Road freight transport and sustainability in Britain 1984-2007

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September 2010

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Report produced as part of the Green Logistics Project

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Acknowledgements:

The research reported in this document was funded by the Engineering and Physical Science Research Council as part of the University of Westminster's contribution to the Green Logistics project. Many thanks also to the Road Freight Statistics and Vehicle Licensing Statistics Teams at the Department for Transport for providing data used for analysis in this report. However the views expressed in the report are entirely those of the authors.

Further details of the Green Logistics project can be found at:

http://www.greenlogistics.org

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1. Introduction

Freight transport plays an important role in providing the goods and services required to ensure economic vitality and quality of life. However, in doing so these transport operations impose negative social and environmental impacts including fossil fuel consumption, air pollution, noise, accidents, and traffic congestion. This relationship between the economic, social and environmental impacts (both positive and negative) lies at the centre of the interaction between freight transport and sustainable development.

This report considers a range of issues associated with the sustainability and road freight transport. It builds on a conceptual framework developed by McKinnon (2007) for analysing the performance and impacts of freight transport. This framework is used to analyse the performance of road freight transport by heavy goods vehicles (HGVs) in Britain over the period from 1984 to 2007 via a spreadsheet model developed for this purpose. The starting year in the analysis is the year after the maximum permissible gross weight of goods vehicles was raised from 32.5 tonnes to 38 tonnes. As the analysis shows, the full effects of this change in regulation took several years to transpire due to the vehicle replacement cycle of operators.

Section 2 begins by examining the importance of road freight transport. It then presents the conceptual framework used to analyse the efficiency and intensity of freight transport operations. The approach takes account of the determinants and key variables associated with freight operations in order to calculate the freight "outputs". These outputs reflect the impacts associated with freight operations. The main source of data for HGV operations used in the report (the Continuing Survey of Road Goods Transport or CSRGT) is also discussed in terms of its history and evolution.

An analysis of road freight transport activity for British-registered HGVs in operating in Britain over the period since the 1984 is presented in Section 3 using data from the CSRGT. This consists of a consideration of changes in the level of road freight activity over time (in terms of freight lifted, moved and vehicle kilometres performed), as well as total fuel consumed and CO_2 emissions. The decomposition of this activity into its constituent parts and the key variables that determine these parts is explained together with an analysis of how these key variables and outputs have changed over time. This uses the framework described in section 2 and provides insight into the performance and impacts of all HGV road freight transport between 1984 and 2007.

Section 4 considers the trends in HGV activity between 1984 and 2007 presented in section 3 and analyses the efficiency and intensity of HGV use over the period.

Section 5 provides a more detailed insight into the road freight transport intensity and efficiency of HGVs in Britain over the last 25 years by HGV type and weight. This helps to illustrate how the importance of rigid and articulated HGVs of different weight categories has changed over time as operators have altered the composition of their fleet, as well as showing the total work and performance of each HGV type.

Section 6 considers the determinants that have led to the changes in HGV key variables (including length of haul, vehicle carrying capacity, lading factor, and empty running) over the period 1984-2007 presented in sections 3-5.

Section 7 investigates the arguments put forward by Buchan (2008) about the efficiency of articulated HGV operations in Britain and provides an alternative viewpoint based on the analysis carried out in this report.

Section 8 contains forecasting of the future level of HGV activity in 2020 based on the analysis of changes in the key variables over the period studied as presented in earlier sections. This was achieved through the use of the spreadsheet model developed which was used to consider likely future trends in the vehicle kilometres travelled by HGVs, as well as total fuel consumed and total CO_2 emissions.

Conclusions are presented in section 9.

Appendix 1 discusses the usefulness of the tonne-kilometre as a measure of freight activity and puts forward some alternative measures that could be used alongside it.

2. Measuring road freight transport activity at a national scale

2.1 The importance of road freight transport

The focus of this report is on road freight transport by heavy goods vehicles (i.e. over 3.5 tonnes gross weight). The vast majority of commercial transport in Britain is carried out by road. Road freight was responsible for 79 per cent of goods lifted in the country in 2007 compared with 5%, 4% and 6% by water, rail and pipeline respectively. In terms of tonnes moved (i.e. tonne-kilometres) road freight was responsible for 68% in 2007, compared with 20%, 8% and 4% by water, rail and pipeline respectively (DfT, 2008a).Two types of vehicle are used to carry out the overwhelming majority of commercial road freight transport: light goods vehicles (LGVs) and heavy goods vehicles (HGVs)[1]. LGVs are vehicles up and including to 3.5 tonnes gross vehicle weight (i.e. the maximum permissible weight of the unladen vehicle plus the goods it carries), while HGVs are vehicles over 3.5 tonnes gross weight.

HGVs are predominantly used for goods transport (i.e. to collect and deliver goods), while LGVs are widely used for both goods transport and to provide a wide range of services. In addition, LGVs are also commonly used for commuting to and from work (as many of those using these vehicles park them at home overnight), and are also used for personal trips by those who have access to them outside working hours (both in terms of goods trips such as shopping and other trips including visiting friends and relatives and leisure trips).

Analysis of the Department for Transport's Company Van Survey (DfT, 2007) and Survey of Privately-Owned Vans (DfT, 2004) suggests that goods trips by LGVs account for about 30% of total LGV vehicle kilometres (kms) performed in Britain, service trips by LGVs account for about 25% of LGV vehicle kms, commuting for approximately 36% of LGV vehicle kms, and personal trips for about 8% of LGV vehicle kms (Allen and Browne, 2008).

It has been estimated that of the 84% of all freight lifted by road in 2007, 79% was lifted by HGVs and 5% by LGVs. Similarly, in terms of tonnes moved, of the 68% of all freight moved by road in 2007, 64% was moved by HGVs, and 4% by LGVs (DfT, 2008a).

2.2 The analytical framework

McKinnon (2007) has constructed an analytical framework incorporating many of the factors which influence freight traffic levels and related energy consumption. This framework illustrates the links between freight transport and the economic activities that it serves. The framework links the raw materials used in the production of goods with the road freight transport activity used to transport goods to their destinations, together with the negative economic, social and environmental impacts of freight operations (including CO_2 and other pollutant emissions; noise, accidents, vibrations and visual intrusion; as well as the contribution to traffic congestion). For the purposes of this work we have adapted McKinnon's framework by: i) extending it - so that it also relates to the total HGV fleet used to carry out the road freight transport) and ii) modifying it – by taking into account imported finished goods as well as goods produced domestically and also by reversing the sequence in which the handling factor and modal split are depicted (see Figure 2.1).

This relationship can be decomposed into a series of key variables each of which converts one output value into another. These variables are explained below.

[1] Other modes are used to perform commercial goods and service trips including motorcycles, cars, bicycles and on-foot – but these represent a very small proportion of the total in terms of trips, distance and weight lifted.

- Handling factor – each tonne of product is typically handled more than once as it makes it way through the supply chain from point of production to point of sale/consumption. The handling factor determines how the goods produced and imported into the economy are translated into the total tonnes of lifted that require to be lifted by all transport modes.

- Modal split – determines the quantity of goods produced and imported into the economy that are handled by road freight (as opposed to other freight transport modes)

- Length of haul – the average length of links in the supply chain over which goods lifted are transported on road freight trips. The length of haul and the handling factor together determine the 'transport intensity' of an economy. The tonne-kilometres of road freight activity are a product of the total tonnes lifted by road and average length of haul.

- Load on laden trips – the quantity of goods carried on a road freight vehicle is one of the two determinants of the vehicle traffic (i.e. vehicle kilometres travelled) required to move these tonne-kilometres (the other being empty running). The average load on laden trips is in turn determined by the carrying capacity of the vehicle (i.e. how much it is capable of carrying) and the lading factor (i.e. the extent to which the carrying capacity of the vehicle is utilised on laden trips).

- Empty running – the other determinant of vehicle kilometres travelled (together with the average load on laden trips) is empty running. This refers to the distance that the vehicle travels empty (i.e. without a load).

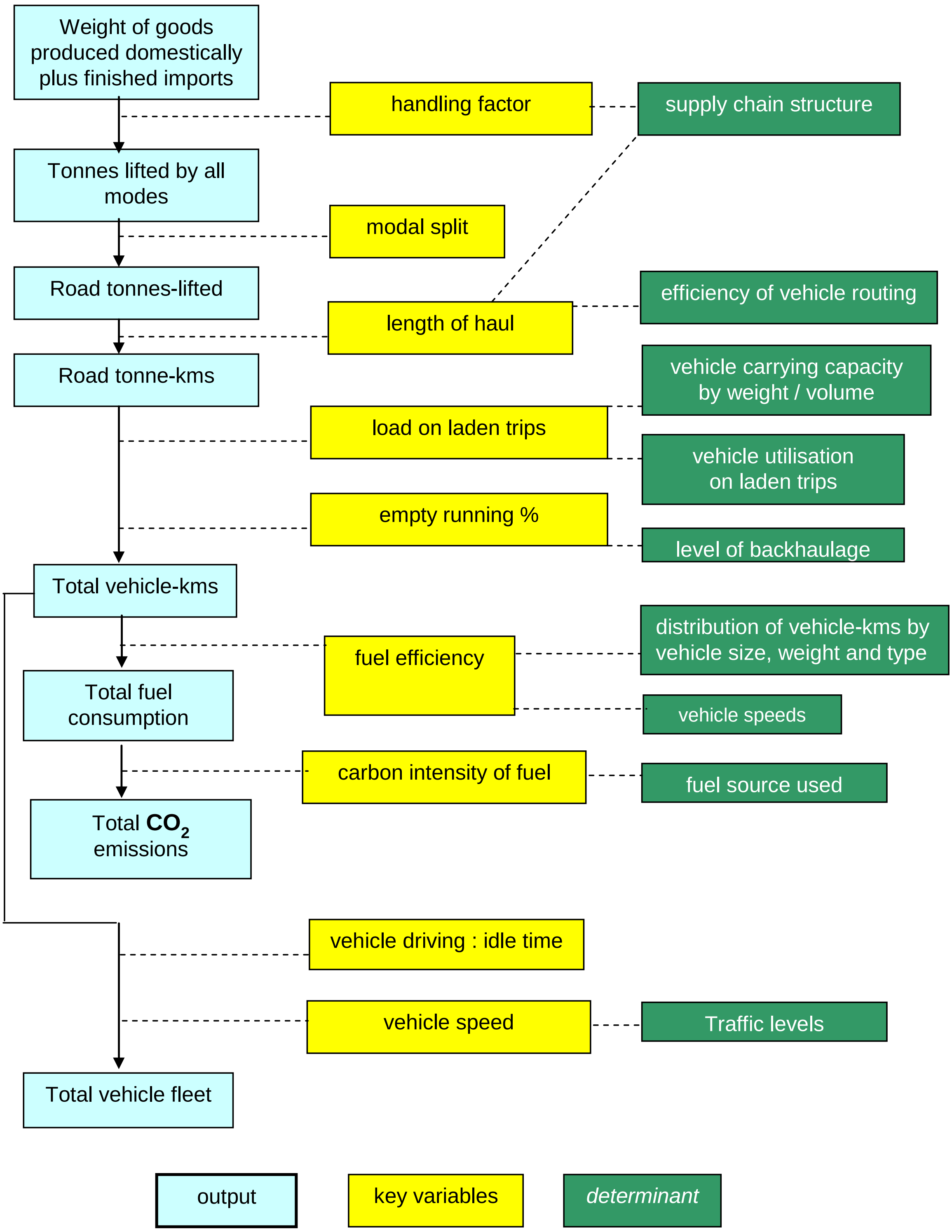
- The fuel efficiency of the vehicle determines the total quantity of fuel consumed on a journey. This depends on the mix of vehicle size, type and weight used, as well as the average vehicle speed, which depends on traffic levels and is influenced by the pattern, timing and location of road freight activities and the traffic conditions at these times on particular roads. Driver behaviour also plays a part.

- The carbon intensity of the fuel determines the total CO_2 emitted from the together quantity of fuel consumed.

- The total time that goods vehicles are driven for together with the average speed at which they are driven determine the total vehicle fleet required to carry out the required quantity of vehicle kilometres.

Figure 2.1 shows the relationships between these determinants, key variables and outputs.

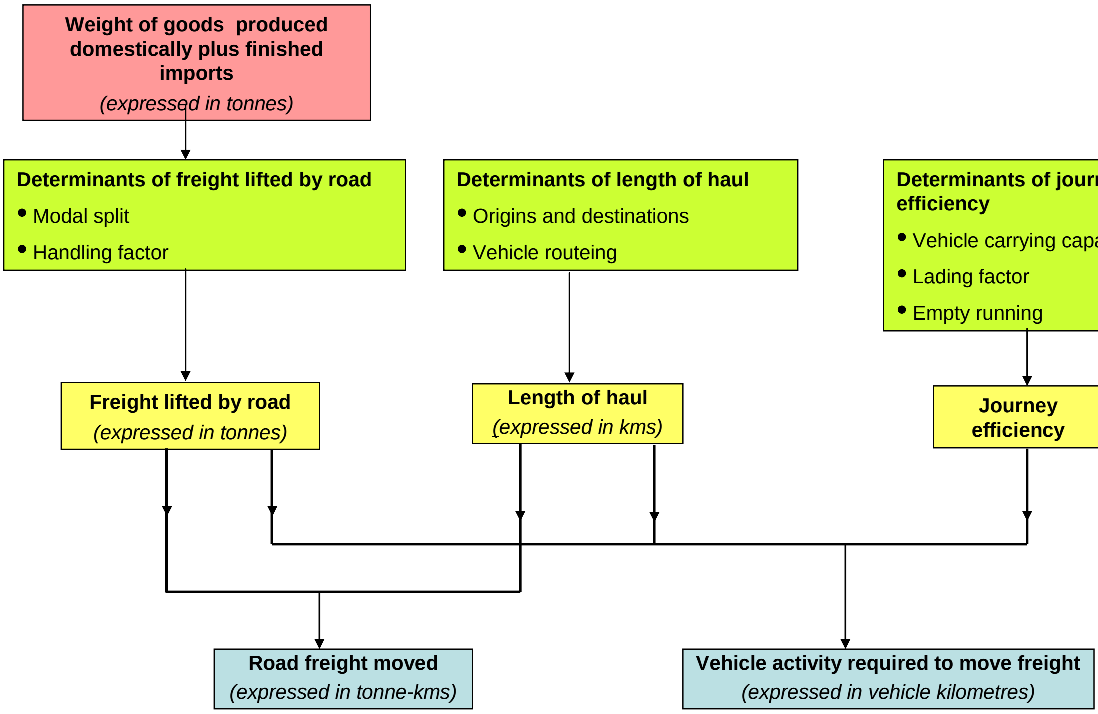
Figure 2.1: Relationship between determinants, key variables and outputs of road freight transport



Source: adapted from McKinnon, 2007.

Banister (2005) has noted that travel (including freight transport) “can be broken down into three component parts: volume, distance and efficiency”. As explained above, “volume” (i.e. quantity of goods lifted) and “distance” can be combined to provide road freight tonne-kilometres performed. “Efficiency” relates to important factors such as travel times and prices, resource use, technology and organisation. Figure 2.2 provides a diagrammatic representation of the relationship between these component parts in the case of road goods transport.

Figure 2.2: Relationship between road freight transport volume, distance and efficiency



These efficiency factors (described in the previous paragraph) together with important supply chain decisions (including supply chain structures, mode choice, vehicle fleet mixes, backhaulage rates, and lading factors) influence the “key variables”.

2.3 Calculating changes in key variables for light and heavy goods vehicles in Britain

Using data collected by the UK Department for Transport it is possible to analyse how these key variables and determinants of road freight transport activity have changed since 1984 onwards using the framework described in the previous section. The main source of this data is the Continuing Survey of Road Goods Transport (CSRGT), which is a survey of British-registered goods vehicles carrying out domestic operations (for the latest edition see DfT, 2008b).

The CSRGT was initially developed by two statisticians working in the Ministry of Transport during the 1950s, K.F. Glover and D.N. Miller. They were responding to the lack of data available about road freight operations in terms of factors such as the total quantity of goods lifted, the distance over which it was transported, and the types of goods carried. This was in contrast to the railways for which much data existed. They therefore set about developing a one-off survey that could be carried out on a sample of operators to obtain this insight. They obtained useful background information for their initial survey design from a one-week survey of freight operators that had taken place in 1948 to investigate the effects of fuel rationing. Glover and Miller designed a survey that was sent to approximately 8,000 goods vehicle operators requesting one week of operational data about one of their vehicles. It was a statutory survey and it achieved a response rate of approximately 90%. All weights of goods vehicles were included in the survey but steam and electrically powered vehicles were excluded. Information collected included vehicle age, unladen weight, carrying capacity, fuel source and time spent idle by the vehicle. Respondents were asked to provide details of all journeys carried out during the survey week including details of the origin and destination, the type and weight of goods carried, the distance travelled (split into distance travelled when more than 50% full by weight, less than 50% full by weight, and empty), and the maximum load weight at any point on the each journey. From the data collected Glover and Miller calculated tonnes moved, average length of haul and produced annual estimates (Glover and Miller, 1954).

The Ministry of Transport carried out a similar week-long survey in 1958 using a similar sampling methodology (Glover, 1960). In 1962 the Ministry of Transport carried out another survey, this time the survey was conducted with a much larger sample size than the previous two surveys and was spread across four one-week survey across the entire year to provide information about seasonal patterns in activity and to provide a more reliable estimate of total annual activity. The 1962 survey also collected data about vehicle body type, and more detail about loaded journeys (Ministry of Transport, 1962). The survey was repeated again in 1967/8 and then again in 1973, from which point on it became an annual, continuous year-round survey and was referred to as the CSRGT (Cundill and Shane, 1980). The CSRGT collects data from approximately 350 vehicles per week.

It is important to make two points about this CSRGT data. First, the data in CSRGT is based on the weight of goods carried by HGVs rather than the volume of goods. If the weight to volume ratio of goods (i.e. the bulk density) has been changing over time this would result in this weight-based analysis only providing a partial insight of the performance of HGVs. It is highly likely that a reduction in the bulk density of goods has been taking place over recent decades. This is due to two factors: i) product manufacturers and designers efforts to reduce the amount of heavy materials used to manufacture a particular product and its packaging (known as lightweighting), and ii) increased consumption of new-to-market products with lower average bulk densities than in the past (i.e. the types of new products being purchased by consumers in recent years have lower bulk densities than the products that were being purchased say ten or twenty years ago). If changes in the average bulk densities of products have been occurring then the performance of HGVs may be better if measured by volume than is reflected by a product weight-based analysis. Unfortunately only the latter is possible due to the lack of data collection in CSRGT about product and vehicle load volumes.

Second, only goods vehicles with a gross weight of over 3.5 tonnes (i.e. HGVs) are included in CSRGT. Light goods vehicles (i.e. goods vehicles up to and including 3.5 tonnes gross) are also used to carry out goods collection and delivery (in addition to heavy goods vehicles). Unlike HGVs, LGVs have other uses to just carrying goods and are also used to perform servicing tasks, for commuting, and for personal travel (Allen and Browne, 2008). However there is far less data available about the use of LGVs for goods transport and other activities than for HGVs. Only occasional surveys of the activity of LGVs have been carried out by the Department for Transport, and these have tended to capture less detail than the CSRGT has about HGV activity. This precludes the same level of analysis of LGV activity over the period 1984 to 2007 that is presented for HGVs in this report.

2.4 Developing a spreadsheet to relate the determinants, key variables and outputs

For the research carried out as part of this report a spreadsheet model was developed to relate the determinants, key variables and outputs (as shown in Figure 2.1). The model was populated with data from the CSRGT (DfT, 2008b) for the period 1984 to 2007, together with data on material extracted and imported for production of goods from the Environmental Accounts (ONS, 2009), data for goods lifted and moved domestically by non-road modes, and finished goods imported by water, rail and air (DfT, 2008a) and vehicle fleet data (DfT, 2008a).

The CSRGT contains details of British-registered goods vehicles and therefore the analysis excludes the activity of foreign-registered goods vehicles operating in Britain (including those from Northern Ireland).

Figure 2.3 shows where the data coverage of the CSRGT starts and ends in relation to this framework.

Figure 2.3: Data coverage of CSRGT in relation to the framework

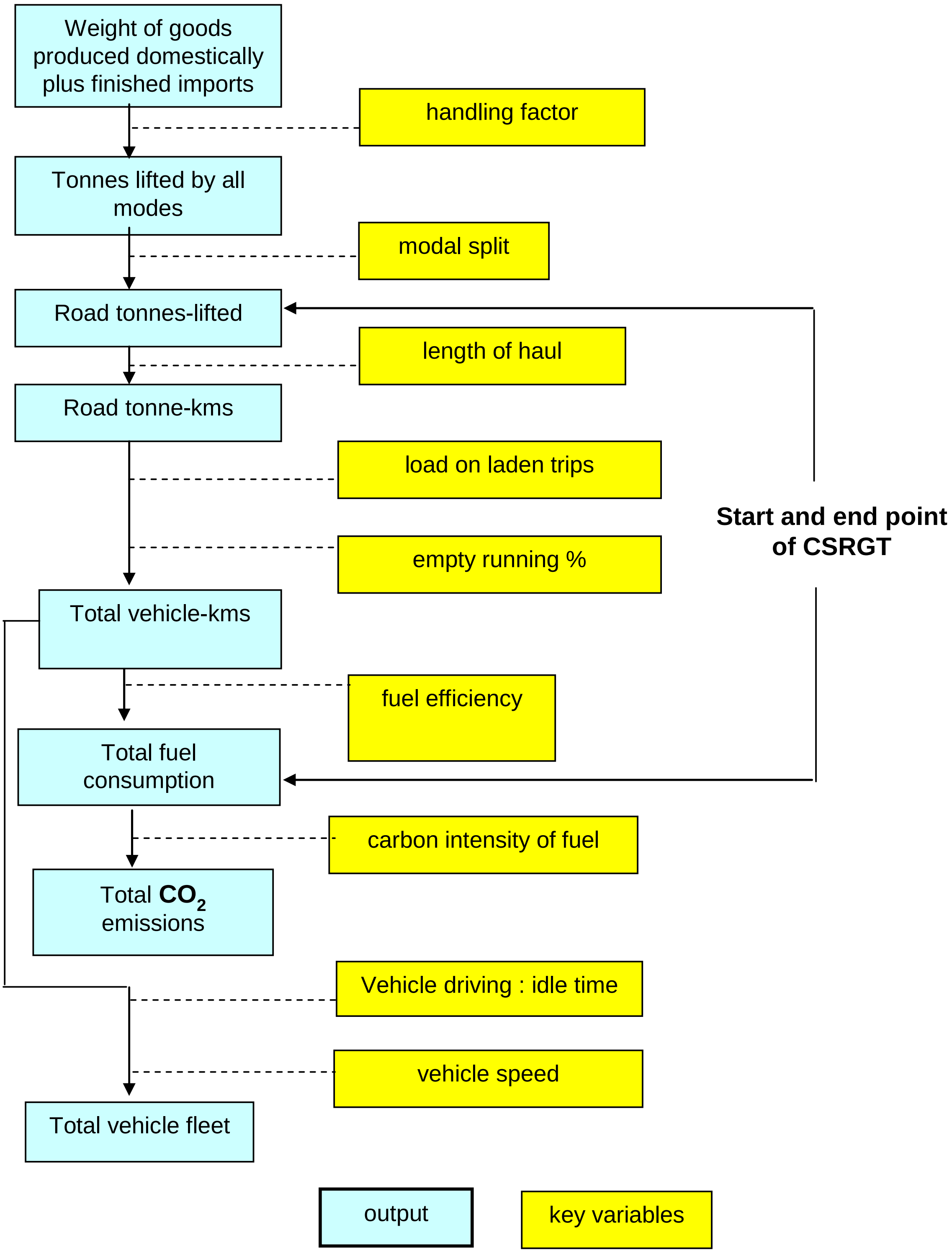


Table 2.1 shows which of the determinants, key variables and outputs needed to be calculated and which were obtained from existing sources (together with the source).

Table 2.1: Details of which determinants, key variables and outputs had to calculated and which were obtained from existing sources together with their units

Determinant, key variable or output	Units	Symbol	Source of data
Goods and materials produced and finished goods imported	Tonnes	A	Data from DfT, 2008a; ONS, 2009.
Handling factor	Stages	B	Calculated
Total goods lifted by all modes	Tonnes	C	Data from DfT, 2008a
Modal share	Percentage	D	Calculated
Goods lifted by road	Tonnes	E	Data from DfT, 2008b
Length of haul	Kilometres	F	Data from DfT, 2008b
Goods moved by road	Tonne-kilometres	G	Calculated
Vehicle utilisation on laden trips	Percentage	H	Data from DfT, 2008b
Vehicle carrying capacity by weight	Tonnes	I	Calculated
Load on laden trips	Tonnes	J	Calculated
Load on all trips (laden and empty)	Tonnes	K	Calculated
Empty running	Percentage	L	Data from DfT, 2008b
Laden vehicle kilometres	Kilometres	M	Calculated
Empty vehicle kilometres	Kilometres	N	Calculated
Total vehicle kilometres	Kilometres	O	Data from DfT, 2008b
Fuel efficiency	Kilometres per litre	P	Data from DfT, 2008b
Total fuel consumed	Litres	Q	Calculated
CO_2 content of fuel	Kg per litre	R	Data from DfT, 2008a
Total CO_2 emissions	Tonnes	S	Calculated
Vehicle speed	Kilometres per hour	T	Assumed
Distance travelled per vehicle	Kilometres	U	Calculated
Total vehicle fleet	Number of vehicles	V	Data from DfT, 2008a

The mathematical relationships between the data assembled in order to determine the values of the determinants, key variables and outputs are described below.

(1) B = C / A

(2) D = C / E

(3) G = E x F

(4) I = (G / (O x (100-N/100))) / J

(5) J = G / ((O x (100-N/100) x I)

(6) K = G / (O x I)

(7) M = G / J

(8) N = (O x (100-N/100))

(9) Q = O / P

(10) S = O / R

(11) U = O / V

2.5 Measuring the intensity, utilisation and efficiency of HGV activity

Several measures of the intensity, utilisation and efficiency of road freight transport in relation to the analytical framework have been devised. Figure 2.4 shows efficiency and utilisation measures, while Figure 2.5 shows transport intensity measures that can be used to analyse road freight transport.

The efficiency and utilisation of road freight transport is based on analysis per tonne-kilometre of road freight. The intensity of road freight transport is based on analysis per tonne of freight lifted by road (see Figure 2.1). An analysis of vehicle kilometres per tonne lifted takes account of length of haul, vehicle carrying capacity, lading factor, and rates of empty running. By contrast an analysis of the ratio of vehicle kilometres to tonne-kilometres takes account of vehicle carrying capacity, lading factor, and rates of empty running but not length of haul.

Therefore analysis of vehicle kilometres per tonne lifted reflects the distance over which the goods are transported as well as the efficiency of vehicle use in terms variables that determine how tonne-kilometres are translated into vehicle kilometres, whereas the an analysis of the ratio of vehicle kilometres to tonne-kilometre will only take account of the efficiency variables (as tonne-kilometres already reflect distance travelled).

Given that measuring road freight transport intensity (in terms of vehicle kilometres or fuel consumed or CO_2 emissions per tonne lifted) reflects the distance over which goods are transported (as well as other variables) it can be seen to reflect the efficiency of vehicle use and the vehicle kilometres travelled. Given that vehicle kilometres determine, or are most strongly related to, many of the negative impacts of HGV activity (such as fuel consumption, pollutant emissions, contribution to congestion, number of casualties, noise, vibrations and visual intrusion), the road freight transport intensity can be seen to reflect the sustainability of goods vehicle operations.

Therefore from the perspective of a policy maker, the intensity of road freight transport is of the greatest interest as it reflects the distance that HGVs are driven on the roads, the fuel they consume or CO_2 emissions per tonne of goods lifted. Reducing the road freight transport intensity would result in less HGV activity per unit of freight handled, thereby alleviating the negative impacts associated with HGV activity.

A measure of either road freight transport efficiency or intensity (i.e. in tonne-kilometres or tonnes lifted) that is expressed on a per vehicle per annum basis will reflect the vehicle speed and vehicle time utilisation (in terms of the proportion of time that the vehicle is being used productively on the road).

It is also possible to measure the road freight transport intensity per tonne of goods produced domestically plus finished imports rather than per tonne of road freight lifted. This would also take account of the handling factor and the modal split. However data on weight of goods produced domestically plus finished imports is not as reliable as CSRGT data and comes from several different sources, so the result is unlikely to be as robust and reliable as a measure.

The method of calculation of these measures of intensity, utilisation and efficiency together with their units are provided below (letters used in the equations refer to Table 2.1).

(1) Vehicle utilization = G / O

(Units tonne-kms: vehicle kms)

The ratio of tonne-kilometres to total vehicle kilometres reflects the efficiency of road freight transport in relation to the vehicle carrying capacity, the lading factor on laden journeys and the extent of empty running.

(2) Road freight transport fuel efficiency = Q / G

(Units: litres of fuel consumed per tonne-km)

The ratio of tonne-kilometres to total fuel consumption reflects the efficiency of road freight transport in relation to the vehicle carrying capacity, the lading factor on laden journeys, the extent of empty running, and the fuel efficiency of vehicles.

(3) Road freight transport CO_2 efficiency = S / G

(Units: kg CO_2 per tonne-km)

The ratio of tonne-kilometres to CO_2 emissions reflects the efficiency of road freight transport in relation to the vehicle carrying capacity, the lading factor on laden journeys, the extent of empty running, the fuel efficiency of vehicles, and the carbon intensity of fuel.

(4) Road freight transport efficiency per vehicle = G / V

(Units: Tonne-kms per annum per vehicle)

The tonne-kms per vehicle per year is dependent on the vehicle carrying capacity, the lading factor of goods vehicles on laden journeys, the extent of empty running, the average vehicle speed and the time utilisation of the vehicle.

(5) Road freight transport intensity = O / E

(Units: vehicle kilometres travelled per tonne lifted – i.e. how far each tonne lifted is being transported)

The vehicle kilometres per tonne lifted is dependent on the length of haul, the vehicle carrying capacity, the lading factor of goods vehicles on laden journeys, and the extent of empty running. Therefore, vehicle kilometres are the ultimate outcome of the degree of efficiency of goods vehicle operations as well as reflecting the distance over which goods are transported. In addition, vehicle kilometres determine, or are most strongly related to, many of the negative impacts of HGV activity (such as fuel consumption, pollutant emissions, contribution to congestion, number of casualties, noise, vibrations and visual intrusion). The intensity (and the sustainability) of goods vehicle operations can therefore be reflected in the relationship between total goods lifted by goods vehicles and the total vehicle kilometres performed by goods vehicles.

(6) Road freight transport fuel intensity = Q / E

(Units: litres of fuel consumed per tonne lifted)

The fuel consumed per tonne lifted is dependent on the length of haul, the vehicle carrying capacity, the lading factor of goods vehicles on laden journeys, the extent of empty running, and the fuel efficiency of vehicles.

(7) Road freight transport CO_2 intensity = S / E

(Units: kg CO_2 per tonne lifted)

The fuel consumed per tonne lifted is dependent on the length of haul, the vehicle carrying capacity, the lading factor of goods vehicles on laden journeys, the extent of empty running, the fuel efficiency of vehicles, and the carbon intensity of fuel.

(8) Road freight transport intensity per vehicle = E / V

(Units: Tonnes lifted per annum per vehicle)

The tonne lifted per vehicle per year is dependent on the length of haul, the vehicle carrying capacity, the lading factor of goods vehicles on laden journeys, the extent of empty running, the average vehicle speed and the time utilisation of the vehicle.

(9) An alternative measure of road freight transport intensity = O / A

This will reflect the handling factor and the modal split as well as the average length of haul, the average vehicle carrying capacity, the lading factor of goods vehicles on laden journeys, and the extent of empty running. However, as discussed above, the quality of available data is likely to make this measure less reliable.

Figure 2.4: Measures of road freight transport utilisation and efficiency in relation to the framework

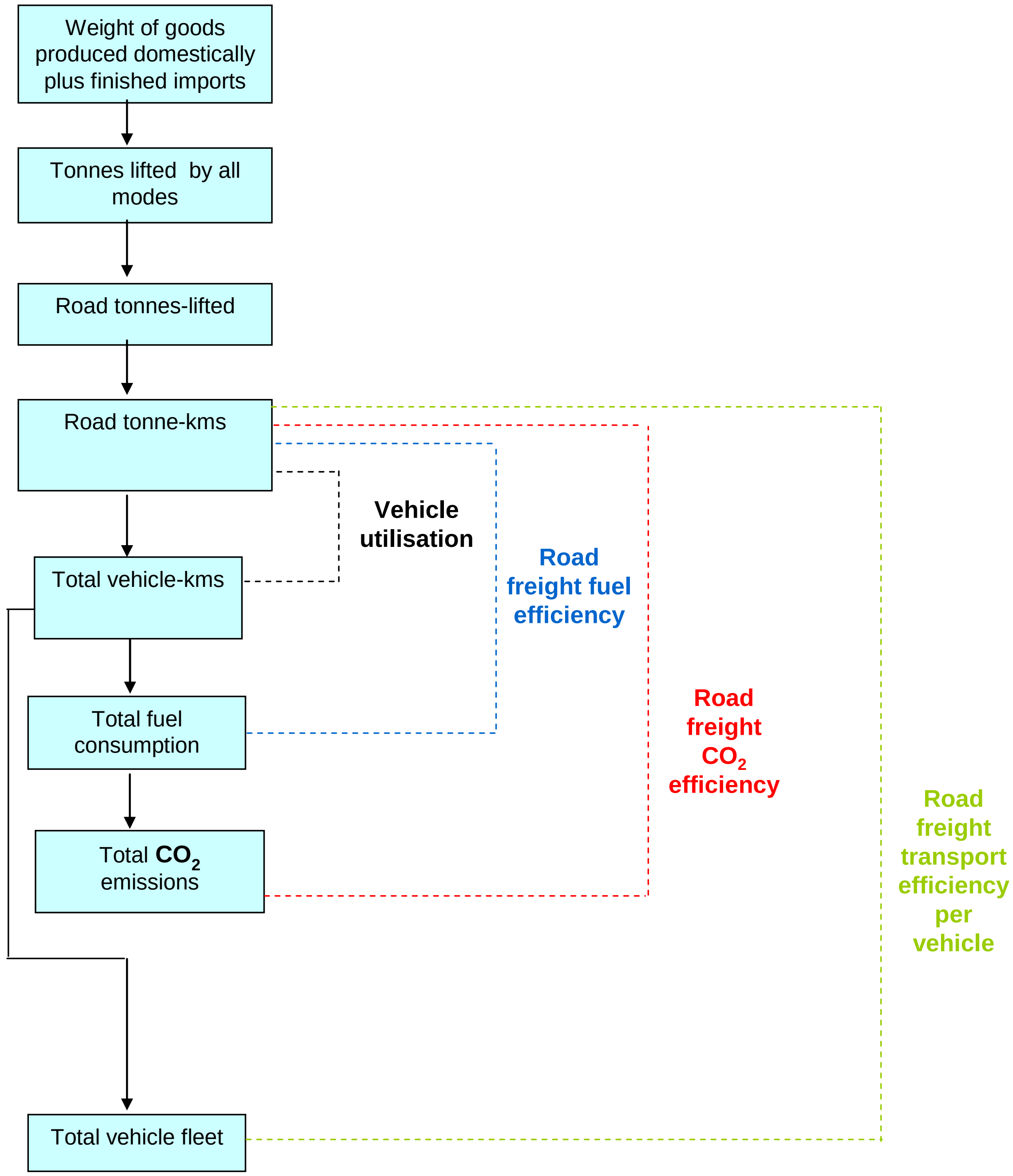
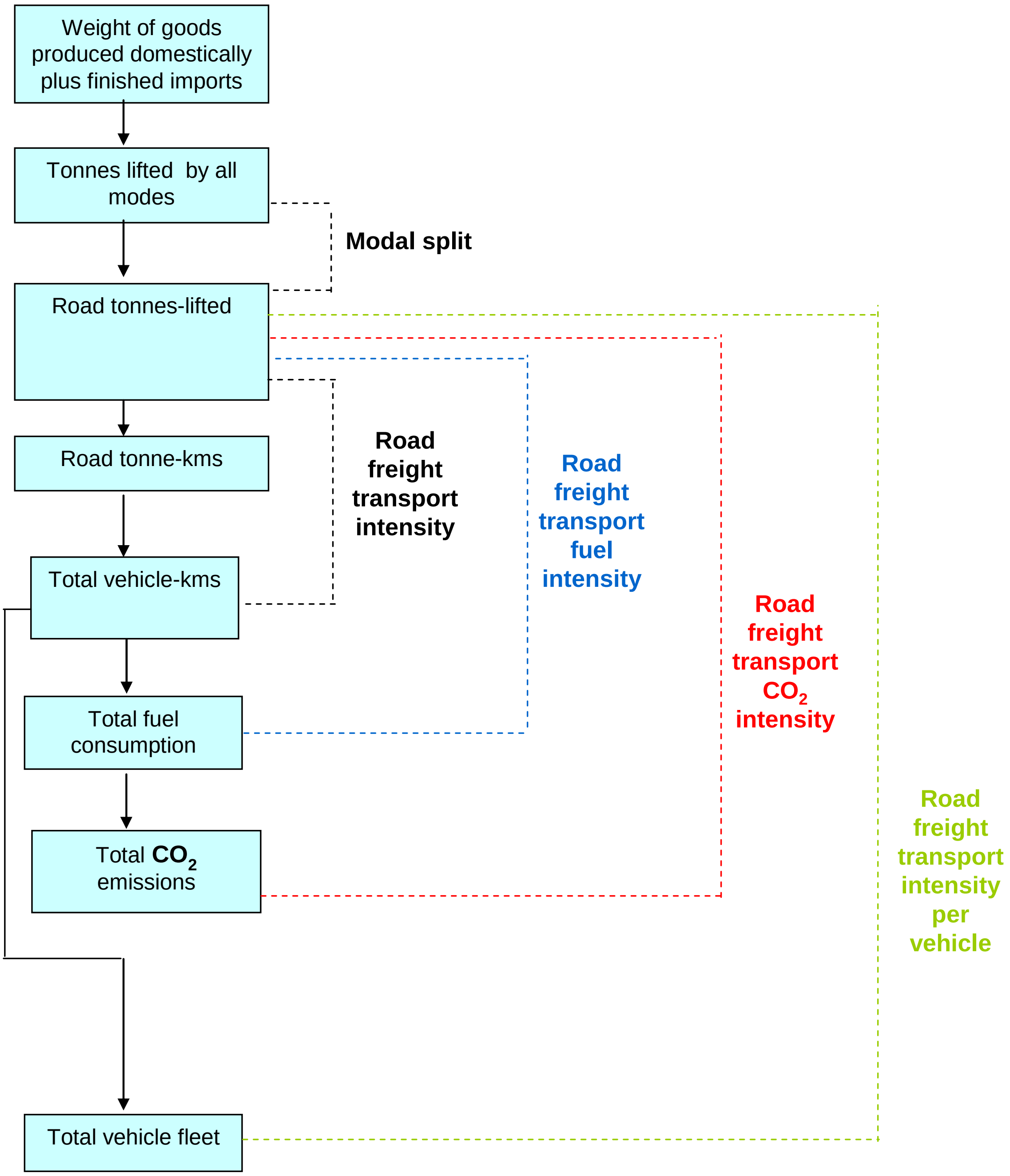


Figure 2.5: Measures of road freight transport intensity in relation to the framework



3. Analysis of total HGV activity in Britain

This section contains an analysis of all HGV (i.e. goods vehicles over 3.5 tonnes gross weight) activity in Britain by British-registered vehicles between 1984 and 2007 using the framework described in sections 2.2-2.4. The key variables and outputs in Figure 2.1 are dealt with in the following sections, starting with goods produced domestically plus finished imports (section 3.1) and ending with road safety (section 3.14).

3.1 Goods produced domestically plus finished imports

The CSGRT collects data about goods moved by HGVs without attempting to determine the number of times that the same goods are transported during their travel along their particular supply chain from point of production to point of consumption. Therefore it is not possible to derive the handling factor from CSRGT data.

This is referred to as the handling factor and it reflects the way on which the goods produced and imported into the economy are translated into the total tonnes of lifted that require to be lifted by all transport modes.

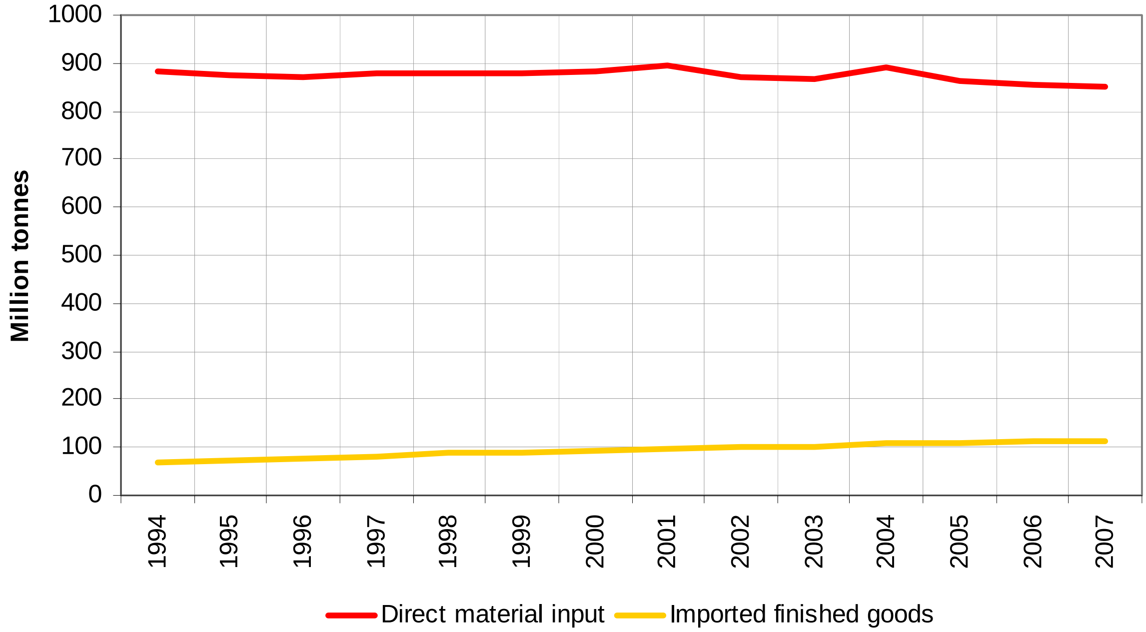
It is however possible to attempt to calculate the handling factor for goods transported in Britain. This can be done by using two sources of data: i) material flows data as reflected by the Direct Material Input (DMI), and ii) the quantity of finished goods imported into the country.

Direct Material Input (DMI) is “the sum of the total amounts of primary resources extracted from the UK environment and the amount of imports into the UK” (ONS, 2009). It therefore reflects all the movement of fuels and raw materials (made up of biomass, minerals, fossil fuels and other products) into and within the country for goods production and energy needs. DMI can therefore be used as a proxy for all goods and materials requiring transportation in order to be economically useful. These goods will potentially require transporting more than once as they make their way through stages of production and move between various manufacturing, stockholding and retailing/consumption locations.

The other source of goods that require transportation in Britain that are not accounted for by DMI are finished and semi-finished products that are manufactured overseas and imported into the country (by water, rail and air). These goods need to be transported from their point of entry to the country to their final point of sale/consumption.

Figure 3.1 shows the quantity of DMI in the UK and finished (and semi-finished) goods imported into the country for the period 1994-2007. It is not possible to obtain data for the period prior to 1994 due to the unavailability of port statistics by commodity type. This shows that DMI was roughly eight times greater than the quantity of imported finished and semi-finished goods (approximately 800 million tonnes in 2007 compared with approximately 100 million tonnes).

Figure 3.1: DMI and imported finished goods, 1994-2007 (million tonnes)

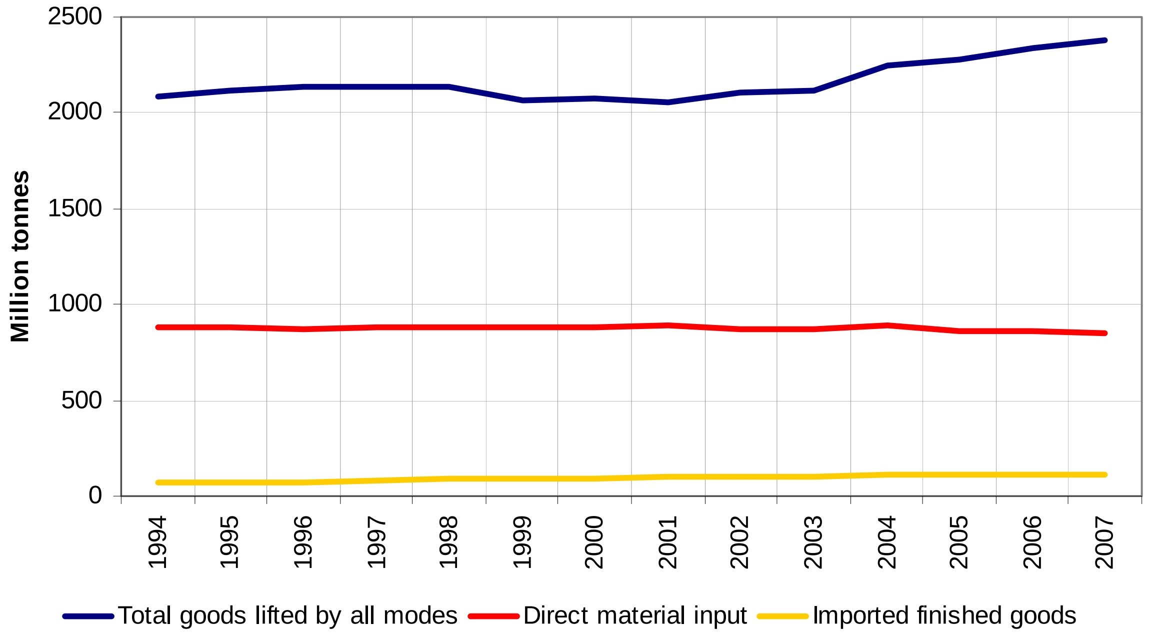


Source: ONS, 2009; DfT, 2008a; Eurotunnel, 2008.

However, the weight of imported finished goods rose by 65% between 1994 and 2007, while the weight of DMI fell by 4% over the same period. This reflects the decline in manufacturing in Britain and its growing dependence on imported finished goods.

Figure 3.2 shows the total quantity of goods transported domestically within Britain by British-registered transport modes together with the quantity of DMI and imported finished goods over the period 1994 to 2007. The difference between the weight of DMI and imported finished goods, and the total weight of goods lifted for transportation by all modes is accounted for by the handling factor (i.e. the fact that goods are typically transported more than once within their respective supply chains from production to consumption.

Figure 3.2: DMI, imported finished goods, and total goods lifted domestically by all transport modes, 1994-2007 (million tonnes)



Source: ONS, 2009; DfT, 2008a; Eurotunnel, 2008.

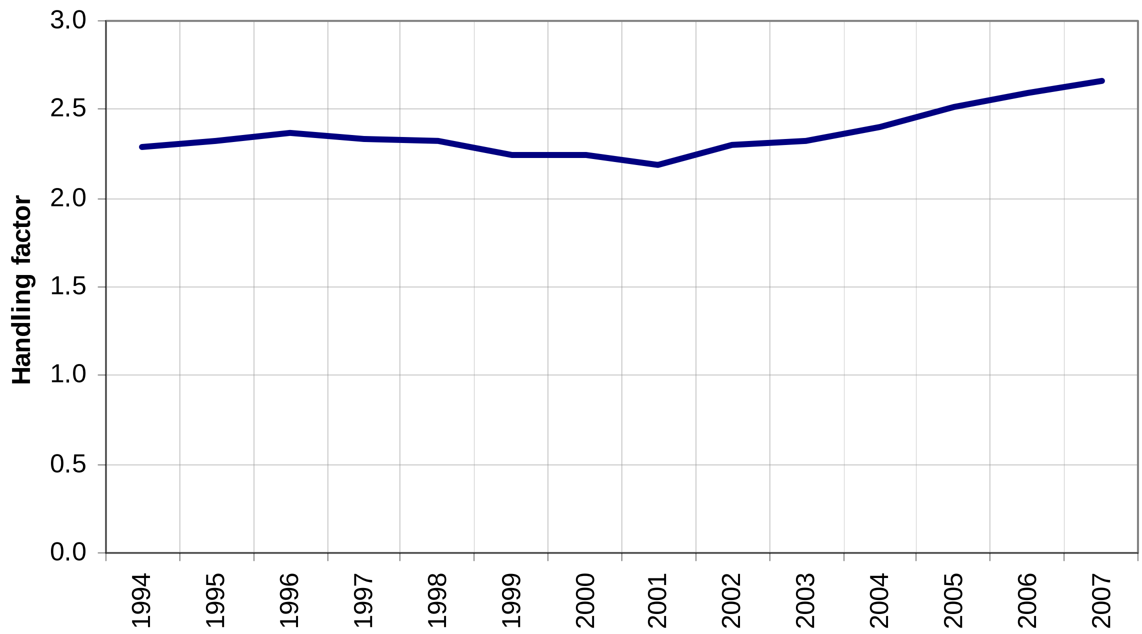
3.2 Handling factor

In calculating the handling factor an important distinction needs to be made between DMI (i.e. raw materials and energy used in production in Britain) and imported finished and semi-finished goods. While DMI is subject to various manufacturing and processing stages and the consequent transportation associated with this, imported finished and semi-finished goods will be subject to fewer transport stages due to the fact that they have already been subject to manufacturing in their country of origin.

Imported finished and semi-finished goods will consist of the following transport activity: i) some finished goods will be transported directly from their point of entry to the country to their final destination on British-registered vehicles (a handling factor of 1), ii) some finished goods will be transported via a distribution centre to their final destination on British-registered vehicles (a handling factor of 2) iii) some semi-finished goods will be transported on British-registered vehicles to a manufacturing/processing facility and eventually to their final destination (a handling factor of more than 1), iv) in the case of finished and semi-finished goods entering the country by Roll-On Roll-Off ferries these will be transported by foreign-registered goods vehicles either directly to their final destination (a handling factor of 0 as these goods are not lifted by British-registered vehicles) or to distribution centre or manufacturing facility (a handling factor of 0 with a handling factor of 1 or more from distribution centre/manufacturing facility onwards to their final destination). Given this range of transport possibilities for imported finished and semi-finished goods it has been assumed that these goods have an average handling factor of 1 within Britain. Multiplying the quantity of finished and semi-finished imported goods by a handling factor of 1 provides an estimate of the total freight lifted by British-registered transport modes that these goods account for.

The DMI will be responsible for the remainder of the total freight lifted by British-registered transport modes once the imported finished goods have been taken into account. The handling factor for DMI can then be estimated by dividing this remaining freight lifted by British-registered transport modes by the DMI. The estimated handling factor for DMI is shown in Figure 3.3. The estimate indicates that the handling factor in 2007 was 2.7, compared with 2.3 in 1994. This suggests that the number of stages in product supply chains in Britain has been increasing over the period.

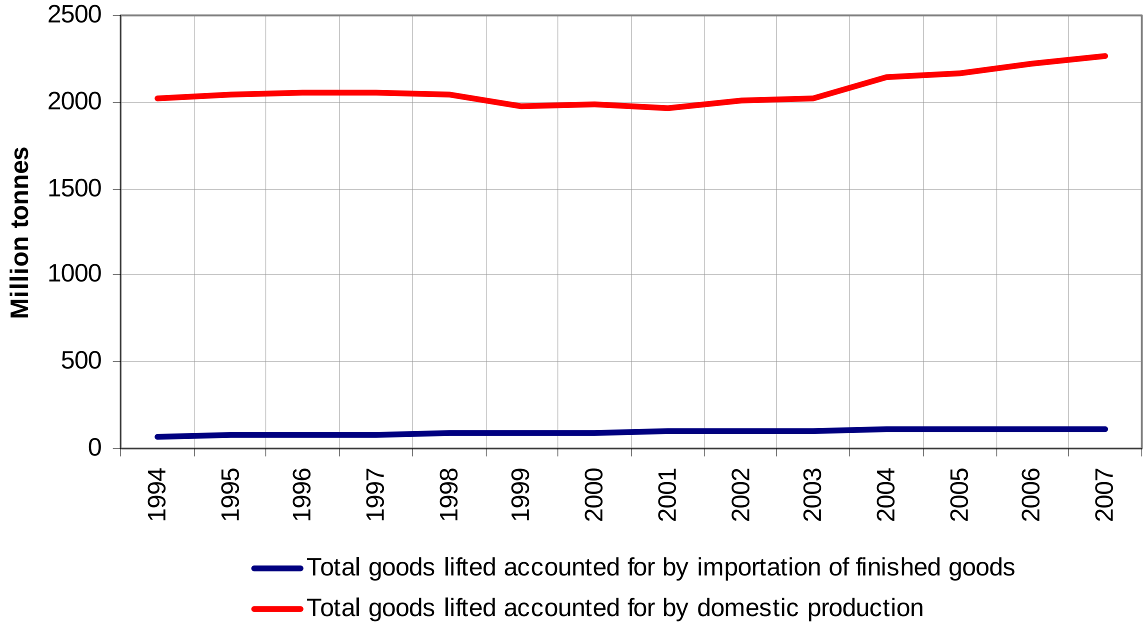
Figure 3.3: Estimated handling factor for DMI lifted in Britain, 1994-2007



Source: calculated from data in ONS, 2009; DfT, 2008a.

Figure 3.4 shows the estimated split of all tonnes lifted domestically in Britain between DMI and finished imported goods based on their respective handling factors.

Figure 3.4: Split of all tonnes lifted domestically in Britain between DMI and finished imported goods, 1994-2007



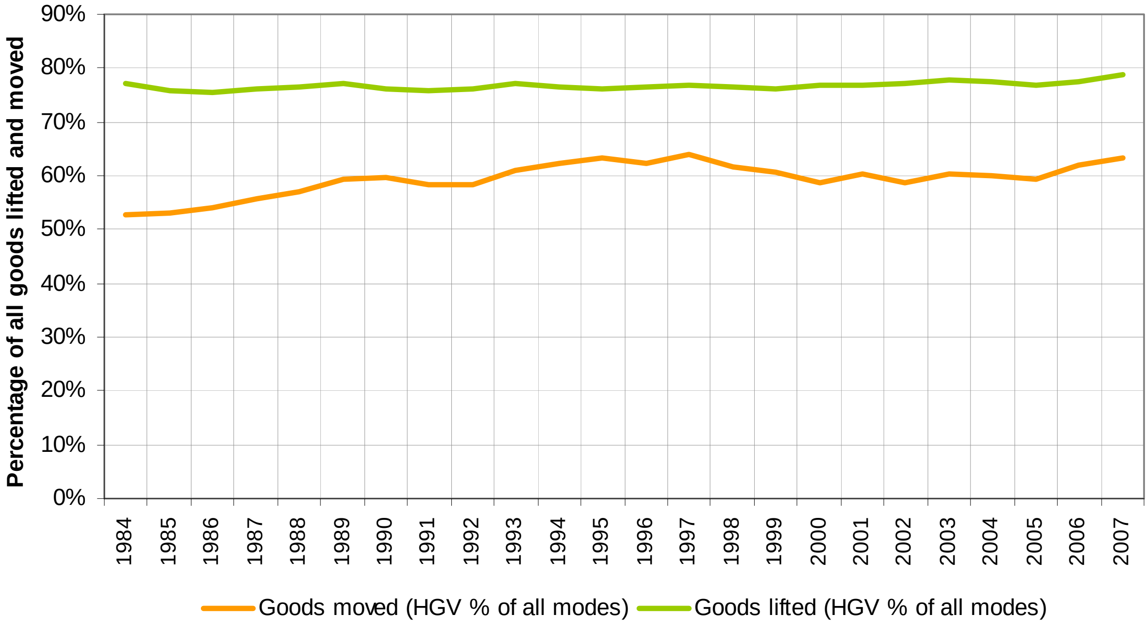
Source: calculated from data in ONS, 2009; DfT, 2008a.

3.3 Modal split

Domestic freight activity (in terms of goods lifted and moved) in Britain is carried out by several modes including road, rail, water and pipeline

Figure 3.5 shows the proportion of all goods lifted and moved by road goods vehicles in Britain between 1984 and 2007.

Figure 3.5: Proportion of total goods lifted and moved by road goods vehicles in Britain, 1984-2007



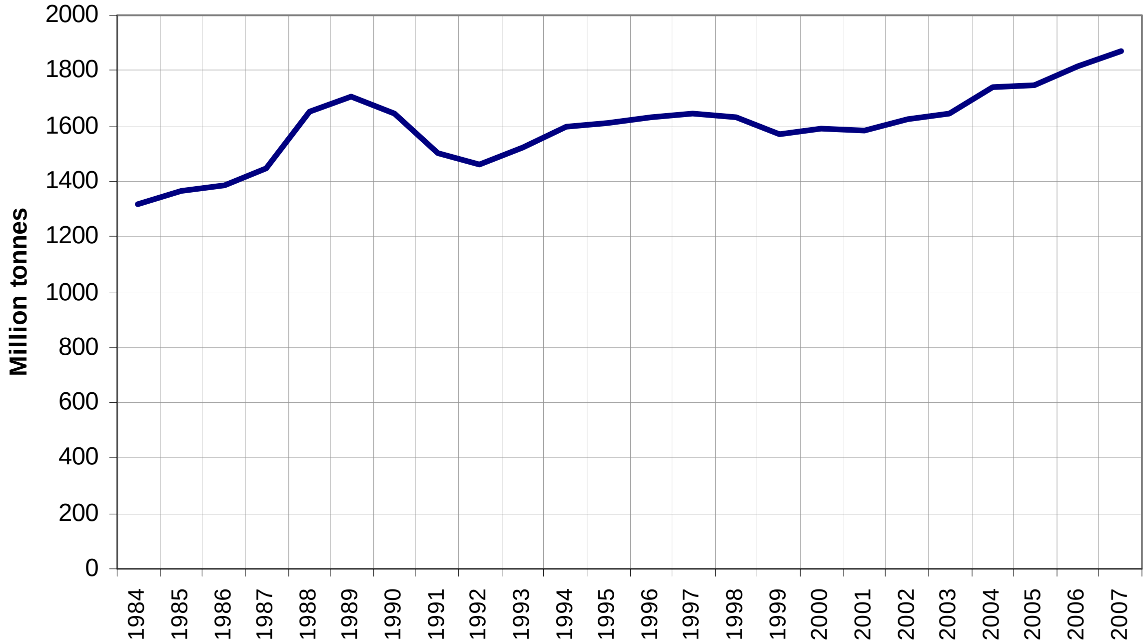
Source: DfT, 2008a.

Figure 3.5 shows that HGVs were responsible for 77% of goods lifted and 53% of goods moved by all modes (road, water, water and pipeline) in Britain in 1984. Although the proportion of goods lifted by road only rose slightly over the period shown (to 79% in 2007), the proportion of freight lifted by road has risen markedly over the period (to 63% by 2007).

<u>3.4 Goods lifted by HGVs</u>

The modal split (as discussed in the previous section) determines the total quantity of goods lifted by HGVs (i.e. goods vehicles over 3.5 tonnes). Figure 3.6 shows the quantity of goods lifted by HGVs in Britain over the period 1982 to 2007. This reflects a general upward trend in the quantity of goods lifted by HGVs over the last 25 years, albeit with declines during periods of recession, such as in the early 1990s.

Figure 3.6: Goods lifted by HGVs in Britain, 1984-2007

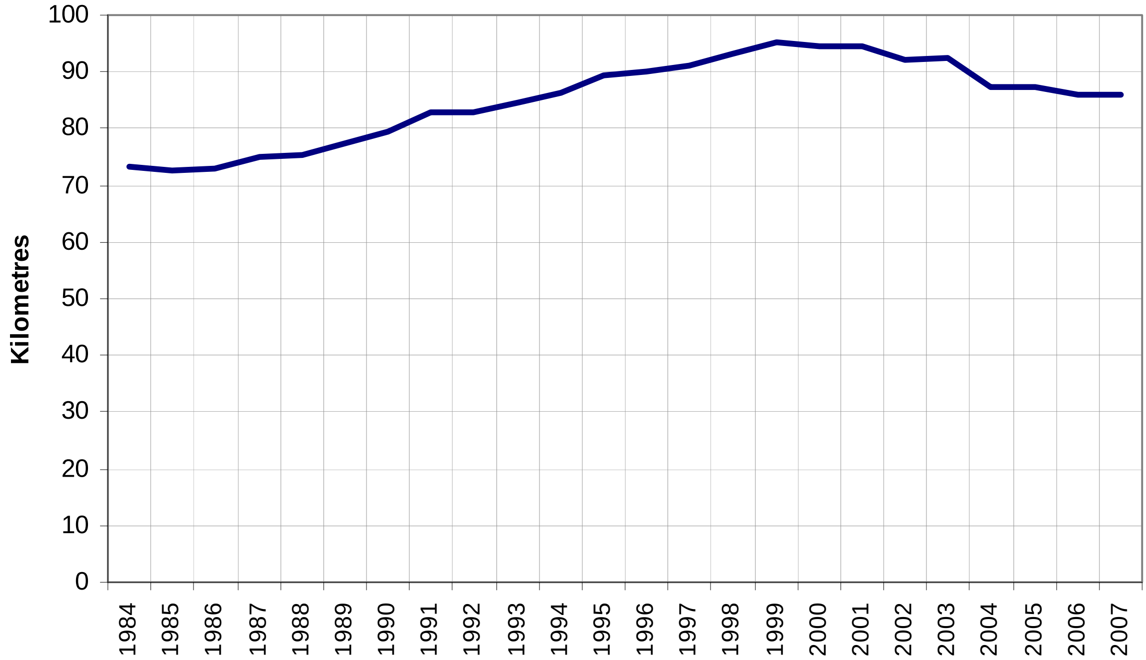


Source: DfT, 2008b, 1999, 1995.

<u>3.5 Average length of haul by HGVs</u>

Figure 3.7 shows changes in the average length of haul (tonne-kms / tonnes) by HGVs over the period 1982-2007. Average length of haul can be seen to have risen substantially between 1984 and 1999, since when it has fallen (but remains well above its 1984 level)

Figure 3.7: Average length of haul by HGVs in Britain, 1984-2007



Source: DfT, 2008b, 1999, 1995.

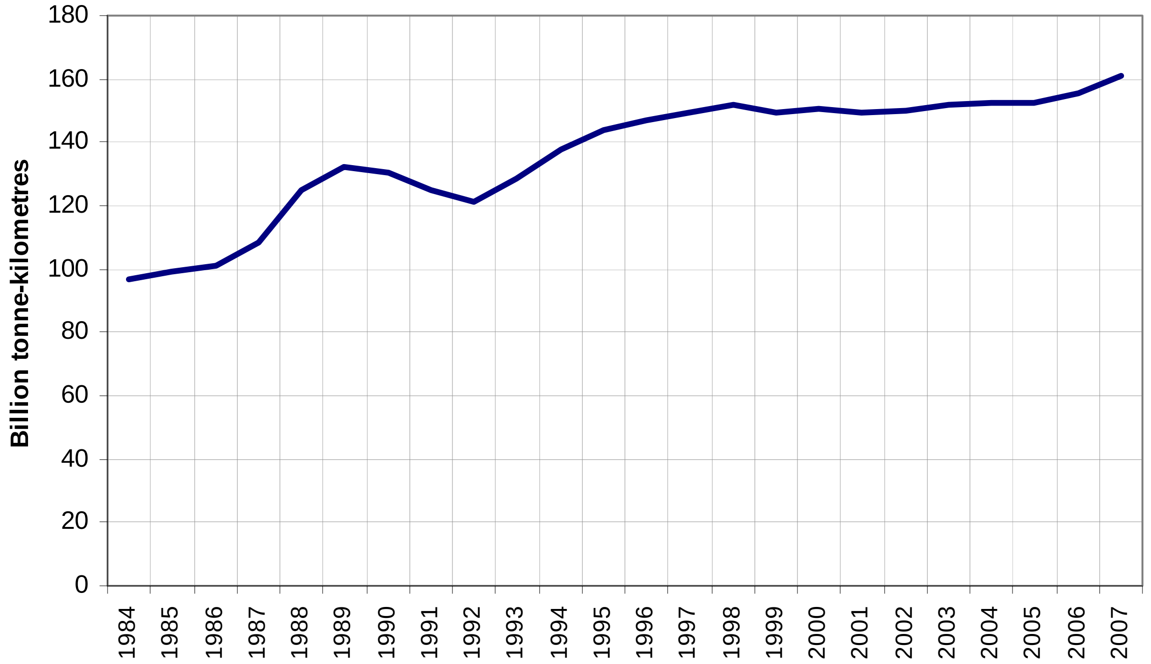
Increases in the average length of haul during the 1980s and 1990s have been attributed to the centralisation of manufacturing and stockholding facilities in the country. The reduction in the length of haul over the last decade may be due to increases in trip times and trip time unreliability as a result of rising traffic levels leading to manufacturers and freight operators resorting to more decentralised stockholding facilities in their supply chains.

3.6 Goods moved by HGVs

Figure 3.8 shows the goods moved (i.e. tonne-kilometres performed) on HGV trips in Britain over the last 25 years. The quantity of tonne-kilometres performed is a reflection of the effects of distance over which goods are moved (i.e. the average length of haul) on the goods lifted in Figure 3.7. Figure 3.8 reflects that tonne-kilometres performed by HGVs have moved in a similar way to tonnes lifted over the period.

This reflects that despite the reduction in the average length of haul since 2000 (see Figure 3.7), tonne-kilometres performed have continued to rise due to the increase in the quantity of goods lifted (see Figure 3.8).

Figure 3.8: Goods moved (tonne-kilometres) by HGVs in Britain, 1984-2007



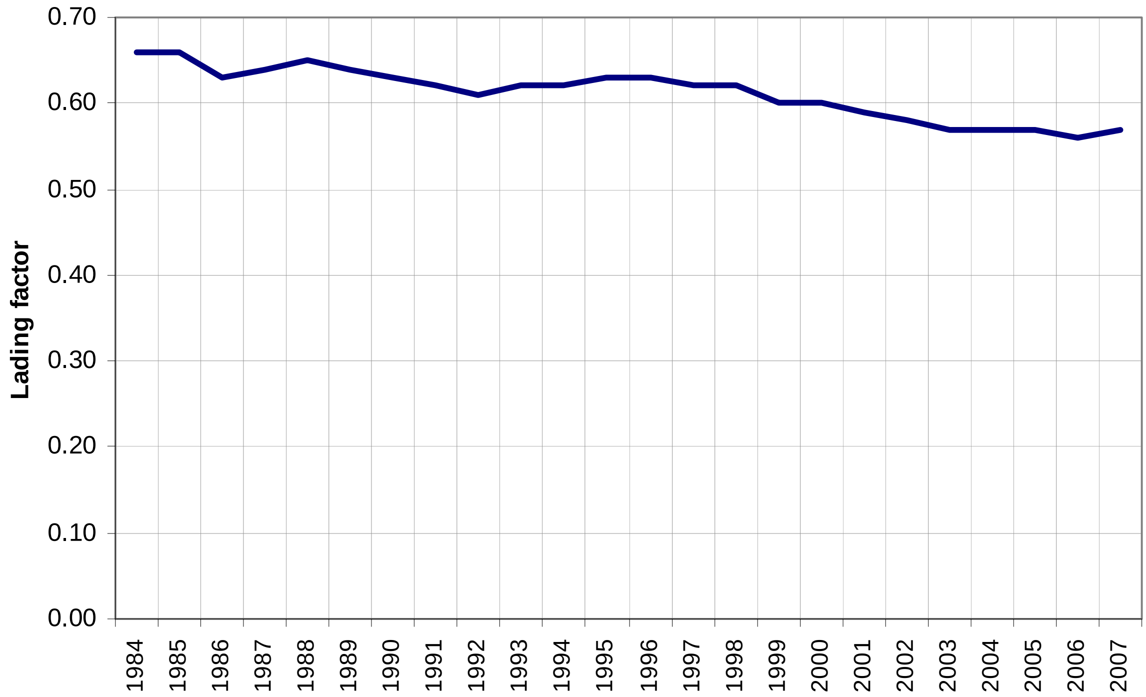
Source: DfT, 2008b, 1999, 1995.

3.7 Average load on laden trips by HGVs

The average weight of goods carried on an HGV is dependent on two factors: i) the lading factor (i.e. the extent to which the carrying capacity of the vehicle is utilised), and ii) the carrying capacity of the vehicle.

The lading factor is defined in the CSRGT survey as the “ratio of the actual goods moved to the maximum tonne-kms achievable if the vehicles, whenever loaded, were loaded to their maximum carrying capacity” (DfT, 2008b). Figure 3.9 shows how the lading factor for all HGV trips has changed between 1984 and 2007.

Figure 3.9: Average lading factor for HGVs in Britain, 1984-2007



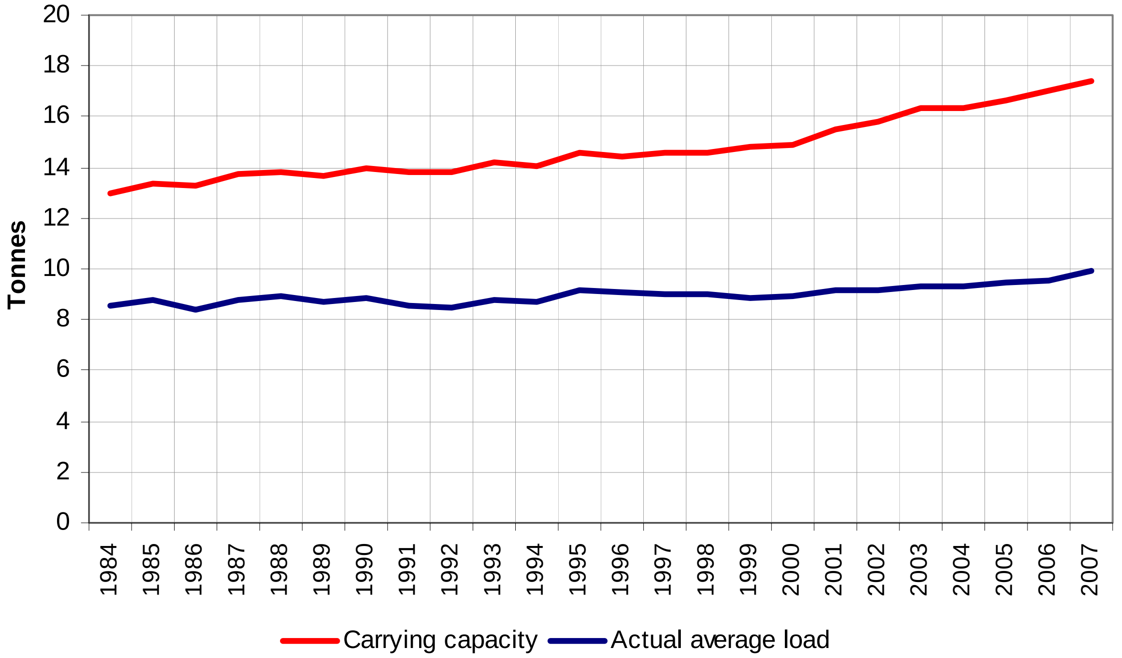
Source: DfT, 2008b, 1999, 1995.

Figure 3.9 shows that there has been a reduction in the average lading factor over the period shown. As mentioned previously, lading factors as measured by CSRGT, are based on the weight of goods carried. There is therefore no way of knowing from the CSRGT data whether HGVs are carrying less in terms of both weight and volume, or only in terms of weight.

The maximum permissible gross weight of HGVs has risen twice in the last decade: from 38 to 41 tonnes in 1999, and from 41 to 44 tonnes in 2001. This has therefore resulted in an increase in the average carrying capacity of HGVs in terms of weight. There have also been increases in the maximum dimensions of HGVs in the last twenty years: the maximum permissible length of HGVs was increased from 15.5 to 16.5 metres in 1990, and the maximum width was increased from 2.5 to 2.55 metres in 1996. Maximum height restrictions on HGVs were also removed in the last decade (subject to safe securing of loads). These changes in regulations have therefore resulted in increases in the average carrying capacity of HGVs in terms of both weight and volume.

Unfortunately CSRGT does not allow us to calculate the average volume carried on HGV trips, but the data does allow the average weight carried per trip to be calculated. It is also possible to calculate the average carrying capacity by weight (i.e. the maximum potential average weight of load) that could be carried on laden HGV trips (if the vehicles were fully laden in weight terms), and this can be compared with the average weight actually carried on laden trips. This is shown in Figure 3.10.

Figure 3.10: Comparison of carrying capacity and average weight of load carried by HGVs on laden trips in Britain, 1984-2007



Source: calculated from data in DfT, 2008b, 1999, 1995.

Figure 3.10 shows that the vehicle carrying capacity has been increasing over the period 1984 to 2007 (from 13.0 to 17.4 tonnes – an increase of 34%). This is due to two factors: i) shifts in the composition and use of the British HGV fleet towards heavier vehicles which has taken place over the entire period in question, and ii) the increase in maximum permissible gross weight of the heaviest goods vehicles in 1983, 1999 and 2001.

The actual average load can also be seen to have increased over the period (from 8.6 tonnes to 9.9 tonnes – an increase of 15.3%). However, this increase in actual average load has been far less than the maximum potential average load (with the proportion of vehicle carrying capacity by weight utilised falling over time - see lading factor in Figure 3.9). This suggests that although operators are making some use of the additional goods weight their vehicles can carry over time (due to a shift towards the use of heavier vehicles and the regulations increasing maximum gross weights) they are not making full use of it. This could either be due to changes in the bulk density of products (i.e. vehicles are reaching volume capacity before weight capacity) or could be due to operators not making full use of their vehicles payload capacity by weight (i.e. they could carry more goods by weight but are not).

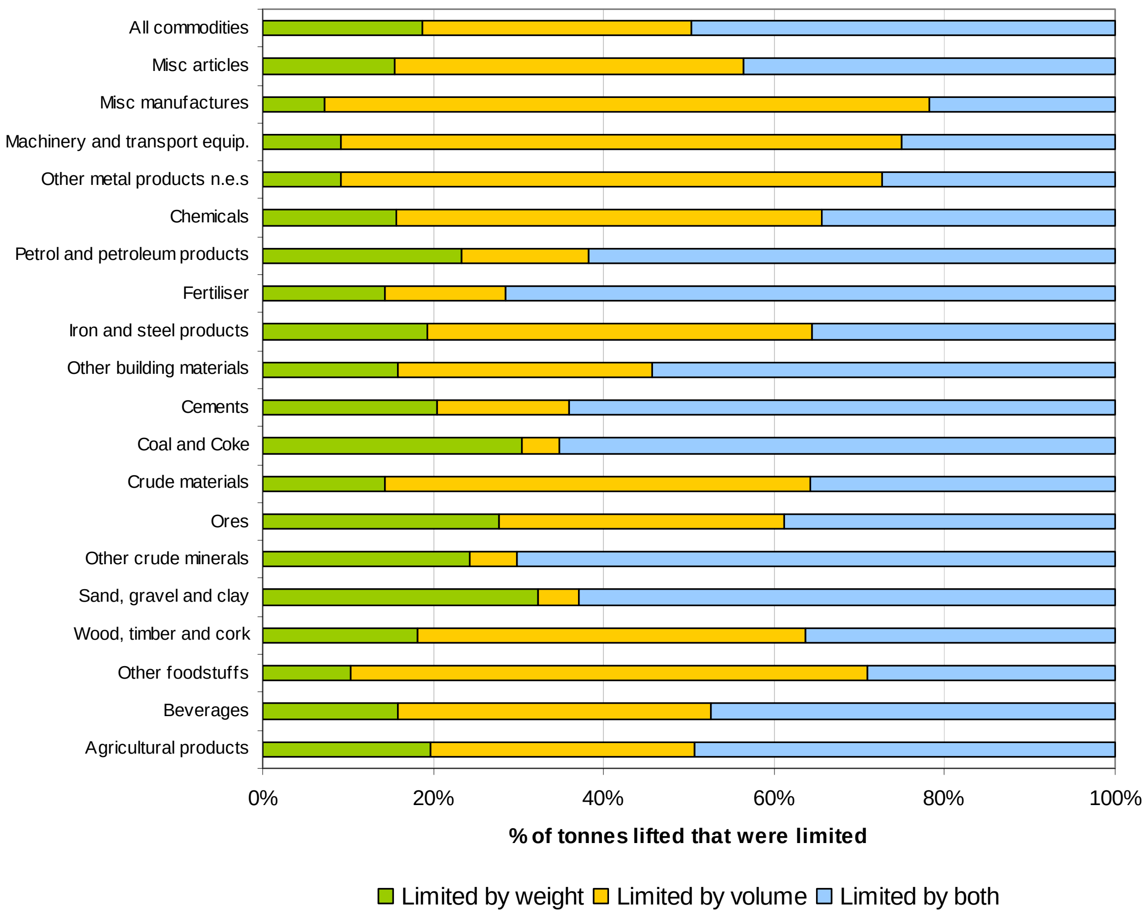
CSRGT does attempt to determine from respondents whether the vehicle load was limited by weight or volume (or limited by both weight and volume) on each trip. Unfortunately the way in which this question is asked changed in 2004, so it is not possible to compare answers before 2004 with those since. However, analysis of the most recently available data for 2007 shows that an important proportion of vehicle loads are limited by volume. Figure 3.11 shows the proportion of tonnes lifted that are limited by i) weight, ii) volume, or iii) weight and volume by type of commodity. It does not include i) loads that are not limited, and ii) loads that may have been limited by load, volume or both but which were not recorded as such by respondents. Figure 3.12 shows the proportion of tonne-kms limited by weight, volume or both according to type of commodity.

Figures 3.11 and 3.12 show that the lack of vehicle carrying capacity in terms of volume is a major factor in loads that are limited.

Volume was the sole constraint for 32% of goods lifted and 43% of goods moved by HGVs in 2007 that were limited by either weight, volume or both. Far more tonnes lifted and tonnes moved were limited by volume constraints than by weight constraints. Weight was the sole constraint for 19% of goods lifted and 17% of goods moved by HGVs in 2007.

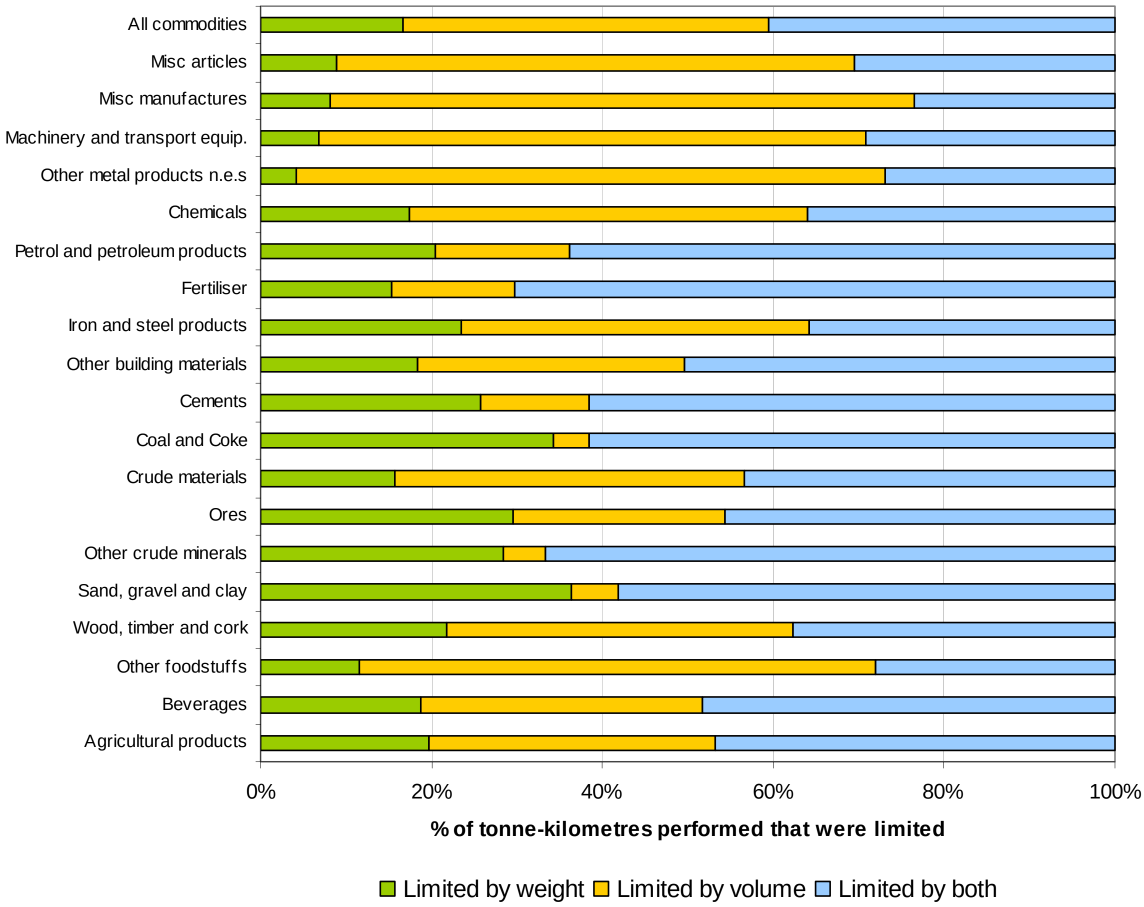
As would be expected, some types of loads are more affected by volume constraints than others. Figures 3.11 and 3.12 shows that types of load that were worst affected by volume constraints include: agricultural products; beverages; other foodstuffs; wood, timber and cork; crude materials; iron and steel products; chemicals; other metal products not elsewhere specified; machinery and transport equipment; miscellaneous manufactures; and miscellaneous articles.

Figure 3.11: Limits on loads - goods lifted by HGVs in Britain in 2007 by type of commodity



Source: calculated data in from DfT, 2008b.

Figure 3.12: Limits on loads - goods moved by HGVs in Britain in 2007 by type of commodity



Source: calculated data in from DfT, 2008b.

Table 3.1 shows the importance of loads limited solely by volume as a proportion of all goods lifted and moved by HGVs in 2007. This shows that 22% of all tonnes lifted and 30% of all tonnes moved were subject specifically to volume constraints in 2007.

Table 3.1: Proportion of total tonnes lifted and moved by HGVs in Britain in 2007 that are subject to volume constraints

	% of all tonnes lifted	% of all tonne-kms
Food, drink & tobacco		
Agricultural products	1.3%	2.0%
Beverages	0.7%	1.0%
Other foodstuffs	4.1%	6.5%
Subtotal	*6.3%*	*9.5%*
Bulk products		
Wood, timber and cork	0.5%	0.7%
Sand, gravel and clay	0.3%	0.2%
Other crude minerals	0.7%	0.3%
Ores	0.3%	0.2%
Crude materials	0.4%	0.5%
Coal and Coke	0.1%	0.0%
Cements	0.6%	0.3%
Other building materials	0.9%	1.1%
Iron and steel products	0.7%	1.2%
Subtotal	*4.5%*	*4.4%*
Chemicals, petrol & fertiliser		
Fertiliser	0.1%	0.1%
Petrol and petroleum products	0.4%	0.3%
Chemicals	0.9%	1.4%
Subtotal	*1.3%*	*1.8%*
Miscellaneous products		
Other metal products n.e.s	0.4%	0.5%
Machinery and transport equip.	1.6%	2.2%
Misc manufactures	2.6%	4.5%
Misc articles	5.8%	7.1%
Subtotal	*10.4%*	*14.2%*
All commodities	**22.5%**	**30.0%**

Source: calculated data in from DfT, 2008b.

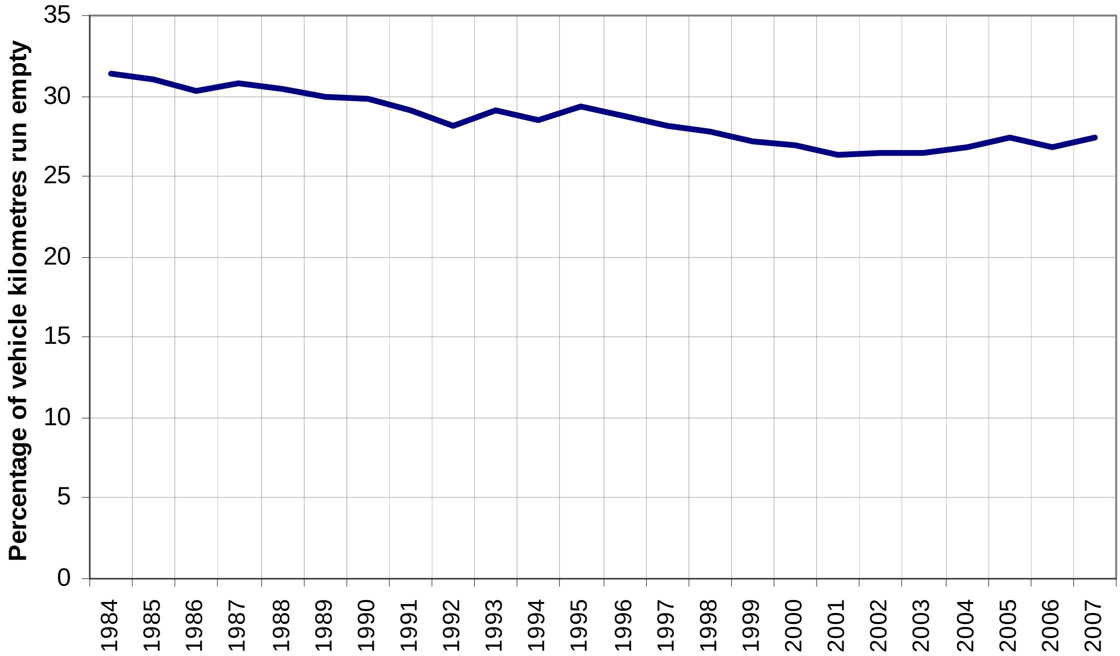
Note: data shows proportion of loads limited by volume as a proportion of all loads lifted and moved including those that were either not constrained at all or for which information about load constraints was not recorded.

The above discussion has illustrated the significance of volume constraints on HGV operations in Britain, and that volume constraints were more problematic for HGV operations than weight constraints in 2007.

3.8 Empty running by HGVs

Figure 3.13 shows that over the period 1984-2007 empty running (i.e. the percentage of total vehicle kilometres travelled during which the vehicle was empty) has fallen over the period 1984 to 2007 (from 31.4% to 27.4%).

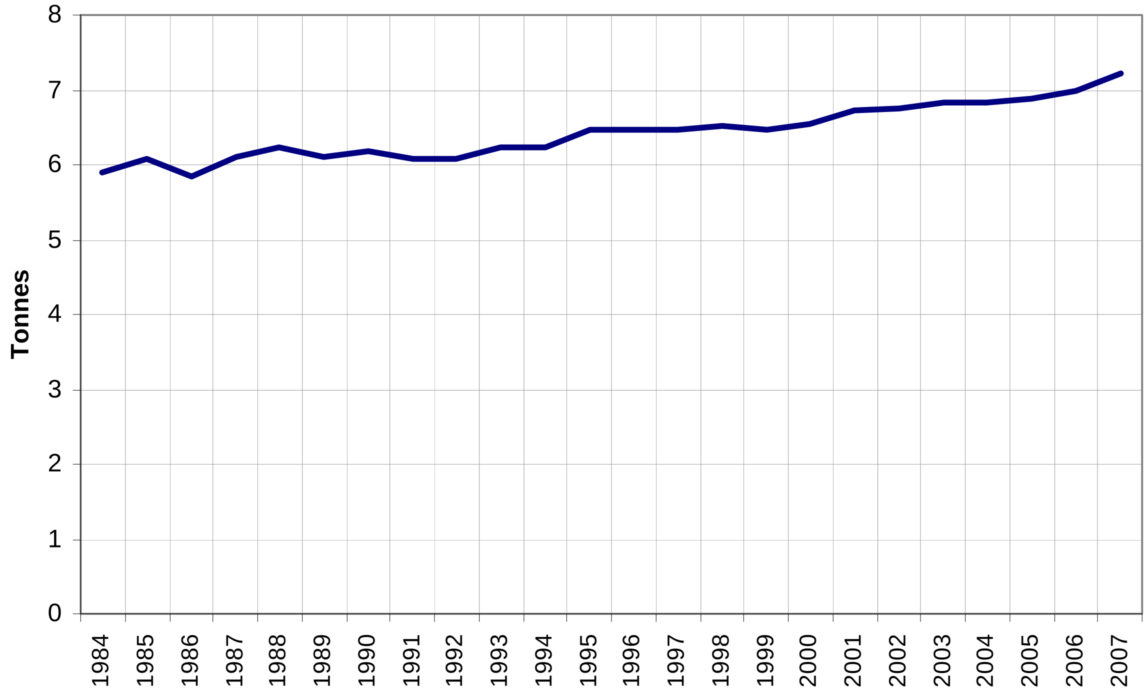
Figure 3.13: Empty running by HGVs in Britain, 1984-2007



Source: DfT, 2008b, 1999, 1995.

Figure 3.14 shows the average weight of load carried on all HGV trips in Britain (i.e. taking into account empty running). This is the ratio of actual tonne-kms to total vehicle kms. This has been rising gradually over the period 1984 – 2007. It can be compared with the average load carried on laden trips in Figure 3.9 to understand the effect of empty running on the average weight of load carried on all vehicle kilometres (taking into account laden and empty kms).

Figure 3.14: Average weight of load carried by HGVs on all trips (empty and laden) in Britain, 1984-2007

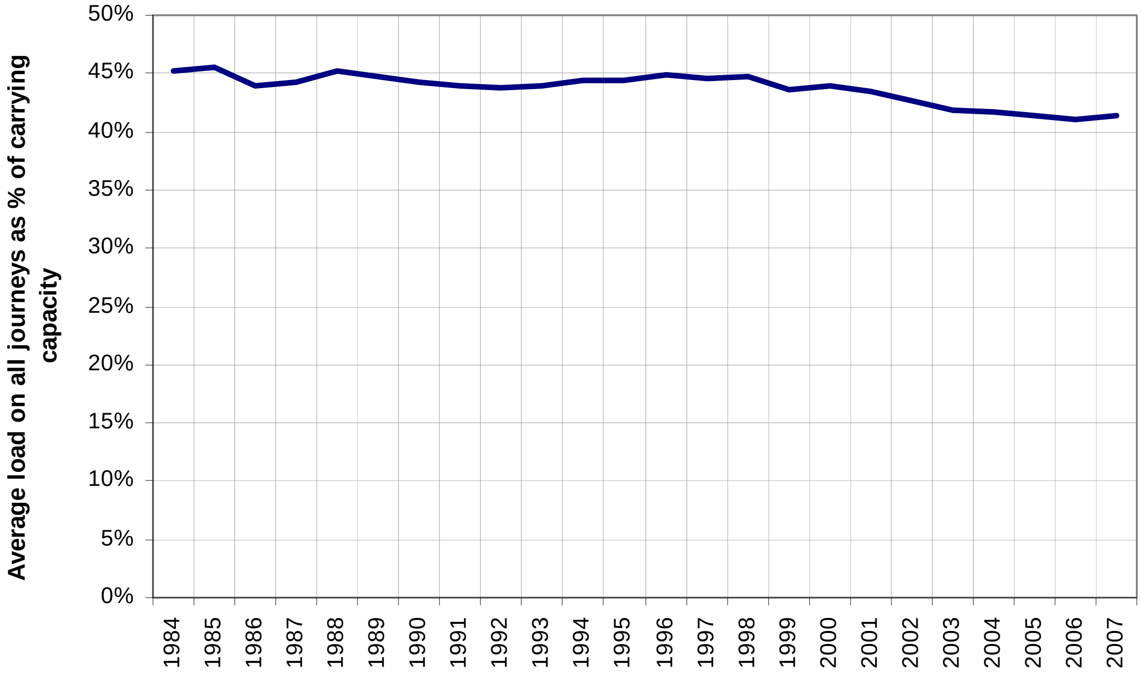


Source: calculated from data in DfT, 2008b, 1999, 1995.

Figure 3.15 shows the proportion of vehicle carrying capacity (by weight) utilised on all HGV trips (i.e. taking into account both laden and empty trips). This shows that, on average, 40-45% of total vehicle carrying capacity (by weight) has been utilised on all HGV trips over the period. The proportion has fallen from 45% in 1984 to 41% in 2007. This reflects that although the average load weight on all trips has risen over the period (see Figure 3.15) this has been more than offset by the increase in vehicle carrying capacity resulting from increases in maximum permissible gross vehicle weight (see Figure 3.9).

The reduction in empty running over the last 25 years has meant that the proportion of vehicle carrying capacity utilised on all (i.e. laden and empty) HGV trips (see Figure 3.15) has fallen by less than the proportion of vehicle carrying capacity utilised on laden HGV trips (see Figure 3.10) over the period.

Figure 3.15: Proportion of vehicle carrying capacity (by weight) utilised on all HGV trips (laden and empty) in Britain 1984 - 2007

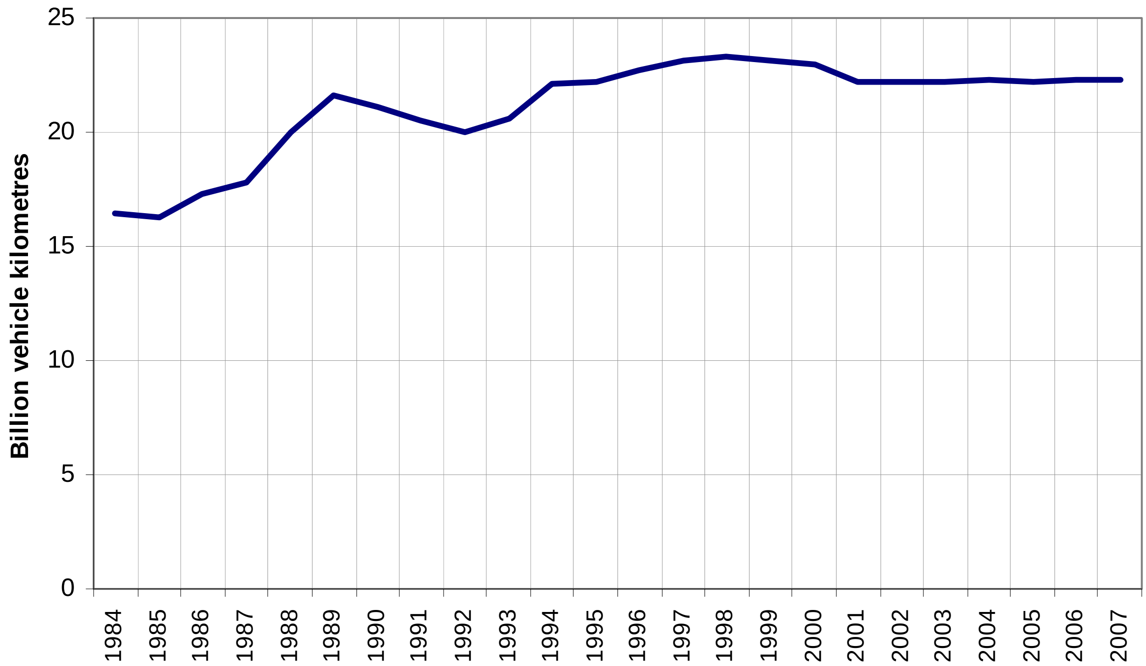


Source: calculated from data in DfT, 2008b, 1999, 1995.

<u>3.9 Vehicle kilometres by HGVs</u>

Empty running, lading factors and the vehicle carrying capacity determine how the tonne-kilometres shown in Figure 3.8 are transformed into total vehicle kilometres performed by HGV in Britain. This is shown in Figure 3.16. The total vehicle kilometres performed rose sharply between 1984 and the early 1990s, but have remained relatively stable since then.

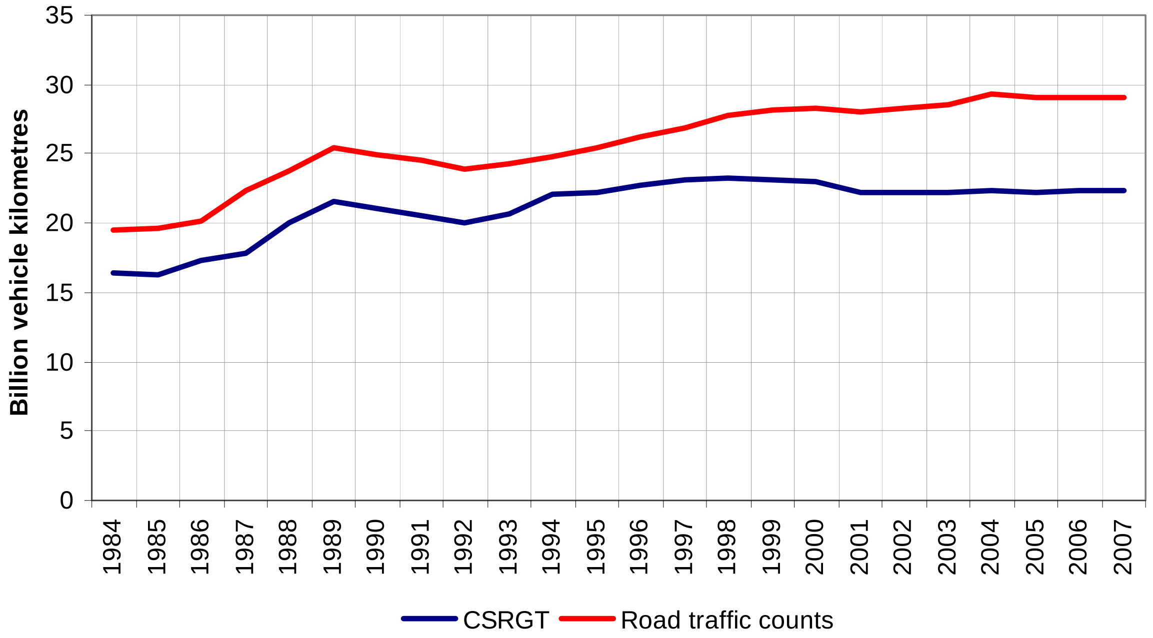
Figure 3.16: Vehicle kilometres by HGVs in Britain (reported by CSRGT), 1984-2007



Source: DfT, 2008b, 1999, 1995.

It is important to note that the vehicle kilometres by HGVs reported by the CSRGT differ from those reported for HGVs by road traffic count data (see Figure 3.17). The difference between these two calculations are likely to be due to three issues: i) the distance travelled by foreign-registered HGVs is included in the road traffic count data but not in the CSRGT data – it is estimated that in 2008 foreign-registered HGVs were responsible for approximately 3.5% of all HGV vehicle kilometres in the road traffic count data, ii) the road traffic count data collects data from approximately 180 Automatic Traffic Counters combined with manual vehicle counts from approximately ten thousand sites. The CSRGT vehicle km estimate is based on trip diary data provided by a sample of operators for a one-week period of activity. Trip diaries can be subject to under-reporting when respondents fail to provide data for all trips made during the survey week, iii) CSRGT only includes HGVs in the goods vehicle tax class. In 2008 there were 83,000 goods vehicles that were not taxed as goods vehicles are were not therefore included in the CSRGT. By comparison, the road traffic counts include all HGVs regardless of their tax class (DfT, 2009).

Figure 3.17: Vehicle kilometres by HGVs in Britain reported by CSRGT and road traffic counts, 1984-2007

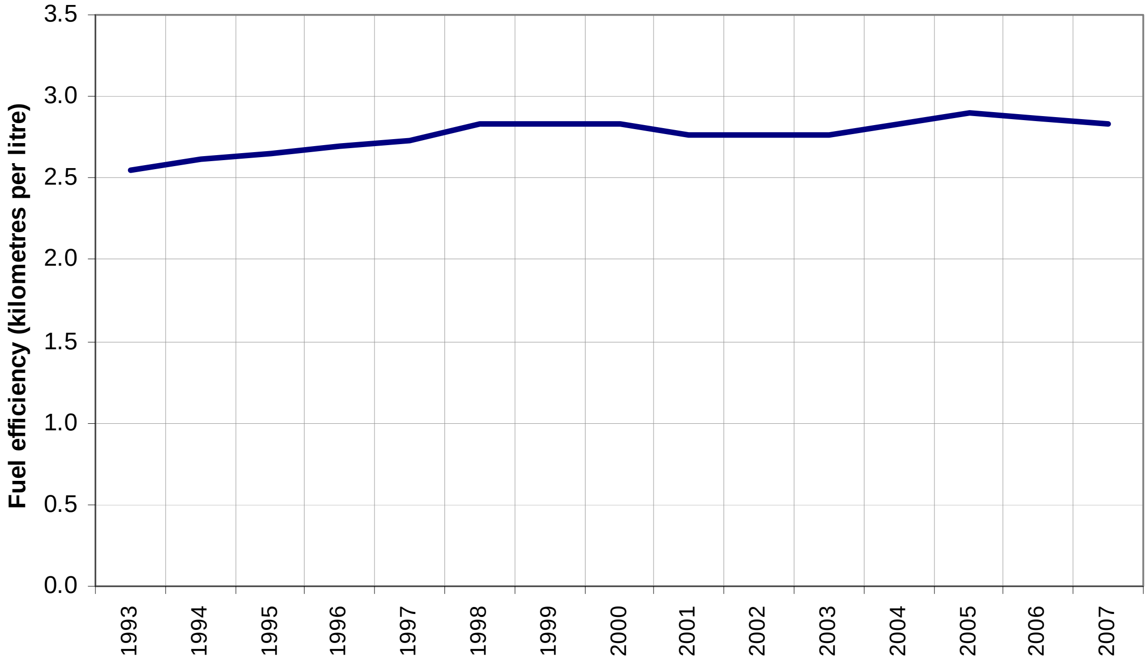


Source: DfT, 2008a, 2008b, 1999, 1995.

3.10 Fuel consumption and CO_2 emissions by HGVs

Figure 3.18 shows the average fuel efficiency of HGVs over the period 1993-2007 based on data reported in the CSRGT (DfT, 2008b). This shows that the average fuel efficiency was approximately 11% higher in 2007 compared with 1997. Most of this improvement took place between 1993 and 1998, however it is important to bear in mind that the average weight of vehicles and the loads they carry has been increasing over the entire period, so, on average, more tonnes are being carried on each kilometre performed (see Figure 3.10 and 3.14).

Figure 3.18: Average fuel efficiency of HGVs (kilometres per litre) in Britain, 1993-2007



Source: calculated from data in DfT, 2008b.

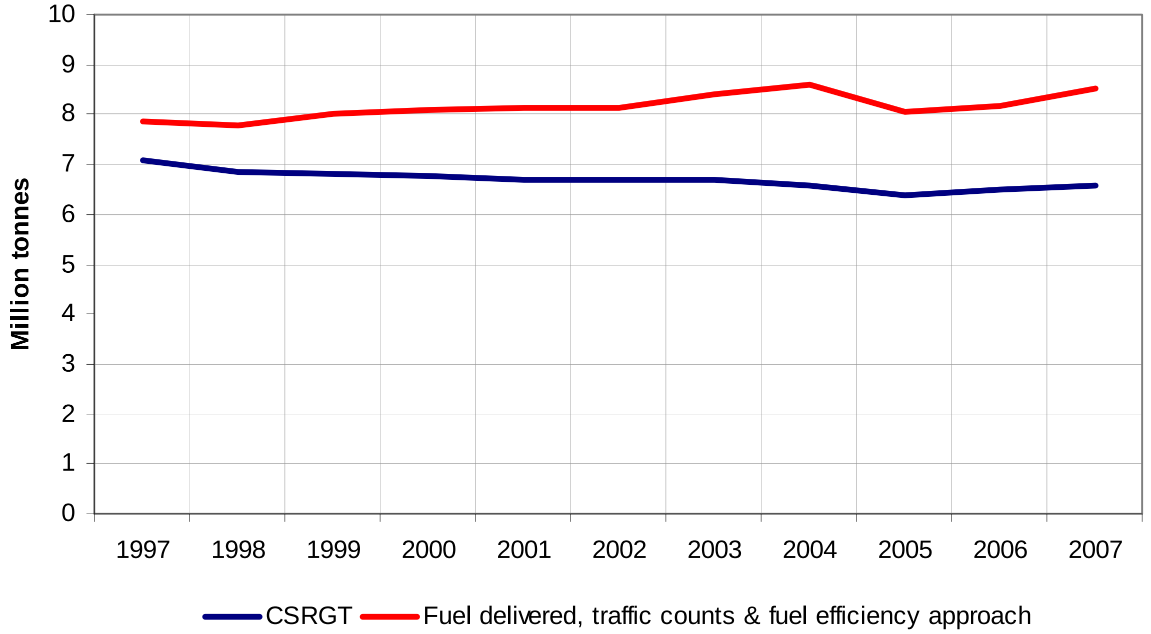
It is possible to calculate the total diesel consumed by HGVs in Britain from CSRGT (as the survey collects data about the fuel consumption rates (mile per gallon) of the HGVs reporting). From this calculation of total fuel consumed it is also possible to calculate the total CO_2 emissions from HGV operations in Britain.

Separate calculations of total fuel consumed and CO_2 emissions by HGVs are published by DfT which use data based on the actual quantity of diesel delivered together with estimates of the vehicle types using this fuel from road traffic count data and assumptions about the fuel consumption rates of the various configurations of HGVs.

Given the differences in vehicle kilometres performed by HGVs estimated by CSRGT and road traffic counts this also leads to differences in total fuel consumed and CO_2 emissions estimates from the two survey approaches. Figure 3.19 shows the comparison of the estimated total fuel consumed by HGVs from CSRGT and road traffic count data between 1997 and 2007.

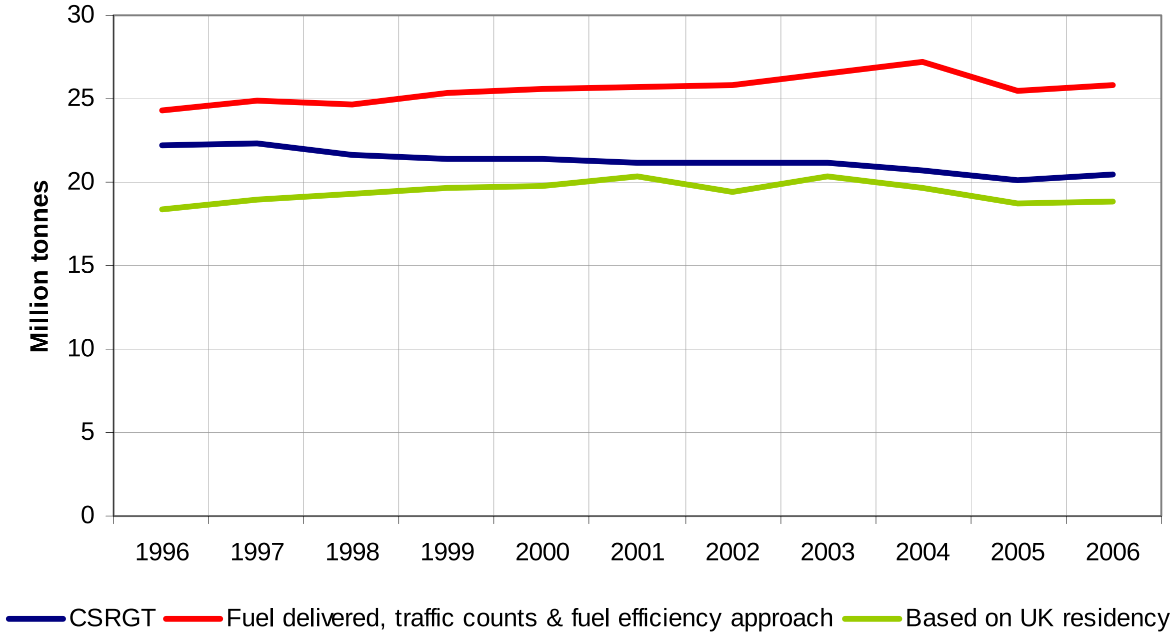
Figure 3.20 provides estimates of CO_2 emissions by HGVs between 1996 and 2006 from three different survey approaches: i) the authors' own calculations using CSRGT data, ii) data published by DfT (2008b) based on fuel sales, road traffic data and assumptions about fuel consumption rates of various configurations of HGVs (referred to as "fuel delivered, traffic counts and fuel efficiency approach"), and iii) data published by DfT that has been calculated by AEA based on estimated fuel sales to UK residents only (thereby removing sales to foreign-registered HGVs – referred to as "based on UK residency").

Figure 3.19: Total diesel consumed by HGVs in Britain, 1997-2007



Source: DfT, 2008a, and calculated from data in DfT, 2008b, 1999.

Figure 3.20: Total carbon dioxide (CO_2) emissions by HGVs in Britain, 1996-2006

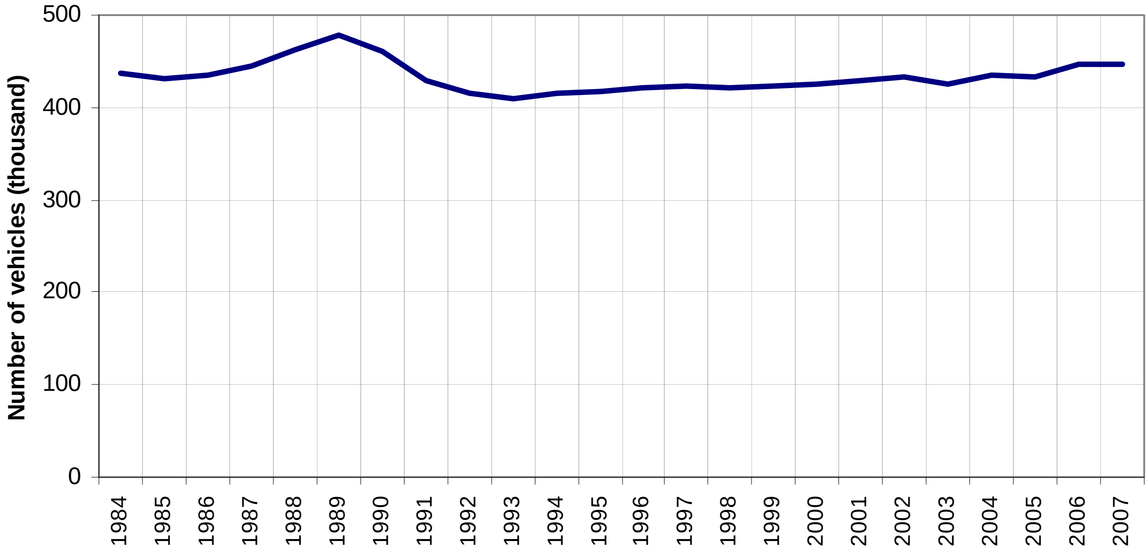


Source: DfT, 2008a, and calculated from data in DfT, 2008b, 1999.

3.11 Vehicle fleet and average vehicle activity

Figure 3.21 shows the total HGV fleet in Britain over the period 1984-2007 (this comprises all the British-registered HGVs licensed in the goods vehicle tax class – there are additional HGVs in Britain that are not registered in the goods vehicle tax class which are therefore assumed not to be used commercially). This shows that the total fleet rose between 1984 and 1990, then fell to 1993, since when it has risen slightly.

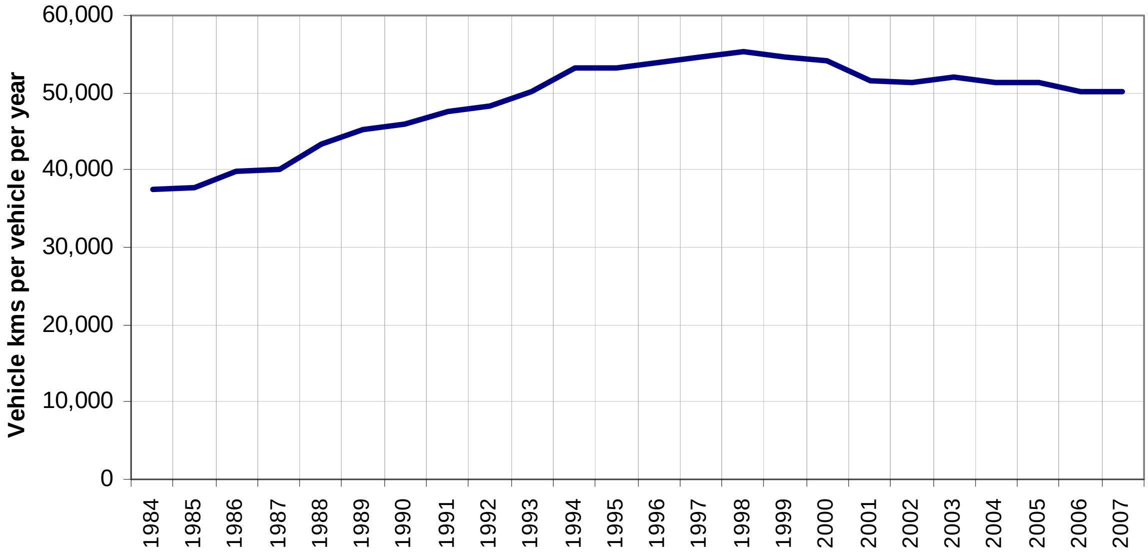
Figure 3.21: Total HGV fleet licensed in Britain, 1984-2007



Source: DfT, 2010
Note: includes all goods vehicles licensed in the goods vehicle tax class

Figure 3.22 shows the changes in the average annual vehicle kilometres travelled per HGV over the period 1984 to 2007. This shows an increase in the average distance travelled annually per vehicle between 1984 and 1998, and a slight decline since then. This slight decline since 1998 coincides with the period over which average length of haul has also declined.

Figure 3.22: Average annual vehicle kilometres per HGV in Britain, 1984-2007



Source: DfT, 2010, 2008b, 1999, 1995.

The distance driven per vehicle per year is determined by the speed achieved by the vehicle and the total time spent driving on the road by the vehicle. Therefore if there is stability in the vehicle kilometres travelled per vehicle per year could be a reflection that average speeds and the average time spent driving have also both remained stable. However, one of these determinants could have fallen while the other rose.

The increase in vehicle kilometres travelled per vehicle per year between 1984 and 1998 could have been achieved in two ways: i) through increases in average vehicle speeds, and/or ii) through increases in the total amount of time that each vehicle is driven on the road (i.e. a reduction in idle time).

Vehicle speeds

There is no available data about average vehicle speeds or specifically HGV speeds across the entire British road network. However there are sources of data that provide some insight into average vehicle speeds in recent years. The RAC Trafficmaster Journey Time Survey found that across 26 selected commuter and commercial inter-urban routes the journey time increased on average by 2.6% between 2005 and 2008 (Trafficmaster/RAC Foundation, 2008).

Data from the DfT about average vehicle speeds on inter-urban roads only provides free-flow speeds, and therefore does not reflect the impact on traffic congestion and hence delays on average speeds.

Until 2006 DfT did calculate average vehicle speeds in the peak and off-peak in London, and produced a time-series of this data. This data shows that across the whole of London average vehicle speeds fell from 16.9 miles per hour (mph) in 1983-6 to 14.8 mph in 2003-6 in the morning peak (a fall of approximately 12%), from 20.9 mph in 1983-6 to 18.3 mph in 2003-6 in the peak (also a fall of approximately 12%), and from 17.2 mph in 1983-6 to 16.0 mph in 2003-6 in the evening peak (a fall of 7%). The average speeds fell continuously over the period in question (DfT, 2006d).

In 2007, HGVs performed 42% of their total distance travelled on motorways, 36% on rural A roads, 7% on rural minor roads and 16% on urban roads (DfT, 2008a).

Between 1984 and 2007 the total length of motorways in Britain increase by approximately 30%. The vast majority of this increase in total motorway length took place between 1984 and 1998 (DfT, 2008a). The extent of dual carriageways also increased. In addition, maximum vehicle speed limits were increased on these roads in 1984. For HGVs up to 7.5 tonnes gross weight speed limits on motorways were increased from 60 to 70 miles per hour, while on dual carriageways speed limits were increased from 40 to 60 miles per hour for HGVs up to 7.5 tonnes gross weight, and from 40 to 50 miles per hour for all other HGVs (Armstrong et al., 2003). This expansion in the supply of faster roads together with higher speed limits would be expected to result in increases in average speeds on these roads, all other things being equal. This may well have improved average motorway and dual carriageway speeds between 1984 and 1998. Between 1998 and 2007 the total vehicle kilometres travelled on motorways by all vehicles increased by 18% which was the greatest rate of traffic growth on any road type over the period (DfT, 2008a). Given the relatively small increase in total motorway length since 1998, the increase in total vehicle flows, and the introduction of speed limiters from 1992 on to prevent goods vehicles exceeding the national speed limit, these factors are likely to have resulted in lower average journey speeds during busy periods on motorways when congestion effects are taken into account.

The London average speed data discussed above indicates the significant decline in daytime vehicle speeds over the entire period 1984 to 2006. A similar but probably less substantial decline in daytime average speeds is likely to have occurred in other urban areas over the period from 1998 to 2007. Daytime average speeds on rural A and minor roads are also likely to have fallen as traffic flows and congestion incidents have increased.

One response that HGV operators have taken to reducing daytime average speeds has been to perform more activity during the night when higher speeds are possible. McKinnon et al (2008) have noted that the proportion of all HGV vehicle kilometres run between 8pm and 6am increased from 16% to almost 20% between 1995 and 2005.

<u>Time that each vehicle is driven on the road</u>

There has been no systematic on-going data collection of the time HGVs spend driving as opposed to idle. The only insight to the proportion of total time HGVs spend driving is provided by the Key Performance (KPI) surveys sponsored by the UK Government since 1997 (McKinnon, 2009). These surveys provide a 48-hour snapshot of company HGV fleets working in selected sectors of road freight transport, and do not therefore provide a comparison over time. However they do provide useful insight into driving as opposed to idle time for the fleets studied.

Table 3.2 provides vehicle time utilisation results from these KPI studies. These show that the proportion of the 48-hour period that vehicles spent driving on the road varied from 19-38% depending on sector. A further 1-6% of time was spent on driver rest breaks on the road, while 7-16% of time was spent in loading and unloading activities. The results indicate that vehicles in the surveys vehicle spent, on average, 43-70% of their time inactive (either loaded awaiting departure, loaded and inactive for other reasons, delayed, stationary and empty or having maintenance or repairs).

It seems likely that average daytime vehicle speeds have been falling since the late 1990s. Given that the annual average vehicle kilometres travelled per vehicle rose substantially between 1984 and 1998 and have remained stable since 1998 (when average daytime speeds have been worsening), implies that operators have made use of two strategies: i) increased the total time each vehicle spends driving each year, and ii) made greater use of off-peak times for vehicle travel in order to achieve greater average journey speeds.

The total time spent driving on the road by each HGV has probably been increasing over the period from 1984 to 2007, together with a growing proportion of evening and night work from the 1990s onwards. Although the inactive vehicle time in the KPI surveys represents a major proportion of total time, this may have diminished over time since the early 1980s as operators attempt to get better productivity from their assets and vehicle reliability has improved. An important factor in efforts to improve vehicle productivity has been greater use of third party logistics services and the advent of new communications, planning and handling technologies. This has coincided with a substantial reduction in the power of the Transport and General Workers' Union (TGWU) and other unions involved in the road haulage industry resulting from the legal framework established by the Conservative government after coming to office in 1979 following the "winter of discontent" and especially the "hire-and-reward" haulage strike (Smith, 1999).

However insufficient data is available to fully analyse changes in HGV journey speeds and the proportion of time they spend being driven on the road. Also, a lack of data prevents detailed consideration of the various influencing factors. This is an area for further research in future. These issues are further discussed in section 6.

Table 3.2: Time utilisation of vehicles over 48-hour period surveyed by activity (percentage of 48-hour period)

KPI survey	Running on the road	On the road (daily rest)	Loading /unloading	Pre-loaded awaiting departure	Delayed or otherwise loaded and inactive	Idle (empty and stationary)	Maintenance / repair	Total
Food KPI 1997	35	6	16	12	4	21	6	100
Food KPI 2002	28	2	16	15	4	28	7	100
Builders merchants KPI 2006*	19	3	8	25	0	43	2	100
Builders merchants KPI 2006**	21	3	7	18	1	43	7	100
Non-food KPI 2003	23	1	15	21	12	21	7	100
Parcels KPI 2006	31	1	8	2	1	56	1	100
Pallets KPI 2007***	31	3	15	5	4	40	2	100
Pallets KPI 2007****	38	3	16	4	6	32	1	100

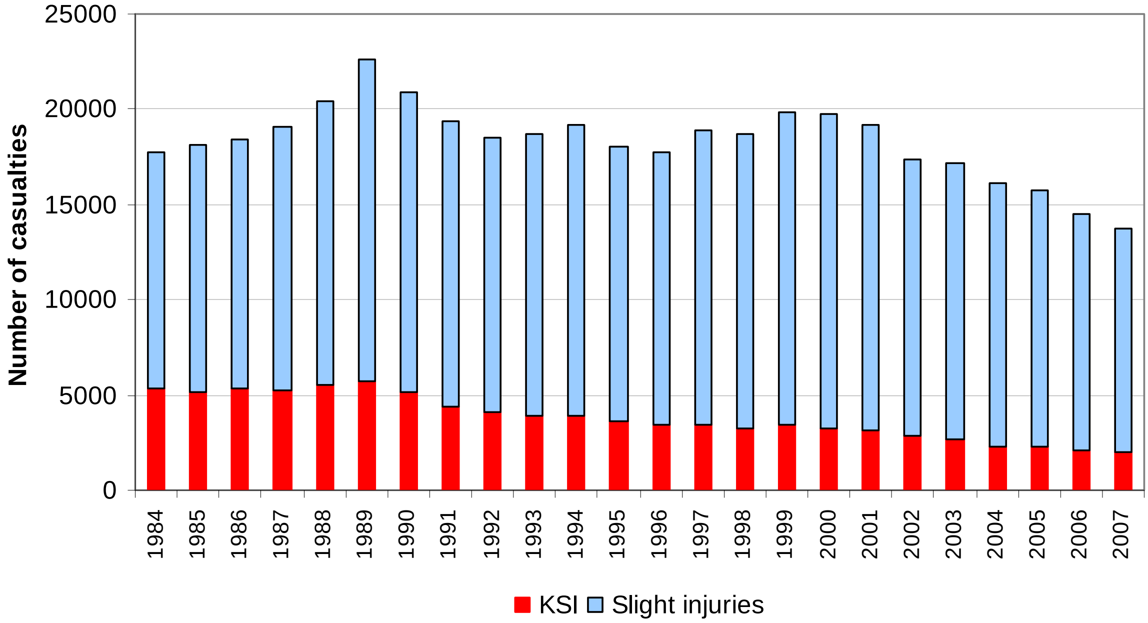
Source: DETR, 1999a; DfT, 2003a; DfT, 2003b; DfT, 2006a; DfT, 2006b; DfT, 2006c.

Note:
* - vehicles performing light activities
** - vehicles performing heavy activities
*** - vehicles collection and delivery activities
**** - vehicles performing trunking activities

3.12 Road safety

Figure 3.23 shows the total number of casualties resulting from collisions involving HGVs in Britain from 1984 to 2007. It is important to note that the data presented in Figure 3.23 shows the involvement of HGVs in collisions resulting in casualties, it does not reflect the cause of these collisions. The number of killed and seriously injured casualties has been falling since 1989. Slight casualties have fallen each year since 2000.

Figure 3.23: Casualties resulting from collisions involving HGVs in Britain, 1984-2007

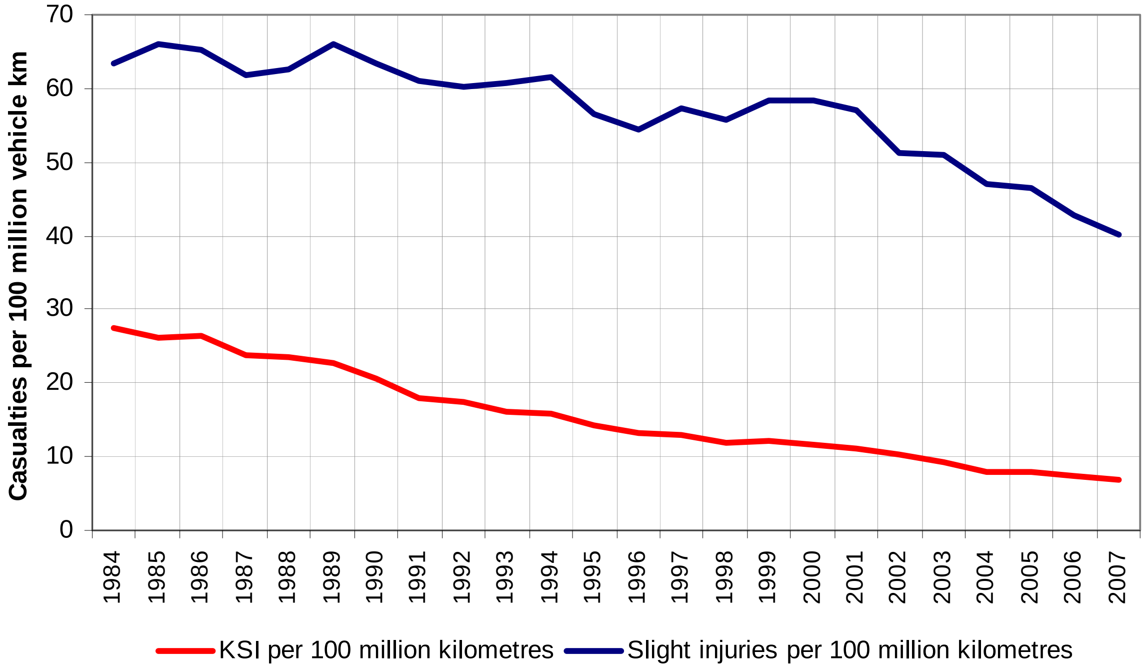


Source: DfT, 2008b.

Notes:
Based on casualties resulting from collisions involving British- and foreign-registered HGVs in Britain.

Figure 3.24 shows the number of killed and serious injuries (KSI) and slight injuries per 100 million HGV vehicle kilometres. Both have a downward trend over the period.

Figure 3.24: Number of KSI and slight injuries per 100 million vehicle kilometres in collisions involving HGVs in Britain, 1984-2007



Source: calculated from data in DfT, 2008a, 2008b.

Notes:
Based on casualties resulting from collisions involving British- and foreign-registered HGVs in Britain.
Based on road traffic count estimate of vehicle kilometres, so as to include foreign-registered HGV kilometres.

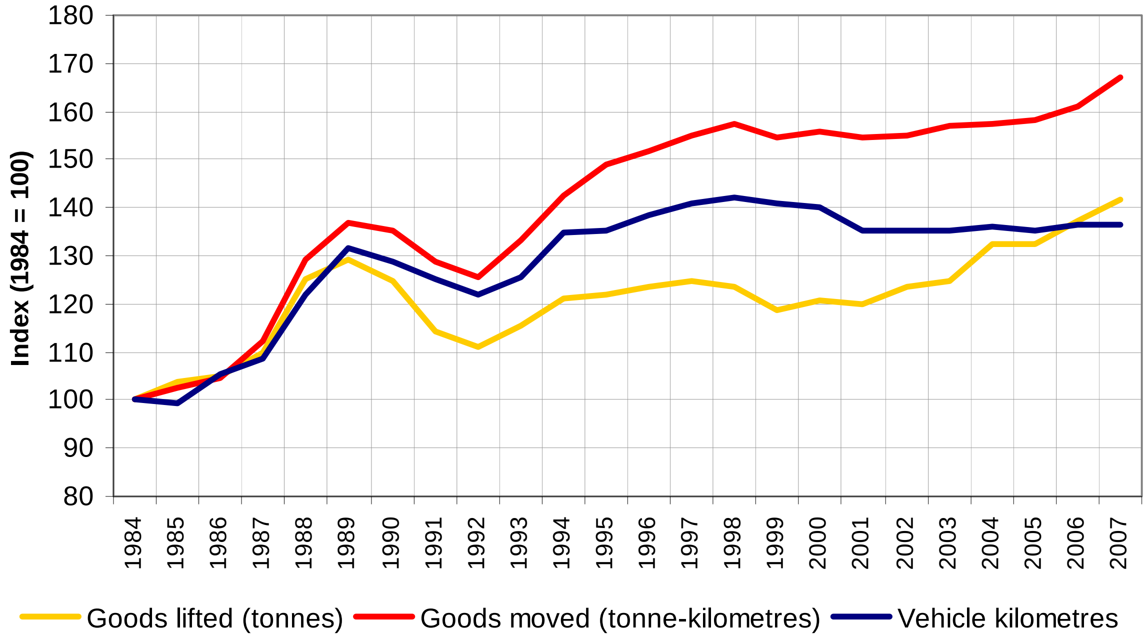
4. HGV activity and the intensity and efficiency of HGV operations

This section considers the trends in HGV activity between 1984 and 2007 presented in section 3 and analyses the efficiency and intensity of HGV use over the period.

4.1 Understanding trends in tonnes lifted, tonne-kilometres and vehicle kilometres

Figure 4.1 shows the trends in tonnes lifted, tonne-kilometres and vehicle kilometres for all HGVs between 1984 and 2007. Table 4.1 shows the percentage change in these three measures of freight output.

Figure 4.1: Tonnes lifted, tonne-kilometres and vehicle kilometres by HGVs in Britain, 1984-2007, (index 1984=100)



Source: calculated from data in DfT, 2008b, 1999, 1995.

Table 4.1: Changes in tonnes lifted, tonne-kilometres and vehicle kilometres by HGVs in Britain, 1984-2007 (percentages)

	Tonnes lifted	Tonne-kilometres	Vehicle kilometres
1984-1992	11%	26%	22%
1992-2000	9%	24%	15%
2000-2007	19%	7%	-3%
1984-2007	42%	67%	37%

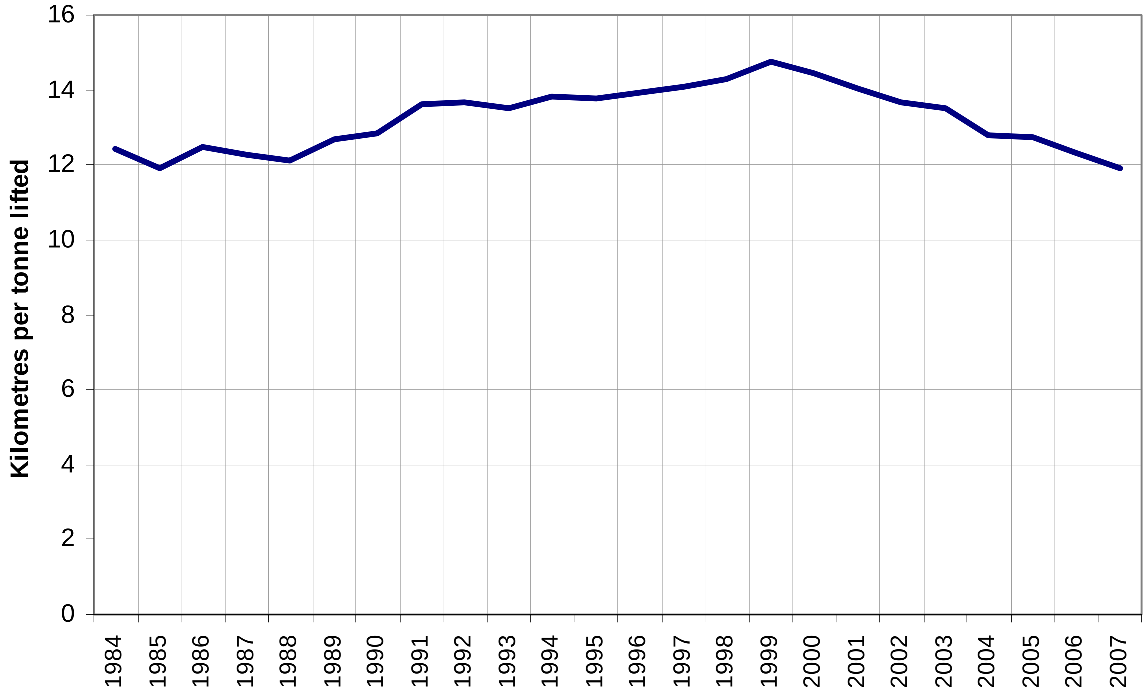
Source: calculated from data in DfT, 2008b, 1999, 1995.

Tonne-kilometres have grown most rapidly over the period 1984 to 2007, which is to be expected as it is a product of tonnes lifted and the distance travelled (average length of haul), so will rise more rapidly than tonnes lifted and vehicle kilometres if they are both rising. However in the period 2000-2007 total vehicle fell by 3%, and tonne-kilometre growth fell to only 7%, while growth in tonnes lifted was greater than in the periods 1984-1992 and 1992-2000.

As shown in the conceptual framework (see Figure 3.1), tonne-kilometres performed by the HGV fleet are dependent on the total quantity of goods lifted and the average length of haul over which these are moved. Vehicle kilometres performed by the HGV fleet are dependent on the average length of haul, the average vehicle carrying capacity, the average utilisation of goods vehicles on laden trips, and the extent of empty running. Therefore, the relationship between total goods lifted by HGVs and total vehicle kilometres performed by HGVs is the key indicator of the degree of sustainability of HGV operations.

Figure 4.2 shows that the average distance travelled by HGVs per tonne lifted rose from 12.4 km in 1984 to 14.7 km in 1999. However since then it has fallen annually to 11.9 km in 2007.

Figure 4.2: Vehicle kilometres travelled per tonne of goods lifted by HGVs in Britain, 1984-2007



Source: calculated from data in DfT, 2008b, 1999, 1995.

Note: based on CSRGT estimate of HGV vehicle kilometres.

In addition, vehicle kilometres (rather than tonnes lifted or tonne-kilometres) are the output that is most strongly related to many of the negative impacts of HGV activity (such as fuel consumption, pollutant emissions, contribution to congestion, number of casualties, noise, vibrations and visual intrusion). Therefore, in attempting to improve the economic, social and environmental sustainability of HGV operations both policymakers and operators should target reductions in the total vehicle kilometres performed by the HGV fleet as the key priority.

Table 4.2 suggests that despite annual increases in tonne-kilometres and tonnes lifted by HGVs in all years except 2001, growth in HGV kilometres in these years has been negligible or negative. This implies that HGV operations have become increasingly efficient.

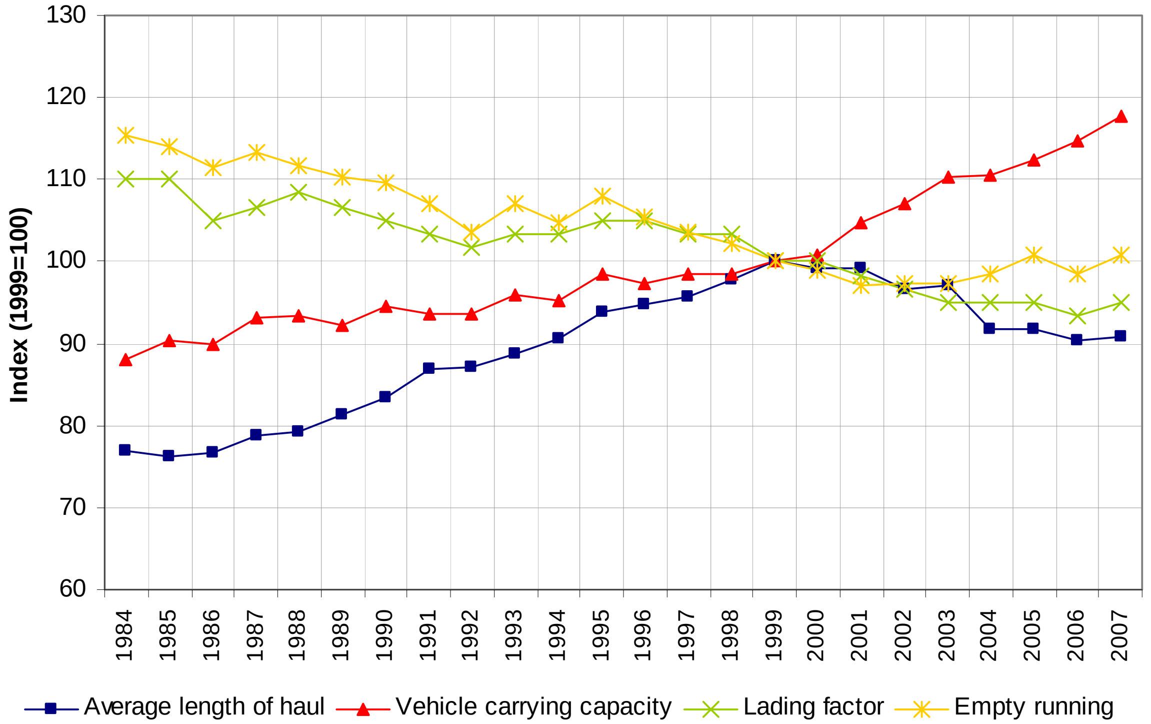
Table 4.2: Annual change in HGV tonnes lifted, tonne-kms and vehicle kms in Britain, 2000-2007

	Percentage change on previous year							
	2000	2001	2002	2003	2004	2005	2006	2007
Goods moved (tonne-kms)	0.9%	-0.7%	0.3%	1.3%	0.3%	0.3%	1.9%	3.8%
Goods lifted (tonnes)	1.7%	-0.8%	2.9%	1.0%	6.1%	0.1%	3.8%	3.1%
Vehicle kms (CSRGT data)	-0.4%	-3.5%	0.0%	0.0%	0.5%	-0.4%	0.5%	0.4%

Source: calculated from data in DfT, 2008b.

To obtain further insight into these changes in tonnes lifted, tonne-kilometres and vehicle kilometres travelled by HGVs between 1984 and 2007 it is necessary to analyse the changes in all the key variables in the conceptual framework (see Figure 3.1) that come between road freight lifted and vehicle kilometres travelled. This is presented in Figure 4.3 and is indexed to 1999, the year in which the average length of haul began to fall (whereas it had been rising continually prior to this).

Figure 4.3: Changes in key variables of HGV activity in Britain, 1984-2007



Source: calculated from data in DfT, 2008b, 1999, 1995.

Figure 4.3 indicates that, prior to 1984, the increases in vehicle km per tonne lifted by HGVs were due to a combination of increases in average length of haul and falls in the lading factor. Meanwhile empty running fell (i.e. improved) and vehicle carrying capacity rose over this period but the improvement in these two variables was not sufficient to offset negative changes in the other two variables. From 1999 to 2007 two variables have changed in a direction that has reduced vehicle km per tonne lifted, namely average length of haul (which has fallen) and vehicle carrying capacity (which has risen substantially). The changes in these two variables have more than offset the falls in lading factor and the relative stability in empty running, thereby resulting in fewer vehicle km per tonne lifted (and hence more efficient road freight transport).

Table 4.3 shows the percentage changes in the key variables and the vehicle km per tonne lifted by HGVs between 1984 and 2007.

Table 4.3: Changes in key variables and vehicle km per tonne lifted for HGVs, 1984-2007 (percentages)

	Average length of haul	Vehicle carrying capacity	Lading factor	Empty running*	Vehicle km per tonne lifted
1984-1990	8%	8%	-5%	-5%	3%
1990-2000	19%	7%	-5%	-10%	13%
2000-2007	-9%	17%	-5%	2%	-17%
1984-2007	**17%**	**34%**	**-14%**	**-13%**	**-4%**

Source: calculated from data in DfT, 2008b, 1999, 1995.

Note:
* - a negative change in empty running reflects and improvement (i.e. the level of vehicle kilometres run empty has reduced).

A change in average length of haul, vehicle carrying capacity, and lading factor bring about a proportional change in the total vehicle kilometres travelled (i.e. a 1% improvement in any of these variables results in a 1% reduction in total vehicle kilometres). However, in the case of empty running, a 1% improvement results in a less than proportionate reduction in total vehicle kilometres. Using 2007 data, a 1% improvement in empty running (i.e. from 27.4% to 27.1%) would result in a 0.4% reduction in total vehicle kilometres.

Therefore, Table 4.3 indicates that over the period 1984 to 2007, the increase in vehicle carrying capacity (34%) was the most important factor in reducing the average vehicle kilometres travelled per tonne lifted, followed by improvements in empty running (-13%). Increases in the average length of haul (17%) and a deterioration in lading factor (-14%) were of similar importance in raising vehicle kilometres travelled per tonne lifted over this period.

Table 4.3 shows that increases in vehicle carrying capacity (17%) was also the most important factor in reducing the average vehicle kilometres travelled per tonne lifted over the period from 2000 to 2007, followed by a reduction in the average length of haul (-9%). Meanwhile a worsening in lading factor (-5%) and empty running (2%) had the effect of increasing the average vehicle kilometres travelled per tonne lifted between 2000 and 2007.

Discussion of the determinants that have influenced these changes in the key variables over the period 1984 to 2007 is provided in section 5.

4.2 Measures of road freight transport efficiency and utilisation

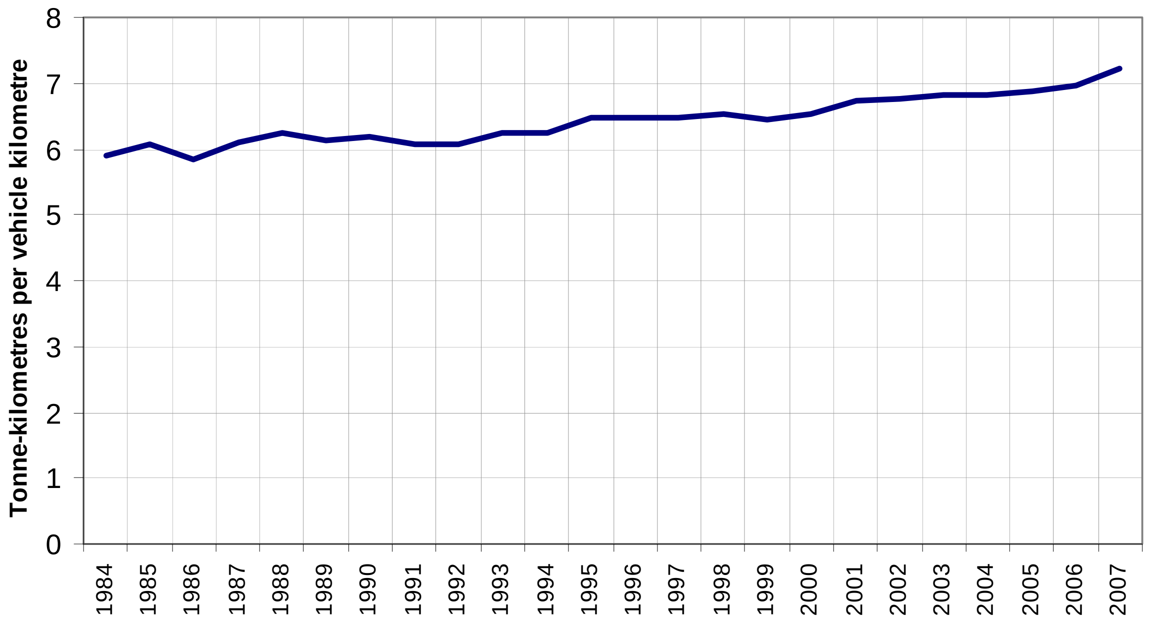
Section 2.5 proposed four measures of HGV utilisation and efficiency. These were:

- Vehicle utilisation on journeys (tonne-kms / vehicle kms)
- Road freight transport fuel efficiency (litres of fuel consumed per tonne-km)
- Road freight transport CO_2 efficiency (kg CO_2 per tonne-km)
- Road freight transport efficiency per vehicle (tonne-kms per vehicle per annum)

The results of the first three of the first measures listed above are presented in this section, while the results of the last measure (tonne-kilometres per vehicle per annum) are presented in section 4.4.

Figure 4.4 shows the vehicle utilisation on HGV journeys (measured as tonne-kilometres per vehicle kilometres). This measure reflects the efficiency of HGV operations in terms of the lading factor, vehicle carrying capacity, and the proportion of empty running. In 1984 HGVs performed, on average, 5.9 tonne-kms per vehicle kilometre. By 2007 this had risen to 7.2 – a 22% increase. As explained in section 4.1 this improvement was mostly due to the increase in vehicle carrying capacity over the period.

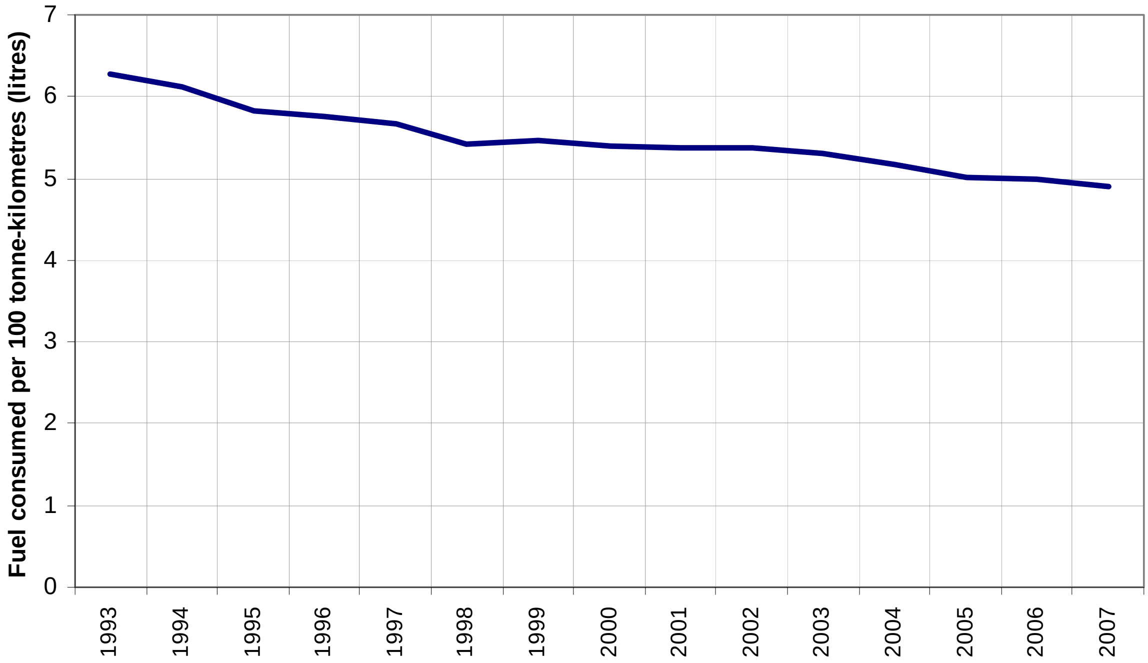
Figure 4.4: Tonne-kilometres : vehicle kilometres for HGVs in Britain, 1984-2007



Source: Calculated from data in DfT, 2008b.

The fuel efficiency of HGV activity in Britain can be measured in terms of the litres of fuel consumed per tonne-km. The lower the result the more sustainable the activity in terms of total fuel consumption. Figure 4.5 provides the analysis or the period 1993-2007 (analysis can only be conducted from 1993 due to unavailability of fuel consumption data prior to this). The results indicate that the diesel fuel used per 100 tonne-kilometres has fallen over the entire period.

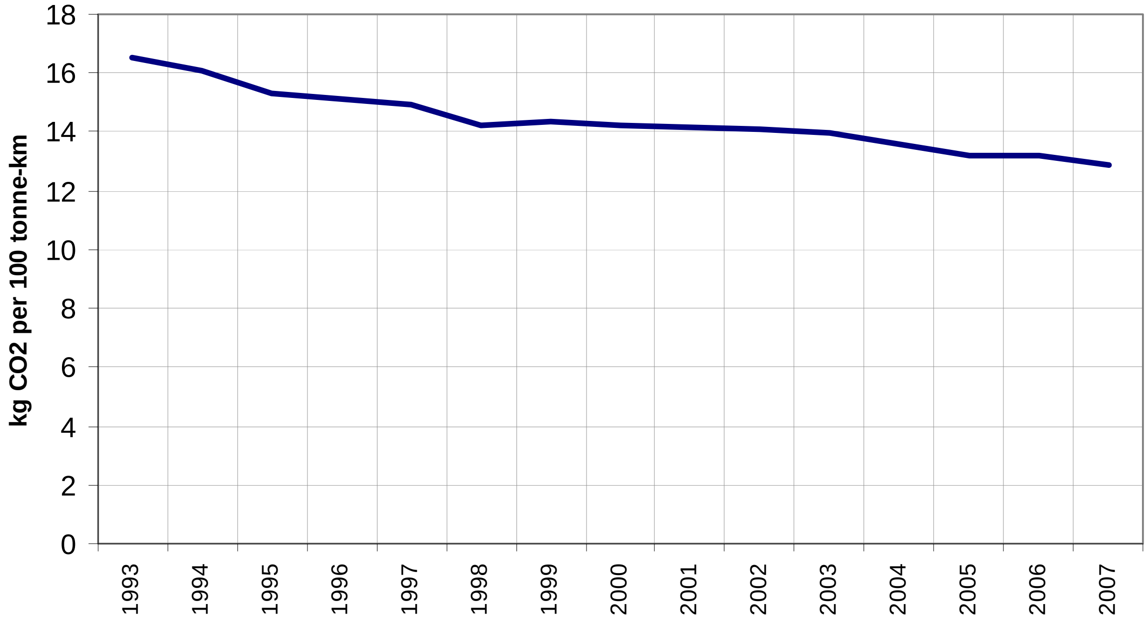
Figure 4.5: Road freight transport fuel efficiency (litres of fuel consumed per 100 tonne-kilometres by HGVs in Britain), 1993-2007



Source: calculated from data in DfT, 2008b.

The carbon dioxide (CO_2) efficiency of HGV activity in Britain can be measured in terms of the kilogrammes of CO_2 emitted per tonne-km. The lower the result the more sustainable the activity in terms of total fuel consumption. Figure 4.7 provides the analysis or the period 1993-2007. This shows the same trend as fuel consumed (shown in Figure 4.5) as HGVs have continued to be diesel-powered and the carbon content of diesel has not changed over the period studied.

Figure 4.6: Road freight transport CO_2 efficiency in Britain (CO_2 emitted per tonne-km by HGVs) 1993-2007



Source: Calculated from data in DfT, 2008b.

4.3 Measures of road freight transport intensity

Section 2.5 proposed four measures of HGV utilisation and efficiency. These were:

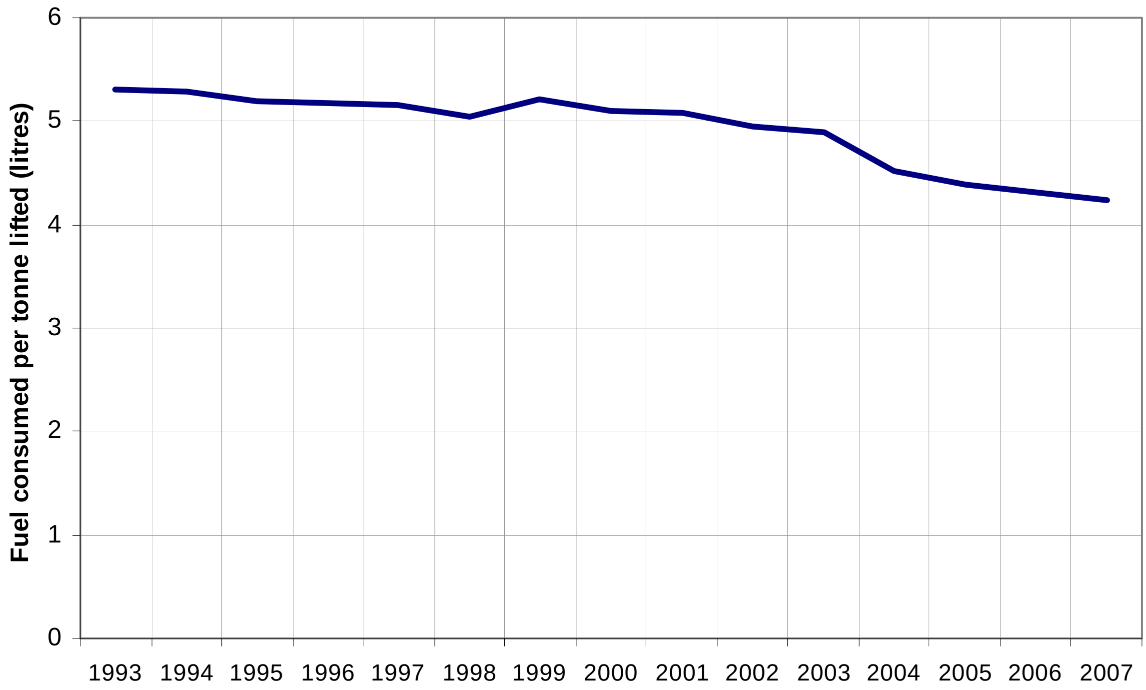
- Road freight transport intensity (vehicle kilometres per tonne lifted by road)
- Road freight transport fuel intensity (litres of fuel consumed per tonne lifted)
- Road freight transport CO_2 intensity (kg CO_2 per tonne lifted)
- Road freight transport intensity per vehicle (tonnes lifted per vehicle per annum)

The first three of the first measures listed above are discussed in this section, while the results of the last measure (tonnes lifted per vehicle per annum) are presented in section 4.4.

Road freight transport intensity (the first measure listed above – measured in vehicle kilometres per tonne lifted) was presented in section 4.1 (see Figure 4.2). The results showed that the average distance travelled by HGVs per tonne lifted rose from 12.4 km in 1984 to 14.7 km in 1999. However since then it has fallen annually to 11.9 km in 2007.

Road freight transport fuel intensity is shown in Figure 4.7.

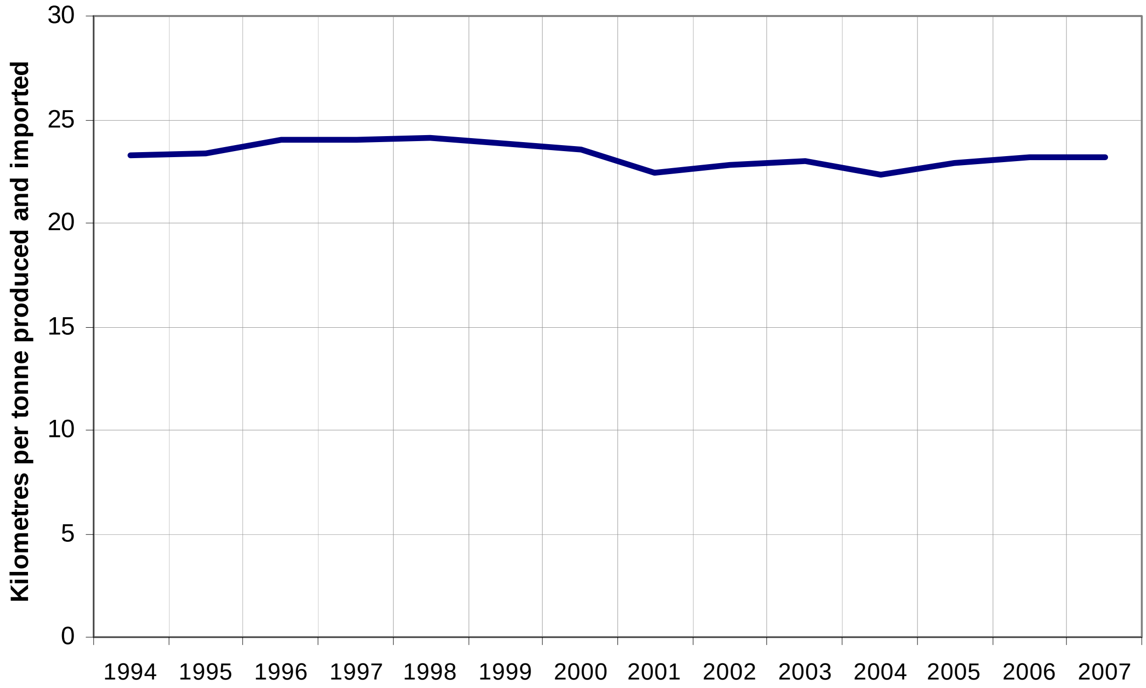
Figure 4.7: Road freight transport fuel intensity



As shown in the previous section, the road freight transport fuel intensity and the road freight transport CO_2 intensity will produce exactly the same trend over time as the carbon intensity of diesel fuel has not changed over the period in question and the HGV fleet continues to rely on diesel fuel.

As discussed in section 2.4 another measure of the road freight transport intensity is the vehicle kilometres per tonne of goods produced domestically plus finished imports rather than per tonne of road freight lifted. This measure takes account of the handling factor and the modal split. However data on weight of goods produced domestically plus finished imports is not as reliable as CSRGT data and comes from several different sources, so the result is unlikely to be as robust and reliable as a measure. Figure 4.9 shows the results for this alternative method of calculating road freight transport intensity between 1994 and 2007. The results indicate that using this measure road freight transport intensity has remained relatively stable over the period (at approximately 24 km per tonne of goods produced and imported). The difference between this result and the result per tonne lifted by HGVs in Figure 4.2 (which showed a reduction in intensity since 1999 mostly as a result of reductions in the average length of haul) is based on the estimated increase in the handling factor since 2001 (see Figure 3.3) rather than due to any change in modal share lifted by road (as this has remained stable – Figure 3.5).

Figure 4.9: Vehicle kilometres per tonne of goods produced and imported

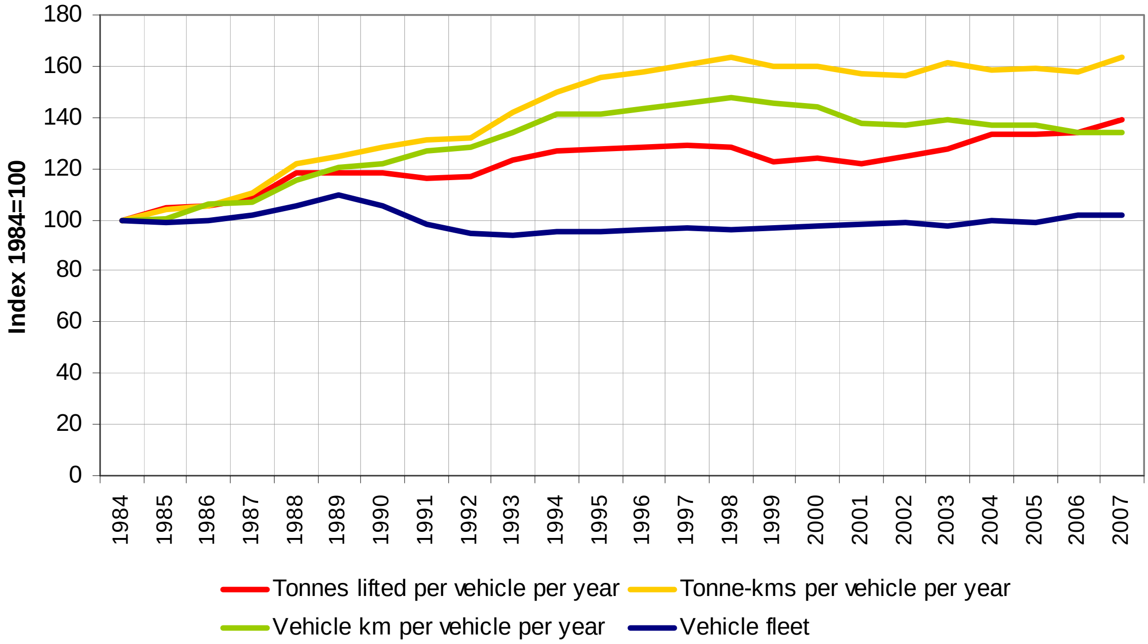


<u>4.4 Road freight transport efficiency and intensity per vehicle</u>

As discussed in section 3.11, in order to cope efficiently with the quantity of tonnes lifted and the distance over which this needs to be moved between 1984 and 2007, HGV operators have responded by both making use of vehicles with greater carrying capacities, and using vehicles more intensively rather than simply increasing the number of HGVs in the UK fleet. Legislation in 1983, 1999 and 2001 increased to the maximum gross weight of HGVs to 38 tonnes, then 41 tonnes and then 44 tonnes. This facilitated the heaviest permissible articulated HGVs to carry more tonnes of goods than had previously been possible.

By progressively shifting towards greater use of heavier goods vehicles rather than simply increasing their fleet sizes, operators have managed to exercise control over road freight transport costs. Figure 4.7 shows that the total HGV fleet has remained virtually unchanged since 1984. As a result, each HGV in 2007 has, on average, had to do far more work than an HGV in 1984 in order to cope with the growing demand (with the average vehicle lifting 39% more tonnes, travelling 24% more kilometres, and performing 64% more tonne-kilometres per annum in 2007 than in 1984). However, since 1999 the average vehicle kilometres travelled per vehicle each year has been falling. This is likely to be a result of two factors: lower average journey speeds which may be preventing drivers from making as many trips in a working day as they did previously, and reductions in average length of haul which may be reflection of supply chains being reconfigured to take account of lower average travel speeds (see section 3.5).

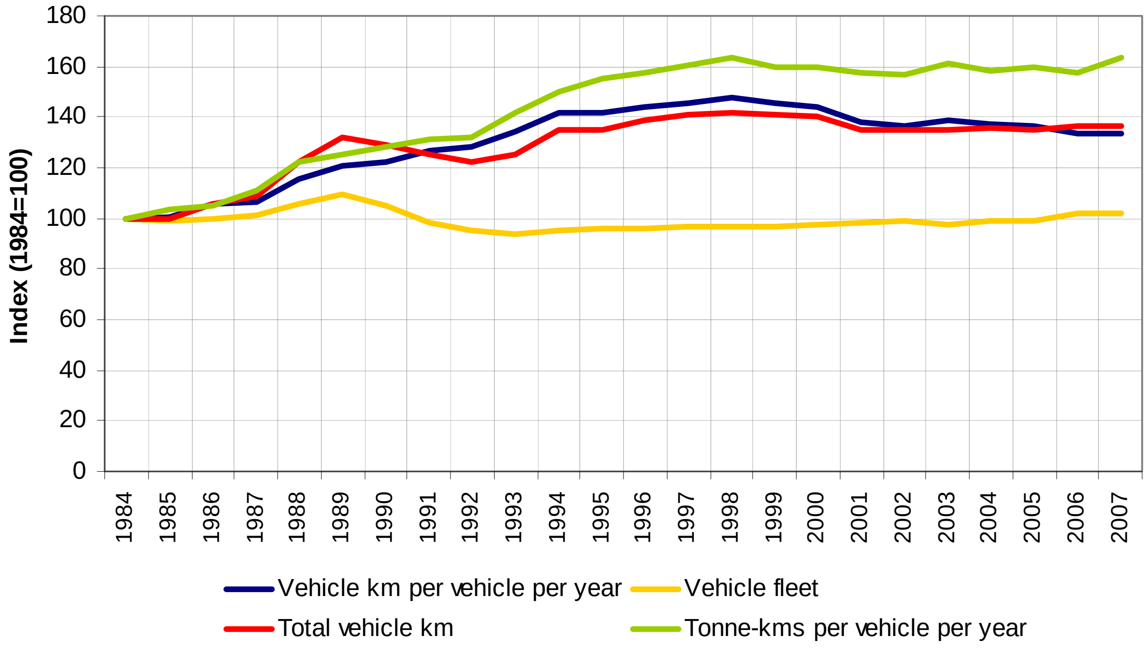
Figure 4.7: Average annual vehicle kms, tonnes lifted and tonne-kms per HGV and total fleet size in Britain, 1984-2007 (index 1984=100)



Source: calculated from data in DfT, 2008b, 2010.

This is borne out by Figure 4.8, which also shows that since 1998 total vehicle kilometres performed by the fleet and the average annual kilometres per vehicle have tracked each other closely. This reflects that changes in total kilometres travelled by the entire HGV fleet have resulted from changes in the average annual distance travelled by each vehicle rather than by changes to the fleet size.

Figure 4.8: HGV vehicle fleet, total vehicle km, and vehicle km per vehicle per year, 1984-2007 (index 1984=100)



Source: calculated from data in DfT, 2008b, 2010.

Figure 4.8 indicates that the annual productive use of HGVs (in terms of vehicle kms per vehicle and tonne-kms per vehicle) rose between 1984 and 1998, since when it has stabilised. This is shown in greater detail in Table 4.4.

Between 1984 and 1998 despite a 25% increase in total tonnes lifted, a 42% increase in total HGV kilometres, and a 63% increase in total tonne-kms, the HGV fleet size actually fell by 4%. This reflects the shift towards the use of heavier HGVs over this period. Increases in average tonne-kms per vehicle per year were greater than increases in average vehicle km per vehicle per year over the period 1984-1998 as a result of the increases in average load carried which resulted from the shift towards the purchase and use of heavier vehicles among operators together with the increase in maximum permissible gross vehicle weight in 1983.

Between 1998 and 2007 the situation was completely different to the period 1984-1998, with a 6% increase in vehicle fleet, and a 4% reduction in total vehicle kilometres, 9% reduction in vehicle kms per vehicle, and no change in tonne-kms per vehicle. This is likely to be a reflection of growing traffic congestion on British roads resulting is slower and less reliable journeys (rather than a reduction in the total amount of time that each vehicle is driven on the road).

Table 4.4: Changes in HGV vehicle fleet, total vehicle km, and vehicle km per vehicle per year, 1984-2007 (percentages)

	Vehicle fleet	Total vehicle km	Vehicle km per vehicle per year	Tonne-kms per vehicle per year
1984-1998	-4%	42%	47%	63%
1998-2007	6%	-4%	-9%	0%
1984-2007	2%	37%	34%	64%

Source: calculated from data in DfT, 2008b, 2010.

As discussed in section 3.11, there is no available source of data that shows how average speed across the entire road network changed during the daytime changed over the period 1984 to 2007. However, the data that is available suggests that journey speeds on motorways and other major roads have fallen especially over the last decade. This has resulted in HGV operators making greater use of night deliveries when free-flow speeds can be achieved. However, not all deliveries can feasibly be made at night and therefore the majority of HGV activity continues to take place during the working day. In order to prevent the need for an ever-growing HGV fleet as daytime speeds have fallen, operators have shifted towards the use of heavier HGVs and it is likely that operators have also ensured that their vehicles spend a longer proportion of their time driving on the road than they did previously. However, data longitudinal data does not exist to provide evidence for this latter point. Table 4.5 shows the estimated effect of lower average speeds on the time that HGV fleet would have needed to spend driving on the roads in 2007 compared to 1984 if there had not been a shift towards the use of heavier HGVs and night deliveries (or the increase in the HGV fleet size that would have been necessary if each HGV had not been driven for longer).

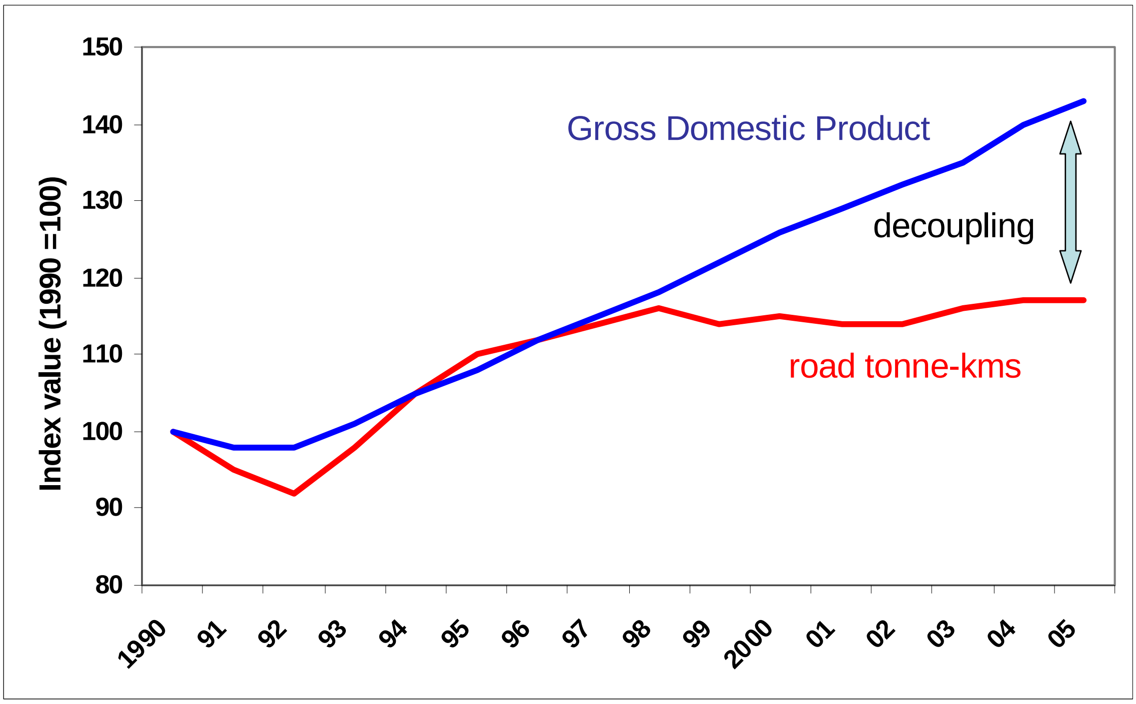
Table 4.5: Estimated increase in average time that HGVs would have spent driving on the roads in 2007 compared to 1984 if operators had not switched towards heavier vehicles and night deliveries (percentages)

Assumed reduction in average journey speed between 1984 and 2007	Percentage increase in time each HGV would need to have been driven on the roads
No change	34%
2% reduction	36%
5% reduction	41%
10% reduction	49%

4.5 GDP and HGV activity

McKinnon (2007) has noted that in the UK for "several decades there was a close correlation between economic growth and the growth of freight movement measured in tonne-kms. These two trends have decoupled over the past decade, with GDP increasing steadily at 2.5-3% per annum, while tonne-kms have remained fairly stable" (see Figure 4.8). This "decoupling" between GDP and tonne-kms could be due to i) changes in the economy, with service sectors, which generate less freight per unit of output than manufacturing, becoming ever-more important, ii) increased "off-shoring" of UK manufacturing and greater import penetration – which reduces the inbound freight trips comprising raw materials and parts, and iii) weakening of centralisation trends in production, warehousing and servicing – centralisation of facilities occurred between the 1960s and 1990s (as indicated by the growth in the average lengths of haul) but appears to be stabilising now (McKinnon, 2007).

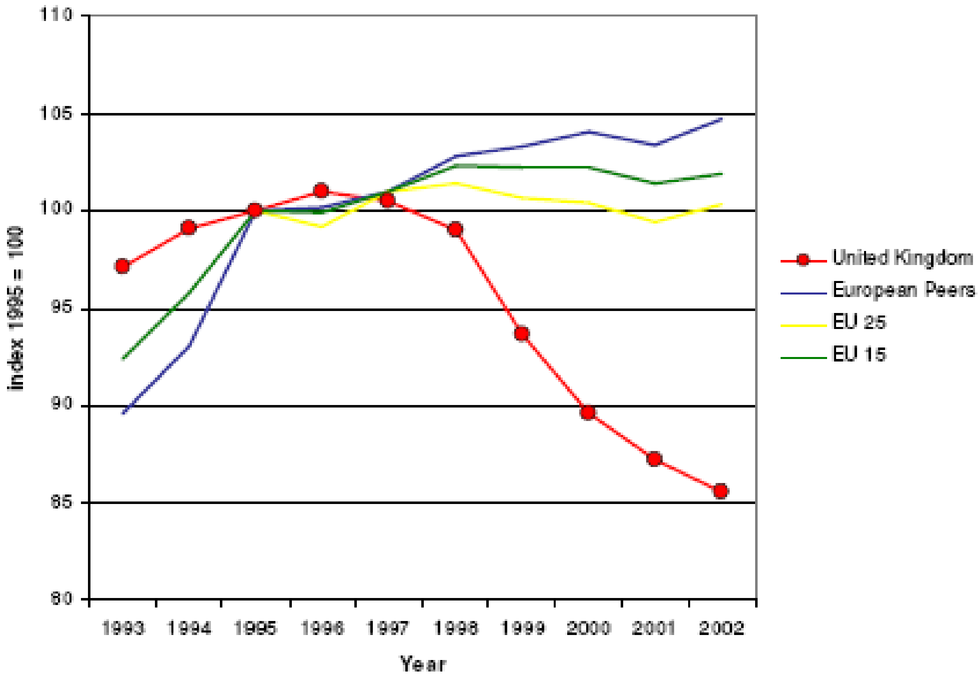
Figure 4.8: Decoupling of economic growth and road freight traffic growth



Source: McKinnon et al, 2007.

This decoupling of GDP and tonne-km has been much more pronounced in the UK than in most other EU countries. In some EU countries, such as Spain and Ireland, GDP and tonne-kms changed in the opposite manner, with freight tonne-km growth exceeding GDP growth (McKinnon, 2007). Figure 4.9 shows the relationship between tonne-kms for all freight modes and GDP in other countries.

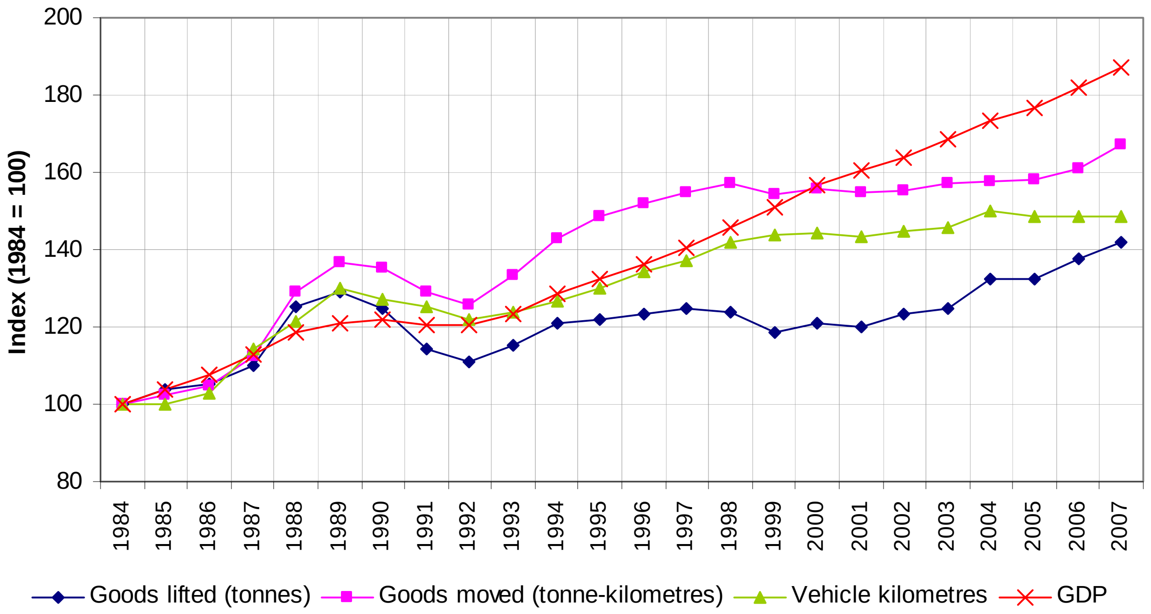
Figure 4.9: Tonne-kms to GDP - Comparing the United Kingdom to its European Peer group, EU 15 and EU 25



Source: Jacobs Consultancy, 2006.

Figure 4.10 shows the relationship between GDP and HGV tonne-kms, tonnes lifted and vehicle kms (as estimated by road traffic counts rather than CSRGT) in Britain from 1984 to 2007. This shows the decoupling between GDP and HGV tonne-kms in the initial years after 2000 (as also reflected in Figure 3.20). It also shows the decoupling between GDP and HGV vehicle kms (since the late-1990s) and tonnes lifted (since approximately 1990).

Figure 4.10: Relationship between GDP and HGV tonne-kms, tonnes and vehicle km in Britain, 1984-2007



Source: calculated from data in DfT, 2008a and 2008b.
Notes:
GDP is constant prices
Vehicle km data is taken from road traffic statistics rather than from CSRGT.

However, recent research by McKinnon, Piecyk and Somerville (2008) suggests that the decoupling trend in the UK shown in Figure 4.8 has come to an end, with growth in tonne-kilometres close to matching GDP growth in 2006 and 2007. Table 4.4 shows the annual change in each of these variables since 2000. This shows that both HGV tonnes lifted and tonne-kms grew more than GDP between 2006 and 2007. Meanwhile annual growth in HGV vehicle kilometres (measured both by road traffic count data and by the CSRGT survey data) has been very low and even negative in some years.

Table 4.4: Annual change in GDP and HGV tonnes lifted, tonne-kms and vehicle kms 2000-2007

	Percentage change on previous year							
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
GDP	3.9%	2.5%	2.1%	2.8%	2.8%	2.1%	2.8%	3.0%
Goods moved (tonne-kms)	0.9%	-0.7%	0.3%	1.3%	0.3%	0.3%	1.9%	3.8%
Goods lifted (tonnes)	1.7%	-0.8%	2.9%	1.0%	6.1%	0.1%	3.8%	3.1%
Vehicle kms (traffic count data)	0.4%	-0.6%	0.9%	0.6%	3.1%	-1.1%	0.2%	0.0%
Vehicle kms (CSRGT data)	-0.4%	-3.5%	0.0%	0.0%	0.5%	-0.4%	0.5%	0.4%

4.6 Further analysis of key variables and outputs for HGVs

As previously explained, for the research carried out as part of this report a spreadsheet model was developed to relate the determinants, key variables and outputs (from tonnes lifted down to the vehicle kilometres (and fuel consumption) shown in Figure 3.1). The model was populated with data from the CSRGT for the period 1984 to 2007.

Table 4.5 shows the outputs and key variables for road freight transport by HGVs in Britain for every five years between 1986 and 2007 (from modal share through to vehicle kilometres – 1986 chosen as the start year rather than 1987 as national population data is not available for 1987). A range of performance indicators were calculated from these outputs, and are shown in Table 4.6.

Table 4.5: Road freight transport by HGVs in Britain 1986-2007 - key variables and outputs

Key variables and outputs	1986	1991	1997	2002	2007
Handling factor					
Road modal share – freight lifted (%)	75.5	75.8	77.0	77.3	78.7
Freight lifted by HGV (million tonnes)	1386	1505	1643	1627	1869
Length of haul (km)	73	83	91	92	86
Freight moved by HGV (billion tonne-kms)	101	125	150	150	161
Vehicle utilisation on laden trips (ratio)	0.63	0.62	0.62	0.58	0.57
Vehicle carrying capacity by weight (tonnes)	13.3	13.8	14.5	15.8	17.4
Average load on laden trips (tonnes)	8.4	8.6	9.0	9.2	9.9
Empty running (%)	30.3	29.1	28.2	26.5	27.4
Laden kilometres (billion)	12.1	14.5	16.6	16.3	16.2
Empty kilometres (billion)	5.2	6.0	6.5	5.9	6.1
Vehicle kilometres (billion)	17.3	20.5	23.1	22.2	22.3
Fuel efficiency (kilometres per litre)	n/a	2.48	2.73	2.76	2.83
Fuel consumed (billion litres)	n/a	8.27	8.47	8.04	7.87
CO_2 emissions (million tonnes)	n/a	21.8	22.3	21.1	20.7

Notes:
Data only includes HGVs (i.e. goods vehicles over 3.5 tonnes)
All results shown above based on CSRGT data.

Source: calculated from data in DfT, 2008b, 1999 and 1995.

Table 4.6: Road freight transport by HGVs in Britain 1986-2007 – performance measures

Performance measures	1986	1991	1997	2002	2007
Road freight transport intensity (vehicle kms per tonne lifted)	12.5	13.6	14.1	13.6	11.9
Road freight transport fuel intensity (litres per tonne lifted)	n/a	5.5	5.2	4.9	4.2
Road freight transport CO_2 intensity (kg CO_2 per tonne lifted)	n/a	14.5	13.6	13.0	11.1
Tonnes lifted per vehicle per year	2,864	3,352	3,969	3,826	4,191
Road freight transport utilisation (tonne-kms : vehicle kms)	5.8	6.1	6.5	6.7	7.2
Road freight transport fuel efficiency (litres per 100 tonne-km	n/a	6.6	5.7	5.4	4.9
Road freight transport CO_2 efficiency (kg CO_2 per tonne-km)	n/a	17.5	14.9	14.1	12.9
Tonne-kms per vehicle per year (thousand)	232	290	355	346	362
Road freight transport intensity (vehicle kms per tonne produced and imported)	20.3	23.7	26.3	25.5	26.3
Average load on all vehicle km (loaded and empty kms) (tonnes)	5.8	6.1	6.5	6.7	7.2
GDP / tonne-kms	7.2	6.5	6.4	7.4	7.9
Tonnes lifted per capita	25.1	27.0	29.0	28.2	31.6
Vehicle kms per capita	314	367	408	385	377
KSI per 100 million vehicle km	26.3	18.1	12.9	10.3	6.9
Slight casualties per 100 million vehicle km	65.3	61.1	57.4	51.2	40.2

Notes:
“n/a” – not available
Data only includes HGVs (i.e. goods vehicles over 3.5 tonnes)
All results shown above based on CSRGT data, with the exception of casualty data which uses road traffic estimates of vehicle kms.
Source: calculated from data in DfT, 2008b; 1999 and 1995.

5. Analysis of HGV activity in Britain by vehicle type and weight category

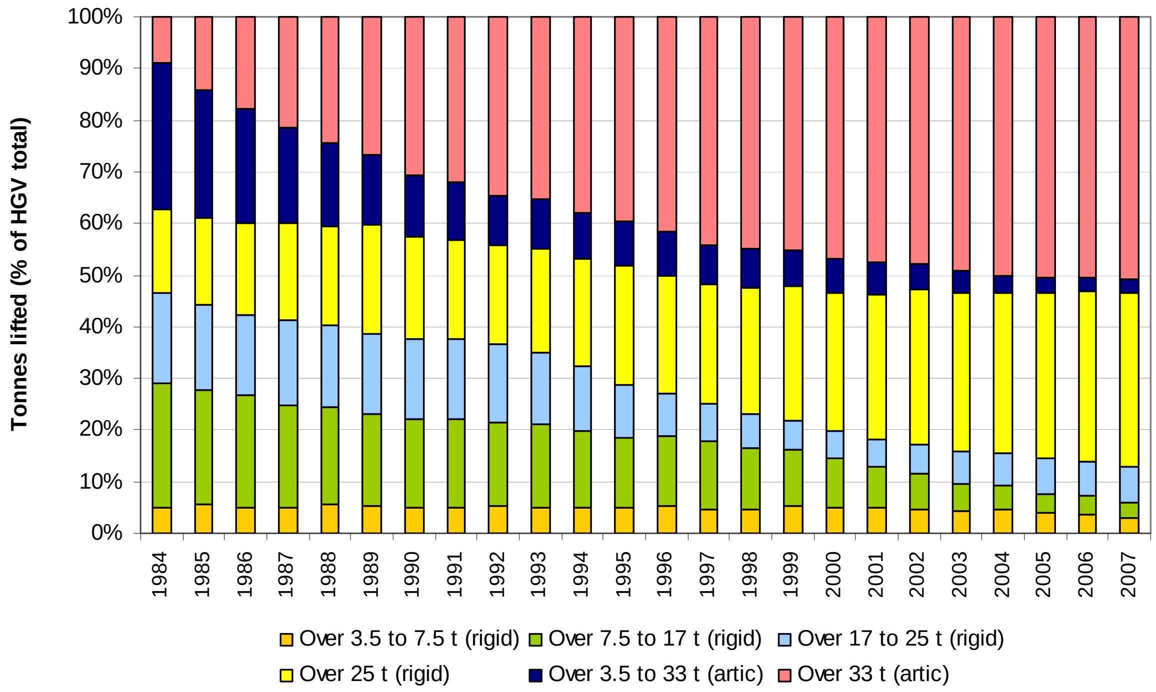
Sections 3 and 4 presented analysis of all British-registered HGV (i.e. all goods vehicles over 3.5 tonne gross weight) activity in Britain since 1984. This section presents an analysis of determinants, key variables and outputs by vehicle type (rigid or articulated) and vehicle gross weight category. For the purposes of the analysis, rigid vehicles are subdivided into four gross weight categories (over 3.5 – 7.5 tonnes, over 7.5 – 17 tonnes, over 17 – 25 tonnes, and over 25 tonnes), and rigid are divided into two gross weight categories (over 3.5 – 33 tonnes, and over 33 tonnes). These are the gross weight categories commonly used for analysis in CSRGT.

5.1 Goods lifted

Figure 5.1 shows the proportion of goods lifted by each HGV type and gross weight category over the period 1984 – 2007. This shows that the importance of some HGV types in terms of goods lifted has increased markedly (most notably articulated vehicles over 33 tonnes, and rigid vehicle over 25 tonnes) while the importance of others has diminished (including articulated vehicles up to 33 tonnes, and rigid vehicles between 7.5 and 25 tonnes).

Figure 5.1 shows that in 1984 articulated vehicles over 33 tonnes gross weight and rigid vehicles over 25 tonnes gross weight were only responsible for 9% and 16% respectively of total goods lifted by HGVs. By 2007, articulated vehicles over 33 tonnes lifted 51% while rigid vehicles over 25 tonnes lifted 34% of total freight.

Figure 5.1: Freight lifted by HGV type and gross weight category, 1984-2007

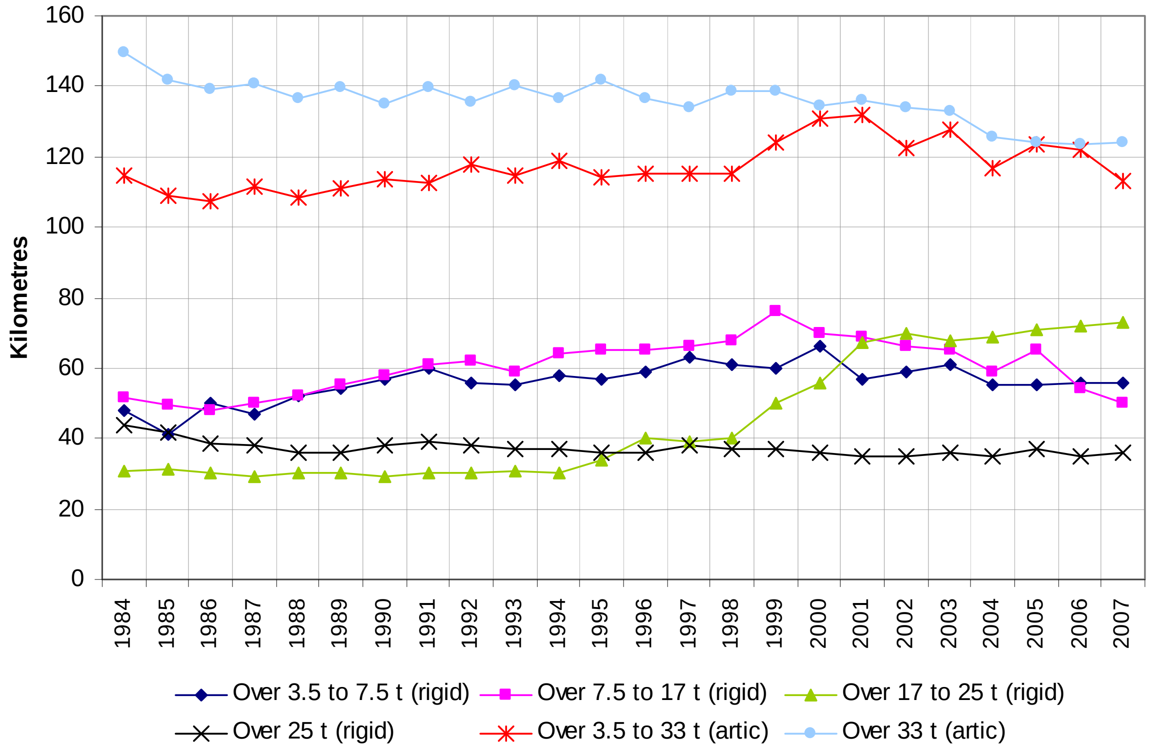


Source: calculated from data in DfT, 2008b, 1999, 1995.

5.2 Average length of haul

Figure 5.2 shows the average length of haul for these various types and weights of goods vehicles. In general, the heavier vehicle types have the longest average lengths of haul (with the exception of rigid vehicles over 25 tonnes which are commonly used for moving quarried and building materials and waste over relatively short distances). It can be seen that average haul lengths are far higher for articulated vehicles than rigid vehicles. Although the overall trend for all goods vehicles was a rising average length of haul from 1984-1999 and a stable/slightly falling average length of haul between 1999-2007, this trend does not exist for all categories of HGVs. In fact only rigid vehicles in the 3.5 – 7.5 tonnes and 7.5-17 tonnes categories show a similar pattern. Articulated vehicles (both up to and over 33 tonnes) exhibited a stable average haul length between 1984 and 1999, which has reduced a little since then. Rigid vehicles between 17-25 tonnes showed a stable haul length between 1984-1994, which has risen considerably since then. Therefore the pattern in average haul length has shown considerable variation between these different HGV categories over the period 1984-2007.

Figure 5.2: Average length of haul by HGV type and gross weight category, 1984-2007



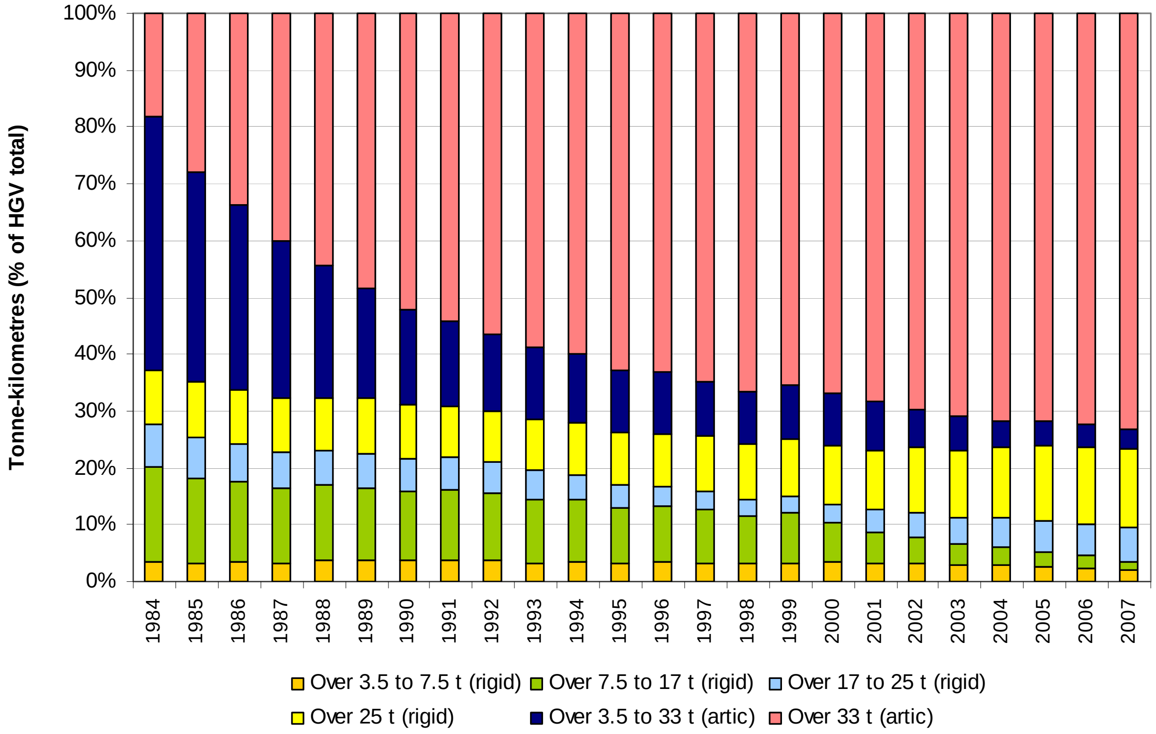
Source: DfT, 2008b, 1999, 1995.

5.3 Goods moved

Figure 5.3 shows the proportion of goods moved by each HGV type and gross weight category over the period 1984 – 2007. This reflects effect of the distance over which goods are moved on the goods lifted in Figure 4.1. As was the case for goods lifted, Figure 5.3 shows that the importance of some HGV types in terms of goods moved has increased markedly. The change over the time period is even more significant than for goods lifted. Articulated vehicles over 33 tonnes have increased their share of goods moved from 18% in 1984 to 73% in 2007. The maximum permissible gross weight of articulated vehicles was increased from 32.5 tonnes to 38 tonnes in 1983, the year prior to the data shown in Figure 5.3. The maximum gross weight of these vehicles was increased again to 41 tonnes in 1991 and 44 tonnes in 2001. The vehicle type and weight category that has diminished most over this period is articulated vehicles of up to 33 tonnes as operators substituted these vehicles for the heavier articulated vehicles made possible by the changes in gross weight implemented by government.

Although rigid vehicles over 25 tonnes have increased notably in importance in terms of goods lifted (see Figure 5.1) this has not been reflected in the tonne-kms that they perform (see Figure 5.3). This is due to their very low average length of haul in comparison with other HGV types (see Figure 5.2).

Figure 5.3: Freight moved by HGV type and gross weight category, 1984-2007

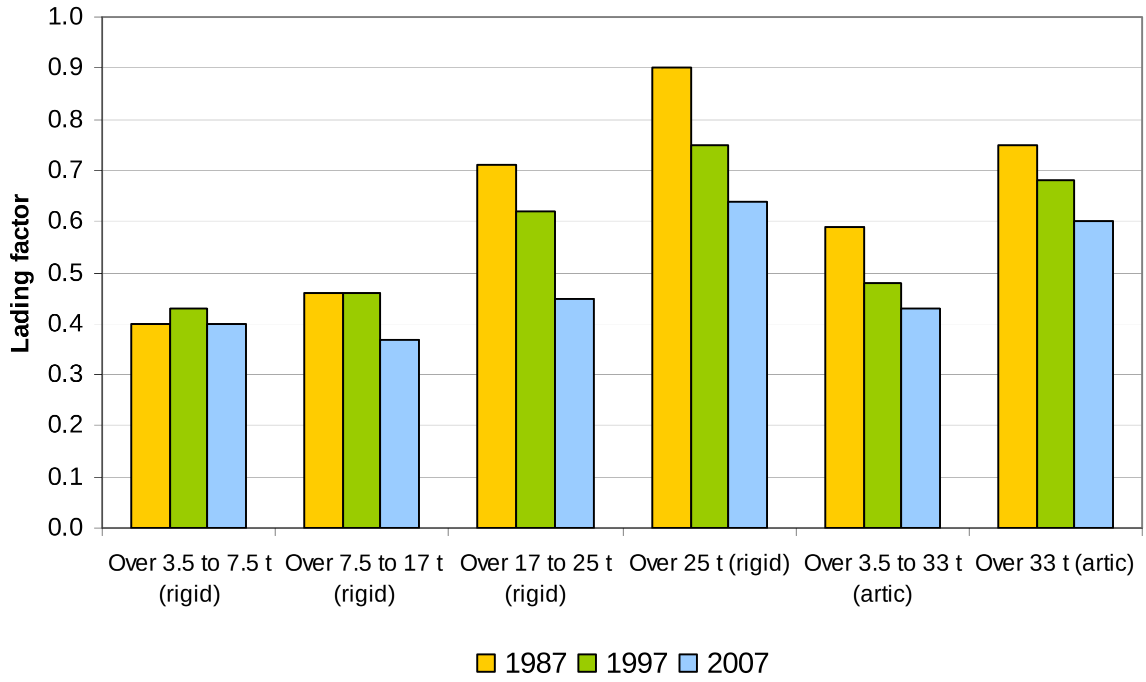


Source: calculated from data in DfT, 2008b, 1999, 1995.

5.4 Average load on laden trips

Figure 5.4 shows average lading factor by HGV type and weight category in 1987, 1997 and 2007. This shows that, in general, heavier goods vehicles tend to have higher lading factors than lighter ones (i.e. rigid vehicles over 25 tonnes and articulated vehicles over 33 tonnes have higher average lading factors than other HGV categories). Average lading factors can be seen to have fallen over the period shown for all categories of HGV (with the exception of rigid vehicles 3.5-7.5 tonnes).

Figure 5.4: Average lading factors by HGV type and gross weight category, 1987, 1997 and 2007

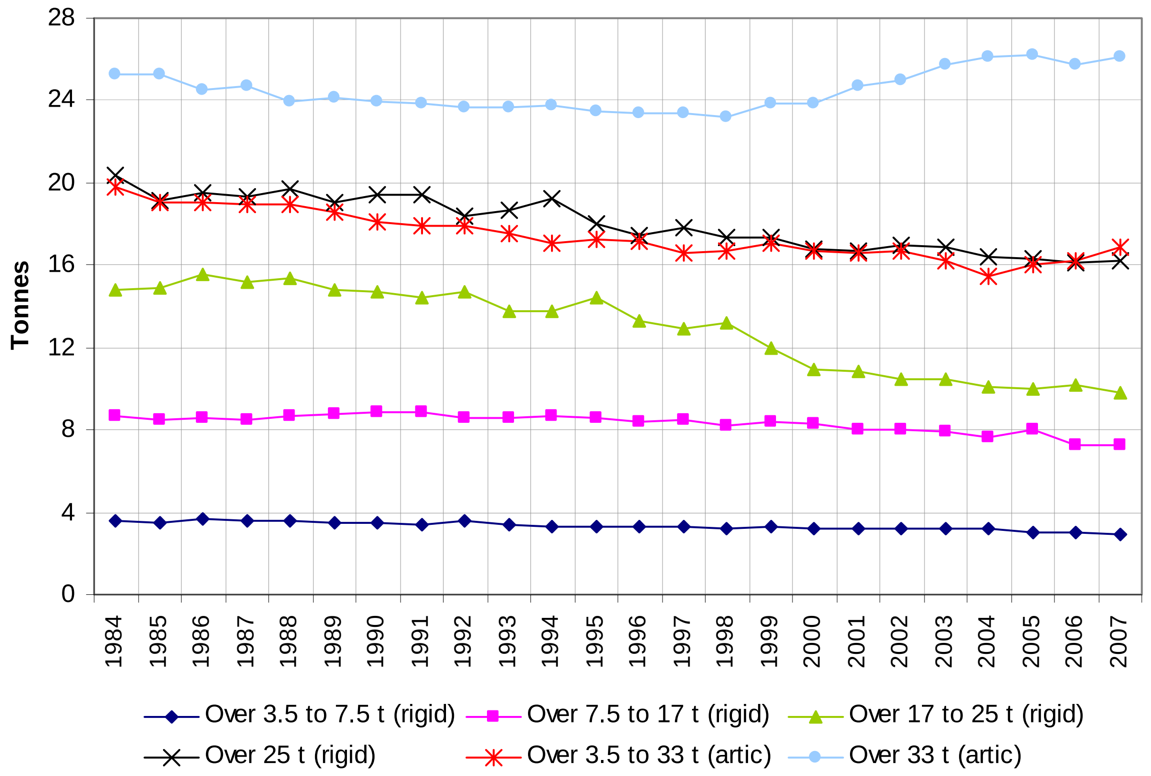


Source: DfT, 2008b, 1999, 1995.

Figure 5.5 shows the carrying capacity (i.e. the maximum potential average weight of load that could be carried if the vehicles were fully laden in weight terms) on HGV trips by vehicle type and weight category. The carrying capacity (in weight terms) by vehicle weight category can change for two reasons: i) shifts in the composition and use of the British HGV fleet towards heavier vehicles within a weight category and ii) increases in maximum permissible gross weight of HGVs (which will only affect the heaviest goods vehicle weight categories) Figure 5.5 shows that for most vehicle weight categories the maximum potential average load remained stable or even fell over the period 1984-2007. However, for articulated vehicles over 33 tonnes, the carrying capacity can be seen to have increased substantially since 1999. This has been caused by the regulations increasing the maximum permissible gross weight or articulated vehicles in 1999 (to 41 tonnes) and in 2001 (to 44 tonnes), and the subsequent adoption of these vehicles by operators.

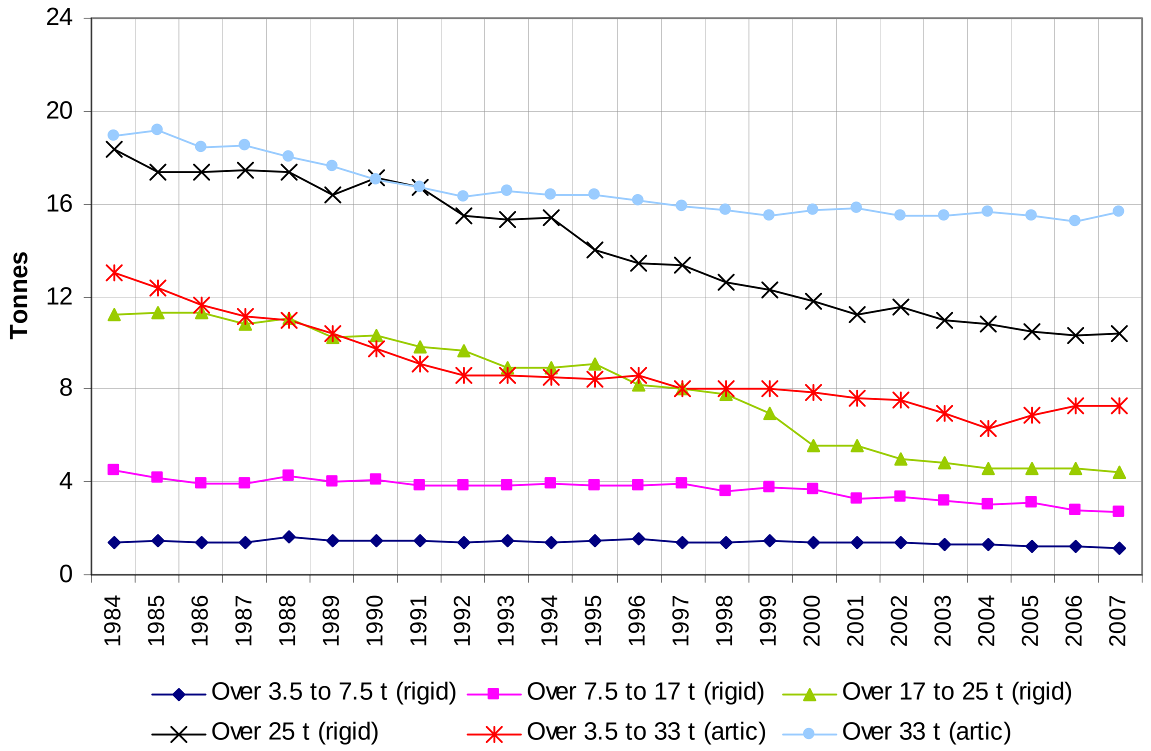
The carrying capacity in Figure 5.5 can be compared with the average load actually carried by HGVs on laden trips according to type and weight category shown in Figure 5.6. Figure 5.6 shows that over the period 1984–2007 the average weight of load carried by all HGV categories has fallen with the exception of rigid vehicles over 25 tonnes (which fell until 2004 and then rose). This is particularly surprising for articulated vehicles over 33 tonnes given the increase in their carrying capacity as a result of increases in maximum gross vehicle weights (see section 3.7). If only articulated vehicles over 33 tonnes exhibited this trend, then it could potentially be explained by operators using vehicles that are plated at heavier weights than they actually require for most of their work. However, as the trend is occurring across the majority of vehicle types and weight categories it is more likely to be due to changes in the type of products and reductions in the bulk densities of products that vehicles are carrying, resulting in them reaching their volume capacity before the weight payload has been reached (see section 6 for further discussion of this issue).

Figure 5.5: Carrying capacity by weight by HGV type & gross weight, 1984-2007



Source: calculated from data in DfT, 2008b, 1999, 1995.

Figure 5.6: Average load carried on laden trips by HGV type and gross weight category, 1984-2007

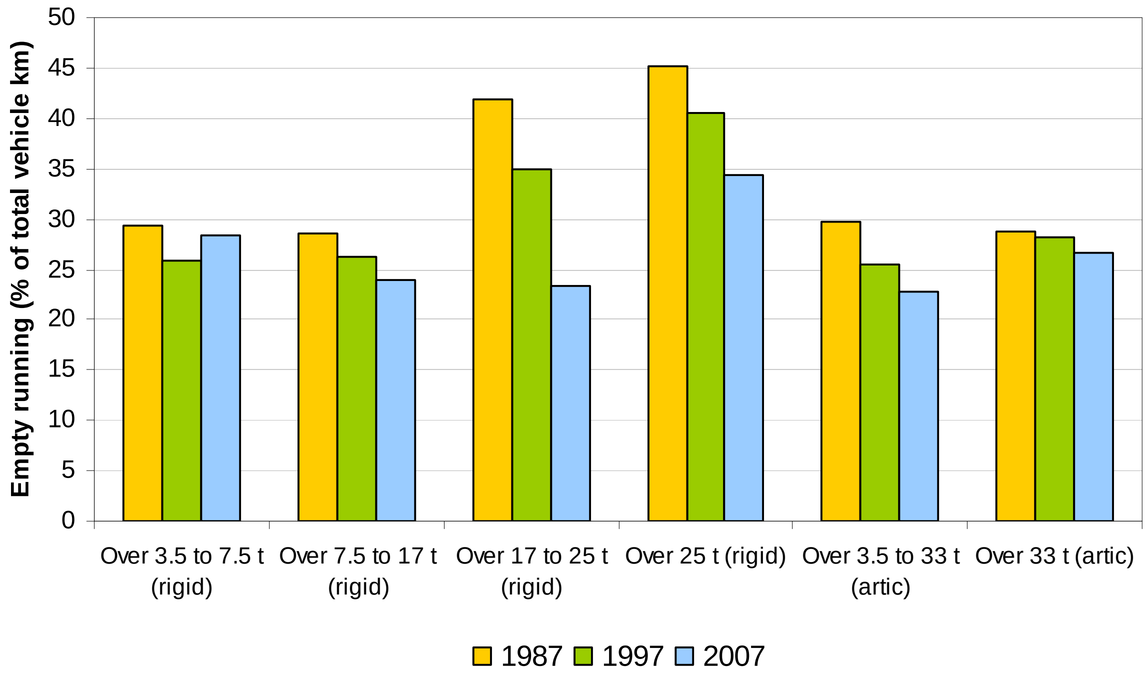


Source: calculated from data in DfT, 2008b, 1999, 1995.

5.5 Empty running

Figure 5.7 shows the proportion of vehicle kilometres run empty by HGV type and weight category. This shows that empty running was most prevalent among the heavier rigid vehicle categories (over 17-25 tonnes and over 25 tonnes) in 1987 and 1997. By 2007 rigid vehicles over 25 tonnes still exhibited a higher proportion of empty running than any other HGV category, but the difference with other categories was less than in 1987 and 1997. Most categories of HGV improved their proportion of empty running over the period studied with the exception of 3.5 – 7.5 tonne rigid vehicles (and articulated vehicles over 33 tonnes only showed a very modest improvement).

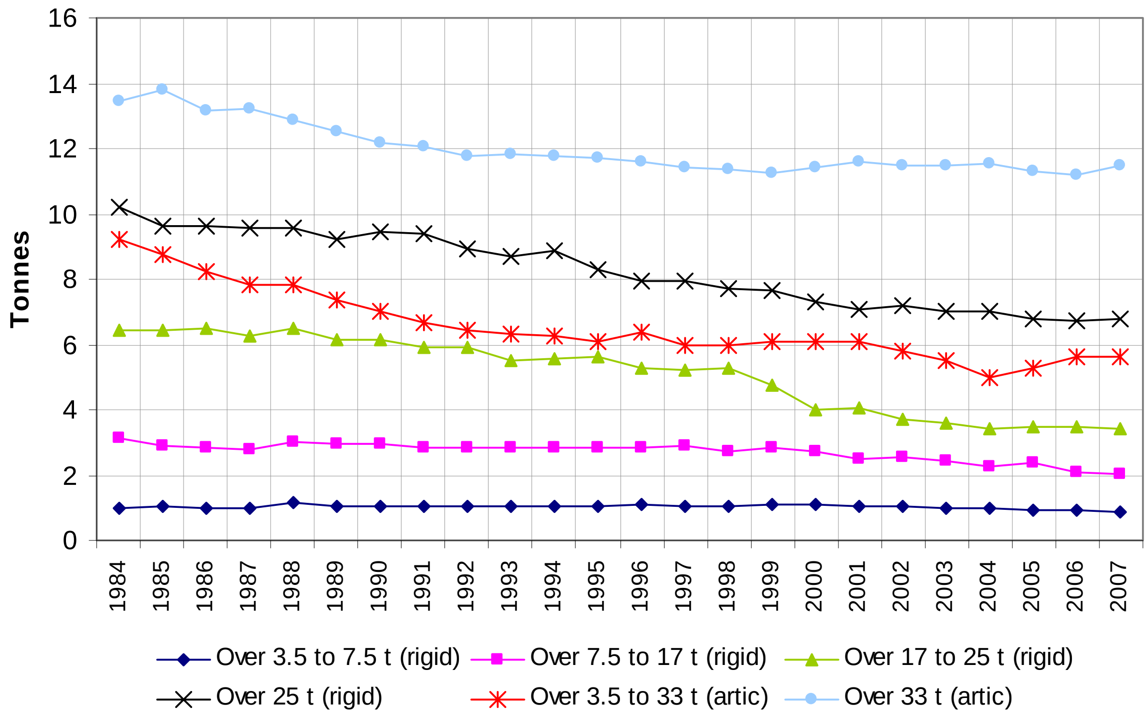
Figure 5.7: Empty running by HGV type and gross weight category, 1987, 1997 and 2007



Source: DfT, 2008b, 1999, 1995.

Figure 5.8 shows the effect of empty running on the average load carried by HGVs on all vehicle kms (i.e. taking into account laden and empty vehicle kilometres) according to type and weight category. It can be compared with the average load carried on laden trips in Figure 5.6 to understand the effect of empty running on the average weight of load carried on all vehicle kilometres (taking into account laden and empty kms) by HGV type and weight category.

Figure 5.8: Average weight of load carried on all trips (empty and laden) by HGV type and gross weight category, 1984-2007



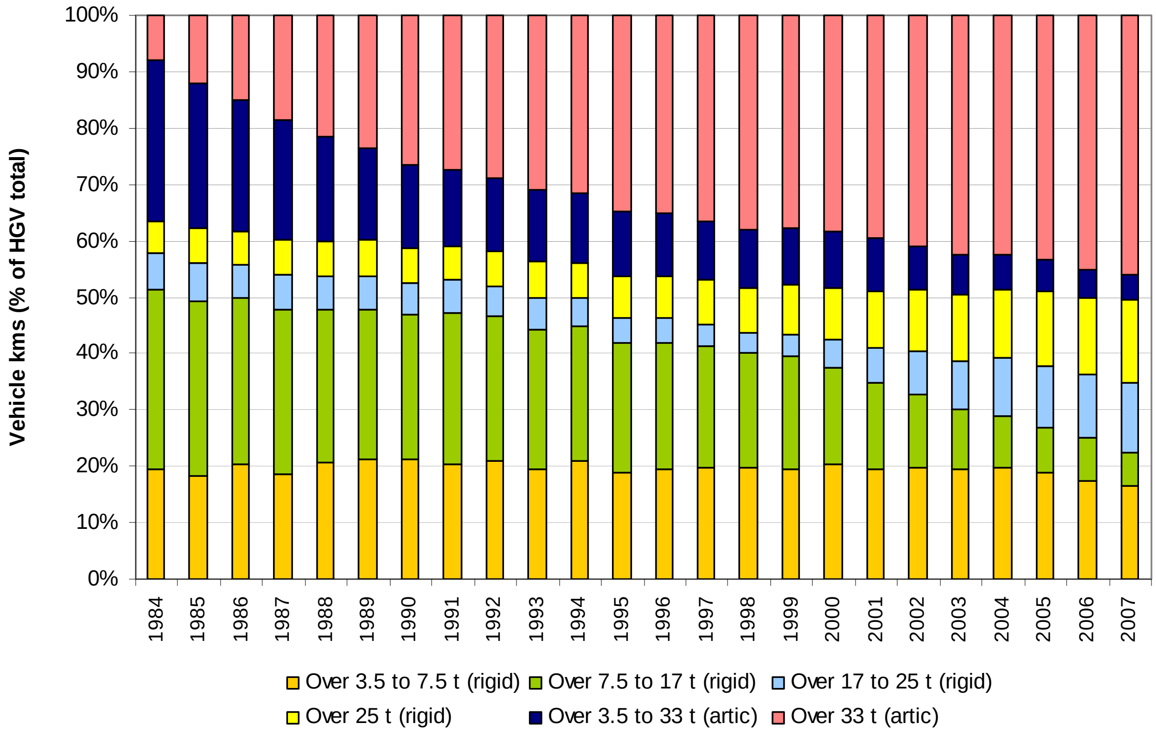
Source: calculated from data in DfT, 2008b, 1999, 1995.

Figure 5.8 shows that the average load carried on all vehicle kilometres has fallen over the period 1984 – 2007 for all types/weights of goods vehicles. For several of these vehicle types/weights (including rigid vehicles 3.5-7.5 tonnes 7.5-17 tonnes and both weights of articulated vehicles), the average load carried on all vehicle kilometres fell between 1984 and the late 1990s, since when it has bee relatively stable. However for rigid vehicles 17-25 tonnes and over 25 tonnes it continued to fall through the late 1990s and 2000s. Improvements in empty running over the period 1984-2007 have offset the reductions in lading factors on loaded trips to some extent.

5.6 Vehicle kilometres

The empty running shown in Figure 5.7 determines how the tonne-kms shown in Figure 5.6 are transformed into total vehicle kilometres performed by the types of HGV. This is shown in Figure 5.9. In 1984 all rigid vehicles were responsible for 63% of HGV vehicle kilometres, articulated vehicles up to 33 tonnes for 29%, and articulated vehicles over 33 tonnes for 8%. By 2007 all rigid vehicles were responsible for 50% of HGV vehicle kilometres, articulated vehicles over 33 tonnes for 46%, and articulated vehicles up to 33 tonnes for 4%. One weight category of rigid vehicles (over 7.5 to 17 tonnes) has diminished in importance over the period (from 32% of vehicle kms in 1984 to 6% in 2007).

Figure 5.9: Vehicle kilometres by HGV type and gross weight category, 1984-2007

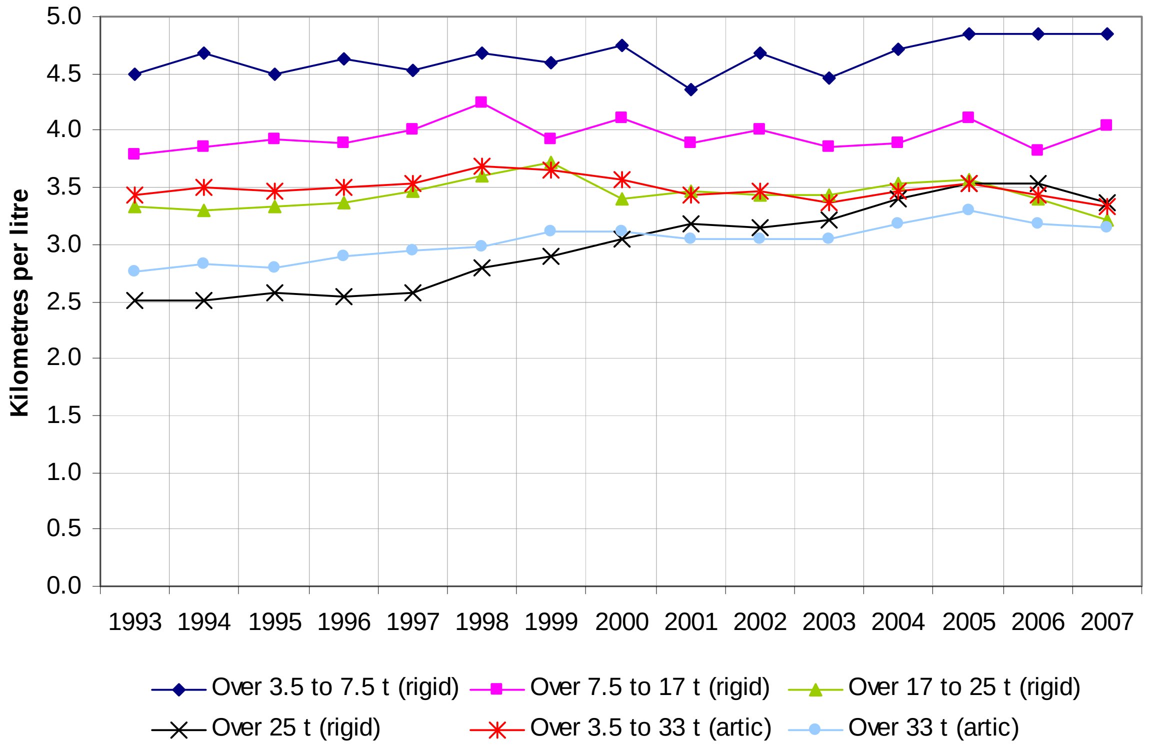


Source: DfT, 2008b, 1999, 1995.

5.7 Fuel consumption

Figure 5.10 shows changes in the fuel efficiency (in terms of kilometres per litre of fuel) of the various weight categories of HGV between 1993 and 2007. This indicates that fuel efficiency of articulated vehicles over 33 tonnes, and rigid vehicles over 25 tonnes have improved over this period. Fuel efficiencies for other types of HGV have changed relatively little over the period probably reflecting the fact that they tend to do more work in busy urban areas where vehicles speeds have been falling thereby leading to poorer fuel efficiencies.

Figure 5.10: Average fuel efficiency (kilometres per litre) by HGV type and gross weight category, 1993-2007

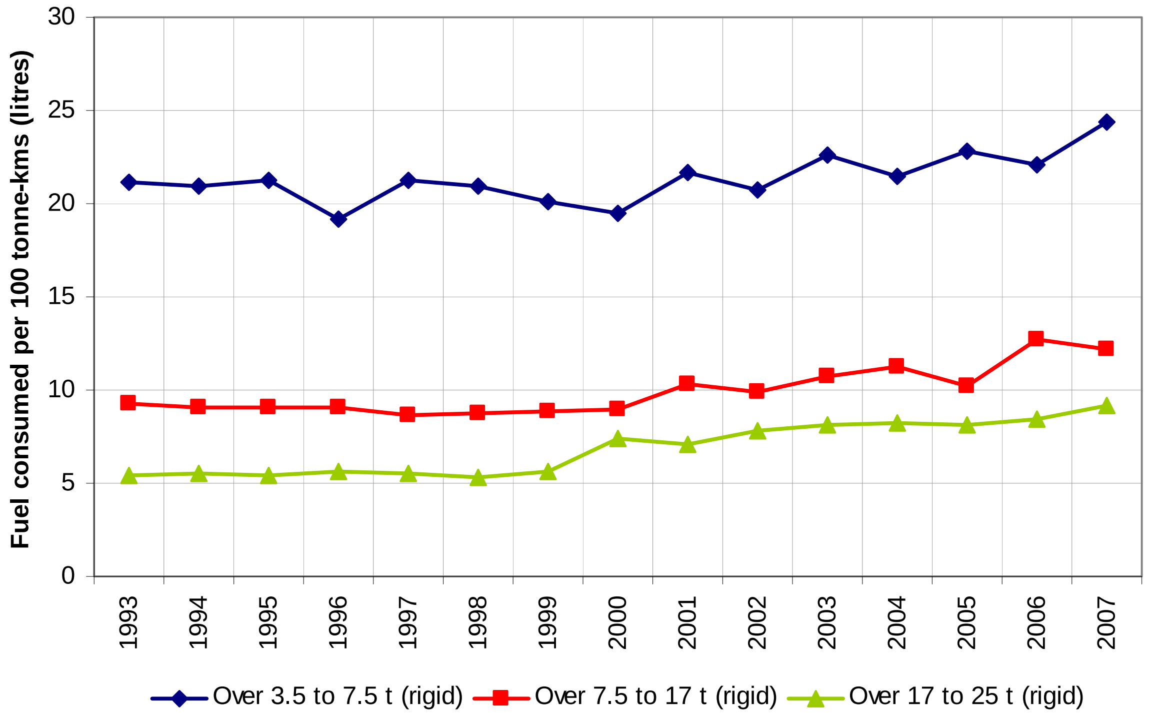


Source: DfT, 2008b

Figures 5.11 – 5.12 show the diesel consumed per 100 tonne-kilometres by HGV vehicle type and weight category. Three HGV type and weight categories are shown on each graph due to the differences in fuel consumption between the various vehicle categories.

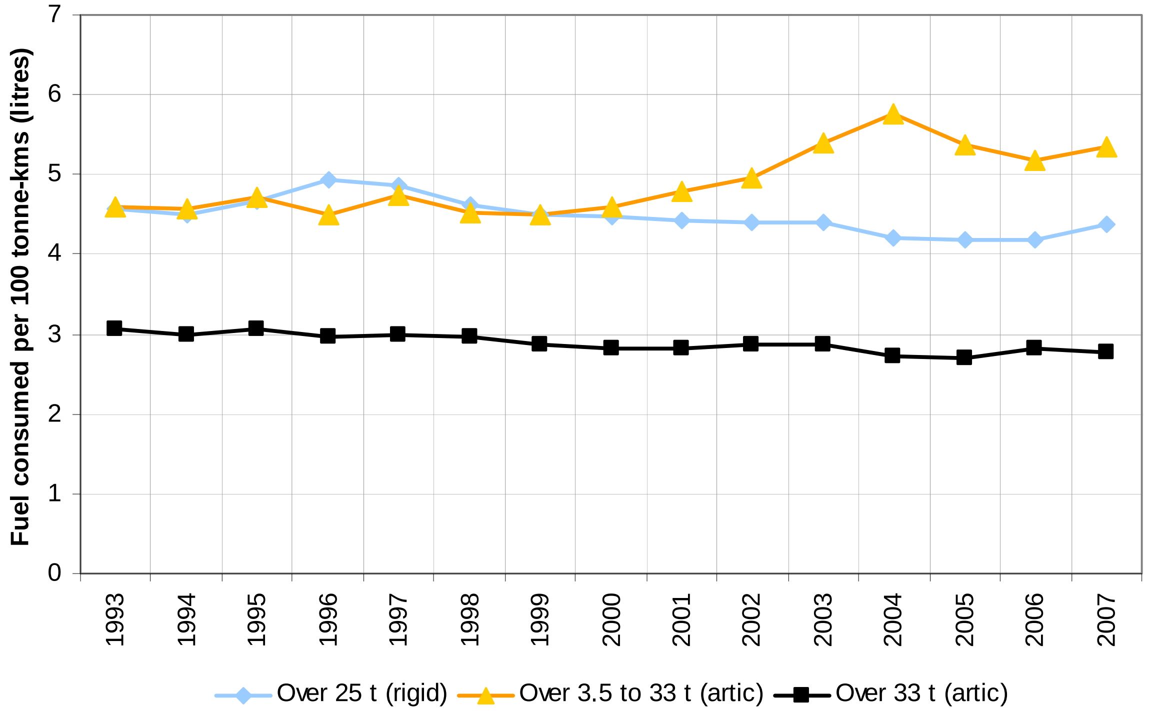
Only two types/weights of HGV have consumed a diminishing quantity of fuel per tonne-kilometre performed over the entire period studied (namely rigid vehicles over 25 tonnes, and articulated vehicles over 33 tonnes gross weight). Articulated vehicles up to 33 tonnes tonnes increased their fuel consumption per tonne-km from 1993 to 2004, since when it has fallen (see Figure 5.12). All other lighter categories of HGV have exhibited increasing fuel consumption per tonne-km performed over the period (see Figure 5.11).

Figure 5.11: Diesel consumed per 100 tonne-kilometres by HGV type and gross weight category, 1993-2007



Source: calculated from data in DfT, 2008b, 1999.

Figure 5.12: Diesel consumed per 100 tonne-kilometres by HGV type and gross weight category, 1993-2007



Source: calculated from data in DfT, 2008b, 1999.

Figures 5.11 and 5.12 show that articulated vehicles over 33 tonnes were by far the most fuel efficient per tonne-km performed over the period as a result of their greater payload. Table 5.1 shows the percentage more fuel per tonne-km performed used by other HGVs compared with articulated vehicles over 33 tonnes gross weight in 2007.

Overall improvements in fuel efficiency across the entire HGV fleet (discussed in section 3.10) in terms of kms per litre, and fuel consumed per tonne lifted and moved over the period 1993-2007 are greater than for any specific weight category of HGV. This reflects that fleet-wide improvements in HGV fuel efficiency have been related to the shift towards the greater use of heavier HGVs by operators, rather than all individual weight categories of HGV achieving such improvements. McKinnon (2007) has come to similar conclusions about this.

Table 5.1: Fuel used per tonne-km performed in comparison with articulated vehicles over 33 tonnes gross weight, 2007

Type and weight category of HGV	Percentage greater fuel used per tonne-km than articulated vehicles over 33 tonnes
Rigid vehicles over 3.5 -7.5 tonnes	779%
Rigid vehicles over 7.5 – 17 tonnes	339%
Rigid vehicles over 17 – 25 tonnes	230%
Rigid vehicles over 25 tonnes	58%
Articulated vehicles over 3.5 – 33 tonnes	93%

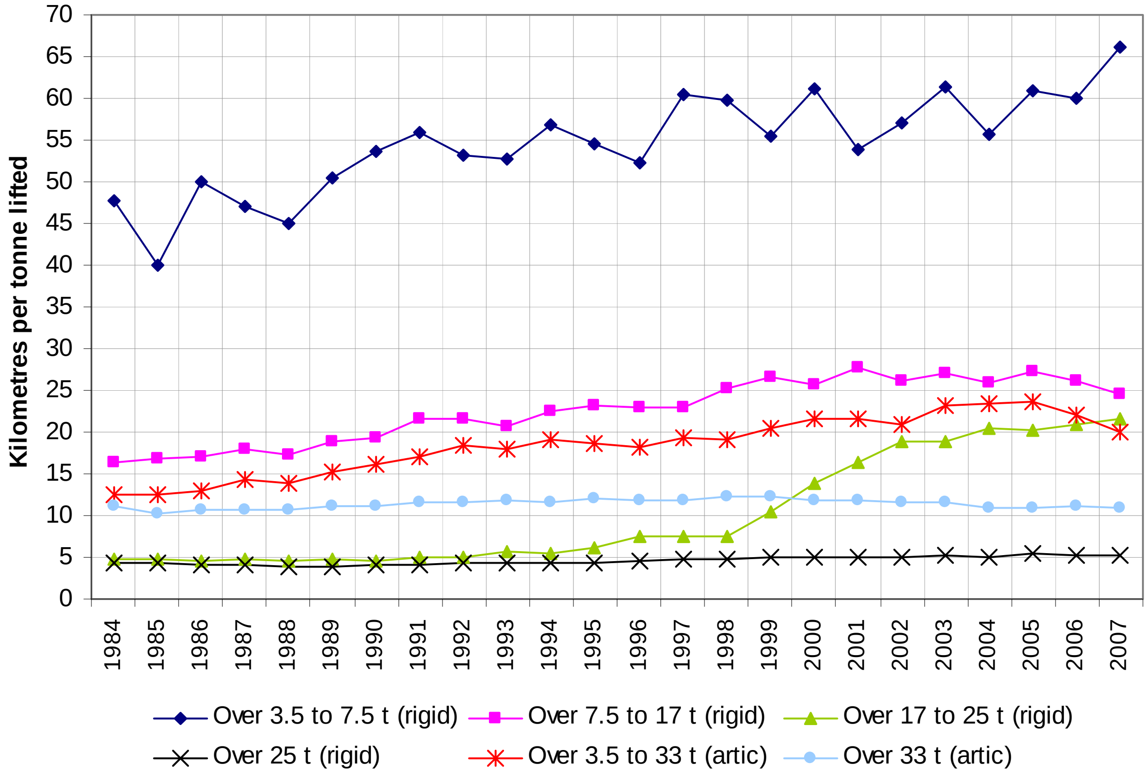
Source: calculated from data in DfT, 2008b.

5.8 Transport intensity, efficiency and further analysis

Whether or not the operations of the HGV fleet in Britain have become more or less efficient and intensive (and hence sustainable) over time can be reflected in the relationship between goods lifted by HGVs and vehicle kilometres performed. Figure 5.13 shows (using CSRGT estimates of vehicle kilometres) the average distance travelled per tonne lifted for each of the types and weight categories of HGVs between 1984 and 2007.

Figure 5.13 reflects that the number of kilometres travelled per tonne of freight lifted varies widely between the types and weight categories of HGV. In addition the direction of change in the number of kilometres travelled per tonne of freight lifted between the types and weight categories of HGV also varies over the period 1984 to 2007. It has risen over the period since 1984 for rigid vehicles over 3.5 to 7.5 tonnes, rigid vehicles over 17 to 25 tonnes, and rigid vehicles over 25 tonnes gross weight. In the case of rigid vehicles over 7.5 to 17 tonnes, and the two weight categories of articulated vehicles, it rose between 1984 and the early 2000s but has since declined.

Figure 5.13: Vehicle kilometres travelled per tonne of freight lifted by HGV type and gross weight category, 1984-2007

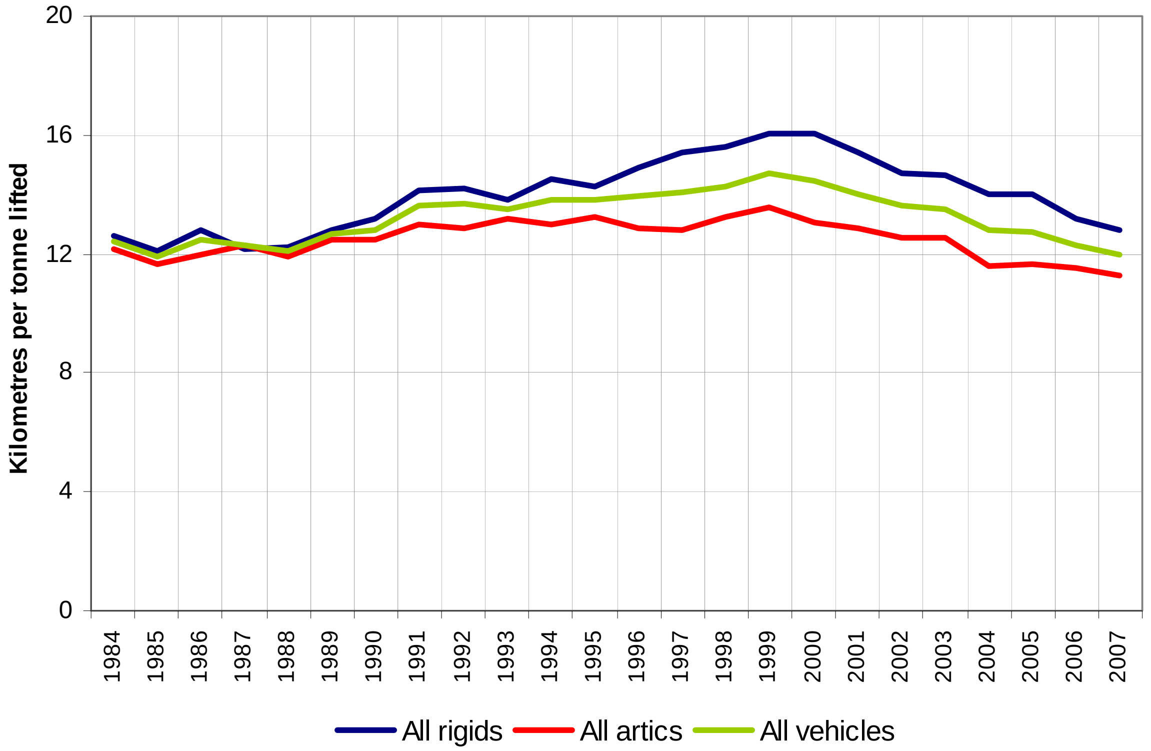


Source: calculated from data in DfT, 2008b, 1999, 1995.

Figure 5.14 shows (using CSRGT estimates of vehicle kilometres) the average distance travelled per tonne lifted for all rigid goods vehicles, all articulated goods vehicles and all goods vehicles (this is referred to as a measure of road freight transport intensity). This reflects that when the various types and weights of goods vehicles are summed within these two vehicle categories (i.e. all rigid and all articulated vehicles) the pattern is similar to that for all goods vehicles, with the average distance travelled per tonne lifted rising between 1984 and 1999 and then falling since 1999.

Figure 5.13 indicates that the vehicle kilometres per tonne lifted trends for some categories rigid and articulated goods vehicles types and weight display a different pattern to that for all rigid and articulated vehicles shown in Figure 5.14. These differences occur among vehicle types that are responsible for a relatively small proportion of total tonnes lifted (including rigid vehicles over 3.5 to 7.5 tonnes, and rigid vehicles over 17 to 25 tonnes gross weight). However given that rigid vehicles over 25 tonnes and articulated vehicles over 33 tonnes account for such an important and growing proportion of all tonnes lifted and vehicle kilometres travelled by goods vehicles (accounting for approximately 85% of tonnes lifted and 60% of vehicle kilometres in 2007 - see Figures 5.1 and 5.9) the trend of these vehicles over the period dominates the results for all vehicles.

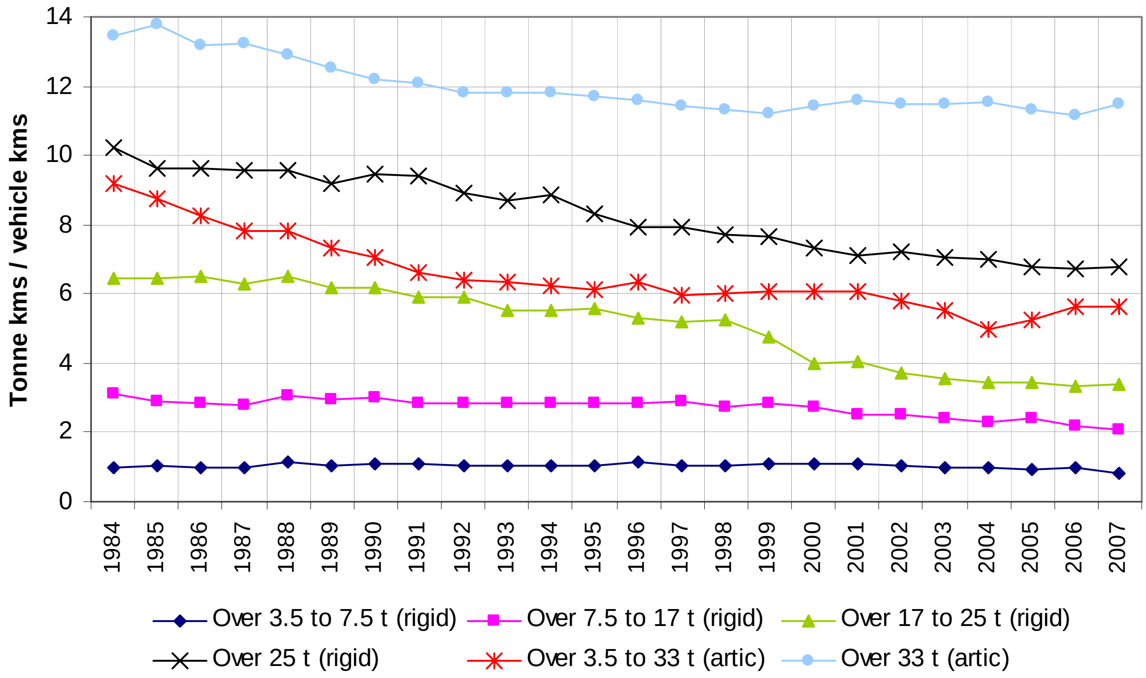
Figure 5.14: Vehicle kilometres travelled per tonne of freight lifted for rigid, articulated and all HGVs, 1984-2007



Source: calculated from data in DfT, 2008b, 1999, 1995.

Figure 5.15 shows the ratio of tonne-kilometres to vehicle kilometres by type and weight of HGVs between 1984 and 2007 (referred to as a measure of road freight transport utilisation). This shows that for all categories of HGV this ratio was lower in 2007 than in 1984, reflecting worsening vehicle utilisation. However, the ratio stabilised for articulated HGVs over 33 tonnes from 1999 onwards. This is due entirely to the increases in maximum permissible gross weights in 1999 and 2001, as lading factors for articulated HGVs worsened over this period (see Figure 5.4). This reduction in tonne-kms : vehicle kms in 2007 compared to 1984 for all HGV types and weights is in contrast to the result for the entire HGV fleet (see Figure 4.4) and reflects that the improvement in vehicle utilisation for the entire fleet is due to the change in composition of the fleet over the period as the average weight of goods vehicles owned and operated has increased.

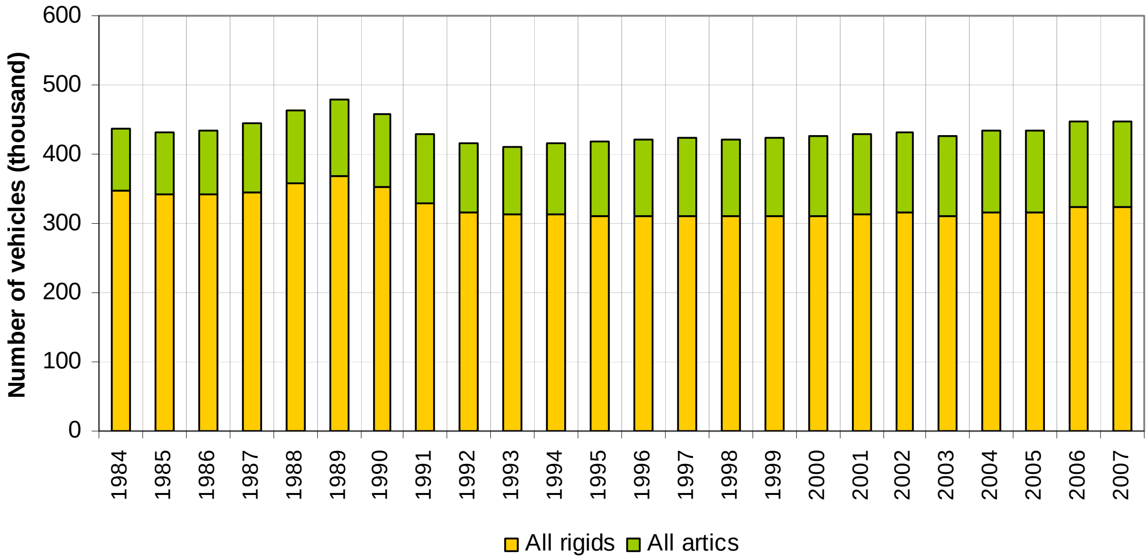
Figure 5.15: Tonne-kms : vehicle kilometres by vehicle type and weight, 1994-2007



Source: calculated from data in DfT, 2008b, 1999, 1995.

Figure 5.16 shows the composition of the HGV fleet in Britain between 1984 and 2007 in terms of the number of rigid and articulated vehicles. This reflects the growing proportion of the total fleet accounted for by articulated HGVs (27% in 2007, compared to 21% in 1984).

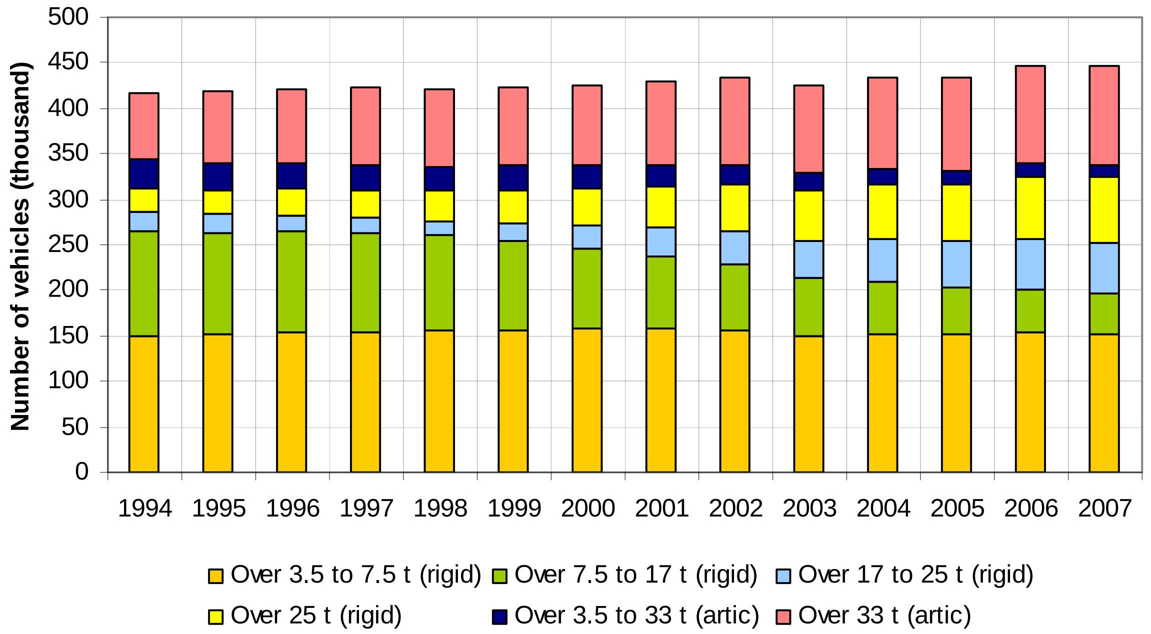
Figure 5.16: Total HGV fleet in Britain, 1984-2007



Source: DfT, 2010.

Figure 5.17 provides a more detailed breakdown of the HGV fleet by type and weight. This reflects the growing importance of the heaviest categories of rigid and articulated HGVs as a proportion of the total fleet between 1994 and 2007. This more detailed fleet analysis is only possible from 1994 onwards due to the unavailability of this data prior to that date.

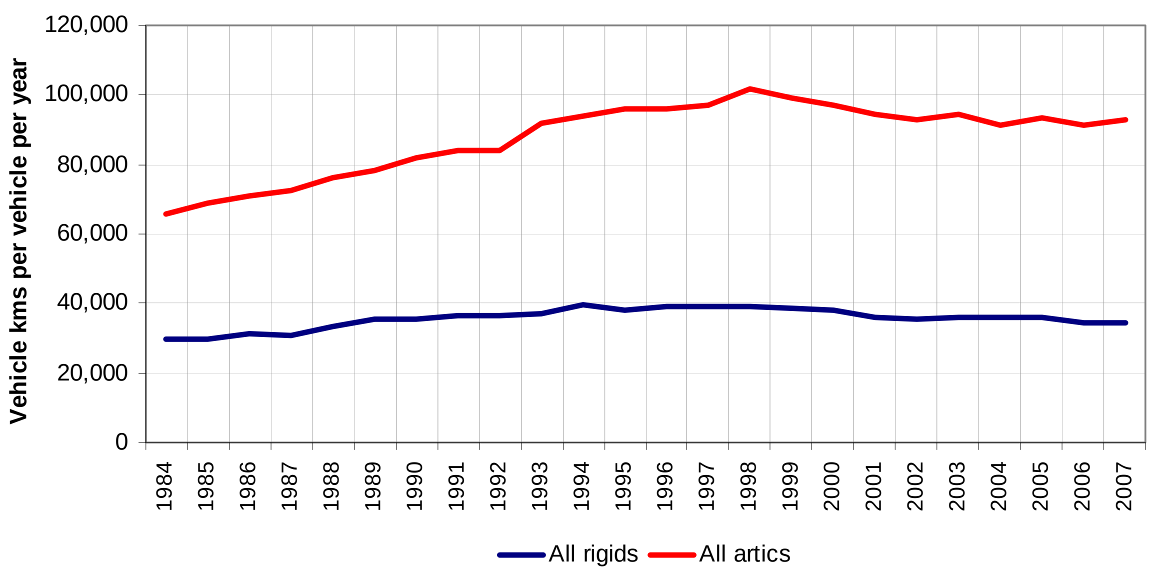
Figure 5.17: Total HGV fleet by vehicle type and weight, 1994-2007



Source: DfT, 2010.

Figure 5.18 shows the average annual vehicle kilometres travelled per vehicle for rigid and articulated vehicles since 1984. This reflects the far greater average distance travelled per vehicle by articulated vehicle than rigid ones (on average, each articulated HGV travelled 2.8 times further than each rigid HGV in 2007). The average distance travelled per vehicle rose for both articulated and rigid HGVs between 1984 and 2007 (with the distance travelled by articulated HGVs rising faster). Since 1999 the average distance travelled by each type of HGV has fallen.

Figure 5.18: Average annual vehicle kms per vehicle for rigid and articulated HGVs, 1984-2007



Source: calculated from data in DfT, 2010, 2008b.

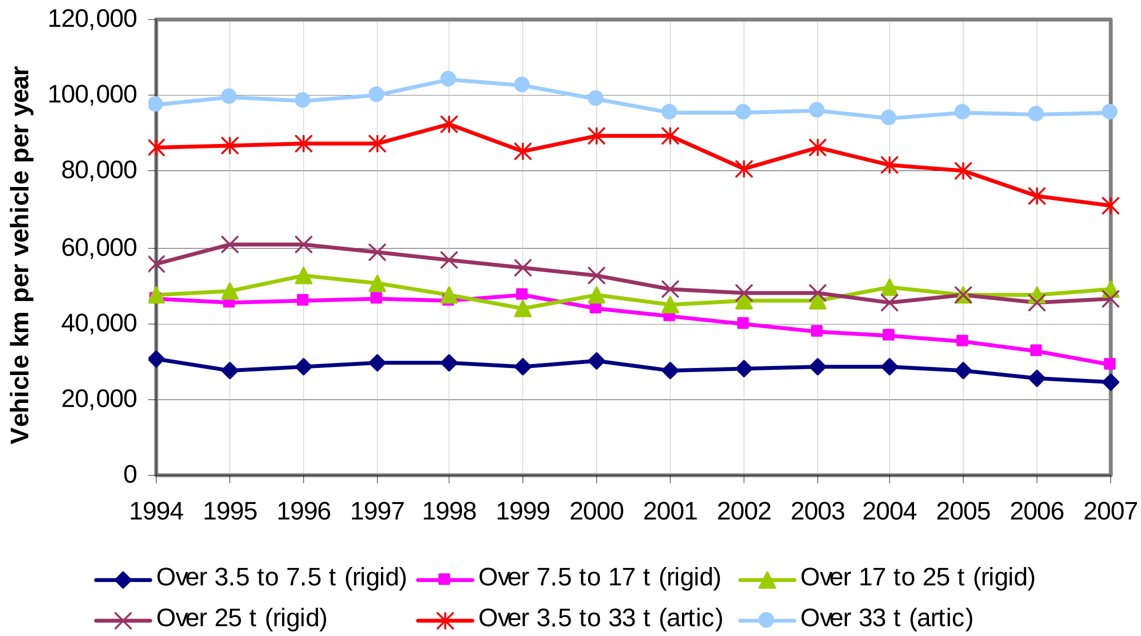
Figure 5.19 shows the average annual vehicle kilometres travelled per vehicle by type and weight category from 1994 to 2007.

This shows that the average distance travelled by lighter articulated HGVs has fallen considerably since the late 1990s, (23% since 1998) while for the heavier articulated HGVs this fell between 1998 and 2001 but has been stable since then (falling by 9% by 2007 compared with 1998).

The average distance travelled by all but one weight category of rigid HGV have also fallen between 1998 and 2007. However these falls have varied between weight categories, with the average distance travelled by 7.5-17 tonne vehicles falling 37%, over 25 tonne vehicles falling by 19%, and 3.5-7.5 tonne vehicles falling by 17%. Meanwhile the average distance travelled by 17 to 25 tonne vehicles rose by 3% over the period.

This compares with a fall of 9% in the average distance travelled by all HGVs over the period 1992-2007 (see Table 3.2). Again, this relatively small fall compared with the falls in each specific vehicle weight and type category indicates the importance of articulated HGVs over 33 tonnes, and the shift that has taken place towards the use of these vehicles over the period.

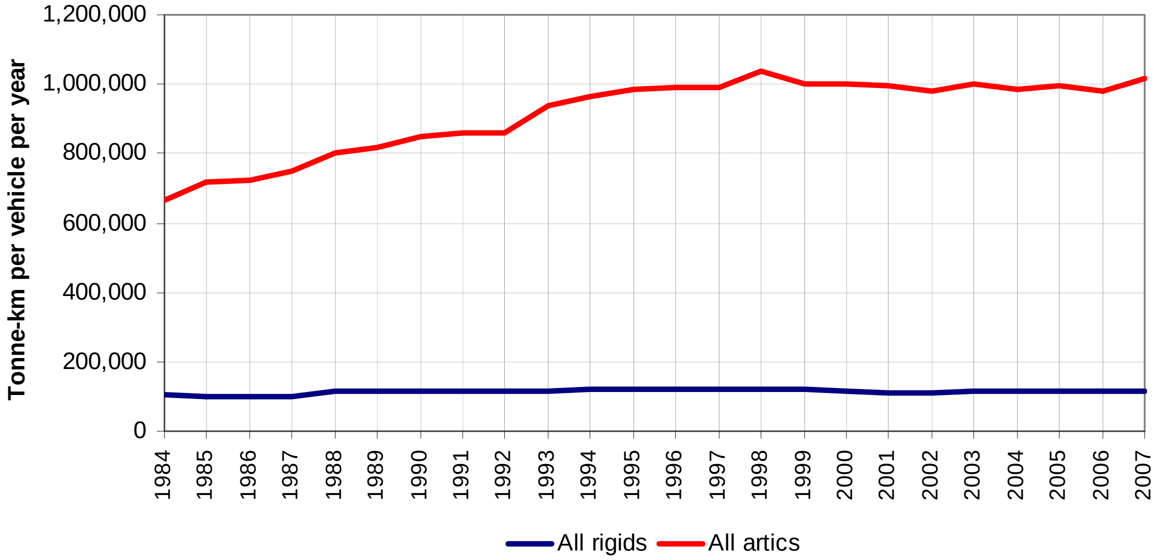
Figure 5.19: Average annual vehicle kilometres per vehicle by vehicle type and weight, 1994-2007



Source: calculated from data in DfT, 2010, 2008b.

Figure 5.20 provides insight into the average annual tonne-kilometres per vehicle. This reflects the growth in tonne-kms performed by each articulated HGV between 1984 and 1998 (with relatively stability since then). By comparison the tonne-kms per rigid HGV remained relatively unchanged over the entire period from 1984 to 2007.

Figure 5.20: Average annual tonne-kms per vehicle for rigid and articulated HGVs, 1984-2007



Source: calculated from data in DfT, 2010, 2008b.

Table 5.2 shows the outputs, key variables, determinants and performance measures for HGVs by vehicle type and weight in 1986. Tables 5.3 and 5.4 present the same information by HGV type and weight category in 1996 and 2006 for comparison purposes.

Table 5.2: Road freight transport by HGVs in Britain in 1986 by type and weight category - determinants, key variables, outputs and performance measures

	Over 3.5 to 7.5 t (rigid)	Over 7.5 to 17 t (rigid)	Over 17 to 25 t (rigid)	Over 25t (rigid)	Over 3.5 to 33 t (artic)	Over 33t (artic)
Freight lifted by HGV (million tonnes)	70	300	216	248	307	246
Length of haul (km)	50	48	30	39	107	139
Freight moved by HGV (billion tonne-kms)	3.5	14.4	6.5	9.6	33.0	34.2
Vehicle utilisation on laden trips (ratio)	0.38	0.46	0.73	0.89	0.61	0.75
Vehicle carrying capacity by weight (tonnes)	3.7	8.6	15.5	19.5	19.1	24.5
Average load on laden trips (tonnes)	1.4	3.9	11.3	17.4	11.6	18.4
Empty running (%)	28.0	28.3	42.6	44.7	29.1	28.5
Laden kilometres (billion)	2.5	3.7	0.6	0.6	2.8	1.9
Empty kilometres (billion)	1.0	1.4	0.4	0.4	1.2	0.7
Vehicle kilometres (billion)	3.5	5.1	1.0	1.0	4.0	2.6
Fuel efficiency (kilometres per litre)	n/a	n/a	n/a	n/a	n/a	n/a
Fuel consumed (billion litres)	n/a	n/a	n/a	n/a	n/a	n/a
CO_2 emissions (million tonnes)	n/a	n/a	n/a	n/a	n/a	n/a
Average distance travelled per tonne lifted (loaded and empty kms) (kilometres)	50.0	17.0	4.6	4.0	13.0	10.6
Average load on all vehicle km (loaded and empty kms) (tonnes)	1.0	2.8	6.5	9.6	8.3	13.2
Maximum potential tonne-kms (billion)	9.2	31.3	8.9	10.8	54.1	45.6
Potential average load if fully laden by weight (loaded and empty kms) (tonnes)	2.6	6.1	8.9	10.8	13.5	17.5
Fuel used per 100 tonne-km (litres)	n/a	n/a	n/a	n/a	n/a	n/a
Tonne-kms : vehicle kms	1.0	2.8	6.5	9.6	8.3	13.2
Fuel consumed per tonne lifted (litres)	n/a	n/a	n/a	n/a	n/a	n/a
CO_2 emitted per tonne lifted (kg)	n/a	n/a	n/a	n/a	n/a	n/a

Source: calculated from data in DfT, 2008b, 1999 and 1995.
Notes:
“n/a” – not available
Data only includes HGVs (i.e. goods vehicles over 3.5 tonnes)
All results shown above based on CSRGT data.

Table 5.3: Road freight transport by HGVs in Britain in 1997 by type and weight category - determinants, key variables, outputs and performance measures

	Over 3.5 to 7.5 t (rigid)	Over 7.5 to 17 t (rigid)	Over 17 to 25 t (rigid)	Over 25t (rigid)	Over 3.5 to 33 t (artic)	Over 33t (artic)
Freight lifted by HGV (million tonnes)	76	218	120	380	124	726
Length of haul (km)	63	66	39	38	115	134
Freight moved by HGV (billion tonne-kms)	4.8	14.4	4.7	14.4	14.3	97.1
Vehicle utilisation on laden trips (ratio)	0.43	0.46	0.62	0.75	0.48	0.68
Vehicle carrying capacity by weight (tonnes)	3.3	8.5	12.9	17.8	16.6	23.4
Average load on laden trips (tonnes)	1.4	3.9	8.0	13.4	8.0	15.9
Empty running (%)	25.8	26.2	34.9	40.6	25.4	28.1
Laden kilometres (billion)	3.4	3.7	0.6	1.1	1.8	6.1
Empty kilometres (billion)	1.2	1.3	0.3	0.7	0.6	2.4
Vehicle kilometres (billion)	4.6	5.0	0.9	1.8	2.4	8.5
Fuel efficiency (kilometres per litre)	4.53	4.00	3.47	2.58	3.54	2.94
Fuel consumed (billion litres)	1.01	1.25	0.26	0.70	0.68	2.89
CO_2 emissions (million tonnes)	2.7	3.3	0.7	1.8	1.8	7.6
Average distance travelled per tonne lifted (loaded and empty kms) (kilometres)	60.5	22.9	7.5	4.8	19.4	11.7
Average load on all vehicle km (loaded and empty kms) (tonnes)	1.0	2.9	5.2	7.9	6.0	11.4
Maximum potential tonne-kms (billion)	11.1	31.3	7.5	19.3	29.8	142.8
Potential average load if fully laden by weight (loaded and empty kms) (tonnes)	2.4	6.3	8.4	10.6	12.4	16.8
Fuel used per 100 tonne-km (litres)	21.2	8.7	5.5	4.9	4.7	3.0
Tonne-kms : vehicle kms	1.0	2.9	5.2	7.9	6.0	11.4
Fuel consumed per tonne lifted (litres)	21.2	8.7	5.5	4.9	3.0	3.7
CO_2 emitted per tonne lifted (kg)	55.8	22.8	14.5	12.8	12.5	7.8

Source: calculated from data in DfT, 2008b, 1999 and 1995.
Notes:
Data only includes HGVs (i.e. goods vehicles over 3.5 tonnes)
All results shown above based on CSRGT data.

Table 5.4: Road freight transport by HGVs in Britain in 2007 by type and weight category - determinants, key variables, outputs and performance measures

	Over 3.5 to 7.5 t (rigid)	Over 7.5 to 17 t (rigid)	Over 17 to 25 t (rigid)	Over 25t (rigid)	Over 3.5 to 33 t (artic)	Over 33t (artic)
Freight lifted by HGV (million tonnes)	56	53	130	629	50	952
Length of haul (km)	56	50	73	36	113	124
Freight moved by HGV (billion tonne-kms)	3.1	2.6	9.5	22.6	5.6	118.0
Vehicle utilisation on laden trips (ratio)	0.40	0.37	0.45	0.64	0.43	0.60
Vehicle carrying capacity by weight (tonnes)	3.0	7.2	9.8	16.2	16.9	26.1
Average load on laden trips (tonnes)	1.2	2.7	4.4	10.4	7.3	15.6
Empty running (%)	28.4	24.0	23.3	34.4	22.8	26.7
Laden kilometres (billion)	2.7	1.0	2.1	2.2	0.8	7.5
Empty kilometres (billion)	1.1	0.3	0.7	1.1	0.2	2.7
Vehicle kilometres (billion)	3.7	1.3	2.8	3.3	1.0	10.3
Fuel efficiency (kilometres per litre)	4.85	4.04	3.22	3.36	3.33	3.15
Fuel consumed (billion litres)	0.80	0.32	0.87	0.99	0.30	3.27
CO_2 emissions (million tonnes)	2.0	0.8	2.3	2.6	0.8	8.6
Average distance travelled per tonne lifted (loaded & empty kms) (kilometres)	66.1	24.5	21.5	5.3	20.1	10.8
Average load on all vehicle km (loaded & empty) (tonnes)	0.9	2.0	3.4	6.8	5.6	11.5
Maximum potential tonne-kms (billion)	7.8	7.2	21.1	35.4	13.1	196.7
Potential average load if fully laden by weight (loaded & empty kms) (tonnes)	2.1	5.5	7.5	10.6	13.1	19.1
Fuel used per 100 tonne-km (litres)	24.3	12.2	9.1	4.4	5.4	2.8
Tonne-kms : vehicle kms	0.8	2.1	3.4	6.8	5.6	11.5
Fuel consumed per 100 tonne-km (litres)	24.6	11.9	9.1	4.4	5.4	2.8
CO_2 emitted per 100 tonne-km (kg)	64.7	31.4	24.1	12.9	14.3	7.4

Source: calculated from data in DfT, 2008b, 1999 and 1995.
Notes:
Data only includes HGVs (i.e. goods vehicles over 3.5 tonnes)
All results shown above based on CSRGT data.

6. Discussion of determinants affecting HGV key variables

Sections 3 – 5 have illustrated the changes in HGV key variables (such as average length of haul, vehicle carrying capacity, lading factor, empty running etc.) over the period 1984-2007 and how these changes in key variables have affected HGV outputs in terms of total tonnes lifted, tonnes moved and vehicle kilometres travelled. This section discusses the determinants that have led to these changes in key variables (see section 2.2 for details of determinants, key variables, and outputs).

Before commencing of this discussion it should be noted that it is not possible to explain precisely the extent to which each determinant led to changes in a specific key variable. This is due to two factors: i) each key variable is potentially influenced by many different determinants, and ii) there is a lack of data about the relationship between determinants and key variables.

In thinking about logistical determinants and the way in which they have influenced the key variables since 1984 it is useful to make use of a framework comprising four levels of company and supply chain logistical decision-making first proposed by McKinnon and Woodburn (1995). These four levels comprise:

1. Logistic structures: determined by high-level strategic decisions affecting the numbers, locations and capacity of factories, warehouses and handling facilities.

2. Pattern of trading links: determined by commercial decisions on sourcing, sub-contracting and distribution. These decisions establish the freight network linking a company's premises to those of its trading partners.

3. Scheduling of product flow: decisions on the scheduling of production and distribution operations translate trading relationships into discrete freight flows.

4. Management of transport resources: within the framework defined by decisions at the previous three levels, transport managers still have discretion over the use of transport resources.

To the four levels proposed by McKinnon and Woodburn (1995) can be added four other factors that determine HGV key variables and hence the pattern and quantity of HGV transport:

5. Product-related factors – aspects of the product and vehicle load, in terms size, weight and packaging that influence the load carrying potential of HGVs.

6. Technological factors – developments in road freight transport-related technology that affect the way in which HGVs are used.

7. Transport regulation and legislation – rules governing the construction and use of HGVs and other vehicles and modes including the taxation of transport.

8. The total level of demand for and supply of transport capacity on a transport network.

A firm's demand for freight transport (and specifically HGV transport) is the result of a complex interaction between decisions made at these different levels. Decisions at levels 1 and 2 often only partly involve freight transport and logistics managers. Decisions made at these levels determine the supply chain structure and network and have a major influence on trip distance and hence tonne-kilometres. Freight transport and logistics managers are more closely involved in the decisions taken at levels 3 and 4 which translate the demand for freight transport movement into vehicle kilometres travelled by deciding about types and weights of vehicles used, the frequency and scheduling of distribution activity, which affects the lading factor and empty running.

Factor 5 also has an important bearing on vehicle selection, lading factors and levels of empty running. Factor 6 has a bearing on the scheduling and routeing of vehicles, and the opportunities for backloading and therefore affects the same issues as level 5 plus can potentially affect trip distance. Transport regulation and legislation (factor 7) can affect all aspects of transport-decision making and operations (especially in relation to taxation-related legislation) but is especially relevant to mode choice and vehicle carrying capacity. Factor 8 determines the traffic level on a given transport network and thereby influences the level of congestion, the journey time and journey time reliability. Decision-making about transport mode can be influenced by all eight factors levels.

The following sections comprise a discussion of the major determinants that are likely to have influenced the key variables for HGVs since 1984.

Average length of haul

The average length of haul for HGVs rose between 1984 and 1999. This is likely to have been due to increasing centralisation of manufacturing and of stockholding, expansion in market areas, off-shoring of production facilities, and sourcing from more remote (and foreign) suppliers. It may have stopped rising since 1999 due to: i) the centralisation of manufacturing and of stockholding having run its course – there is a limit to the degree of centralisation that is possible when the maximum economic size of factory or warehouse is reached and/or a company has centralised its entire manufacturing or stockholding activity on a single site, ii) sourcing may also have become national across the country leaving little scope for further expansion.

The reduction in average length of haul since 1999 may have been influenced by companies beginning to reconfigure their supply chains to: i) reflect the difficulties that can arise when sourcing over long distances (either nationally or internationally), and ii) to move away from a highly centralised system of production and manufacturing facilities to a more regional approach. Both of these could have happened due to logistical problems in receiving raw material and goods and supplying market areas which could be a product of growing congestion and hence slower and less reliable HGV journeys. It could also be related to the uptake of technology such as computerised vehicle routeing and scheduling (CVRS) technology has the potential to reduce journey distances.

Vehicle carrying capacity

Vehicle carrying capacity in weight terms have risen over the entire period from 1984 to 2007 from 13.0 tonnes in 1984 to 17.4 tonnes in 2007. This has occurred for two main reasons: i) there has been a shift towards the ownership and use of heavier vehicles in the HGV fleet over the entire period 1984 to 2007, and ii) the increases in the maximum permissible HGV gross weight in 1984, 1999 and 2001 has resulted in operators obtaining heavier vehicles.

Lading factors

Lading factors for the HGV fleet fell from 0.66 in 1984 to 0.57 in 2003 since when it has remained relatively stable. There are several possible explanations for this decline in lading factors: i) although the average carrying capacity of the HGV fleet has increased over the period – due to the shift towards the ownership and use of heavier vehicles in the HGV fleet and the increases in maximum permissible gross weights - having a heavier vehicle with more payload does not necessarily translate into heavier average loads – instead operators may be purchasing vehicles with greater load carrying capacities and then not managing to obtain loads that make full use of their weight carrying capacity, ii) companies may have traded-off HGV lading factors against efficiency, cost-saving and revenue maximising in other logistics activities and aspects of their business – and are therefore prepared to run vehicles less well loaded than they could be in order to achieve stockholding cost savings (through just-in-time delivery systems) or improved sales through enhanced customer service levels, iii) the bulk density of products and loads may have been falling over time resulting in vehicle becoming full in volume terms before they become full in weight terms. Evidence shows that twice as many loads lifted by HGVs in 2007 were limited by volume than by weight, iv) geographical imbalances in trade flows between regions may have increased over time making it more difficult to achieve well loaded vehicles on return journeys.

The average load carried is determined by the vehicle carrying capacity and the lading factor. The analysis in this report shows that although the average load carried rose between 1984 and 2007 it did not increase at the same rate as the average vehicle carrying capacity by weight.

Empty running

The level of empty running for all HGV activity fell from 31.4% in 1984 to 26.4% in 2001, but rose a little to 27.4% by 2007. The reduction in empty running up until 2001 was the result of factors including: the increasing length of freight trips, expansion of load matching agencies and online freight exchanges, an increase in reverse logistics, and various company initiatives to increase the level of backloading (McKinnon and Ge, 2006).

Vehicle driving time

The amount of time that a vehicle is able to spend driving on the road is related to several factors including: i) the time taken to load and unload vehicles, ii) the time vehicles spend queuing waiting to make deliveries at destinations, iii) the proportion of the entire working day and week that is used for productive work (as opposed to vehicles wither lying empty and stationary or loaded awaiting departure), and iv) improved vehicle reliability resulting in fewer breakdowns and less need for lengthy maintenance. The time spent by each vehicle driving has an influence on the total HGV fleet required.

Although it is not possible to quantify the extent of all these improvements since 1984, vehicle loading and unloading times have been reduced through greater use of unitised loads (e.g. pallets, roll cages, stillages and containers), improved mechanical handling equipment, better vehicle load planning through the use of computer software tools, and computer-based routeing and scheduling tools.

Queuing time at destinations has also been reduced through greater use of nominated delivery slots, and the use of technology and communications equipment to alert depots to changes in expected vehicle arrival times (first through the use of Citizens Band radio and then mobile phones).

Far more logistics operations have become round-the-clock with depots operating 24 hours per day, 7 days per week, and greater opportunities for out-of-hours deliveries at a wide range of establishments (due to increases in the working hours of receiving staff, systems allowing drivers to access establishments even when shut, and through the use of remote drop points outside the establishment). This has resulted in the ability for vehicles to be used for more shifts per day (i.e. double-shifting, treble-shifting etc.).

Vehicle reliability has also increased over the period resulting in the time spent by vehicles off the road due to mechanical problems being reduced. In 1988, 8% of the vehicles surveyed were being repaired, compared with 5% in 1998, and 4% in 2008 (DoT, 1989; DETR, 1999b; DfT, 2009).

Many of these operational improvements and the introduction of new technologies have occurred at the time when (since the 1980s) companies have moved away from in-house road freight transport towards the contracting out of these activities to third party logistics providers. This has also coincided with a substantial reduction in the power of the Transport and General Workers' Union (TGWU) and other unions involved in the road haulage industry resulting from the legal framework established by the Conservative government after coming to office in 1979 following the "winter of discontent" and especially the "hire-and-reward" haulage strike (Smith, 1999).

Vehicle speeds and journey reliability

The speed of HGVs on the road network has an influence on the total HGV fleet required. Daytime vehicle speeds are likely to have increased between 1984 and the mid-1990s on the trunk road network as a result of a growing quantity of motorways and dual carriageways together with increased maximum speed limits on these roads. However, over the last decade this trend is likely to have reversed due to growing traffic levels and traffic incidents on the trunk road network as well as in urban areas and on all other roads, together with the introduction of speed limiters that have prevented goods vehicles exceeding the national speed limit. See section 3.11 for further discussion of changes in average vehicle speeds.

One response that HGV operators may have taken to reducing daytime average speeds is to perform more activity during the night when higher speeds are possible. McKinnon et al (2008) have noted that the proportion of all HGV vehicle kilometres run between 8pm and 6am increased from 16% to almost 20% between 1995 and 2005.

Fuel efficiency (kilometres per litre consumed)

The fuel consumption (in terms of kilometres travelled per litre of fuel consumed) of the HGV fleet in Britain has improved by 8% between 1994 and 2007 (from 2.6 to 2.8 km per litre). Fuel efficiency can be improved through a range of factors include technical improvements to engines and vehicle aerodynamics, the lightweighting of vehicles, vehicle maintenance and driver behaviour. However, technical improvements in engines are likely to have been the most important factor in this improvement.

This improvement in fuel efficiency has come about despite the shift towards the use of heavier vehicles (which by definition have lower fuel efficiencies per vehicle km than lighter vehicles. This is reflected by the fact that vehicle fuel efficiency within specific weight categories of heavier vehicles has improved by at least 8% in all vehicle weight categories over the period. For instance, the kilometres travelled per litre of fuel has improved on average by 11% for articulated HGVs over 33 tonnes gross weight between 1994 and 2007.

However most of the gains in fuel efficiency of HGVs resulting from technical improvements to engines occurred between the 1970s and 1990s. Since then the need to modify engines to meet emissions criteria, especially for nitrogen oxide has resulted in little if any further fuel efficiencies through technical improvements (McKinnon, 2010). This is reflected by the fact that between 2000 and 2007 the fuel efficiency of the HGV fleet in Britain did not change; all the improvements were achieved prior to 2000. This also suggests that other factors that can result in improved fuel efficiency have not been widely implemented by HGV operators.

CO_2 intensity of energy

Diesel has been the overwhelmingly dominant fuel for HGVs in recent decades, resulting in the carbon intensity of the fuel used remaining constant. This has resulted in the CO_2 intensity of the fuel used by HGVs remaining constant over the period 1984-2007 (with approximately 2.6 kg CO_2 per litre). However, this is likely to change in future, mostly due to efforts to mix biofuels with diesel (as well as efforts to use other renewable fuel types).

Table 6.1 attempts to relate the determinants discussed in this section to the key variables for HGVs. It is adapted from and attempts to build on a table developed in the REDEFINE project (Netherlands Economic Institute et al., 1999) and then modified in the SULOGTRA project Technical University of Berlin et al., 2001).

Table 6.1: Relationships between determinants and key variables for HGVs in Britain

	Handling factor	Modal split (road share)	Length of haul	Vehicle carrying capacity	Lading factor	Empty running	Fuel efficiency (km per litre)	Carbon intensity of fuel
1 Logistics structures								
Number of manufacturing steps/locations	✓							
Spatial concentration of production			✓	(✓)	(✓)			
Spatial concentration of inventory			✓	(✓)	(✓)			
Use of consolidation centres	✓		✓	(✓)	✓			
Use of hub-and-spoke network	✓		✓	(✓)	✓			
2 Pattern of trading links								
Vertical dis / integration of production	✓		(✓)	(✓)				
Local / more distant sourcing from suppliers		(✓)	✓					
Change in extent of market area			✓					
Change in retailer's control over supply chain				(✓)	(✓)			
Degree of concentration of international trade through hub ports / airports	(✓)	(✓)	✓					
3 Scheduling of product flows								
JIT distribution systems (smaller, more frequent deliveries)				✓	✓	(✓)		
Timed delivery systems / 'nominated day' deliveries				✓	✓	(✓)		
Out-of-hours delivery							✓	
4 Management of transport resources								
Change in road's relative cost / performance		✓						
Degree of outsourcing of transport requirements				(✓)	(✓)	(✓)		
Changes in vehicle size / weight used				✓			✓	
Changes in handling systems				✓				
Backloading initiatives					(✓)	✓		
5 Product- and load-related factors								
Change in bulk density of products					✓			
Change in load design/packaging					✓			
Increase in complexity, sophistication of product								
6. Technological factors								
Use of computerised vehicle routeing and scheduling (CVRS)			✓		✓	✓		
Freight exchanges/load matching services					✓	✓		
Improved engine performance							✓	
7. Regulation/legislation								
Change in taxes on road freight transport and fuel		(✓)	(✓)	(✓)	(✓)	(✓)	(✓)	
Recycling/reuse of products			✓		✓	✓		
Change in max permissible vehicle weight or size		✓		✓				
Changes to drivers' hours regulations		(✓)						
Lack of supply of HGV drivers		(✓)						
Use of alternative fuels								✓
Use of biofuel/diesel mix								✓
8. Demand and supply on road network								
Average journey speed		(✓)	(✓)	(✓)	(✓)		✓	

Note: ✓= impact (✓) = possible impact

7. Considering an analysis of the efficiency of articulated HGVs

The value of the spreadsheet model that was developed to relate the determinants, key variables and outputs (see section 2.2) is demonstrated by applying it to a recent debate about the efficiency of articulated HGVs. Buchan (2008) has carried out an analysis of CSRGT data for articulated goods vehicles over 33 tonne gross weight and has shown that the average load carried by these vehicles (tonne-kms divided by vehicle kms) has fallen considerably since 1984 (from 13.5 tonnes down to approximately 11.5 tonnes in 2005 – as shown in Figure 5.5). As he points out the average load has been relatively stable since 1995 (i.e. the fall in average load took place between 1983 and 1995). He notes that weight limits have increased twice over this period (to from 38 to 41 tonnes in 1999, and to 44 tonnes in 2001), and this has allowed approximately an extra 5 tonnes of goods to be carried on 6-axle maximum weight vehicles.

Buchan (2008, p.143) goes on to argue that analysis of the CSRGT data shows that, "there is also evidence that the capacity of the fleet has grown faster than the amount of freight transport actually carried or the weight of goods transported. This is referred to as the 'average lading factor'". He is again referring to articulated goods vehicles with gross weights over 33 tonnes in making this statement.

The CSRGT data (presented by Buchan and also analysed in Figure 5.4 in this report) clearly shows that the average load weight of articulated vehicles over 33 tonnes gross weight fell between 1983 and 1995 and has remained relatively stable since. Buchan also shows that the average lading factor for these vehicles has fallen between 1985 and 2005 (and see Figure 5.6 in this report). This is not what would be expected if the increase in payload weight made possible by the legislation had been made use of. Instead we would expect to see an increase in the average load carried by these articulated vehicles (assuming that there is not an increase in the proportion of empty running), together with a stable average lading factor.

But Buchan's analysis only assesses articulated vehicles over 33 tonnes gross weight and is therefore only presenting part of the picture. Figure 5.6 shows that the average load weight also fell over the period in question for other HGV types and weight categories. Therefore this phenomena was not restricted to articulated vehicles over 33 tonnes. The topic of analysis should be the operational efficiency of the entire HGV fleet (i.e. all goods vehicles over 3.5 tonne gross weight – both rigid and articulated vehicles) rather than a single category of HGV.

An analysis of all HGVs (i.e. goods vehicles over 3.5 tonnes) shows an improvement in the average payload weight carried by all HGVs between 1986 and 2007 (from 8.4 to 9.9 tonnes on laden trips and from 5.8 to 7.2 tonnes on all trips including empty ones – see Tables 4.5 and 4.6). This has come about as a result of a shift in vehicle ownership and use away from lighter vehicles towards heavier ones (especially articulated vehicles - see Figures 5.1, 5.2 and 5.9). The maximum potential tonne-kms is a calculation of how many tonne-kms would have been performed if all vehicles on laden trips had been completely full by weight. This performance measure therefore reflects how the increased average payload of vehicles (resulting from increases in the maximum permissible gross weight in 1999 and 2001) has affected the maximum potential freight movement of the entire fleet. Tables 4.5 and 4.6 show that while the average load weight carried by all HGVs increased by approximately 20% between 1986 and 2007 (from 5.8 to 7.2 tonnes) the potential average load weight if goods had travelled fully laden by weight increased by approximately 33% over the same period (from 9.3 to 12.6 tonnes). This illustrates that the increase in average payload is far below the actual payload that could have been carried had vehicles been fully laden by weight.

In considering Buchan's argument there are several important points to bear in mind. First, it is important to note that the average lading factor is not a measure of the capacity of goods vehicles. It is instead a measure of how full vehicles are in terms of the weight of goods they carry compared with their maximum potential payload by weight when travelling loaded. To demonstrate that lading factor is not a general measure of vehicle capacity is best done by providing an example. A vehicle that made only one loaded journey per year in which it was fully laden by weight, but for the rest of the year made empty journeys for half the time and sat idle for the rest of the time would have an average lading factor of 1 (implying that it used 100% of its capacity if lading factor is taken as a measure of capacity). A measure of the overall capacity of goods vehicles would need to take account of:

- how well utilised the vehicles were in terms of the proportion of time they spent working productively (tonne-kms takes no account of empty trips - as there are no goods carried on these trips - which is a key determinant of potential vehicle capacity. Tonne-kms also fails to reflect the time that the vehicle is idle and could have been working productively which also determine the capacity of the vehicle/fleet).

- the proportion of their weight <u>and volume</u> payload used on loaded trips (tonne-kms takes no account of the volume of goods carried compared with the vehicle's volume available).

As previously discussed, CRSGT data is based on tonnages and does not take account of the volume of goods transport. Therefore, even if vehicles are carrying lighter average loads this tells us nothing about whether they are more or less full in terms of volume. While data is not available about the volume of each load carried by goods vehicle surveyed in CSRGT (only weight data is collected), the analysis presented in section 3.7 of this report has shown that in 2007 the volume of loads was a major, and more important, constraint on HGV operations than the weight of loads.

There is no available data to compare the extent to which volume limits on HGV trips have changed over any sizeable period of time as the data used in section 3.7 has only been collected in its current form since 2004. Also, there is no data to establish changes in bulk density of products carried by goods vehicles over time. However, it may well be the case that average bulk densities have fallen over time due to both "lightweighting" and also due to shifts in customer demand.

Buchan's hypothesis that hauliers are buying the maximum gross weight articulated vehicles to be able to cope with whatever work they get may well be true but is not provable from CSRGT data given the limitations of the data. However, if Buchan's hypothesis is correct, it is not clear why he is so concerned about such a phenomenon. These maximum gross weight articulated vehicles have unladen weights that are only slightly higher than the 38 tonne articulated vehicles that they superseded in 1999 due to increases in maximum permissible gross weights. If these maximum gross weight articulated vehicles are operating with less than full loads (by weight or volume, or both) and their work could have been done by articulated vehicles with slightly lighter unladen weights, this could result in minor reductions in impacts including fuel consumption and road wear. However, in terms of the sustainability of road freight operations, other factors such as empty running, the total number of vehicle kilometres travelled, and the idle, unproductive time spent by vehicles (which impacts on the number of vehicles manufactured and scrapped) are likely to have a far greater impact.

Using vehicles that have slightly heavier unladen weights than required does not result in greater vehicle activity (in terms of trips and vehicle kms) it only means that some of the vehicles operating at any given time are slightly heavier than they need to be. In fact, if some or all operators with maximum weight articulated vehicles were to switch their vehicles for lighter articulated models (the logical outcome of Buchan's argument), this could perversely lead to an increase in empty running and vehicle kilometres in the case of heavy loads that require maximum weight vehicles there would be less flexibility in vehicle selection. Some of these vehicles with lower unladen weight and payload limits would be unable to carry such loads and would therefore potentially have to return to base empty or perform empty running to their next job, while the smaller number of maximum weight vehicles would need to be despatched over greater distances to carry loads that required their payload. Alternatively, more than one of the vehicles with a smaller weight payload would need to be used to carry the load resulting in additional vehicle trips and kilometres.

Using the spreadsheet model it is possible to test the effect of using the HGV types and weight categories that performed road freight work in 1984 on the quantity of freight lifted and average length of haul in 2007 in order to see the effect on vehicle kilometres and other outputs. Two scenarios can be tested: scenario 1 assumes that the 1984 HGV fleet is used in 2007 to meet the requirements for road freight to be lifted and moved - this fleet is assumed to achieve the lading factors and empty running that it did in 1984. Scenario 2 assumes that the 1984 HGV fleet is used in 2007 (as in the first scenario) but that this fleet achieves the lading factors and empty running of the actual HGV fleet in 2007. It is assumed that the weight carrying capacity achieved by the HGVs are those achieved in 1984 in both scenarios, and that the tonnes lifted and average length of haul are those actually performed in 2006 in both scenarios. The results are shown in Table 7.1.

Table 7.1: Comparison of using 1984 HGV fleet to carry out 2007 road freight activity in Britain

Determinants, key variables and outputs	2007 (actual)	Scenario 1 – 2007 (using 1984 fleet and 1984 lading factor and empty running variables)	Scenario 2 – 2007 (using 1984 fleet and 2007 lading factor and empty running variables)
Freight lifted by HGV (million tonnes)	1869	1869	1869
Length of haul (km)	86	86	86
Freight moved by HGV (billion tonne-kms)	160.7	160.7	160.7
Vehicle utilisation on laden trips (ratio)	0.57	0.66	0.57
Vehicle carrying capacity by weight (tonnes)	17.4	13.0	13.0
Average load on laden trips (tonnes)	9.9	8.6	7.4
Empty running (%)	27.4	31.4	27.4
Laden kilometres (billion)	16.2	18.7	21.7
Empty kilometres (billion)	6.1	8.6	8.2
Vehicle kilometres (billion)	22.3	27.3	29.9

Source: calculated from data in DfT, 2008b, 1999 and 1995.

The results in Table 7.1 indicate that using the 1984 fleet to meet the demand for road freight in 2007 would result in major increases in total vehicle kilometres performed in both scenarios (an increase of 22% in scenario 1 and 34% in scenario 2). This illustrates the benefits of increasing the maximum permissible weight of articulated goods vehicles in 1999 and 2001 in terms of total road freight activity performed (even if it were the case that HGV operational efficiency in terms of the weight of loads carried could have been even higher – which is not necessarily true if the volume is a greater constraint than the weight). It is worth noting that, independently, a recent study into the feasibility of longer, heavier goods vehicles reached similar conclusions to these (Knight et al, 2008).

8. Estimating HGV activity, fuel consumption and CO_2 emissions in 2020

8.1 Future HGV activity

Forecasting the future level of HGV activity is notoriously difficult. However analysing the key variables that influence how tonnes lifted are converted into HGV kilometres (as in this report) helps to provide insight into the causes of past trends. It also assists in considering how the relationship between tonnes lifted, vehicle kilometres, total fuel consumed and total CO_2 emissions may change in future. However, it does not help to analyse how the total quantity of freight lifted will change over time, as this is based on other economic, technological and social factors.

Using the spreadsheet model developed in this work it is possible to consider likely future trends in the vehicle kilometres travelled by HGVs, as well as total fuel consumed and total CO_2 emissions.

In 2007, on average every tonne lifted was transported 12 kilometres. If all the key variables remain at their 2007 level in future years, then a 1% increase in the total tonnes lifted by HGVs will result in an additional 1% of vehicle kilometres travelled by HGVs (and conversely every 1% reduction in total tonnes lifted by HGVs will result in a 1% reduction in total vehicle kilometres travelled by HGVs). Therefore if we witness a 25% increase in the total tonnes lifted by HGVs between 2007 and 2020 (which is approximately equivalent to the increase in tonnes lifted by HGVs in the 13 years between 1994 and 2007), then all other things being equal, this would result in a 25% increase in total HGV kilometres.

However, based on past trends and what we know about the determinants of the key variables it is unlikely that all the key variables will remain unchanged between now and 2020.

The modal share of freight lifted by road has changed very little between 1984 and 2007 (accounting for approximately 77% of total freight lifted in 1984 and 79% in 2007). There is no reason to think that this will change to any great extent in the coming years and therefore this can be assumed to remain at its 2007 level.

As explained in this report handling factors are difficult to calculate, and can at best only be roughly estimated. It is therefore not sensible to try to predict changes in this variable.

After a long period of increases, the average length of haul fell between 1999 and 2004 (from 95 km to 86 km) since when it has remained virtually unchanged. There is no reason to expect the average length of haul to change in future. Average length of haul had increased for many years up to the early 2000s and this was probably due to increasing centralisation of production and stockholding facilities in supply chains and growing market areas. However given the degree of centralisation achieved and the size of the country these trends had probably reached their maximum possible. The reduction in average length of haul since 1999 is probably due to some relaxing of these centralisation trends plus greater use of computerised vehicle routeing and scheduling tools which have reduced journey length. There is no particular reason to expect average length of haul to return to its upward trend or continue to decrease in future (unless traffic congestion becomes such a problem in terms of journey time and reliability that supply chain networks are forced to become increasingly localised but this is unlikely to any great extent as governments would be forced to take action in terms of rationing road space through pricing or other means).

However, the other key variables (lading factor, average carrying capacity, and empty running) are less likely to remain unchanged from 2007 levels. Empty running and lading factor have both worsened over the period between 1984 and 2007. The average lading factor is likely to continue to worsen to a small extent due to two existing factors: i) operators replacing their vehicles with heavier ones and then not managing to always fill them with loads as well as they did previously, and ii) the trend for the bulk density of loads to reduce over time resulting in an increasing proportion of vehicle loadings being full in volume terms before they have reached their payload capacity in weight terms. Despite initiatives that can be taken by hauliers to reduce empty running rates the long term trend has been for these rates to worsen, and there is no reason to expect this to stop.

Table 8.1 shows the key variables in 1984, 2000 and 2007, and our estimates for 2020, as well as the vehicle km per tonne lifted that these variables result in. Table 8.2 shows the percentage change in the key variables and vehicle km per tonne lifted between 1984-2007, 2000-2007 and 2007-2020 (based on our estimates of change).

Overall, our estimates of key variables in 2020 would result in HGV activity becoming 3% more efficient in terms of vehicle kilometres per tonne lifted compared with 2007 (11.6 km per tonne lifted compared with 12.0 km).

Assuming that the total freight lifted by HGVs remained unchanged in 2020 compared to their 2007 levels then total vehicle kilometres travelled by HGVs would be 3% lower in 2020 than in 2007.

Table 8.1: Changes in key variables and vehicle km per tonne lifted for HGVs, 1984-2020

	1984 actual	**2000 actual**	**2007 Actual**	**2020 our estimate**
Modal share by HGV	77%	77%	79%	79%
Average length of haul	73	94	86	86
Vehicle carrying capacity	13.01	14.9	17.4	18.5
Lading factor	0.66	0.60	0.57	0.55
Empty running	31.4%	26.9%	27.4%	27.0%
Vehicle km per tonne lifted	12.4	14.4	12.0	11.6*

Note:
* - vehicle km per tonne lifted for 2020 has been calculated based on the other variables not estimated.

Table 8.2: Assumed changes in key variables and calculated vehicle km per tonne lifted for HGVs, 1984-2020 (percentage change)

	1984-2007	**2000-2007**	**2007-2020**
Modal share by HGV	-1%	3%	0%
Average length of haul	17%	-9%	0%
Vehicle carrying capacity	34%	17%	6%
Lading factor	-14%	-5%	-4%
Empty running*	-13%	2%	-1%
Vehicle km per tonne lifted	-4%	-17%	-3%

Note:

* - a negative change in empty running reflects and improvement (i.e. the level of vehicle kilometres run empty has reduced).

Over the thirteen years between 1994 and 2007, the total weight of freight lifted by HGVs rose by 23% (from 1.5 billion tones to 1.9 billion tonnes). If the total weight of freight lifted by HGVs rose by a similar proportion (say 25%) between 2007 and 2020, then taking into account our estimates of key variables in 2020, this would result in a 21% increase in total HGV kilometres travelled. A 10% increase in tonnes lifted would lead to a 7% increase in vehicle kilometres.

8.2 HGV fuel consumption

The fuel consumption (in terms of kms travelled per litre of fuel consumed) of the HGV fleet in Britain has improved by 8% between 1994 and 2007 (from 2.6 to 2.8 km per litre). Fuel efficiency can be improved through a range of factors include technical improvements to engines and vehicle aerodynamics, the lightweighting of vehicles, vehicle maintenance and driver behaviour. However, technical improvements in engines is likely to have been the most important factor.

This improvement in fuel efficiency has come about despite the shift towards the use of heavier vehicles (which by definition have lower fuel efficiencies per vehicle km than lighter vehicles. This is reflected by the fact that vehicle fuel efficiency within specific weight categories of heavier vehicles have improved by more than 8% over the period. For instance, the kilometres travelled per litre of fuel have improved on average by 11% for articulated HGVs over 33 tonnes gross weight between 1993-2007.

However most of the gains in fuel efficiency of HGVs resulting from technical improvements to engines occurred between the 1970s and 1990s. Since then the need to modify engines to meet emissions criteria, especially for nitrogen oxide has resulted in little if any further fuel efficiencies through technical improvements (McKinnon, 2010). This is reflected by the fact that between 2000 and 2007 the fuel efficiency of the HGV fleet in Britain did not change; all the improvements were achieved prior to 2000. This also suggests that other factors that can result in improved fuel efficiency have not been widely implemented by HGV operators.

Efforts to improve HGV fuel efficiency are becoming increasingly important given concerns about the effects of climate change as well as the cost of fuel. Therefore it is reasonable to assume that HGV fuel efficiency will improve by 2020 as a result of technical, maintenance and driving style factors as well as a continuation of the shift towards the use of heavier vehicles.

If it is assumed that vehicle fuel efficiency (in terms of kms per litre) improves by 10% between 2007 and 2020 (from 2.8 to 3.1 kms per litre) then, all others things being equal, this would result in a 9% reduction in total fuel consumed by HGVs in 2020 compared with 2007. If this 10% improvement in fuel efficiency is combined with our estimates of changes in other key variables this would result in a 12% reduction in total fuel consumed by HGVs (assuming that the tonnes lifted remain at their 2007 level).

If the tonnes lifted were to increase by 10% by 2020 compared to 2007, then even given these assumed improvements in vehicle fuel efficiency and changes in other key variables then the total fuel consumed by HGVs would increase by 7% compared to 2007. A 25% increase in tonnes lifted would increase HGV total fuel consumed by 21%.

8.3 Carbon dioxide emissions

Diesel has remained the fuel of choice for HGVs in recent decades resulting in the carbon intensity of the fuel used remaining constant. This is likely to change by 2020, mostly due to efforts to mix biofuels with diesel (as well as efforts to use other renewable fuel types). It is feasible to add up to 10% biomass to the existing diesel fuel without any need to modify existing engines and the Renewable Transport Fuel Obligation has set this as a target in the UK by 2020 (Cullinane and Edwards, 2010).

If a 10% reduction in the carbon intensity of HGV fuel is achieved for all HGV fuel used by 2020, then, all other things being equal, this would result in a 10% reduction in total CO_2 emissions by HGVs compared with 2007.

If this 10% reduction in the carbon intensity of HGV fuel is combined with our estimates of changes in other key variables (including improvements in fuel efficiency), this would result in a 21% reduction in total CO_2 emissions by HGVs compared with 2007 (assuming that the tonnes lifted remain at their 2007 level).

If the tonnes lifted were to increase by 10% by 2020 compared to 2007, and all key variables remained at their 2007 level then even given these assumed improvements in the carbon intensity of fuel, vehicle fuel efficiency and changes in other key variables then the total CO_2 emissions by HGVs would decrease by 13% compared to 2007. A 25% increase in tonnes lifted would result in total CO_2 emissions by HGVs decreasing by 1% compared to 2007.

8.4 Summary

Table 8.3 summarises these effect of changes in key variables discussed in sections 8.1 - 8.3 on total vehicle kilometres travelled, total fuel consumed, and total CO_2 emissions by HGVs based on: i) if the total tonnes lifted by HGVs remain unchanged between 2007 and 2020, ii) if the total tonnes lifted by HGVs in 2020 are 10% greater than in 2007, and ii) if the total tonnes lifted by HGVs in 2020 are 25% greater than in 2007.

Table 8.3: Effect of changes in key variables on vehicle kilometres, fuel consumed and CO2 emissions by HGVs between 2007 and 2020

	% change 2007-2020 if tonnes lifted remain unchanged	% change 2007-2020 if tonnes lifted increase by 10%	% change 2007-2020 if tonnes lifted increase by 25%
Estimated change in lading factor, vehicle carrying capacity and empty running			
Total vehicle kilometres	-3%	+7%	+21%
Total fuel consumed	-3%	+7%	+21%
Total CO_2 emissions	-3%	+7%	+21%
Estimated improvement in fuel efficiency (10%)			
Total vehicle kilometres	0%	+10%	+25%
Total fuel consumed	-9%	0%	+14%
Total CO_2 emissions	-9%	0%	+14%
Estimated reduction in carbon intensity of fuel (10%)			
Total vehicle kilometres	0%	+10%	+25%
Total fuel consumed	0%	+10%	+25%
Total CO_2 emissions	-10%	-1%	+12%
Combined effect of all above			
Total vehicle kilometres	-3%	+7%	+21%
Total fuel consumed	-12%	-3%	+10%
Total CO_2 emissions	-21%	-13%	-1%

9. Conclusions

9.1 The intensity of HGV operations and changes in key variables

The research has proposed a new measure of the intensity of road freight activity by HGVs. This is the vehicle kilometres travelled per tonne lifted. Vehicle kilometres performed by the HGV fleet are dependent on the length of haul, the vehicle carrying capacity, the utilisation of goods vehicles on laden trips, and the extent of empty running. Therefore, the relationship between total goods lifted by HGVs and total vehicle kilometres performed by HGVs is the key indicator of the degree of intensity (and hence sustainability) of HGV operations.

In addition, vehicle kilometres (rather than tonnes lifted or tonne-kilometres) are the output that is most strongly related to many of the negative impacts of HGV activity (such as fuel consumption, pollutant emissions, contribution to congestion, number of casualties, noise, vibrations and visual intrusion). Therefore, in attempting to improve the economic, social and environmental sustainability of HGV operations both policymakers and operators should target reductions in the total vehicle kilometres performed by the HGV fleet as the key priority.

The research has shown that the average distance travelled by British-registered HGVs in Britain per tonne lifted rose from 12.4 km in 1984 to 14.7 km in 1999. However since then it has fallen annually to 11.9 km in 2007. Prior to 1984, the increases in vehicle km per tonne lifted by HGVs were due to a combination of increases in length of haul, falls in the lading factor (empty running fell (i.e. improved) and vehicle carrying capacity rose over this period but the improvement in these two variables was not sufficient to offset negative changes in the other two variables). From 1999 to 2007 two variables have changed in a direction that has reduced vehicle km per tonne lifted, namely length of haul (which has fallen) and vehicle carrying capacity (which has risen substantially). The changes in these two variables have more than offset the falls in lading factor and the relative stability in empty running, thereby resulting in fewer vehicle km per tonne lifted (and hence more efficient road freight transport).

Over the entire period 1984 to 2007, the increase in vehicle carrying capacity (34%) was the most important factor in reducing the average vehicle kilometres travelled per tonne lifted, followed by improvements in empty running (-13%). Increases in the length of haul (17%) and a deterioration in lading factor (-14%) were of similar importance in raising vehicle kilometres travelled per tonne lifted over this period.

Between 2000 and 2007 the increase in vehicle carrying capacity (17%) was also the most important factor in reducing the average vehicle kilometres travelled per tonne lifted, followed by a reduction in the length of haul (-9%). Meanwhile a worsening in the lading factor (-5%) and empty running (2%) had the effect of increasing the average vehicle kilometres travelled per tonne lifted between 2000 and 2007.

Increase in average load weight over the last 25 years have been driven by two factors: i) government increases in the maximum permissible gross weights of the heaviest HGVs (from 32.5 tonnes in 1982 to 44 tonnes today), and ii) the trend among operators to purchase and operate a growing proportion of heavier vehicles. Meanwhile lading factors have worsened over the period (thereby reducing the average weight of loads). It is doubtful whether the reduction in vehicle km per tonne lifted which has occurred since 1999 can be sustained without further increases in the maximum permissible gross weight of HGVs (which are unlikely in the near future), especially as the trend towards substitution of lighter for heavier HGVs by operators is likely to slow down substantially as it runs its course.

Reductions in the average length of haul since 1999 have reversed a trend that goes back as far as HGV activity data to the early 1960s. the reasons for this reversal are unclear but may well be connected with factors including centralisation processes (of manufacturing and stockholding sites) having run their course, the possibility that some supply chains are becoming more regional (a move away from national systems), and the increased use of technology such as computerised vehicle routeing and scheduling to reduce journey distance.

The worsening of lading factors over the last 25 years has resulted in the average carrying capacity of HGVs increasing at a faster rate than the average load carried. This is likely to be due to changes in the bulk density of products and loads, which are resulting in vehicle volume constraints becoming a greater problem for HGV operators than weight constraints.

The number of killed and seriously injured (KSI) casualties resulting from collisions involving HGVs in Britain has been falling since 1989 while the number of slight casualties has been falling since 2000. The number of KSI and slight injuries per 100 million HGV vehicle kilometres have both fallen continuously between 1984 and 2007.

9.2 Developments in HGV analysis

The research has extended the framework proposed by McKinnon (2007) to include consideration of the relationship between total HGV kilometres and the total HGV fleet. It has also reorganised the top part of the framework, so as to address handling factor across the supply chain for all transport modes, rather than addressing these factors specifically for road freight.

The research has proposed a new method for calculating the handling factor across supply chains in Britain and, using this approach, has estimated that the handling factor increased between 1994 and 2007 (from 2.4 to 2.8).

The spreadsheet development in accordance with this framework has been used for several purposes: i) to analyse HGV operations between 1984 and 2007 using CSRGT data, ii) to reappraise a debate about the efficiency of articulated HGV use, and iii) to estimate likely changes in HGV kilometres, fuel use and CO_2 emissions by 2020.

The analysis has shown that the assertions of Buchan (2008) are correct in that the capacity of the articulated HGV fleet has grown faster than the amount of freight transport carried out or the weight of goods transported by these vehicles. However, our work has reflected that in 2007 the volume of loads was a major, and more important, constraint on HGV operations than the weight of loads. Using the spreadsheet model developed it was possible to test the effect of using the HGV types and weight categories that performed road freight work in 1984 on the quantity of freight lifted in 2007 in order to see the effect on vehicle kilometres and other outputs. The results indicate that using the 1984 fleet to meet the demand for road freight in 2007 would have resulted in major increases in total vehicle kilometres performed. This illustrates the benefits of increases in the maximum permissible weight of articulated goods vehicles in 1999 and 2001 in terms of the total distance travelled on Britain's roads by HGVs and their related negative impacts.

The work has estimated that if in 2020 the same quantity of freight is lifted by HGVs as was lifted in 2007 then this is likely to be achieved with 3% fewer vehicle kilometres than in 2007 (and hence 3% fewer vehicle kilometres per tonne lifted) due to further improvements in the average vehicle carrying capacity of the HGV fleet (due to continued substitution of lighter for heavier vehicles). It is estimated that improvements in fuel efficiency and the carbon intensity of fuel will, together with this increase in the efficiency of road freight lead to an

12% reduction in total fuel consumption and a21% reduction in total CO_2 emissions by 2020 compared with 2007.

9.3 Data and analytical issues raised by the research

Much of the analysis in the report is dependent on the quality of the CSRGT data. One of the possible weaknesses in the data relates to the differences between the CRSGT estimate of HGV vehicle kilometres and the estimate obtained from road traffic statistics. In 2007 road traffic statistics provided an estimate of HGV vehicle kilometres that was 24% higher than that from CSRGT. These differences are due to three factors: i) the road traffic statistics include the distance travelled by foreign-registered HGVs, the road traffic statistics include the distance travelled by all HGVs regardless of tax class, whereas the CSRGT data only includes HGVs with an HGV tax class (approximately 80,000 fewer vehicles), and iii) possible under-reporting of distance travelled by CSRGT respondents.

It has been estimated that foreign-registered HGVs accounted for 3.5% of all HGV vehicle kilometres in the road traffic count data in 2008 (DfT, 2009). Therefore the distance travelled by the 80,000 HGVs not registered in the HGV tax class and under-reporting in the CSRGT should account for the remaining 20% difference between CSRGT and road traffic statistic estimates of HGV kilometres. The 80,000 non-tax class HGVs represent approximately 15% of all HGVs. Therefore if these vehicles travel the same average annual distance as HGVs with an HGV tax class this could account for a 15% difference in vehicle kilometres between the two estimates. However, it is somewhat unlikely that these 80,000 vehicles do travel as far each year as HGVs with an HGV tax class as many of them are not thought to be commercially active. These vehicles are therefore likely to account for considerably less than a 15% difference. Assuming these vehicles account for a 5-10% difference in HGV kilometres between CSRGT and road traffic statistics, then this would mean that under-reporting of distance travelled by CSRGT respondents may account for a 10-15% difference. If this is the case, a 10-15% under-reporting of vehicle kilometres travelled in CSRGT would represent a major under-estimate and would obviously have important consequences for using CSRGT data to assess the efficiency and intensity of HGV operations.

The research has also highlighted the problems raised in assessing the efficiency and intensity of HGV operations using weight-based measures (i.e. tonnages) if the bulk density of products and loads are reducing over time. If this is the case then weight-based measures of efficiency are likely to be under-emphasising the efficiency of HGV operations (due to underestimating the lading factor when volume fill is taken into account).

The research has also raised some of the problems associated with using tonne-kilometres as a measure of road freight activity. Some alternative measures including m^3-kilometres, tonne-hours and m^3-hours have been suggested.

9.4 Further research topics raised by the research

Further research topics possibilities raised by this work include:

- Consideration of the possibility of capturing data about vehicle capacity in volume terms and the volume fill of the vehicle per load in CSRGT or other freight data survey work to compare HGV lading factors, output and efficiency in volume as well as weight terms

- The possibility of capturing time-related data in CSRGT or other freight data survey work (in terms of trip arrival and departure times). This could be used to analyse HGV time utilisation and to calculate HGV average journey speeds) as well as to consider HGV efficiency in terms of time-related measures.

- Considering whether CRSGT data can be used to analyse the total number of HGV journeys being made, the average journey length, and the average number of legs per journey on multi-leg journeys. If this analysis is possible this would provide additional insight into the pattern of HGV operations and could be monitored over time to identify changes in HGV operations.

- Further analysis of the reasons for the differences in CSRGT and road traffic estimates of HGV kilometres to establish the extent caused by i) under-reporting of CSRGT respondents and ii) distance travelled by HGVs not taxed as goods vehicles.

- Research into the bulk density of products and loads carried, whether this has changed over time and whether such changes are continuing.

- Further consideration of appropriate techniques and data availability for calculating handling factors.

Even if it is not possible to adapt CSRGT to examine some of these points, it would be possible to consider carrying out one-off research studies into them.

Appendix 1. Issues concerning tonne-kilometres as an output measure

The tonne-kilometre is defined by the Department for Transport (2008b) as "a measure of freight moved which takes account of the weight of the load and the distance through which it is hauled". If a vehicle load of 25 tonnes is carried a distance of 10 kilometres this represents 250 tonne-kilometres.

Although the tonne-kilometre is a useful measure of the work done by HGVs as it incorporates both the goods lifted and the distance over which these goods are transported there are several problems with it. These are discussed below.

A1.1 Difficulties in comparing tonne-kilometre values

As the tonne-kilometre is a product of weight and distance, a given tonne-kilometre value can be derived from differing weight and distance values.

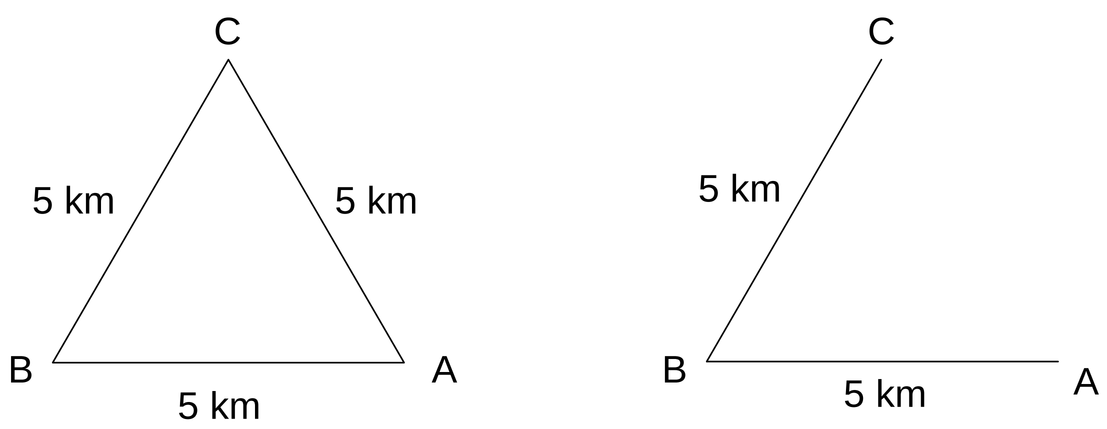
An example can be provided by comparing two different single-drop trips by the same HGV. In the first case a 2 tonne load moved over a distance of 20 kilometres. This represents 40 tonne-kilometres. In the second case a 20 tonne load is moved over 2 kilometres (i.e. 40 tonne-kilometres). Both of these trips have the same tonne-kilometre value and, in this case, are performed by the same HGV. However, the transport activity associated with these two movements is very different, as are the road freight transport costs and external impacts associated with them. If confronted with a tonne-kilometre value and no other information, there is no way of knowing the proportion of the tonne-kilometre value accounted for by weight and the proportion accounted for by distance.

Also the tonne-kilometre measure takes no account of empty running (it only refers to loaded trips and the distance they travel). The rate of empty running is a form of inefficiency (but obviously a certain degree of empty running is likely to always be unavoidable due to the need to reposition vehicles) and therefore a measure that excludes it will fail to reflect the total impact of freight operations.

A1.2 Tonne-kilometres on single and multi-drop HGV trips

When distribution rounds are served by HGV multi-drop operations (i.e. in which one vehicle visits several collection or delivery points on a journey) this produces very different results in terms of tonne-kilometres to these same collections and deliveries being carried out by HGVs on single drop operations (i.e. the vehicle drives to the delivery point, makes the delivery and then returns to its depot empty). Take the example on the illustrated in Figure 9.1.

Figure 9.1: Multi-drop and single drop HGV operations



In the left hand case, an HGV with a 20 tonne maximum payload travels from its depot at point A, to a delivery point at B, then travels on to another delivery point C, before returning to it depot empty (A). Assuming that 10 tonnes are delivered at point B and C. The HGV therefore departs it depot (A) with a load of 20 tonnes and travels 5 km to B (100 tonne-kms). It then travels 5 km to C with the remaining load of 10 tonnes (50 tonne-km). It then returns the 5 km to its depot (A) empty (0 tonne-km). This operation therefore represents a total of 150 tonne-kilometres.

In the right hand case, the delivery points at B and C are served by separate HGVs each of which makes the delivery and then returns to its depot empty (A). The first vehicle departs its depot (A) and drives 5 km to B to deliver its 10 tonne load (50 tonne-kms) and then returns to A empty. The second vehicle departs its depot at B and drives 5 km to C to deliver its 10 tonne load (50 tonne-kms) and then returns to B empty (50 tonne-kilometres).

In these two cases exactly the same quantity of freight has been delivered (i.e. the output is the same) but the first represents 150 tonne-kms and the second only 100 tonne-kms.

In addition these two operations produce differences in terms of other key variables and outputs. Although the multi-drop operation produces more tonne-kilometres, it produces fewer total vehicle kilometres, has a lower rate of empty running, and higher lading factor and average load. The multi-drop operation is therefore more sustainable (producing only 0.75 vehicle kms per tonne lifted compared with 1.0 in the single drop operation), and is more efficient (with 10 tonne-kms per vehicle km compared with 5 in the single drop operation). This is shown in Table 9.1. However given that the multi-drop operation produces more tonne-kms than the single drop operation it appears to generate more freight moved.

Table 9.1: Key variables, outputs, efficiency and intensity of the two operations

	Multi-drop operation	Single drop operation
Goods lifted	20 tonnes	20 tonnes
Total tonne-kms	150 tonne-km	100 tonne-km
Lading factor	0.75	0.50
Carrying capacity of vehicle	20 tonnes	20 tonnes
Average load carried	15 tonnes	10 tonnes
Empty running	33%	50%
Laden vehicle kilometres	10 km	10 km
Empty vehicle kilometres	5 km	10 km
Total vehicle kilometres	15 km	20 km
Vehicle km per tonnes lifted	0.75	1.0
Tonne-kms per vehicle kms	10	5

This is further complicated if the multi-drop operation involves different load weights for different delivery points.

To illustrate this let us assume that 15 tonnes are delivered at B and only 5 tonnes at C. For the multi-drop operation, an HGV with a 20 tonne maximum payload travels from its depot at point A, to a delivery point at B and delivers 15 tonnes (100 tonne-kms) and then travels on to C and delivers 5 tonnes (25 tonne-km) before returning to its depot empty (A). This generates a total of 125 tonne-kms.

Now consider if only 5 tonnes are delivered at B and 15 tonnes at C. This results in 100 tonne-kms from A to B (20 tonnes x 5 km), and then 75 tonne-kms from B to C (15 tonnes x 5 km). This therefore generates a total of 175 tonne-kms, 40% more than when the heavier load is delivered first. The results are shown in Table 9.2 together with the original round performed by the multi-drop operation in which equal load weights are delivered at B and C.

Table 9.2: Key variables, outputs, efficiency and intensity of the multi-drop operation

	10 tonnes delivered at each	15 tonne load delivered first	5 tonne load delivered first
Goods lifted	20 tonnes	20 tonnes	20 tonnes
Total tonne-kms	150 tonne-km	125 tonne-km	175 tonne-km
Lading factor	0.75	0.625	0.875
Carrying capacity of vehicle	20 tonnes	20 tonnes	20 tonnes
Average load carried	15 tonnes	12.5 tonnes	17.5 tonnes
Empty running	33%	33%	33%
Laden vehicle kilometres	10 km	10 km	10 km
Empty vehicle kilometres	5 km	5 km	5 km
Total vehicle kilometres	15 km	15 km	15 km
Vehicle km per tonnes lifted	0.75	0.75	0.75
Tonne-kms per vehicle kms	10	8.3	11.7

Table 9.2 reflects the problems associated with tonne-kms as a measure of output (as three different results can be produced for three operations in which the output is the same in terms of tonnes delivered and distance travelled). It also shows the effect of these various methods of operation on the lading factor and hence the average load. It also highlights the problems associated with using measures of efficiency that use tonne-kms (such as the ratio of tonne-kms : vehicle kms). It does though indicate the strength of using total vehicle kilometres per tonne lifted as a measure of the intensity of HGV activity as this result remains constant in all three multi-drop operations.

<u>A1.3 Addressing the issue of load volume as well as load weight</u>

As discussed in section 3.7, the volume of loads is a major constraint on HGV activity. In 2007 load volume was the sole constraint for 32% of goods lifted and 43% of goods moved by HGVs that were limited by either weight, volume or both. Far more tonnes lifted and tonnes moved were limited by volume constraints than by weight constraints. By comparison, weight was the sole constraint for 19% of goods lifted and 17% of goods moved by HGVs in 2007.

Obviously the extent of volume constraints is far greater for some types of products than others (i.e. products with low bulk densities). Unfortunately CSRGT only collects data about the weight of loads carried by HGV, not the volume of these loads. Analysing HGV activity by volume would provide a very different insight into the efficiency of HGV operations.

For example, assume an operation on which an HGV with a maximum payload of 20 tonnes and 70m3 carries a load that results in it being fully loaded in weight terms (i.e. a load of 20 tonnes) but only half loaded in volume terms (i.e. a load of 35m^3). This load is transport a distance on 10 km. This represents 200 tonne-kms and 350 m^3-kms.

We can compare this with the same HGV (i.e. with the same weight and volume capacity) next carrying a load that results in it being half loaded in weight terms (i.e. a load of 10 tonnes) but fully loaded in volume terms (i.e. a load of 70 m^3). This vehicle also travels a journey of 10 km. This represents 100 tonne-kms and 700 m^3-kms. The key variables and outputs for these two journeys are shown in Table 9.3, with results in weight and volume terms. This reflects that the results in expressed in weight terms are the opposite of those expressed in volume terms. This highlights the need to understand load and vehicle capacity in terms of volume as well as in weight terms if the key variables, outputs, efficiency and intensity of HGV operations are to be fully understood.

Table 9.3: Key variables, outputs, efficiency and intensity of the two loads carried by the same HGV

	20 tonne and 35m^3 load	10 tonne and 70m^3 load
In weight terms		
Goods lifted	20 tonnes	10 tonnes
Total tonne-kms	200 tonne-km	100 tonne-km
Lading factor	1.0	0.5
Carrying capacity of vehicle	20 tonnes	20 tonnes
Load carried	20 tonnes	10 tonnes
Empty running	0%	0%
Laden vehicle kilometres	10 km	10 km
Empty vehicle kilometres	0 km	0 km
Total vehicle kilometres	10 km	10 km
Vehicle km per tonnes lifted	0.5	1.0
Tonne-kms per vehicle kms	20	10
In volume terms		
Goods lifted	35 m^3	70 m^3
Total m^3-kms	350 m^3-kms	700 m^3-kms
Lading factor	0.5	1.0
Carrying capacity of vehicle	30 m^3	70 m^3
Average load carried	70 m^3	70 m^3
Empty running	0%	0%
Laden vehicle kilometres	10 km	10 km
Empty vehicle kilometres	0 km	0 km
Total vehicle kilometres	10 km	10 km
Vehicle km per m^3 lifted	0.29	0.14
m^3 kms per vehicle kms	35	70

A1.4 Taking time into account in HGV output and efficiency calculations

As Bayliss (1988) has noted an HGV operator working in a busy urban environment will only perform a fraction of the total distance travelled by an operator doing similar work between locations on the inter-urban road network. However, if they are using similar vehicles and carrying similar consignments their operating costs and the value of their output would not be dissimilar. However when measuring output in terms of tonnes-kilometres the urban operator's HGV will represent far fewer. Bayliss therefore proposes the concept of the tonne-hour. If output was measured using the tonne-hour then, assuming both operators loaded their vehicles with the same weight of goods and worked for the same quantity of time, then their tonne-hours would be identical.

For example, an HGV carrying operating in London has a load of 20 tonnes and carries it a distance of 15 km. It takes 1 hour to complete the work. This represents 300 tonne-kms and 20 tonne-hours. By contrast if the same HGV carries a load of 20 tonnes a distance of 60 km between two sites located on the motorway network and takes 1 hour to do so, this also represents 20 tonne-hours but 1200 tonne-kms, four times more. However both vehicles have been active for the same period of time and carried the same quantity of freight.

In order to calculate tonne-hours it would be necessary to collect data about the time HGVs spent working (as in the KPI surveys – see section 3.11). This time-related data is not currently collected in the CSRGT but as Bayliss notes may be relatively easy for operators to provide. It would also be possible to consider calculating m^3-hours for comparison purposes given the issues involved in using tonnages if the bulk densities of loads are falling over time.

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