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Energy efficiency and rebound effect in European road freight transport

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ABSTRACT

Energy efficiency has become a primary energy policy goal in Europe and many countries and has conditioned the policies towards energy-intensive sectors such as road freight transport. However, energy efficiency improvements can lead to changes in the demand for energy services that offset some of the achieved energy savings in the form of rebound effects. Consequently, forecasts of energy savings can be overstated. This paper analyses the energy efficiency and rebound effects for road freight transport in 15 European countries during the 1992–2012 period. We use a recent methodology to estimate an energy demand function using a stochastic frontier analysis approach and examine the influence of key features of rebound effect in the road freight transport sector. We obtain, on average, a fuel efficiency of 89% and a rebound effect of 4%. Our results indicate that the achieved energy efficiencies are retained to a large extent. We also find, among other results, that the rebound effect is higher in countries with higher fuel efficiency and better quality of logistics. Finally, a simulation analysis shows significant environmental externalities costs even in countries with lower rebound effect.

1. Introduction

In recent decades there has been an increasing interest in adoption of energy and environmental policies that stimulate energy consumption reduction. The main goals of these policies are to reduce dependence on fossil fuels and mitigate the emissions of pollutants and Greenhouse Gas (GHG) emissions. This has in particular been the case for energy-intensive sectors such as transportation. In 2010, freight transport accounted for about 43% of global energy use in transport, which in turn represented 12% of total energy consumption and 10% of energy-related CO_2 emissions (IPCC, 2014). Moreover, the amount of fuel used by the trucking industry is expected to rise in the US and the EU (Léonardi and Baumgartner, 2004; IEA, 2010; De Borger and Mulalic, 2012), where trucks and vans emit 67% of the GHG emissions associated with transport (McKinnon, 2015).

A major means to tackle these issues has been to promote energy efficiency. Different countries have adopted different targets and policies to achieve energy and environmental objectives. In the European Union, where transport accounts for 25% of energy-related GHG emissions (Walnum et al., 2014), the European Commission has passed specific directives for the sector. Since the introduction of the Council Directive 88/77/EEC in 1988 and followed by other legislation, the implementation of 'Euro' Standards and the 2001 White Paper on transport, the energy consumption reduction objective have

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been partially achieved. The objective has been to reduce GHG emissions by 80–95% below the 1990 levels by 2050. The Commission recognises that the specific targets for the transport sector need to be adjusted downwards to 60% due to the complexity of this sector (European Commission, 2011; Walnum et al., 2014). The development and deployment of new and more efficient technologies remain one of the main strategies to achieve these objectives.

Broadly, energy efficiency improvement can be viewed as a reduction in energy use while the same level of demand for energy services is maintained and the comfort and quality of life are not reduced.[1] When energy savings are estimated based on potential energy efficiency enhancements, it is normally assumed that the demand for energy services remains the same. However, as these improvements also imply a reduction in the relative cost of the service, they may also lead to some increase in demand for energy services. This increase in energy consumption can, partially or totally, offset the initial expected savings. This phenomenon, or the so-called rebound effect, is normally overlooked in energy demand forecasts and design of energy and environmental policies.[2] If the magnitude of this effect is non-negligible, policies to reduce energy consumption through promotion of energy efficiency may not be fully effective.

Some researchers consider rebound effect as a natural adjustment to changing economic factors. Borenstein (2015) states that rebound effect can be considered as a reoptimisation process in response to variations of price and income. This means that rebound effect can be treated as welfare improvement in standard economic analysis. It should be noted that in order to assess the net effect of rebound effect on the overall welfare, the external costs generated by this phenomenon should also be incorporated in the analysis.

There is a large and diverse literature on rebound effect that analyse a broad range of countries, economic sectors using alternative definitions and measures. In the case of the transport sector, most estimates of rebound effects are in the range of 10 to 30% (see, e.g., Sorrell, 2007; Hymel et al., 2010), though large estimates have also been obtained both in the short and the long run.

Rebound effect is also relevant in road freight transport. Maxwell et al. (2011) state that fuel efficiency improvement reduces the cost of freight transport which in turn make transportation cost efficient for more goods, for longer distances and with more frequency. This implies that fuel consumption could be reduced less than expected as a result of energy efficiency improvement. However, due to the lack of empirical studies and limited understanding of rebound effect in this sector, further research is needed (Winebrake et al., 2012, 2015a,b). Measuring rebound effect in road freight is also relevant from a policy perspective to assess the effect of energy efficiency improvements and national and international energy and climate change policies (Geller et al., 2006; Barker et al., 2007).

This paper aims to partially contribute to fill this gap in the literature by carrying out an empirical analysis of energy efficiency and rebound effect in the road freight transport of 15 European countries for the period 1992–2012. We use a recent econometric approach based on the estimation of Stochastic Frontier Analysis (SFA) models to estimate energy demand frontier functions. Through explicit modelling of energy efficiency, this approach allows us to obtain separate energy efficiency and rebound effect for each year of the study period and the countries analysed. Moreover, this method allows us to examine the determinants of rebound effect in the sector. The main contributions of the paper are in the application of the new methodology and the novelty of the sector analysed.

The paper is organised as follows. Section 2 provides a brief review of the literature on the demand for energy in road freight transport and the rebound effect. Section 3 describes the methodology and the specification of the energy demand function to be estimated. Section 4 presents the data used in the empirical analysis, reports the parameter estimates and presents the results obtained from those estimates. Section 5 is conclusions.

2. Energy demand and rebound effect in road freight

The demand for road fuel is a derived demand for energy services in road transport. In essence this implies that there is a demand for transporting goods and people that is to be satisfied through a combination of capital, labour and fuel. There is an extensive body of literature on the economics of transport in which the demand for fuel is modelled through a range of approaches such as econometric techniques, artificial intelligence approximations, multi-criteria analysis or simulation methods (see, e.g., Limanond et al., 2011; or Suganthi and Samuel, 2012).

Among the econometric approaches, Llorca et al. (2017) propose modelling the demand for fuel in the transport sector in Latin American and Caribbean countries through the estimation of several SFA models. This approach was proposed by Filippini and Hunt (2011) to estimate aggregate energy frontier demands and allows obtaining measures of the energy efficiency of specific sectors or for the whole economy.[3] In this framework fuel is considered an input factor that is used in combination with other inputs to produce energy services. According to Filippini and Orea (2014) aggregate energy demand frontier functions can be understood as reduced-forms of underlying structural models that are based on utility optimising problems.

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[1] Sustainability and environmental issues can also be incorporated into this broad definition.

[2] There are, however, some exceptions in where rebound effects are considered by policy-makers. One example is in the evaluation of the voluntary agreement package by the British Department of Transport (DfT, 2005). The existence of rebound effect (labelled as "comfort taking") is recognised and calculated in this evaluation and incorporated in their macroeconomic models. Nevertheless, rebound effect has not been generally considered as a "self-consistent political issue" (Gloger, 2011) in many countries.

[3] The use of this type of approach has become common in recent years (see, Evans et al., 2013; Filippini and Hunt, 2011, 2012, 2015a,b; Filippini and Zhang, 2016; Filippini et al., 2014; Llorca et al., 2017; Lundgren et al., 2016; and Orea et al., 2015).