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A meta-analysis on the price elasticity of energy demand☆

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ABSTRACT

Price elasticities of energy demand have become increasingly relevant in estimating the socio-economic and environmental effects of energy policies or other events that influence the price of energy goods. Since the 1970s, a large number of academic papers have provided both short and long-term price elasticity estimates for different countries using several models, data and estimation techniques. Yet the literature offers a rather wide range of estimates for the price elasticities of demand for energy. This paper quantitatively summarizes the recent, but sizeable, empirical evidence to facilitate a sounder economic assessment of (in some cases policy-related) energy price changes. It uses meta-analysis to identify the main factors affecting short and long term elasticity results for energy, in general, as well as for specific products, i.e., electricity, natural gas, gasoline, diesel and heating oil.

1. Introduction

In contemporary economies, energy is a key element for the production of goods and services; but it is also a direct source of welfare for individuals. It is therefore crucial to know how price changes, given by market dynamics and/or energy-related public policies, affect producer and consumer energy demand. Over the last few years energy deregulation and sharp movements in the price of primary energy goods, together with policies related to climate change and energy security concerns, have actually fostered renewed interest in this area. Energy savings are likely to play a crucial role in attaining climate objectives (see e.g. IPCC, 2014), thus the need to correctly quantify actual mitigation potentials within energy demands. Robust evidence on price elasticities of energy demand could facilitate a better understanding of the environmental, economic and distributional[1] consequences of varying energy prices and enable societies to make *ex-ante* decisions on energy and environmental matters.

Although the economic literature on energy demand dates back to the last century (it began with Houthakker (1951)), a large number of recent academic studies have used several techniques to estimate (both short and long-term) price elasticity demand for different energy products in various countries, thus yielding rather sizeable empirical evidence. Given the practical relevance of price elasticities of energy demand within this context, it is particularly interesting to develop methods that summarize (qualitatively and quantitatively) existing evidence and identify the main factors systematically affecting the results. Meta-analysis, or the statistical analysis of studies in an area, first proposed by Glass (1976) in the field of education but subsequently extended to many other disciplines, seems to be an appropriate and useful approach for this purpose. After the work of Stanley and Jarrell (1989), multiple meta-analyses have been conducted in economics; at least one third of these studies relate to environmental and resource economics (Nelson and Kennedy, 2009).

Unfortunately the use of meta-analysis has been rather limited in the field of energy demand. The few existing exercises focus almost exclusively on price elasticities of gasoline demand. So the first objective of this paper is to incorporate other energy goods, i.e., electricity, natural gas, diesel, heating oil and energy in general, and provide a more profuse analysis and improved conclusions concerning growing empirical evidence on price elasticities in the energy domain.

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[1] In this context, energy goods may be particularly exposed to price increases and collateral distributive effects from post-Paris climate policies (see Sterner (2007)). However, the analysis of the distributive impacts of energy price variations is beyond the scope and capabilities of this article. For a detailed discussion on this matter see Sterner (2012).

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Table 1
Selected surveys on price elasticity of energy demand.

Study	Energy Product	Elasticity range	
		Short-term	Long-term
Taylor (1975)	Electricity	[−0.90; −0.13]	[−2.00; 0]
Kouris (1983)	Car fuels	[−0.26; −0.05]	[−1.77; −0.18]
	Energy	[−0.79; 0.30]	[−1.75; 1.03]
Bohi and Zimmerman (1984)	Electricity	[−0.88; −0.07]	[−4.56; −0.18]
	Gasoline	[−0.77; −0.07]	[−1.59; −0.14]
	Heating oil	[−0.19; −0.18]	[−0.67; −0.62]
	Natural Gas	[−0.63; −0.03]	[−3.44; −0.26]
Drollas (1984)	Gasoline	[−0.78; −0.07]	[−1.37; −0.23]
Dahl (1986)	Gasoline	[−0.52; −0.01]	[−1.61; −0.05]
Al-Sahlawi (1989)	Natural Gas	[−0.95; −0.05]	[−4.60; −0.12]
Dahl and Sterner (1991a)	Gasoline	[−0.77; 0.28]	[−2.72; −0.29]
Dahl (1995)	Gasoline	[−0.8; 0]	[−1.6; 0]
Graham and Glaister (2004)	Car fuels	[−2.13; 0.59]	[−22.00; 0.85]
Basso and Oum (2007)	Car fuels	[−0.37; −0.04]	[−1.12; −0.12]
Dahl (2012)	Diesel	[−0.94; 2.13]	[−6.18; 2.29]
	Gasoline	[−1.65; 0.63]	[−61.11; 5.89]

It also contemplates aggregated as well as residential, industrial and commercial energy demand. However, it only deals with the latest evidence available (papers published as of 1990) for two reasons: the need to update and relate a scarce number of academic contributions that previously considered these matters through comparable methodologies, and the remarkable increase in the quality and reliability of recent results given the significant technical advances in data collection and processing witnessed throughout the last two decades.

This research carries out a meta-analysis following the procedure outlined by Nelson and Kennedy (2009), using a regression analysis (see also Stanley and Jarrell (1989)). That is to say, it performs a regression analysis employing the entire set of results selected from the literature and an extensive specification of the factors determining these elasticities. Thus, the paper addresses the need to determine, as accurately as possible, the value of price elasticities of energy demand in general as well as the price elasticities of the demand for the aforementioned energy goods. As a secondary outcome, it identifies the variables that explain the heterogeneity of price elasticities reported in the literature.

The article is divided into five sections, including this introduction. The second section describes existing academic literature using meta-analysis to summarize and analyze price elasticities of energy demand. The subsequent part provides details on the implemented empirical application and also describes the factors that influence the estimation of price elasticities for energy demand. Section 4 presents the empirical results obtained by applying the meta-analysis to the updated literature review, and Section 5 concludes. The paper also includes two annexes with full estimation results and a list of the papers employed in the meta-analysis, respectively.

2. Meta-analyses of price elasticities of energy demand

A number of papers have used a variety of studies, methodologies, time spans and geographical areas to summarize the empirical literature on price elasticities of energy demand. Table 1 presents a selection of surveys that depict a large variability in the estimated short and long-term elasticities. Most surveys attempt to identify the factors behind such dispersion; in some cases they also try to approach the true elasticity value (see e.g. Dahl and Sterner, 1991b; Goodwin, 1992).

At any rate, the large number of surveys on price elasticities of energy demand contrasts with scarce attempts by the literature to summarize these elasticities in a single value through meta-analysis. What is more, as we may see in Table 2, most of these existing meta-analyses have been applied to the literature on price elasticities of gasoline demand.

In particular, Espey (1996) carried out the first meta-analysis that included the characteristics of the data, the model structure and the estimation technique as explanatory variables to examine the existence of factors systematically affecting gasoline price (and income) elasticity estimates in the United States. An extension of this work is provided in Espey (1998), with the use of existing empirical evidence on gasoline demand across the globe and the separate analysis of long-term and

Table 2
Meta-analyses for price elasticity of energy demand.
Source: Brons et al. (2008) and the cited literature.

Study	Period	Considered papers	Observations	Energy Product	Elasticities
Espey (1996)	1936–1990	41	70	Gasoline	−0.65 (LT)
Espey (1998)	1929–1993	101	640	Gasoline	−0.16 (ST) −0.81 (LT)
Hanly et al. (2002)	1929–1991	69	491	Car fuels	−0.76 (ST) −1.16 (LT) −0.54 (STA)
Graham and Glaister (2002)	1966–2000	113	600	Car fuels	−0.25 (ST) −0.77 (LT)
Espey and Espey (2004)	1947–1997	36	248	Electricity	−0.35 (ST) −0.85 (LT)
Brons et al. (2008)	1949–2003	43	312	Gasoline	−0.36 (ST) −0.81 (LT)
Havranek et al. (2012)	1974–2011	41	202	Gasoline	−0.09 (ST) −0.31 (LT)

Note: LT, long term; ST, short term; STA, result obtained by using only papers that employ statistical models.