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Elasticities of fuel and traffic demand and the direct rebound effects: An econometric estimation in the case of Norway

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ABSTRACT

We estimate the elasticities of fuel and travel demand with respect to fuel prices and income in the case of Norway. Furthermore, we derive the direct rebound effects that explain the degree to which a fuel price increase is "offset" in the form of greater fuel use and/or travel due to improvements in vehicle fuel efficiency. For this purpose, we use and compare two alternative econometric approaches: the error correction model (ECM) and the dynamic model. Our initial assumption is that one should not be indifferent with respect to the approach used to derive elasticities. The data used are for the period 1980–2011. Our results indicate the following: (1) the dynamic model fits the data better than the ECM model does; (2) the estimated elasticities of fuel demand with respect to price and income are −0.26 and 0.06 in the short run and −0.36 and 0.09 in the long run. For travel demand, the respective elasticities are −0.11 and 0.06 in the short run and −0.24 and 0.13 in the long run, implying inelastic demands for fuel and travel demand; and (3) rebound effects indicate that 0.26% and 0.06% of fuel savings as a result of fuel price increase will be offset in the form of more fuel use in the short run and in the long run, respectively, if fuel efficiency increases by 1%. Our policy recommendations are that policies should not be indifferent to the methods used to derive elasticities. We contend that it is crucial to seriously consider rebound effects in policy making because basic elasticity estimates exaggerate the impact of fuel price increases.

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1. Introduction

The determinants of fuel and travel demand have received substantial attention since the early 1970s. The 1973 oil crisis that had global ramifications appears to have encouraged economic and transportation planners to begin to seriously consider the determinants of fuel and travel demand (Espey, 1996). It has since become apparent that understanding the determinants of fuel and travel (road traffic) demand represents a key to the development of transportation and environmental policies. Policy questions that have since become common in this respect include but are not limited to the following: how does the demand for fuel and road travel respond when the price of fuel increases (decreases); how does the demand for fuel and road travel respond if disposable income per capita increases (decreases); what are the appropriate levels of fuel taxes to achieve a certain amount of emissions, e.g., CO_2 reduction; and do increases in fuel prices or taxes have a pure effect on the

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demand for fuel and travel or is there a ''rebound'' effect in the sense that technological developments make vehicles more fuel efficient, thus inducing individuals to use more fuel or travel more (and thus to consume more fuel), thereby crowding out the intended impact of fuel price increases.

To accurately address these questions, a measure of the responsiveness of fuel and travel demand to changes in factors that affect demand, such as fuel price and income, is necessary. The notion of demand elasticity represents such a response measure. Typically, transportation policy makers consider six informative demand elasticities that are measured in this respect: (1) the elasticity of travel demand as measured by vehicle kilometers (VKM) traveled with respect to the price of fuel; (2) the elasticity of fuel demand with respect to the price of fuel; (3) the elasticity of fuel demand with respect to disposable income; (4) the elasticity of travel demand with respect to income; (5) the elasticity of fuel demand with respect to fuel efficiency; and (6) the elasticity of travel demand with respect to fuel efficiency. The latter two elasticities are rarely considered in the transportation literature, whereas they are commonly considered in the energy literature; see, for instance, Matos and Silva (2011). Information concerning these elasticities is indispensable for policy makers: they determine the magnitude of the so-called rebound-effects, which determine the percentage of the impact of fuel prices on the demand for fuel and travel that, will be either offset or crowded out as a consequence of increased fuel efficiency.

Numerous econometric methods are used to derive the above mentioned elasticities, which vary widely in the literature, see, for instance, Graham and Glaister (2005) and Goodwin et al. (2004) for reviews. The estimates of these elasticities may therefore depend on the method used. This implies that one should not be indifferent with respect to the method used and, ideally, use different econometric approaches to gain insights into the impact of the methodologies employed; see, e.g., Li et al. (2010).

In this paper, we estimate the elasticities of fuel and travel demand with respect to fuel prices and income in the case of Norway. Furthermore, we derive the direct rebound effects. To estimate the elasticities, we use two econometric approaches: the error correction model (ECM) and the dynamic model. We use time-series data for the period 1980–2011, a period for which data are highly reliable with respect to the databases available and that experienced no particularly alarming oil shocks. Thus, the main objective is to obtain reliable elasticity estimates that can be used in first-stage policy calculations to project the expected changes in road traffic and fuel demand at the national level.

This paper makes numerous contributions to the literature on transportation economics and planning. The first and that should be stressed is that, whereas the elasticities of fuel and road traffic demand with respect to their determining factors are abundant in the literature, the elasticity of fuel efficiency remains under-addressed. Therefore, the derived elasticities are often under-/overestimated. Second and that should also be stressed is that, in the transportation literature, different types of modeling methods have been applied to estimate fuel and road traffic demand, each of which has methodological advantages and disadvantages. Therefore, it is useful to consider alternative methods to ascertain the extent to which the derived results are method dependent, as suggested by, e.g., Li et al. (2010). However, as has been demonstrated in Dahl and Sterner (1991), if carefully stratified, compared and interpreted, different methods and data types tend to yield a reasonable degree of consistency. Thus, although we compare two approaches and choose the method that best fits the data, this does not necessarily imply that the discarded method is irrelevant. Instead, it simply indicates that the discarded method does not fit our data well relative to the method selected. Third, previous measurements of the elasticity of road travel and fuel demand with respect to fuel prices and income for Norway date to the 1990s, see Fridstrøm (1998). However the elasticity of fuel efficiency with respect to fuel prices has yet to be investigated. Thus, more current elasticities for Norway are unavailable in the literature, as the magnitudes of elasticities may change over time.

The remainder of this paper is organized as follows. Section 2 presents a literature review. Section 3 describes the theoretical model used to derive the five above mentioned elasticities, including the rebound effect. Section 4 describes the data used, and Section 5 presents the results. Section 6 provides concluding remarks.

2. Literature review

A variety of studies have examined how the demands for fuel and road transportation relate to the price of fuel and income. With respect to the international literature, numerous studies examine the elasticity of fuel prices and income with respect to fuel and road travel demand, and it is nearly impossible to review them all. In addition to the numerous country-specific studies, others have surveyed or reviewed the literature, which if summarized, provide an adequate overview of the literature. The most notable reviews in recent decades are those of Dahl and Sterner (1991), Espey (1998), Goodwin (1992), Graham and Glaister (2002), Goodwin et al. (2004) and Fouquet and Pearson (2012). With respect to the rebound effects, Sorrell et al. (2009) provide the most recent review of studies that include transportation and energy in general. The findings from these studies are briefly summarized below.

In their early review of the elasticities of fuel demand, Dahl and Sterner (1991) argued that the shorter the time period, the greater the emphasis on the short-run character of the elasticity. They reported mean long-run elasticities of −0.53 for fuel prices and 1.16 for income. The mean short-run elasticities were approximately half the size of the long-run elasticities.

Espey (1998) acknowledged the findings of Dahl and Sterner (1991) but used a meta-analysis to determine whether factors exist that systematically affect price and income elasticity estimates in studies on fuel demand. Explanatory variables in the meta-regression model include functional form, lag structure, time span, national setting, estimation technique, and other features of the models employed. In the studies included here, short-run price elasticity estimates of the demand

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