.

Vasquez, D., M. Bruce and R. Studd (2003), A case study exploring the packaging design management process with a UK food retailer, *British Food Journal*, 105(9), pp602-617.

VenW and VROM (2006), *Nota Mobiliteit, Na parlementaire behandeling vastgestelde PKB, Deel IV*, Den Haag: Ministerie van Verkeer en Waterstaat en Ministerie van Volkshuisvesting en Ruimtelijke ordening en Milieubeheer.

VOSA (2007), *Rules on Drivers' Hours and Tachographs – Goods Vehicles in the UK and Europe (revised 2007)*, Vehicle & Operator Service Agency.

Walker, D., M. Pitt and U.J. Thakur (2007), Environmental management systems: information management and corporate responsibility, *Journal of Facilities Management*, 5(1), pp49-61.

Waller, M.A., P.A. Dabholkar and J.J. Gentry (2000), Postponement, product customization, and market-oriented supply chain management, *Journal of Business Logistics*, 21(2), pp133-159.

Wang,Y., A. Potter and M. Naim (2007), Electronic marketplaces for tailored logistics, *Industrial Management & Data Systems*, 107(8), pp1170-1187.

Watson, M. (2004), Environmental auditing in the new Europe, *Managerial Auditing Journal*, 19(9), pp1131-1139.

Watson, M. and A.R.T. Emery (2004), The reality of environmental self-regulation, *Managerial Auditing Journal*, 19(7), pp916-928.

WBCSD (2001), *Mobility 2001, World Mobility at the End of the Twentieth Century and its Sustainability*, World Business Council.for Sustainable Development, Geneva.

Webb, B., Marshall, B., Czarnomski, S., Tilley, N. (2006), *Fly-tipping: Causes, Incentives and Solutions*, Jill Dando Institue of Crime Science, UCL.

Whiteing, A.E. and S.J.F. Edwards (1996), *Urban Freight Facilities: A European Comparative Study of the Potential for Urban Freight Trans-shipment Facilities*, University of Huddersfield.

Wong, C.Y., Karia, N. (2009), Explaining the competitive advantage of logistics service providers: a resource-based view approach, *International Journal of Production Economics*, article in progress, available online in September 2009.

Woodburn, A.G. (2001), *The role of logistical structure in the development of rail freight services in Great Britain*, PhD thesis, Napier University.

Woodburn. A.G., M. Browne, M. Piotrowska and J. Allen (2007), *Scope for Modal Shift through Fiscal, Regulatory and Organisational Change*, Literature Review of Green Logistics Project.

World Commission on Environment and Development (1987), *Our Common Future*, Oxford University Press, Oxford.

World LPGA (2005), *Autogas Incentive Policies – A Country-by-Country Analysis of Why and How Governments Promote Autogas and What Works*, World LP Gas Association, Paris.

Wu, H.-J. and S.C. Dunn (1995), Environmentally responsible logistics systems, *International Journal of Physical Distribution & Logistics Management*, 25(2), pp20-38.

Wurzel, R.K.W., A. Jordan , A.R. Zito and L. Bruckner (2003), From high regulatory state to social and ecological market economy? 'New' environmental policy instruments in Germany, *Environmental Politics*, 12(1), pp115-36.

Yang, B., N. Burns and C. Backhouse (2004), Management of uncertainty through postponement, *International Journal of Production Researc*h, 42(6), pp1049-64.

Yang, B. and Burns, N. (2003), Implications of postponement for the supply chain, *International Journal of Production Research*, 41(9), pp2075-90.

Yeh, S. (2007), An empirical analysis on the adoption of alternative fuel vehicles: the case of natural gas vehicles, *Energy Policy*, 35(11), pp5865-5875.

Zachariadis, T. (2005), Assessing policies towards sustainable transport in Europe: an integrated model, *Energy Policy*, 33, pp1509-1525.

Zanni, A.M. and Bristow, A.L. (2008), Emissions of CO_2 from freight transport in London: trends and policies for long run reductions, *European Transport Conference 2008*.

Zelenka, K., Cartellieri, W. and Herzog, P. (1996), Worldwide diesel emission standards, current experiences and future needs, *Applied Catalysis B: Environmental*, 10, pp3-28.

Zografos K. G. and I.M. Giannouli (2001), Development and application of a methodological framework for assessing supply chain management trends, *International Journal of Logistics*, 4(2), pp153-190.

Appendix One: Breakdown List of Sustainable Logistics Solutions

1 Modal Shift

2 Alternative Fuels

- 2.1 Biofuels
- 2.2 Hydrogen
- 2.3 Other lower emission fuels

3 Inclusion of the Road Transport in the EU Emission Trading Scheme (ETS)

4 Diesel Fuel Taxation

5 Road Pricing

- 5.1 Congestion charge scheme
- 5.2 Low Emission Zone
- 5.3 National road pricing (“pay-as-you-drive” scheme)

6 Government Support

- 6.1 Regulating
- 6.2 Procurement
- 6.3 Facilitating - Funding and other support

7 Urban Logistics

- 7.1 Urban transhipment/consolidation centre
- 7.2 Time/route/vehicle size/weight restrictions

8 Reverse Logistics

- 8.1 Waster management
- 8.2 Other reverse logistics

9 Supply Chain Optimisation

- 9.1 Green sourcing
- 9.2 Local sourcing
- 9.3 Postponement
- 9.4 Transport/logistics optimisation

10 Information and Communication Technology

- 10.1 Computerised vehicle routing and scheduling (CVRS)
- 10.2 Online freight exchange marketplace
- 10.3 Telematics
- 10.4 Other operational information systems

11 Vehicle Design

- 11.1 Engine design
- 11.2 Aerodynamic design
- 11.3 Lower rolling-resistance tyres
- 11.4 Air flow deflector kit
- 11.5 Trailer modification
- 11.6 Tractor add-ons
- 11.7 Double-decker
- 11.8 Longer, heavier vehicles (LHVs)

12 Product/Package Design

13 Environmental Management Systems

- 13.1 Environmental/carbon management and auditing systems
- 13.2 Corporate social responsibility (CSR)

14 Driver Training

Appendix Two: Questionnaires Used for Industrial Survey

Sustainable Logistics Survey

- *Policies & Corporate Strategies*

The University of Westminster is carrying out topical research within the 'sustainable logistics' theme. This research involves the development of a framework to assess current policies and potential solutions for greening logistics operations, and seeks to find out how these issues are going to impact on businesses such as yours. A survey has been designed for this purpose, and your views on the issues it covers are regarded as being of great value in assessing the practicalities of implementing green solutions. We would therefore very much appreciate your input into this research.

We have done our best to make the survey as simple as possible and it will take you no more than 5 minutes to complete it.

Participation in this survey will enable you to:

- Identify opportunities for greening your operation, often at the same time as reducing costs
- Learn how Government policy affects your business
- Keep abreast of the latest developments and best practices in sustainable logistics

As return for your support, we would provide you with:

- The survey results showing common practices in sustainable logistics in the UK;
- The possibility of your company being represented in the report as a case study

Both the survey results and case study will be anonymised in the research report. All your information will be kept completely confidential unless you agree that you or your company will be named. .

To make it easy for you, we have provided a <u>prepaid envelope</u> with our address on. Thank you for your participation!

Amanda Mao

1. Your business is:

Logistics Service Provider ☐
Managing your own logistics activities ☐
Outsourcing your logistics function ☐
Logistics service user ☐
Others – please specify: ______________________

2. The geographic scope of your logistics operation is:

Local/Regional ☐
National ☐
International ☐

3. Please tick the transport modes your business is using (Note： if you are using multiple modes, please also circle the major mode with the greatest freight volume):

Road ☐
Rail (including Channel Tunnel) ☐
Shipping (including deep-sea and coastal shipping) ☐
Air ☐
Inland Water ☐
Others – please specify: ______________________

4． If you are using road haulage, please give an estimate to the size of the fleet you are using or operating; otherwise please go to Question 5:

Less than 20 vehicles ☐
20 ~ 49 vehicles ☐
50 ~ 99 vehicles ☐
100 ~ 199 vehicles ☐
200 vehicles and above ☐

5. Sectors – please tick the market sectors where your main logistics activities are:

Food, drink and tobacco ☐
Other FMCG (manufacture) ☐
Retail ☐
Chemical ☐
Automotive ☐
Other Industrial ☐
Others – specify: ______________________

6. Your contact details:

Name: ______________________

Position: ______________________

Tel: ______________________

Email: ______________________

7*. Please rank (from 1 to 5) the top 5 sustainable solutions which have the most significant impacts on your logistics operation.

Rank (1-5)

______ Alternative fuels

______ Diesel Fuel Taxation on Road Transport

______ Driver Training

______ Environmental Management and Auditing

______ Government Support

______ Inclusion of Transport in the EU Emission Trading Scheme

______ Information and Communication Technology (ICT)

______ Modal shift

______ Product/Packaging Design

______ Reverse Logistics

______ Road Pricing

______ Supply Chain Optimisation

______ Urban Logistics

______ Vehicle Design Technology

8. Do you have experience in greening your logistics operations that could be included in our research project in the form of a case study?

Yes ☐ No ☐

9. Are you willing to be contacted for a short, informal interview?

Yes, and a brief face-to-face interview is preferred. ☐

Yes, and a brief telephone interview is preferred. ☐

No, thanks. ☐

* We propose to send you a short supplementary questionnaire covering the five solutions that you have identified above, and it would be much appreciated if you could provide some additional responses on these aspects.

Section 1 – Alternative Fuels

1.1 Are you using any alternative fuels in your operation?

Yes.	☐
No, but I am considering switching at least part of the fuel consumption to alternative fuels.	☐
No, and I am not sure of future adoption.	☐ (- go to question **1.3**)

1.2 What types of alternative fuel are you using or considering using, and how much does it account for (as percentage of your freight fleet using it)?

	< 5%	5%-10%	11%-20%	21%-50%	>50%
Biofuel	☐	☐	☐	☐	☐
Fuel cell	☐	☐	☐	☐	☐
CNG	☐	☐	☐	☐	☐
LPG	☐	☐	☐	☐	☐
Electricity - battery	☐	☐	☐	☐	☐
Others – specify: ____________	☐	☐	☐	☐	☐

1.3 What are the main drivers to your using more alternative fuels?

Regulation (e.g.RTFO[1]) __________
Road pricing __________
Increasing diesel fuel cost __________
Environmental benefits __________
Fuel duty incentives __________
Corporate image __________
Others: ______ Specify: ____

1.4 What are your main concerns of using alternative fuels?

High alternative fuel price __________
Vehicle modification / fleet upgrading __________
Higher fuel consumption (e.g. lower energy content) __________
Availability __________
Inconvenience __________
Maintenance cost __________
Vehicle performance __________
Others: ______ Specify: ____

1.5 In financial terms, can the benefit of using more alternative fuels justify the additional cost occurred in your business?

Yes ☐ *No* ☐ *Not sure* ☐

[1] the Renewable Transport Fuel Obligation.

Section 2 – Diesel Fuel Taxation on Road Transport

2.1 How effective a stimulus do you think fuel taxation is for sustainable transport? Please rate from 1 to 5: 1 – not effective; 5 – very effective.

1	2	3	4	5
☐	☐	☐	☐	☐

2.2 Do you think it is practical to tax non-UK lorries that come into the country on business?

Yes ☐ No ☐ Not sure ☐

2.3 Your main strategies in response to increasing diesel fuel taxation are/would be:
(Please select no more than 3 answers and rank them by priority, e.g. 1 for first priority)

Enhancing fuel efficiency ____________
Passing the cost on to customers ____________
Overhaul and reorganise operation ____________
Fleet upgrading ____________
Alternative fuel ____________
'Absorbing' cost internally ____________
Modal shift ____________
Others: ______ Specify: ________________________________

2.4 Do you think the overall benefit of diesel fuel taxation (in environmental, social and economic terms) outweighs the cost?

Yes ☐ No ☐ Not sure ☐

2.5 Which approach do you think will work better for sustainable transport?

Diesel Fuel tax on road transport ☐
Road Pricing ☐
Including transport into the Emission Trading Scheme (ETS) ☐
None ☐

Please give the reason of your choice: ________________________________
____

Section 3 – Driver Training

3.1 What types of training programmes do you provide to your drivers?

In-house one-off training ☐
In-house on-going training ☐
Written safety policy and guidelines ☐
Defensive / safe driving training ☐
Driving risk assessment ☐
Driving behaviour monitoring and performance assessment ☐
Participate in the Safe and Fuel Efficient Drivers (SAFED) Scheme[2] ☐
None ☐
Others: ☐ Specify: ____________________

3.2 What are the main reasons for training your drivers?
(Please select no more than 3 answers and rank them by priority, e.g. 1 for first priority)

Improve fuel efficiency
Improve operation efficiency
Better customer service
Compliance to regulations[3]
Health and safety (e.g. accident rate reduction)
Environmental benefits (emission reduction)
Deployment of new technology (e.g. CIT systems or fleet upgrading)
Corporate image ____________
Others: ☐ Specify: ____________________

3.3 What are your main concerns in providing training to your drivers?
(Please select no more than 3 answers and rank them by priority, e.g. 1 for first priority)

Lack of information / expertise ________
Lack of resources ________
High cost ________
High staff turnover ________
Complexity of implementation ________
Lack of return on investment ________
Others: ☐ Specify: ____________________

3.4 In your business can the financial benefit of providing driver training justify the additional cost occurred?

Yes ☐ No ☐ Not sure ☐

[2] Launched and funded by DfT for van drivers training and assessment which aims to improve safe and fuel efficient driving techniques of commercial vehicle drivers.
[3] EU Driver Training Directive, for instance, has set to introduce compulsory initial qualification and periodic training for all LGV drivers from Sep. 2008 for HGV drivers.

Section 4 – Environmental Management and Auditing Systems

4.1 What forms of environmental management and auditing do you have in place or are you considering to adopt in 5 years' time?

	In place	Considering
ISO 14001 or 9001	☐	☐
The EU Eco-Management and Audit Scheme (EMAS)	☐	☐
Formal sustainable policy	☐	☐
Informal sustainable policy	☐	☐
Internal environmental auditing	☐	☐
External environmental auditing	☐	☐
None	☐	

Others: ☐ Specify: ____________________

4.2 If you have such a system in place, for how long has it been established?

Less than 2 years	2 – 5 years	6 – 10 years	More than 10 years	N/A
☐	☐	☐	☐	☐

4.3 Do you have a department/team/staff dedicated to sustainable issues?

Yes. ☐ No. Not sure. ☐

4.4 What are the main motivations for your business to establish and implement an environmental management and auditing system? (Please select no more than 3 answers)

Comply with environmental regulations	_______	Improve corporate image	_______
Innovation	_______	Cost reduction	_______
Environmental benefit	_______	Risk reduction	_______
Competitive advantage	_______	Commercial opportunities	_______
Public relationship with stakeholders	_______	Operational effeciency	_______

Others: ☐ Specify: ____________________

4.5 What are the main disincentives to establishing and implementing an environmental management and auditing system in your business?

(Please select no more than 3 answers)

Lack of information/expertise	☐	Complexity of implementation	☐
Lack of return on investment	☐	High cost	☐
Lack of consumers' recognition	☐	Lack of resources	☐

Others: ☐ Specify: ____________________

4.6 In your business can the benefit of Environmental Management and Auditing justify the additional cost occurred?

Yes ☐ No ☐ Not sure ☐

Section 5 – Government Support

5.1 Have you participated or heard of any of the following government support programmes? Please specify other programmes you have been or are involved.

	Participated	*Heard of*	*Never heard but interested*	*Never heard and not interested*
Freight Best Practice	☐	☐	☐	☐
The Sustainable Distribution Fund[4]	☐	☐	☐	☐
The SAFED for Vans programme	☐	☐	☐	☐
Freight Logistics Research Programme	☐	☐	☐	☐

Other Programmes. ***Specify:*** ______________________________

5.2 What benefits are you anticipating from the government support programmes?

Financial support	☐	Corporate image/certificate	☐
Information & advice	☐	Operation efficiency improvement	☐
Partnership with authorities	☐	New market opportunity	☐
Cost Reduction	☐	Infrastructure development & improvement	☐
Technical support	☐		

Others: ☐ Specify: ______________________________

5.3 What is the main obstacle preventing you from taking part in the supporting programmes?

Lack of information	☐
Extra cost	☐
Lack of prospective returns	☐
Limited resource	☐
Complexity of application procedures.	☐
Transparency of decision making	☐
None.	☐

Others-pls specify: ______________________________

5.4 In your business can the overall benefit of joining in the programmes outweigh the cost?

Yes ☐ No ☐ Not sure ☐

5.5 Do you think the role that government plays in sustainable logistics operation should be:

Critical. ☐ Limited. ☐ Insignificant. ☐

5.6 Do you think the government is doing enough to support sustainable logistics?

Yes. ☐ No. ☐ Not sure. ☐

[4] Including the Rail Freight Grants, water freight grants, road haulage schemes, and efficiency programme.

Section 6 – Inclusion of Transport into the EU Emission Trading Scheme

6.1 Do you think transport should be included in an Emission Trading Scheme (ETS) to cut emissions? And if yes, on what scale should it be included?

	Yes			No
	EU-wide ETS	UK self-standing ETS	A separate closed ETS for the sector	
Aviation	☐	☐	☐	☐
Road transport	☐	☐	☐	☐
Rail transport	☐	☐	☐	☐
Waterborne transport	☐	☐	☐	☐

6.2 Which option is more appropriate for including transport in ETS?

Regulating fuel producers ☐
Regulating vehicle manufacturers ☐
Regulating transport operators & users ☐

6.3 What strategy would you have if transport was included in ETS?

Alternative fuel	☐	Fleet modification/upgrade	☐
ICT	☐	Improve operational efficienc	☐
Overhaul and reorganise your operation	☐	Modal shift	☐
More localised sourcing	☐		

Others: ☐ Specify: ______________________________

6.4 What are the possible benefits you can obtain by joining ETS?

Enhance competitiveness via cost-effective emission abatement ☐
New market opportunity ☐
Sustainable and efficient operation ☐
Improving environmental management
Long-term investment in new technology ☐
Others: ☐ Specify: ______________________________

6.5 What is your main concern about including the transport sector in an ETS?

Economic implications	☐	Carbon allowance price	☐
Harm to the competitiveness of the industry	☐	Lack of information	☐

Complexity of management (e.g. trading transaction, monitoring & reporting etc.) ☐
Others: ☐ Specify: ______________________________

6.6 Which of the following policies work better for you in terms of carbon reduction?

Fuel tax ☐
Inclusion of transport into ETS ☐
Road Pricing ☐
Combination of above ☐ – specify which with which: ____________

Section 7 – Information & Communication Technology (ICT)

7.1 Which ICT systems are you currently using or expect to introduce in 5 years' time?

	In place	*Expect*
Supply Chain Planning & Management systems	☐	☐
Paperless Manifest / POD systems	☐	☐
Online Freight Exchanges	☐	☐
Traffic Information Systems	☐	☐
CVRS systems /or Simple Journey Planning Tools	☐	☐
Telematics	☐	☐
Vehicle Tracking systems	☐	☐
Vehicle Diagnostics systems	☐	☐
Product Scanning & Tracking (RFID)	☐	☐
Fuel recording systems	☐	☐

Others: ☐ Specify: ____________________________________

7.2 The ICT applications you are using or considering using is:

Intra-firm system (between your company & others) ☐ Inter-firm systems (within your company) ☐ Combination of both ☐

7.3 Please rate between 0 and 5 regarding the significance of your ICT applications' contribution to sustainable logistics (e.g. 0 – no significance; 5 – great significance):__.

7.4 What are the main reasons for introducing the ICT systems in question:

Legislation requirement ☐
Improve operational efficiency ☐
Improve environmental performance ☐
Customer service benefit ☐
Market expansion ☐
Cost reduction ☐
Asset security ☐
Others: ☐ Specify: ____________________________________

7.5 What are the main disincentives for you to employ new ICT system?

High cost ☐
Non-compatibility with current system ☐
Lack of resources ☐
High complexity ☐
Long implementation period ☐
Too much information sharing / confidentiality ☐
Others: ☐ Specify: ____________________________________

7.6 In your business can the financial benefit of ICT justify the additional cost occurred?

Yes ☐ No ☐ Not sure ☐

Section 8 – Modal Shift

8.1. Which alternative transport modes to road are you using or considering for [domestic] goods distribution?

	In use	*Considering as potential*
Rail	☐	☐
Deepsea shipping	☐	☐
Inland waterway/ Coastal shipping	☐	☐
Aviation	☐	☐
Intermodal	☐	☐

8.2 What makes you consider alternative modes?

Improved service	☐	Low cost	☐
Environmental benefit	☐	Road congestion	☐
Liberalisation of EU-wide rail freight network[5]	☐	Increasing fuel tax and price	☐
Sustainability credentials (e.g. CSR- Corporate Social Responsibility)			☐
Impact of potential lorry road user charging	☐	Others – please specify: ____________	

8.3 What are the main logistical factors affecting your mode choice decision making?

Cost	☐	Location	☐
Trading relationship	☐	Distribution network	☐
Product attributes	☐	Scheduling	☐
Service quality (e.g. availability, reliability and flexibility etc)			☐

Others: ☐ Specify: ______________________________

8.4 What do you perceive as the main obstacles for the growth of alternative modes?

The density and coverage of infrastructure network	☐
Bad experience in the past	☐
Limited capacity and facilities on offer	☐
High operating cost (e.g. track access charge for rail operators, doubling handling)	☐
Not suitable for type of product / movement	☐
Heavy regulation (e.g. weight and speed restriction, planning policies for new infrastructure and facility development)	☐

Others: ☐ Specify: ______________________________

8.5 What is needed to increase the market share of rail freight?

Multimodality – seamless integration with other modes	☐
Loading gauge enhancement	☐
Route capacity enhancement[6]	☐
On-train capacity improvement	☐
Freight terminal development and capacity enhancement	☐
Cost reduction : Internal cost ☐ External cost ☐ both ☐	
Self improvement in efficiency and service provision	☐
Government policy / support	☐
Liberalisation of EU-wide rail freight network	☐

[5] Since 1 January 2007, the rail freight transport market has been completely opened throughout the European Union.
[6] e.g. better route management and utilization, new rail links to ports, double tracking, and modern signaling systems.

Section 9 – Product / Package Design

9.1 Please select or specify the major green design practice in your business:

	In place	*Interested*
Using less polluting material/substances	☐	☐
Adopting clean technology in production	☐	☐
Using renewable/recyclable material	☐	☐
Product/package design for logistics	☐	☐

Others: ☐ Specify: ____________________________

9.2 What are your main drivers for green product/package design?

Comply with legislation	☐	__________
Respond to market demand	☐	__________
Corporate image	☐	__________
Cost reduction	☐	__________
Environmental sustainability	☐	__________
Improve logistics efficiency	☐	__________
Differentiate from competitors	☐	__________

Others: ☐ Specify: ____________________________

9.3 What are the main disincentives for applying green product/package design in your business?

Lack of information / expertise	☐
Lack of resources	☐
Complexity of implementation	☐
Limted return on investment	☐
High costs	☐

Others: ☐ Specify: ____________________________

9.4 In financial terms, can the benefit of product/package design justify the additional cost accrued to your business?

Yes ☐ No ☐ Not sure ☐

Section 10 – Reverse Logistics

10.1 Which of the following forms of reverse logistics structure do you have in your supply chain?

Product return / take-back ☐ Packaging ☐
Waste management ☐
Others – specify: ______________________

10.2 Please select your core strategies/activities of reverse logistics:

Resource reduction / waste prevention ☐ Reuse ☐
Recycling ☐ Disposal ☐
Others: ☐ Specify: ______________________

10.3 How do you operate your reverse logistics?

Manage by yourself ☐
Outsourced to other specialists ☐
Co-operate/partner with other organisations ☐
Others – specify: ______________________

10.4 What are the main reasons for you to establish a reverse logistics structure?

Legislation ☐ Nature of the product/sector ☐
Cost reduction ☐ Environment and sustainability ☐
Corporate image ☐ New market opportunity ☐
Customer satisfaction ☐
Others: ☐ Specify: ______________________

10.5 What are the major <u>THREE</u> obstacles to establishing reverse logistics operation in your business?

Complexity of reverse operation ☐ Lack of resources ☐
Lack of information / Poor data collection ☐ High cost ☐
Lack of end markets for the recyclates and recovered goods ☐
Others: ☐ Specify: ______________________

10.6 Which of the following solutions would help most to improve your reverse logistics operation?

Better design of the product / packaging ☐ Application of ICT ☐
Supply chain integration and collaboration ☐ Alternative transport modes ☐
Local authorities' support and advice ☐ Business Process Reengineering ☐
Others: ☐ Specify: ______________________

10.7 In your business can the overall benefit of reverse logistics justify the cost occurred?

Yes ☐ No ☐ Not sure ☐

Section 11 – Road Pricing

11.1 Please <u>rank</u> the following road charging schemes by their influence / likely influence on your business operation (e.g. 1 - the most influential; 3- the least).

Urban Congestion Charge (e.g. London) ____________
Low Emission Zone ____________
Time-distance-place national road user pricing scheme ____________

11.2 Your business would be most affected by road pricing because of:

Fleet ☐
Operating time ☐
Long haulage distance ☐
Operating location ☐
Others: ☐ Specify: ____

11.3 In your business can the benefit you get from road pricing (e.g. delivery time saving) justify the additional cost occurred?

Yes ☐ No ☐ Not sure ☐

11.4 Please choose and <u>rank</u> your top THREE strategies in response to the introduction of road pricing (e.g. 1 for first priority):

Improve fuel efficiency ____________
Passing the cost on to customers ____________
'Absorbing' cost internally ____________
Fleet upgrading ____________
Retiming the trips ____________
Modal shift ____________
Distribution network restructuring (e.g. relocation) ____________
others – pls specify: ____

11.5 Which approach do you think will work better for sustainable freight transport?

Fuel tax ☐
National road Pricing ☐
Both are good ☐
Neither ☐

Please give the reason of your choice: ____
____

Section 12 –Supply Chain Optimisation

12.1 Which approaches have you adopted to optimise your supply chain?

Green sourcing (e.g. selecting certified suppliers or products) ☐
Local sourcing ☐
ICT (Information and Communication Technology) ☐
Collaboration - Shared database/distribution network/skills/other resources ☐
Restructuring distribution network ☐
Streamlining logistics operations (e.g backhauling) ☐
None ☐
Others: ☐ Specify: ______________________________

12.2 Functions most involved in greening your supply chain are:

Design	☐	Sourcing	☐
Manufacturing	☐	Distribution	☐
Warehousing	☐	Transportation	☐
Reverse Logistics	☐		

Others: ☐ Specify: ______________________________

12.3 Are any other supply chain parties involved in or influencing in your green supply chain approach?

Suppliers	☐	Consumers (B2C)	☐
3PLs	☐	Government authorities	☐
Subcontractors	☐	NGO/Associations	☐
Clients (B2B)	☐	Environmental think-tanks	☐

None
Others: ☐ Specify: ______________________________

12.4 Which of the following inefficiencies in your supply chain are your main concerns?

Fuel consumption/efficiency ☐
Empty running ☐
Low loading factor ☐
Overcapacity/undercapacity
Order processing/fulfillment
Communication and coordination
Warehousing operations
Increasing lead time
Others: ☐ Specify: ______________________________

12.5 What are the main causes of unsustainability / inefficiency in your supply chain?

Demand fluctuation	☐	Postponement	☐
Low inventory policy / Just-in-time delivery	☐	Congestion	☐
Growth of ecommerce and home delivery	☐	Package design	☐
Government regulations (e.g. WTD[7])	☐	Warehousing configuration	☐
Priority to outbound distribution	☐		

Fleet configuration (i.e. incompatible with products or not conform to stringent environmental standards) ☐
lack of communication and collaboration along supply chain ☐
Non-strategic roles of logistics within the company ☐
Others: ☐ Specify: ______________________________

12.6 What are the main disincentives for you to establishing a green supply chain?

Lack of information/communication. ☐
The complexity of implementing. ☐
Lack of return on investment. ☐
Lack of resources needed. ☐
Lack of consumer recognition. ☐
High costs. ☐
Difficulty in coordinating with other parties within supply chain. ☐
Others: ☐ Specify: ______________________________

12.8 What are your main drivers of optimising your supply chain?

Improve corporate image	☐	Satisfy customer requirements	☐
Differentiate from competitors	☐	Reduce logistics costs	☐
Establish a competitive advantage	☐	Improve operation efficiency	☐
Optimise manufacturing	☐	Expand to new markets	☐

Others: ☐ Specify: ______________________________

12.9 Do you think the financial benefits of establishing green supply chain in your business:

outweigh the costs ☐
cannot justify the costs ☐
not sure. ☐

[7] Working Time Directive.

13.1 Assuming you have to be involved in the following urban logistics schemes, please rate them from -5 to +5 by the scale of their potential impacts on your operation (e.g. -5 as the measure with the greatest negative impact, and +5 as the one with the greatest positive impact).

Transshipment centre ______
Shared distribution network with other companies ______
Use of other modes - rail/waterway/underground/metro systems ______
Low Emission Zone ______
Congestion Charge ______
Out of hours/night delivery ______
Road space priority over other vehicles (e.g. shared bus/lorry lanes) ______
Time, vehicle weight/size restrictions on access to certain urban area ______
Dedicated inner city neighbourhood reception place ______
Dedicated on-street /off-street delivery bays for goods vehicle loading and unloading ______

13.2 What are your major concerns of the access restrictions in urban area?

Congestion outside restricted delivery hours ☐
Inefficient distribution/supply chain operation ☐
Vehicle upgrading cost ☐
Lower fuel efficiency ☐
Lost sales ☐
Higher operating cost ☐
Others: ☐ Specify: ______________________________

13.3 What (if any) are your major concerns about shared transshipment centres for urban deliveries?

Additional cost ☐
Risk of losing business ☐
Co-operation with competitors ☐
Poor service quality ☐
Dedicated distribution strategy preferred (i.e. higher levels of logistics control) ☐
Loss /damage / insurance of goods ☐
Others: ☐ Specify: ______________________________

Section 14 – Vehicle Design Technology

14.1 Which of the following measures have you taken or interested in?

	In place	*Interested*
Low rolling-resistance tyres	☐	☐
Aerodynamic styling	☐	☐
Alternative fuel vehicles	☐	☐
Fuel-efficient engines	☐	☐
Double-deckers	☐	☐
Longer, heavier vehicles	☐	☐

Others: ☐ Specify: ______________________

14.2 What is the average replacement cycle of your vehicles?

Less than 3 years	3 – 5 years	6 – 10 years	More than 10 years
☐	☐	☐	☐

14.3 Which policy has potential impact on your fleet? Rate the impact from 0 to 5 (e.g. 0 indicates no impact, 5 indicates significant impact).

	0	*1*	*2*	*3*	*4*	*5*
Low Emission Zone	☐	☐	☐	☐	☐	☐
Fuel Tax	☐	☐	☐	☐	☐	☐
Lorry Road User charge	☐	☐	☐	☐	☐	☐
Inclusion of road transport into EU ETS	☐	☐	☐	☐	☐	☐

Others: ☐ Specify: ______________________

14.4 What are the main disincentives for you to adopt green vehicle design?

Lack of information.	☐
High cost.	☐
Too complex to implement.	☐
Inadequate return on investment.	☐

Others: ☐ Specify: ______________________

14.5 What are the main drivers for you to adopt green vehicle design?

Comply with legislations (e.g Euro IV& V)	☐
Adapt to urban restrictions (e.g. LEZ, night delivery)	☐
Corporate image	☐
Cost reduction	☐
Improve logistics efficiency	☐
Competitive advantage	☐

Others: ☐ Specify: ______________________

14.6 In financial terms, can the benefit of applying the green vehicle design techniques justify the additional cost incurred in your business?

Yes ☐ No ☐ Not sure ☐

University of Westminster

Thank you for your participation in this survey! We will keep you informed of the detailed result of this survey.

Please return the completed questionnaire using the freepost envelope provided.

Should you have any inquiries, please feel free to contact the coordinator of this project:

Amanda Mao
Department of Transport Studies
University of Westminster
35 Marylebone Road, London NW1 5LS

Email: maoj@wmin.ac.uk
Phone: 020- 7911 5000 ex. 3271

Appendix Three: Interview Schedule Used as Basis for In-Depth Interviews

This information is additional to that already supplied by the companies in their questionnaires. The irrelevant sections / questions are filtered out based on the particular respondents' responses provided in the survey.

Attributes of Logistics Operation

- Logistics role – What is your main logistics role in your company? How is your responsibility mainly defined? (e.g. geographically, by product, or by customer)
- Cargo type – What is the range of supplies/products that you are responsible for within your company? Please also give the value density estimation.
- Cargo volume – How much freight are you handling per week/month/annually in term of weight, volume or units (depending on the type of data the respondents have in hand)
- Vehicle type – What is the constitution of your goods vehicle fleet (for road operation)?
- Operational scale – How many vehicles are regularly in operation in your fleet?
- Transport mode – If multi modes were identified by the respondent in the questionnaire, which is the dominant mode and what is the respective share of each mode in use.
- Intermodal – If multi modes were identified in the case, are they being used independently or in the form of intermodal? Which type of intermodal is being used and what is the percentage of the total freight in the company moved in this manner?

Structure of Logistics Network

- Position in supply chain – which aspect of the supply chain does your company deal with? (i.e. inbound movements of raw materials/products from suppliers, movements of materials/products between company sites, distribution of products to customers, reverse logistics etc.)
- Type, number and location of 'nodes' – including the information on production site, warehouse, distribution/transhipment centre and local depots.
- Mileage – What is the average length of the typical haulage?
- Route – What are the main routes/coverage of your logistics activities? To what extent are the goods vehicles operating in urban areas?

Interrelationship within the Supply Chain

- Which part of the supply chain has the greatest influence on your logistics operation? (e.g. upstream or downstream)
- Which specific parties are exerting their influence in your operation? And what are they doing that affect your logistics arrangement?
- To what extent those influential parties have facilitated or impeded the sustainable logistics initiatives?

Attitude and Practice on Sustainable Logistics Operation (Company and sector specific)

- What is your view on the importance of sustainable development (especially environmentally)?
- How do you prioritise among cost, efficiency and sustainability?
- What is your company's major motivation to improve your environmental performance?
- What are the major environmental issues in your company/sector? (e.g. main types of pollution/major environmental concerns and their severity)
- What mitigation actions has your company taken in addressing these issues? Including as much details as possible regarding to current mitigations methods, implementation and effectiveness.
- What is the general practice in the industry sector? And how well your company is performing in terms of environmental friendliness compared with industry common practice?

Rationale of the Survey Responses

The 5 solutions of the respondent's choice were gone through one by one at last to avoid any potential input that would limit/lead the interviewee's view. Certain solutions have to be altered/rephrased with explanation to suit the specific segment in question (e.g. 'road pricing' should be referred to as 'toll charge' in deepwater shipping sector). And each question in the selected sections should be answered with brief explanation. Finally, associations between sustainable solutions are discussed.

Other Useful Information:

- What is your company's main strategy in sustainability? Was it followed in practice?
- Are there any potential difficulties and barriers experienced in practice?
- Are there any other areas where things could be done differently to achieve more environmental benefits?
- Has your company's strategy in sustainability changed since the economic

downturn (Does the deteriorated economy have great impact in your operation?) How and to what extent does it change? (e.g. would the sustainability be sacrificed or put to a lower priority in a deteriorating economic environment?)

Note: The pilot interviews lasted, on average, 2 hour, covering all the points listed above. Since the interviews were not carried out in a strictly formal way, it did not appear as a major issue. For formal telephone interviews, the structure sometimes was slimmed down to an extent so that the interview duration won't be uncomfortably long for interviewees. In the case of any main points missing in the structure, it was possible to follow up with a short interview or emails with previous interviewees.

Appendix Four: Main Industry Sectors Served by Top 100 (2006) Logistics Companies

Top 100 (2006)	Operator	Industry Sector Focus												
		Mail /Express	**Automotive**	**Industrial**	**Life Science /Healthcare**	**Chemical**	**Retail**	**Consumer (FMCG)**	**Fashion**	**Technology**	**Aerospace &Defence**	**Energy and Petroleum**	**Paper& Packaging**	**Others**
1	DHL	√	√	√	√	√	√	√	√	√	√			Industrial Projects
2	Wincanton		√	√		√	√	√		√		√		Water,container
3	Kuehne & Nagel		√	√	√	√	√	√		√	√			In-flight Services
4	UPS (UK Holding)	√												
5	*TNT Logistics UK*													
6	Christian Salvesen		√	√	√	√	√	√	√		√		√	Reverse Logistics
7	Gist					√	√	√		√		√		
8	Parcelforce Worldwide	√												
9	NYK Logistics (UK)		√	√	√		√	√						
10	Interlink & Parceline	√												
11	TDG			√		√	√	√					√	
12	Business Post	√												
13	Home Delivery Network						√	√	√	√				
14	Autologic Holdings	√												
15	Frans Maas (UK)													
16	Ryder		√	√			√			√				
17	Bibby Distribution		√	√	√	√		√	√		√		√	Photographic
18	Eddie Stobart			√	√		√	√			√		√	
19	*Target Express Holdings*													
20	Malcolm Group			√		√	√	√					√	
21	*ANC Group*	√												
22	UBC					√		√						Bulk
23	Initial City Link	√							b					
24	Innovate Logistics							√						
25	Nightfreight (GB)	√	√	√		√		√						
26	Gefco UK		√											
27	Turners (Soham)						√	√						Government contrac
28	Hoyer UK			√		√		√				√		Bulk
29	NFT Distribution						√	√						
30	Amtrak Express Parcels	√						√	√	√				Home delivery
31	The R H Group													
32	Fowler Welch-Coolchain			√			√	√					√	
33	Norbert Dentressangle UK					√				√				Reverse logistics
34	Tuffnells Parcels Express													

Top 100 (2006)	Operator	Industry Sector Focus												
		Mail /Express	**Automotive**	**Industrial**	**Life Science /Healthcare**	**Chemical**	**Retail**	**Consumer (FMCG)**	**Fashion**	**Technology**	**Aerospace &Defence**	**Energy and Petroleum**	**Paper& Packaging**	**Others**
35	Gregory Distribution			√			√	√						Waste disposal
36	Culina Logistics							√						
37	Lloyd Fraser						√	√						Home delivery
38	Stiller Group		√	√		√	√	√						Waste & recycling
39	Canute Haulage Group			√	√		√							Agriculture
40	Europa Freight Group	√	√		√				√					Media
41	Maritime Group													Container
42	Great Bear Distribution		√				√	√	√					Home delivery
43	*Hanbury Davies*							√						
44	MCC Transport													
45	CEL Group													
46	Clipper Group Holdings			√			√	√	√	√				Airline business
47	Roadferry													Roll-on,roll-off
48	Hellman Worldwide Logistics	√						√	√					
49	Currie European Transport													Airline business
50	Hargreaves Group (Transport)			√		√						√		Bulk; Waste; Agricu
51	*Baylis Logistics*													
52	AAG Distribution												√	
53	Langdon Group							√						
54	Sutton & Son (St Helens)													
55	James Irlam & Sons						√	√						
56	Interoute Transport													
57	Cert Octavian							√						
58	John G Russell (Transport)													
59	ARR Craib Transport			√				√				√		
60	ACS&T (Associated Cold Stores &Transport)							√						
61	C M Downton			√			√	√		√				Media
62	Macfarlane Transport		√					√		√				Media
63	TM Logistics		√	√				√					√	
64	Rhys Davies Freight Logistics					√		√					√	Waste
65	C Butt Logistics													
66	Link Logistics		√	√		√	√	√					√	Bulk
67	MRS Distribution			√			√	√						
68	Boughey Distribution						√	√					√	

Top 100 (2006)	Operator	Industry Sector Focus												
		Mail /Express	Automotive	Industrial	Life Science /Healthcare	Chemical	Retail	Consumer (FMCG)	Fashion	Technology	Aerospace &Defence	Energy and Petroleum	Paper& Packaging	Others
69	Online Group													
70	Reed Boardall Transport						√	√						
71	Widdowson Group			√			√						√	
72	Knowles Transport							√						
73	Prestons of Potto							√						
74	Fergusons (Blyth)	√					√	√					√	
75	Circle Express													Airfreight forwardin
76	Seafield Logistics			√		√		√					√	Steel, glass
77	Eastbrook													
78	Taygroup							√						
79	Maxi Haulage													Commercial vehicle
80	J W Suckling Transport											√		
81	Saints transport													Airfreight
82	MKG Holdings							√						
83	Owens (Road Services)			√			√	√						Steel
84	Aspray Transport													
85	Kammac			√			√	√					√	Waste management
86	Brit European Transport		√	√		√		√						
87=	Dodds Group		√					√		√				
87=	The Potter Group			√	√	√		√					√	
89	UFD Group (United Fleet Distribution)													Driven vehicle deliv
90	Archbold Logistics		√					√					√	
91	Grocontinental							√					√	
92	Meachers Group Holdings			√										
93	Jack Richards & Son													
94=	Stan Robinson													
94=	F Swain & Sons			√			√	√						
96	Birds Groupage Services		√	√										
97	CPD Logistics			√										
98	Erith Haulage Company			√										Waste recycling
99	Laser Transport International		√								√		√	
100	Lenham Storage Company													
	Counts	**13**	**20**	**34**	**9**	**19**	**31**	**54**	**9**	**12**	**6**	**6**	**19**	

Note: Info not available *Sold or discontinued* Acquired but still in business

Appendix Five: Case Studies

Case One: U21 – Large retailer

Background

U21 is one of the leading retail groups in the country, with over 200 stores and shops nationwide being replenished on a daily basis. It is operating a fleet of 1,800 commercial vehicles that makes over a million deliveries travelling approximately 43 million miles in a typical year. During the last decade it has established the online business segments operating both home grocery deliveries and internet shopping fulfilment for its supermarket unit and department store unit respectively, which largely increased the mileage of the fleet. With its ambitious expansion strategies and development plans, it acknowledges that all reasonable steps have to be taken in order to decouple the business growth from the increased detrimental effect of its operations. Having identified the two largest sources of its environmental externalities as real estate related energy consumption / emission and transport fuel consumption / carbon emissions, the sustainable actions were primarily taken in these two fields.

Sustainable Strategies

U21 has a long-standing commitment of operating in a sustainable way. As a growing business with increasing number of stores and longer trading hours, it has established a comprehensive carbon management programme with the objective of reducing the relative emission to sales revenue by 20% in 2020 against 2001 baseline, which is currently on track according to its performance in the past decade. In the long run, the objective is set to 60% reduction by 2050, which is less ambitious as the government's target of 80% but deemed as 'achievable' by U21. The near term priority is placed on tacking the CO_2 emissions from its UK operations, though it is also aware of the environmental impacts associated with the global production, distribution and consumption of the products in the entire life cycle across supply chain.

Sustainable logistics practice:

Carbon footprint monitoring and reporting - EMS

Overall the Corporate Social Responsibility (CSR) of the group has been monitored and measured with a set of key performance indicators (KPIs). The quantification of the KPIs has been compiled and compared on a year-on-year basis since year 2001/02. Not only the CO2 equivalent emissions during goods distribution are measured and recorded, breakdown details by business unit and operation type (i.e. in-house and outsourced freight mileage) are also available for evaluation. KPIs employed include CO2 equivalent emissions calculated on total mileage of goods vehicles, emissions by sales revenue, mileage per gallon (MPG), and avoided mileage from back- and forward-hauling. Apart from transport related carbon emission, packaging, in terms of primary packaging generated and secondary and tertiary packaging handled, is measured by weight, along with the weight of waste disposed and recycled.

With the EMS's monitoring and reporting function, U21 is able to set specific transport emission target and keep track of it. In year 2008/09 a 7% of transport emission was achieved in term of emission per £million sales on year 2005/06.

Mileage reduction

Since the logistics operation of its online business was taken back in-house in 2007, U21's own goods vehicle fleet and subsequently its environmental externalities has exponentially increased. Transport consolidation opportunities hence has been reviewed within the distribution networks resulting in optimising milk-run collection at suppliers' before delivering to U21's regional distribution centres (RDCs). By combining small consignments of different suppliers, not only total mileage was reduced while greater load factor was achieved, as a considerable proportion of this milk-run collection was assigned to the return journeys of outbound deliveries, empty running was also largely reduced. Currently U21 is experimenting with a scheme which allows local suppliers to deliver directly to shops rather than DCs.

Computerised route planning is fully exploited to avoid unnecessary mileage, load vehicles more efficiently, and make use of empty vehicles on return journeysbia 'back-hauling' (i.e. pick up stock from a nearby supplier on the way back to the depot, saving fuel and saving the supplier from having to use their own lorry) and 'forward-hauling' where a supplier's lorry delivers goods to a shop on its way back from a distribution centre. In year 2007/08, it was reported that over 2 million miles were saved by suppliers using back- and forward-hauling.

Clean vehicle technology

Operating its own goods vehicle fleet enabled U21 to specify the configuration of the vehicles and apply aerodynamic technologies to enhance fuel-efficiency and trial other new technologies. All the goods vehicles are featured with rounded front corners and aerodynamic side-skirts to minimise wind resistance and reduce fuel consumption; while the refrigerated lorries have advanced cooling systems with less environmental discharges, maximised chilling space and being quieter than conventional systems. In increasing vehicle loading factors, U21 now has over 130 multi-deck trailers in use in addition to double-decker trailers, which is estimated to reduce 4 million miles per year.

Alternative fuel options have been investigated with trials on biodiesel from waste cooking oil at one distribution site in south England and the feasibility and effectiveness are yet to be evaluated. Nevertheless, with concerns over the effects of biofuels on food stock, food price and environment, U21 decided to only use the amount of biofuels stipulated by law under the Renewable Transport Fuel Obligation (RTFO). To secure the 20% carbon footprint reduction target for its fleet, U21 asked the commercial vehicle manufacturers to develop prototype eco-vans, low carbon vehicles (e.g. electric or hybrid electric vehicles) or high bio-content fuels from renewable sources (e.g. biomethane from waste). Although with limited success to date, U21 is committed to carrying on implementing new projects and “deliver useful information for moving towards sustainable solutions”. There is currently experiment with route planning using live traffic information, and investigation is undertaken in the viability of using bespoke rail services through consolidation of certain routes and operations.

Reverse Logistics – waste and recycling

Particularly in its supermarket operation, the target of reduce food waste was partially delivered through accurate ordering. Diverting food waste from landfill to its anaerobic digestion plant where ‘green’ energy in the form of electricity and high nutrient fertilizer is produced has turned out to be a success, and the practice is expanding to more branches. Similarly following a successful trial, a bed recycle scheme has been rolled out across all the department stores which incents customers buying new bed with an offer of removing the old ones at an economic price. As the removal is carried out when the new bed is delivered, no additional emission is created while the utilization of resources enhanced through back-hauling. In cooperation with the bed manufacturer, 100% of the old beds are sent to the shredding plant and recycled, reducing waste sent to landfill. It is one of the typical “green gold” sustainable measures which generate revenue for the business as well as environmental benefits in a broader sense.

U21 has also taken actions in redesigning its own brand packaging. Not only overall packaging reduction and increasing recycled material in packaging objectives were set for its own product packaging, in working with suppliers, it has reduced the amount of packaging in many areas such as toys, linens and cookshop and is currently working on more areas.

Safe and economic driving

An internal rating system to assess the performance of its commercial drivers was established where the statistics were collated to identify the drivers who need extra training.

Distribution centre construction

As a major supply chain investment project, an automated national distribution centre developed in 2007 employed the latest environmental measurements and technologies, with the aim of reducing the overall environmental impact of its construction as well as the carbon footprint of the building in the long term.

Sustainability was laid at the heart of the partnership of this project between U21 and its selected logistics space developer. The new building incorporates a wide range of eco measures including, rain water harvesting and recycling, energy efficient lighting, solar panels, low water use appliances, FSC approved timber, photovoltaic panels, solar thermal energy, low toxic paints / furnishings and local provenance vegetation. An on-site wind turbine and biofuel plant is also being considered to provide additional eco savings for the DC.

The environmental savings provided by these sustainable measures include:

- 39% CO_2 reduction pa (1826 tonnes)

- 40% energy usage saving pa (2990 MWh)

- 61% water usage saving pa (740,000 litres)

Further more, economically the retailer can save annual operating cost of £240,000. It is estimated that across the 20 year lease period on this site, the saving will be in excess of £4.7m.

In addition to the distribution facilities development, the sustainable construction principles and practices have also been applied to the construction of new stores and refurbishment of existing ones. For instance, the carbon dioxide emissions were estimated to be cut by 24% through use of more natural light and ventilation and new escalators, boilers, chillers, catering equipment and lighting in one of its flagship department stores. The good practice of sustainable construction in retail sector has been established in collaboration with its partner NGOs as a guideline framework for the whole industry.

Sharing and disseminating best practice

An innovative initiative rolled out between U21 and a LSP serving one of the leading fast food chains was specifically design to share and exchange best practice in logistics operations between the two companies. Taking the form of a job swap scheme, the initiative entails middle managers working with a counterpart in a similar role in the other company for a week, learning how other leading companies operate their supply chains. The critical feedback process requires the participant managers to make action plan to improve operations by implementing ideas from job swap. It was reported that warehouse shop floor practices, shift pattern management, communication and employee engagement have all been highlighted as areas for study and improvement. Noticing that this type of partnership was established between leading LSP and LSU from different sectors, hence to a great extent ease the concerns over commercial confidence and competitive issues.

Supply chain optimisation – interactions with other parties

Working closely with its suppliers, distributors and agents, U21 insisted that all the farmers supplying domestic fruit and vegetable adopt the LEAF certification standard which is designed to improve their environmental stewardship through reduced pesticide use, protecting threatened species, conserving water and energy, and preventing soil erosion. Through its responsible sourcing code of practice and associated compliance programme, U21 is also requesting information on environmental issues (including emissions) from its own label suppliers. Furthermore, pilot collaborative projects were initiated to help its manufacturer suppliers to achieve more accurate and meaningful reductions in carbon emissions.

In addition to the interactions with its trading partners, U21 is playing active roles in various areas of sustainability. As a member of the Corporate Leaders Group on Climate Change, it is committed to supporting the Government in developing new, long-term policies for tackling climate change. It was also involved in the Institute of Grocery Distribution (IGD) working group on carbon footprinting for the food and grocery sector and through the BRC fed into the British Standards Institute (BSI) group, the Carbon Trust and Defra who established the PAS 2050 standard for calculating a product's or service's total carbon footprint, providing a good example of multi-facet collaborative working amongst leading companies, government, and industry trading associations.

Case Two: P15 – Leading express and logistics provider

Background

P15 is a global integrated logistics solution provider which is also specialized in mail and express services.

Sustainable Strategies

Sustainable strategies are under constant review and the environmental objective is set to enhance the CO_2 efficiency by 30% by 2020 (against a baseline of its 2007 performance). To achieve this goal, a comprehensive climate change programme was launched in 2008 across all the operations including its transportation subcontractors; while a milestone of 10% CO_2 efficiency improvement by 2012 was targeted for its own operations. Taking a precautionary approach to environment, P15 places its priority in “tackling the causes of climate change” which requires all major investment projects to be assessed in terms of CO_2 efficiency in addition to financial parameters.

Sustainable logistics practice:

EMS and carbon reporting

In P15, one key approach to environment management is for its business units to have their operations certified to the ISO 14001 standard. Up to year 2008/09 46% of its global workforce was working under ISO 14001 certified EMSs and in its express division, 80% certification coverage of its European sites was achieved.

In order to be able to identify the opportunities for sustainable operation and track the performance, P15 has a dedicated carbon accounting team and is currently working on the establishment of a carbon accounting system linked to its financial accounting system. The Greenhouse Gas Protocol has been used for calculating and reporting he carbon footprint data.

Improving CO2 efficiency in freight transport

Three areas that generate the majority of emissions from P15’s own operations were identified – air freight, surface transport and construction and maintenance of facilities.

Operating a large fleet of own and contracted aircraft, air freight transport is the largest source of CO_2 emission which is under direct control of P15, thus fleet optimization has been the obvious measure to address this issue. By replacing old aircraft with newer and more fuel efficient ones (e.g. Boeing 777-200 LRF, Boeing 747-400F, and Boeing 767-300F), the fleet upgrading also benefited the environmental with lower level of air pollutants (e.g. NOx) and noise affecting local air quality and communities. In 2008, P15 successfully initiated a pilot to improve the capacity utilization of its cargo aircraft through training and staff incentives. More shipments were able to be carried by each aircraft through container loading optimization, reducing air miles and emissions as a result. With both financial and environmental credentials of the pilot, the practice is to be rolled out to P15’s operations worldwide.

In minimizing the carbon footprint of its road transport operations, a range of measures have been adopted, including vehicle upgrading, alternative fuels and eco-driver training. For instance, P15 has been testing on biofuels, electric and hybrid vehicles with major vehicle manufacturers and technology companies. In descending order by the number of vehicles on trial, the tested alternative fuels are CNG (compressed natural gas), LPG (liquefied petroleum gas), Bi-fuel/Flexi-fuel (i.e. vehicles with an engine capable of using different fuel types), biogas, hybrid diesel, full electric and fuel cell. Development of ‘intelligent’ vehicle using dynamic route planning and live traffic data was also initiated to improve the efficiency in terms of time, cost and CO_2 emissions.

Smart energy management system was implemented together with low-energy lighting and heating controls to reduce the emission of P15’s operating facilities. The sites also use energy from verified renewable sources where practical. In the latest development of new warehouses, sustainable features such as skylights that minimizing the use of electric lights, ventilation systems that save electricity and other ways to use energy and water sparingly were designed into the buildings.

Interactions - Sustainable sourcing, product/service design and responses to regulations/policies

Recognising that the products and services it provides to the customers can account for a significant part of their carbon footprint, P15 has developed a broad range of environmentally friendly products and services mainly involving carbon offsetting schemes or transport modes that are generally regarded as being less carbon-intensive such as sea and rail freight. Based on the analysis of the customers’ supply chains, P15 tends to offer solutions with greater environmental benefits which, in many cases, also turn out to be more economic.

Having a substantial proportion of operations involving air freight, P15 has generally positive views on the inclusion of aviation into EU ETS in 2012 while slight concerns remain over the potential market distortion if implemented in a discriminatory manner amongst carriers. It is also keen on the European Commission’s initiative of “Single European Sky” which is believed to be an “easy-to-achieve” measure to reduce the emission of aviation.

Appendix Six: Freight Operator by Annual Turnover and Employment Level

Road Haulage (Industrial Report) - UK - May 2009 - 4. INDUSTRY STRUCTURE

Analysis of the Financial Structure of the Road Haulage Sector, 2007 and 2008

Turnover (£000)	2007*	% of Total	2008*	% of Total
1-49	5050	16%	5 145	15%
50-99	9845	31%	10 815	32%
100-249	7920	25%	8 720	26%
250-499	3365	11%	3 600	11%
500-999	2395	8%	2 535	7%
1000-4999	2610	0.08	2 740	0.08
5000+	585	2%	615	2%
Total	31 770	1	34 170	1

* Number of Companies

Note: Percentages do not add due to rounding

Analysis of the Employment Structure of the Road Haulage Sector, 2007 and 2008

Employment Level	2007	% of Total	2008	% of Total
0-4	25315	75%	27 500	76%
5-9	3710	11%	3 900	11%
10-19	2270	7%	2 320	6%
20-49	1615	5%	1 610	4%
50-99	520	2%	570	2%
100-249	300	1%	335	1%
250+	100	neg	95	neg
Total	33 830	100%	36 330	100%

Number of Establishments and Employees

Note: Percentages do not add due to rounding

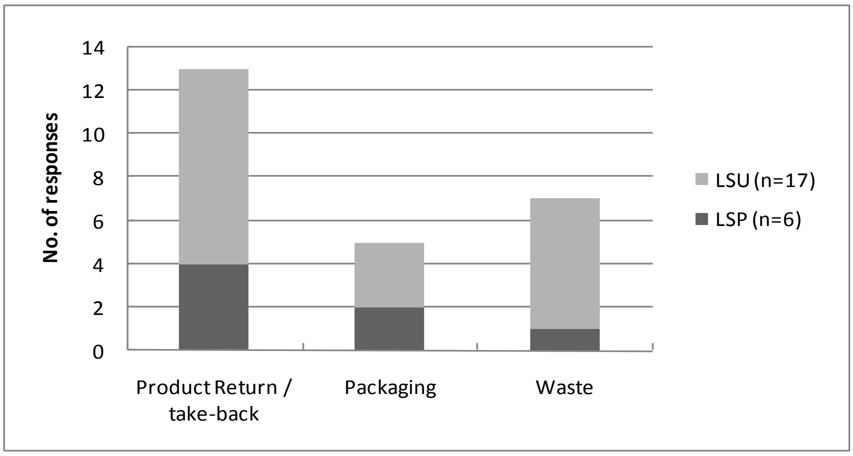
Source: Mintel, 2009

Appendix Seven: Survey Results of the Five Sustainable Logistics Solutions with the Lowest Perceived Impact

1. Reverse Logistics

Among the 14 sustainable alternatives, reverse logistics has seen the widest split between the LSPs and LSUs groups in evaluation of its impact on logistics operations. Only 17% of LSPs regarded reverse logistics as one of the five most influential areas for their supply chains, while the equivalent proportion for LSUs was 45%. The variation was not so evident when rankings given by respondents according to their perceived impacts of the identified solutions were taken into account, as a large proportion of LSUs ranked reverse logistics relatively low, which might be an underestimate given the partial ranking method adopted for this survey. As with the response pattern for reverse logistics at the first stage, the detailed questionnaire on the topic for the second stage was completed by six LSPs and 17 LSUs, with the types of reverse supply chain that they are operating in terms of the returned goods type illustrated in *Figure A1*.

Figure A1: Type of goods handled in reverse supply chain by group



Source: author's questionnaire survey, stage 2; N=23 (multiple response)

The findings reveal that 57% (13 out of 23) of respondents are dealing mainly with reverse flow of finished products, including customer returns, defective products, end-of-life products and so on, while seven and five respondent companies respectively are operating waste (both commercial and household) and packaging materials (e.g. pallets, containers and other packaging materials). As a generic survey of multiple sectors, the questions designed for this section are kept as broad as is appropriate so as to address common issues faced by different sectors. Having said that, it is still possible to identify the sectors in which reverse logistics has great implications by looking into the respondents' business attributes, so that focus can be placed on the targeted sectors in the subsequent interviews. *Table A1* lists all the vertical sectors of LSUs from the sample in order of frequency. It would appear that the FMCG (manufacturing), automotive, industrial (construction and steel in particular) and pharmaceutical sectors more often give higher priority to reverse logistics operation, with publishing and retail indicating a certain level of interest as well.

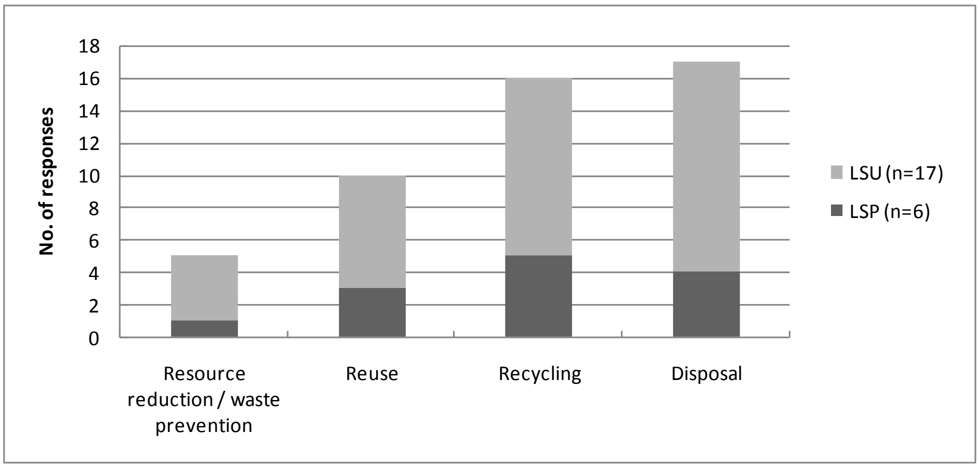
Table A1: Breakdown of LSUs industry sectors by group

Sectors	Number of Respondents
FMCG	5
Automotive	3
Construction	2
Steel	2
Pharmaceutical	2
Chemical	1
Publishing	1
Retail	1
Total	17

Source: author's questionnaire survey, stage 2; N=17

Closely associated as they are with the specific regulatory requirements and operational environments of certain industry sectors, the primary reverse logistics strategies and activities of respondent businesses have been categorised on the basis of waste hierarchy into resource reduction, reuse, recycling and disposal, as shown in *Figure A2*.

Figure A2: Reverse logistics strategies by group

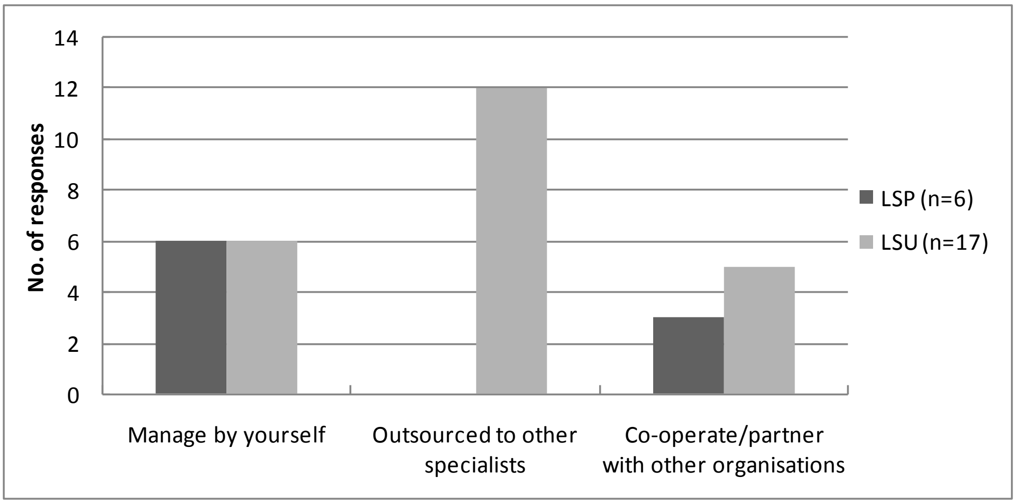


Source: author's questionnaire survey, stage 2; N=23 (multiple response)

The quite alarming situation depicted in the figure above reveals that most businesses are still focusing on the strategies which are lower in the hierarchy for their reverse logistics. Although many respondents adopt more than one strategy during the operations, 74% of the sample have disposal as a core function within their reverse supply chain, which is the least resource efficient and environmentally friendly approach in waste management. To what extent this observed state of reverse logistics practice leaves room for businesses to obtain further economic and environmental benefits by reviewing and re-devising their reverser supply chain strategies were further explored in the interviews.

In reply to the question about the way that the reverse logistics activities are managed, a mix of responses, many with multiple selections, were received; these are presented in *Figure A3*. As for the LSPs group, all LSPs are providing specialised services in reverse logistics operations for their clients, and hence classified as managing their own activities. Half of them claimed that their reverse supply chain operations also involve co-operation/partnership with other organisations. LSU responses indicate that outsourcing the management of reverse logistics function is currently dominant in most sectors, as 71% of them are contracting out the handling of return goods flow to third party specialists. However, as mentioned, the patterns are compounded, with many respondents having more than one form of management in their reverse chain. Three LSUs, for instance, seemed to have partially outsourced their reverse logistics management, while at the same time still maintained in-house operations for certain purposes. Two of them have all three forms of operation in their businesses, again reflecting the greater complexity and formidable challenge of operating return flows of products compared with traditional forward supply chains.

Figure A3: Reverse logistics management by group



Source: author's questionnaire survey, stage 2; N=23 (multiple response)

Although the main drivers for different industry sectors to establish reverse supply chains may vary due to the attributes of products and prevalent business models/practices within each sector, efforts were made to address the motivation issue in generic terms that could be applied across sectors. Based on this consideration, all drivers that were related to the nature of the product, market and sector are integrated as one factor in parallel with other driving forces such as cost reduction and compliance with legislation, for ease of comparison and generalisation. The findings are reported in *Table A2*.

Table A2: Drivers of reverse logistics by group

Drivers	LSP (n=6)	LSU (n=17)	Combined
Customer satisfaction	4	10	14
Cost reduction	2	12	14
Nature of the product/sector	1	6	7
Environment and sustainability	2	7	9
Legislation	0	7	7
New Market opportunity	5	2	7
Corporate image	0	3	3

Source: author's questionnaire survey, stage 2; N=23 (multiple response)

Noting that LSPs and LSUs took disparate perspectives on this issue, and that the same phrases in the question may have different interpretations for different roles, it is more appropriate to examine the response patterns separately. LSPs, normally as partners or contractors who manage reverse logistics operations on behalf of their business clients, are not directly subject to legislation or regulations to conduct product return. Their activities in reverse logistics are initiated to suit their customers' needs, or, put simply, are market-driven. Therefore, it is unsurprising that 83% of LSPs cited new market opportunity as one of their main drivers, while 67% of them chose customer (i.e. LSU) satisfaction. Cost reduction, environmental benefits and nature of product or sector were also quoted by a minority of respondents in the group, whereas legislation and corporate image had no responses from LSPs at all.

Reporting mainly economically oriented motivations for reverse logistics operation, the LSUs cited cost reduction and customer satisfaction, accounting for 71% and 59% of the sample respectively. Compared with LSPs, LSUs have more diversified motivations for managing their reverse logistics, including legislation, sustainability and the nature of the products or sectors. New market opportunity was cited by 12% of the LSUs, typically secured by reselling the returned or refurbished products to consumers or other organisations. And 18% of LSUs believe that a well-established reverse supply chain can help to improve their corporate image in general.

In *Table A3*, obstacles encountered or perceived by the participant businesses are compiled for comparison between the groups. The complexity of reverse logistics operations, followed by a lack of information or poor communication turned out to be the LSPs' major concerns, both having implications for operational efficiency. Cost associated with operating a reverse supply chain appears to be less of a major obstacle for LSPs to undertaking these activities, and was chosen by one third of them. Given the fact that it is one of the revenue-generating segments of the LSPs' service provision portfolio, it can be inferred that by quoting cost issues, the LSPs might deem it as a potential area for improving the profitability of the operation, rather than a prohibitive barrier for conducting business in this segment.

Table A3: Obstacles to reverse logistics by group

Obstacles	LSP (n=6)	LSU (n=17)	Combined
High cost	2	12	14
Complexity of reverse operation	5	8	13
Lack of information / poor data collection / communication	3	7	10
Lack of resources	0	5	5
Lack of end markets for the recyclates and recovered goods	0	2	2

Source: author's questionnaire survey, stage 2; N=23 (multiple response)

Unlike the service providers, the LSUs certainly had their concerns about economic obstacles, with 71% of them citing high cost. It is generally understood that in many cases the relatively high costs related to 'reuse or recycling' simply cannot be financially justified with the extracted value from returned products, which presents the most critical obstacle for businesses from engaging in reverse logistics activities. Complexity of operation and lack of information/ communication are also cited by nearly half of the respondents within the group, stressing the common issues in this sphere of operation. Finally, 29% of LSUs cited lack of resources as a major obstacle, while 12% specified that the problem lay with end markets for recycled or recovered products, be it the lack of demand or the uncompetitive market price for them.

As can be seen in *Table A4*, in response to being invited to state the most effective way of improving reverse logistics operations, supply chain integration and collaboration was most frequently cited by both LSPs and LSUs as the critical factor affecting their reverse logistics performance, highlighting the complexity and sophistication of reverse logistics as a system which involves multiple players and a series of processes ranging from collecting, sorting and stock-keeping to transport, reprocessing/remanufacturing and reuse. Support and advice from government and local authorities, in contrast, received a large amount of interest from the LSUs group whilst being of low priority for LSPs – presumably a result of the higher level of government intervention through environmental regulations in the selected industry sectors as opposed to the logistics sector itself. Cited by half of the LSPs and 53% of the LSUs, application of information systems emerged as being of great importance in reverse logistics development, reflecting the strategic part that information flow management is playing in practice, and displaying a strong 'productive' linkage between these two solutions. Among other critical factors identified by respondents are better design of product/packaging, business process re-engineering and alternative transport modes. Receiving the least number of responses from LSUs, and no responses from LSPs, modal shift seems to have limited implications for improving reverse logistics' environmental performance, and, given the increasing trend of outsourcing reverse logistics functions, is likely to further diminish in influence in the future.

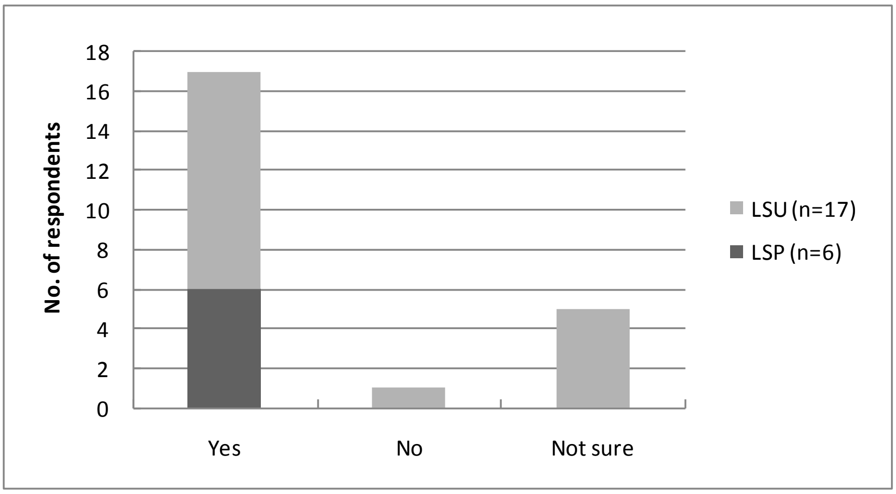
Table A4: Critical factors in improving reverse logistics by group

Critical Factors	LSP (n=6)	LSU (n=17)	Combined
Supply chain integration and collaboration	3	11	14
Application of ICT	3	9	12
Local authorities' support and advice	1	8	9
Better design of the product / packaging	2	7	9
Business Process Re-engineering (BPR)	2	5	7
Alternative transport modes	0	3	3

Source: author's questionnaire survey, stage 2; N=23 (multiple response)

In a manner similar to that used in evaluating overall benefit against implementation costs for other sustainable solutions, companies were asked to give their opinions on the cost-effectiveness of their reverse logistics operation; the responses are shown in *Figure A4*.

Figure A4: Can the overall benefit of reverse logistics justify the cost?



Source: author's questionnaire survey, stage 2; N=23

As can be seen, all the LSPs hold positive views on reverse logistics, which is not surprising given that their undertakings are mainly, if not solely, based on the financial feasibility of the operations. The LSUs tend to have a mix of opinions. Although most (65%) of them are positive on the issue as well, 29% are 'not sure', and another 6% think that the cost of reverse logistics operations cannot be justified even by the economic and environmental benefits combined. Since the responses indicating a negative view account for only a small proportion of the sample, overall the consensus appears to be reached on the justifiability of reverse logistics.

2. Modal Shift

The first stage survey findings revealed that one fifth of respondents had identified modal shift as one of the five most influential sustainable solutions for their businesses. Being contacted for the second stage detailed survey, 65% of these respondents returned the completed questionnaires, which comprise 11 responses from LSPs and 4 from LSUs. Like other solutions at lower positions of the ranking chart (as shown in *Table 4.5*), the number of responses is not sufficiently large for statistical analysis, and extra caution needs to be taken for interpreting the quantification of the results. Less generalisable it may be, which necessitates the supplementary qualitative methods for more insightful comprehension of the issue, it increases the convenience for tracing individual cases of the respondents to gain a better understanding especially in the rationale of their attitudes to and behaviours in modal shift.

One of the primary intentions of the second stage survey on modal shift was to discover the present states of the alternative modes measured by the number of their current users and the perspective of their growth in the future through the number of respondents who consider them with potential in their operations. The responses are summarised in *Table A5*. For comparison purpose, the percentages of current users for each of the alternative modes in all the respondents from the first stage survey (i.e. N=115) are incorporated and differentiated in bold. And the data from the second stage are also presented in proportions for consistency.

Table A5: Current and future use of alternative transport modes by group

Transport Mode	LSP (n=11)			LSU (n=4)		
	In use (Stage 1)	In use (Stage 2)	Consider as potential	In use (Stage 1)	In use (Stage 2)	Consider as potential
Rail	**20%**	45%	18%	**15%**	50%	25%
Deepsea shipping	**28%**	45%	9%	**55%**	75%	25%
Inland waterway/Coastal shipping	**5%**	9%	0%	**5%**	0%	0%
Aviation	**20%**	36%	9%	**27%**	25%	0%
Multimodal* / Intermodal	**35%***	27%	27%	**64%***	25%	50%

** Data collected at stage 1 is for companies using multiple modes and is listed in the table merely as rough estimation for intermodal usage.*

Source: author's questionnaire survey, stage 1&2 (multiple response)

As aforementioned, the percentages in bold were obtained from a larger sample with 115 respondents, hence more representative and less skewed to sampling errors than the proportions calculated from the small-scale sample with the size of 15. It indicates that of all the alternative freight modes, deepsea shipping and aviation are being used by the largest proportion of the sample companies, both with greater prevalence among LSUs. Information on intermodal is not available from the first stage general survey, and the estimation given by multiple-mode users would exaggerate the actual percentage since a large proportion of which may simply represent separate operations of various modes at the same time. Looking into the data in *Table A5*, rail freight, albeit being generally regarded as the most suitable and sustainable candidate as displacement of road freight traffic in academic researches and transport policies, still seems to lack competitiveness in international transport market. Considering that a substantial amount of air cargo and especially deepsea shipment is for international transport, however, rail might be at a relatively better position in domestic freight market.

Comparing to the current user percentages of the 115 respondents, the proportions of current users from those who think modal shift have/would have a great impact on their operations are considerably higher in general. It suggests that modal shift might have greater implications on the companies who are already using alternative modes than those without previous experience. Another somewhat encouraging observation is that although underperforming compared with other major alternative modes in terms of user bases, rail freight is being considered for future use by 20% of the respondents, when one third are considering using intermodal which is likely to involve rail freight use as well. At aggregate level, the current and potential future users of rail freight would appear to reach two thirds of the sample, certainly signifying a relatively better outlook for rail should the potential users do switch in the near future.

A close examination into the companies' attributes of the 15 respondents reveals that their logistics operational scale (measured by fleet size) shows a great degree of polarisation, with half of them running a fleet of less than 20 goods vehicles and anther half operating over 200 vehicles. Interestingly, the industry sectors that the respondent companies are classified into appeared to be concentrating on a few sectors which are not traditionally regarded as rail freight users such as food, FMCG and retail, along with the more typical users including chemical, automotive and industrial sectors, highlighting the focus of emerging markets for alternative modes, particularly rail freight.

With a unique set of characteristics, each of the alternative modes has its own features appealing to present or potential users. However, by taking a holistic view all these modes serve as alternatives to road freight transport which has been dominating the logistics market for decades and indeed one of the major contributors to climate change. The critical factors with great effects on businesses' modal choice decision in favour of alternative modes have been explored through the survey questionnaire and the result is detailed in *Table A6*.

Table A6: Driving forces of modal shift by group

General Driving Forces	LSP (n=11)	LSU (n=4)	Total (n=15)
Increasing fuel tax and price	6	2	8
Road pricing	5	3	8
Road congestion	5	2	7
Company's logistics requirements	5	2	7
Lower cost	4	2	6
Improved service	3	1	4
Sustainability/environmental credentials	3	0	3
Government policy and legislation	2	0	2

Source: author's questionnaire survey, stage2; N=15 (multiple response)

The first batch of three most cited drivers for alternative modes turned out to be, in descending order, increasing fuel price and tax, road pricing and road congestion, all related to the drawbacks of or increasing restraints placed on road transport, hence 'push' factors from road rather than 'pull' of more freight to alternative modes with improved, attractive features and performances. Changes in company's logistics requirements, such as supply chain restructuring, business growth and logistics network expansion, cited by 7 respondents (47% of the sample), is another determinant factor in modal choice decisions. Merits of alternative modes, either in lower cost or improved services constitute the batch of less significance in promoting the role that alternative transport can play for various businesses. But it is the environmental credential and legislation that received the least number of responses, indicating the limited scope of them to play a part in companies' strategy making on modal choices. Overall, the competitiveness of alternative modes with road transport and the consequent decisions of end users would appear to be largely formed on economic grounds with great consideration also given to operational efficiencies and to what extent different forms of transport aligns with their logistics needs.

To gain a more comprehensive insight into the specific logistics requirements with substantial implications in businesses' modal choice decision, *Table A7* ranks the logistics factors identified by the respondents. Two thirds of the respondents cited logistics network structure as the critical factors affecting their modal choice. This includes the centralisation / decentralisation of production, storage or distribution functions, location of operating sites, geographic scope of operation, and any changes related to the physical arrangement of the network. Scheduling as the second popular factor is closely associated with the required frequency, flexibility and reliability of the service and normally specified with lead time requirement. Incapability of matching the logistics scheduling requirements can be a major obstacle for many alternative modes due to limited service availability. Inference can therefore be made that to encourage alternative modes, issues about their coverage, connectivity and service provision have to be addressed with higher priority.

Table A7: Logistics factors affecting modal selection by group

Logistics Factors	LSP (n=11)	LSU (n=4)	Total (n=15)
Logistics network structure	7	3	10
Scheduling	6	2	8
Cost	5	2	7
Trading relationship	5	1	6
Own fleet operation	5	1	6
Product attributes	4	2	6
Freight volume	2	1	3

Source: author's questionnaire survey, stage 2; N=15 (multiple response)

The findings also revealed that cost reduction offering by alternative modes, if realised, would be an effective elements in businesses' decision-making process. Trading relationship reflects interactions between different partners along the supply chain, primarily LSPs and LSUs but also involving other parties such as suppliers, manufacturers and customers. Like own road fleet operation and product attributes, there is limited scope for alternative transport modes to alter these aspects which are almost inherent to the businesses, supply chains or sectors and will take a long term to change. Freight volume, on the contrary, can be coped with increased capacity of alternative modes which nevertheless remains a major issue for most of them.

In addition to general driving forces and critical logistics factors for modal shift, it is also instructive to study the main disincentives for businesses to start using alternative modes for their freight transport. The responses are summarised in *Table A8*.

Table A8: Obstacles of modal shift by group

Disincentives	LSP (n=11)	LSU (n=4)	Total (n=15)
Service level & quality	8	3	11
Limited capacity and facilities on offer	8	2	10
The density and coverage of infrastructure network	6	3	9
High operating cost	7	2	9
Not suitable for type of product / movement	4	2	6
Heavy regulation	3	0	3
Bad experience in the past	2	0	2

Source: author's questionnaire survey, stage 2; N=15 (multiple response)

In line with the previous analysis, the findings highlighted the major obstacles that alternative modes need to make significant improvement with in order to attract more freight traffic from road and increase their market shares. Service level and quality, along with limited capacity and facilities on offer, appeared to be the most concerned features among the respondents with over two thirds citing them. Infrastructure development and high operating cost constitutes another area lack of confidence among users. Partly due to the underdevelopment of infrastructure and facilities, operating cost rises considerably during the process of goods handling between different transport modes when the operational efficiency is decreased, to a large extent offsetting the benefits by using alternative modes rather than road haulage alone. 40% of respondents also stated that alternative modes are not suitable for the type of products, such as perishable, bulky or high valued goods with high security or handling requirements. Heavy regulations and unsuccessful experience in the past did not seem to be a major issue with alternative modes, whilst from the previous survey findings they are more likely to act as restrictions on road sector in government's attempt to promote more sustainable forms for freight transport.

Lastly, particular attention was given to rail freight which, compared to other alternative modes such as air freight, inland water and coastal shipping, either bears more sustainability credentials or more realistically a competitive mode against road in domestic sphere. *Table A9* listed the responses received on most desired improvements for rail freight in order to increase its mode share among end users.

Table A9: Improvement in need for rail freight by group

Improvement	LSP (n=11)	LSU (n=4)	Total (n=15)
Self improvement in efficiency and service provision	6	3	9
Multimodality – seamless integration with other modes	6	2	8
Cost reduction	5	3	8
Route capacity enhancement	4	0	4
Freight terminal development and capacity enhancement	3	1	4
Government policy / support	3	1	4
Loading gauge enhancement	3	1	4
Liberalisation of EU-wide rail freight network	2	1	3
On-train capacity improvement	1	0	1

Source: author's questionnaire survey, stage 2; N=15 (multiple response)

Quite as anticipated and similar to the earlier discoveries for general alternative modes, improvements in service provision, operating cost and capacity (especially on major routes rather than on-train capacity) turned out to be the areas in most needs of improvement from the businesses' perspective. Multimodality, which ensures seamless integration with other modes and thus reduces operating cost and improves efficiency and service qualities at the same time, is also highly valued by the respondents in their responses, reflecting the prospect of substantial growth in intermodal segment. Other desired changes with less number of responses can be categorised into infrastructure improvement including terminal development and loading gauge enhancement, and government support (e.g. through subsidies or regulations and policy-making). And liberalisation of rail freight network on international market was cited by 20% of the respondents as an effective incentive for them to use the mode as well.

3. Product/Packaging Design

Altogether product and packaging design received merely 20 responses (12 from LSPs and 8 from LSUs) during the first stage survey regarding to its impact on logistics operations, resulting in its low rank in *Table 4.5*. The previous findings also revealed that taking into account the corresponding priorities given by the respondents LSPs seemed to have much higher evaluation on its logistics implications compared with LSUs when the latter produced the lowest score among all 14 sustainable solutions. Building on these facts and figures, this section looks into the main approaches and focused functions of product / package design within logistics groups, along with the motivations, disincentives and cost-effectiveness of its implementation.

In *Table A10* the main approaches to sustainable product / packaging design adopted by respondent companies have been presented, supplemented by the level of interest each approach received among those who have not applied them at present. Due to the very limited sample sizes, the results can only serve for indicative purpose.

Table A10: Approaches of sustainable design by group

Approach	In place			Interested		
	LSP (N=7)	LSU (n=5)	Total	LSP (N=7)	LSU (n=5)	Total
Using renewable/recyclable material	4	5	9	3	0	3
Product / package design for logistics	6	2	8	1	3	4
Using less polluting material/substances	3	4	7	2	1	5
Adopting clean technology in production	0	4	4	1	1	2

Source: author's questionnaire survey, stage2; N=12 (multiple response)

Of the four alternative approaches, two focus on the material / substance side while the other two tackle the issue with emphasis on process / technology and logistics features of product and its package. Taking a view of manufacturing, these approaches represent the key stages of production covering input (raw material), processing/manufacturing and output (finished product). The results, as can be seen in *Table A10*, revealed that the LSUs from the sample tend to focus on product design at earlier stages of production, i.e. by using renewable, recyclable or less polluting materials or substances in their products, and adopting green technology to reduce the harmful discharges to the environment. Only 40% of them have incorporated the logistics implications into their product development, which may have great impacts on the operational costs, logistics efficiency and resource utilisation at later stages of handling, warehousing and transportation. In contrast, the LSPs appeared to be focusing on product and packaging design, with around half of them also using less polluting and recyclable materials in operations. Apart from clean technology for production process, which is not applicable for many LSPs, all the respondents have shown interests in those approaches they have not adopted, indicating the positive attitude held by the businesses to product and packaging designs.

By and large product / packaging design can be categorised by purpose into three broad groups - design for environment, design for operation / logistics, and most commonly, design for market. However, there are other factors such as legislation, corporate image and environmental credential that may reinforce the benefits of sustainable design. In order to identify the main driving forces for businesses to uptake good design practice, each respondent had selected up to three most important motivations and the results were reported in relative terms in *Table A11*.

Table A11: Motivations of sustainable design by group

Motivation	LSP (n=7)	LSU (n=5)	Total (n=12)
Comply with legislation	3	4	7
Environmental sustainability	4	3	7
Respond to market demand	3	2	5
Cost reduction	3	2	5
Improve logistics efficiency	4	1	5
Corporate image	1	2	3
Differentiate from competitors	1	0	1

Source: author's questionnaire survey, stage2; N=12 (multiple response)

Overall, it turned out that compliance of legislation was the most common reason for the businesses to take initiatives in their products design, although the driving force is considerably stronger for LSUs than LSPs. Environmentally-conscious design, market-oriented design and economic drivers appeared to be the next batch of motivations that received most responses from both groups, highlighting the effectiveness of financial incentives as well as the high profile concerns on environmental issues. The attitudinal split between the LSPs and LSUs groups occurred in logistics efficiency and corporate image, with the former more prevalent among LSPs and the latter more evident with LSUs. Surprisingly, gaining competitive edge by differentiating with competitors did not seem to be a major reason for both groups in product design, to some extent reflecting the lack of benchmarking practice and peer pressure in this area.

Reponses on major disincentives keeping the businesses from undertaking sustainable product and packaging design, as summarised in *Table A12*, presented a fairly evenly distribution across the categories. Cited reasons include complexity of implementation, lack of information or expertise in this area, cost concerns, lack of resources for implementation and limited return on investment. Since the categories were kept in broad terms to suit different types of businesses, the specific forms of difficulties encountered in the field of product /package design were incorporated into the interviewing structure and will be fully developed in the next chapter.

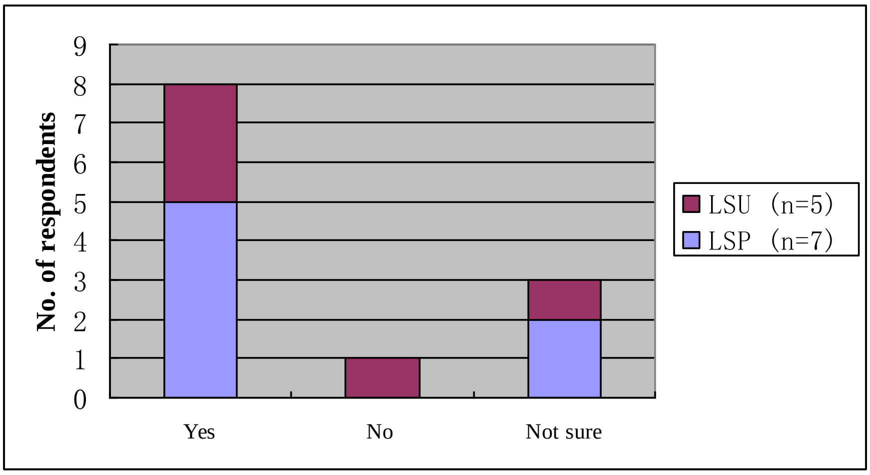
Table A12: Disincentives of sustainable design by group

Disincentive	LSP (n=7)	LSU (n=5)	Total (n=12)
Complexity of implementation	4	3	7
Lack of information / expertise	2	3	5
High costs	3	2	5
Lack of resources	2	2	4
Limited return on investment	2	2	4

Source: author's questionnaire survey, stage2; N=12 (multiple response)

As with most other sustainable solutions, the firms' attitudes on the cost-effectiveness of product / packaging design has been sought through the question asking whether or not the benefits of sustainable product/packaging design are able to justify the cost of implementation. *Figure A5* shows a mixed pattern of views on this matter, though overall positive attitude still dominates. The reasons of the one third respondents who were negative or 'not sure' about the solution's cost-effectiveness were addressed in the interviews and covered in the following chapter as well.

Figure A5: can the overall benefit of product/package design justify the cost?



Source: author's questionnaire survey, stage 2; N=12

4. Inclusion of Transport in the EU Emission Trading Scheme

Inclusion of the whole transport sector in the EU Emission Trading Scheme (ETS) did not appear to have a major impact on both LSPs and LSUs according to the earlier survey results, receiving 15% and 13% responses from each group respectively. Measured by weighted frequency on the basis of the given priorities, this solution was ranked the 13th out of 14 by both groups, reflecting the lack of recognition in its implications among the respondent across different industry sectors. Due to the limited number of respondents fallen into this category, only 5 LSPs and 4 LSUs completed the second stage of the survey which aims to interrogate their general attitudes to the hypothetical policy in respect of the implementation scope, method of the scheme, potential benefits and concerns for them to join the scheme along with their responsive strategies. The overview of the results is discussed in this section.

Firstly, the participants were asked to give their views on whether they think transport sector should be included into the ETS, and with anticipation of overwhelming negative responses on this matter, all of them were requested to choose an appropriate implementation scope if the policy were to be enforced. As *Table A13* describes, most respondents were against the idea of transport sector joining ETS, with only one LSU having the opposite view. Regarding to the implementation scope, an EU-wide trading system as being carried out for other targeted sectors at present turned out to be the most popular option with transport sector as well, followed by a closed sector specific ETS chosen by one of the LSPs. UK self-standing ETS received no response from either group, implying a preference to wider scale of ETS across countries.

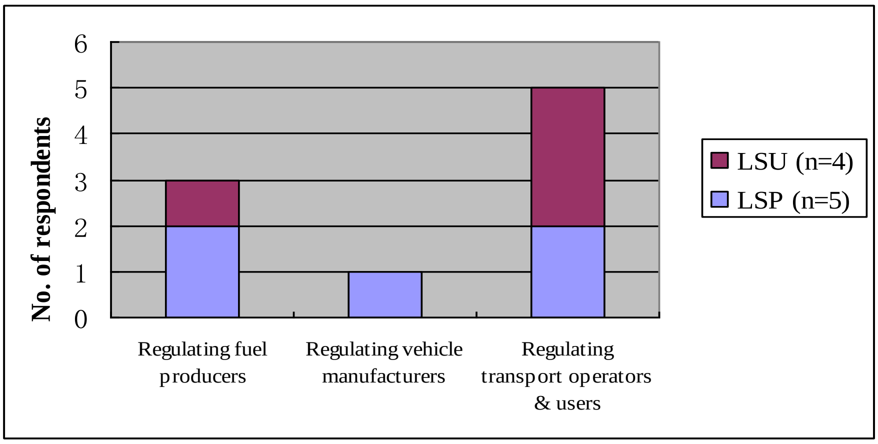
Table A13: General attitude to the implementation and scale of including transport sector into ETS by group

	LSP (n=5)	LSU (n=4)	Total (n=9)
EU-wide ETS	4	4	8
UK self-standing ETS	0	0	0
A separate closed ETS for the sector	1	0	1
No	5	3	8

Source: author's questionnaire survey, stage 2; N=9

Unlike the inclusion of aviation into the EU ETS from 2012, incorporating the entire transport sector is a far more complicated matter primarily as a result of its multi-modal characteristic. Under this consideration, major proposed implementation approaches were listed in parallel for the respondents to identify the one which they believe is the most suitable and workable for the sector, and results are reported in *Figure A6*.

Figure A6: Methods of introducing ETS to transport sector



Source: author's questionnaire survey, stage 2; N=9

As the figure indicates, although responses did spread across the three options, over half of them (56%) concentrated on the approach of regulating transport operators and users. Another one third cited regulating fuel producers as effective method, while only 11% believed that the ETS should be implemented on transport sector by regulating vehicle manufacturers. One of the reasons behind the pattern observed might be that there are currently quite a few large fuel producers and vehicle manufacturers covered in the EU ETS and the effects on transport sector in terms of reducing GHG emission are indirect and insignificant.

Given the scenario of the policy of including transport into ETS being enacted, the respondents were then asked to identify their likely strategies in response. The distribution of responses is presented by *Table A14*.

Table A14: Main strategies in response to the inclusion of transport in ETS by group

Strategy	LSP (n=5)	LSU (n=4)	Total (n=9)
Improve operational efficiency	5	3	8
Fleet modification & upgrade	3	2	5
Alternative fuel	2	2	4
More localised sourcing	1	2	3
ICT	2	1	3
Modal shift	1	1	2
Overhaul and reorganise your operation	1	1	2

Source: author's questionnaire survey, stage 2; N=9 (multiple response)

Improving operational efficiency, presumably fuel efficiency in particular, was cited by most respondents as one of their main strategies in reaction to ETS. Also as resorts to emission reduction, fleet modification and upgrading was identified by five respondents, along with increasing the use of alternative fuels, quoted by four respondent businesses. In general, compared with the remainder strategies which all require changes to be undertaken to existing operational network structures or processes to various extents, the respondent companies appeared to have preferences for the strategies that involve minimal logistics rearrangements while improving their environmental performances. Amongst the less commonly selected strategies, ICT was specified by one third of the sample, which could be indicative of potential interactions between the two sustainable solutions. Whether it is related to the efficiency enhancement purpose or a more pressing need for reporting and verifying the emissions under ETS regulations was investigated through interviews and addressed in the next chapter.

As with other sustainable solutions under examination in this research, major benefits and obstacles for businesses to engage themselves to the particular sustainable undertaking has been explored via the survey, only except that the implications of ETS will be purely the perceptions of businesses as the inclusion of transport sector is so far a hypothetical case which may or may not be realised in the future. *Table A15* and *A16* have, respectively, reported the perceived benefits and concerns of the respondents in joining ETS. Noticing that although both questions required no more than three answers from each respondent to ensure the identification of the prioritised factors, on average the sample gave two responses in the question on perceived benefits and three on concerns, it is believed, based on the evidence at this stage, that the businesses felt stronger on the concerning issues compared to the benefits that they might possibly obtain from joining ETS. The reasoning will be tested with more evidences from other sources and the result discussed in full details later.

Table A15: Perceived benefits of transport joining in ETS by group

Benefit	LSP (n=5)	LSU (n=4)	Total (n=9)
Sustainable and efficient operations	3	3	6
Improving environemntal management	3	2	5
New market opportunity	2	2	4
Enhancing competitiveness via cost-effective emission abatement	1	1	2
Long-term investment in new technology & equipment	1	1	2

Source: author's questionnaire survey, stage 2; N=9 (multiple response)

According to the survey result illustrated in *Table A15*, efficient and sustainable operation is the mostly expected benefit from joining ETS, with apparent implications in emission reduction which, consequently, can be translated into monetised benefit in carbon trading market. Primarily upon the requirements of verification and reporting under ETS, environmental management in the installations would have to be systemised and improved, which is also highly expected by over half of the respondents as one of the major benefits. The businesses seemed to be less optimistic about new market opportunity along with ETS with only four of them selected this category, whereas only a small minority of them (two respondents) anticipated reaping benefits through enhancing competitiveness via cost-effective emission abatement as well as long-term investment in new technology and equipment as a result of joining in ETS.

Table A16: Major concerns of transport joining in ETS by group

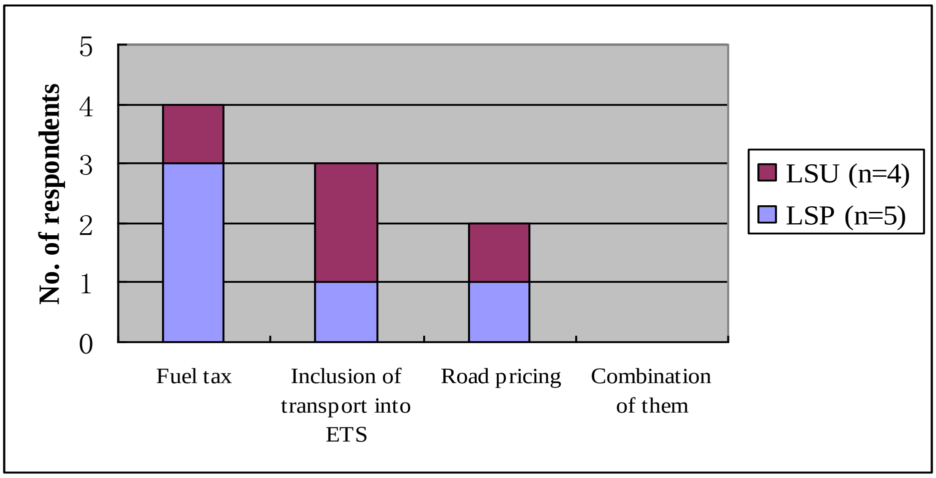
Major Concerns	LSP (n=5)	LSU (n=4)	Total (n=9)
Complexity of management & administration	3	3	6
Carbon allowance price	4	2	6
Other economic implications	3	2	5
Lack of information	3	2	5
Harm to the competitiveness of the industry	2	1	3

Source: author's questionnaire survey, stage 2; N=9 (multiple response)

Amongst the five concerns stated in *Table A16*, the most cited ones are complexity of management and administration involved in joining ETS and carbon allowance price. The former entails precious business resources to deal with the administrative burdens of registration, application for emission permit, verification and trading on the market, to name a few, while the latter has a knock-on effect on businesses' bottom lines. Other economic implications of ETS, such as all the costs incurred by businesses to cover the national cost of operating the scheme, whether it is one-off cost or annual operating cost, the cost of compliance or penalty, and the cost of setting up environmental monitoring and reporting systems, appeared to be another major concern for 56% of the sample. The same proportion of the respondents also quoted lack of information as one of the major obstacles, which could either result from lack of knowledge of the legislation or short of expertise in monitoring and calculating the emissions discharged by the installation. Harm to the competitiveness of the industry turned out to be the issue of least importance for the businesses, selected by only one third of the sample.

Instead of asking respondents to evaluate the cost-effectiveness of the solution as in other sections, the final question conducted a simple state preference investigation on businesses' attitudes to three major national sustainable transport policy instruments studied in this research, namely, diesel fuel tax, national road charge scheme and ETS. The reason of doing so is on one hand, the cost of the hypothetical scenario is not only highly uncertain hence difficult to estimate but also largely subject to great variations among businesses; on the other hand, it provides valuable insights in comparing businesses' attitudes to different policy measures. As *Figure A7* reveals, fuel tax as the only currently enforced measure, was perceived as most effective in carbon reduction by most number of the respondents, indicating a preserved and reactive attitude to changes. Interestingly, inclusion of transport into ETS has gained more responses compared to road pricing, although the variation was not great enough to show a strong preference and it is likely to be a result from the sample frame which only contains those respondents with great interest in ETS at the first place. None of the respondents selected a combination of policies, reflecting an overall negative view in terms of their (actual or potential) impacts on the businesses.

Figure A7: Which of the following policies do you think work better in terms of carbon reduction?



Source: author's questionnaire survey, stage 2; N=9

5. Urban Logistics

As the very sustainable category lying at the bottom of the ranking chart regarding logistics implication, urban logistics was clearly not a critical issue for the vast majority of respondents, receiving merely 1 response (with lowest rank, i.e. the 5th) from LSPs group and 7 from LSUs. It was also evident that the LSUs group showed relatively greater interest in urban logistics practice. And the case was reinforced when the weighted frequencies taking assigned priorities into account were calculated and used for ranking all the 14 solutions, seeing urban logistics ranking the 12th with LSUs group while still coming as the last with LSPs. Inevitably the extremely limited sample frame led to a sample with a even smaller number of respondents taking part into the second stage survey, including 1 LSP and 5 LSUs. As a result, there is no need in this section trying to differentiate different response patterns between the two groups as it would not be appropriate for one respondent to represent the whole group of LSPs.

Similar to other broad sustainable categories with a wide range of specific measures in practice such as reverse logistics and supply chain optimisation, urban logistics is featured with a large, diverse selection of methods and policies serving various purposes and focuses in the area, thus not suitable for generic questions addressing the category as a whole which have been used for most other solutions (e.g. cost and benefit implication). In attempt to obtain informative data, the survey was designed to allow comparison across major urban freight schemes in terms of their effects on logistics operations, and meanwhile explore further into the most commonly applied form of urban freight restrictions and the frequently studied and proposed trans-shipment centre for urban distribution.

In assessing the effects of various urban logistics schemes perceived by respondents, the five point Likert scale question was developed, where one represented no impact and five represented very significant impact. As the schemes under consideration are a mixed selection of the ones already in operation and ones in proposal, the respondents were asked to evaluate the impact of each option on their businesses assuming they were covered in the scheme. The outcome is shown in *Table A17* in a descending order by mean value.

Table A17: Degree of impact of each urban logistics scheme on businesses (1 as no impact and 5 as great impact)

Urban Logistics Schemes/Practices	Mean	Standard Deviation
Transhipment / consolidation centre	4.00	0.89
Shared distribution network with other companies	3.67	0.82
Out of hours/night delivery	3.50	0.55
Dedicated on-street /off-street delivery bays for goods vehicle loading and unloading	3.50	0.55
Congestion Charge	3.50	1.05
Time, vehicle weight/size restrictions on access to certain urban area	3.17	0.75
Road space priority over other vehicles (e.g. shared bus/lorry lanes)	2.83	0.75
Low Emission Zone	2.67	0.52
Use of other modes - rail/waterway/underground/metro systems	2.67	1.63
Dedicated inner city neighbourhood reception place	2.50	1.05

Source: author's questionnaire survey, stage 2; N=6

All but one urban logistics schemes were regarded as of greater impacts than neutral (i.e. 2.5 on the scale) when dedicated reception place received lowest ratings on average, meaning that it has the least effect on logistics operations compared with other schemes in the list. Trans-shipment / consolidation centre was ranked as the scheme with most significant implication on the respondents' businesses, with a relatively higher yet still reasonable standard deviation as indicator for the level of agreement on the rating. Followed right behind was shared distribution network with similar standard deviation, suggesting that the businesses tend to pay more attention in those schemes that require changes in existing supply chain arrangement and structure. Out of hours/night delivery, urban freight facilities (i.e. dedicated loading bays etc.), and congestion charge were ranked the third equal, with the former two having small standard deviation hence high degree of uniformity in responses and the latter's substantially lower. Of note is that although low emission zone (sometimes referred to environmental zones as more general term) and alternative modes both received fairly low ratings, indicating their less significant impacts on logistics operations, the former had the smallest standard deviation in contrast to the latter's being the biggest among all. This could be explained, presumably, by the different interpretation of the respondents on the hypothetical undertaking of alternative modes for their urban logistics activities. After all, the practice is not common and thus may subject to other assumptions made by respondents in evaluating the scale of its impact.

Further developing on the widely implemented and debated issue of urban freight restriction in various forms, most commonly on access time, vehicle weight, size and routes, major concerns of the respondents were sought and the results are reported in *Table A18*.

Table A18: Major concerns on restrictions of goods vehicle in urban areas

Concerns	No. of respondents
Inefficient distribution/supply chain operation	5
Higher operating cost	4
Congestion outside restricted delivery hours	3
Lost sales	2
Lower load consolidation	2
Lower fuel efficiency	2
Vehicle upgrading cost	0

Source: author's questionnaire survey, stage 2; N=6 (multiple response)

Based on the responses, the businesses seemed to have encountered lower efficiency in distribution as a consequence of current urban restrictions. Higher operating cost and congestion constituted the other two major concerns of companies, while lost sale, lower load consolidation and fuel efficiency were each cited by one third of the respondents. Cost implication of vehicle upgrading did not appear to be concerned by businesses, reflecting the willingness of companies in investing in new vehicle technology in compliance with the relevant regulations.

In response to urban restrictions imposed on them, the respondents identified their corresponding strategies. Four respondents cited compliance strategy which means operating outside the restricted hours and areas. Only one respondent stated preference to more proactive strategy by adopting quieter and greener vehicles and equipments if it could help to exempt them from the restrictions. And another chose to increase their stock level in premises within restricted urban area, a trade-off approach calibrating transport related cost with inventory and storage cost.

Businesses' opinions on shared trans-shipment / consolidation centre for urban delivery was investigated through the questionnaire survey as well, primarily focusing on the potential drawbacks that might put businesses off the conception. Responses are summarised in *Table A19*.

Table A19: Major concerns on trans-shipment centre for urban distribution

Concerns	No. of respondents
Lack of logistics control in the supply chair	4
Additional cost	4
Risk of losing business	3
Poor service quality	3
Cooperation with competitors	2
Loss /damage / insurance of goods	2

Source: author's questionnaire survey, stage 2; N=6 (multiple response)

As shown in the table above, the requirements of businesses having high degree of logistics control over their supply chains, together with extra cost that might be incurred with additional operations of trans-shipment centre for the last mile delivery in urban areas received most responses. The second set of common concerns including worries of losing business and the lack of confidence in maintaining the same level of service quality with the involvement of trans-shipment centres. Both the concerns can be regarded as implications of losing control over part of the supply chain management, again reinforces the apparent businesses' preference to dedicated distribution strategy over shared operation. Likewise, other stated issues such as having to cooperate with competitors, and concerns over loss, damage or insurance of goods have all to some degree reflected the reluctance among the businesses to participate in such a shared-users based scheme, requiring more incentive mechanism to be devised in order to promote the practice.

Appendix Eight: Summary of Information Provided by Interviewees

Company	Fuel Taxation	Driver Training	Vehicle Design	SC Optimisati	ICT	Road Pricing	AF	Gov Support	EMS	Reverse Logistics	Modal Shift	Product/Packaging	ETS	Urban Logistics
P1			•	•	•		•		•			•		
P2		•												
P3		•								•				
P4				•										
P5		•							•					
P6			•		•							•		
P7		•		•	•									
P8				•										
P9				•										
P10		•						•						•
P11			•	•	•					•				
P12					•				•					
P13					•									
P14			•	•	•				•			•		
P15				•						•				•
P16		•	•	•	•									
P17					•									
P18												•		
P19									•		•			
P20					•									
P21		•												
P22		•		•						•				
P23				•										

Company	Fuel Taxation	Driver Training	Vehicle Design	SC Optimisati	ICT	Road Pricing	AF	Gov Support	EMS	Reverse Logistics	Modal Shift	Product/P ackaging	ETS	Urban Logistics
U1				•					•					
U2		•		•										•
U3		•	•											
U4		•												
U5				•	•									
U6				•	•		•		•	•	•			
U7				•					•					
U8				•						•				
U9														
U10				•										•
U11			•						•			•		
U12				•					•	•	•			
U13		•			•									
U14				•			•		•		•			
U15		•												
U16		•												
U17			•	•	•									
U18				•										
U19				•			•			•	•			
U20					•									
U21			•	•	•			•	•	•				•
U22		•		•	•			•	•					
U23									•					

Company	Fuel Taxation	Driver Training	Vehicle Design	SC Optimisati	ICT	Road Pricing	AF	Gov Support	EMS	Reverse Logistics	Modal Shift	Product/Packaging	ETS	Urban Logistics
U24				•							•			
U25				•					•	•		•		
U26				•	•					•				
U27		•	•	•	•								•	
U28			•								•			
U29					•							•		
U30		•												
U31											•			
U32			•		•				•	•		•		
U33				•	•					•				

Appendix Nine: 2007 Statistics of Road Haulage by Distance

International and Domestic Freight transport by road (Domestic: length of haul by goods vehicles over 3.5 tonnes: 19

Goods lifted	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
										Million tonnes	
Not over 100 kilometres	1,132	1,073	1,093	1,083	1,129	1,132	1,223	1,228	1,286	1,320	1,211
Over 100 kilometres	497	494	501	496	498	509	521	518	527	549	523
All distances (over 3.5t)	1,630	1,567	1,593	1,581	1,627	1,643	1,744	1,746	1,813	1,869	1,734
Domestic Road (all goods vehicle)	1,727	1,664	1,693	1,682	1,734	1,753	1,863	1,868	1,940	2,001	1,868
International (over 3.5t)	5,119	6,094	n/a	n/a	n/a	n/a	n/a	n/a	n/a	11.2	n/a

Goods moved	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
										Billion tonne - kilometres	
Not over 100 kilometres	38.6	36.9	38.1	36.8	38.8	39.4	41.7	42.9	44.4	45.9	43.8
Over 100 kilometres	113.3	112.3	112.4	112.6	111.0	112.0	110.6	109.8	111.1	115.6	107.9
All distances	151.9	149.2	150.5	149.4	149.8	151.7	152.2	152.7	155.6	161.5	151.7
Domestic Road (all goods vehicle)	160.3	157.7	159.4	158.5	159.4	161.7	162.5	163.4	166.7	173.1	163.5
International (over 3.5t)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	4.2	4.5	8.7	n/a

Source: extracted from DfT, 2009

Appendix Ten: Practical Examples of Good Industry Practice in Implementing Sustainable Logistics Solutions

Sustainable Solution	Case	Practice	Cost	Environmental Benefit
Alternative Fuels	Hermes Versand Service (3000) - fuel cell vehicle, as part of the company's EMS	The Mercedes Sprinter fuel cell-powered vehicle was first put into operation in 2001 and ran up more than 16000 kms in service. The vehicle operates on compressed hydrogen, with a range of 120-150 kms for daily delivery work. The company also tested other AFs such as electric and gas vehicles.	The company had to make a one-time investment of EUR 250000 to put the fuel cell-powered vehicle into operation.	Zero emissions: there are no ecologically harmful waste products with carbon compounds - only water comes out of the exhaust pipe. Furthermore, the fuel cell drive is extraordinarily quiet and twice as efficient as conventional gasoline engine technology.
	Alstom Transport – hybrid shunting locomotive	The new locomotive saves energy by reusing braking power. The diesel engine in the hybrid locomotive is smaller, and in principle is not kept running during the often long waiting times in the shunting process. The auxiliary and drive systems are then powered by a battery. With a hybrid locomotive the diesel engine runs at maximum capacity only when there is a demand for maximum power or in order to charge the battery.	Because of the smaller diesel generator and the battery pack, savings can be made on fuel and maintenance costs, and so the investment in such a locomotive can be recouped in just a few years	Alstom expects to achieve fuel savings of at least 40% and to halve the volume of CO2, NO_x and particulate emissions. Noise will also certainly be reduced by 15 dBa.
	INDITEX – Pro-Kyoto Project	As one of the initiatives for the Strategic Environmental Plan (2007-2010), a bio-desel programme for the entire vehicle fleet has been implemented. For this purpose a supply network will be set up at loading points and along trucking routes.	Not available.	The use of biofuels accounts for 80% of the CO_2 reductions objective, which add up to 850 tonnes per year.

	TNT Express – electric vehicles in urban environment	One hundred 7.5 tonne Smith Newton delivery trucks were put to use on urban routes by TNT, replacing a fleet of diesel vehicles. Changes are required in operating practices, as well as the installation of charging equipment. There are now 4,000 registered electric vans in the United Kingdom. Other companies using electric vehicles include Fedex, UPS, CEVA Logistics, Sainsbury's Online, Marks & Spencer, Tesco, DHL, Royal Mail, the Co-operative Group, Speedy Plant Hire and Enterprise plc.	Fuel cost approximately 20% of diesel equivalent.	Zero emissions at point of use. Lower total CO_2 emissions overall – electricity from the National Grid has a cleaner make-up. TNT estimated that CO_2 emissions will be reduced by 1300 tonnes annually. Quiet running vehicles – which may be a benefit for operating in noise-restricted areas.
	Commercial Group – biodiesel with fuel management system (ICT)	Fuel is delivered via an innovative real-time blending system. Biodiesel and mineral diesel are blended between 0 - 100% by vehicle and by fill-up, ensuring that any diesel vehicle can run on an optimum blend of biodiesel. The fuel management system integrates with the biodiesel pump, allowing each vehicle, driver, route and delivery to be carbon managed.	Equipment and installation costs are less than £100,000.	The company has reduced its fleet emissions by over 70% since 2006. As well as reducing emissions, the carbon reduction programme has helped Commercial gain significant new contracts, worth over £8m, as well as saving over £100,000 a year.
Driver Training	Carl F.* (35) – Eco-Driving project	As part of the fundamental change in the salary system, the project involves all drivers. Fuel consumption is measured every second month, with the figures placed on the company's notice board for everyone to see.	Higher personnel cost.	The drivers used 5-20% less fuel. However, it is hard to estimate the exact impact of this system on fuel consumption because many of the trucks drive in the city. The benefits will have to be evaluated on a long-term basis.

		Those who drive fuel efficiently are rewarded with the annual bonus.		
	Setz Gütertransport AG	The fuel consumption of each vehicle is determined every month and analysed by a software programme. The drivers who have the ten worst results are spoken to and assessed. Measures used to correct the problem include: altering route plan, driver training by external driving instructor, and inspecting vehicle in the garage.	The costs for training, consulting fees, and internal services (e.g. investment and personnel) amount to approximately EUR 34000 per year.	Fuel consumption is reduced by an average of 2.4% per year (1995-2000). Reduction in CO_2 emissions proportional to fuel consumption, reduction in the emission of NOx, CO, HC, and particles.
	Merzger Spedition GmbH* (50+)	Driver training program is provided for all drivers. Driver assessment including fuel efficiency before and after training and accident records enables Metzger to chart and compare improvements. Incentives are provided to above-average driving; while the causes of abnormally high fuel consumption are analysed to find solution.	The training costs in 1997 amounted to EUR 6100, which is equivalent to EUR 120 per year for each of the 50 drivers.	Fuel efficiency has increased by 12%. The company has saved a total of 30000 litres in fuel. At the same time, CO_2 emissions have been reduced by a total of 81000 kg. The number of accidents has decreased by more than 8%.
	John Mitchell (Grangemouth) Ltd.	Driver training with the help of the Safe and Fuel Efficient Driving (SAFED) programme. For modern vehicles the cost of switching off the engine and starting up again is usually less than the cost of leaving the engine idling. Thus the company also invested in an anti-idling campaign.	Relatively low (unspecified).	7% reduction in fuel consumption and CO_2 output and fuel costs saved in the amount of £274,089 through driver training. Anti-idling measures led to weekly savings of £700 per week.

	Asda – driver training with the help of ICT	A capital investment in vehicle telematics has been made to provide information on various aspects of engine and driver style performance. In addition an investment in dedicated resource to enable new approach to driver training was made.	Unknown.	• 2.7% MPG improvement through 2007 • 3.1% MPG improvement through 2008 •Target of a further 2% improvement through 2009
	PepsiCo	Fuel monitoring equipment was installed on a couple of vehicles as a trial and an immediate improvement was noticed on these vehicles. This improved further when linked to a driver re-training programme As a result of this the fuel monitoring equipment was rolled out across the whole of the fleet.	Unknown. (A payback on equipment within 2 years is estimated.)	The average fuel efficiency improved from 3.7km/litre to 3.9km/litre and this has been maintained of a period of several years.
EMS	Simssee-Transport GmbH* (11)	In accordance with regulation 1836/93 (EWG) and EMAS II, the company has been working on a continuous improvement process (the Kaizen principle) and adapting their activities, such as reducing resource consumption, increasing intermodal transport and utilization of railway resource (e.g. wagons) to reduce use of swap bodies, reducing empty trips, and reducing emissions caused by accident.	The total investment in environment protection amounts to circa EUR 30000.	Different measures have resulted in approximately 15% less waste each year over a longer period of time. Nowadays total waste production has reached a very low level, therefore a further reduction seems hard to achieve.
	Vognmand Johnny Amtoft* (7) – Green	Examples:	The preparation of the first green account took circa 16 hours. The most	Green accounts are produced annually, and compared with the baseline of 1999. In 2000 the consumption of diesel oil was reduced by

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<tr><td colspan="4">Input-output statement – Vognmand Johnny Amtoft trucks
The basis year for indexing is 1999 = 100</td></tr>
<tr><td>Energy consumption</td><td>Quantity 2000</td><td>Quantity per km</td><td>Index 2000</td></tr>
<tr><td>Electricity (kWh)</td><td>8'127</td><td>-</td><td>103</td></tr>
<tr><td>Heating (litre of fuel)</td><td>3'066</td><td>-</td><td>95</td></tr>
<tr><td>Water (m^3)</td><td>120</td><td>-</td><td>98</td></tr>
<tr><td>Raw material consumption</td><td></td><td></td><td></td></tr>
<tr><td>Diesel oil (litre)</td><td>326'918</td><td>3'082</td><td>99</td></tr>
<tr><td>Lubricants (litre)</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Emissions into the air</td><td></td><td></td><td></td></tr>
<tr><td>CO_2 – goods transport (g)</td><td>865'024'868</td><td>858.48</td><td>99</td></tr>
<tr><td>CO_2 – others (g)</td><td>13'862'562</td><td>-</td><td>98</td></tr>
<tr><td>SO_2 – goods transport (g)</td><td>27'461</td><td>0.03</td><td>25</td></tr>
<tr><td>SO_2 – others (g)</td><td>15'700</td><td>-</td><td>100</td></tr>
<tr><td>NO_x – goods transport (g)</td><td>9'143'574</td><td>37'081</td><td>100</td></tr>
<tr><td>NO_x – others (g)</td><td>18'522</td><td>-</td><td>101</td></tr>
<tr><td colspan="4">The environmental index for diesel consumption of goods transport is calculated as diesel consumption per km driven. Similarly, the environmental index for emissions of goods transport is calculated as emissions per km driven. The remaining environmental indicies are calculated on the basis of absolute amounts.</td></tr>
</table>
</td>
<td>time-consuming task was the documentation. The subsequent green account was less time-consuming as the company knew the procedure.</td>
<td>1% from 1999 to 2000. Emissions of HC, CO and particles remained unchanged, while the emission of SO_2 was reduced by 75%, as a result of the usage of low-sulphur diesel (50 ppm).</td>
</tr>
<tr>
<td></td>
<td>Transportes Ochoa SA (1000+) – implementation of an EMS</td>
<td>The company started the implementation process for an EMS in 1999 by participating in the SIGMA I and SIGMA II projects. The system is in accordance with the ISO 14001 standard. One of the major obstacles during implementation is the geographical scope of the standard, which includes all processes at all 68 company sites, spread all over Spain. As the legislation is not always homogeneous in different regions and municipalities, it is especially difficult to comply with all the legal requirements for application of the EMS.</td>
<td>The breakdown of implementation costs: Consultancy fees and EMS development costs €11840; Legal consultancy fees € 2400; Personnel costs € 22550; Estimated certification costs: initial audit € 2200; Periodic audits € 750 each.</td>
<td>The fleet renovation has resulted in a significant decrease in fuel consumption. The mean fuel consumption in 1998 was 29.52 litres/100 km. This was reduced to 28.17 litres/100 km in 2000, re presenting a decrease of 4.56% in just two years. In quantitative terms, Transportes Ochoa saved 232971 litres thanks to the reduced average fuel consumption of the fleet.</td>
</tr>
<tr>
<td>ICT</td>
<td>VSV Frakt AB – ICT in the context of EMS and driver training</td>
<td>In order to support the introduction of an EMS, the company has developed an ICT system called TROMB for transport guidance and communication. Each mobile communication unit consists of a GIS, GPS,</td>
<td>The software was developed by VSV itself and accounts for most of the organization's investment in the system.</td>
<td>As an example, it has been possible to increase the efficiency of round-trip timber transports for one of VSV's main clients. Emissions were reduced significantly in 1999 compared with 1998.</td>
</tr>
</table>

		email and emergency alarms, and can be coupled with sensors on the vehicle to record fuel consumption, temperature and service intervals. Drivers were provided a PC-based general training course and a two-day onboard training. A special training centre was built where 4 drivers can learn simultaneously. A major obstacle during implementation was that some partners and clients are not convinced of the benefits of the system and reluctant to change.	The hardware is the main cost for the individual drivers who are VSV's partners. The computers used in the rugged cab environment have to be able to cope with factors such as large variations in temperature, vibration, shock and dust, hence cost considerably more than a standard computer. Each mobile unit costs about EUR 6300 including mounting, accessories and antennas. It is calculated that the system can be amortized in under two years.	On the basis of an annual survey of all logging trucks, it is estimated that the TROMB system will reduce CO_2, NO_x, and particle emissions by 5% per transported tonne between 1998 and 2003.
	United Biscuits – ICT to aid load planning & increase vehicle fill	Over 2000 product lines, each having a different pallet weight and pallet support weight, a large variation in case dimensions, and differing rules of customers regarding pick pallet and load build all add to the complexity of load planning. UB have developed 3	A business project was raised enabling the investment to develop and interface systems and the project was tightly managed to ensure it was	The system enhancements helped deliver an 11% improvement in overall fill ie pallets per load and a further 6.3% improvement in picked pallet fill ie cases per picked pallet. The project also resulted in a reduction in customer complaints and refusals and a

		systems, all interfaced to provide planners with the ultimate aid enabling optimum load fill. UB used SAP for all its order to cash processing. It used Manugistics TM for its vehicle and route scheduling and transport allocation. UB's warehouse management system (WMS) however has been developed and incorporates load compliance, product dimensions and all customer rules enabling load building and compaction. This processing provides planners with an accurate view of minimum footprint each order will occupy.	delivered seamlessly i.e. on time, on budget and with no service impact to customers.	reduction in planning issues experienced in the warehouse.
	DHL (Berlin) - SmartTruck for urban delivery	All parcels are loaded in the SmartTruck with RFID tags and reader are used to check that the right parcels are on board; dispatch center sends the optimal route, based on the current traffic conditions; dispatch centre can change the turn-by- turn navigation route.	Overall decrease of costs of 10-15 % and increase of productivity of almost 10 %.	Average driving distance per tour decreased by 10 -15%; the distance of some tours was decreased by 20%; Reduction of fuel usage of 10-15%; Reduction of CO_2 emissions of 10-15 %; Increase of number of stops (pickup or delivery of parcels) per hour of 8 to 9 %.
Modal Shift	Netherland, Switzerland - the Abroll Container Transport System (ACTS)	It was originally developed for road freight in the Netherlands. With adaptation, it enables the specially designed loading units to be transhipped between lorries and wagons quickly without using other equipments at terminals. There are similar systems in other European countries (e.g. RSS, Roland	The cost is positively related to the scale of use. It requires relatively low investment for small traffic flows, yet becomes less economic compared to fixed transhipment	This efficient and flexible transfer technology benefits the operations with reduced transshipment time, especially for waste and general goods transport in regions with low traffic levels.

		Umschlag Schiene Strasse, in Germany) that have been adapted for intermodal exchange.	equipments (e.g. cranes) at terminals when the volume grows to a certain (break-even) level.	
	SNCF, France – Commutor	It offers automatic and fast transshipment of loading units between different modes of transport.	Not available.	Loading and unloading of boxes is performed fully automatically and simultaneously on all the wagons of a train during a stopping time of approximately 15 minutes
	Deutsche Bundesbahn (DB) – MB Kombi-Lifter	Equipped rail-wagon can lift the swap bodies positioned directly over the track.	Operation at the terminals has to be organised in an efficient and economic way due to the time constraints.	Standard swap bodies can be used without modification. Transhipment can be decentralised and congestion relieved at intensively used terminals.
	Deutsche Bundesbahn (DB) – Train Coupling Sharing /Cargo Sprinter	Small innovative train (about 5 wagons – each able to load 2 containers or swap bodies) that use infrastructure efficiently	Not available.	The ease of coupling, splitting and (un)locking trains means that operations can be continuously adjusted to freight volumes.
	Mercedes-Benz , Germany – Central Shipping Department	The plant in Stuttgart-Untertürkheim has centralized its global outbound logistics activities at Stuttgart's inner harbour. The Mercedes-Benz Central Shipping Department replaces the shipping areas of each of the 7	The buildings of the new site are rented. Thus, the investment was only restricted to logistics assets with about 12	In 2003 100% of international outbound shipments were carried out by truck. Since the implementation of the project road transport has been reduced to 26% of all international shipments whereas 44% use

		sub-plants in the Neckar valley.	million Euro. As the annual savings mount up to 7.5 million Euro per year the own investment costs were already covered after two years.	inland waterways and 30% rail (figures from 2008). As a result the distance covered by truck could be reduced by 3.7 million km per year, and accordingly the CO_2 emissions by 5,383 tons per year.
	London, UK – Megahub: Wembley European Freight Operating Centre	It acts as a hub for the bundling and sorting of Tunnel freight. Intermodal services from regional terminals are reassembled into single destination block trains – and correspondingly inbound trains from the continent are sectioned and reassembled into regional trains serving the UK terminals	Not available.	It represents a time and cost efficient solution for freight trains leaving regional terminals with less than full train traffic.
	SBB (the Swiss Rail) – Cargo Domizil	Created as a division of SBB to execute unit load rail shipments, Cargo Domizil uses the company's rail capacity to solve the problems of the Swiss night trucking ban and the high tolls for trucks on Swiss roads. It offers less-than-full-truckload (LTL) shipments via combined rail/road facilities.	Structural changes were accompanied by a training programme. The high tolls for trucks on Swiss roads are avoided.	Apart from solving the problems of the Swiss night trucking ban, it also offers significant advantages in Switzerland's mountainous regions, which are sometimes difficult to reach for large trucks.
	Lafarge Cement Ltd / The Malcolm Group / Freightliner Ltd – Short	This multi-modal service provides end-to-end connections, using road to rail and then back to road for final delivery. It provides a seamless customer collection and delivery service for products that can be containerised.	It is cost effective for customers.	There are significant savings in fuel and reduction of CO_2 output (e.g. for Malcolm annual fuel use was reduced from 352,538 litres to 158,326 litres, and CO_2 output was reduced from 927 tonnes per year to 416

	Haul Rail Freight			tonnes).
	JF Hillebrand, UK – the Wine Train and Wine Barge	• Working closely with Freightliner, the company lauched "the wine train" in 2008 - an innovative and exclusive Tilbury to Daventry rail service. • Tesco's New World wine shipments have been re-engineered. Before the shipments arrived in the UK at various southern ports by ship and then driven to the Manchester bottling depot. Now they are shipped directly into Liverpool and transshipped to the container terminal in Manchester, ensuring the traffic stays on the water rather than roads for as long as possible.	• The Wine Train: It took about two years of planning and development and initial investment of £1 million. There is no additional cost for customers. • The Wine Barge: not available.	• The Wine Train: The service is estimated to save an average of 326km per road-trip equivalent. The savings are estimated to be over 280,360 gm CO_2 emissions per container shipped via the rail service, which equates to at least 1.7 billion grams of CO_2 savings per year. • The Wine Barge: This method cut carbon emissions by 80%. It will also take 50 lorries off the road every week, resulting in an incredible saving of 1.1 million kilometres of heavy lorry journeys on British roads.
	Ewals Cargo Care, Belgium – service provider	Ewals has set up a hub-and-spoke network for long-distance haulage. At least two modes are used to transport the cargo from pick-up to delivery.	No extra cost compared to road haulage	The intermodal transport has reached and even bettered the goal of 92% utilisation, and CO_2 reduced by at least 32% in comparison to road transport.
	Mercadona, Spain – service user	Intermodal collaboration distribution, where the supermarket work with its suppliers and logistics providers to promote sustainable transport.	Not available.	CO_2 emissions were reduced by over 12,000 tonnes due to the number of its truck deliveries being reduced by up to 9,152 truck delivery journeys. Fuel consumption has been cut with less truck use, equaling a 70%

				energy consumption saving.
Pdt/packaging Design	Pepsio – case reengineering	In order to reduce the complexity of the logistics operation by limiting the number of case sizes being used and challenging the existing pack configurations to optimise the efficiency of the case and pallet, the current range of multi-pack case sizes was reviewed, including both pack and case count. As a result, the whole of the Walkers multi-pack range was consolidated down to 2 case sizes.	Ensuring the buy in from the commercial team was critical to the success of the project as well as the effective communication to the customer to ensure they understood the options and potential benefits of such a change.	• Corrugate converters were able to product much larger run sizes and manage stock levels more effectively. • The single footprint, which was exactly twice that of the new standard case footprint simplified the picking process and created more stable pallets. • The larger case improved the packing efficiency by increasing the overall packs per pallet and reducing the total number of loads being distributed.
	P&G	Using life cycle inventory (CLI) to quantify the emissions and energy requirements associated with specific products/packages, based on which design strategies were then made.	Resources and emissions are measured along the entire life of products and packages, including fuel for transportation and emissions from different disposal options.	The processes with significant resource usage and emissions can be identified as high priority improvement opportunity.
	Lufthansa Cargo – glass fibre/Kevlar air cargo container	Lufthansa Cargo has been trialling a new type of air cargo container. They are constructed of innovative and lighter composites of glass fibre and kevlar, instead of aluminium, which reduces their weight by 20%, thus lowering fuel burn and carbon emissions.	For new containers (Not known).	Reduction of fuel burn and GHG emissions.

	United Biscuits – multi pack project	A cross-functional project was launched involving manufacturing, marketing, commercial, procurement and logistics, which demonstrates how a review and reduction of air contained within Hula Hoop multpacks has improved case, pallet and vehicle utilisation resulting in distribution and packaging cost savings. Once the manufacturing process for reducing the volume of air sealed within the multipack bag was developed, the number of multipack bags within the case were reviewed and increased and travel tests trials were undertaken to ensure any change would not impact on product quality. The commercial teams then approached customers to get sign off of a change in number of mutipack bags within a case.	Manufacturing process change requiring capital investment (unknown)	Case fill improved by between 15 and 25% reducing the number of pallets distributed by 30,000 pallets per annum. This generated a significant transport and pallet handling saving throughout the supply chain as well as a packaging (cardboard) saving.
	Kimberly-Clark (UK) – product specification	It was identified that it would not be possible to stack product to a transportable height due to the product specifications. By working with marketing and manufacturing teams it was identified that the Fiesta kitchen towel height could be reduced by a minimal amount (4mm) and that this would facilitate an alternative pallet stacking pattern. This in turn would	Internal management of the project, and changes to the product. This project was initiated in 2003, and took around 15 months to implement, including manufacturing/ product changes.	A minor change to product specification delivered the capability to add one extra layer of product to every pallet, reducing the number of loads required to be moved by 17%. Reduction in road miles through fewer vehicles on the road, both on the continent and then for onward delivery in the UK.

		allow product to be stacked to the maximum 3m high pallets.		
	JF Hillebrand/ UK – transport of wine in bulk	Although bottled product remains the favoured way of importing wines and spirits into the UK, many shippers are looking for an alternative which will provide cost and environmental benefits without compromising the quality of the wine. In 2007 the company acquired Trans Ocean Distribution Ltd, with its expertise in designing and manufacturing flexitanks for bulk liquids, and started transporting wine in bulk.	Unknown.	Hillebrand Bulk's VinBulk system holds 24000 litres of wine, which more than doubles capacity of a single container (10584 litres of bottled wine). This cuts transportation cost dramatically and reduces carbon emissions in some cases by up to 50%.
	HP	Design of ClearView packaging to ship high-end printers: ClearView protects products using foam supports and a widely recyclable film wrapper		• Avoided the use of approximately 320 tonnes of packaging material • Reducing packaging volume and decreasing weight by up to 70% compared with traditional corrugated cardboard and foam packaging
	ADEME and AFNOR**	Responding to French government mandate to provide a full environmental product profile for every product sold in France by 2011	The first phase involves testing a lifecycle assessment approach on 300 consumer products.	It has been well funded by the French government.
Reverse Logistics	LondonWaste, Bywaters, and SmartBarge Ltd	Waste management and recycling companies LondonWaste and Bywaters teamed up with Hertfordshire-based water transport firm	£ 7 million	The SmartBarge has a tremendous flexibility as it can be filled with different types of containers and different loads. GHG

	– transport of waste materials by water	SmartBarge for the trial which saw one container of commingled recyclables transported down the River Lee Navigation by barge from the London Waste EcoPark at Edmonton in North London to the Bow docks.		emissions are reduced (water transport has 20% of the carbon footprint of road).
Supply Chain Optimisation	Duijghuijzen* (25) – with application of ICT	• Introduction of an "early-morning" distribution system, to avoid traffic jams and optimize the utilization of trucks by using the same number of trucks for more trips. • The recording of loaded and empty kms by onboard computers. • Employing route optimization software.	The costs for the onboard computers were about EUR 1150 for each truck. The route optimisation software was about EUR 2500.	• The "early-morning" distribution system led to a reduction in the number of kilometers driven by circa 1% or about 25000 km per year. • The onboard computers resulted in a reduction of empty kms by 5%. Over a span of three years, Duijghuijzen's entire truck fleet saved about 125000 empty kilometres. • The efficiency of the distribution system improved by circa 5% (or 120000 less kilometres) through the use of route optimisation software.
	Brakes – optimize backhaul operation	To review current group backhaul operations by site and destination, all UK suppliers were mapped by temperature and geographic location with limited "software package". The PD (Primary Distribution) routes were then over laid to find suppliers that were in the vicinity of the PD routes. Once the suppliers and routes were identified a closer look at the	Not available.	Vehicle fill was significantly increased in the first 6 months of the project. Reduction in Empty running was calculated at ½ million miles. Continual backhaul review was established to ensure that new product launches were in scope as were product de-lists, ensuring that any space capacity was filled.

		supplier was undertaken, volume, frequency, and time were the 3 key factors to be considered.		
	J. W. Suckling Transport Limited* (48) – shared user service	As the first groupage service for the fuels distribution industry in the UK, the Tankshare scheme was launched in 2000, operating compartmentalized tanker vehicles suitable for carrying a variety of products such as petrol, diesel and kerosene, without the need for cleaning or flushing of compartments.	TankShare is a commercial initiative and, apart from the purchase of new vehicles, required no specific funding to launch. The idea of a groupage service for fuel distribution shows that sustainable operations can be established without additional expenses.	Improved vehicle utilization and consequent reduction in empty runnings.
	IKEA – reconfiguration of the supply chain structure	IKEA evaluated logistics potential of all Polish suppliers. The most important issue was geographical concentration (50-100 km) of producers. A leader of the project was chosen and cooperation between the leader and the smaller suppliers was established. By consolidating the whole stock of products into one warehouse the overall efficiency was improved.	Unknown.	Not only reduction in transport costs, but also environmental gains; development of European "green" corridors; positive impact on resources utilisation; decreased fuel consumption; more effective land and facilities use; reduction of CO_2 and noise emission
	K.I. Transport* (30+) – LSP &	In the process of defining a mutual environmental strategy, a communication	The company expects the above initiatives to be part	By increasing the overall planning time for individual transport tasks from two to six

	LSU collaboration	group was founded that consists of members from K.I. Transport and its most important transport buyer, Krog Iversen. Before this group, K.I. was informed about quantities and destinations only when the loaded truck was scheduled to leave Krog. As a result, the vehicles were not fully utilized and best routes couldn't be planned. The collaborating group ensures a faster exchange of data and better understanding of the importance of the data needed by transport companies.	of a continuous and necessary process to improve customer relationships, and thus to incur no extra costs.	hours, capacity utilization of the vehicles was increased by 5-10%. The reduction in kilometres driven resulted in reduced fuel consumption and environmental impact.
	Nestlé / United Biscuits – horizontal collaboration	Both companies recognised they had empty running which was a potential opportunity if they could find a third party with opposite transport flows. They agreed on some simple processes to ensure questions of product integrity, brand protection and load protection.	Unknown. The collaboration has also generated a financial saving split between both businesses.	Between Oct 2007 and Feb 2009 the collaboration and reduction in empty running removed 280,000 truck kms from the roads. This has resulted in a reduction of 85,000 litres of fuel and a reduction of 223 tonnes of CO_2.
Urban Logistics	Évora, Portugal - Ecologus project (with application of alternative fuels)	In mitigating the negative impact of goods delivery on the preservation of the historical city centre, 9 transport companies participated the project monitored by the Portuguese national road transport association. An ecoefficient distribution system is being implemented, with the	EUR 30/tonne	• The number of trips per day and vehicle decreased by 35% - from 32 trips/day with 14 vehicles to a maximum of 21 trips/day with 10 vehicles. • Reducing emissions: Emissions are reduced at least by 35% if the fleet uses normal diesel fuel. If biodiesel is used, the overall CO_2

		adoption of biodiesel vehicles adapted to narrow streets of Évora, and a shared central warehouse outside the city centre for grouping deliveries.		emissions will be zero, as biodiesel is a renewable primary resource.
	Bristol Consolidation Center (DHL/UK)	• Environmental benefits through consolidated • Now serving 63 retail outlets • Electric vehicle in operation • Use of bus lane now agreed with Bristol CC	Unknown. Operation began in May 2004 with European funding and continues under the EU Intelligent Energy Europe Programme	• 76% reduction in delivery trips for retailers • Saving over 227,000 vehicle kilometres • 27 tonnes of CO_2, 870kgs of NO_x saved • Over half of retailers achieve 20 minute saving per delivery • 100% on time delivery
	Nearby Delivery Areas –Espace de livraison de proximité (ELP), France	In some French cities including Bordeaux and Rouen, urban transhipment platforms are established on which dedicated personnel provide assistance for the dispatching of consignments for the last mile.	Unknown.	Goods are unloaded from incoming vehicles, and can be loaded onto trolleys, carts, electric vehicles and bicycles for the final distribution leg.
	Barcelona, Spain	In Barcelona, all new bars and restaurants are asked to build a storage area with a minimal size of 5 m^2 within their premises.	Not applicable.	Beverages and food do not need to be delivered daily.
	Sainsbury's – trials on night time deliveries	Over 30% of the stores have some form of time restricted delivery constraint placed on them, which results in logistics inefficiencies. A number of stores were identified where there was some scope for discussion and/or	Wandsworth trial took place in 2007 and Beckenham in 2009. The preparation work took about 2-3 months, with	In both cases the following could be demonstrated: • Improved availability to customers • Reduced journey times • Improved turnaround times

		where the greatest benefit could be gained. The process involved communicating with local authorities, specific noise mitigation, agreed escalation routes and criteria for success. Also this included agreements on timescales and "what if..." scenarios in the event of significant complaints. In two trials, two daytime deliveries were moved into night delivery time slots. This could only be done once the mitigation activities had been completed and all parties were happy to proceed. Noise readings were taken before, during and after in order to provide valid comparisons.	the trials lasting circa 2-4 months. The main obstacle was to get all the parties to the table and agree to work on what is a very sensitive subject.	•Improved vehicle utilisation potential due to less time on the road • Improved fuel economy • Less CO_2 and associated emissions due to reduced fuel use In the case of Wandsworth no complaints were received and therefore night time deliveries continued beyond the trial. In the case of Beckenham, complaints were received and therefore once the trial ceased the company did not continue with night deliveries, but are reviewing other mitigation methods.
Vehicle Design	CarlF.* (35) - In the context of reverse logistics	The company introduced waste and garbage trucks with 6 different sections for batteries, electronic waste, glass, hard plastic, lighting tubes and metal waste. The most common vehicles are only with 2 sections. All waste is weighed and recorded during collection, providing environmental accounting for companies that work with ISO 14001.	The extra costs per vehicle are EUR 60313, which are 40-50% more than conventional vehicles.	These vehicles allow the company to transport six different types of waste in one trip instead of in six separate trips. The estimated fuel reduction will be more than 50%.
	Duijghuijzen* (25)	Transition to an environmental-friendly type of fork-lift truck. The new fork-lift truck uses significantly less fuel than previous ones. It	The cost for the special fork-lift truck was about 10% higher than the costs	The new fork-lift truck uses about 20% less fuel than previous trucks. In absolute numbers, each hour of operation saves about

		also has better and faster handling because foot pedals are placed for both directions.	for comparable machines.	0.6 litres. With a yearly operation time of about 2500 hours for each of the 6 fork-lift trucks, a total of 9000 litres of diesel fuel are saved each year.
	Frydenlund Transport A/S* (6) – in the context of urban logistics	The introduction of “city trailer” which has a high load capacity with the ability to being easily manoeuvred through very narrow passages in cities. It is a new concept in Norway, where this type of 4-axle high capacity tank vehicle has been deem unsuitable due to tough winter conditions.	The vehicle cost NOK 2 million (EUR 270000), not including development costs.	Annually, the company transports roughly the same volume of petrol products as before with 2/3 of the trips. This leads to reduced fuel consumption and emissions. In addition, the change from EURO 0 to EURO 3 has also made a significant difference.
	Nilsen og Kokkersvold AS – Optimised vehicle fleet renewal	The company developed its own data application to make vehicle replacement decision. Extensive information about each vehicle is collected in order to find out the right replacement for achieving maximum emission reduction for the whole fleet. This can, for example, lead to keeping an old EURO 1 vehicle, because its annual driving distance is little or because it is used for lighter tasks. Instead, a newer EURO 2 vehicle is exchanged with an EURO 3.	Development costs have been very low, because the Managing Director himself has developed the data application.	In 2001, a Volvo F16 was exchanged for the smaller, but more efficient FH12 truck. This led to a reduction in fuel consumption of 0.123 litres/km. At the same time, the tank equipment was rebuilt, so that the load capacity was increased from 44 to 46 m^3. This led to an increased loading from 40’000 litres to 43000 litres or 7.5% increase. Despite this increase, the vehicle’s fuel consumption was reduced from 2.61 litres/km to 2.56 litres/km or 4.63%.
	van der Luyt & Zonen B.V.* (45) - Tyre	The company worked with Michelin for a tailor-made tyre management solution, in order to achieve lowest cost per mile. The	The personnel costs for training and education of the responsible person	• The utilisation of resources is minimized by extending the life span of tyres. This signifies an active contribution to sustainable

	management	Remix tyre (remoulded by Michelin) plays an essential role, creating 4 lives for 1 tyre. Michelin also provides recommendations on issues such as tyre pressure, when to regroove a tyre and aligning vehicles.	within van der Luyt for the Tyre Management Plan is about EUR 2500 a year.	development in road transport. • Since adapting the tyre management plan for the new type of Michelin tyre, van der Luyt has saved 5% in fuel.
	Emons Cargo BV* (34) – Double-Decker	Due to the dramatic reduction in load factor experienced when transporting unstackable cargo with a height between 1.25 m and 1.80 m, it became impossible to move such loads efficiently. Emons then developed a new double-deck trailer jointly with trailer manufacturers, which took 3 years. Equipped with its own handling equipment and built-in loading lift, the capacity was increased from 33 to 52 pallets.	The price of the new two-floor trailer is about EUR 90000 - about 2.5 times that of a conventional ones. The purchase cost of the 35 2WIN® trailers amounted to more than EUR 3 million. In addition, Emons invested about two full man-years in design, construction and testing of the 2WIN® trailer.	With 52% greater capacity than conventional 33 pallet trailers, a reduction in kms driven of 34% for the same volume in terms of pallet kms has been achieved. Fuel consumption of 32 l/100 km with 2WIN trailer is the same as with conventional ones. The company hence saved 3 million trailer-km and 930000 litres of fuel in one year. An additional benefit is the reduced requirement for packaging material, as the pallets are not stacked inside the truck during transport. Emons estimates that about 5% of all full-load shipments in Europe would be suitable for transport with the 2WIN® trailer. This would mean fewer shipments and fewer trucks on the road.
	Boots – Multi-deck, urban delivery	Boots has recognised an opportunity to reduce miles within its regional distribution fleet whereby access restriction issues to its	Issue – Backhaul – Suppliers unable to load top deck	The trailer is 10m in length and only 4.1m high, yet carries the same volume as 13.6m full length trucks. This has therefore given the

	trailers	stores has traditionally meant that a short urban artic or rigid has driven inefficient vehicle and driver utilization. An urban trailer has been designed and manufactured that meets all of the physical limitations that exist whilst has the capacity of carrying the volume of a maximum length standard trailer. No such trailer existed of this specification.		company the opportunity to gain benefits in various areas including miles saved, increased cube and reduced costs. The design gives an increased capacity of 65% over a traditional 10m urban trailer.
	UK Mail – a combination of technologies	• All double deck trailers have sloping fronts, driving down CO_2 emissions by up to 25t per vehicle per year. They are also in the process of trialling a new aerodynamic, teardrop trailer design which has indicated an 8.5% decrease in emissions. Also all powered vehicles have bespoke aerodynamic kits which have resulted in mpg improvements of between 5-10%. • They also trialled using 'energy' tyres which provide approximately 6% less rolling resistance and reduce fuel consumption. • A total of 54% of their forklift trucks are now electric (as opposed to diesel run counterbalance) slashing carbon emissions by 700 tonnes per annum. In addition, all new company cars now have CO_2 emissions below 160g/km. • All their vehicles utilise bio-diesel which reduces the CO_2 emissions from their vehicles by 3% and they aim to continue the use of bio-diesel at current levels. • The obligatory use of route software. Partially automated sortation and new vehicle loading techniques also had the effect of reducing the number of vehicle routes.		
	Tesco – modal shift and double-decker	• Switching to multimodal transport has resulted in a drop of CO_2 emissions by over 2,750 tonnes per year. • In one year they increased the use of double-deck units by 7% from 191 to 205 trips per day, taking 1,221,492 km off the road and saving 948 tonnes per year of CO_2. • All measures together saved 7,489 tonnes of CO_2 per year.		

Note: cases marked with * indicate that it was implemented by SMEs; the number in brackets indicates the number of goods vehicles being operated where available.

** ADEME is the equivalent of the Environment Agency in France; and AFNOR is the French national standards body.

Source: CLECAT 2009, 2010; EIA, 2011; Hill, 2009; IRU, 2002; Khan and Creazza, 2009; Kuta et al, 1995;