Transportation Research Part A 103 (2017) 154–171

Contents lists available at ScienceDirect

Transportation Research Part A

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

Estimating the price elasticity of fuel demand with stated preferences derived from a situational approach

Reinhard Hössinger [a], Christoph Link [a], Axel Sonntag [b], Juliane Stark [a,*]

[a] Institute for Transport Studies, University of Natural Resources and Life Sciences, Peter Jordan Str. 82, 1190 Vienna, Austria
[b] Vienna Center for Experimental Economics, University of Vienna, Oskar-Morgenstern-Platz 1, 1090 Vienna, Austria

ARTICLE INFO

Article history:
Received 19 July 2016
Received in revised form 18 May 2017
Accepted 5 June 2017

Keywords:
Price elasticities
Fuel demand
Stated preference
Choice experiment
Discrete choice modelling

ABSTRACT

An evidence-based policy debate about future fuel demand requires reliable estimates for fuel price elasticities. Such predictions are often based on revealed preference (RP) data. However, this procedure will only yield reliable results in the absence of severe structural discontinuities. In order to overcome this potential limitation we used a situational stated preference (SP) survey to estimate the response to hypothetical fuel price changes beyond the scope of previous observations. We elicit fuel price elasticities for price increases up to four Euros per liter and find that the situational approach predicts the actual responses to previously observed fuel price changes very well. We conclude that applying a situational approach is particularly useful, if behavioral predictions for unprecedented (non-monetary) policy interventions or supply side shocks are of interest that go beyond the reach of standard RP approaches.

1. Introduction

Climate protections goals, strategic energy security and reducing local emissions are good reasons why policy makers might have a vivid interest in reducing fossil fuel consumption. It is therefore no surprise that much attention has been paid to the transport sector and its dependency on fossil fuels, particularly since the crude oil shocks in the 1970s and thereafter. Independent of the specific fuel consumption target, it is crucial to have a good understanding of how the fuel demand would react to (policy induced) fuel price changes. This article complements the literature by proposing a *situational* stated preference approach to provide a complementary tool for estimating fuel price elasticities, particularly for unprecedentedly high fuel price increases.

The fuel price elasticity of demand is typically derived from revealed preference (RP) data (for a recent application see Odeck and Johansen, 2016). This technique is feasible if the environment is sufficiently stable. However, RP estimates imply an extrapolation from the range of past variation. If the environment changes dramatically in terms of new options or a fundamental change of circumstances, this may cause biased results (Ortúzar and Willumsen, 2011). In this paper, we argue that especially when the conditions of fuel consumption are expected to change drastically, using a stated preference survey that takes behavioral choice constraints into account (situational approach) could be a valuable complementary estimation technique. In fact, the situational approach has already successfully been applied in other disciplines but, to our knowledge, has not been used to estimate the effect of fuel price increases on fuel demand of private households. This paper is the first to

* Corresponding author.
E-mail addresses: reinhard.hoessinger@boku.ac.at (R. Hössinger), christoph.link@boku.ac.at (C. Link), axel.sonntag@univie.ac.at (A. Sonntag), juliane.stark@boku.ac.at (J. Stark).

http://dx.doi.org/10.1016/j.tra.2017.06.001
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contrast results from estimating fuel price elasticities from aggregate consumption data (RP) with a particular version of a stated preference approach (SP) which considers important situational constraints to travel decisions such as trip chains, passengers, weather conditions, etc. as well.

We found that the elasticity estimates derived from our situational SP approach very well correspond with actually observed demand behavior. We discuss the merits of both approaches and conclude that the higher effort of using a SP method might be well invested if behavioral predictions for unprecedented price increases or non-monetary policy interventions are of interest.

Section 2 briefly reviews estimates of fuel price elasticity in the literature and Section 3 explains the situational approach in detail. Section 4 describes the used sample and the estimated models and Section 5 presents simulation results of fuel demand. Finally, Section 6 discusses the results and Section 7 concludes with the main findings of the paper.

2. Background

The magnitude of the price elasticity of fuel demand is subject of an extensive debate in both the academic and the policy realm (Frondel and Vance, 2010). A key issue of concern is the uncertainty of estimation caused by the complex nature of fuel demand. It is the result of lots of different decisions, each of which is influenced by many factors. Whether or not a car trip will be replaced or omitted in response to an increasing fuel price does not only depend on the cost, but also on situational factors such as trip purpose, time pressure, luggage or passengers to carry, weather conditions, etc. Given that travel decisions are strongly related to other household decisions, activity-based models are a promising approach to better understand the travel behavior within the context of overall time and budget allocation.

In the realm of fuel demand models, Johansson and Schipper (1997) introduced a concept that we followed in our work. They estimated the long term fuel demand for cars based on aggregate data of 12 OECD countries. Importantly, the total demand was evaluated by separately estimating total vehicle stock, mean fuel intensity, and mean annual driving distance. Based on this seminal contribution, Brons et al. (2008) picked up the idea for a meta-analytical study of the price elasticity of gasoline demand. They decomposed the total fuel demand of passenger road transport into three different elasticities: car ownership, fuel economy (specific fuel consumption of the vehicle), and travel demand. This is still an over-arching framework; each of the three elasticities is an aggregate of many different reactions. More fuel economy for instance can be achieved by purchasing a hybrid car, using the more fuel efficient car among those cars available in the household (De Borger et al., 2016a), or driving in fuel saving mode. The possible reactions to reduce car travel demand are even more versatile: switching to car passenger or transit, driving to a closer destination, staying at home, etc. Related to that, Austin and Dinan (2005) emphasized an important difference between fuel economy and travel demand, when they estimated the costs of reducing gasoline consumption by increasing corporate average fuel-economy (CAFE) standards. The maximum gasoline savings would be realized only after all existing vehicles were replaced (14 years in their model), whereas a gasoline tax would produce greater immediate savings by encouraging people to drive less. Considering the above, we describe how we operationalized the individual parts of our framework in Section 4.1.

When it comes to data commonly used for estimating the price elasticity of fuel demand, Dargay (2007) distinguishes two sorts of RP data: panel data and aggregate time-series data, made up of observations over long periods of time of large groups of individuals. In a meta-analysis of 69 primary studies covering both kinds of data sources, Goodwin et al. (2004) found that short term elasticities range from −0.01 to −0.57, but only a small part of this range could be assigned to specific factors such as exposure time (short term vs. long term), different countries, and different years of measurement.

Table 1 lists several RP estimates of price elasticities of fuel demand reported in the literature. They are based on a wide range of geographical areas, mostly focusing on North America, and some of them are rather advanced in age. The table distinguishes between short term and long term responses and also between disaggregate and aggregate data sources. According to Goodwin (1992) and Goodwin et al. (2004), short term responses are those made within one period, while long term refers to the asymptotic end state when responses are completed; in most cases periods of 5–10 years, within which the greatest change happens in the first 3–5 years. Other authors such as Puller and Greening (1999) distinguish between changes in travel demand (short term) and changes in vehicle stock (long term).

With respect to the level of aggregation it is well recognized that estimates derived from aggregate data face severe limitations: They ignore that different individuals may have diverging consumption responses to the same price fluctuations (Wadud et al., 2010a, 2010b). Consequently, a fuel tax can impose critical hardship on parts of the population (Kayser, 2000), even if the average response suggests a moderate effect. The hardship will likely cause political barriers to implementation. Despite this limitation, it seems that the average elasticity estimates of disaggregate and aggregate data sources do not differ systematically from each other on a ceteris paribus basis. This is important for our study, which includes a comparison of elasticity estimates from disaggregate and aggregate data (see Section 5).

It is however well documented that the price elasticity of fuel demand varies a lot with respect to many other dimensions. For example, Huntington (2010) found that a new all-time high has a larger effect than sub-maximum changes, i.e. price cuts and recoveries. The population group makes a difference, too. According to Kayser (2000) rural households and those with no public transport available are more resistant to higher fuel prices than those in an urban setting and with access to public transport. Wadud et al. (2009) found the elasticity to follow a U-shape across five different income groups, while De Borger et al. (2016b) report a decreasing fuel price elasticity of driving demand among groups with higher income. Moreover, Dahl