Energy Policy 41 (2012) 84–97

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Decoupling of road freight energy use from economic growth in the United Kingdom

Steve Sorrell [a,*], Markku Lehtonen [a], Lee Stapleton [a], Javier Pujol [a], Toby Champion [b]

[a] Sussex Energy Group, SPRU (Science & Technology Policy Research), Freeman Centre, University of Sussex, Falmer, Brighton, BN1 9QE, UK
[b] Toby Champion Associates, UK

ARTICLE INFO

Article history:
Received 12 November 2009
Accepted 2 July 2010
Available online 3 August 2010

Keywords:
Freight transport
Energy intensity
Decoupling

ABSTRACT

Between 1989 and 2004, energy consumption for road freight in the UK is estimated to have increased by only 6.3%. Over the same period, UK GDP increased by 43.3%, implying that the aggregate energy intensity of UK road freight fell by 25.8%. During this period, therefore, the UK achieved relative but not absolute decoupling of road freight energy consumption from GDP. Other measures of road freight activity, such as tonnes lifted, tonnes moved, loaded distance travelled and total distance travelled also increased much slower than GDP. The main factor contributing to the observed decoupling was the declining value of manufactured goods relative to GDP. Reductions in the average payload weight, the amount of empty running and the fuel use per vehicle kilometre also appear to have made a contribution, while other factors have acted to increase aggregate energy intensity. The results demonstrate that the UK has been more successful than most EU countries in decoupling the environmental impacts of road freight transport from GDP. However, this is largely the unintended outcome of various economic trends rather than the deliberate result of policy.

1. Introduction

The contribution of freight transport to climate change is substantial and growing. Globally, freight transport accounts for one third of transport energy consumption and around 8% of total energy-related carbon dioxide (CO_2) emissions. The bulk of these emissions derive from heavy goods vehicles (HGVs), which in most countries account for the majority of freight activity. In the UK, for example, HGVs account for more than 68% of goods moved (tonne kilometres), 24% of road fuel use, 22% of transport CO_2 emissions and 5% of total CO_2 emissions (DfT, 2005b).

Despite this, freight transport has been relatively neglected in terms of both climate policy and the associated policy research. Policy initiatives to restrain the growth in energy use and carbon emissions from this sector (e.g. the UK Sustainable Distribution Strategy and Freight Best Practice programme) have been both limited and ineffective, while policy research has focused disproportionately upon passenger transport. Both the European Union and the UK have the stated goal of decoupling various measures of road freight activity from GDP, but this has generally been interpreted as relative rather than absolute decoupling – implying that energy use and carbon emissions could continue to increase, even if the objective was met.

Freight activity is driven by complex and interlinked trends in production, trade, distribution and retail, including income growth, wider sourcing of products, increased specialisation, 'just-in-time' distribution and increasing concentration of manufacturing and stockholding (Lehtonen, 2008; McKinnon and Woodburn, 1996; NEI, 1997). The corresponding impact on energy use and carbon emissions may be either enhanced or offset by parallel trends in logistics, vehicle technology and the management of transport resources, including factors such as the size, fuel efficiency and average load factor of vehicles. Some of these trends have led to greater energy use in this sector over recent years, while others have encouraged reductions in energy use. If the growth in carbon emissions from freight transport is to be halted and reversed, the nature and relative importance of these trends needs to be better understood.

This paper contributes to that end by examining trends in ten variables that have strongly influenced UK road freight energy consumption over the period 1989–2004. Following McKinnon (2007), we call these variables *key ratios* since they are each formed from the ratio of two other variables which we term *key quantities*. For example, the ratio of the 'goods moved' by freight vehicles (tonne kilometres) to the 'goods lifted' by freight vehicles (tonnes lifted) represents one such key ratio (the average 'length of haul').

This paper shows how UK road freight energy consumption can be expressed as the product of these ten key ratios and GDP. Some of these key ratios (e.g. the average length of haul) have increased in magnitude since 1989 and thereby led to greater

* Corresponding author. Tel.: +44 1273 877067; fax: +44 1273 685865.
E-mail address: s.r.sorrell@sussex.ac.uk (S. Sorrell).

0301-4215/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.enpol.2010.07.007

energy consumption, while others (e.g. the amount of empty running) have decreased and led to reduced energy consumption. The paper explores the measurement, meaning and significance of these key ratios, together with the key quantities from which they are formed, and summarises their trends over the period 1989–2004. It also examines how these trends vary between different vehicle types and commodity groups. The analysis is much more disaggregated than previous studies in this area (e.g. Kamakaté and Schipper, 2009) and provides a nuanced picture of the factors underlying the aggregate trend in UK road freight fuel consumption. This in turn allows the main reasons for the observed decoupling to be identified.

2. Method of approach

During the period 1989–2004, energy consumption for road freight in the UK is estimated to have increased by only 6.3% while UK GDP increased by 43.3%, implying that the aggregate energy intensity of UK road freight fell by 25.8% (Fig. 1). During this period, therefore, the UK achieved relative but not absolute decoupling of road freight energy consumption from GDP. Our interest is in exploring the contribution of different variables to this aggregate trend.

Trends in aggregate quantities such as road freight energy consumption can be usefully expressed as the product of two or more variables. For example, the energy consumption of a particular category of road freight vehicle (k) in year t ($FUEL_{kt}$) could be expressed as the product of the total distance travelled by that category of vehicle ($VKMT_{kt}$) and the average fuel use per kilometre of that category of vehicle ($EINT_{kt}=FUEL_{kt}/VKMT_{kt}$). The total energy consumption for all categories of road freight vehicle in year t ($FUEL_t$) could then be expressed as

$$FUEL_t = \sum_k FUEL_{kt} = \sum_k VKMT_{kt} * \frac{FUEL_{kt}}{VKMT_{kt}} \tag{1}$$

$$FUEL_t = \sum_k VKMT_{kt} * EINT_{kt} \tag{2}$$

Letting $S_{kt}=VKMT_{kt}/VKMT_t$ represent the share of each vehicle type in the total distance travelled by all road freight vehicles in year t ($VKMT_t$), we can rewrite this as

$$FUEL_t = \sum_k VKMT_t * \frac{VKM_{kt}}{VKMT_t} \frac{FUEL_{kt}}{VKM_{kt}} \tag{3}$$

$$FUEL_t = \sum_k VKM_{kt} * S_{kt} * EINT_{kt} \tag{4}$$

In the terminology of this paper, S_{kt} and $EINT_{kt}$ are *key ratios* while all the other variables are *key quantities*. The key ratios are defined for each year and each vehicle type (S_{kt} and $EINT_{kt}$), but could also be estimated annually for all vehicle types combined (S_t and $EINT_t$). Depending upon data availability, the decomposition could be made more complex through the inclusion of additional key ratios, or more of the key ratios could be broken down into additional subcategories – such as different types of commodity (c). For example, we could estimate the energy intensity of vehicle type k carrying commodity c in year t – $EINT_{ckt}$.

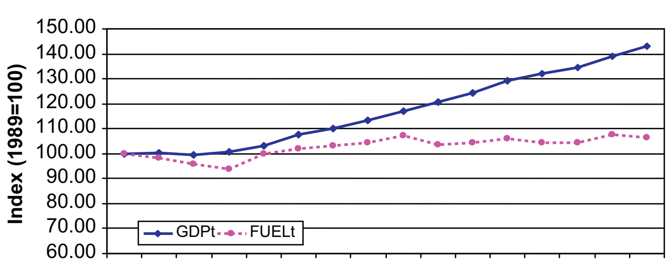

Fig. 1. Decoupling of UK road freight energy use from GDP.

Table 1
Key quantities.

Acronym	Definition	Measure
GDP_t	UK gross domestic product	£
$MAND_{ct}$	Value of domestically produced manufactured goods in basic prices, broken down by commodity group	£
$MANT_{ct}$	Value of the total supply of manufactured goods in basic prices, broken down by commodity group	£
$MLIFT_{ct}$	Weight of goods lifted by all modes of freight transport	Tonnes
$TLIFT_{ckt}$	Weight of goods lifted by HGVs	Tonnes
TKM_{ckt}	Weight of goods moved by HGVs	Tonne-km
VKM_{ckt}	Distance driven in loaded HGVs	Vehicle-km
$VKMT_{ckt}$	Distance driven in loaded and unloaded HGVs	Vehicle-km
$FUEL_{ckt}$	Estimated energy consumption by HGVs	Litres of fuel

Notes:

- All key quantities refer to the UK. All transport key quantities include the activities of both UK and foreign-registered HGVs.
- Basic prices include taxes (less subsidies) on production, but do not include taxes/subsidies on the products themselves (e.g. VAT).

This study uses *ten* key ratios to investigate the sources of change in UK road freight energy use over the period 1989–2004.[1] The analysis is confined to energy use by heavy goods vehicles (HGVs) which account for approximately 80% of goods lifted (tonnes) and 95% of goods moved (tonne kilometres) by road in the UK. Freight transport by light goods vehicles (<3.5 tonnes) is excluded owing to inadequate data, although this is acknowledged to be an important and growing source of freight transport.

The key ratios and associated key quantities are defined in Tables 1 and 2. Key ratios 1–3 are relevant to the supply of goods in the UK economy while key ratios 4–10 are relevant to the transport of those goods. The key ratios have been estimated for each year (t) and several have been disaggregated by fifteen commodity groups (c) and/or six vehicle types (k) (Tables 3 and 4). In the graphical presentations that follow, the trends in the key ratios are presented at the aggregate level (i.e. all commodities and vehicle types combined), or broken down by either vehicle type (k) or *primary* commodity category (p) (Table 3). The aim is to highlight the main trends in these variables over the period 1989–2004 and to identify their likely importance for road freight energy consumption. In a companion paper, Sorrell et al. (2009) conduct a formal decomposition analysis of UK road freight energy consumption, using the full breakdown by commodity group (c), vehicle type (k) and year (t).

Using the key quantities, the total energy consumption of truck type k carrying commodity group c in year t may be expressed as

$$FUEL_{ckt} = GDP_t \frac{MAND_t}{GDP_t} \frac{MAND_{ct}}{MAND_t} \frac{MANT_{ct}}{MAND_{ct}} \frac{MLIFT_{ct}}{MANT_{ct}} \frac{TLIFT_{ct}}{MLIFT_{ct}} \times \frac{TLIFT_{ckt}}{TLIFT_{ct}} \frac{TKM_{ckt}}{TLIFT_{ckt}} \frac{VKM_{ckt}}{TKM_{ckt}} \frac{VKMT_{ckt}}{VKM_{ckt}} \frac{FUEL_{ckt}}{VKMT_{ckt}} \tag{5}$$

[1] A longer time series would be desirable, but inconsistencies in the UK Input Output tables make it difficult to extend the analysis to before 1989. The analysis may subsequently be updated to include more recent years, but the 2005 changes in the format of UK freight statistics may create some discontinuities. Also, such updating is far from straightforward since there are numerous gaps and inconsistencies in the relevant time series and a great deal of effort is required to estimate the missing data – see Sorrell et al. (2008).