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Fuel price elasticities for single-unit truck operations in the United States

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ABSTRACT

This paper provides fuel price elasticity estimates for single-unit truck activity, where single-unit trucks are defined as vehicles on a single frame with either (1) at least two axles and six tires; or (2) a gross vehicle weight greater than 10,000 lb. Using data from 1980 to 2012, this paper applies first-difference and error correction models and finds that single-unit truck activity is sensitive to certain macroeconomic and infrastructure factors (gross domestic product, lane miles expansion, and housing construction), but is not sensitive to diesel fuel prices. These results suggest that fuel price elasticities of single unit truck activity are inelastic. These results may be used by policymakers in considering policies that have a direct impact on fuel prices, or policies whose effects may be equivalent to fuel price adjustments.

Introduction

Over the past several decades, the relative contribution of heavy-duty vehicles (HDV) to total transportation energy use and emissions in the United States (US) has increased. The share of highway vehicle miles traveled (VMT) attributable to HDVs increased from 6% in 1970 to 9% in 2011 (BTS, 2014a), while the share of highway vehicle energy consumption by HDVs nearly doubled from 13% to 25% (BTS, 2014b,c,d,e). With this growing energy use comes increased greenhouse gas (GHG) emissions and other pollutants, and HDVs are now a focus of new regulatory actions aimed at improving fuel efficiency and reducing GHG emissions from the transportation sector.

Unlike the light-duty vehicle (LDV) sector, HDVs never had to meet fuel efficiency standards in the US. This changed in 2011 when the US Environmental Protection Agency (EPA) and the US National Highway Transportation and Safety Administration (NHTSA) jointly established GHG emissions and fuel efficiency standards for US HDVs for the first time (EPA and NHTSA, 2011). The standards, focused on truck model years 2014–2018, regulate GHGs (measured in gCO_2/ton-mile) and fuel consumption (measured in gallons per thousand ton-miles) and aim to reduce lifetime fuel consumption and emissions by 20% for combination (i.e. freight) trucks and 10% for vocational (mostly single-unit) trucks (The White House, 2014a). The US recently announced plans to extend these regulations beyond model year 2018 (The White House, 2014b).

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However, technical efficiency improvements do not always meet engineering expectations for fuel consumption and emissions reductions due to what is called the "rebound effect" (Berkhout et al., 2000; De Borger and Mulalic, 2012; Greene, 2012; Greene et al., 1999; Greening et al., 2000; Hymel and Small, 2015; Matos and Silva, 2011; Small and Van Dender, 2005; Sorrell and Dimitropoulos, 2007; Winebrake et al., 2012). The rebound effect refers to the phenomenon whereby technical efficiency improvements effectively reduce the fuel cost of an energy service, thereby inducing increased activity or demand for the service, "taking back" some of the intended energy savings.[1] Policymakers must understand the anticipated magnitude of the rebound effect to better estimate the actual changes in energy consumption and emissions in response to technical efficiency improvement standards.

Estimating the rebound effect for the HDV sector is challenging for a variety of reasons. In addition to reasons discussed in previous work (Winebrake et al., 2012), robust time-series data on HDV fuel efficiency is lacking, as discussed in the concluding section of this paper. As an alternative, one can look to other elasticities – such as fuel price elasticities of HDV VMT – as proxies for the rebound effect under certain assumptions, including the assumption that firms respond to price increases and decreases symmetrically; that firms respond to changes in fuel prices and fuel efficiency uniformly; and that fuel efficiency itself is not affected by fuel price (Winebrake et al., 2012). However, there is some suggestive evidence in the literature that these assumptions may not hold (e.g. Dargay and Gately, 1997; Gately, 1993; Greene, 2012; Hymel and Small, 2015; Sentenac-Chemin, 2012; Winebrake et al., 2012).

This paper builds off new methodological approaches recently applied to combination truck data to estimate fuel price elasticities of single-unit truck activity (measured in VMT) (Winebrake et al., 2015). The paper applies both a first-difference model and an error correction model (ECM) using data from 1980 to 2012. By themselves, these calculated elasticities provide valuable information for evaluating the impact of fuel price changes (either market-driven or policy-driven). However, in combination with other assumptions these elasticities may also provide insights into rebound effects under certain limiting conditions (Winebrake et al., 2012).

The paper is divided into five main sections. The next section ('Background') provides context surrounding the research question. That is followed by a 'Data and methodology' section, which presents the data and modeling approach used; and 'Results' and 'Discussion' sections that present our results and discuss their importance, respectively. We end with a 'Conclusion' section that provides greater context for our results and identifies areas of future research.

Background

Energy consumption in the US heavy-duty vehicle sector

The HDV sector in the US may be categorized by vehicle sub-sectors. For our purposes, we follow US practice and divide the sector into "combination trucks" or "single-unit trucks." Combination trucks include "all [Class 7/8] trucks designed to be used in combination with one or more trailers with a gross vehicle weight rating over 26,000 lbs" (AFDC, 2014; ORNL, 2013). Single-unit trucks include "single frame trucks that have 2 axles and at least 6 tires *or* a gross vehicle weight rating exceeding 10,000 lbs" (FHWA, 2013a), and include for instance, refuse trucks and local delivery trucks.

As shown in Figs. 1 and 2, miles traveled and fuel consumption for both combination and single-unit trucks have been increasing over time, with the exception being the aftershocks of the 2008 recession, which reversed the upward growth trends exhibited since 1980.[2] The figures also show that single-unit trucks have made up a fairly consistent proportion of VMT and fuel consumption in the HDV sector since 1980. For example, in 1980 single-unit trucks made up about 37% of HDV VMT and 35% of HDV fuel consumption; in 2012, single-unit trucks made up about 39% of HDV VMT and 34% HDV fuel consumption. Since the HDV sector consumes about 25% of all energy used in the transportation sector in the US (BTS, 2014b,c,d,e), we estimate that single-unit trucks and combination trucks are responsible for ~8% (0.34×0.25) and ~17% (0.66×0.25) of that total energy consumption, respectively.

Fuel price elasticities and rebound effects in the literature

As discussed in previous work (Winebrake et al., 2012), the vast majority of literature examining rebound effects and fuel price elasticities of vehicle travel demand focuses on LDVs (Dahl, 2012; Espey, 1998; Graham and Glaister, 2004; Greene, 2012; Litman, 2013; Poor et al., 2007). Fuel price elasticities of LDV travel demand are typically in the range of −0.10 to −0.30, though research has indicated these elasticities may change over time (Brons et al., 2008; Dahl, 2012; Goodwin et al., 2004; Greene, 2012; Li et al., 2014; Litman, 2013). Unfortunately, because the HDV sector is quite different than the LDV sector – namely due to reasons related to vehicle ownership (individuals vs. firms) and incentives (maximizing consumer utility vs. profit maximization and cost minimization) (Berkhout et al., 2000) – LDV rebound effect estimates cannot be applied to the HDV sector with any confidence.

[1] This is the definition of "rebound effect" we use in this paper, which is a common description found in the literature. We note that there are different types of rebound effects discussed in the literature – e.g., direct, indirect, and economy-wide (Winebrake et al., 2012). The results of our paper are most relevant for estimating the direct HDV rebound effect.

[2] Figs. 1 and 2 demonstrate a data collection issue that occurs in the 1999–2000 period and reflects a methodological shift in how the US FHWA collected data from the trucking sector. This shift is statistically important and is addressed in the methodology section of this paper.