Synchronised Auditing of Truck Utilisation and Energy Efficiency:

A Review of the British Government's Transport KPI Programme.

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Summary

In 1997 the British government established a programme for benchmarking vehicle utilisation and energy efficiency across large samples of truck fleets. Since 1997, eight surveys have been undertaken in the food, automotive, non-food retail, pallet-load (LTL), air cargo and pallet-load sectors. This paper outlines the innovative methodology adopted for these surveys and discusses some of the key results to emerge from the work. It has shown that similar distribution operations can have markedly different energy intensity.

The paper provides a critique of the programme, outlines its various deficiencies and the lessons that have been learned.

Key words: Road freight, operational efficiency, benchmarking, energy intensity

1. Introduction

Of the numerous measures that can be used to promote environmentally sustainable distribution, those which yield economic as well as environmental benefits generally command the greatest support and are the easiest to implement. One such measure is the benchmarking of vehicle utilisation and energy efficiency. This invariably reveals that some truck fleets are operated more efficiently than others and usually gives the managers of under-performing fleets an incentive to raise their efficiency. Since 1997, the British government has sponsored a road freight benchmarking programme which it now regards as a key element in its sustainable distribution strategy. As it is a standard set of Key Performance Indicators that is benchmarked, the initiative has become known as the 'transport KPI programme'.

This paper reviews the first ten years of this programme. It explains how it originated and has evolved over the past decade. It outlines the objectives of the programme and considers to what extent they have been achieved. Finally, it examines the problems and constraints that have been experienced and outlines efforts to overcome them.

2. Origins of the Transport KPI Programme

This initiative was essentially industry-led. In the mid-1990s companies belonging to a major trade association, the Cold Storage and Distribution Federation (CSDF), expressed concern about the adverse effect of just-in-time replenishment on the utilisation of truck capacity, particularly in refrigerated vehicles. More frequent delivery of smaller consignments within shorter lead times was depressing vehicle load factors and increasing transport costs per unit. For example, a survey of frozen food manufacturers revealed that between 1995 and 1998 average frequency of delivery increased by 28% while average drop size diminished by 16% (from 12 to 10 pallet-loads) (McKinnon and Campbell, 1998). Several members of the CSDF argued that to maintain transport efficiency in a trading environment characterised by low inventory and quick response much greater collaboration would be required across the supply chain. This collaboration was being inhibited, however, by, among other things, a lack of consistent data about levels of transport efficiency across the supply chain (Department of the Environment, Transport and the Regions, 1998). A mixed group of large supermarket chains, food manufacturers and logistics service providers recognised the need for an industry-wide survey and expressed a willingness to provide the necessary data.

Meanwhile the British government had been operating for several years an 'Energy Efficiency Best Practice Programme' designed to promote greater fuel efficiency in car and truck fleets. It agreed, as part of this programme, to provide financial support for a benchmarking survey of companies involved in temperature-controlled transport. This funding was used to commission the Logistics Research Centre of Heriot-Watt University, as an independent agency and 'honest broker', to devise a suitable methodology and conduct the survey. It was agreed by the business, government and academic partners that this should be a 'bottom-up' exercise developed in consultation with the industry. At an early stage, a two-day workshop was held for operations and logistics directors of several major corporations to discuss the choice of KPIs, possible methods of data collection and procedures for analysing and disseminating the results.

Following the success of the 1997 and 1998 surveys, the government decided to diversify the transport KPI programme into other sectors. Table 1 gives details of the surveys that have been carried out to date[1]. Across the seven surveys listed, a total of 162 fleets have had their efficiency monitored, comprising almost 8500 trailers and just over 1400 rigid vehicles and vans. Altogether 17,400 trips have been surveyed with a combined distance of 4.2 million kilometres.

Sector	Date	Fleets	Tractors	Trailers	Rigids	Vans	Trips	Kms Travelled	Units Delivered
Refrigerated food	1997	11	795	1265	0		2981	519963	72801
Food	1998	36	1393	1952	182		4024	1161911	206202
Automotive	2001	7	143	343	50		679	179428	
Food	2002	53	1446	3088	546		6068	1454221	220657
Non-food retailing	2002	26	705	1734	145		2496	744087	136664
Pallet-load networks	2004	17	34	63	105		295	65880	11609
Next day parcel delivery	2005	12	42	42	107	282	863	111464	
		162	4558	8487	1135	282	17406	4236954	4268984

Table 1: Transport KPI surveys 1997 – 2005: summary statistics.

3. Objectives of the Programme

According to both industry and government partners, the prime objective of the transport KPI initiative was to benchmark the efficiency of road freight operations on a consistent basis against a standard set of KPIs. The surveys also had several other objectives:

- To promote the adoption of standard methods of performance measurement in road freight transport.
- To provide the government with information on a range of transport variables excluded from its main road freight survey (the Continuing Survey of Road Goods Transport (CSRGT)), including volumetric and time-based measures of vehicle utilisation, delivery schedules and delays.
- To calculate the potential for improving transport and energy efficiency across industry sectors.

Although not originally specified as an objective, it was recognised that the large trip data-bases generated by these KPI surveys could be used for retrospective analysis of the opportunities for backloading and more efficient vehicle routing.

4. Choice of Key Performance Indicators

After much deliberation, five sets of KPIs were identified, reflecting the strong interest in vehicle loading and fuel efficiency:

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, non-food retailing and automotive, where

[1] It excludes data for the survey of road legs of air cargo movements which was not published.

many products are of relatively low density, vehicle loading is constrained much more by the available deck-area and / or space than by weight. Weight-based measures of utilisation, therefore, give a misleading impression of vehicle fill. Metrics that take account of the use of vehicle space are much more appropriate in these sectors. As the vast majority of loads in those sectors covered by KPI surveys are unitised on wooden pallets, roll cages, dollies or stillages, '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 are 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 the utilization of vehicle floorspace. 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 most of the subsequent surveys.

Data have been 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 excludes the return movement of empty handling equipment where this prevents the collection of a backload. These movements are separately recorded as a form of loaded trip.

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

   Following advice from senior logistics managers in the food industry, it was decided not to collect data on the fuel consumed by tractor units during the period of the survey. Instead annual average fuel efficiency values were obtained for particular types of vehicle within each fleet. In contrast, the fuel consumed by vehicle fridge units was recorded during the period of the survey. The KPI surveys conducted in other sectors have successfully monitored the amounts of fuel used during the survey period, providing a closer link with operational conditions during this period.

4. *Vehicle time utilisation*: This has been measured at hourly intervals over the 48 hour period for all the vehicles surveyed. In the food sector, the survey units have been either the trailer of an articulated vehicle or a rigid vehicle. In other sectors, the activities of tractors have also been separately monitored. A record is made of the dominant activity of the vehicle over the previous hour. Time is classified into seven activities depending on whether the vehicle is: 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 or empty and stationary.

5. *Deviations from schedule*: Companies have been asked to log all significant delays and attribute them 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 or lack of a driver

This KPI was included because instability in transport schedules can have a bearing on vehicle utilisation and energy efficiency as it makes it harder for companies to exploit backloading opportunities and organize complex collection and delivery rounds.

The vehicle audit employed all three types of logistical KPIs classified by Caplice and Sheffi (1994):

Type of KPI	***definition***	***road transport KPI***
Utilization	Ratio of actual capacity used to maximum capacity available	vehicle fill empty running time utilisation
Productivity	Ratio of inputs to outputs	fuel efficiency
Effectiveness	Performance judged relative to a norm	deviations from schedule

This ensured that the assessment was broadly-based and concerned with both inputs to and outputs from the road freight system.

5. Data Collection, Analysis and Benchmarking

All the KPI surveys conducted to date have taken the form of 'synchronised audits' with participating companies monitoring their vehicle fleets over the same 48 hour periods. Synchronicity has been justified on the grounds that all fleets are exposed to the same trading and traffic conditions during the period of the survey. It has also had two other advantages. First, it makes the survey more of an 'event' in a company's calendar, concentrating the minds of transport managers and encouraging greater collective action across an industry sector. Second, it makes the provision of support services, particularly the telephone and online helpline services, more efficient. In each of the sectoral KPI surveys discussions have been held with company managers to determine which days of the week and weeks of the year will give a representative view of operational efficiency.

Recruiting companies for the KPI surveys has proved a labour-intensive exercise. Although participation is free, it requires a significant commitment of staff time to attend workshops and to collect and collate the data. Debriefing of companies taking part in the first large-scale KPI audit in 1998 revealed that participation in the survey required an average of 7.9 days of staff time (McKinnon, 1999). Companies must be persuaded that this investment of time can yield an adequate return. Trade bodies and, on occasion, senior government officials have helped to reinforce this marketing message.

Figure 1 outlines the typical organization of a transport KPI survey from the point at which a company commits to taking part. Companies signing-up for a survey have to decide on the numbers, types and locations of vehicles to be included. Some have identified a sample of vehicles at a particular location, while others have committed whole fleets based at one or more depots. Some companies have used the KPI surveys to benchmark the operational efficiency of several of their own fleets based at different locations, performing 'in-house benchmarking'.

Transport and logistics managers have to work out how to manage the data collection process internally. General advice is provided in workshops, documentation and by phone, on how this can be done, though the data collection and collation must be customized to the particular operating procedures and IT systems of individual companies. It usually involves the delegation of tasks to supervisors, clerks and drivers and liaison with IT staff.

Participating companies are given an Excel workbook comprising three spreadsheets for:

1. General data on the vehicle fleet, nature of the delivery operations and the typical weights and dimensions of unitised loads
2. Data on all trips performed during the 48 hour period, in most cases disaggregated by journey leg.
3. Hourly audit of vehicle activity during this period.

Companies can either enter data manually into these spreadsheets or download relevant statistics from company data bases. An increasing proportion of companies have developed the capability to transfer data from existing IT systems, facilitating data entry.

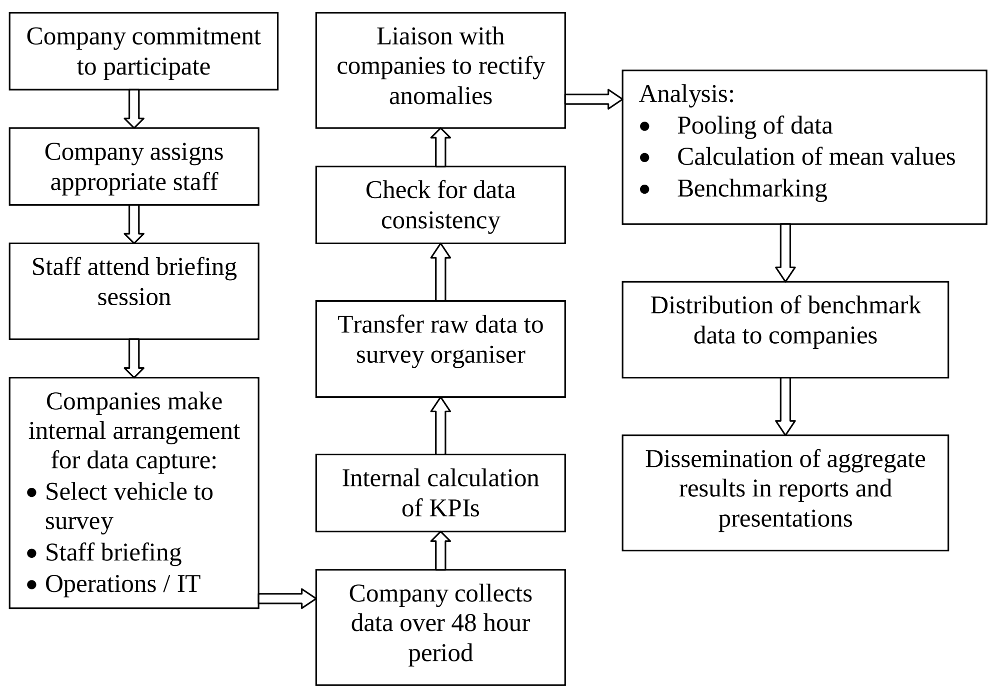

Figure 1: Organisation of a transport KPI survey.

The data are subject to several levels of consistency check. An initial check, at the time of data entry, ensures that numerical values fall within acceptable ranges. Once all the data has been entered, higher-level checks automatically detect anomalies and missing values. Where these would significantly affect the analysis companies are normally contacted in an effort to correct / complete their data-sets.

In the first two surveys companies had to return all raw data to the organizers for calculation of their individual KPI values and the benchmarking service. Since 2002, however, the Exel workbook has contained macros that enable companies to calculate their KPI values themselves *in situ.* To participate in the benchmarking exercise, however, they still have to return their raw data for further consistency checking and pooling with other companies' data sets. Once the benchmarking analysis is completed, participating companies are sent summary sheets comparing the performance of their fleet(s) against sectoral and sub-sectoral mean values for the main KPIs.

In the food sector, fleets have been classified into sub-sectors by their dominant role in the supply chain, operating at either primary, secondary or tertiary levels in the chain (Figure 2). This reflects the 'echelon' structure of the food supply chain. In contrast the pallet-load and express parcels sectors have hub-and-spoke networks, making it more appropriate in these sectors to distinguish trunking from local collection / delivery operations (Figure 3).

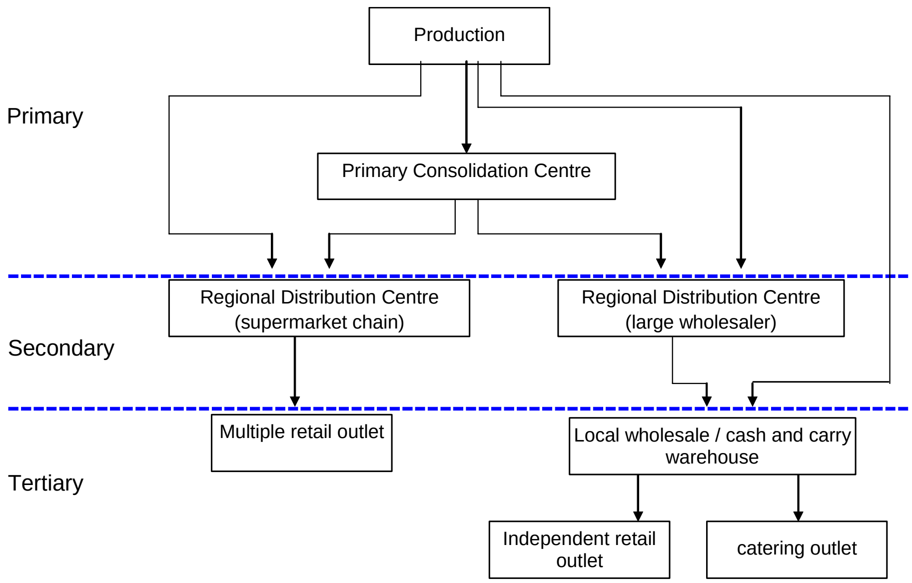

Figure 2: Echelon structure of food supply chain: classification of fleets by level

6. Refinements to the Transport KPI Methodology

Many of the core features of the KPI surveys have remained fixed over the past decade. All but one survey has audited fleets on a synchronous basis over 48 hours and have used the standard set of five KPIs. The three-spreadsheet format and definitions of terms such journey leg and empty running have also remained standard. Some aspects of the programme have changed, however, partly to upgrade the process but also to respond to the specific requests of industry groups within the different sectors. General improvements to the survey have included:

- Better interfacing of the software with companies' own IT systems
- Giving companies the ability to calculate their own KPIs themselves
- Auditing the activities of tractors as well as trailers
- Surveying fuel use during the survey and relying less on annual average fuel data
- Collecting information about the use of fuel saving devices including aerodynamic profiling of trucks, engine management systems and telematics.
- Increasing the amount of benchmark detail supplied to participating companies
- More rigorous checking of data for consistency

Customisation of the survey to particular industrial sectors has involved the inclusion of questions about the impact of driver availability on delivery reliability (food sector), cross-border freight movement (automotive sector) and the double-decking of vehicles (non-food retailing and pallet-load sectors) (Logistics Business Ltd, 2003) .

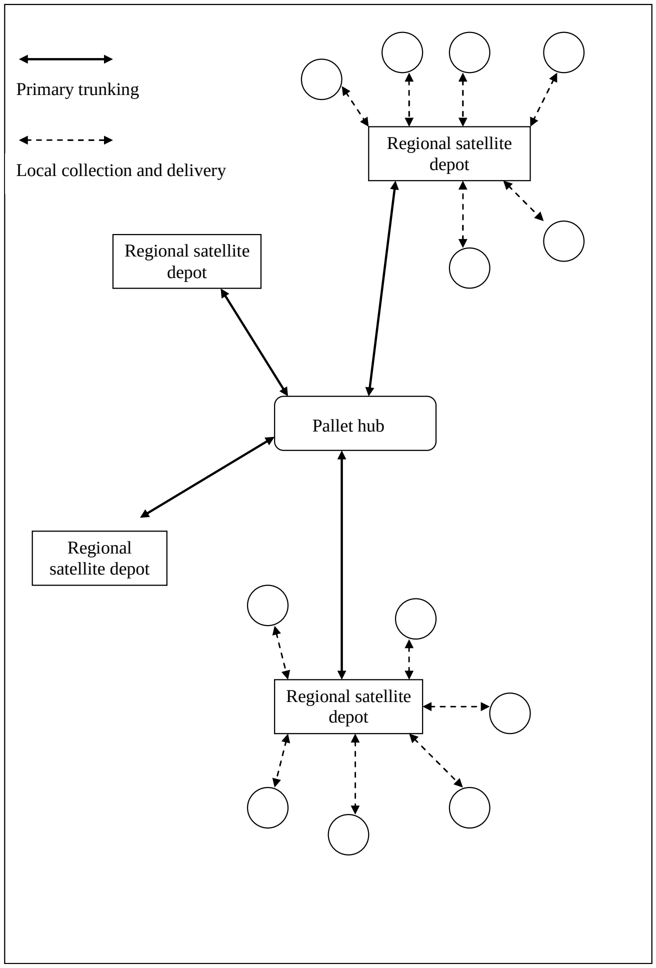

Figure 3: Hub-and-spoke structure of pallet-load and express parcel carriers.
(Adapted from Freight Best Practice Programme, 2005)

7. Key Results of the Benchmarking Exercises

Summary results of all but one[2] of the surveys have been published at either the government's 'Freight Best Practice' website (Freight Best Practice Programme, 2005, 2006a, 2006b, 2006c) or the Logistics Research Centre website (McKinnon, 1999; McKinnon and Leuchars, 2002; McKinnon, Ge and Leuchars, 2003). In this paper there is space only to highlight some of the main findings that have emerged on the subject of energy efficiency in road freight operations.

[2] The exception is the KPI survey of the road legs of air cargo movements.

1. Significant differences in energy efficiency[3] exist both within and between industry sub-sectors. Previous research has revealed wide differences in the fuel efficiency (i.e. kms per litre) of particular classes of truck operated within particular countries (Freight Transport Association, 1997; Office of Energy Efficiency, 2001). Very few studies, however, analysed inter-fleet variations in energy efficiency values, expressed on a tonne-km, pallet-km or cubic metre-km basis. Research by Leonardi and Baumgartner (2004), using trip-based questionnaires distributed to truck drivers in Germany, found wide variations in CO_2-intensity of road freight operations, from 0.8 to 26 tonne-kms per kg of CO2 emitted. As CO_2 emissions correlate closely with fuel consumption, energy intensity will have varied across a similarly wide range. The hauliers in their sample served many different sectors and their vehicles carried a broad variety of products. As the UK transport KPI surveys have been sector-specific they have revealed a narrower range of energy intensity values, but still suggest that there is good potential for cutting energy consumption in road freight transport.

Since the range can be skewed by one or two rogue values, the coefficient of variation (CoV) generally provides a more consistent basis for comparing the variability of energy intensity values within particular sub-sectors. This is calculated by dividing the standard deviation by the mean and multiplying by 100%. Of the sub-sectors for which variability data has been published, this coefficient is highest for the primary movement of ambient-temperature food and lowest for non-food retailing (Table 2).

	mean	**SD**	**Coefficient of Variation**
Ambient Food (primary distribution)	12.2	6.5	53%
Food (local wholesale dist.)	37.3	12.3	33%
Pallet-load (trunking)	9.5	2.7	28%
Food (secondary distribution)	19.2	4.9	26%
Refrigerated Food (primary distribution)	19.3	4.9	25%
Pallet-load (C&D)	41.2	6.9	17%
Non-food retailing	22.1	2.3	10%

Table 2: Mean and variability of energy intensity values for sub-sectors: ml of fuel per pallet-km

Some of the results of this comparison were counter-intuitive and require further investigation. For example, one might have expected that the primary movement of food, generally in heavier articulated trucks, would have a lower CoV than non-food retailing, which comprises a more heterogeneous range of products and a broader mix of vehicles. One might also have anticipated a higher CoV for the local collection and delivery of pallet-loads, reflecting geographical differences in drop-density and regional carrier performance, than for the more standardized trunk movements to and from sortation hubs.

The greater the variability in energy intensity at a sub-sectoral level, the more opportunity there should be for reducing average energy consumption through the dissemination of best

[3] In this paper energy efficiency is defined as the ratio of freight movement, expressed in tonne-kms, pallet-kms or cubic-metre-kms, to fuel consumed. Energy intensity is the converse of this measure: i.e. milli-litres of fuel consumed per tonne-km, pallet-km or cubic-metre km. Fuel efficiency, on the other hand, is defined as the ratio of distance travelled to fuel consumed (i.e. kms per litre).

practice. Estimates have been made of the potential savings in fuel, CO_2 emissions and operating costs that would accrue if fleets with relatively low efficiency could match either the best performing fleet or their sectoral / sub-sectoral mean. For example, in the non-food retail survey, fuel efficiency for 40 tonne trucks running on 5 axles varied from 3.1-3.8 kms per litre. In this case, 'for the worst to match the best a 22.6% improvement is required. At 100,000 kms per annum and a cost of 75 pence per litre this would give a saving of approximately £6000 per vehicle. With 74.1 gm of CO_2 / mJoule and 35.6 joules per litre, this is a reduction of over 21 tonnes of carbon dioxide emissions per vehicle per annum (Logistics Business Ltd., 2003). Estimates of potential energy savings in the food supply chain have been based on differences in energy intensity, rather than fuel efficiency, and envisaged situations in which fleets with below average energy efficiency raise their performance either to the sub-sectoral mean or to that of the top third of companies in the sample. Within these scenarios, based on 2002 data, total fuel consumption would drop, respectively, by 5% and 19% (Freight Best Practice, 2006a).

2. 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. In the food and pallet-load surveys there was only a weak correlation, across the sample fleets, between average fuel consumption (measured in km-per-litre) and average energy intensity (measured in ml-per-pallet-km). Figures 4 and 5 show the relationships between fuel efficiency and energy intensity for different classes of truck within these two sectors. Analysis of the 2002 food KPI database revealed that only in the case of large rigid vehicles was the correlation statistically significant (at the 5% level). This analysis shows that companies operating the same type of vehicle at 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 and highlights the importance of reporting fuel consumption on a pallet-km or tonne-km basis rather than vehicle-km basis.

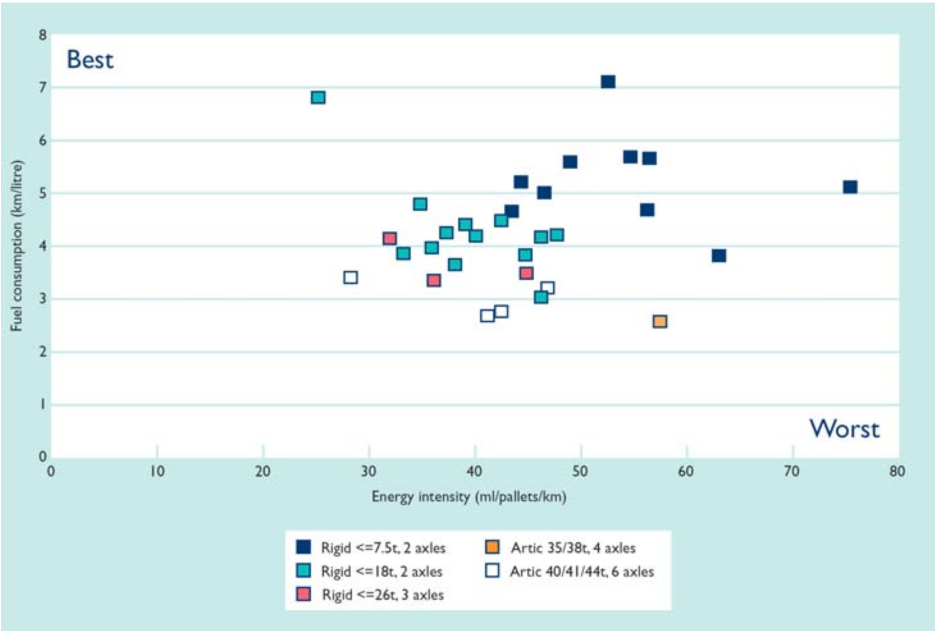

Figure 4: Relationship between energy intensity and fuel efficiency:
collection and delivery of pallet-loads. (Source: Freight Best Practice. 2005)

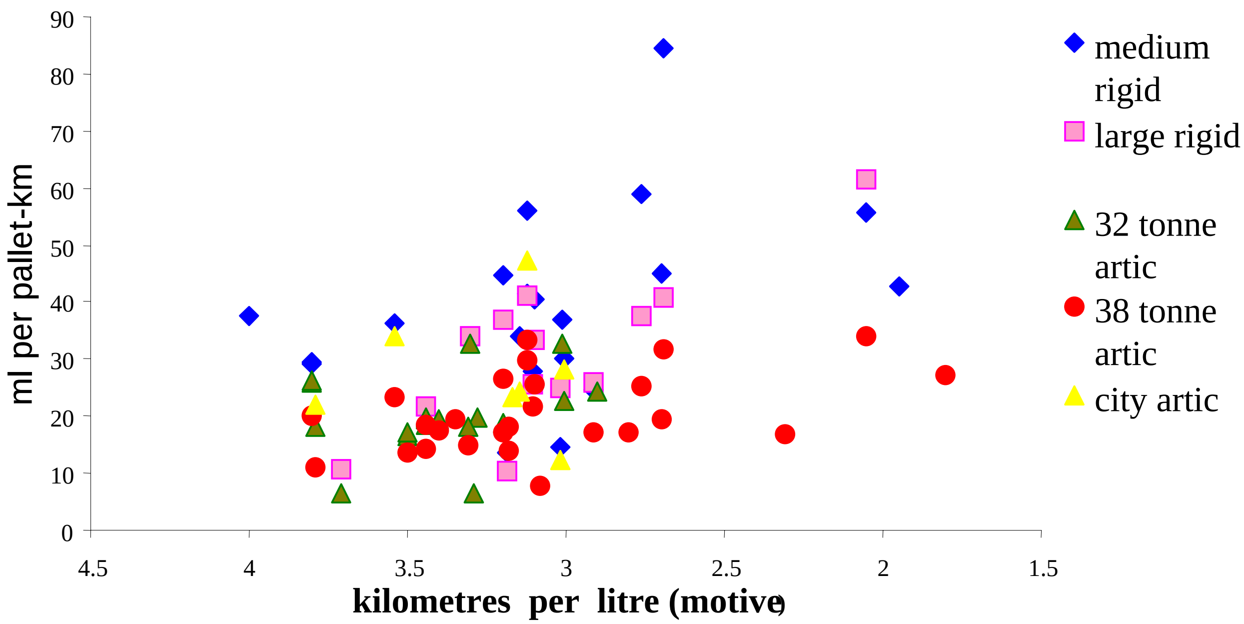

Figure 5: Relationship between energy intensity and fuel efficiency: food supply chain (Source: McKinnon and Ge, 2004)

3. Energy intensity varies much more widely across fleets of rigid vehicles than articulated vehicle fleets, regardless of sector. This 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 run their rigid vehicles very inefficiently both in terms of loading and fuel consumption. This was particularly evident in the automotive survey where just-in-time pressures were intense and some fleets' weight and volume utilization factors averaged under 20% (McKinnon and Leuchars, 2002). Local collection and delivery of express parcels, which mainly involves rigid vehicles and vans, is also characterized by wide variations in energy efficiency. Figure 6 shows the wide variations observed in this sector both in fuel efficiency and consignments delivered per litre of fuel consumed (Freight Best Practice Programme, 2006c).

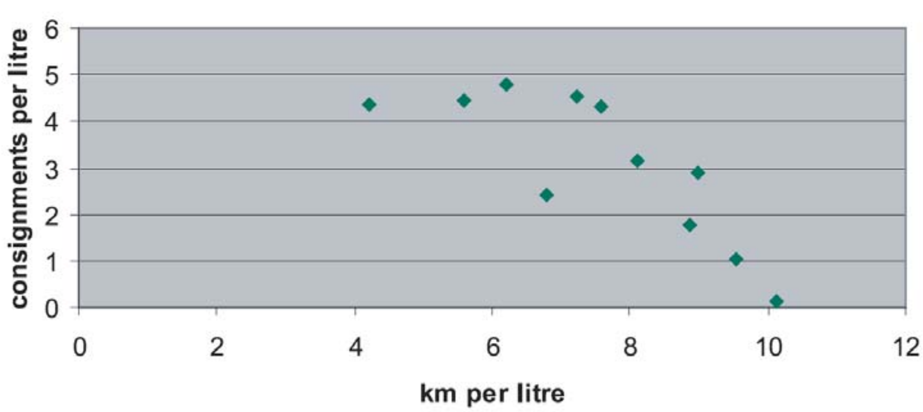

Figure 6: Relationship between fuel efficiency (kms per litre) and consignments per litre in the collection and delivery operations for express parcels: 11 sample fleets. (Source: Freight Best Practice Programme, 2006c)

4. Energy efficiency is being adversely affected by the scheduling of deliveries, particularly in the food sector. In 1998, 20% of the running time of trucks carrying food products occurred between 0700 and 1000 when the road network was at its busiest and fuel efficiency most severely impaired by prevailing traffic conditions (Department of the Environment, Transport and the Regions, 1998). The vehicles traveled 16% of their daily mileage between 0700 and 1000. This suggested that the average speed during the morning peak was around 24% lower than that achieved during the rest of the day. As no fuel consumption data were collected during the period of the survey, it was not possible to assess the impact of peak-time delivery on fuel efficiency. Driving conditions during the morning peak, however, invariably increase fuel consumption per vehicle-km traveled.

There were two other respects in which scheduling appeared to be impairing energy efficiency in the food supply chain. First, within this chain deliveries peak during the morning 'rush hour' at both the primary distribution (factory to distribution centre) and secondary distribution (DC to shop) levels. While secondary distribution to retail outlets is largely constrained by shop opening hours, there is less justification for concentrating primary deliveries in the morning peak period (McKinnon, Ge, and Leuchars, 2003). By altering daily delivery cycles, particularly for the movement of supplies into DCs, it would be possible to co-ordinate primary and secondary operations more effectively and exploit more backloading opportunities (Department of the Environment, Transport and the Regions, 1998). Secondly, the 1997 KPI survey found that refrigerated vehicles were loaded at cold stores an average of 5 hours before the delivery. This was done mainly to spread the workload and improve productivity in the warehouse. This practice carries a significant energy consumption penalty, however, as it requires much more energy per tonne to store temperature-controlled products in a truck than in a cold store (McKinnon and Campbell, 1998).

8. Other Uses of the Transport KPI Data

The data has not simply been used to inform companies of the relative efficiency of their road freight operations. It has found several other applications:

1. Supplementing other statistics compiled by the UK government in periodic reviews of the country's freight transport system (Department for Transport, 2003).

2. Cross-sectoral comparison of transport efficiency. The operational efficiency of food and non-food retailers has been compared drawing KPI data from two different surveys (McKinnon, 2004).

3. Supporting the development of a new model (EUNET 2) capable of forecasting the geographical pattern of freight movement and take account of logistics structures. Data from the food transport KPI survey 'has been valuable in terms of identifying for each distribution leg: the typical type of vehicle used, of load carried, of length of haul and of number of drops per trip' (WSP Policy and Research, 2005).

4. Providing empirical data for government strategy documents and official studies. Detailed reference is made to the 1998 transport KPI survey in the UK government's main policy document on Sustainable Distribution (Department of the Environment, Transport and the Regions, 1999b). Data on delivery reliability from the KPI surveys is also discussed in the recent report of the Eddington Transport Study (HM Treasury, 2006).

5. Retrospective analysis of opportunities for backloading and more efficient vehicle routing (McKinnon, Ge and McClelland, 2004). Data from the 2002 food transport KPI survey has

been used to analyse approximately 9000 journey legs run by 29 fleets of trucks to assess the extent to which empty running could have been reduced (McKinnon and Ge, 2006). New spatial modeling tools were developed to screen possible backloads against four operational criteria. The analysis found limited opportunity for additional backloading in the UK food supply chain, where average length of haul is short, the scheduling tight and a substantial proportion of freight requires refrigeration.

9. Problems and Limitations

The research and consultancy teams that have undertaken the transport KPI surveys over the past decade have encountered a number of problems. In benchmarking and analyzing the results, they have also recognized several limitations with this type of data collection. This section outlines the main shortcomings and indicates what has been done to try to overcome them:

1. Difficulty of securing adequate company involvement: The KPI surveys completed to date have varied widely in the level of industrial support. A planned survey in the home delivery sector had to be abandoned because too firms were prepared to supply the necessary operational data. At the other extreme, the food and non-retail surveys in 2002 attracted a great deal of interest. Success in recruiting companies appears to be related to the following factors:

- Support of a trade association
- Backing of industrial ‘champions’ who are respected within the industry
- Continuing engagement with the companies during the preparatory phases of the survey
- Participation of a few major companies against whom other business are keen to benchmark their transport operations.

2. Failure to survey other logistical variables: According to the literature (e.g Hanman, 1997; Randall, 2003) the most effective benchmarking is holistic, in the sense that it monitors a range of corporate functions. This permits the analysis of inter-functional trade-offs and can help to explain why a company under-performs in one area but excels in another. For example, companies that appear to have energy inefficient delivery operations may be behaving perfectly rationally, sacrificing transport efficiency for greater gains in the management of production, inventory or warehousing operations. Such behaviour may not only increase profitability: it can also minimize externalities (McIntyre et al ., 1998).

3. Non-random sampling: Companies participating in the transport KPI surveys have been self-selecting and chosen randomly. The aim of the marketing has been to encourage as many companies as possible in the targeted sectors to volunteer for the survey. Care must therefore be exercised in interpreting the aggregate results as these may not be representative of particular sectors and sub-sectors. An attempt was, nevertheless, made to assess the representativeness of results obtained by the 2002 KPI survey in the food sector by comparing the survey results with corresponding values from the government’s CSRGT (Department for Transport, 2003), which is based on a much larger, randomly-generated sample of vehicles (McKinnon and Ge, 2004). The average values for some of the key parameters such as empty running and fuel efficiency were very similar, suggesting that the road transport operations monitored over the two-day period are fairly representative of the general movement of food by road in the UK[4].

4. Difficulty of measuring particular KPIs: Several KPIs proved difficult to measure accurately and this degree of difficulty varied between sectors. The benchmarking of vehicle utilisation and energy efficiency in the automotive sector, for example, was inherently much more harder than in other sectors because of the diversity of handling equipment and large proportion of non-unitised freight. In the automotive sector, most loads comprise relatively low density products, making volumetric measurement much more important than weight-based measures. As relatively few companies recorded accurate data on the volume of consignments, there was heavy reliance on subjective assessment of cube utilisation. Even in sectors where the use of pallets and roll-cages is near universal, measuring the average of height of loads generally involved subjective estimation by drivers and / or traffic clerks.

Measuring the utilisation of truck capacity on multiple drop rounds has also presented both conceptual and practical problems. The conceptual problem relates to the progressive reduction in load factor at each off-loading point on a delivery round. On such a journey, the average weight-based load factor is maximized where the heavier consignments are delivered last, even if this means routing the vehicle more circuitously. This would be perverse, however, as it would reduce the energy efficiency of the operation. To address this anomaly it is necessary also to take account of the minimum number of tonne-kms generated by the delivery round.

The practical problem relates to the collection of journey leg-specific data by companies whose vehicles typically make very large numbers of drops (or collections) on a single round. Collecting leg-specific data can be particularly onerous under these circumstances. In the case of the automotive KPI survey, in response to company concerns, a decision was made not to collect leg-specific data for trips with four or more legs, but simply to average values at a trip level. Much of the richness in the survey data was therefore sacrificed to enlarge the sample size.

5. Limited analysis of the reasons for observed differences in performance: Benchmarking is more likely to have a beneficial impact on behaviour when the causes of under-performance are diagnosed and guidance offered on improvement measures. Until recently, the UK government contracts awarded for transport KPI surveys made no allowance for causal analysis or follow-up advice to specific companies. In workshops held to present summary results to participating companies, managers have discussed factors constraining the efficiency of their use of vehicle space and fuel, but many would have preferred company-specific analysis of deficiencies and opportunities for improvement. On the other hand, best-practice operators are naturally reluctant to risk losing some competitive advantage by divulging details of their superior performance.

6. *Difficult of finding well-matched comparators:* Even within industry sub-sectors, there can be significant differences between companies' distribution operations. Some of the variation in KPI values can be ascribed to differences in the nature of the customer base, the product range and production scheduling, all factors outside the logistics manager's control. Particular circumstances can justifiably cause a company's energy-efficiency value to deviate from the

[4] Within the NST commodity classification used by the government's Continuing Survey of Road Goods Transport, the nearest commodity category to 'groceries' is 'other foodstuffs'. It is not possible to disaggregate CSRGT fuel efficiency data by commodity class. The CSRGT figures for fuel efficiency therefore relate to road freight operations as a whole.

average of its benchmark group. One senior manager proposed the acronym DATUB ('does not apply to us because..') to describe a common reaction of managers to a below average set of KPI figures. Benchmarking at least places gives managers an incentive to explain why their indicator values are below (or above) their sub-sectoral averages.

10. Conclusion

The UK road transport KPI programme, which is now approaching its tenth anniversary, has pioneered a new method of data collection developed in close consultation with industry. It was motivated initially by a desire to compare levels of transport efficiency at different levels of the food supply chain, but has since become the standard method in the UK for benchmarking road freight operations at sectoral and sub-sectoral levels. Follow-up surveys have found that the majority of companies taking part have found the KPI programme very beneficial. In a survey of participating companies in the food sector, respectively, 83% and 78% of respondents awarded scores of 4 or 5 out 5 for the amount of benefit derived from benchmarking their own fleet(s) and the overall survey results. The KPI surveys have also proved quite an effective catalyst for industry-wide discussion of the opportunities for improving transport efficiency.

There is clear evidence that the programme has encouraged more companies to monitor the efficiency of their transport operations against standardized indices. It is not known, however, to what extent this has translated into more efficient operation and tangible reductions in fuel consumption and emissions. In theory, the repetition of the survey in a particular sector after several years should indicate trends in the KPIs. Only the food sector has been surveyed twice, but differences in the composition of the sample both at company and fleet levels prevented a direct comparison of average KPI values between the two surveys. Even if it had been possible to monitor trends through time, it would still have been difficult to determine the influence of the KPI surveys on changes in performance.

The government remains committed to the programme and has just commissioned four new surveys over the next four years: two more in the food sector and two new ones in the drinks industry to be conducted in alternate years. It is also promoting a more basic and non-synchronous version of the efficiency audit ('KPI-lite') to small road hauliers to give them access to a benchmarking service. It is hoped that in the longer term, it may be possible to undertake regular surveys in a broad range of industrial sectors. To date surveys have been confined to sectors handling mainly low density products moved in unitized loads. The distribution of bulk product, both in solid and liquid forms, has yet to be tackled and would require some modification of KPI software. Future diversification and repetition of KPI surveys may be financially constrained unless companies agree to contribute to their cost.

The KPI data has also been used for several other purposes, supplementing the government's main annual survey of road goods transport, particularly in the spatial modeling of freight flows. As freight modelling was not in the original specification of the survey design, the content and structure of the KPI data-bases are not ideally suited to this type of analysis. If the government and its industry partners wish to make the freight modelling an explicit objective of future transport KPI surveys it will be necessary to change their specification. This issue is explored elsewhere (McKinnon, Ge and McClelland, 2004).

This paper has also reviewed the main weaknesses of the transport KPI survey, some of which, such as non-random sampling, are inherent to the programme while others, such as the lack of causal analysis, could be rectified if more time and resource were allocated to the programme. Any other countries considering the development of a similar programme can learn from the UK experience. If they were to adopt a similar approach and methodology, opportunities would be created for the international benchmarking of road freight efficiency.

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