Applied Energy 165 (2016) 849–857

Contents lists available at ScienceDirect

Applied Energy

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

Diesel demand in the road freight sector in the UK: Estimates for different vehicle types

Zia Wadud *

Centre for Integrated Energy Research, Institute for Transport Studies and School of Chemical and Process Engineering, University of Leeds, Leeds LS2 9JT, UK

HIGHLIGHTS

- UK diesel demand for light and heavy freight vehicles modelled.
- The transition from petrol to diesel engines controlled for in the model.
- Both light and heavy duty sectors have income elasticity of around 0.8.
- Rigid trucks have lower income elasticity than articulated trucks.
- Light duty trucks are insensitive to price changes, heavy duty trucks respond by a small amount.

ARTICLE INFO

Article history:
Received 17 August 2015
Received in revised form 1 December 2015
Accepted 24 December 2015
Available online 11 January 2016

Keywords:
Diesel fuel
Freight transport
Demand elasticity
Fuel switch
HGV
LGV

ABSTRACT

Demand elasticity for petrol or diesel is an important policy parameter, both from energy security and global warming perspective. Despite an abundance of literature on petrol demand, there are few studies on diesel demand, and even fewer on demand by different vehicle types. This paper aims to model diesel demand for different freight duty vehicle types (e.g. heavy vs. light goods vehicles and rigid vs. articulated trucks) in the UK. We argue that the switch to diesel from petrol engines in the light vehicles sectors could have biased earlier petrol or diesel demand elasticities in Europe, and show that it was indeed the case for the light goods vehicle sector. Results show that both light and heavy goods vehicles have similar income elasticities, although within the heavy duty sector, articulated trucks are more elastic than rigid trucks. Overall, heavy goods vehicles were responsive to fuel prices, but light goods vehicles were not. Within the heavy duty sector, rigid trucks showed statistically significant price elasticity, but articulated trucks did not respond to changes in fuel prices. Our results show that price-based policies to curb fuel consumption from the light or heavy goods vehicles are unlikely to be effective.

1. Introduction

The use of diesel in light duty vehicles has attracted substantial attention in the UK recently. In an attempt to combat the adverse effects of climate change, various incentives were put forward in the UK during mid 1990s in order to reduce carbon emissions from the personal road transport sector. The quickest response to these incentives was a switch to diesel engines, which were more fuel and carbon efficient than similar petrol engines. Nearly two decades into these incentives, diesel cars and light goods vehicles (LGV) now have a larger market share in new vehicle sales in the UK. However, the resulting increases in NO_x[1] means that many UK cities now exceed the ambient NO_x standards. On the other hand, road freight transport – which is also dominated by diesel engines – has steadily increased its share of total road transport energy consumption (and carbon emissions) from 28.8% to 35.6% between 1970 and 2014. Since electrification is unlikely to be viable for decarbonising the heavy duty freight sector, liquid fuel are likely to remain in the fuel mix for a longer time. These two trends of dieselization of light duty fleet and increasing share of road freight in transport energy consumption is also observed in most European countries. These factors have led to a renewed interest in energy and, especially, diesel demand in the transport sector.

Energy demand for personal transport is one of the most widely researched area in energy economics because of the crucial role that energy plays in an economy. Elasticity for fuel demand, defined as the ratio of changes in fuel demand with respect to changes in price or income is an important parameter for policy-makers. Income elasticities are especially useful to determine the future growth or slowdown in fuel consumption in response to

* Tel.: +44 (0)113 343 7733.
E-mail address: z.wadud@leeds.ac.uk

[1] Diesel engines emit more NO_x than petrol engines.

http://dx.doi.org/10.1016/j.apenergy.2015.12.102
0306-2619/

rising income (or GDP). On the other hand price elasticities are useful to understand the effects of carbon taxes, fuel taxes or such fiscal policies on consumption.

Traditionally, petrol or gasoline spark ignition engine was the dominant engine technology for personal vehicles (i.e. cars), and as such studies on petrol demand abounds. In comparison, literature on demand for diesel, which had primarily been used for heavier duty freight vehicles, is much smaller. More importantly, the distinction between passenger vehicles and freight vehicles on the basis of petrol or diesel engines has been blurred in most European countries as a result of diesel's growing market share during the past two decades [1]. Since the two fuels no longer exclusively cover a specific activity (personal vs. freight travel), modelling total petrol or total diesel consumption has lost some of its previous usefulness in policy discussions. For example, transport and city planners may need to know the effect of taxation on diesel fuel on heavy-duty truck travel, but elasticities may be available only for total transport diesel, which would include cars and light commercial vehicles. Similarly petrol demand no longer represent fuel demand by all private cars, since a large share of private cars in Europe currently runs on diesel. As such, policymakers may be interested in knowing separate responses for fuel demand elasticities for freight and personal travel for these two major fuel types. However, there is a dearth of literature on the responses of different vehicle sectors to fuel price or income changes, with only one credible study by Winebrake et al. [2], which is for articulated trucks in the US. Separate diesel demand models for light and heavy goods vehicles and rigid trucks or articulated trucks within the heavy duty fleet are not available in any study.

The dieselization of the UK and European light duty (cars and LGVs) vehicle fleet poses another methodological problem. The transition to diesel was primarily a result of innovations in diesel technology, rather than a response to price and income changes. This means that in any study, where this transition is not explicitly modelled, the income and price elasticities would be biased. Given nearly all recent studies on petrol or diesel demand use time-series data, which includes data during the last two decades, there is a possibility that the elasticity estimates in most European countries, including in the UK, were estimated incorrectly.[2] Indeed, Dahl [3] – in her extensive review of diesel demand studies – noted that income elasticity of diesel in Europe during 1990–2007 was 1.79, which was much higher than most other countries, indicating the possible bias in the published elasticity estimates. Similarly, petrol demand has been falling in the UK and European countries since the late 1990s, which could also bias the price and income elasticity of petrol demand if the transition from petrol to diesel engines is not controlled for. Therefore there is a need for a method to derive demand elasticity after controlling for the fuel transition observed in most European countries.

Following this background, we make novel contribution to the literature in diesel demand by addressing these limitations in this research. Firstly, we model diesel demand for different types of road freight vehicles so that implications of price or income changes on diesel consumption in each of these vehicle fleet can be understood. To our knowledge, this is the first study to model price and income elasticities of diesel demand for light and heavy goods vehicles as well as rigid trucks and articulated trucks within the heavy duty fleet. Secondly, we make novel contributions to the modelling strategy in order to control for the transition of the fleet from predominantly petrol to predominantly diesel to correct the bias in the elasticity estimates of diesel demand that has afflicted previous studies, especially in European countries. Thirdly, although the methodological control for fuel transition is applied for diesel in LGV fleet in this study, the method can be applied for petrol or diesel demand in cars too, which makes our methods more widely applicable.

The paper is laid out as follows. Section 2 reviews the literature with a focus on diesel demand. Section 3 describes the data and provides some background on the evolution of diesel fuel demand in the freight sector in the UK. Section 4 describes the detail of the econometric model, while Section 5 presents the detailed results for various vehicle segments and discusses the results. Section 6 draws conclusions.

2. Literature on diesel demand

The literature on diesel demand is much smaller as compared to that in petrol demand.[3] As such the methods used to model diesel demand are also more uniform. Table 1 summarises the features and findings of fifteen recent primary studies on diesel demand, all published since 2000. Each of these studies uses variations in aggregate diesel demand in temporal dimension and explains them with respect to fuel price, income and occasional other explanatory factors. Although cross-sectional information is used in conjunction with timeseries in some of these studies in a panel structure (e.g. Gonzalez-Marrero et al. [7]), the demand data is still at an aggregate level, be it regional or national. Unlike in petrol demand models, using household level disaggregate data for modelling diesel consumption has not gained much purchase, presumably because of the historic use of diesel in heavy duty freight vehicles.

Dahl [3] reviewed 34 studies which modelled diesel demand and find that price and income elasticities were −0.16 and near 1 respectively. However, as mentioned earlier, Dahl [3] also find that the income elasticity in European countries were larger – around 1.79, which is an indication of our premise that elasticities could be biased if the petrol to diesel transition is not accounted for. In the UK, Ramli and Graham [8] have recently modelled diesel demand, but their aggregate demand data contains diesel consumption from all heavy goods vehicles (HGV) and a share of light goods vehicles (LGV) and personal cars. Since the rapid penetration of diesel engines in both passenger cars and LGVs during their observation period was not accounted for, it is likely that their income elasticity of 1.5 was also on the higher side. Using these high income elasticities to make long term diesel demand forecasts would most likely overestimate the demand. Interestingly, despite diesel's growing market share in Europe, there is a shortage of studies that model diesel demand in Europe.

Only a few recent studies attempted to control the transition from petrol to diesel while modelling elasticity of petrol or diesel demand. Pock [9], although deals with petrol, is relevant here since the transition of European petrol car fleet to diesel has been explicitly modelled through using the size of petrol and diesel car fleet as additional explanatory variables. However his use of petrol consumption *per car* as the dependent variable misses a critical mechanism influencing petrol or diesel demand – the changes in car ownership *per capita* as a response to changes in income or fuel prices. It is likely that the low to statistically insignificant income elasticity for petrol demand is a direct outcome of the modelling strategy. Pock [10] considers diesel demand, but like Ramli and Graham [8] contains all automotive diesel, including cars and trucks, complicating modelling. Also the use of diesel *per car* as the dependent variable as in Pock [9] has the same methodological limitation. Among other studies of diesel demand in European countries, Liu [11] and Pedregal et al. [12] did not control for the diesel switch in Europe and Spain respectively, while Gonzalez-Marrero et al. [7] found statistically insignificant income

[2] Note that this will not be a problem in the US, since petrol to diesel transition did not occur there.

[3] Extensive review of petrol demand is available in Wadud [4], Dahl and Sterner [5], or Basso and Oum [6]. In this section we focus on recent diesel demand works only.