Energy 79 (2015) 40–49

Contents lists available at ScienceDirect

Energy

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

Demand and price uncertainty: Rational habits in international gasoline demand

K. Rebecca Scott

Oxford University, Department of Economics, Manor Road, Oxford, OX1 3UQ, UK

ARTICLE INFO

Article history:
Received 30 July 2014
Accepted 23 September 2014
Available online 6 November 2014

Keywords:
Gasoline demand
Price elasticity
Rational habits

ABSTRACT

Given a rational agent, demand for a habit-forming good is sensitive to uncertainty in future prices. In particular, price uncertainty reduces both the level and the price responsiveness of demand. These two effects, which may bear heavily on the efficacy of policies to discourage consumption of harmful addictive goods, can be tested by augmenting a simple demand model with a measure of price uncertainty.

Modeling gasoline as a habit-forming good offers a succinct way to capture the investment and behavioral decisions that determine gasoline usage. An uncertainty-augmented model is therefore applied to gasoline demand across a panel of 29 countries, 1990–2011. Price uncertainty as proxied by a measure of forecast error does in fact depress the level and the price responsiveness of demand. This suggests that consumers care about the time-series process of gasoline prices, and that traditional demand models will systematically mis-predict the consumer reaction to any policy that tinkers with this process.

1. Introduction

Concern about energy security and the environment has fostered widespread interest in reducing gasoline consumption—and in the policies that might do so. The effectiveness of those policies hinges on gasoline demand and the behaviors that drive it.

Gasoline's entanglement in day-to-day routines, as well as its role as a substitute or complement to a variety of investments, implies that its demand will be influenced by price dynamics. Although consumers pay for fuel at the pump, their gasoline purchases are determined largely outside the gas station—via nearly-continuous choices about alternative transport, non-essential travel, and other aspects of daily life; and via discrete, infrequent choices about what kind of vehicle to drive and where to live in relation to work. The habitual nature of the former choices and the investment nature of the latter help to explain consumers' sluggish response to price changes, and also suggest that forward-looking consumers will be sensitive to the expected *path* of gasoline prices. Sluggishness is usually incorporated into gasoline demand models. Price dynamics are not.

One way to incorporate habitual and investment behavior into demand is via a rational habits model. ‘Habits’ here means only that a consumer's utility for a good is a function of past consumption. Since past consumption was influenced by past investments, the habit mechanism captures investment-driven behavior alongside any reluctance to adjust routines. ‘Rational’, meanwhile, implies that the consumer is forward-looking and aware of his utility function. When deciding his current gasoline consumption, the consumer considers how this will affect his future utility. The burden of a gasoline habit depends on future market conditions, and so demand in this model depends on the consumer's expectations of the future, particularly of future prices.

Demand models that ignore price dynamics have the potential to skew measurements of price elasticity and provide misleading evaluations of policy options. If indeed rational habits shape behavior, demand will be a function not only of the current price, but of the *process* by which prices are generated: price uncertainty will reduce demand and dampen the effect of price changes. Any policy that changes the gasoline price process will have an effect that is systematically mis-forecast by a traditional demand model.

2. Literature review

Despite the potential importance of price dynamics and rational habits, they have received relatively little attention in the gasoline demand literature. Scott [61] applies rational habits theory to US gasoline demand, showing that consumers react to future taxes and

E-mail address: rebecca.scott@economics.ox.ac.uk.

http://dx.doi.org/10.1016/j.energy.2014.09.066
0360-5442/

that they respond more strongly to tax- than to market-driven price changes. The latter effect is also demonstrated in Scott [63] and Li, Linn, and Muehlegger [40]. An analogous effect is apparent in Canada, where Rivers and Schaufele [55] find British Columbia's carbon tax to provoke a greater reduction in gasoline use than a comparable non-tax price increase.

Aside from this recent attention to gasoline price components, which are likely to behave differently from one another over time, most work has considered prices only in terms of their total contemporary values. Indeed, the predominant focus in the gasoline demand literature has been on measuring simple income and price elasticities. Studies that estimate these elasticities abound: in a 1998 meta-analysis, for instance, Espey [29] considers 363 short- or medium-run and 277 long-run price elasticities. These elasticities run a wide gamut, with own-price elasticity estimates ranging from 0 to −1.36 in the short run and 0 to −2.72 in the long run, and income elasticity estimates ranging from 0 to 2.91 in the short run and 0 to 2.73 in the long run. Across the major recent literature reviews, average price elasticity lies around −0.25 to −0.3 in the short run and −0.6 to −0.8 in the long run, while average income elasticity is about 0.4 in the short run and approximately unit elastic in the long run. Results of these reviews are summarized in Table 1.

The majority of the studies included in these reviews are based on partial adjustment models. In recent years, increasing attention has been diverted towards error-correction models and questions of cointegration. Table 2, therefore, summarizes the estimates of studies based on such gasoline demand models.

There is a large variation in elasticity estimates across studies. One source of this variation is methodological. Studies based on a panel of countries, for instance, tend to yield elasticities that are similar to single-country studies' elasticities in the short run but of higher magnitude in the long run [29]. Elasticities are also affected by the inclusion of controls for vehicle ownership and/or characteristics of the vehicle stock [25,29].

Another source of variation in the estimates is variation in true underlying elasticities across both place and time. Variation across place is noted by Espey [29], who observes short-run price responsiveness to be relatively low in the US and relatively high in Europe. Variation over time is demonstrated by Hughes, Knittel, and Sperling [32], who find that US short-run price elasticities have shifted since the 1970s; and by Neto [44], who finds that price elasticity has fluctuated over time in Switzerland. There are many potential sources of elasticity variation across place and time, but rational habits imply one further explanation: variation in price uncertainty implies variation in price responsiveness.

3. Models

Testing for rational habits requires a model appropriate for the context of international gasoline demand. Unfortunately, many of the existing models are inappropriate for this application.

Table 1
Average elasticities in gasoline demand literature reviews.

Study	Average price elasticity		Average income elasticity	
	Short run	Long run	Short run	Long run
[25] [a]	−0.24	−0.80	0.45	1.31
[30] [b]	−0.27	−0.71		
[29]	−0.26	−0.58	0.42	0.88
[31] [c]	−0.25	−0.64	0.39	1.08
[20]	−0.34	−0.84		

[a] Lagged endogenous models, annual.
[b] Time series models.
[c] Price: time series models; income: dynamic models.

Table 2
Gasoline demand studies based on cointegration and error-correction models.

Study	Country	Price elasticity		Income elasticity	
		Short run	Long run	Short run	Long run
[2]	South Africa		−0.47		0.36
[3]	Brazil	−0.0919	−0.465	0.122[g]	0.122[g]
[14] [a]	Denmark	−0.32	−0.41	0.89	1.04
[21]	China	−0.19	−0.56	1.64	0.97
[27] [b]	Namibia		−0.794		0.957
[28]	Kuwait	−0.37	−0.46	−0.47	0.92
[41]	14 OECD countries	−0.155	−0.429	0.283	0.344
[39] [c]	World	−0.02	−0.005	1.54	1.2
[42] [d]	France	−0.06	−0.09	0.27	0.28
[51]	Greece	−0.10	−0.38	0.36	0.79
[52]	India	−0.209	−0.319	1.178	2.682
[53] [d]	Oman	−0.05	−0.52	0.35	0.96
[54]	Figi		−0.159 to −0.244		0.427 − 0.462
[59] [e]	Australia	−0.2	−0.12	0.25	0.52
[66] [f]	US	−0.085	−0.116	0.520	0.592

[a] Elasticities with respect to vehicles per capita substituted for income elasticities.
[b] 1990q1–2002q4.
[c] Estimates elasticity of demand for crude oil, not gasoline. Results for 1973–1999.
[d] As reported in Ref. [66].
[e] Energy for transport, not just gasoline.
[f] Single-step nonlinear least squares, post-1978.
[g] Reported short- and long-run elasticities in fact the same.

The empirical approach pioneered in earlier literature such as Becker, Grossman, and Murphy [13], for example, channels the effect of non-contemporary prices through past and future consumption. This approach therefore obscures the price-process effects of interest here.

The approach used to examine US gasoline demand in Scott [61], meanwhile, relies on market characteristics that do not hold internationally. In the US, nearly all gasoline taxes are specific, so their behavior over time is very different from that of before-tax prices. In the US situation, it is therefore sensible to test not only whether consumers respond to anticipated future prices, but also whether they respond differently to (future) tax and before-tax price components. Scott [61] thus estimates models of the forms

$$\text{Lead price model}: g_{it} = \lambda g_{i,t-1} + \beta_1 y_{it} + \beta_2 p_{it} + \beta_3 p_{i,t+1} + \beta_4 t + \mu_i + \varepsilon_{it} \quad (1)$$

$$\text{Lead price components model}: \quad g_{it} = \lambda g_{i,t-1} + \beta_1 y_{it} + \beta_2 p_{it} + \beta_5 \ln(1+\tau_{i,t+1}) + \beta_6 \ln \text{BeforeTax}_{i,t+1} + \beta_4 t + \mu_i + \varepsilon_{it} \quad (2)$$

$$\text{Price components model}: \quad g_{it} = \lambda g_{i,t-1} + \beta_1 y_{it} + \beta_2 p_{it} + \beta_7 \ln(1+\tau_{it}) + \beta_8 \ln \text{BeforeTax}_{it} + \beta_4 t + \mu_i + \varepsilon_{it} \quad (3)$$

where g is log per-capita gasoline consumption in state i, y is log real per-capita income, p is the log real gasoline price, BeforeTax is the real price before taxes, and τ is the ratio of the tax to the before-tax price. In both the US and the international case, the lead price model is relatively uninformative, as anticipated lead prices are difficult to identify. In the international case, the price components models are also uninformative, as a major component of the gasoline tax in most OECD countries is a VAT of 10–25% [33], levied alongside a specific tax. The VAT moves in lock-step with the pretax