Literature Review WM7:
Scope for modal shift through fiscal, regulatory and organisational change

Carried out as part of Work Module 1
Green Logistics Project

Final version

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ABSTRACT

Purpose

To provide a review of the key issues from the literature relating to modal shift of freight movements from road to less environmentally damaging modes, primarily rail but also waterways, as a result of fiscal, regulatory and organisational change.

Design/Methodology/Approach

An attempt has been made to identify the key British literature relating to modal shift in freight transport. This comprised searching both printed documents and web-based sources. Types of literature consulted included academic journal and conference papers, government statistical publications, official reports, and internet-based information.

Findings

The review details the changing environment within which mode choice decisions for freight transport are being taken, notably the increase in attention being devoted to non-road modes as a result of environmental and economic concerns. The challenges of integrating non-road modes in to domestic supply chains that have evolved around the ubiquity of road haulage are identified, as are some potential solutions raised in the literature that may enhance the role of non-road modes.

Research limitations/implications

Much of the publicly available quantified information is at a very broad level or is inconsistent over time, so as a result does not readily lend itself to time series analysis or the detailed analysis of specific trends. This is particularly an issue for rail freight since rail privatisation, where commercial considerations result in difficulties in obtaining detailed statistics about rail operations. Some of the studies identified in the literature review essentially give a snapshot of modal shift issues, but are not particularly well-placed to provide a comprehensive overview of the issues and trends.

Practical implications

The review contains useful background information for those involved in rail freight and in the wider logistics industry, e.g. with examples of recent developments in service provision and in government policy towards modal shift.

Originality/value

The review summarises and updates previous UK-focused research relating to the modal shift issue, and considers its role within wider supply chain issues which adds to its originality.

1. Introduction

There is growing concern about the effects of the increasing use of road freight and in particular the negative impacts that it has on the environment. This has led to demands for greater use to be made of modes that are less environmentally damaging, which in the UK essentially refers to rail and coastal shipping. There have been many logistical changes that potentially could affect the modal split decision. For example, changes in the location of activity, the structure of manufacturing and distribution networks, the trading relationships between firms and the scheduling of production and distribution may all be important factors that influence mode choice for freight movements.

Given the growth of interest in logistics as a discipline in its own right since the 1970s and the recent emphasis on finding ways to alter the modal split in favour of less environmentally-damaging modes of transport, surprisingly little research has been carried out examining the interactions between logistical structure and modal choice. There have, however, been widespread changes in companies' logistical systems that are likely to have had at least some impact on modal choice. Much previous academic work on the potential for increasing rail's modal share has been at the theoretical level, focusing on operational research, mathematical modelling and demand elasticities (e.g. Cordeau *et al* (1998), Ferreira (1997), Abdelwahab (1998)). While this type of work is of significance in attempting to quantify some measure of rail freight service quality, and the components thereof, it tends to ignore the other factors that affect rail freight operations. The lack of incorporation of the essentially unquantifiable human and political influences on mode choice and performance in particular means that the theoretical solutions proposed cannot always be implemented successfully in reality. Other studies (see, for example, FTA, 1995; Plowden and Buchan, 1995; Komor, 1995) have focused almost exclusively on the characteristics of rail freight and the environmental and social benefits, arguing that only relatively minor policy changes are required to effect a significant modal shift from road to rail. A common theme of these studies, however, is a lack of a detailed understanding of the extent to which the logistical changes that have taken place in the last 20 years have affected mode choice. As a result, there have been overly-optimistic opinions of the ease of increasing rail's share of freight movements.

It is recognized that growing environmental problems and congestion on many road networks requires new solutions to freight transport operations. This literature review aims to summarise the key issues raised and discussed in the previous literature relating to freight mode choice, focusing on the non-road modes and, within this, particularly on the use of rail. It should be noted that coverage of freight transport literature varies in its definitions, sometimes focusing only on road, rail and water, but in other cases including pipelines and/or air freight. Pipelines have a relatively limited role, catering only for certain product types, and air freight has largely negative impacts and, in any case, extremely limited use for freight within Britain. As a consequence, references to 'non-road modes' in this review generally relate to rail and water, with much of the discussion relating specifically to rail. Much of the content of this literature review is based on previous research carried out by the University of Westminster (see, for example, Woodburn, 2001a, 2001b, 2004a, 2004b, 2006, 2007, forthcoming (a and b)) and the University of Leeds.

2. Background

2.1 Overview of freight transport policies relating to modal shift

Both at the European Union and national (British) level, freight transport policies since the late-1990s have been heavily focused on encouraging the use of non-road modes where practicable. The key policy documents include the following:

- Integrated Transport White Paper (DETR, 1998): more freight could and should be moved by non-road modes, endorsing the growth targets set by rail freight operators and resulting in an expected 10% decline in road tonne kilometres
- Sustainable Distribution (DETR, 1999): reinforced the policies of the pervious year's white paper
- Ten Year Plan (DETR, 2000): formalisation of target of 80 per cent increase in rail freight tonne kilometres by 2010, with a wide range of measures to support non-road modes
- European Transport Policy for 2010: Time to Decide (European Commission, 2001): recognition of the problems associated with rapid road transport growth, with policies to encourage the development of non-road modes such as intermodalism, rail liberalisation and motorways of the sea; a target to increase rail's market share to 20% by 2020 was included

In addition, there are other key ways in which non-road modes are favoured in government policy, for example with Planning Policy Guidance which encourages the development of facilities and service provision for rail and water. Overall, there appears to be an expectation that non-road modes, particularly rail, should and will play a much greater role in the future than it is doing at present. It is not always clear, however, how individual elements of the transport strategy should best be pursued so as to achieve this overall objective, not least for freight transport. At the European Union level, an indicator has been developed to monitor freight transport mode share, this being percentage share of road in total inland transport (which includes road, rail and inland waterways).

2.2 General role of the modes and extent of networks

Table 1 shows the key data relating to the network lengths (or nearest equivalent) for Great Britain for the various transport modes. It is evident that none of the other modes can match road in terms of its network length, though less than 1% of the road network is classified as motorways. The coastline of Britain is slightly longer than the entire rail network, though only 120 ports are commercially active, while the navigable inland waterway network is less than one third of the rail network's length. Freight tonnage moving by air through British airports is heavily concentrated in a small number of locations.

Table 1: Network lengths for different transport modes (Great Britain)

Transport mode	**Total network length (km)**
Road	388,008
Of which motorway	3,519
Rail	16,584
Inland waters (navigable)	5,320
Coastline (mainland Britain)	17,820
Ports (no. commercially active)	120
Airports (95% of tonnage)	5

Source: EST (2004); DfT (2006a); Ordnance Survey (2007); British Waterways Scotland (2007)

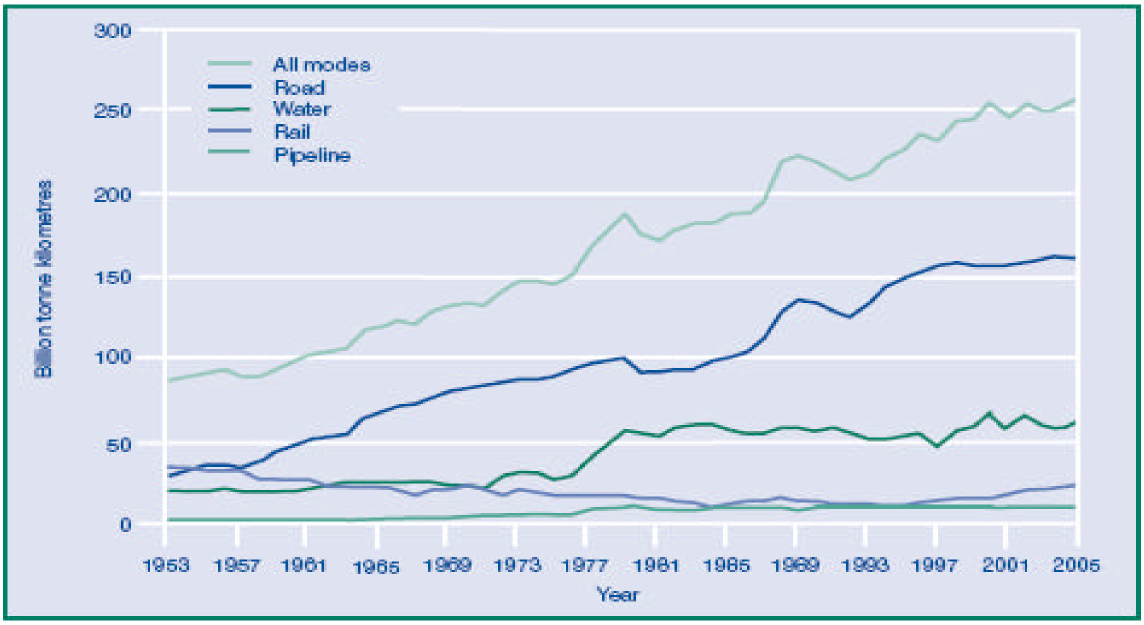
2.3 Main freight transport trends

There are a number of government publications that provide information relating to freight transport trends in Britain and it is not the intention to repeat all of this information here; instead, the key trends are highlighted. The main sources of official data include Transport Statistics Great Britain (published annually by the DfT) and Focus on Freight (published periodically by the DfT), together with a number of more specific data sources produced by the Department for Transport and mode-specific bodies such as the Office of Rail Regulation (and, previously, the Strategic Rail Authority) and the Department for Trade and Industry (which has responsibilities for pipelines). The subsequent sections of this chapter provide an overview of freight transport trends and then consider the key mode-specific trends for rail and water.

2.4 Freight transport volumes and mode share

Freight transport activity has grown considerably and in a fairly sustained manner over the last 50 years, as can be seen in Figure 1. The total number of tonne kilometres increased more than threefold between 1953 and 2005 to stand at just over 250 billion tonne kilometres in 2005. It is evident that the majority of this growth has come from the road haulage market, though with a considerable contribution from water at certain points within the time period under consideration.

Figure 1: Goods moved, total and by mode (1953 – 2005)

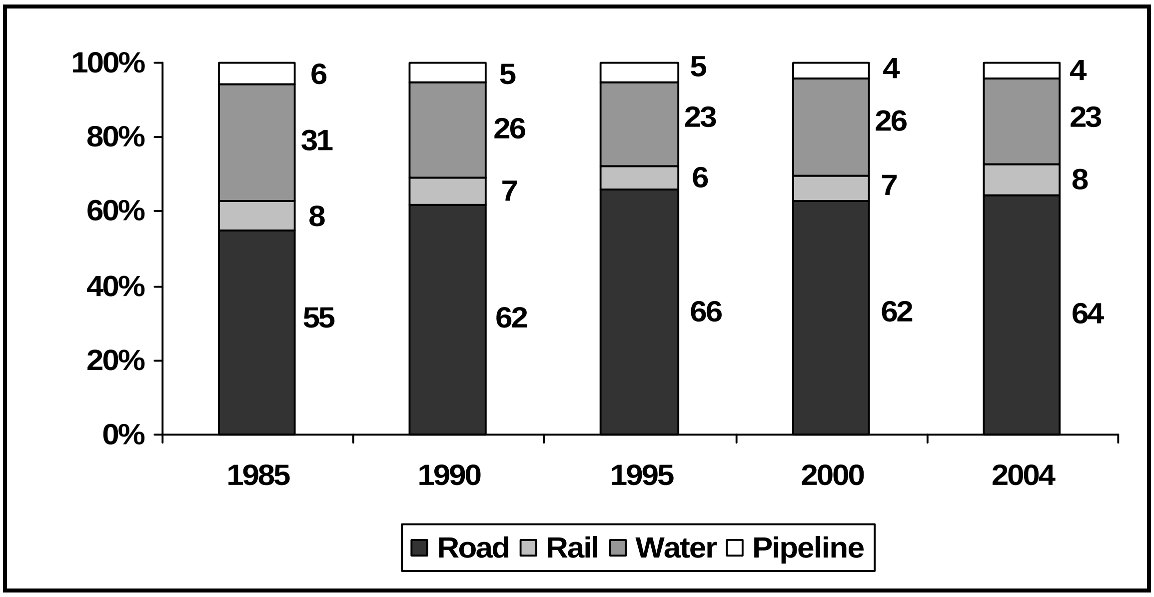


Source: DfT (2006a)

Figure 2 shows the freight market share, expressed in tonne kilometres, of each of the modes of transport in selected years since the mid-1980s. During this period, the overall growth in freight volumes was one third, and road was the only mode to increase its share of the total. Rail's share of the market declined from 8% in 1985 to 6% in 1995 before rising back to 8% by 2004 as a result of strong growth in volumes carried, while water has seen its share decrease from 31% in

1985 to 23% in 2004. The overwhelming majority of waterborne traffic is coastal shipping rather than by inland waterway. The mode share of pipelines has decreased recently, largely as a result of limited new pipeline construction, so relatively stable pipeline volumes have led to a diminishing market share in the face of freight transport growth.

Figure 2: Market share for domestic freight transport in Great Britain (1985 - 2004; % of tonne kilometres)



Source: DfT (2006b); totals do not always add up to 100% due to rounding

Typically, rail and water cater for bulk and semi-bulk products, while road generally handles smaller consignments and consumer goods; this is a considerable over-simplification, though, and further details about non-road usage follows.

2.5 Rail freight trends

Rail freight has been generally in decline in many European Union countries in recent years, particularly in terms of its share of all freight but also in absolute volume in some countries. From 1995 to 2004, rail's mode share of all freight (including sea and air) across the 25 European Union countries decreased from 12% to 10% (European Commission, 2006), contrary to the European target (European Commission, 2001).

Table 2 shows that rail freight in Britain has a relatively low share of freight movement compared to most other large European Union countries, resulting from a lack of investment over a number of decades when government policy favoured road construction combined with a reduced role for the rail network. In addition, the geography of Britain effectively limits the distance over which most freight moves. The majority of the British population and industry is concentrated within the southern third of the country, as are the major ports handling international freight flows. Rail typically has a higher mode share over longer distances, but struggles to offer the flexibility of road haulage over shorter distances (Eurostat, 2003). The challenges for increasing rail's mode share in Britain, particularly for non-bulk flows that do not offer the volume benefits of bulk flows, are therefore considerable.

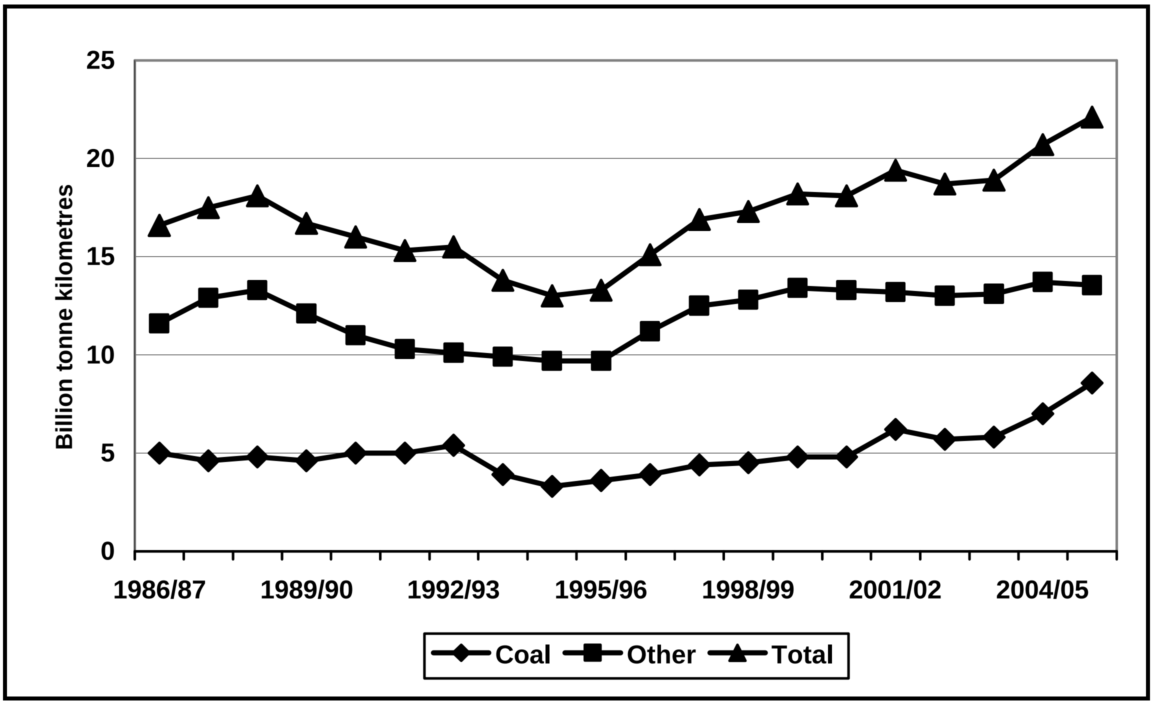
Table 2: Rail freight mode share of inland market (road, rail, inland waterway), by country (2000)

	EU-15	**Britain**	**France**	**Germany**	**Italy**	**Spain**
% of tonne km	15	8	21	18	11	8

Source: Eurostat (2003)

The volume of freight moved by rail in Britain suffered a long period of decline from the Second World War through to the mid-1990s. The reductions in rail freight volumes in the early- to mid-1990s continued at a time of increasing road freight traffic and greater concern for the environment. As a result, a shift from road to rail gained more prominence in transport policy. In Figure 3, the 20-year trend in rail freight tonne kilometres in Britain is displayed. Following a period of decline, there was a 66% increase between 1995/6 and 2005/06 in the number of tonne kilometres carried by rail, the upturn coinciding with the privatisation of the rail network. The late-1990s was characterised by a large rise in non-coal traffic, while the main contributor to growth in more recent years has been increasing coal volumes.

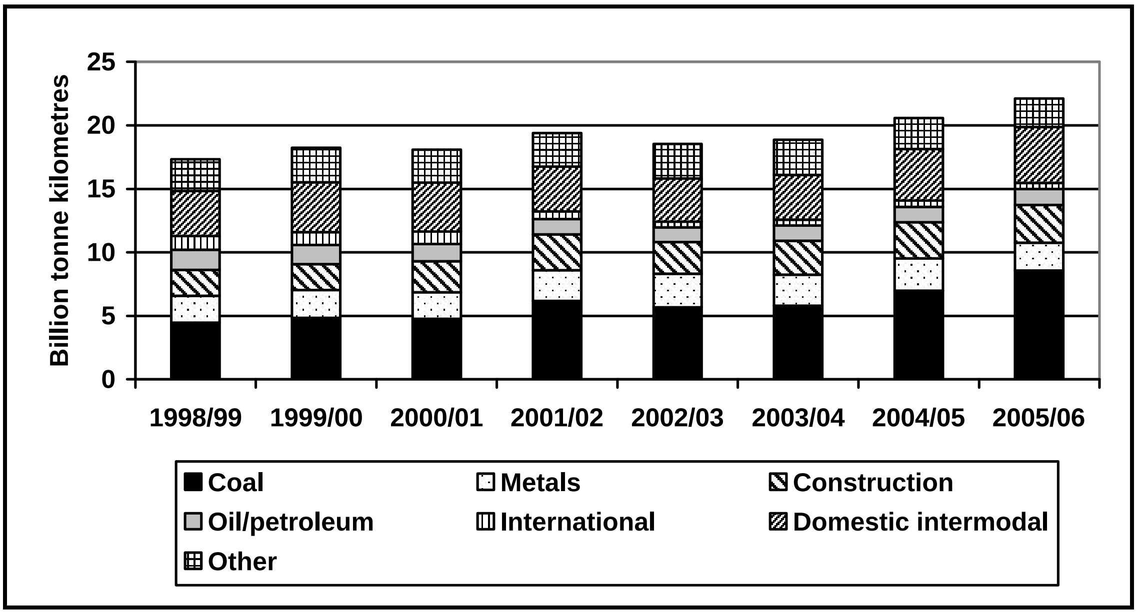
Figure 3: Freight moved by rail in Great Britain (billion tonne kilometres)



Source: ORR (2006)

It is clear from the graph that coal accounts for a significant proportion of the total. In fact its proportion of tonne kilometres was higher in 2005/06 (at 39 per cent) than it was in 1986/87, when it was 30 per cent. The growth has mainly resulted from an increase in the average length of haul, with imported coal having replaced a lot of indigenous (and local) sources. Disaggregated data relating to other commodity sectors has been published only since the late-1990s; the trends are shown in Figure 4. However, a basic assessment of the bulk share of the market (i.e. coal, metals, construction and oil/petroleum) reveals that it has gradually increased its share of total tonne kilometres from 59 per cent of the total in 1998/99 to 68 per cent in 2005/06, mostly as a result of the aforementioned coal increases but also with significant growth in construction volumes. Metals traffic has shown little growth in absolute terms, and now has a reduced share of the rail market, while oil/petroleum has seen a considerable reduction in volume moved by rail. Domestic intermodal (which includes container movements to/from ports) has increased strongly in the last four years after suffering a dip in volumes, while international traffic (i.e. that through the Channel Tunnel) has more than halved since 1998/99; other traffic, not covered by the main categories, has decreased slightly in absolute terms.

Figure 4: Freight moved by rail in Great Britain, by commodity type (1998/99 – 2005/06)



Source: ORR (2006)

A number of attempts have been made to forecast future rail freight trends. In 2004, the SRA undertook a number of market studies, examining trends and making projections about the future of a number of commodity sectors. Separate studies were conducted for aggregates, automotive, coal, metals, petrol, waste and general freight (SRA, 2004a, 2004b, 2004c, 2004d, 2004e, 2004f, 2004g). The Department for Transport (DfT) now expects the rail freight industry to develop its own traffic forecasts as an input to the High Level Output Statement that the DfT is required to provide to Network Rail. The forecast growth between 2003 and 2014 is shown in Table 3. It should be noted that these forecasts are expressed in tonnes lifted, rather than tonne kilometres, and the 2003 figure is based on the industry's own statistics rather than those published by the DfT.

Table 3: British rail freight forecasts: 2014 (millions of tonnes lifted)

Commodity	2003 actual	2014 forecast	% change
Coal	46.0	52.9	15
Ore	6.1	5.7	(7)
Other minerals	19.7	24.9	26
Metals	10.5	12.1	15
Petroleum and chemicals	6.8	7.2	6
Waste	2.2	2.0	(9)
Auto	0.4	0.4	0
Network Rail own haulage	7.4	6.5	(12)
Maritime containers	11.1	21.1	90
Channel Tunnel	2.0	7.2	260
Domestic intermodal/ wagonload	0.9	4.7	422
Total	**113.1**	**144.7**	**28**

Source: RFG (2005)

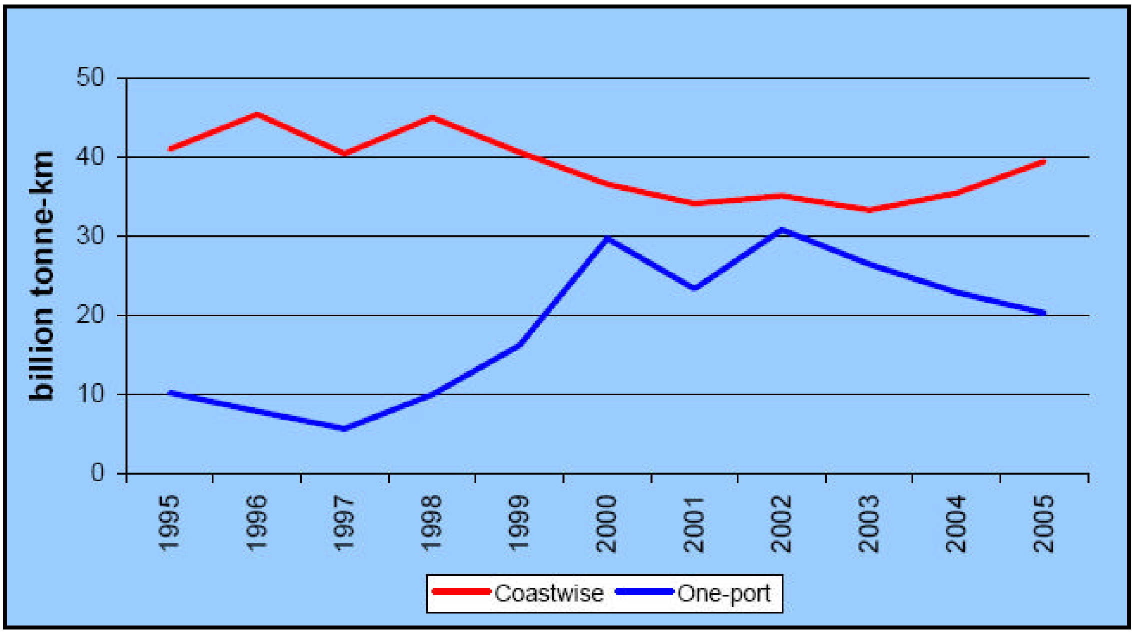
More recently, Network Rail's emerging series of Route Utilisation Strategies (particularly that for freight) has examined freight demand and assessed future demand, with a clear expectation that future growth will occur.

2.6 Trends in domestic water-based freight transport

Figure 5 shows the key trends in domestic freight volumes moved by sea in the 10 years to 2005. Coastwise relates to those goods being moved between two ports on the British coastline, while one-port relates mainly to goods moved to/from offshore installations together with flows resulting from sea dredging or dumping. Petroleum-related flows dominate domestic waterborne freight, with

83% of one-port traffic and 77% of coastwise traffic in 2005 being crude petroleum and petroleum products. The majority of the remainder of the flows are categorised under ‘other dry bulk’, ‘unitised’ and ‘other cargo’.

Figure 5: Coastwise and one-port domestic goods moved (1995-2005)

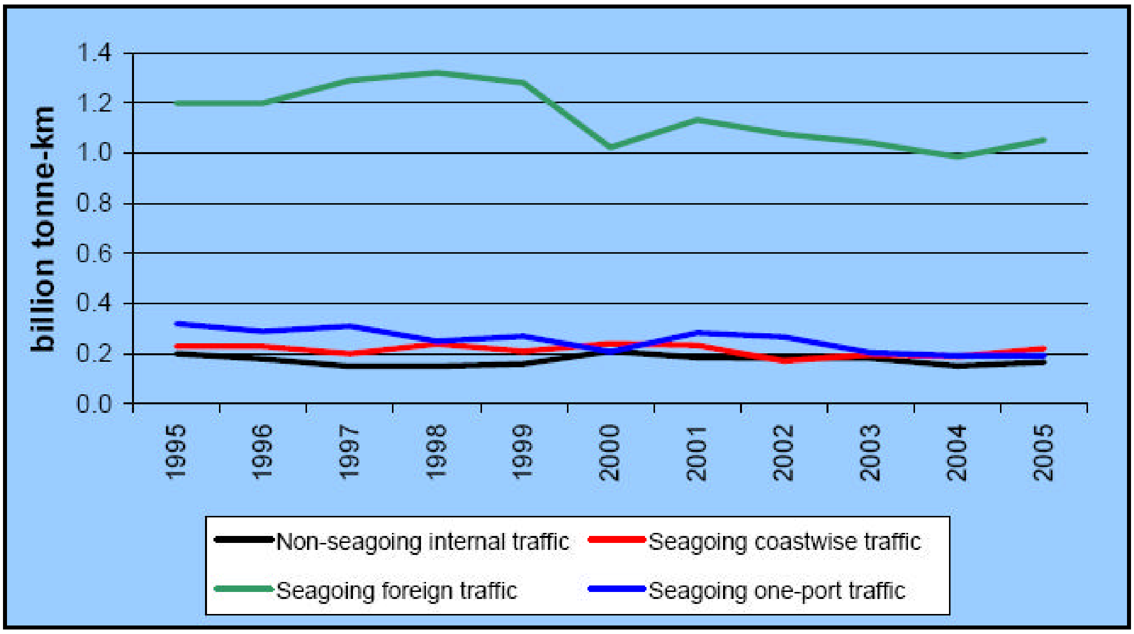


Source: DfT (2006c)

Overall, domestic water-based traffic has shown growth since 1995 of just less than 10%, largely as a result of the increase in one-port traffic. The latter has actually shown quite considerable decline in recent years, while the former has increased back to a similar volume that was carried in 1995.

In Figure 6, the trend for goods moved on UK inland waters is presented. Only the ‘non-seagoing internal traffic’ flows are wholly internal to inland waters, with ‘seagoing coastwise traffic’ and ‘one-port seagoing traffic’ essentially being double counted from the totals in Figure 5. It is evident that, while coastal shipping accounts for a large volume of freight moved, internal inland waters traffic is extremely limited and fairly static in volume terms. The Thames/Kent and Humber areas account for virtually all of the internal inland water traffic, with 'dry bulk' being the largest of the cargo categories.

Figure 6: Goods moved on UK inland waters (1995-2005)



Source: DfT (2006c)

2.7 Trends in international freight transport (to/from UK)

Shipping is an important way of freight transport in EU; over 90% of its external trade and some 43% of its internal trade is moved by water. In the UK geographical characteristics and strong economic position influence especially important role of shipping which carries 95% of the country's imports and exports. Figure 7 displays the recent trend in tonnages passing through UK ports, with relatively sustained growth occurring for imported tonnage but slight declines for export tonnes handled. These statistics are not produced in tonne kilometres units given that the international flows arrive in to or leave from UK waters and their distance is not known.

Figure 7: UK port goods traffic (thousand tonnes; 1997 – 2005)

Source: based on DfT (2006d)

3. Key approaches to analysing freight mode share and mode choice

This section discusses the main ways in which the literature deals with data availability and analysis. First, issues relating to quantification are dealt with; this is followed by discussion of qualitative approaches.

3.1 Quantitative methods

Much of the recent analysis in the published literature has attempted to quantify the trends in mode share and predict future trends. The previous section presented a range of statistics relating to non-road freight activity in the UK. These mainly referred to goods moved, as measured in tonne kilometres, which is recognised as the standard comparative measure between modes. Alternative measures commonly utilised are goods lifted, measured in tonnes, and the average length of haul, which is the division of goods moved by goods lifted. Mode share is most commonly considered in terms of goods moved, as are growth targets (e.g. that developed for rail freight in the Ten Year Plan (DETR, 2000)). Of the two measurements, that of tonne kilometres tends to be more dominant given that it incorporates the distance element of the freight movement. The amount of freight activity (and associated network and environmental impacts) generated by 10 tonnes of product will be very different dependent on whether the product is moved over a distance of 50 kilometres or 500 kilometres.

It is quite clear, though, that a different picture emerges dependent upon the units of measurement used. While the number of tonne kilometres by rail shows a general upward trend since the mid-1990s, the number of tonnes lifted essentially dipped from its mid-1990s level by approximately 15 per cent and only returned to the previous level in 2004/05 largely as a result in the growth of coal traffic (ORR, 2006). A change in data collection for tonnes lifted may account for some of the difference, but the major factor causing the divergent trends has been the increasing average length of haul for rail freight consignments.

There are some clear benefits associated with the standard tonne-based units of measurement when considering the role and importance of non-road modes:

- They are relatively simple: first, they are easy to collect, since they are based upon data routinely gathered by the rail industry (and other transport modes); and second, they are easy to understand
- Standard tonne-based forms of measurement, particularly tonne kilometres, are increasingly used both nationally and internationally in official statistics, so their use allows international, longitudinal and modal comparisons

However, the focus on these forms of measurement raises a number of concerns:

- The narrow focus of tonne-based forms of measurement in rail freight targets and forecasts means that they are not necessarily aligned with broader policy objectives that consider, for example, social and environmental issues
- The emphasis on tonnes appears contrary to the likelihood that the majority of potential rail freight growth will come from relatively low weight sectors rather than traditional heavy products
- The forms of measurement largely ignore the effects of, and implications for, rail network capacity and capability, both in terms of routing services through the network and the wider issues associated with the availability and utilisation of train paths

Traditionally, rail freight (and water freight) has rightly been seen as being dominated by commodities associated with heavy industry (e.g. coal, steel, aggregates, petroleum). If the non-road modes are to diversify into the growth freight areas, particularly premium logistics, then tonne-based forms of measurement may not be the most appropriate units to use to assess these non-road modes' "worth". Passengers, by and large, exhibit more homogeneous characteristics than do freight consignments, so the main forms of measurement of their activity (i.e. passenger kilometres and passenger journeys) do not give particular cause for concern. For freight, though, a trainload of coal or aggregates could weigh several times more than a similar length trainload of "premium logistics" products. While both may remove similar numbers of lorry journeys from the road network, offering decongestion and environmental benefits, the latter will be under-reflected in tonne-based statistics. Table 4 presents an assessment of alternative forms of measurement that were developed by the Strategic Rail Authority (SRA) in 2003.

Table 4: Alternative forms of measurement of rail freight activity introduced by the Strategic Rail Authority (SRA)

Measurement	**Benefits**	**Drawbacks**
Share of surface market (rail and HGVs)	• Close fit with public policies encouraging freight by less environmentally-damaging modes • Relatively easy to measure and understand, using data already collected as standard	• Considers only road and rail and omits, in particular, coastal shipping which is significant in the British market • Tonne-based units of measurement
Share of overall market (rail, HGV, LGV, pipelines and water transport)	• Close fit with public policies encouraging freight by less environmentally-damaging modes • Relatively easy to measure and understand, using data already collected as standard	• Tonne-based units of measurement • Inclusion of light goods vehicles (LGVs) adds in a freight market for which rail is not generally able to compete • Pipelines and water transport are also generally seen as less environmentally-damaging, so rail could achieve a higher market share without providing the desired policy benefits
Impacts on road haulage – rail freight lorry kilometres equivalent	• Close fit with emphasis in broader public policies to encourage sustainability • Particular emphasis on the road freight activity avoided through rail use • Closely relates to existing calculations utilised for rail freight grant funding	• Need either for large scale data collection and validation or relatively crude assumptions about nature and routing of consignments • Ignores location and timing of lorry kilometres avoided
Impacts on road haulage – lorry journeys avoided	• Close fit with emphasis in public policies to encourage freight by less environmentally-damaging modes	• Crude assumptions utilised to convert from rail freight volumes to lorry journey equivalents, unless comprehensive data are collected • Takes no account of distance, or of location or timing of lorry journeys avoided
Number of freight trains operated	• Relatively close relationship with utilisation of, and requirements for, train paths • No bias towards heavier consignments, unlike the tonne-based measurements	• Takes no account of train length and volume carried • Gives equal prominence to light and heavy trainloads, which may be problematic if statistics are not interpreted with caution

Source: original analysis of measures developed by SRA (2003)

There are benefits and drawbacks associated with each of these new forms of measurement, just as there are with the established tonne-based ones. However, it is evident from Table 4 that many of the forms of measurement could be complementary to both tonne kilometres and each other, and that some sort of "basket" of indicators is ideally what is needed. Those that appear to offer the best coverage to supplement tonne kilometres are market share (in some form), rail freight lorry kilometres equivalent and number of freight trains operated.

3.2 Qualitative methods

A different strand of research has considered mode choice using more qualitative research techniques. For example, Woodburn (2001a) examined mode choice decision making with particular reference to rail, using in-depth interviews which examined issues relating to specific companies and to the nature of the supply chains within which they were placed. This was further developed in Woodburn (2004b), whereby the likelihood of meeting the rail freight growth target was assessed, again through the use of in-depth interviews with a sample of relevant companies. Stated preference techniques have also been applied to freight mode choice (see, for example, Shinghal and Fowkes (2002) and Beuthe *et al.* (2003), using a mixture of quantified and qualitative attributes.

4. Modal differences in environmental and social impacts

In general terms, rail and water impose lower impacts on the environment than does road haulage. However, 'there is in any case no universal hierarchy as to which mode has the lowest environmental impact. Load factors, operating efficiency, engine technology, fuel quality and respect of emissions standards and maintenance requirements are all important in determining the relative performance of each mode in practice.' (CEMT/CM, 2002, p.3). It is also recognised that using aggregated averages to determine impact of various transport modes on the environment may be misleading. According to van Wee *et al.* (2005, p.23) 'when comparing the environmental performance of freight transport modes, it makes no sense to compare averages for road transport, freight trains and inland ships. This is because, on average, lorries move goods with lower specific gravities than trains or ships, which, more often, move bulk goods. To calculate the effect of shifting container freight from road to rail, data are required on the environmental performance of road and rail transport for moving containers.'

4.1 Energy use

Freight transport is a key consumer of energy, mainly oil, and therefore has considerable impacts on energy use and consequent emissions (May, 2005). It is recognized by van Wee *et al.* (2005) that energy use and transport mode emissions are influenced by factors that can be divided into two groups: direct and indirect. Direct factors include the following:

- Technical factors, e.g. vehicle characteristics such as vehicle weight and shape, engine and fuel type and loading capacity;
- Operational factors are associated with the way a vehicle is used and consider for example: average driving speed and incidence of speed variations-driving dynamics;
- Logistical factors, e.g. load factors for lorries, barges and goods trains, specific gravity of the freight and density of infrastructure networks.

Indirect factors that play an important role in total energy use and emissions are associated with the construction, production and maintenance of infrastructure and vehicles. Construction of rail infrastructure is especially energy intensive relative to the energy consumed for operation. Indirect energy use per tonne kilometre of rail freight equates to 40-60% of direct energy use, while taking total road infrastructure into consideration, the indirect energy use of road haulage is 25% of its direct energy use (van Wee, 2005). Overall, though, according to the Royal Commission on Environmental Pollution (RCEP, 1994) with the exception of the less flexible and slower modes of pipeline and water, rail is the most energy and space-efficient way of transport. Ford *et al.* (cited in Robinson and Mortimer, 2004) established that rail can offer 50% reduction in energy used for each tonne-km compared to road freight. At the same time however it is claimed by Carpenter (cited in Shaw et al, 2003, p.143) that rail generally uses 'non-renewable energy resources and 'take' land in the same way as roads.' Overall, there seems to be no clear consensus as yet as to the precise energy use impacts of the different freight transport modes, but there is considerable acceptance that non-road modes are typically less energy intensive than road.

4.2 Emissions

With environmental issues in the centre of attention of policy makers and industry representative alike, problem of emissions becomes increasingly important. Table 5 presents the greenhouse gas emissions from different types of UK transport. It should be noted that for the non-road modes shown, the emissions relate to both passenger and freight transport while for road the data relate specifically to freight operations. The fastest growth has occurred in aviation, but toad emissions grew by almost one third between 1990 and 2002 while water emissions grew more slowly and rail's decreased considerably. These data relate to absolute emissions but rail traffic, both passenger and freight, has increased since the mid-1990s.

From these data, it seems clear that at an aggregate rail freight emits less CO_2 (and equivalent emissions) than does road, given the relative differences in their shares of tonne kilometres. Within road freight, most of the growth in emissions since 1990 has occurred in the articulated HGV category, which accounted for three quarters of road freight emissions in 2002. Emissions from LGVs doubled during the same time period but were estimated to be responsible for just 8% of road freight emissions in 2002.

Table 5: Greenhouse gas emissions from different types of UK transport [in million tonnes of CO_2 equivalent]

Mode	**1990**	**1995**	**1997**	**1999**	**2002**
Rail (all)	2.5	2.4	2	2	1.5
Road (freight)	15.8	19.2	21.3	21.7	23.4
Water (all)	11.6	12.1	16.8	14.7	15
Air (all)	20.2	26	30.5	37.2	37.5

Source: Based on ONS (2002)

Van Wee *et al.* (2005, p.12) note that 'the average emission factors for CO_2 from goods transport by road are about three times higher than from transport by rail and inland shipping. Road emissions of NO_x are about 75% higher than emissions from diesel trains and inland shipping, and about 30 times higher than emissions from electric trains.' Likewise, Riddles (cited in Garbutt, 2005. p.51) claims that CO_2 emissions from shipping are around a third of that produced by road vehicles, while acidification and smog formation about half. While comparisons such as these are useful, it should be borne in mind that the outcomes may change over time as a result of different operating practices, introduction of new technologies, etc. It is often recognised that the marginal (extra) environmental pressure of a additional tonne moved by train is relatively low as the train will operate anyway, despite this extra tonne. In case of lorries this is much less true; an extra tonne to be moved would often require additional vehicle to be engaged in the operation and each extra lorry shows average emissions. Therefore, a shift from road to rail, leading to longer trains but not their higher number, will have lower marginal impacts than a shift from road to a new railway line (van Wee *et al.*, 2005).

At the same time it must be remembered that efficiency of trains and level of emissions they produce depend on a type of engine they are fitted with. Electric engines are more efficient than internal combustion engines (ICE) and do not emit any pollutants at the vehicle level. ICE engines can use different fuel types. According to Färnlund et al (2001) those using diesel fuel produce more particulate matter than petrol-fuelled ICE engines while Joumard et al (1995) and Kageson (1996) claim that the diesel-fuelled engines emit less volatile organic compounds and carbon monoxide than petrol-fuelled engines, even when the latter are fitted with catalytic converters (cited in van Wee et al, 2005, p.6).

With respect to modal differences, according to Swiss Agency for the Environment, Forests and Landscape (2000) today's new lorry engine, meeting the Euro 3 emissions limits, produce far fewer particulates than a comparable engine built 10 years ago. As noted by Bunting (2001), exhaust after-treatment, like a de-NO_x catalyst or an exhaust particulate trap, is not yet common for heavy-duty vehicles, but will soon be required to meet the 2008 emission standards (Euro 5) for heavy-duty lorry engines. (cited in van Wee et al, 2005, p.6). It may therefore be the case that the gap in emissions between road and the non-road modes is being eroded by the more rapid adoption of new technologies for road vehicles, as a result of tightening emissions standards. It may be the case that improvements have been made for the non-road modes, for example with the wholesale replacement by rail freight operators of older diesel engines by new ones within the last decade, though no extensive research appears to have yet been undertaken to evaluate the effects.

An important issue that must be remembered relates to the emission of pollutants through the overall flow of energy from the import of the primary energy to its consumption. As noted by Masui and Yurimoto (2000), even though rail using electric power rarely emits contaminants, air pollutants are produced when electricity is generated from primary energy sources such as petroleum, coal, natural gas, nuclear energy and hydroelectric energy at power generation stations. In reality, very little rail freight in Britain is actually hauled by electric locomotives, with diesel engines dominating.

Although maritime transport is considered to be the most environmentally friendly, it is recognised that potential accidents involving ships can create serious environmental pollution. According to Giziakis and Bardi-Giziaki (2002) the risk of pollution incidents increases with the size of a ship involved, therefore tankers dominate in the risk of pollution followed by bulk carriers, general cargo and fishing vessels. The most common causes of an accident include: collision, hull/machinery/equipment damage and grounding but their share in the overall number of accidents varies for different ships. The authors' another finding claims that 60% of the accidents involved in pollution have happened in regulated zones and ports. This clearly indicates the importance of port regulations and controls to prevent similar incidents in the future.

4.3 Social impacts

The main social impacts of freight transport are:

- Safety/accidents
- Network congestion
- Noise/vibration

In terms of safety/accidents, the non-road modes (including air) are considerably safer than road, although the statistics (DfT, 2006b) do not allow easy differentiation of the freight operations of each mode. Modal shift from road is therefore likely to lead to an improvement in freight safety and a decrease in casualties. Specific safety-related issues have affected the rail network, notably the significant disruption as a result of speed limits imposed following the broken rail at Hatfield in late-2000, which severely impacted on the performance of rail freight operators and dramatically increased costs within the rail industry, with longer-term consequences for network capability as a result of increased maintenance works overnight, when much freight traffic operates. In general terms, the road haulage sector is less heavily regulated.

Network congestion is typically identified as a road-related problem, with road haulage both contributing to and suffering from congested networks. Congestion leads to transport unreliability, both in terms of absolute journey time and the journey time variability, which can affect freight transport reliability. While road tends to suffer the most from congestion, the non-road modes are not immune from the problem; the existing literature recognises the increasing problem of transport network congestion across all land modes the UK and most often lack of sufficient capacity is being blamed for the situation. For example, growth in rail traffic (both passenger and freight) has resulted in increasing demands being placed on the rail network, and Network Rail has identified a number of constraints to future growth, notably in its draft Freight Route Utilisation Strategy (Network Rail, 2006). As Potter (2004, p.18) has identified, 'the growth in global sourcing, the resulting increase in container traffic….are putting an increasing pressure on UK ports and modal transfer facilities'. The lack of loading/unloading and storage capacity as well as intermediate terminals along many routes and the lack of road/rail infrastructure capable of handling the growing volume of container traffic is expected to result in worsening congestion in the future and translate into reduced UK's competitiveness. At the same time any future modal shift will be endangered as well as large freight interchanges are required for the process to happen. Network congestion problems therefore affect all modes to some extent, although the lack of control over road movements makes road congestion less predictable and harder to deal with, and are affected both by route and terminal capacity issues.

For noise and vibration, road haulage is perceived to present a much larger problem than the non-road modes, though this is likely to be influenced by the proximity of people to road networks and the dominance of road haulage over the alternative modes. Forkenbrock (2001, p.333), identified that the existing literature ‘suggests that a given level of noise produced by a freight train is usually perceived as less annoying than noise produced by vehicle traffic on a highway’, and reports that the Commission of the European Communities claims that the cost of road traffic noise is over six times higher than noise from freight rail.

5. Modal differences in freight operations

Road freight transport has considerable differences in operating characteristics when compared to the non-road modes. An FTA (2002) study of rail freight customers is fairly typical in the issues that it raises, namely:

- Trust (e.g. proven track record, good communication, partnership approach sound strategy, customer knowledge, consignment tracking)
- Reliability (e.g. service frequency, regularity, on-time pick up and delivery)
- Cost (e.g. cost transparency, cost control, infrastructure costs, internal/external costs)
- Business attitude (e.g. innovative logistical solutions, flexibility in services offered, contingency planning)
- Cargo care (e.g. safety, equipment quality, availability of equipment, cargo security)
- Ease of doing business (e.g. procedures, documentation, responsiveness)

Similarly, Woodburn (2001a) identified several key barriers preventing companies from using rail rather than mode, the most important being incompatibility for type of product/movement, lack of suitable rail connection/infrastructure, lack of flexibility, too slow and too expensive. Many of these issues are interrelated, but the most important differences highlighted in the literature tend to relate to performance/quality and, to a lesser extent, costs.

5.1 Service quality

The principal elements relating to quality of service from any transport mode tend to be:

- total journey time and urgency involved
- on-time delivery requirement
- safety of consignment

These factors related to quality of service are linked directly to customer satisfaction. Faster and more reliable services may be charged at higher rates per unit. Many customers are prepared to pay a premium price for speedy and prompt deliveries especially when time-sensitive products are involved (Harris & McIntosh, 2003). Service punctuality is good in most of the intermodal examples, and in some cases it is better than that for equivalent road operations; in many cases, it is a punctual arrival time that is more important than the actual journey time. Rail is handling some fairly time-sensitive consignments on a regular basis, generally with a high degree of customer satisfaction. However, it must be borne in mind that rail has a negligible share of the fast moving consumer goods (FMCG) market, with flows tending to be concentrated on longer distance corridors such as southern ports to the Midlands and beyond, or the Midlands to Scotland.

Smaller volume flows tend to be more sensitive to service quality issues, together with price, than are traditional trainload flows which are often fairly captive to rail. Although this had generally been becoming less common, wagons, for example, may still be going missing in transit. More critical is the lack of information about delayed arrivals and the impacts that such delays have on rolling stock availability, the latter being a particular issue. Even where service performs as scheduled, infrequent trip workings (i.e. local collection and delivery of wagons feeding into and out of the “hub” yards) can add days on to a wagon’s round trip. The problems with rail service quality often relate to a lack of network capacity, high costs, poor performance (i.e. service reliability and punctuality) and, specifically, the disruption to Channel Tunnel services as a result of security issues.

These issues have to be solved if rail is to become more competitive freight operator in increasingly competitive market. Wider issues surrounding service costs and provision must also be addressed to ensure that the benefits of funding can be maximised, since service quality problems appear to be the single most significant reason for actual flows being lower than those anticipated. Rail’s service quality will have a big impact on its future. As noted by Potter (2004), rail must attract new customers and new business from existing ones in order to increase the volume of goods it moves. Rail will remain the preferred option for bulk products and Intermodal traffic but ‘to attract more FMCG customers, the rail freight operators will have to provide the levels of customer service, reliability and communication that are demanded by today’s supply-chain operations’ (Potter (2004, p.19). Further discussion of supply chain issues is in Section 6.4.

5.2 Operating costs

Operating costs vary greatly dependent upon the nature of the consignment (e.g. weight, cubic area, urgency, distance, handling requirements, regularity of flow), and it is very difficult to generalise about the costs of different modes. However, the cost of transport or distribution is typically a very important factor deciding about mode to by which goods will be carried. Although one part of the journey may be cost effective, transferring a load from one mode to another is potentially very expensive. The best example of such a situation is freight movement involving shipping. 'Water is the cheapest form of transport in tonne-mileage terms, but the total cost may be greater if extra transfers have to take place' (Garbutt, 2005, p.51). Similar problem affects movements by rail, where at the end of the journey, load has to be transferred onto road vehicles for delivery to the final destination.

An important disadvantage relating to rail are high capital costs for its new facilities, which often cannot be justified by companies on a purely commercial basis, certainly not in the short- to medium-term. Large facilities for waterborne freight are also very expensive. This compares with the relatively low access costs for the road network, where users typically do not have to pay large sums of money to gain access. Despite this, according to Potter (2004), rail has proved cost-effective even over short journeys for heavy bulky goods such as paper reels, and ideal for bulk materials such as coal and building materials. However it is also valuable for non-bulk goods such as high-value car components, food and textiles.

6. Potential ways to encourage greater use of non-road modes

This section focuses on the range of measures that have been identified that can be utilised to influence mode choice and encourage a greater share for the non-road modes. The following sub-sections deal in turn with fiscal measures, regulatory measures and organisational measures, identifying means by which non-road mode use can be encouraged. The section concludes with a discussion about the integration of non-road modes in to the supply chain.

6.1 Fiscal measures

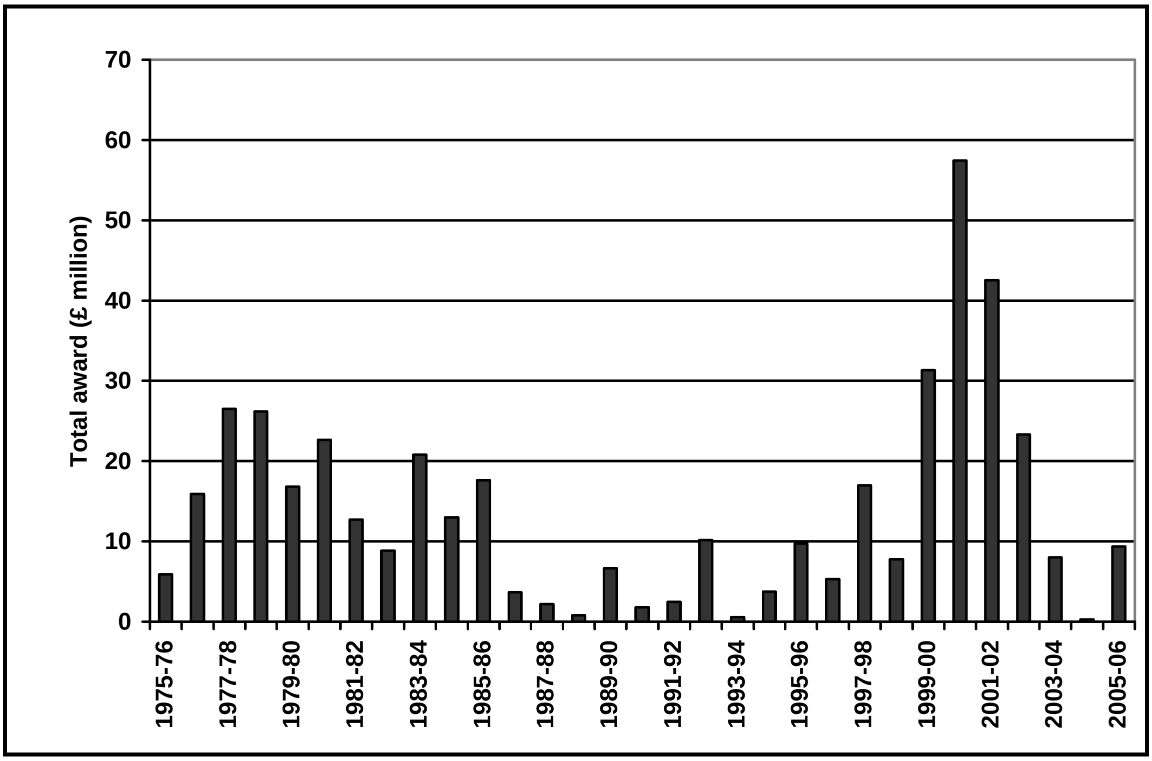
While Britain, like many other countries, has advanced transport deregulation and privatisation policies over the last 30 years there remain good reasons for continued government involvement (Docherty et al, 2004). Freight mode choice can be influenced by governments influencing the relative costs of different modes in either direct or indirect ways. For rail, British Rail's finances were the government's responsibility, but since privatisation in 1996 the freight operators have been expected to operate essentially on a commercial basis. In reality, prior to this time rail freight was largely expected to operate without subsidy. Freight services by road and sea have also been provided on a commercial basis for many years, so government support to the freight industry, and therefore the fiscal influences on mode choice, have been relatively limited though not entirely absent.

In terms of direct intervention, financial support in the form of grant funding has been available for rail freight, and latterly also for waterborne freight. The principles by which the rail freight industry in Britain receives grant funding are well-established, having been introduced under the Railways Act 1974 (Gourvish, 2002). Grant funding, in the form of Freight Facilities Grants (FFGs), was offered to existing or potential customers to contribute towards the capital costs of new or replacement assets that were needed either to retain or attract freight on to the rail network. (DfT, 2005d). The budget was increased in the late-1990s but, due to funding constraints, the SRA suspended the FFG programme in England in early-2003. The suspension of the scheme in England in early-2003 is likely to have hindered this development, both directly in terms of the lack of funds to allow specific schemes to proceed and indirectly in terms of the message sent out to businesses by government about its commitment to the rail freight industry.

At rail freight privatisation, additional funding in the form of Track Access Grants (TAGs) was introduced to cover network access charges for certain flows and in

2004, Company Neutral Revenue Support (CNRS) grant was introduced, targeted at intermodal flows. While similar in many respects to TAG, CNRS was awarded on the basis of a pre-determined matrix of rates between British regions while TAG is awarded on flow-by-flow comparisons of road and rail costs. FFGs were extended to cover waterborne freight facilities in the 1990s. Figure 8, focusing on rail FFGs, indicates the extent of funding made available since the mid-1970s and the fluctuations between different years.

Figure 8: Rail Freight Facilities Grant Awards (1975/76 – 2004/05, in 2004/05 prices)



Source: Compiled from The Stationery Office (1997), DfT (2006e)

The evidence suggests that FFG funding has been largely successful, attracting considerable private sector investment. Overall, FFGs have played an important role in developing or retaining rail freight flows, although the processes could be made more transparent and consistent. A broad range of projects has been supported by FFGs since 1997/98, traditionally focusing on bulk commodities but with a more recent emphasis on intermodal facilities. From April 2007, a single Sustainable Distribution fund will be operated for England, which will combine Freight Facilities Grant (FFG), a new Rail Environmental Benefit Procurement Scheme (REPS), and Waterborne Freight Grant (WFG), together with general funding aimed at improving freight transport efficiency (DfT, 2006f). Similar funding also exists for Scotland and Wales. Other measures have had more significance than grant funding. For example, the halving of track access charges in 2002 was financially more significant than the typical annual FFG funds. It is difficult to assess the impacts on rail freight volumes of the access charge changes, though the finances of the operators clearly will have benefited. Targeted funding for specific freight facilities and flows is a key way in which rail freight can increase its mode share and is a more transparent, and therefore politically acceptable, measure than general subsidies. Funding may also be made available for transport infrastructure improvements through the new Transport Innovation Fund, which seems to be favouring projects that enhance rail freight's capabilities (Alexander, 2006).

It seems clear that the FFG scheme, as part of a wider suite of funding sources, is an important and successful means by which rail can retain or gain freight flows. The planned reinstatement of facilities funding later in 2007 is a welcome development, although concern remains about both the level of funding available and the commitment of the government to encourage greater use of the rail network by freight as part of its broader transport policies. In addition, concerns are raised that the grant decision-making processes are too complex and time-consuming, so attention should be paid to simplifying the procedures to make them more flexible and user-friendly, subject to retaining the necessary controls on the use of public funds.

Fuel taxation is a less direct fiscal mechanism through which freight activity can be influenced. The UK typically has high fuel taxation, and for a time in the 1990s a fuel duty escalator was in force which increased fuel duties by more than the rate of inflation. There may be further policy changes in fuel pricing, either as a general taxation measure or as an attempt to make road users pay the true costs of utilising the road network. In addition, the proposed introduction of road pricing, particularly if varied depending on location or time of network usage, may have an effect on individual companies' operations which could vary substantially depending on their transport requirements. In addition to the charging regime for infrastructure usage, policies relating to the provision of new transport infrastructure may be reappraised, leading to road and non-road investment proposals being evaluated using the same criteria. This is a less direct influence, but may affect mode choice nonetheless.

Although transport activities are mainly carried out by private operators, government is still responsible for influencing and regulating the social and environmental impact of freight industry. As the majority of transport infrastructure is financed by public funds, government has to ensure that all the social and environmental costs associated with the network use can be recovered. It will also help plan for the future investments required to increase infrastructure capacity and efficiency of the network. The European Union is keen to ensure a level playing field, where each mode of transport covers the external costs that it imposes, such as accidents, air pollution, noise and congestion (European Union, 2001).

Westermark (2001, p.176) claims that 'it is important that there is a close link between the tax base and the external cost. The use of a carbon tax for mitigating CO_2 emissions is an almost perfect example where the tax item correlates well with the parameter causing the environmental cost'. Favourable taxation and rail infrastructure provision at a comparable cost to road is another fiscal means of influencing mode choice (Harris & McIntosh, 2003). Forkenbrock (2001) notes that, under full cost pricing of freight transport modes, the true costs to society would be reflected in the prices paid by users, allowing for the modes to compete on an equal basis. However the way in which inclusion of external costs would affect competition between rail and road transport would depend on such factors as the relative service quality and the extent to which the modes were able to serve the same markets. At the same time May (2005, p.31) suggests that ‘road freight transport is fairly inelastic because many companies regard the alternatives, mainly rail, as unsuitable. Increasing charges alone is unlikely to be effective.’

6.2 Regulatory measures

Despite transport provision largely being deregulated and liberalised over recent decades, there remain a number of ways in which mode share can potentially be influenced through regulatory measures. These measures can broadly be classified as:

- Network access and competition, particularly relating to rail
- Freight transport operations
- Non-transport-specific legislation and policies that impact upon freight transport operations (e.g. Working Time Directive, land use planning decisions)

Regulation can either be at the national (UK) or European Union level or, in some cases, devolved to a lower level (e.g. local authorities, Scottish Parliament, Welsh Assembly Government). There has been considerable research into the effects of rail freight liberalisation in European Union countries (for example, Cantos & Maudos, 2001; Gouvernal and Daydou, 2005; Taylor and Ciechanski, 2006). European policies relating to the liberalisation of, and access to, international rail freight corridors should assist with further increases in rail freight volumes in the future. In particular, growth should result from the development of the Trans-European Rail Freight Network (European Commission, 2001), which includes the Channel Tunnel and Britain’s key freight routes, and the implementation of the various railway packages, particularly the Second Railway Package which was ratified in 2004 and aims to remove obstacles at national borders and introduce competition to international rail freight services (European Commission, 2004). Progress to date has been slow, but the European Commission remains committed.

Road haulage has been very lightly regulated in terms of network access and competition, the key criterion being that a road haulage operator must be in possession of an Operator License (VOSA, 2005). The 'O' Licensing system aims to maintain quality and safety standards within the road haulage sector. This is supported by other, more general, road regulations relating, for example, to drivers' hours, speed limits and driver blood alcohol levels. Waterborne traffic also receives relatively light touch regulation, with that in existence typically relating to operational safety, while the rail sector has more heavy regulatory involvement despite the changes over the last decade. General competition law and other legislation (such as the Working Time Directive) apply to all operations within the freight transport sector.

For rail, British Rail had a national monopoly until privatisation in the mid-1990s. A detailed account of the rail privatisation process, including the transfer of freight operations to the private sector, can be found in Freeman and Shaw (2000). English Welsh and Scottish Railway (EWS) gained control of five of the six businesses; Freightliner, the sixth, which focused on container movement to/from ports, was sold to a management buyout team. Freightliner subsequently established a Heavy Haul business for bulk flows, while two further operators, Direct Rail Services (DRS) and GB Railfreight, are now well-established in the market. In 2006 two more companes, Jarvis Fastline and Victa Railfreight, commenced operations. As a consequence of this liberalised rail freight environment, there is a growing degree of competition for traffic. For some commodity sectors, notably bulk products (particularly coal) and intermodal flows, three or more of these operators provide similar services and offer choice to potential customers. It must be also remembered that encouraged competition especially within rail industry will have a positive impact on its overall competitiveness as a mode. The more competition between operators, the more competitive rail is likely to become against other modes of transport (European Commission, 2001), since competition impacts on the range and quality of services provided and most probably will result in more competitive rates and higher service quality being offered to customers. Despite the changes, there is still considerable public control of rail through policy, regulation and investment. The freight sector has operated with significantly less direct intervention than have passenger operations, yet government still retains much influence. A fully-competitive open market seems unlikely due to the nature of rail operations, which requires network capacity to be allocated in advance rather than at the time of demand (Brewer, 1996).

The introduction of the Working Time Directive to the transport sector in 2005 was expected to have a major impact on freight operations, coming in addition to the pre-existing significant shortage of lorry drivers together, a high average age of drivers, and a generally unattractive career for young people. A decrease in road transport productivity was anticipated, together with higher costs of operation (Potter, 2004). To date, though, there is little evidence that the introduction of the Directive has had a noticeable impact on freight transport operations or mode share.

Land use planning policy now gives more emphasis to the use of non-road modes where practicable. In particular, PPG13 (and more recent government planning statements) highlights the role of the land use planning process in influencing the movement of freight by rail and water (DETR, 2001). Haywood (2001), highlights the need to use the land use planning process to develop a range of different terminal types to achieve significant growth in rail freight volumes, including major intermodal terminals and local freight depots; to date, though, there has been relatively little progress to report, with particular difficulty being experienced in getting approval for large new rail freight developments. More positively, some of the measures contained in recent planning agreements for port facilities will provide additional capacity and capability, for example through a greater range of routes cleared to carry 9'6" high containers or the ability to run longer trains as a result of changes to passing loop lengths and signalling systems. For example, the agreement relating to the Bathside Bay development includes a capping mechanism to limit the number of lorry movements associated with the movement of containers to and from the terminal (DfT, 2005). While difficult to apply such measures retrospectively, thus limiting the speed at which land use planning decisions can influence freight movement, there is potential for these measures to encourage non-road modes in the longer term.

6.3 Organisational measures – supply side

It is frequently argued that rail can only compete with road over long distances, with a lower threshold value generally assumed to be around 150 to 200 miles (FTA, 1995). This argument is extremely simplistic, since distance is only one of the factors affecting modal choice, important though it may be. The nature of the consignment is a major factor, with bulk flows more suited to rail than are individual wagonloads. Indeed some bulk rail freight flows in Great Britain are less than 25 miles in length.

Competition potentially has a big effect on the supply of services, and was dealt with in the previous section. This section deals with other organisational measures that could be implemented to enhance rail freight service provision, including:

- New or improved infrastructure
- Innovative service provision

- Changes to operating practices
- Better integration with other modes (particularly road)

Infrastructure constraints relate both to the rail routes and to terminal capacity. Upgraded infrastructure, and the increased capacity, capability and/or resilience, would result in more efficient networks, lower congestion and reduced bottlenecks on many routes. Higher speeds and decreased average journey times may also result, which could translate into a more attractive rail-based service and, ultimately, lower transport costs. For example in the port-based sector, the recent gauge enhancement of the West Coast Main Line (WCML) and Felixstowe to London corridor has provided greater network capability for 9'6" high containers, which are rapidly growing in number and are an important market for rail to retain and expand. It is critical that a gauge-enhanced network is developed otherwise rail will find it increasingly difficult to compete in a market becoming dominated by 9'6" high containers. It certainly seems as though the momentum for network enhancement is building, and considerable attention is now being paid to the future requirements for port-based container traffic by rail, as witnessed by the shortlisting of key port rail link projects for money from the Transport Innovation Fund (Alexander, 2006). According to Boughton (2003), increasingly limited current rail capacity results in lower possible impact made by financial incentives, highlighting the interrelationships between different types of measures.

If rail is to increase its share of the market, smaller volume, higher value flows will be needed to supplement the traditionally strong share held by rail of bulk products. This could assist in meeting environmental, social and, indeed, economic objectives, since much road freight movement is of goods that potentially could be transferred to traditional rail wagons. Traditional wagonload services could be transformed in to a coherent overnight hub-and-spoke network catering for palletised and non-palletised goods. Obvious targets are the overnight/next-day market for palletised goods and for parcels, both of which have grown substantially in the past few years. Rail currently has a minimal role in these markets, with an overnight parcels train operating between the Midlands and Scotland and some palletised products moving on both the wagonload network and on trainload services. There has been no concerted attempt by any of the privatised rail freight operators to develop a coherent network serving palletised goods and/or parcels. As a recent benchmarking exercise of the road-based pallet networks showed (Transport Energy Best Practice, 2005), there are around 10 competing networks operating and they cater for large numbers of pallets per night. There are many existing rail terminals that offer potential to act as regional hubs in a national network in much the same way as the road-based pallet networks operate.

Changes to operating practices could make a significant difference to the attractiveness of rail freight. New rolling stock is cheaper to operate per tonne carried, since new wagons usually have greater carrying capacity than those being replaced and often attracts lower track access charges as a result of better design leading to less track damage. In many cases, higher operating speeds can be achieved, leading to shorter journey times. New tracking and tracing technologies, increasingly common in the road haulage sector, can be introduced to monitor movements and provide greater transparency to customers. Service provision that is more responsive to customer requirements demands better network access, particularly paths to operate faster trains and fewer line closures at night when many of the trains are likely to operate. Network Rail is developing a better understanding of these requirements, for example acknowledging the need to allow trains to operate 24 hours per day, 7 days per week where possible (Armitt, 2006).

Intermodal rail freight services have been a particular growth area in recent years. Unitisation of loads in to swapbodies and containers is increasingly common within the freight industry, and the growth in international trade means that more unitised loads are arriving at UK ports. The rail freight operators generally are in a strong position to compete for traffic, particularly in the intermodal sector, as a result of large investments in locomotives and rolling stock since privatisation. New terminals have opened and infrastructure at existing ones has been enhanced. Further growth in service provision may lead to greater economies of scale, resulting in rolling stock and terminals being better utilised, thus leading to lower unit costs and a more competitive rail sector. The current situation shows a huge transformation since the mid-1990s, when Freightliner inherited much of the oldest and most unreliable equipment. The relatively new Anglo-Scottish intermodal services (see, for example, DRS (2006a and 2006b)) are a good operating model, both for intermodal and traditional rail freight, where small volumes for multiple customers are formed in to a trainload at one terminal and transported by rail directly to another terminal for onward local road distribution, making the operation more like a traditional trainload one which tends to have lower cost and higher punctuality levels. It seems that there is considerable scope for rail to expand in the very significant market for small volume consignments through the provision of a fixed network, and would potentially lead to environmental and economic gains through the use of rail for trunk hauls.

In the waterborne freight sector, improvements to the supply of services may lead to growth in volumes and a switch of traffic from road. For example, the EU's proposed development of 'motorways of the sea' could lead to traffic being attracted from long-distance road transport. Water transport including short sea, coastal and inland waterway can reduce costs and improve efficiency within logistics chains. Using natural 'track' such as waterways, estuaries, coastline and adjacent seas, shipping is clean and largely sustainable, as it requires less land space than other modes (Garbutt, 2005). The importance of water transport with its second place in the market share for domestic freight transport in Great Britain comes from the geographical characteristics of the country and it is believed that further growth in freight movement should be facilitated by this mode of transport. Garbutt (2005) identifies the following advantages offered by seaways make them a strong competitor for any land-based mode:

- The sea is free, it already exists and does not require ongoing maintenance
- Seas are barely affected by traffic congestion
- Sea transport capacity can be increased significantly through the addition of more ships, larger or faster ships

6.4 Organisational measures – demand side

It is only by developing an understanding of the wider logistical context within which freight transport mode choice decision-making takes place that appropriate actions can be taken. While supply side changes offer significant potential for modal shift from road, the potential growth of non-road modes' share could be enhanced by better integration of these modes in to supply chains. There may be decisions that companies could take in relation to their supply chain activities that would better enable the use of non-road modes for some of their transport requirements. There appears to have been little overlap between freight mode choice studies and the analysis of logistical systems. Mode choice has traditionally been seen to be low in importance in logistics decision-making. Indeed most recent logistics handbooks and academic texts barely mention the mode of transport to be used at all or, if they do, the assumption is that road will be used. Supply chain research has tended to focus on the importance of human relationships and quality of service factors between stages in the supply chain and has generally neglected the issue of modal choice.

Key trends that have led to an increased demand for freight transport have been the change in the level of sales well as the adoption of low inventory strategies such as just-in-time (JIT) stockholding and production; in general, JIT is better suited to road haulage due to the smaller volumes and more frequent deliveries involved.

Major supply chain changes that could influence mode choice include:

- Company sales volumes or market share
- Materials sourcing patterns or product market area
- Customer (or supplier) requirements
- Number of company locations
- Activities taking place at each company location
- Product attributes (e.g. size, weight, perishability)

Outcomes, in terms of mode choice, may vary dependent on whether decisions are being taken at the company level or across the entire supply chain. In either case, optimisation of cost (or other measure such as profit or service performance) will typically focus on those aspects that are most important. This may result in transport decisions being relatively unimportant, particularly if transport costs are only a small component of total cost. Should (road) transport costs increase in importance, perhaps as a result of implementation of fiscal measures identified earlier, then the weight given to transport in determining supply chain structure may increase.

Shifting from road to rail appears to be just one way in which companies anticipate negating any cost increases or quality decreases associated with road haulage. However, a greater proportion of companies would be likely to improve their road efficiency in response to these changes, while a significant number would also look to restructure their company's operations. This may explain, for example, why the introduction of the Working Time Directive appears to have had only a limited effect on transport operations. Very few companies would consider reducing customer service levels. Companies downstream in supply chains have typically become more demanding of their suppliers and this had major implications for the amount, and possibly nature, of freight transport used.

Much potential traffic, theoretically at least, is fairly easily accessible to rail freight operators, so long as they can meet the quality requirements in particular. For rail freight to become a much more serious competitor to road haulage would require considerable restructuring of either the whole logistical operations of companies within supply chains or far-reaching changes to the capabilities of the rail industry to cope with the demands placed upon it. However, should the potential increases that have been identified be realised then this will place rail in a good position to have a sustained increase in its modal share in the longer term. Trends relating to the actions and attitudes of companies towards the use of rail will continue to be important in future in order to assess the measures required to satisfy policy objectives.

Examples of companies which successfully use rail freight as part of an integrated supply chain have been identified in a number of different case studies, even operating with many JIT features. A growing number of large companies are using rail, though often only for a very small proportion of their transport requirements. In the retail sector, for example, the literature refers to Tesco, Asda, IKEA, Marks and Spencer, Rosebys and Argos as rail freight customers.

Looking to the future, there are a number of emerging trends that may assist in developing the share of the non-road modes. Three of the key ones are the growing concern about climate change and carbon trading, and the associated development of Corporate Social Responsibility policies, the growth in global freight movement by sea and factory gate pricing.

There is now almost unanimous agreement among scientists that climate change is occurring and that there is an urgency to take action. The publication of the

Stern Review (HM Treasury, 2006) attracted considerable attention and has led to a high profile for climate change in politics and the media. Transport accounts for 14% of direct CO_2 emissions, and its share is rising, with other emissions resulting indirectly; the Environmental Audit Committee (EAC, 2006) stated that one-third of end-user carbon emissions are from the transport sector. This relates to all transport, though the share of road haulage is not insignificant. The EAC (2006) concluded that government should take action to encourage modal shift to non-road modes, though there is no clear agenda as yet for promoting this as part of a carbon reduction programme. There is also a growing body of research examining the issue of ‘food miles’, and associated concepts, measuring the extent to which supply chains influence emissions (see, for example, Foster *et al.* (2006). The European Union introduced an Emissions Trading Scheme (ETS) in 2005, initially covering the largest emitters of carbon but with plans to extend both the scope of the scheme and the price of the carbon permits in the coming years (DEFRA, 2006). This is likely to push up the costs associated with generating carbon emissions and, over time, encourage companies to look for less carbon intensive means of working. For some companies, switching to non-road modes may be one way of reducing their level of carbon emissions.

The increasing profile for climate change and carbon trading, together with growing pressure from government and consumers, has led to an increase in the number of companies developing Corporate Social Responsibility (CSR) agendas. While many of these do not deal explicitly with transport activity, never mind modal shift, the impacts of freight transport, and ways of mitigating them, are beginning to attract more attention.

This environmental concern is taking place within a framework of increasing globalisation, with trade volumes increasing rapidly. In pure supply chain terms, the greater concentration of flows through a relatively small number of ports, often with considerable distances to be moved domestically, offers potential for large enough volumes to make rail (and possibly water) viable options. Specifically for containers, a key uncertainty at present is the way in which shipping services are likely to develop in the next 10 – 20 years. Further rationalisation of port calls by ever larger deep sea vessels trying to reduce their time within ports in Europe would be likely to lead to ongoing concentration of activity at a small number of ports mainly within the South East, assuming that the vessels still directly served Britain, placing additional demands on the rail network in this area but potentially generating sufficient numbers of containers to allow additional services to operate over new routes that are not currently viable. The increasing number of longer term agreements, specifying the provision of guaranteed container carrying capacity, between rail freight operators and shipping lines demonstrates the commitment to rail of both parties involved in each agreement (Anon (2003); Freightliner (2003a; Freightliner, 2003b). More recently, a five year contract between Freightliner and Maersk covers the provision of 353 round-trip moves per day solely for the conveyance of Maersk containers (Freightliner, 2006). It seems that such agreements are the favoured means by which shipping lines are seeking to protect or enhance their rail volumes.

Another supply chain trend that may influence freight transport is factory gate pricing (IGD, 2003), largely implemented by retailers who are seeking greater control over their supply chains to achieve cost savings and quality improvements. Such pricing means that the retailers take over responsibility for the primary distribution of products (i.e. from the 'factory gate'). Given that the largest retailers are very big and powerful, they may be able to take advantage of consolidation of flows to enable viable movement by non-road modes and this may help to explain some of the recent growth in retailers' use of rail freight mentioned previously. In addition, retailers are more likely to have developed CSR policies which may make them more amenable to evaluating the potential for alternative modes within their supply chains.

7. Summary

This literature review has summarised the key trends in freight mode choice in the UK and has identified a range of fiscal, regulatory and organisational measures that affect mode choice. This review has focused largely on rail, though issues relating to waterborne freight have also been highlighted. There is good reason to be positive about the future development of non-road modes, particularly in the light of rapid growth of rail freight volumes in the last decade. While there are many measures that can influence companies' decisions about their freight transport, the lack of direction and consistency from the government, particularly the former Strategic Rail Authority and now the Department for Transport, is a concern. To date, pro-rail and pro-environment statements have not been backed up with financial support and strong policy initiatives. There is a lack of confidence in future government support for the rail freight industry and this 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.

APPENDIX

Uncertainty/Variance

There is considerable uncertainty as to the potential for non-road modes to increase their share of the freight transport market in the future as a result of both internal and external influences.

Internal influences relate to such issues as cost, service reliability and punctuality, capacity availability, network capability, industry skills, etc.

External influences relate to issues including government transport policy and funding, environmental initiatives (e.g. carbon trading, fuel sources), changes in supply chain structure, average distances for freight movement, land use planning, etc.

Trends

Rail freight has witnessed an increase both in absolute volumes and in its share of the British freight market in the last decade, albeit rising from a low base – there has typically been sustained year-on-year growth in rail freight volumes (as measured in tonne kilometres) since the mid-1990s. There has also been an increase in competition within the rail freight market during the same time period, with a steady increase in the number of operators, particularly competing in the intermodal market, and an increase in the number of freight-generating companies expressing an interest/desire to use rail where appropriate.

In the maritime sector, international trade growth has resulted in continued growth in freight volumes through British ports.

Measures

Much of the literature relating to freight transport mode share is essentially qualitative in nature. However, the following quantified measures have been identified in the literature consulted:

Tonne kilometres (by mode, and sometimes further disaggregated by commodity)
Tonnes lifted (by mode, and sometimes further disaggregated by commodity)
Average length of haul (by mode, for domestic freight)
Mode share
Volume forecasts
Emissions (by mode)
Number of rail freight services operated (by commodity, operating company, etc.)
Number of train paths utilised
Public sector funding for freight facilities and operations

Methods/Techniques/Tools

The following research techniques have been identified during the literature review:

Interviews with transport/logistics managers within freight-generating companies (e.g. manufacturers; retailers)
Interviews with freight transport providers
Analysis of official statistics (e.g. trend monitoring)
Questionnaires sent to transport/logistics managers within freight-generating companies
Rail freight service provision databases
Freight mode choice modelling

Sectors

The review focuses primarily on non-road freight and, in particular, on rail. As a result, this covers a wide range of sectors, though primarily bulk commodities and intermodal (i.e. containers/swapbodies).

Geography

The focus of the review has been on non-road activity within Great Britain, together with less detailed coverage of international links to/from Great Britain. Some of the British literature is geographically-specific, for example relating to a specific port/terminal or corridor.

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