A SURVEY OF EXPERT OPINION ON THE ENVIRONMENTAL IMPACT OF ROAD FREIGHT TRANSPORT IN THE UK IN 2020

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Abstract
Concern has been mounting over the environmental impact of freight transport, particularly over the contribution of CO_2 emissions from heavy goods vehicles (HGVs) to global warming. In its Sustainable Distribution document and subsequent policy statements the British government has identified a series of policy measures designed to make logistical operations more sustainable in economic, social and environmental terms. However, in order to assess the net impact of these measures it is necessary to construct a reliable business-as-usual (BAU) scenario which would occur in the absence of new policy initiatives. This paper reports on the preliminary results of a Delphi study undertaken in order to produce an expert forecast of future developments in supply chain structure, modal split, vehicle utilisation and fuel management up to 2020.

Keywords**:** road freight transport, environmental impact, climate change, green logistics, Delphi survey

Introduction

In recent years there has been mounting concern over the environmental impact of road freight transport. Goods vehicle traffic has been increasing steadily and, at European level, growth in freight volumes is still strongly coupled to growth in gross domestic product (GDP). According to the European Environmental Agency (2008), between 1995 and 2005, transport actually grew faster than gross domestic product (GDP) in EU-15 Member States. Conversely, in the UK there has been a decoupling of economic growth and the growth in road freight movement (measured in tonne-kms) since the mid-1990s. Nevertheless, road transport still dominates the UK freight market and remains the greatest source of freight-related externalities. The main aim of this paper is to report some of the results of a Delphi survey undertaken to determine the future trends in logistics and supply chain management and associated environmental effects up to 2020. The focus is on the road freight traffic contribution to the climate change.

Based on a literature review and previous studies, an analytical framework has been constructed to map the complex inter-dependence between economic performance, a series of logistics parameters and freight transport-related externalities. In order to derive reliable estimates of changes in key freight and environmental variables expert opinion has been canvassed using the Delphi survey technique. A panel of 100 logistics chain experts expressed their views on the direction and intensity of a series of transport and supply chain trends. This paper will summarise the results of the first round of the Delphi survey. The forecast of changes in key logistics variables up to 2020 is presented and their potential impact on environmental performance of supply chains is considered.

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Research methodology

A Delphi technique is a systematic, iterative procedure for structuring “a group communication process” to elicit a consensus view on a complex problem from a panel of experts (Linstone & Turoff, 2002). The Delphi survey usually involves sending a first-round questionnaire to a number of respondents, collating and analysing the data and then re-circulating the questionnaire accompanied by a summary of results. The experts are asked to confirm or modify their previous responses. This procedure is repeated for a pre-determined number of rounds or until a desired degree of consensus has been reached (Linstone & Turoff, 2002, Mullen, 2003, Hsu & Sandford, 2007).

The Delphi method was developed in the 1950s as a means of expert-supported military decision making process, particularly with reference to planning and developing new technology (McKinnon & Forster, 2000). Since then it has been applied across disciplines and extensively used in planning and policy-making, long- range forecasting and decision support in both private and public sectors. Gupta and Clarke (1996) in their bibliographic study report 463 Delphi-related articles. They also have identified the main domains of Delphi technique applications, which include education, business and management, health care, social science, engineering and many more (Gupta & Clarke, 1996). In the field of logistics and supply chain management the Delphi method has been used to forecast changes in the physical distribution of food products (Walters, 1979), project future directions in distribution systems, logistics and supply chain management (Cranfield School of Management, 1984, Cooper, 1994, McKinnon & Forster, 2000, Ogden, et al., 2005), as well as to investigate factors affecting location decisions in international operations (MacCarthy & Atthirawong, 2003).

A group of 347 logistics and supply chain experts, stratified by stakeholder group, was invited to join a Delphi panel by completing an online questionnaire. The panel members were drawn from a large database to reflect the shares of different types of organisations involved in logistics e.g. manufacturers, retailers or carriers. In the first round a total of 100 respondents expressed their views on the direction and intensity of a series of logistics and environmental trends, giving an overall response rate of 29%. The composition of the sample was: logistics service providers (LSPs) 27%, enablers 17%, manufacturers 15%, academics 14%, trade bodies 11%, retailers 10% and policy makers 6%.

As the main objective of Delphi study is to produce a reliable forecast based on expert judgement, thus the main criteria in drawing a sample were knowledge and experience of potential participants. The analysis uses statistical measures of central tendency and variability to summarise the experts' speculations (McKinnon & Forster, 2000). The respondents were asked what changes would occur by 2020 using the following types of questions:

- To what extent would a particular variable increase or decrease against a base index value of 100 for 2006?
- To what extent would a particular variable change as compared to its actual value in 2006?
- What would be the intensity of future changes in a particular variable on a five point Lickert scale?

The mean and standard deviation were used to analyse the panel members' projections. The mean values indicate both the direction of trends and their relative strength. Standard deviation measures how widely spread the values in the data set are.

After analysis of the first round of responses, a second round questionnaire will be circulated to the participants showing the mean scores for each question on the first round. The respondents will be given the option of modifying their initial response or explaining why they do not agree with the rest of the panel. In this way a greater degree of consensus will be reached and some justification given of divergent responses. The final analysis will be based on the results of the two-round Delphi study.

Key changes in freight transport parameters

Recent experience in the UK suggests that there has been a decoupling of economic growth and the growth in road freight movement. Between 1997 and 2004, GDP rose by 21% in real terms while total tonne-kms grew by only 8% (McKinnon, 2007a). If this trends were to continue, it would indicate a long-term structural change in the UK economy, where increase in national prosperity would not generate proportional increase in freight traffic volumes. Stabilisation and subsequent reduction in freight-related externalities would help to promote the sustainable development policy advocated by the British Government and European Union (DETR, 1999, European Commission, 2001, European Commission, 2006). The Delphi panellists were asked the following question: '*Over the past 10 years UK Gross Domestic Product (GDP) has been growing at a much faster rate than road tonne-kms. How do you think road tonne-kms will grow up to 2020 compared to GDP? Please rate where -2 = much slower, 0 = same rate, 2 = much faster*'. The mean response was -0.5 with a standard deviation of 1.0. This indicates that freight transport activity will continue to grow at a slower pace than economic performance. However, this decoupling may not be strong enough to achieve major reductions in the environmental impact of freight transport.

In order to project by how much total freight tonne-kms will change by 2020 within the UK, experts were asked to indicate if freight traffic volumes are going to increase or decrease against a base index value of 100, representing current situation. The average response was 125 and a standard deviation 24.5. The latest estimates of the total tonne-kms published by Department of Transport, indicate 257 billion tonne-kms in 2005 (Department for Transport, 2007b). Assuming this to be the base value, 322 billion tonne-kms are going to be moved by all modes in 2020.

Supply chain structure and vehicle utilisation strongly influence environmental performance of road freight transport sector (McKinnon, 2003, McKinnon, 2006). Supply chain structure is determined by the number of links and their average length. The number of links in the supply chain is measured crudely by handling factor which is a ratio of the tonnes-lifted statistics to the actual weight of goods produced or consumed. However, very limited data are available on the weight of goods produced and consumed (McKinnon, 2003). An approximate handling factor was calculated based on the material flow data published annually in the UK National Accounts and tonnes lifted estimates from the Continuing Survey of Road Goods Transport (Department for Transport, 2007b, Office for National Statistics, 2007). Vehicle utilisation is described by lading factor and empty running. Lading factor is a ratio of the tonne-kms that a vehicle actually carries to the tonne-kms it could have carried if it was running at its maximum gross weight. Empty running is expressed as a percentage of the total lorry kilometres run. The average length haul, lading factor and empty running figures for 2006 were taken from Road Freight Statistics (Department for Transport, 2007a). Table 1 presents the experts' opinion on future directions in these parameters up to 2020.

Q: How are the following road freight parameters likely to change between now and 2020?	**2006**	**2020 (Mean)**	**Standard deviation**
Average length of haul (km)	87	85.9	17.3
Handling factor	3.4	3.4	0.8
Lading factor (%)	57	63.8	6.5
Empty running (%)	27	22.1	5

Table 1 Projected changes in key logistics variables.

The panellists did not expect any significant changes in supply chain structure. The number of links is going to remain the same and their average length will be reduced by 1 km. It suggests that supply chains have reached their maximum degree of centralisation and as long as business-as-usual (BAU) scenario is considered, the current transport and distribution systems are not going to be a subject to further transformation. However, there will be considerable improvements in the utilisation of lorries. Lading factor is expected to increase to 63.9% and only 22.1% of vehicle kilometres will be run empty. If these improvements can be achieved, they are going to yield substantial environmental benefits.

Modal split

Modal shift is another important means of improving the sustainability of freight transport. By moving freight to less environmentally damaging transport modes like rail or waterborne transport, significant savings in energy intensity and freight-related emissions can be achieved. Table 2 shows the projected modal split in 2020.

Q: What do you think the share of each transport mode expressed in terms of tonne-kms will be in 2020?	**2006**	**2020 (Mean)**	**Standard deviation**
Share of road	64%	59.9%	6
Share of railfreight	9%	11.3%	3.1
Share of inland waterways / coastal shipping	23%	24.4%	4.4
Share of pipeline	4%	4.4%	1.3

Table 2 Projected changes in modal split

As can be seen, there is going to be a modest positive change in modal split. The share of road freight transport is going to decline by over 4%, whereas other modes are going to gain market share.

The biggest increase is expected in the case of railfreight (2.3%). Nevertheless, road transport still remains the dominant mode, thus, the net environmental benefit from modal shift may not be as great as desired by policy makers and pressure groups. Hence, it is important not only to encourage modal shift but also focus on the road freight system in order to maximise its efficiency and minimise the levels of associated externalities.

With regard to rail transport, reliability, flexibility, cost and accessibility of terminals were identified as the major factors influencing the amount of freight carried by 2020. Speed, commodity mix and bureaucracy were least important in comparison to other factors. According to the experts, upgrading rail infrastructure, provision of dedicated freight lanes and simplifying administrative / regulatory framework for rail freight would be most effective means of increasing rail's share of the UK freight market. Encouraging modal shift by enforcing regulations on road freight more rigorously, increasing taxes on diesel fuel or extending emission trading scheme to freight transport were accorded much less importance.

Forecasts of the future share of airfreight were excluded from the survey. Aeroplanes carry currently only 0.01% of all tonne-kms in the UK. Even assuming a huge percentage growth, this mode's share is going to be marginal. Airfreight, nevertheless, produces a high level of externalities per tonne-km. For example, domestic air cargo in the UK is estimated to emit 11 times more CO2 per tonne-km than HGVs and 79 times more than railfreight (McKinnon, 2007b).

Q: How will value, in real terms, of 1 tonne of product moved by the following modes to, from and within UK change by 2020? (Please rate where -2 = large decrease and 2 = large increase)	**Mean**	**Standard deviation**
Road	0.4	0.9
Rail	0.4	0.8
Inland waterway / coastal shipping	0.1	0.7
Deep sea shipping	0.5	1
Airfreight	0.7	1

Table 3 Changes in value of goods moved by different freight transport modes

The experts were asked also what changes they expect in value of products moved by different transport modes (Table 3). The biggest increase in value was anticipated in case of goods delivered to the UK by air. From an environmental perspective this could be a positive development, as only the most valuable goods might be transported by air. If airfreight operators are required to internalise the external costs of their activities, for instance through taxing kerosene fuel, it will become uneconomic to move by air some of the lower value commodities currently moved by this mode. On the other hand, the value of goods moved by inland waterway or coastal shipping was predicted to stay at the current level. This suggests that the experts were very doubtful about initiatives aiming to shift higher value-density products onto these modes. Bulk, low-value goods are going to remain the main products on inland waterway and coastal shipping market. A moderate increase in value was expected for goods transported by road and rail as well as deep sea shipping.

Fuel efficiency and carbon intensity

Fuel efficiency is defined as vehicle-kms per litre of fuel, whereas carbon intensity is expressed as the amount of CO_2 emitted per litre of fuel used. The Delphi panellists projected a substantial increase in fuel efficiency of UK lorry fleets. At the same time carbon intensity of fuel is going to be reduced (Table 4).

Vehicle design, engine performance, information technology (telematics, vehicle routing software) and training schemes for fuel efficient driving were identified as the main drivers of improved fuel efficiency. The greatest incentive for companies to reduce their fleets' fuel consumption will be high fuel prices. Relative to other factors, dissemination of best practice in fuel management was considered the least efficient means of helping road freight transport operators to improve their performance. This suggests that technological developments are going to play the main role in improving fuel efficiency. In order to achieve synergy of efforts, promoting best practice should focus on dissemination of

knowledge on available technological solutions to reduce fuel consumption. Since the completion of the first round of the survey, several reports have been published questioning the sustainability and carbon benefits of switching to biofuels. Responses to the second round may reflect this recent reappraisal of biofuels.

Q: What is the likely change in the following factors going to be between now and 2020? (Please rate where -2 = large decrease and 2 = large increase)	**Mean**	**Standard deviation**
Fuel efficiency	1.1	0.7
Carbon intensity of fuel	-0.7	1.1

Table 4 Projected changes in efficiency and carbon intensity of fuel

Concern about climate change

Climate change is currently at the top of political agenda. In order to investigate the impact of global warming on supply chain practice, the participants were asked to assess to what extent has concern about climate change forced their companies to modify freight transport operations in last three years and how they expect it to affect their logistics systems in the future? The answers were rated on a five-point scale where 0 = not at all, 4 = large extent.

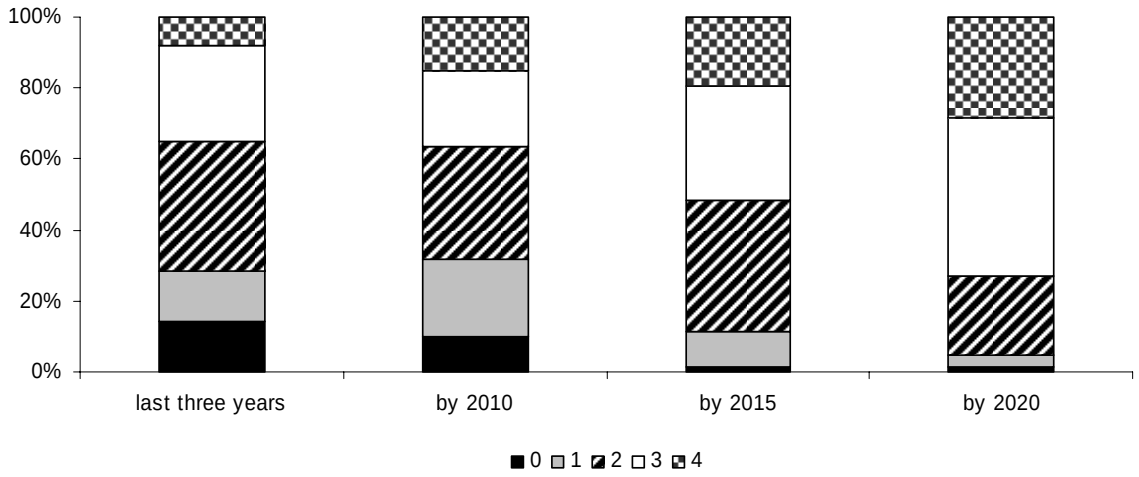

Figure 1 Impact of climate change concerns on companies' freight transport operations

Figure 1 depicts the increasing importance of climate change concerns on companies' logistics and supply chain operations. Although less than 40 percent of businesses indicated that concern about global warming has influenced their operations significantly in last three years (response 3 or 4), this number increases to over 70 percent by 2020. This confirms that managers are aware of the scale and severity of the climate change issue. They anticipate that climate change will exert a steadily increasing influence on the management of freight transport and logistics operations over the next 12 years.

Conclusions and future directions

The preliminary results of the Delphi survey reported in this paper show how complex the inter-relationships are between the broad range of logistics and supply chain trends which interact to determine freight traffic levels and related environmental impact. Future developments in supply chain structure, modal split, vehicle utilisation and fuel efficiency are difficult to forecast. While some of the trends predicted by the panel will increase the environmental footprint of road freight operations, others will have the opposite effect. The Delphi participants were also asked to express their opinion on a range of factors at the upper strategic, commercial and operational levels in the logistics decision-making hierarchy which will have an influence on future trends in the key logistics variables. The interim analysis has been reported in a conference paper by Piecyk & McKinnon (2008).

The standard deviation values also reveal significant differences of opinion on some key variables, which may narrow in the second round of the Delphi survey. Further analysis will be required to evaluate the relative contribution of all factors discussed in this paper to the emission trends and to disaggregate the responses of different stakeholder groups. A spreadsheet model linking macro-economic variables to freight-related emissions via a series of key freight and logistics parameters has been already constructed and initially calibrated using 2006 data. When the final Delphi results are available, they will be used to re-calibrate the model and project the environmental impact of road freight transport on a BAU basis. In this way it will be possible to construct a quantitative forecast of the environmental and social impacts of freight transport in 2020 on the basis of expert opinion.

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