



Analysis of Transport Efficiency in the UK Food Supply Chain

Full Report of the 2002 Key Performance Indicator Survey

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1. Introduction

1.1 Background

Over a two day period in October 1998, the activities of approximately 2,300 vehicles carrying food products were closely monitored. Their operational efficiency was measured against a standard set of key performance indicators (KPIs). It is understood that this was the first major survey of its kind in the world. It allowed the participating companies to benchmark the efficiency of their transport operations, while providing aggregate estimates of potential reductions in operating costs, energy consumption and emissions. In a follow-up survey the companies indicated that the exercise had yielded practical benefits and expressed a desire to take part in a future survey. The full report of this study was published in November 1999¹. This report placed the transport KPI initiative in the context of the UK government's sustainable distribution strategy² and reviewed previous research on the benchmarking of logistical efficiency.

The survey was repeated in May and October 2002 with a much larger and more diverse sample of fleets and vehicles in the food sector. This report outlines the main results of this project. A shorter summary is also available³.

The aggregate results presented in this report cannot be directly compared with those of the earlier survey. The sample of companies and fleets surveyed in 1998 and 2002 were significantly different. For example, local distribution from wholesale depots to catering outlets was much more strongly represented in the 2002 survey, increasing the proportion of multiple collection and delivery rounds in the database. This resulted in a more even distribution of trips across different levels in the supply chain. Even at the sub-sectoral level, one must exercise caution in comparing average values given differences in the sampling frame. Individual companies participating in the 1998 and 2002 surveys have, nevertheless, been able to compare their KPI results and assess changes in performance over the intervening four year period.

The Department for Transport (DfT) funded the survey as part of the TransportEnergy Best Practice programme. The Cold Storage and Distribution Federation recruited participants from the industry and the Logistics Research Centre at Heriot-Watt University ran the survey.

1.2 Objectives

The main objectives of the survey were to

- enable companies to benchmark the efficiency of their road transport
- estimate average levels of transport efficiency at both sectoral and sub-sectoral levels
- assess the potential for improving the efficiency of delivery operations

It can be difficult for an individual firm to assess the potential for improving the utilisation of its vehicle assets and cutting transport costs. Judging the actual loading of vehicles against their maximum technical or legal carrying capacity can set fleet managers an unrealistically high target. A more practical yardstick against which to assess performance is the range of average load factors achieved by companies engaged in similar distribution operations. This requires benchmarking against a standard set of industry-wide KPIs, preferably over the same time period and employing an identical method of data collection.

Governments also have an interest in the overall efficiency of freight transport operations. The UK government, in particular, has identified improved vehicle loading and higher fuel efficiency as key elements in its Sustainable Distribution strategy. Underpinning its 10 year transport plan⁴ are ‘sustainable distribution scenarios’ which assume a significant increase in vehicle load factors between 2000 and 2010. It is acknowledged that, *‘The goods vehicle forecasts critically depend on the assumptions made in respect of the operational efficiency of the vehicle fleet, in particular payload (tonnes per loaded vehicle kilometres) and empty running (ratio of total vehicle kilometres per loaded vehicle kilometres).’* By revealing the inter- and intra-sectoral variations in vehicle utilisation, transport KPI surveys give planners and policy-makers an indication of the extent to which average load factors might be raised.

1.3 Process of Data Collection

The CSDF and DfT publicised the transport KPI initiative among companies in the food sector and encouraged as many as possible to take part. A total of twenty-eight companies participated. Having committed themselves to the survey, companies were asked to assign appropriate staff to the collection and collation of transport data (Figure 1.1). They were invited to three briefing sessions run by the CSDF and LRC at which the data collection

process was outlined in detail. Definitions were clarified and advice given on the methods of collecting and recording the information. At these sessions, companies were issued with manuals and CDs containing the standard Exel workbook into which the data was to be entered. It was then the responsibility of companies to decide on the numbers, types and locations of vehicles to be surveyed. Some identified a sample of vehicles at a particular location, while others committed whole fleets based at one or more depots. Transport and logistics managers had also to work out how to manage the data collection process internally. This usually involved the delegation of tasks to supervisors, clerks and drivers and liaison with IT staff.

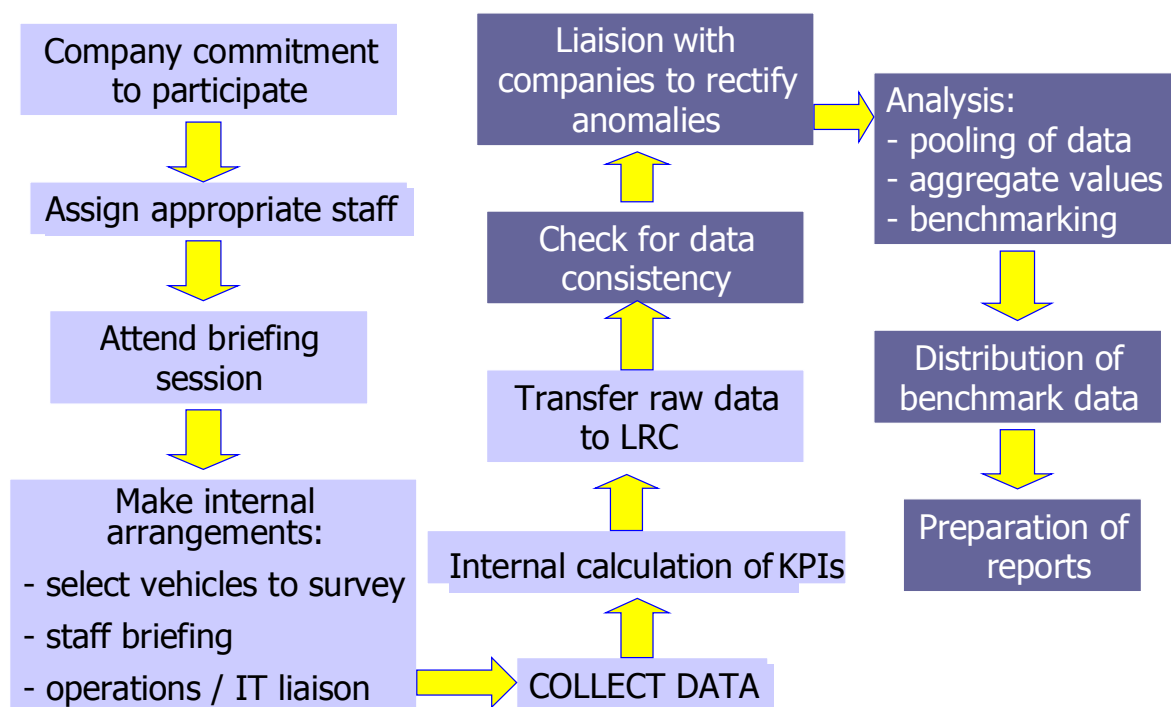


Figure 1.1: Process of Collecting Transport KPI Data

The survey took the form of a ‘synchronised audit’ with most of the companies monitoring their vehicle fleets over the same 48 hour period on Thursday 16th and Friday 17th May 2002. Discussions with logistics managers in the food industry suggested that the volume and pattern of delivery on these days would be fairly typical, giving a good indication of the average level of vehicle usage relative to both weekly and seasonal cycles. For various reasons, two large retailers were unable to survey their fleets on the appointed days. A separate survey was organised for them on Thursday 3rd and Friday 4th October 2002. Two other companies decided to join this later survey. As it was considered that the nature and scale of the distribution operations over these two days would have been broadly similar to

that on the original survey dates, the two sets of KPI data were combined for analytical and benchmarking purposes.

Participating companies were asked to enter their operating data into a standard Exel workbook comprising three spreadsheets for:

1. General data on the vehicle fleet
2. Data on all trips performed during the 48 hour period
3. Hourly audit of vehicle activity during this period.

The survey focused on the activities of rigid vehicles and the trailer units of articulated vehicles. No attempt was made to monitor separately the utilisation of articulated tractor units. Information was collected about trailers while they were hauling trailers.

1.4 Software Improvements

Since 1998, the data collection process had been upgraded in several ways. The software had been completely revised to:

1. Facilitate the downloading of data from companies' internal computer systems:

Many companies already collected information that, with a modest amount of manipulation, could be transferred from their existing computer files into the Exel workbook. This reduced the amount of manual data entry and allowed some companies to increase the sample of vehicles committed to the survey.

2. Undertake more rigorous consistency checks:

These checks were made at the time of data entry and prior to analysis. The initial check ensured that data fell within acceptable ranges. Once all the data was entered, higher-level checks detected anomalies and missing values. Where these would have significantly affected the analysis the company was contacted in an effort to correct / complete their data-set.

3. *Allow companies to calculate their own KPI values:*

Companies participating in the 1998 survey had to return all their raw data to the LRC for analysis. The Excel workbook used in the 2002 survey contained macros which enabled the companies to calculate their KPI values themselves. This gave them control over the analysis and will allow them to use the software at their discretion to measure changes in KPI values at regular intervals. The DfT and CSDF were keen to see companies ‘embed’ the software into their transport IT systems. It was still necessary for them to return the raw data to the LRC to permit the calculation of sectoral and sub-sectoral averages against which individual fleet performance could be benchmarked.

4. *Offer more flexible means of returning data to the LRC for benchmarking:*

Companies were given the option of returning data as an email attachment or on CD.

The raw data returned to the LRC was transferred into an Access data-base. A further set of data consistency checks was run during this transfer.

Once the benchmarking analysis was completed, all participating companies were sent summary sheets comparing the performance of their fleet(s) against sectoral and sub-sectoral mean values for the main KPIs. An additional ‘internal’ benchmarking service was provided to companies supplying data on several fleets. Annex 1 contains a specimen benchmark summary form.

1.5 Choice of Key Performance Indicators

The KPIs monitored in the 2002 survey were identical to those used in 1998, allowing companies taking part in both surveys to compare their performance in these two years. The KPIs fell into five categories:

1. ***Vehicle fill:*** measured by payload weight, pallet numbers and average pallet height.

Traditionally, official government freight surveys have measured load factors solely with respect to weight. In sectors, such as food, where products are of relatively low density, vehicle loading is constrained much more by the available deck-area or space than by weight. Weight-based measures of utilisation, therefore, give a misleading impression of vehicle fill. Measures that take account of the use of vehicle space are much more

appropriate in this sector. As the vast majority of loads of grocery products are unitised either on wooden pallets or in roll cages, 'space-efficiency' can be expressed as the ratio of the actual number of units carried to the maximum number that could have been carried. Where products were transported in non-unitised form, conversion factors have been used to translate the load data into a pallet-equivalent measure. This yields a two-dimensional measure of utilisation. The 1998 survey extended this measurement into the vertical dimension by asking companies to estimate the proportion of trips on which the average height of pallet loads fell into one of four intervals (<0.8 metres, 0.8-1.5 metres, 1.5-1.7 metres and over 1.5 metres). This permitted the calculation of cube utilisation. A similar procedure was employed in the 2002 survey.

Data were collected on the maximum carrying capacity of trailers and rigid vehicles (by weight, pallet numbers and height) and the actual loading expressed as a proportion of these maxima.

2. *Empty running*: the distance the vehicle travelled empty. This excluded the return movement of empty handling equipment where this prevented the collection of a backload. These movements were separately recorded.
3. *Vehicle time utilisation*: This was measured at hourly intervals over the 48 hour period for all the vehicles surveyed. The survey unit was either the trailer of an articulated vehicle or a rigid vehicle. A record was made of the dominant activity of the vehicle over the previous hour. Time was classified into seven activities depending on whether the vehicle was:
 - running on the road (including legal breaks)
 - on the road but stationary during the daily driver rest-period
 - being loaded or unloaded (including time spent on manoeuvring / paperwork)
 - preloaded and awaiting departure
 - delayed or otherwise inactive
 - undergoing maintenance or repair
 - empty and stationary

Although the utilisation of tractor units was not monitored every hour, estimates could be made of the time-utilisation of tractors on activities 1 and 2, while hitched to trailers.

4. *Deviations from schedule*: Companies were asked to log all delays which they considered ‘*sufficiently inconvenient...to be worth recording.*’ These delays were attributed to six possible causes:

- problem at collection point (responsibility of the consigning company)
- problem at delivery point (receiving company’s responsibility)
- own company actions
- traffic congestion
- equipment breakdown
- lack of a driver

This KPI was included because instability in transport schedules can have a bearing on vehicle utilisation as it makes it more difficult for companies to plan backhauls and more complex multiple collection / delivery rounds. It can also affect both the time utilisation of the vehicle and its fuel efficiency.

5. *Fuel consumption*: for both motive power and refrigeration equipment.

The fuel efficiency of the tractor units was expressed on a litres-per-km basis and averaged across the fleet on an annual basis. No attempt was made to estimate fuel consumption during the 48 hour survey period as this was considered impractical. These estimates would, after all, relate to tractor units, whereas the main survey unit was the trailer. The same tractor might haul several different trailers during the survey period. Annual average litres / km figures were obtained for each type of vehicle within each fleet. These were multiplied by the distances travelled during the survey period to obtain estimates of fuel consumption. In contrast, the fuel consumed by vehicle fridge units was recorded during the period of the survey.

1.6 Extent of the Survey

A total of 28 companies participated in the survey. They are listed in Annex 2. Some of these companies outsource all their transport. Although they were not directly involved in the data

collection exercise themselves, they asked their logistics contractor(s) to provide the data on their behalf. The companies operated (or contracted) 53 separate vehicle fleets, comprising 3088 trailers, 1446 tractor units and 546 rigid vehicles. All consignments were converted into industry standard pallet-loads to establish a common denominator for the analysis of vehicle utilisation. The equivalent of just under quarter of a million pallet-loads were distributed by the sample vehicles over the 48 hour period. During this time they travelled almost 1.5 million kilometres. Table 1.1 compares the extent of the surveys in 1998 and 2002.

Figure 1.2 shows the geographical distribution of the main depots at which the 53 fleets were based. This shows that the survey had national coverage with fleets well dispersed across the main areas of population and economic activity in the UK.



Figure 1.2: Main Bases of Fleets included in the 2002 KPI Survey

Table 1.1 Survey Statistics

	1998	2002
No. of fleets	36	53
Tractor Units	1,393	1,446
Trailers	1,952	3,088
Rigid vehicles	182	546
Journeys	4,024	6,068
Journey legs	11,873	24,443
Pallets delivered	206,202	220,657
Kilometres travelled	1,161,911	1,454,221

1.7 Characteristics of the Vehicles and Loads

The 2002 survey covered the same vehicle types as the 1998 survey. Since 1998, however, the maximum lorry weight in the UK has increased twice, from 38 tonnes to 40/41 tonnes in 1999 and to 44 tonnes in 2001. As consignments of food products tend to be space-constrained rather than weight-constrained, most of the companies in the food sector have derived little benefit from the maximum weight increase⁵. Partly for this reason, vehicles plated at the higher weight limits were not separately identified in the 2002 survey. The weight class for the heaviest category of trucks remained at '38 tonnes and above'.

As noted earlier, in the case of articulated vehicles, the survey was primarily concerned with the use of trailer capacity rather than tractor units. Information was nevertheless collected on the numbers of tractor units in the fleet and their Euro-emission standard. This revealed that the average articulation ratio (ratio of tractors to trailers) was 2.1, significantly higher than for the 1998 sample (1.4). The proportion of vehicles meeting the Euro II emission standard had risen sharply from 47% to 88% between 1998 and 2002 (Figure 1.3).

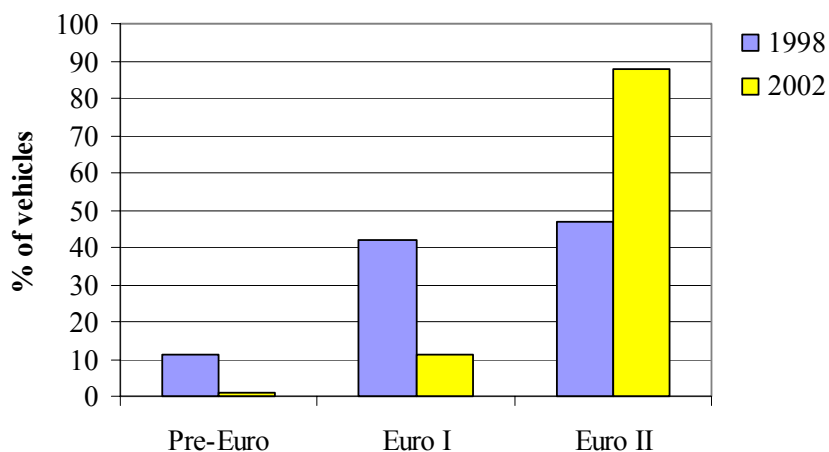


Figure 1.3: Euro-emission Standards of Surveyed Vehicles

The loads carried by the sample vehicles split fairly evenly between temperature-controlled food, ambient-temperature food and other products (Figure 1.4). This was a markedly different product mix from that carried by vehicles in the 1998 survey. In that survey, 60% of products required refrigeration, while non-food products represented only 8% of the total. This reinforces the point made in the introduction that the aggregated results of the two surveys are not directly comparable.

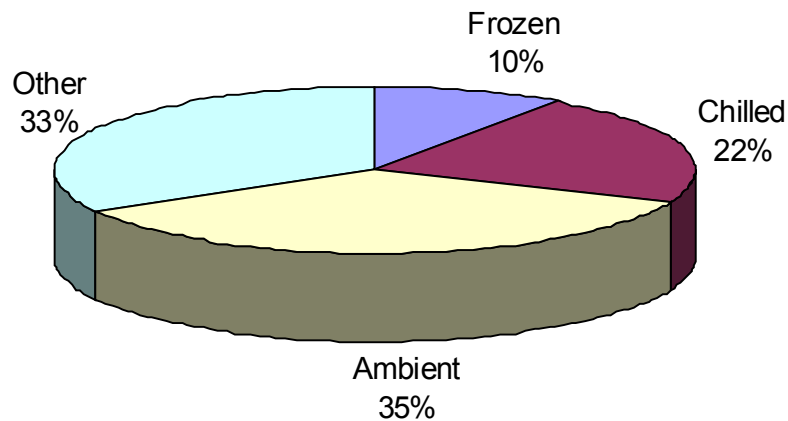


Figure 1.4: Composition of the Pallet-loads Distributed during the Survey Period

The survey covered the *primary* distribution of food from factories to regional distribution centres (RDCs), either directly or via primary consolidation centres (PCCs), *secondary* distribution trips from RDCs to shops and *tertiary* distribution from wholesale depots to independent retailers and catering outlets (Figure 1.5).

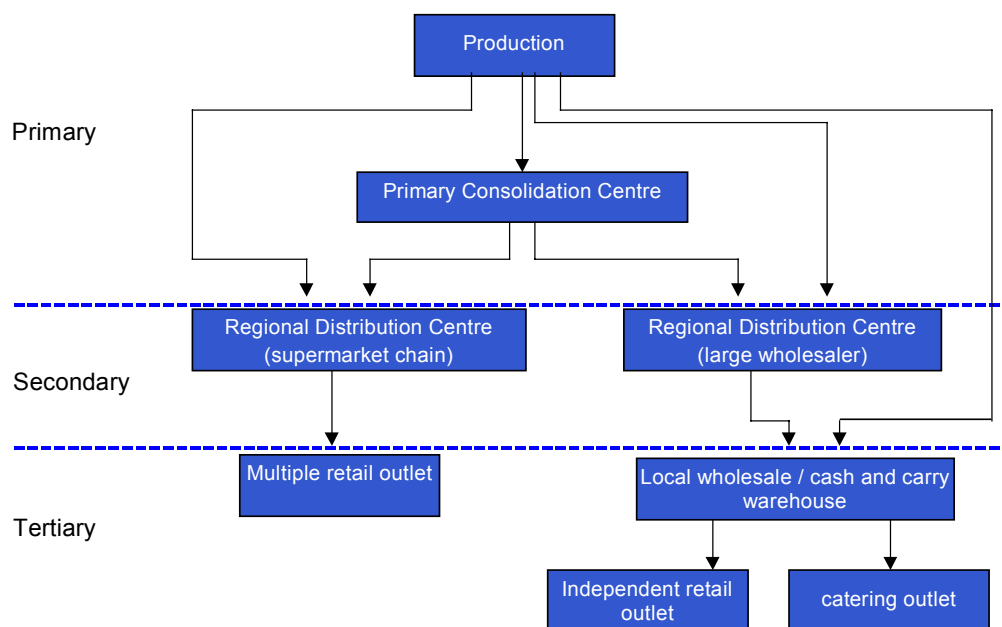


Figure 1.5: Distribution Channels in the Food Sector

1.8 Classification of the Fleets into Sub-sectors

The sample contained a diverse range of companies, including supermarket chains, food manufacturers, food service companies and third party logistics providers carrying groceries on a dedicated or shared-user basis for different types of business. Many of the distribution operations were not directly comparable. To improve the validity of the benchmarking it was necessary to split the sample into five categories. This sub-division primarily reflected the level in the supply chain and degree of temperature control:

- Primary distribution of temperature-controlled products (all articulated vehicles) (P1)
- Primary distribution of ambient temperature products (all articulated vehicles) (P2)
- Secondary distribution to supermarkets and superstores (mainly articulated vehicles) (S)
- Tertiary distribution to small shops and catering outlets (mainly rigid vehicles) (T)
- Mixed distribution to large and small outlets (involving both articulated and rigid vehicles) (M)

The final category contained mixed fleets engaged in primary trunking and local delivery operations. It was not possible to sub-divide fleets for benchmarking purposes. The average KPI values for these mixed fleets partly depends on the balance between trunking and local delivery activities. This category therefore lacks the internal homogeneity of the other sub-sectors. It should be noted, however, that even within these other sub-sectors, there can be significant differences in the nature and scale of the distribution operation.

Sub-sectors P1, P2 and S are broadly comparable to sub-sectors P1, P2 and S1 in the 1998 KPI survey. Table 1.2 shows the number of fleets in each of the 2002 sub-sectors.

<i>Table 1.2 Classification of Fleets</i>	
<i>Sub-sector</i>	<i>Number of fleets</i>
M	9
P1	6
P2	3
S	21
T	14

2. Survey Results

2.1 Utilisation of Vehicle Capacity on Loaded Trips

Vehicle fill was measured primarily in terms of pallet numbers. The actual number of pallets carried was expressed as a percentage of the maximum number that could have been carried. This pallet-load measure indicated the proportion of the vehicle deck area used. On loaded trips, an average of 69% of the available pallet positions were occupied. Figure 2.1 shows the variation in this KPI across the 50 fleets for which deck area utilisation data was provided. Values were spread fairly evenly across the range 49%-86%, with fourteen fleets attaining deck-area utilisation in excess of 75%. The highest floor utilisation was achieved in articulated vehicles engaged in the primary distribution of bulk loads or single-drop secondary distribution from RDCs to supermarkets. The lowest values were recorded by rigid vehicles on multiple drop rounds.

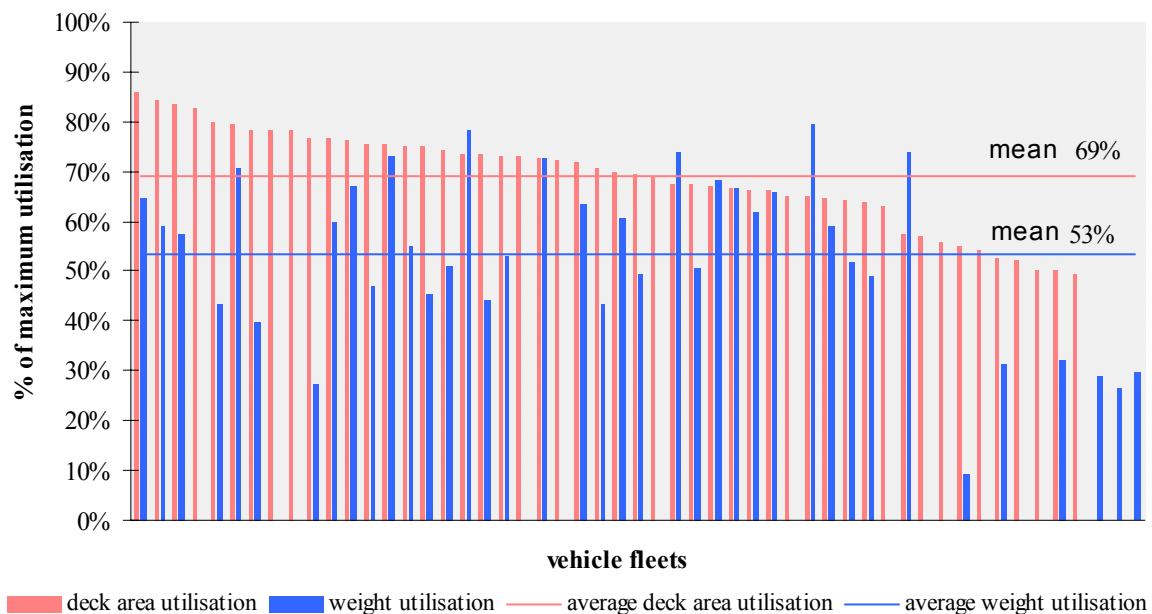


Figure 2.1: Average Deck-area and Weight Utilisation of Vehicles across the 53 Fleets

The survey also collected data on the average height of pallet loads (Figure 2.2). It revealed that on 67% of the loaded journey legs, goods were stacked to an average height of 1.5-1.7 metres, corresponding to the typical slot height in warehouse racking across the food supply chain. On 9% of the loaded trips, average heights fell below 0.8 metres. Across the full sample of loaded trips, approximately 76% of the ‘useable’ height was actually used. In this calculation, allowance was made for empty space required at the top of refrigerated vehicles for the circulation of cold air. Multiplying the mean height utilisation figure by the average deck-area coverage yields an estimate of 52% for average cube utilisation of vehicles on loaded trips.

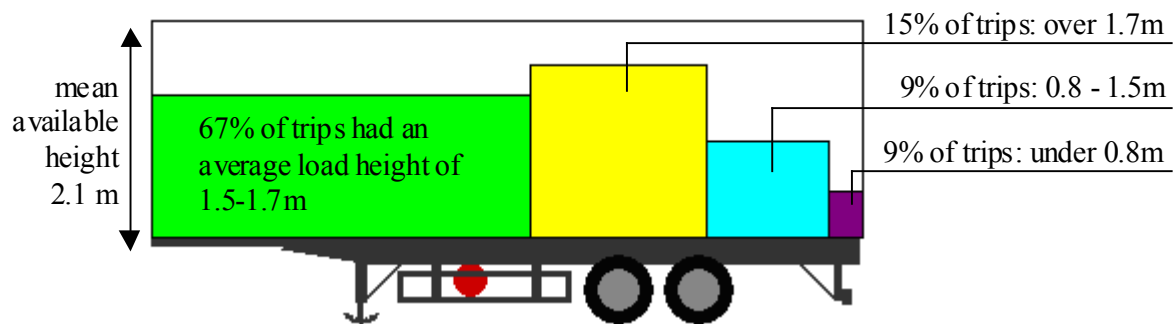


Figure 2.2: Distribution of Laden Trips by Average Pallet Height Range

The average weight-based load factor, at 53%, was very similar to this average cube-utilisation value, though much lower than the mean deck area coverage (69%). As most loads of grocery products have a relatively low density they are constrained much more by the available deck area than by the vehicle weight limit. Weight-based utilisation values exhibited much greater variability than deck area utilisation, partly reflecting wide variations in the density of food products. As in the 1998 survey, there was little correlation between the levels of volume and weight utilisation.

On 41% of loaded journey legs and 27% of the total distance travelled laden the vehicles were less than half full, when measured by deck area utilisation (Table 2.1). Although this level of utilisation may seem low, it should be remembered that many of the legs belonged to multiple drop rounds on which payload diminishes with every delivery and later legs are inevitably lightly loaded. At the other end of the spectrum, on 37% of the distance travelled, vehicles had over 90% of their available deck area filled.

Table 2.1 Incidence of High and Low Vehicle Utilisation				
	Under 50% of available capacity used		Over 90% of available capacity used	
	by deck area	by weight	By deck area	by weight
% journey legs	41%	51%	22%	14%
% distance travelled	27%	36%	37%	20%

Sub-division of the sample revealed that primary distribution operations attained the highest average deck-area utilisation (77%) (Table 2.2). Secondary distribution to supermarkets recorded an average value slightly above the mean. On the other hand, vehicles delivering to catering outlets and independent retailers at the tertiary level achieved relatively low levels of vehicle fill.

Table 2.2 Vehicle utilisation measured by the ratio of actual to maximum pallet numbers.

	Average	Standard deviation
All fleets	69.0	7.3
P1 Primary distribution (temperature-controlled)	76.8	6.3
P2 Primary distribution (ambient)	76.9	5.6
S Secondary distribution	72.5	6.0
T Tertiary distribution	58.6	7.6
M Mixed distribution	65.3	10.3

Even when the fleets are sub-divided into more homogeneous groups, there are still quite wide variations in utilisation levels, as revealed by the standard deviation values. (The relatively high standard deviation value for the 'mixed distribution' category is understandable given the diversity of fleets it contains.) Benchmarking at this disaggregated level should give companies with relatively low pallet utilisation values an incentive to raise load factors to those achieved by similar operations elsewhere, or at least to find a justification for this apparent under-performance.

Companies can do several things to improve the utilisation of vehicle space:

- Increase the degree of load consolidation: this is normally constrained by the demands of the replenishment cycle, particularly where this is managed on a quick-response basis ⁶.
- Change packaging and pallet-wrapping systems to increase stackability
- Modify the design and dimensions of handling equipment ⁷.
- Make greater use of double-deck vehicles that can accommodate two layers of pallets /roll cages ⁸ (only 24 of the 3088 trailers surveyed were double-decked)
- Reduce the carrying capacity of the vehicle to match more closely the typical size and weight of loads carried: This might be done by:

Tailoring vehicle capacity more closely to the dimensions and weight of the load:

Companies often acquire vehicles that are large / heavy enough to accommodate peak flows, which results in their under-utilisation during normal trading conditions. In larger, mixed fleets, however, companies can have greater flexibility to match loads and capacity, though entails more complex scheduling.

Reducing the vehicle height: The results of this survey, like the previous one, indicate that, given the present pattern of loading, many vehicles are taller than they need to be. This carries a fuel penalty as it increases vehicle tare weight and impairs the aerodynamic profiling of the vehicle. A study by one of the participating retailers indicated that by reducing trailer height by one foot it was possible to cut fuel consumption by around 10%.

Downplating: If, for example, a 40 tonne artic seldom carries loads heavier than, say, 16 tonnes, it might be sensible to downplate it to 32 tonnes, taking advantage of the lower rate of vehicle excise duty on lighter lorries. Reducing the legal carrying capacity of the vehicle in this way would raise the weight-based loading factor. This would merely effect a statistical change, however, and not alter the real efficiency of the transport operation. It should be noted too that many hauliers are reluctant to downplate as it might deny them the opportunity to carry the occasional heavy load at a healthy profit.

2.2 Empty Running

Of the 1.45 million kilometres travelled by the sample vehicles over the 48 hour period, 280,000 kms were run empty - approximately 19% of the total. This level of empty running was significantly below the average for the UK truck fleet as a whole in 2001 (26.4%), though only slightly lower than the government's estimate of empty running by vehicles involved in the distribution of foodstuffs (22.7%)⁹.

When averaged at a fleet level, the mean empty running figure was 21.5%. There were, nevertheless, wide variations around the mean value, within the range 1- 43% (Figure 2.3). Analysis of empty running at a disaggregated level revealed wide variations both between sub-sectors and within them, particularly in the case of tertiary and mixed distribution operations (Table 2.3)

Average figures for empty running are particularly sensitive to the mix of trip types in the sample. Where the sample contains a large proportion of multiple drop trips, the average figure for empty running tends to be lower because on these trips it is usually confined to the final leg in the journey and occurs over a small proportion of the total distance travelled. This partly explains the wide variation in the proportion of empty running across the 53 fleets surveyed.

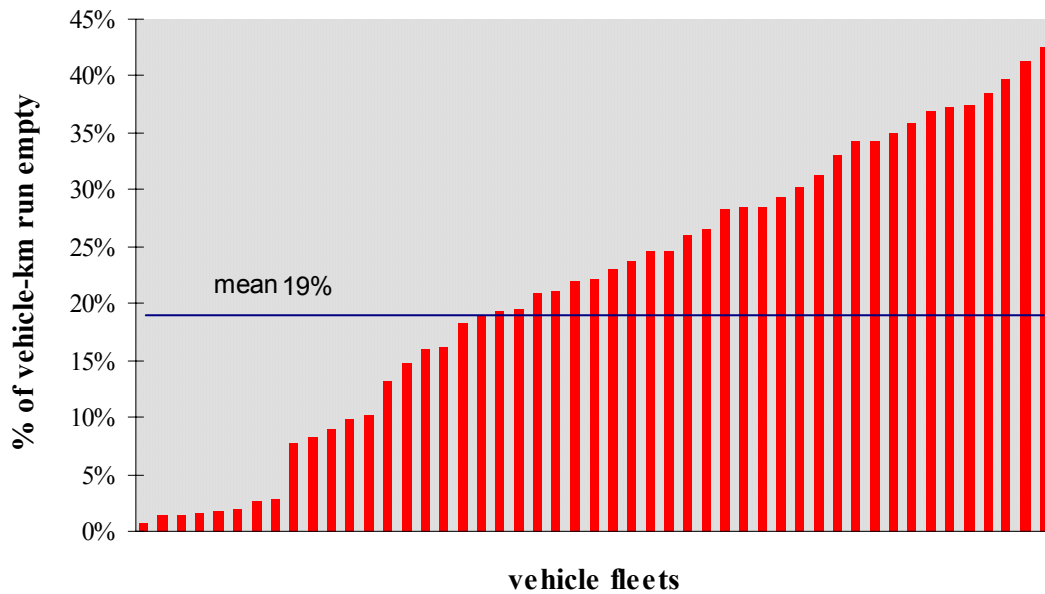


Figure 2.3: Proportion of Vehicle-kms Run Empty by Fleet

Table 2.3 Percentage of Vehicle-kms Run Empty.

	Average	Standard deviation
All fleets	21.5	12.0
P1 Primary distribution (temperature-controlled)	19.6	3.9
P2 Primary distribution (ambient)	25.4	9.3
S Secondary distribution	23.0	11.3
T Tertiary distribution	26.1	13.7
M Mixed distribution	11.8	14.4

Even fleets engaged on a similar pattern of delivery, however, can have markedly different levels of empty running. In some cases, this can be explained by differences in the types of handling equipment used and the manner in which it is returned. The return of roll cages from supermarkets, for instance, was classed as ‘running with returns’ rather than empty running, as it represented an essential stage in the distribution process and limited the opportunity to pick up a back load. A vehicle carrying only its usual complement of wooden pallets, on the other hand, was deemed to be empty as it could be backloaded with product. Some fleets achieving very low levels of empty running tend to handle heavy flows of ‘returns’.

Even once allowance is made for the operational differences outlined above, there remain significant variations in the level of empty running, suggesting that some companies could do more to find back loads. Companies carrying regular return loads of handling equipment could improve their backloading by consolidating this equipment on fewer trips, releasing more vehicle capacity for supplier collections.

2.3 Time Utilisation

On average, the vehicles spent only 28% of their time running on the road (Figure 2.4). They spent a similar amount of time empty and stationary. Of the 3128 vehicles included in the hourly audit, an average of 877 were idle during any given hour, representing a substantial under-utilisation of expensive vehicle assets. The average vehicle also spent around a fifth of the survey period waiting to be loaded, to depart from the collection point or to be unloaded at its destination. Three-quarters of this waiting time occurred at the collection point, where the vehicles were on average preloaded three and a half hours before their departure. In the case of temperature-controlled distribution, this practice significantly increases energy consumption as it is much less efficient to refrigerate products in a vehicle than in a cold store.

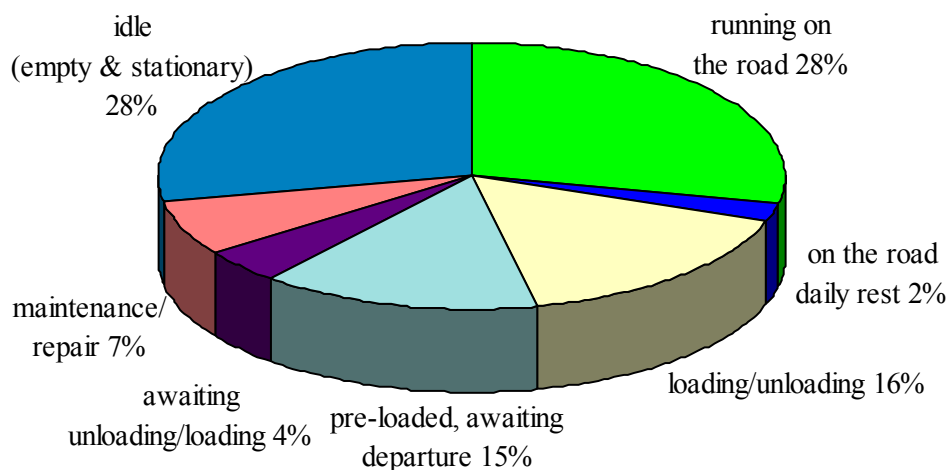


Figure 2.4: A Day in the Life of the Typical Trailer / Rigid Vehicle

2.3.1 Weekly pattern:

The level of distribution activity, measured by the number of pallet-loads delivered, varies with the day of the week (Figure 2.5). Distribution at the primary, secondary and tertiary levels also exhibits different weekly cycles. The volume of primary deliveries, from factory to distribution centre, was fairly constant between Tuesday and Saturday, then dropped to about a third of this level on Sunday and Monday. Secondary distribution volumes were also very low on Monday at around half the daily average and showed a slight peak on Friday and Saturday. At the tertiary level, delivery activity was fairly uniform, except for Mondays, when volumes were around a third of the daily average. Other things being equal, the greater weekday stability at the tertiary level should make it easier to operate vehicles at a higher level of utilisation. This analysis confirmed that the level of delivery activity at different levels in the supply chain was reasonably typical on Thursday and Friday, the two days chosen for the KPI audit.

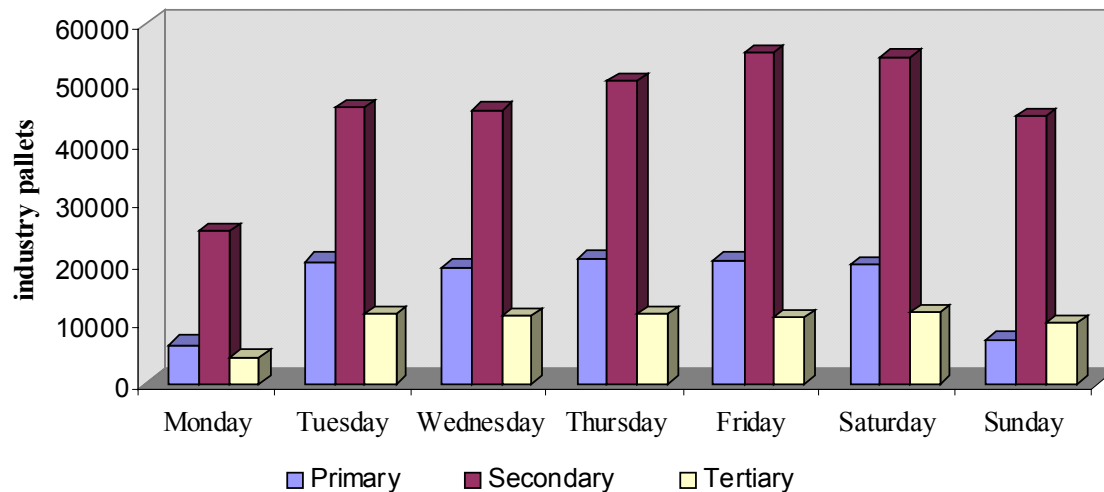


Figure 2.5: Numbers of Pallets Delivered during the Week of the Survey.

2.3.2 Daily breakdown:

Companies were asked to indicate the dominant activity of vehicles on each hour of the survey period. This data was used to construct a time utilisation profile for the full sample of vehicles over 48 hours (Figure 2.6). This shows that the pattern of vehicle usage was very similar over the 2 days of the survey. The proportion of vehicles running on the road rose steeply from 5am, reaching a peak of roughly 50% around 8am. This section of the profile was almost identical to that observed in 1998. Almost exactly 50% of the time the vehicles spent running on the road occurred during a nine hour period between 6am and 3pm. An average of 40% of the fleet was on the road at any given time during this period. In contrast, over the 12 hours between 5pm and 5am an average of only 23% of the fleet was running on the road.

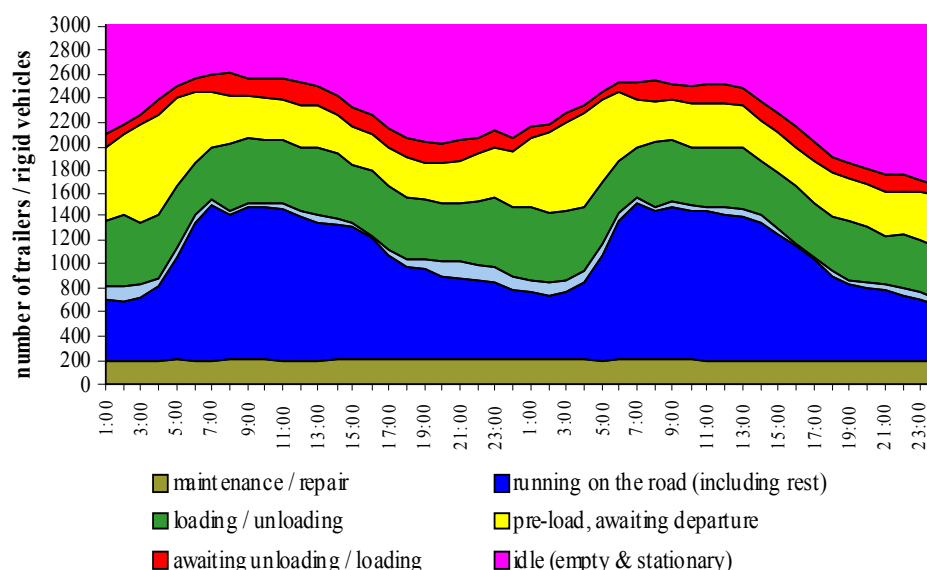


Figure 2.6 Variations in Vehicle Activity over the 48 hour Survey Period

The number of vehicles engaged on other activities remained fairly stable over the 48 hours, with the exception of 'preloaded awaiting departure'. Roughly twice as many vehicles fell into this category between 1am and 5am as at other times of day, as companies pre-loaded vehicles during the night in advance of the main wave of deliveries departing after 5am.

Using the trip audit data, it is possible to analyse fluctuations in the quantity of supplies in the delivery system over the 48 hour period at both the primary and secondary levels of the supply chain (Figure 2.7). The relative proportions of ambient, chilled and frozen product being delivered at each level reflects the composition of the sample and is not representative of the actual mix of food products in the supply chain. In primary distribution, for example, there was a preponderance of frozen food movements. The interest here is in variations in delivery volumes over the period of the survey. At the secondary level (between RDC and supermarket), there was very pronounced peaking between 6am and 8am, particularly for chilled product. There was then a reasonably steady flow of ambient product into retail outlets between 9am and 10pm. There was also a significant amount of secondary delivery to supermarkets in the early hours of the morning, much more than in 1998. Over the past four years, there has been a sharp increase in the number of supermarkets open 24 hours and able to receive deliveries during the night. This proportion could be even higher if delivery restrictions were relaxed on some of 40% of supermarkets located in areas subject to night curfews imposed through local authority environmental health and planning restrictions ¹⁰.

The peaking of primary flows (from factories to RDCs) was less pronounced, but again occurred between 6am and 9am. This coincidence of the delivery 'peaks' at secondary and primary levels during the morning 'rush hour' was also observed in the 1998 survey. It was argued in the report of this survey ¹ that *'while secondary distribution to retail outlets is largely constrained by shop opening hours, there may be less justification for concentrating primary deliveries in the morning peak period...By altering daily delivery cycles, particularly for the movement of supplies into RDCs, it would be possible to integrate primary and secondary operations more effectively to raise vehicle load factors'*. This is again one of the main messages to emerge from the 2002 transport KPI survey. The potential benefits of rescheduling primary deliveries to off-peak periods would be even greater today as the level of traffic congestion during the morning peak has markedly increased since 1998. According to Trafficmaster ¹¹, congestion on the motorway and trunk road network increased by 16% between 1998 and 2002.

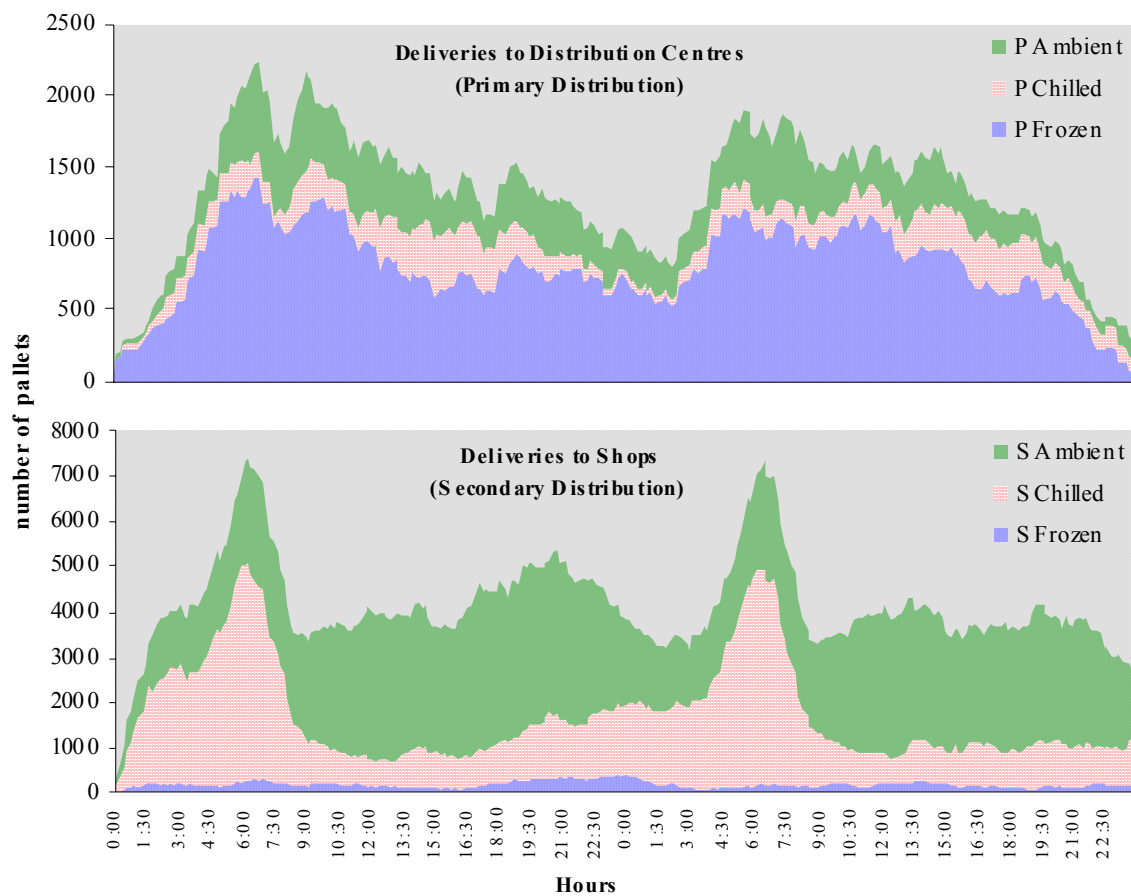


Figure 2.7: Food Products in the Delivery System over the 48-hour Survey Period

2.4 Deviations from Schedule

In the 1998 transport KPI survey, 25% of journey legs were subject to an 'unscheduled delay'. For the sample of 15,252 legs surveyed in 2002 for which sufficient scheduling data was provided, the corresponding figure was 29%. It would be wrong to conclude from these results that the frequency of delays has significantly increased over the past four years. Differences in the distribution of trip lengths and proportion of multiple drop / collection rounds prevent direct comparison of the 1998 and 2002 estimates.

Overall, 31% of delays were blamed mainly on traffic congestion (Figure 2.8). This figure was significantly higher than the corresponding estimate in 1998 (23%), though, as explained above, some of the change may be attributable to differences in average leg length and trip structure. This statistic may also under-estimate the true impact of congestion, in two respects. In the first place, many companies will already have allowed for congestion-related delays in their delivery schedules. Secondly, the causes of delay are inter-related. A vehicle held up on the road may miss its booking-in time at a warehouse and be forced to wait until the next available slot. A delay initially caused by traffic conditions can therefore become cumulative, particularly in the case of multiple collection and delivery rounds.

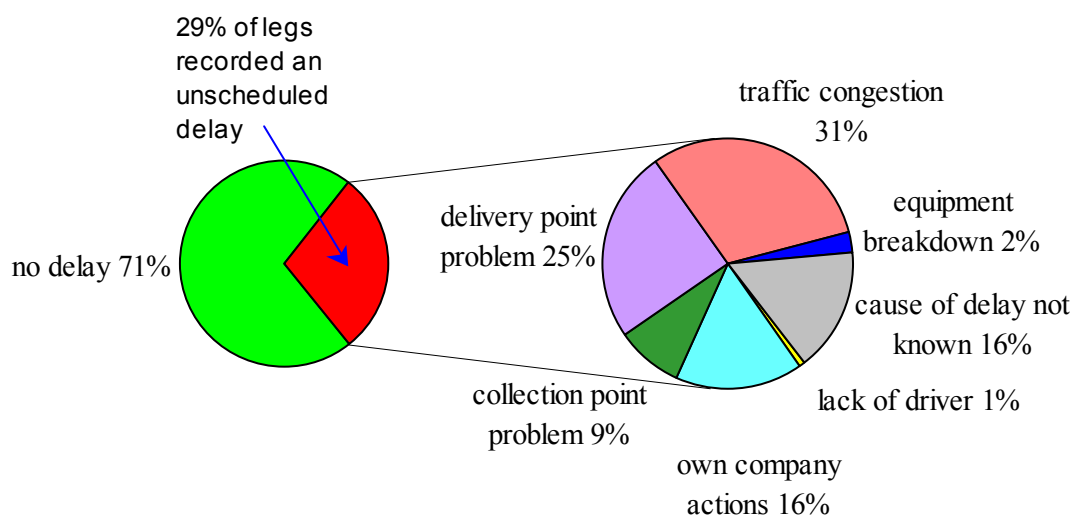


Figure 2.8: Frequency of Delays by Main Cause

On average delays lasted 43 minutes. Delays caused by equipment breakdowns and the lack of a driver were the most disruptive, in both cases lasting just over an hour (Figure 2.9). Delays experienced at collection and delivery points averaged around 40 minutes, while on those journey legs affected by traffic congestion the schedule deviation was typically around 25 minutes.

As in the 1998 survey, most of the deviations from schedule were internal to the logistical system rather than caused by external delays on the road network. In 16% of cases, the company running the vehicles took responsibility for the delay. 34% of the delays occurred at collection and delivery points and were blamed on suppliers or customers. It appears that congestion at the reception bays of distribution centres, factories and shops disrupts delivery schedules more than traffic congestion. These delays cause companies to build extra slack into their delivery systems and make it harder for them to arrange backloads. The average

vehicle spent 43 minutes per day on unscheduled delays at loading and unloading points. Given mean vehicle standing charges ¹², daily trip rates and annual activity levels, this wasted time would be worth approximately £1280 per vehicle per annum and this figure excludes any allowance for losses in operating efficiency due to unreliability.

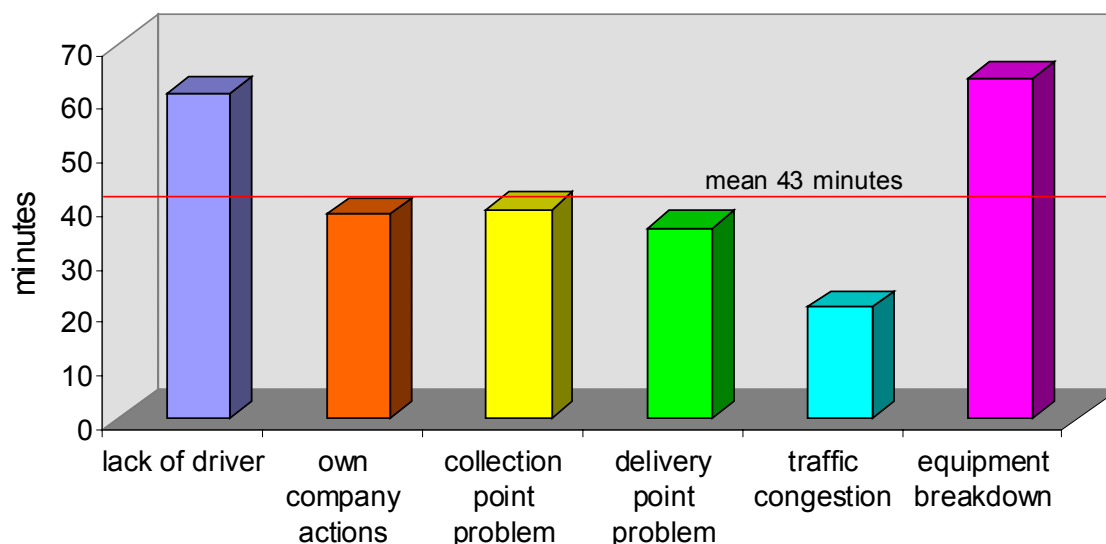


Figure 2.9: Average Duration of Delays by Cause.

For approximately 63% of the journey legs surveyed, information was provided on delivery times (actual and scheduled) and the type of premises at either end of the leg. This made it possible to examine the frequency and duration of delays at different types of collection and delivery point (Figures 2.10 and 2.11). Legs originating at one of the three main collection points, factories, RDCs and primary consolidation centres, had, respectively, a 42%, 36% and 30% probability of being delayed, with these delays averaging 35-45 minutes. The chances of a delivery to an RDC, supermarket or primary consolidation centre being delayed was around 30%. In the case of RDCs, the average delay was 38 minutes. Cash and carry warehouses had by far the highest incidence of delays at both the start and end of journey legs, while, at the other extreme, deliveries to and from catering outlets appeared very reliable.

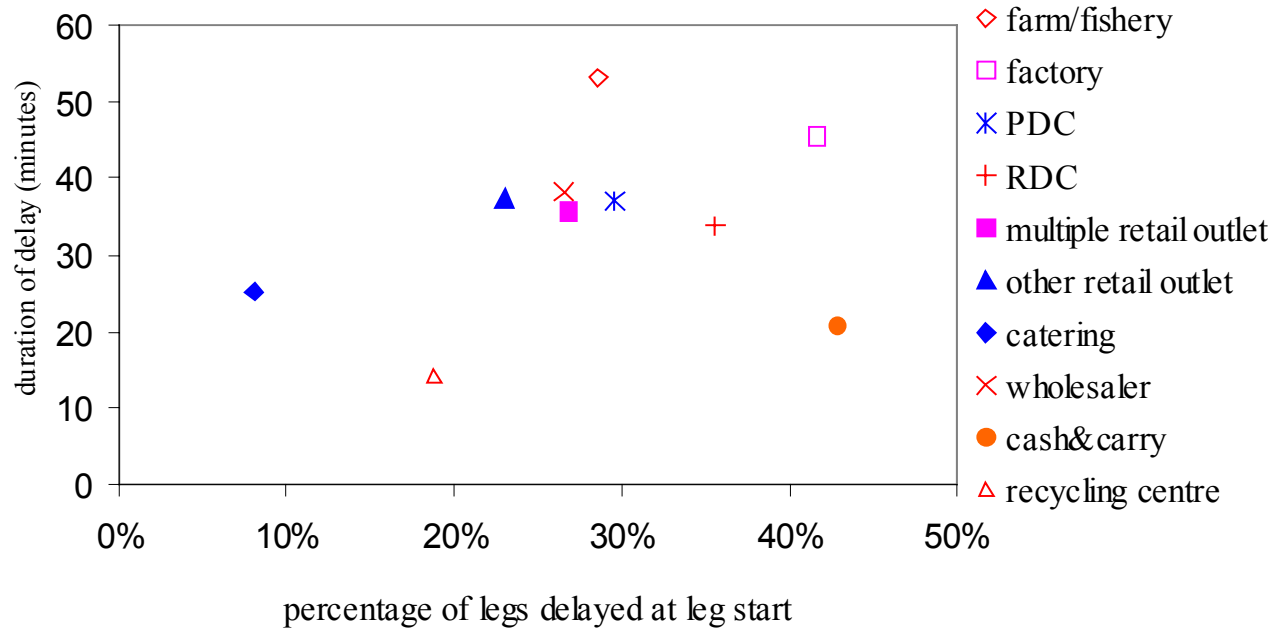


Figure 2.10: Average Frequency and Duration of Delays at Collection Point

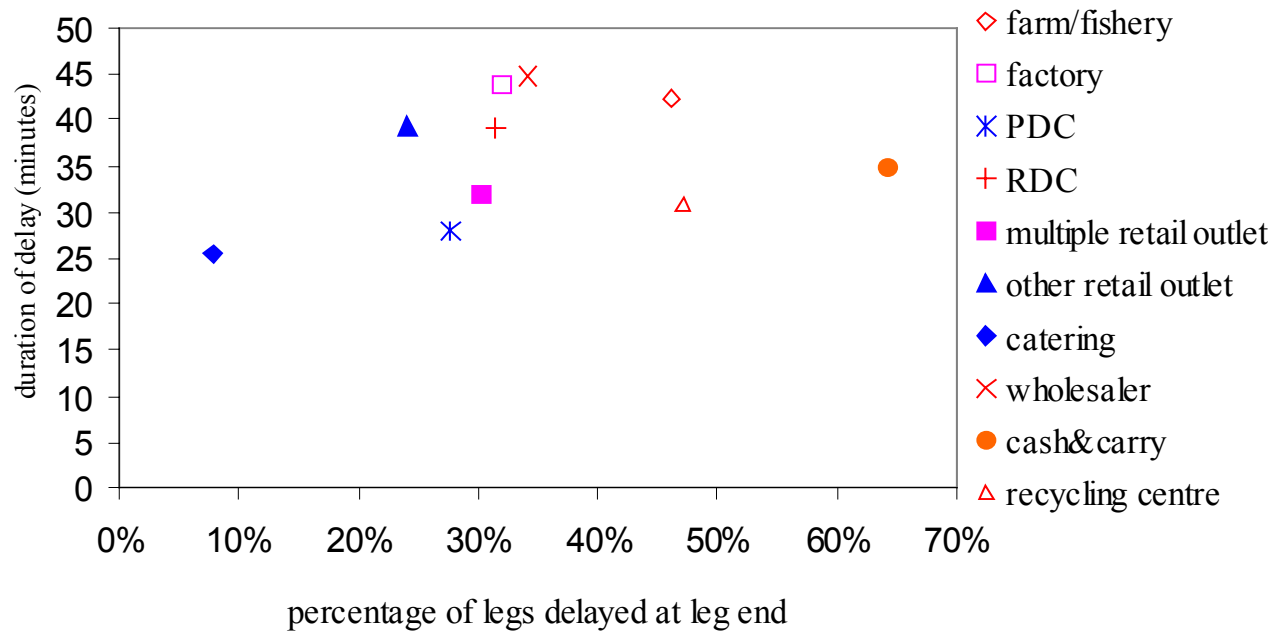


Figure 2.11: Average Frequency and Duration of Delays at Delivery Points

2.5 Fuel Efficiency and Energy Intensity

Fuel consumption data was obtained from company records for the previous year. This indicated average fuel efficiency (expressed in km-per-litre) for seven classes of vehicle. These figures were broadly in line with those compiled by the government's Continuing Survey of Road Goods Transport ⁹ (Table 2.4).

Table 2.4 Average Fuel Efficiency Estimates by Vehicle Class (kilometres per litre)			
Vehicle Class	KPI 1998 Survey	KPI 2002 Survey	CSRG (2001)
Small rigid (2 axles) < 7.5 tonnes	-	4.0	4.1
Medium rigid (2 axles) 7.5 - 18 tonnes	3.7	3.6	3.7 (7.5-14t) 3.3 (14 -17t)
Large rigid (> 2 axles) > 18 tonnes	3.7	3.1	2.9 (17-25t) -2.7 (>25t)
Drawbar combination	-	3.1	-
City semi-trailer (3 axle)	3.2	3.2	-
32 tonne articulated vehicle (4 axles)	3.1	3.2	3.2 (< 33t)
38-44 tonne articulated vehicle (>4 axles)	2.9	2.9	2.9 (> 33t)

As in the 1998 survey, it was found that average km-per-litre varied much more widely across the rigid vehicle fleet than for articulated vehicles (Figure 2.12). The greater variability of fuel efficiency values among rigid vehicles can be partly attributed to wider differences in the nature of the delivery work they undertake. Analysis of the benchmark data at sub-sectoral and individual company levels, however, indicates that this provides only a partial explanation and that some operators could do more to run their rigid fleets more fuel efficiently. 85% of fleets containing articulated vehicles with gross weights of 38 tonnes or more had an average fuel efficiency for this class of vehicle within the range 2.8-3.5 km-per-litre. The difference between the highest and lowest fuel efficiency value for this class of truck, however, was 1.5 km-per-litre. For a typical articulated vehicle of this type, running around 100,000 kms per annum, this difference in fuel efficiency would correspond to an extra 19,800 litres of diesel consumed annually, worth approximately £12,400 at current UK prices (excluding VAT).

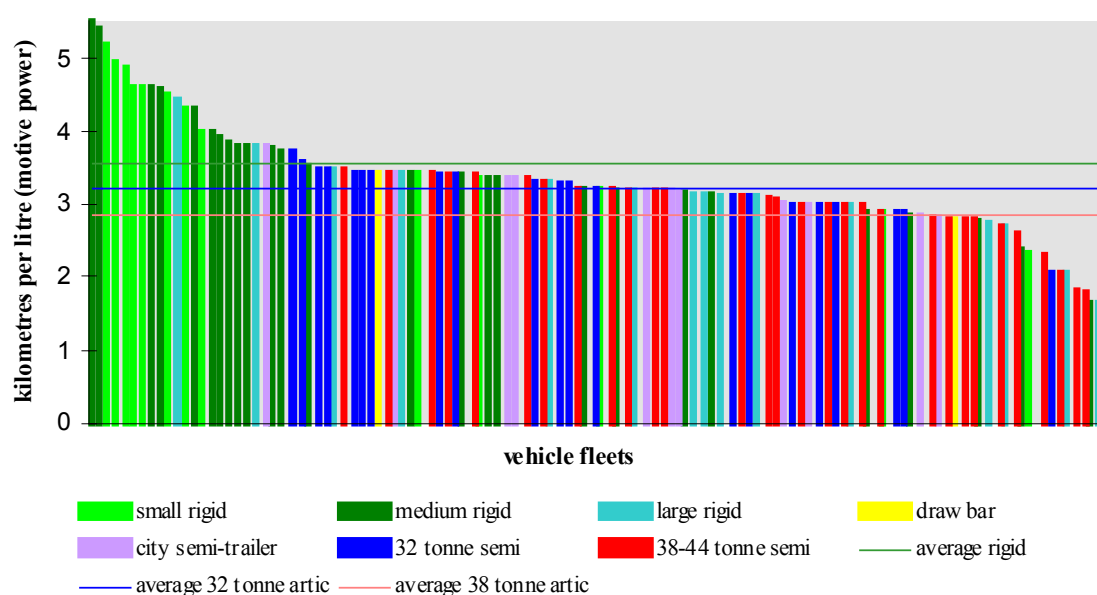


Figure 2.12: Average Fuel Efficiency for Different Vehicle Classes in the Sample Fleets

Companies that achieve high km-per-litre figures do not necessarily have the most energy efficient distribution operations. High fuel efficiency can be offset by poor utilisation of vehicle capacity. Energy efficiency (or 'energy intensity') is best measured therefore by a composite index which expresses fuel consumption on a pallet-km rather than vehicle-km basis. Across the 46 fleets for which this calculation could be done, energy intensity values varied by a factor of seven and a half, from 8 ml of fuel per loaded pallet-km to around 61 ml. (These energy intensity calculations excluded fuel consumed by refrigeration units.) Much of this variation can be attributed to differences in the size and type of vehicle used, the nature of the distribution operation and geography of the delivery area.

The colour coding of these different categories of fleet in Figure 2.13 confirms that variations in energy intensity are largely associated with differences in the nature of the distribution operation. The mean energy intensity varies from 12.2 ml per pallet-km for primary trunking of ambient product (P2) to 37.3 ml per pallet-km for local deliveries to small outlets (T). Even within these more homogeneous sub-sectors, energy-intensity values for individual fleets can still diverge by a significant margin. The greatest variability was found in tertiary distribution (Table 2.5).

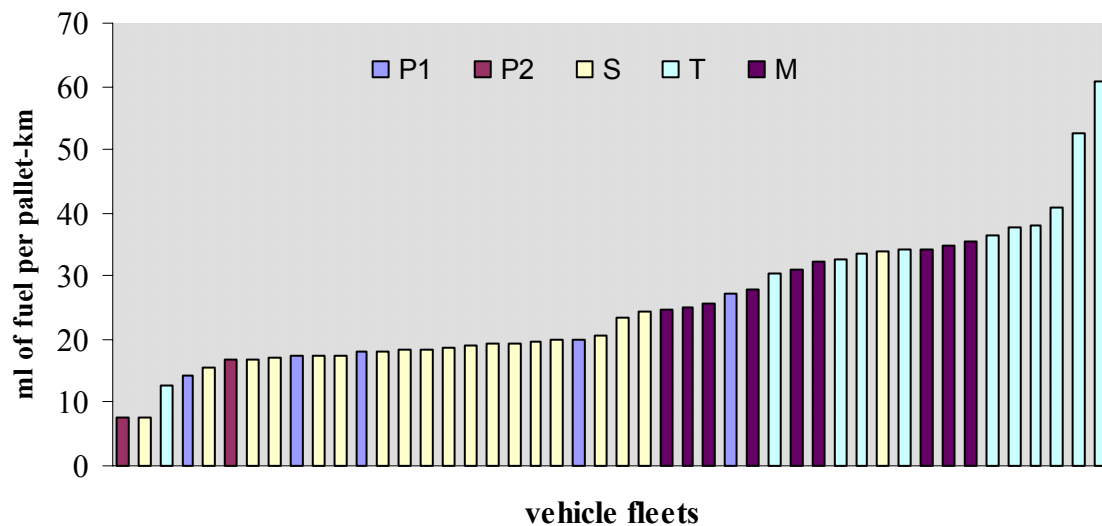


Figure 2.13: Fleet Energy Intensity Values Differentiated by Sub-sector
(see Section 1.7 for definition of sub-sectors)

Differences in average energy-intensity values within sub-sectors often occur for good reason. The classification of fleets is, after all, fairly crude and even within sub-sectors there is seldom an exact match of distribution operations. Particular circumstances can justifiably cause a company's energy-intensity value to deviate from the average of its benchmark group. By exposing these differences, however, the benchmarking exercise can encourage logistics managers to explain why their index is above the sub-sectoral average. It, therefore, prompts further analysis which may reveal sources of inefficiency in areas such as vehicle design and maintenance, driving behaviour, nature of the handling equipment, load building procedures, vehicle scheduling and backhauling.

Table 2.5 Average Energy Intensity of Different Types of Distribution Operation: (ml of fuel/pallet-km)		
	Average	Standard deviation
All fleets	25.4	7.4
P1 Primary distribution (temperature-controlled)	19.3	4.9
P2 Primary distribution (ambient)	12.2	6.5
S Secondary distribution	19.2	4.9
T Tertiary distribution	37.3	12.3
M Mixed distribution	30.1	4.4

As in the 1998 survey, it was found that there was only a weak correlation between average fuel consumption (measured in km-per-litre) and average energy intensity (measured in ml-per-pallet-km). This is illustrated by the fairly random scatter of points in Figure 2.14. The points represent fleets and have been differentiated by vehicle type. They show that companies operating the same type of vehicle at a similar levels of fuel efficiency can require widely varying amounts of energy to move a pallet-load one kilometre. This demonstrates that total energy consumption is also critically dependent on the utilisation of vehicle carrying capacity.

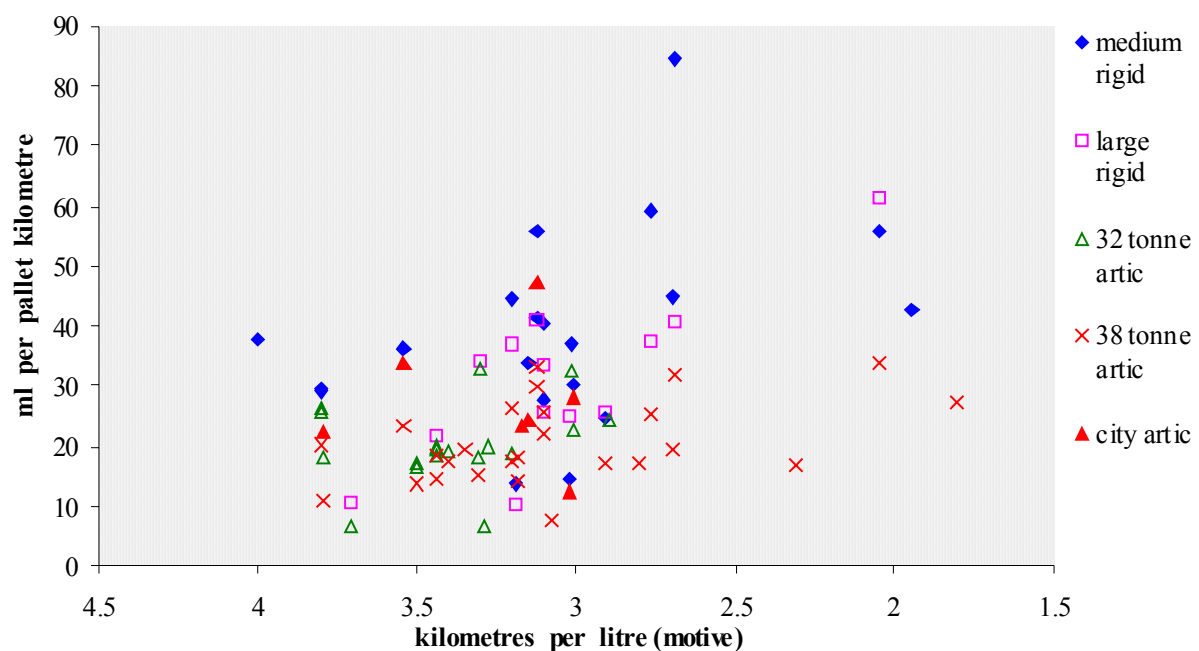


Figure 2.14: Relationship between Fuel Efficiency and Energy Intensity by Vehicle Type

The KPI data was used to estimate by how much energy consumption might be reduced if companies whose energy-intensity value was above the average for their sub-sector could bring it down to this mean (Table 2.6). This would cut the amount of fuel consumed by 5%, reducing annual fuel costs for the average vehicle by £1,115 and annual emissions of CO₂ by 3.9 tonnes per vehicle. If the target energy-intensity value was lowered even further to the mean of the one third of companies with the lowest ml per-pallet-km values, energy savings of 19% could be achieved. One must be careful in interpreting these figures, however, because, as explained above, some of the variation in energy-intensity values will reflect justifiable differences in the nature of the distribution operation and composition of the vehicle fleet within each sub-sector.

Table 2.6 Opportunity to Reduce Fuel Consumption, Emissions and Cost on an Annualised Basis

		If fleets with energy-intensity values above the subsectoral mean lower them to the mean	If fleets with energy-intensity values above the mean of 'top' third of fleets lower them to this mean
Fuel savings (motive)	litres	3,407,811	11,787,934
% Fuel savings	%	5	19
Reduction in CO ₂ emissions	tonnes	9,065	31,356
Total fuel cost savings	£	2,593,344	8,970,618
Fuel cost savings per vehicle	£	1,115	2,231

The possible impact of fleet composition can be seen by comparing the average payload weight, fuel efficiency and energy intensity values for the main classes of vehicle (Table 2.7). For example, heavy articulated vehicles (of 38 tonnes gross weight and above) use, on average, half as much energy to move a pallet-load of food one kilometre as a medium sized rigid vehicle (of 7.5-18 tonnes gross weight). While analysis of energy efficiency at a sub-sectoral level controls for much of the variation in fleet composition, some differences remain. Even if one focuses on the use of particular classes of lorry within particular subsectors, quite wide differences in energy intensity emerge, especially among rigid vehicles (Figure 2.15). In interpreting these benchmark results, participating companies must determine whether these variations exist for good reason or are evidence of inefficiency.

Table 2.7 Average Fuel Efficiency and Energy Intensity by Vehicle Type

units	Fuel efficiency (motive)		Average volume load	Average payload	Energy Intensity
	km/litre	mpg	Pallets	Tonnes	ml/pallet-km
Medium rigid	3.87	10.94	5.78	2.25	32.99
Large rigid	2.91	8.21	8.69	7.41	31.79
City artic	3.14	8.87	11.24	6.57	21.38
32 tonne artic	3.35	9.48	14.38	10.37	19.11
38 tonne artic	2.79	7.88	17.11	11.83	17.96

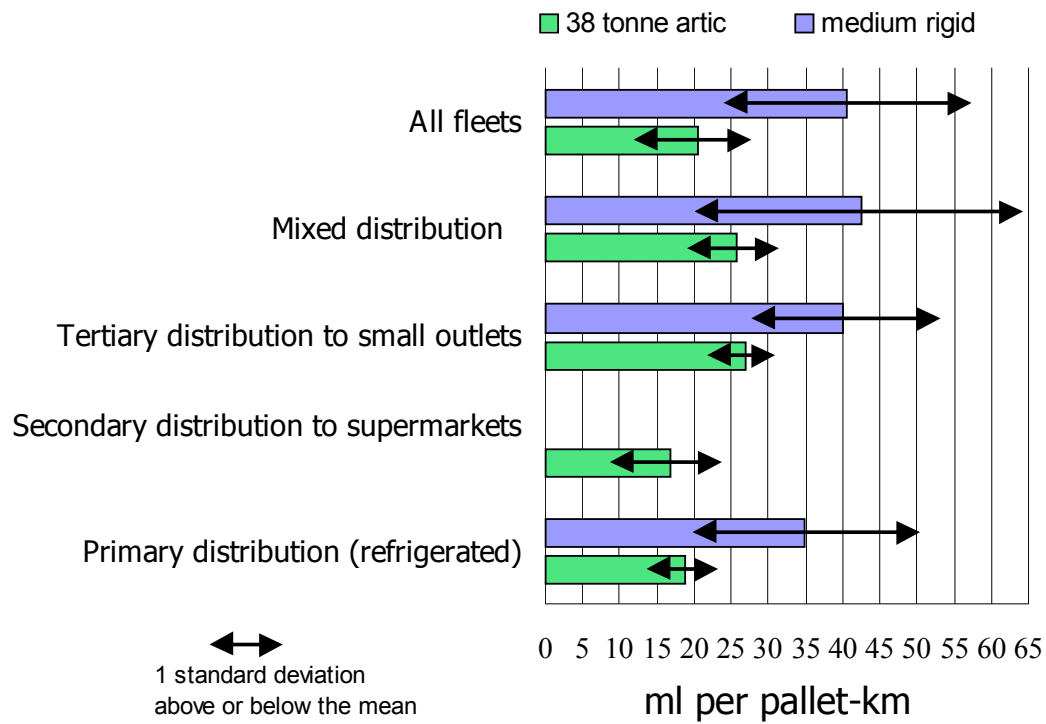


Figure: 2.15: Sub-sectoral Benchmarking of Energy Intensity for Two Classes of Vehicle

3. Summary and Recommendations

This second large-scale audit of vehicle utilisation in the food supply chain has revealed wide variations in vehicle utilisation, delivery reliability and energy efficiency. Some of this variation is due to differences in the nature of the product and pattern of delivery. More detailed analysis of the data at sub-sectoral and inter-company levels suggests, however, that some of the variation is the result of differences in operating performance. The purpose of the benchmarking exercise is to highlight these differences and give managers an incentive to raise operating performance to that of the most efficient fleets in their particular sub-sector. This will not only cut distribution costs; by reducing vehicle kilometres and energy consumption it will also yield wider environmental benefits.

One limitation of this exercise, like most benchmarking surveys, is that it sheds little light on the causes on the observed differences in KPI values. This would require in-depth analysis of the operations of the 53 fleets. In addition to being extremely labour-intensive, this would require a high level of co-operation from the participating companies. If the necessary resources and assistance were secured, future KPI surveys could examine the relationship between transport and other logistical variables. Apparent under-performance on some transport KPIs, for example, may be the result of a deliberate, and perfectly rational, trade-off against lower inventory levels and / or more efficient materials handling.

For example, a company may give greater priority to the utilisation of reception facilities and staff productivity at RDCs than to the backloading of delivery vehicles. Return legs might be so tightly scheduled that the opportunities for picking up a backload are severely constrained. The use of roll-cages in secondary distribution (rather than wooden pallets) is another example of companies sacrificing vehicle cube utilisation, in this case for quicker and more efficiency handling of goods at both the RDC and the shop. The use of roll-cages, however, also permits faster loading / unloading of vehicles and results in more intensive utilisation of the vehicle over the 24 hour cycle. This illustrates how the transport KPIs themselves can be inversely related, with better performance on some measures being achieved at the expense of poorer performance on others.

On the basis of the available data, however, it seems that there are several ways in which transport efficiency can be improved:

- While the average deck area utilisation of 69% is relatively high for the mix delivery operations surveyed, some companies fall well short of this figure and could do more to consolidate loads.
- The average level of empty running is low by comparison with other sectors, though again some companies perform poorly against this KPI and could probably put more effort into finding backloads.
- There could be greater consolidation of ‘returns’ in fewer trips to release vehicles to collect orders from suppliers.
- By spreading deliveries more evenly over the daily cycle and reducing the proportion of vehicle-kms run during the morning peak (particularly in primary distribution), companies could reduce transport costs, vehicle emissions and transit time variability.
- Greater adherence to schedules at collection and delivery points would improve the utilisation of vehicle assets and establish a more stable environment for route planning and back-loading.
- The widespread practice of pre-loading refrigerated vehicles well ahead of the departure time needs to be reassessed in the light of current concerns about fuel efficiency and emissions.
- Energy-intensity should be more widely adopted as a distribution KPI as it makes companies more aware of the combined effect of fuel efficiency and vehicle loading on energy consumption.
- The survey revealed wide variations in the energy-intensity of the fleets both within and between sub-sectors. Some of this variation is the result of differences in distribution operation and fleet composition. Disaggregated analysis of the KPI data for particular vehicle classes within particular sub-sectors, however, indicates that a levelling up to current best practice in food distribution could yield significant economic and environmental benefit.

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- 11 Trafficmaster (2002) '*Journey Time Index: Winter 2002*', Cranfield.
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ANNEX 1: Participating Companies

3663
ACC Distribution
Alldays Stores
Boughey Distribution
Christian Salvesen
Exel
Frigoscandia
Gist
GW Padley,
Holdsworth Food Service
Jacksons
Marks and Spencer
P&O European Transport
Palmer and Harvey
Pentons
Phil HanLey
Safeway
Sainsburys
Somerfield
TDG
Tesco
Vitacress
Waitrose
Weetabix
Whitbread Food Logistics
Wincanton
Yearsley Group

ANNEX 2: KPI Food 2002 Survey – Specimen Benchmark Report

Company: XX

Fleet identifier: XX

Benchmark Group: XX
(Number of fleets:)

1. Basic details

Number of legs:		7125
Number of trips:		1180
Total distance:	km	215292 km
Mean legs per trip:		6.0
Mean kms per leg:	km	30.2 km
Mean kms per trip:	km	182.5 km

2. Utilisation

Empty running

- number of legs:	621 [9%]
- total km:	46044 [21%]

Volume utilisation*: 59%

Weight utilisation*: 39%

* **Note:** For laden legs, utilisation = [carried capacity] / [maximum capacity], weighted by distance

i.e. for volume = SUM(pallets x km) / SUM(max pallets x km)

and for weight = SUM(tonne x km) / SUM(max tonne x km)

Low Utilisation running - number of legs where:

volume carried < 50% max	3306 [46%]
weight carried < 50% max	2289 [32%]

Low Utilisation running - number of km where:

volume carried < 50% max	61749 [29%]
weight carried < 50% max	44736 [21%]

High utilisation running - number of legs where:

volume carried > 90% max	291 [4%]
weight carried > 90% max	120 [2%]

High utilisation running - number of km where:

volume carried > 90% max Text52	25517 [12%]
weight carried > 90% max	2625 [1%]

3. Energy Intensity

(1) ml fuel used per industry standard tonne-km delivered

(2) ml fuel used per industry standard pallet-km delivered ¹

(1)		(2)	
Fleet:	Benchmark Group:	Fleet:	Benchmark Group:
small rigid:	267.5	small rigid:	97.0
medium rigid:	82.4	medium rigid:	34.5
large rigid:	69.8	large rigid:	42.5
city semi-trailer:		city semi-trailer:	14.9
32 tonne semi:	70.1	32 tonne semi:	32.7
38 - 44 semi:	26.0	38 - 44 semi:	25.7
All vehicle types:	71.9	All vehicle types:	30.6

Note: 1. To allow comparison among fleets/groups using different handling units, energy intensity figures are expressed in terms of industry standard pallets. For fleets which use other handling units, the figures have been adjusted in proportion to floor area.

4. Delays

Fleet:		Benchmark Group:		
All delays	No. of delayed legs:	No. of delayed legs:	281	
	% of legs delayed:	% of legs delayed:	4%	
	Average delay: min	Average delay:	31 min	
	Number of legs affected ²	% of all delays ³	Average delay	
Delays caused by: (minutes)				
lack of driver		5	2%	19
own company actions		81	27%	31
collection problem		3	1%	25
delivery problem		:	80	27% 23
traffic congestion		125	42%	21
vehicle breakdown		6	2%	97

Notes: 2. The sum of the column 'Number of legs affected' is greater than the 'No. of delayed legs' above because some legs are subject to more than one type of delay.

3. The column '% of all delays' records the number of occurrences of this type of delay as a percentage of all occurrences of delay, NOT as a percentage of all legs.

Acknowledgement

We are grateful to the Department for Transport for funding this study through its TransportEnergy Best Practice Programme and to John Hutchings, Chief Executive of the Cold Storage and Distribution Federation for championing the cause of transport KPIs in the food industry. David Smith and Chris Sturman provided invaluable support in liaising with companies and encouraging them to take part. Thanks also to Andrew Davies and Christopher Douglas of AEA Technology for assisting with the management of the project. Finally, we are particularly indebted to all the staff in participating companies for the time and effort that they put into collecting the data.

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(The Benchmarking Guide (BG 78) which summarises the results of the survey can be ordered free of charge from the TransportEnergy Helpline.)