

IMPROVING ENERGY EFFICIENCY IN ROAD FREIGHT TRANSPORT SECTOR: THE APPLICATION OF A VEHICLE APPROACH

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Abstract

Several approaches can be used to analyse performance, energy consumption and CO₂ emissions in freight transport. In this paper we define and apply a vehicle-oriented, bottom up survey approach, the so called 'vehicle approach', in contrast to a 'supply chain approach'. The main objective of the approach is to assess the impacts of various freight transport operations on efficiency and energy use. We apply the approach, comparing official statistics on freight transport and energy efficiency in Britain and France. Results on freight intensity, vehicle utilisation, fuel use, fuel efficiency and CO₂ intensity are compared for the two countries. The results indicate comparable levels of operational and fuel efficiency in road freight transport operations in the two countries. Issues that can be addressed with the vehicle approach include: the impacts of technology innovations and logistics decisions implemented in freight companies, and the quantification of the effect of policy measures on fuel use at the national level.

Keywords: Road freight transport, performance, indicators, survey methods, energy use, efficiency, CO₂

Introduction

In research into freight transport and energy consumption, scientists and consultants perform investigations, using a vehicle approach, with the objective to observe, quantify and understand energy consumption at a disaggregate vehicle level. The approach also aims to understand how a behavioural change can lead to a net decrease or increase in vehicle energy use or CO₂ emissions, and to understand how this change can be (potentially) supported by vehicle related measures taken by decision-makers in companies and in the public sector.

The primary objective of the research is to explain the relation between key transport variables and the energy use. The secondary objective is to analyse measures and decisions taken by transportation companies, shippers and manufacturers, mainly related to transport optimisation, which have a direct influence on fuel consumption and, for example, lead to fuel efficiency, fuel switching or reduced fuel demand. Companies can follow three main strategies to improve efficiency and/or fuel use:

1. reduce the mileage of the fleet per tonne lifted, for example with navigation systems;
2. increase the energy and CO₂ intensity per transport unit (l/tkm, l/pallet-km or litre per parcel, box or letter) or per customer, for example with the help of scheduling systems, biofuels or tare weight reduction;
3. change of the driver behaviour through training (with impacts on effects 1 and 2).

Strategic questions for research on freight transport and energy consumption have been discussed in the economics and logistics research community by different authors (McKinnon 2003, Rizet and Keita 2005). Many countries' data and results of inter-country comparisons are available from institutions such as the OECD and its report on decoupling the environmental impacts of transport from economic growth (2006) or the TERM 2005 report from the EEA (2006). Based on many presentations of scientific studies, as part of the European Action COST355 meetings and projects in Europe, some evidence is already available on how to perform freight energy analysis in different ways. One of the possible approaches involves carrying out company surveys or using official statistics and analysing them with a vehicle-oriented perspective. In this vehicle approach, some of the open and fundamental research questions are:

1. What are the differences in the existing survey techniques and how to interpret them?
2. What are the most important vehicle oriented company measures and policy options?
3. What are the data needs for future vehicle oriented surveys?
4. Where are the gaps in knowledge, concerning data and understanding?

One of the important knowledge gaps involves quantifying the effects of company or public transport policy measures, that would potentially induce a change at the vehicle level, or a behavioural change measurable at the vehicle level. In addition, the impact of packages of measures would have to be quantified, and some research could additionally be performed on behavioural choices that are influencing changes, measurable at the vehicle level.

This paper intends to define the vehicle approach and its main methods in general, and present an example of its application. This has been achieved by carrying out a comparative analysis of road freight vehicle statistics and data in the UK and France. This paper provides a partial answer to the four fundamental research questions above, leading to evaluation on some measures and their potential impacts on key transport and energy indicators.

The “vehicle approach” was developed in particular for the investigation of the links between energy use and transport performance matters. Potentially, it could be applied in many other fields. It combines different methods together, mainly data collection, data analysis and decision making analysis, but it takes a vehicle perspective.

The vehicle perspective is the main characteristic of this approach, because this focus differs from the perspectives of company performance, supply chain management, modelling studies or policy assessments. It is a bottom up approach for CO₂ and energy use data analysis. It obtains fuel use data from transport surveys and primary data collections in trucking companies rather than from national fuel sales data from the petroleum and refinery sector.

Comparing road freight efficiency in Britain and France

The data used in the analysis presented in this paper has been obtained from national and international surveys and statistics. For Britain, data from the Continuing Survey of Road Goods Transport (CSRGT) has been used (DfT, 2006; DfT, 2007). For France, the Survey of Road Goods Transport (Transport Routier de Marchandises - TRM) has been used (MTETM/SESP, 2006). Both of these surveys provide annual data about road freight operations carried out by goods vehicles over 3.5 tonnes gross weight.

The CSRGT collects data from 12,000 vehicles per year, each one being monitored during one week. For articulated trucks (artics) over 33 tonnes gross vehicle weight, the CSRGT sample for 2005 encompasses 4,934 vehicles (DfT 2006a).

In France, the Survey of Road Goods Transport provides a similarly in-depth view into the use and efficiency of the French road freight fleet compared with the CSRGT in Britain. The survey covers newer vehicles (under 15 years old), registered in France, over 3.5 tonnes gross weight. Each year about 15,000 trucks and 70,000 tractor units are surveyed. The statistical unit of the survey is vehicle activities per week (truck or tractor), (i.e. the powered vehicle and its potential trailer during one week).

In order to deal with seasonality matters, both the British and French surveys are continuous, and the questionnaires are sent regularly to vehicle users.

Table 1 contains the road freight operational, fuel use and CO₂ indicators calculated for all goods vehicles over 3.5 tonnes gross weight in Britain and France in 2005. For comparison purposes, the energy and transport performance indicators, defined as transport ‘energy intensity’ in McClelland and McKinnon (2004), have been converted to ‘CO₂ intensity’, with the main unit ‘gram CO₂ emitted per tonne-kilometre’ (kg CO₂/tkm). Table 2 contains the indicators divided into rigid and articulated vehicle categories for both countries.

	Index of inland freight transp. to GDP (1995=100)	Modal split - road (based on tonne kms) (%)	Goods lifted (million tonnes)	Goods moved (million tkm)	Vehicle km (million km)	Length of haul (km)	Empty running (%)	Average load (tonnes - tkm/load km)	Tonne km : vehicle km	Ave. fuel efficiency (l/100 km)	Total fuel use (million litres)	Fuel use intensity (l/tkm)	CO ₂ intensity (g CO ₂ /tkm)
Britain	82	83%	1,810	155,762	22,384	86	27%	9.5	7.0	34.5	7,712	0.05	130
France	88.5	74%	2,060	205,279	21,368	100	25%	12.8	9.6	35.7	7,624	0.04	97

Table 1 Key performance indicators and efficiency of all goods vehicles over 3.5 tonnes gross weight in Britain and France in 2006

Sources: DfT, 2006; DfT, 2007; MTETM/SESP, 2007; ECMT, 2007; Eurostat, 2008.

Note: modal split data and the index of inland freight transport relative to GDP is based on 2005 data not 2006.

	Goods lifted (million tonnes)	Goods moved (million tkm)	Vehicle km (million km)	Length of haul (km)	Empty running (%)	Ave. load (tonnes - tkm/load km)	Tonne km : vehicle km	Ave. fuel efficiency (l/100 km)	Total fuel use (million litres)	Fuel use intensity (l/tkm)	CO ₂ intensity (g CO ₂ /tkm)
Britain – all rigids	849	36,817	11,247	43	27.4%	4.5	3.3	34	3,828	0.104	272
Britain – all artics	961	118,944	11,137	124	26.1%	14.5	10.7	34.9	3,884	0.033	86
Britain – all vehicles	1,810	155,762	22,384	86	26.8%	9.5	7.0	34.5	7,712	0.05	130
France – all rigids	686	29,472	7,530	43	27.8%	5.4	3.9	32.2	2,421	0.082	215
France – all artics	1,374	175,807	13,838	128	23.7%	16.7	12.7	37.6	5,203	0.03	78
France – all vehicles	2,060	205,279	21,368	100	25.2%	12.8	9.6	35.7	7,624	0.037	97

Table 2 Key performance indicators & efficiency of rigid & articulated goods vehicles over 3.5 tonnes gross weight in Britain & France in 2006

Sources: DfT, 2006; DfT, 2007; MTETM/SESP, 2007; ECMT, 2007; Eurostat, 2008.

Table 1 contains several indicators that reflect the efficiency of road freight transport operations, and the associated fuel use, and CO₂ emissions. These indicators include those defined by McKinnon (2005) as critical ratios, and include: modal split (road tonne-kms : total tonne-kms), transport intensity (tonne-kms:total output – shown in Table 1 as the index of inland freight transport relative to GDP), vehicle utilisation (shown in table 1 as empty running, average load, and tonne-kms : vehicle kms), fuel efficiency (energy consumed : vehicle-km) and fuel use intensity, and CO₂ intensity.

The results show both similarities and differences in road freight operational, fuel use and CO₂ intensity in the two countries. The index of inland freight transport relative to GDP indicates that total surface freight transport has declined faster in relation to GDP in Britain than in France during the period 1995 to 2005. This could be due to greater increases in the productivity of freight transport operations in Britain, or to greater structural changes in the British economy away from the production of products towards a service economy. The results in Table 1 show that France is less dependent on road freight relative to other modes than is the case in Britain.

The proportion of vehicle kilometres run empty in both countries is similar (27% in Britain compared with 25% in France). However, the average load carried by goods vehicles is approximately 35% greater in France than in Britain. This could be partly due to a greater proportion of work being carried out by articulated vehicles rather than lighter rigid vehicles in France, as well as possibly due to the nature of the types of goods transported in both economies, and the supply chain structures that exist. It is also possible that this result could be due to biases in the survey method. This greater average load in France results in a higher proportion of tonne-kms: vehicle kms in France compared to Britain.

Average fuel efficiency is slightly better in Britain than in France – this is related to the greater proportion of work carried out by rigid vehicles in Britain, but total fuel use is lower in France, this is related to the slightly fewer vehicle kilometres performed in France. There is a slightly lower fuel use intensity (litres/tonne-km) in France. CO₂ intensity is also lower in France than in Britain.

Further discussion of possible explanations for differences in the results

Two possible underlying causes could explain the efficiency differences/similarities in the results:

- One origin of the differences could be concerned with the freight transport characteristics, recorded in the survey samples, as transport movements and vehicles might be very different between Britain and France, due to the patterns and structures of freight-related activities in these surveys;
- Another possible type of cause is the different design of the surveys.

Further consideration of these two explanations is provided below.

Load factor by weight and by volume

There are intrinsic limitations based on a goods vehicle reaching its maximum weight, as its volume might be filled without reaching the maximum weight. This would have an impact on some of the indicators and especially create biases for some commodities. For instance, food is a relatively low-density product and loads moved by truck tend to be volume-constrained rather than weight-constrained. Since volume load factor data are largely missing, their impact on potential differences or similarities in efficiency cannot be analysed. It remains a future task.

Commodity types

Differences in the commodities in the survey samples would also result in differing results. The British and French national surveys include all commodity types. However, since most transport companies do not record what kind of goods they carry, it is difficult to be sure that the commodity mix in both surveys is similar. It might be advisable to use different surveys, or to perform a new survey with innovative methods, where commodity types and energy efficiency are related to investigate this further. The length of haul can also have a bearing on fuel efficiency and the CO₂ intensity due to the higher share of long distance transport involved.

Fleet size and truck types

National fleet composition is relatively similar in the samples from France and Britain. In both countries heavy articulated vehicle perform the majority of tonne kilometres. However, as already noted, rigid vehicles are proportionately more important in terms of tonne-kilometres performed in Britain than in

France. In both countries, the efficiency increases with the size of the vehicle as would be expected. The allowance of 44 tonne gross weight vehicles in Britain does not result in higher efficiency values than in France. Therefore, the cause for efficiency differences may have origins other than the fleet composition of the samples.

Driving conditions and length of haul

Road conditions, especially the extent of congestion, might explain the lower efficiency for British goods vehicles, since the inter-urban road network is more congested than the French. But it is not possible to quantify its impact.

Sample size and accuracy of data gathering method

The sample sizes of both national surveys are high, and the reliability of the samples appears to be good. There are no obvious fundamental weaknesses in the survey approaches. Both surveys include a wide variety of businesses and commodity types.

For both surveys the direct coupling of fuel use measurements with tonnes transported and distance travelled, obtained by a questionnaire filled by a driver/company, is an "old fashioned" survey method that allows a very good accuracy in the results. On board telematics, with sensors registering the fuel use, the vehicle weight and the distance on a computer, would offer even higher data accuracy.

Other factors

One central condition for scientific comparison is that 'everything else remains stable' excepting the differences in the objects of the analysis. This situation is not possible to achieve, as business conditions and countries' economies are changing all the time. Therefore many external factors, not related to vehicles, and not mentioned in the explanations, could have been strongly influencing the results. The influence of cabotage, logistics decision making and other non technological factors have been discussed in McKinnon (2003) and in Leonardi et al. (2005). The interrelation of economic or business specific variables influencing road freight transport performance, load factor and fuel use per tonne-km, are difficult to assess in a quantitative way. Such an assessment has been performed internationally in only a limited number of studies such as Redefine (1999). This should be the target of specific surveys. As there is much potential for logistics and load factor improvements, such studies would potentially produce results of great relevance to business practices and in helping achieve more sustainable transport.

Conclusions

The paper has presented an application of the vehicle approach using official national road freight statistics. The analysis has identified similarities and differences in results in Britain and France. A possible objective of future research is the organisation and design of additional, more detailed surveys to gather company operational data in order to investigate the impacts of policy instruments in term of quantified cause-effects relations at the company level. For example, businesses in Switzerland reduced their total mileage and fuel consumption after the introduction of the Swiss tax on heavy-duty vehicle transport, for the first few years. The Swiss national survey did reflect these changes in road freight operations, but targeted company surveys offer the potential to study the impacts of such a measure on indicators and logistics decision factors in far greater detail using the vehicle approach.

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References

- DfT (UK Department for Transport) (2007), *Road Freight Statistics 2006*, Transport Statistics Bulletin, DfT, London.
- DfT (UK Department for Transport) (2006), *Road Freight Statistics 2005*, Transport Statistics Bulletin, DfT, London.
- ECMT (2007), *Trends in the Transport Sector 1970-2005*, ECMT.

- EEA (European Environment Agency) (2006), *Transport and environment: facing a dilemma. TERM 2005: indicators tracking transport and environment in the European Union*, EEA Report 3/2006, Copenhagen.
- Eurostat (2008), *Key Figures on Europe: 2007/08 edition*, Eurostat.
- Leonardi, J., Baumgartner, M. and Krusch, O. (2005), *Nachhaltigkeitseffekte von Effizienzmaßnahmen im Straßengüterverkehr mit Fokus auf KEP-Dienste und Speditionskooperationen*, NESTOR 2, MPI, Hamburg, <http://www.mpimet.mpg.de/fileadmin/projekte/nestor>
- McClelland, D. and McKinnon, A. (2004), *Use of Vehicle Telematics Systems for the Collection of Key Performance Indicator Data in Road Freight Transport*, Heriot-Watt University, Edinburgh,
- McKinnon, A. (2005), Oil Saving Opportunities in Freight Transport, presentation at IEA / ECMT Workshop: Managing Oil Demand in Transport.
- McKinnon, A. (2003), *Logistics and the Environment*; in: Henscher, D.A. und Button, K.J.: Handbook of Transport and the Environment, Amsterdam: Elsevier, pp.665-685.
- MTETM/SESP (Ministère des Transports de l'Équipement, du Tourisme et de la Mer/ Service économie statistiques et prospective) (2006), *Les comptes des transports en 2005. Premiers résultats*. Paris.
- MTETM/SESP (2007), enquête TRM 2005;
- http://www.statistiques.equipement.gouv.fr/article.php3?id_article=777
- REDEFINE (1999), Relationship between Demand for Freight-transport and Industrial Effect, Summary Report,.REDEFINE project, <http://cordis.europa.eu/transport/src/redefinerep.htm>
- Rizet, C. and Keita, B. (2005), Chaînes logistiques et consommation d'énergie: cas du Yaourt et du Jean in: INRETS (Eds): Actes de la journée INRETS du 18 mai, Consommation d'énergie et émissions de GES en transport de marchandises. Arcueil