



School of Business,
Economics and Law
GÖTEBORG UNIVERSITY

WORKING PAPERS IN ECONOMICS

No 274

**Are Demand Elasticities Affected by Politically
Determined Tax Levels?**

Simultaneous Estimates of Gasoline Demand and Price

by

Lennart Flood, Nizamul Islam and Thomas Sterner

October 2007

ISSN 1403-2473 (print)
ISSN 1403-2465 (online)

SCHOOL OF BUSINESS, ECONOMICS AND LAW, GÖTEBORG UNIVERSITY

Department of Economics

Visiting adress Vasagatan 1,

Postal adress P.O.Box 640, SE 405 30 Göteborg, Sweden

Phone + 46 (0) 31 786 0000

Are Demand Elasticities Affected by Politically Determined Tax Levels? Simultaneous Estimates of Gasoline Demand and Price

Lennart Flood^L
Nizamul Islam
Thomas Sterner

Department of Economics, Göteborg University, Sweden

Abstract

Raising the price of fossil fuels is a key component of any effective policy to deal with climate change. Just how effective such policies are is decided by the price elasticities of demand. Many papers have studied this without recognising that not only is there a demand side response: quantities are decided by the price but also there is a reverse causality: the level of consumption affects the political acceptability of the taxes which are the main component of the final price. Thus prices affect consumption and consumption levels, in turn, have an affect on taxes and thus consumer prices. This paper estimates these functions simultaneously to show that there is indeed an effect on the demand elasticity.

Keywords: climate change, simultaneous, tax

JEL Classification Codes: C33; Q54

^L Corresponding author. Lennart.Flood@handels.gu.se

Introduction

Global carbon emissions from fossil fuels are around 7 Gtons Carbon per year whereof transport fuels in the OECD account for over 1 Gton. Effective policy instruments to deal with climate change will have their main effect through higher fuel prices. To reach any of the scenarios discussed in for instance the Stern or IPPC reports, very large reductions (50-90%) – and thus large price increases will be needed. The exact extent of the necessary rise in prices to reach any particular target hinges on the long-run demand elasticities for fuel. Such elasticities are also of interest for transport economists and market forecasts.

As a result there are few areas that are so well studied particularly after the oil price hikes of the 1970s. The total number of individual studies is several hundred and even the number of surveys is quite large, (see Drollas, 1984; Oum, 1989; Dahl and Sterner, 1991a, 1991b; Goodwin, 1992 Goodwin et al 2004, Hanly et al 2002, Graham and Gleister 2002, 2004). While a range of estimates is found, the consensus is that the long-run price elasticity of demand is around -0.8, while the long-run income elasticity is about one. Typically the short-run (one year) elasticities are about a third of the long run values. Differences between countries are typically moderate but there are differences depending on the type of model and data used. Estimates that only build on time series data for one country tend to give somewhat lower elasticities than studies that include cross-section evidence.

In a recent article which surveys new developments in the field, Basso and Oum (2006), identify a number of important methodological issues not sufficiently explored. One of these was the use of more complex, structural rather than reduced-form models. All earlier studies are founded on the idea that we are indeed estimating a simple demand curve and this is what we are questioning here. The kinds of data used are shown in figure 1.

Figure 1>>

Gasoline has low transport costs and a standardized international price. The differences in consumer price observed are due almost entirely to differences in taxation. In figure 1 we see that countries with higher taxes and prices have lower demand per capita. It is this type of data that underlies the demand elasticities mentioned above.

However Hammar et al (2004) point out that the causality could be the reverse. There is an apparent paradox that it appears more difficult to raise the gasoline taxes in low tax countries

like the USA than in European countries that already have high taxes. In searching to explain this, Hammar et al show that taxes themselves appear to be determined by consumption levels in a form of political feasibility relationship: In countries where almost everyone is dependent on the car and consumption levels are high it is politically almost impossible to raise the gasoline tax level. In countries where fewer people use a car and consumption levels are lower it is politically easier.

These results have consequences that have not yet been explored for the way we ought to model fuel demand and for the design of taxes in the area of vehicle fuels. A full model of the fuel market must have both a demand equation and a tax setting equation. *The question we seek to address here is whether the inclusion of this supply side or tax setting equation will change the magnitude of the demand elasticities .*

Model

The simplest and most frequently used dynamic model¹ is the lagged endogenous where the data might be pooled cross section time series data, assuming a common intercept and slope parameter which can be defined as

$$Q_{it} = a + \gamma Q_{i,t-1} + \beta_1 P_{it} + \beta_2 Y_{it} + u_{it} \quad (1)$$

where Q is gasoline per capita consumption per country $i=1,2,\dots,N$ at time $t=1,2,\dots,T$. P is deflated gasoline price and Y is deflated per capita income (GDP). All variables are in logarithms allowing the parameters to be interpreted directly as elasticities. The coefficients β_1, β_2 and γ capture the effects of price, income and lagged consumption respectively and the last term u is a disturbance term with $E[u_{it}] = 0$ and $Var[u_{it}] = \sigma_u^2$.

Another model is one in which we impose common slopes, but allow for varying intercepts (country effects) and time effects. This represents the simplest type of panel data models, known as the ‘fixed effects’ or ‘within’ estimator. In the fixed effects setting, the procedure involves running the ordinary least square (OLS) regression, the long run effects of P (price) and Y (income) on Q (gasoline consumption) is then calculated by $\beta_1/(1-\gamma)$ and $\beta_2/(1-\gamma)$ respectively

¹ See Sterner (1990, 2007) or Graham and Gleister (2004) for an overview of models.

As mentioned our goal is to take into account the reverse causality from consumption to price through a politically decided tax variable for this reason we specify the following simultaneous equation model

$$\left\{ \begin{array}{l} Q_{it} = a + \gamma Q_{i,t-1} + \beta_1 P_{it} + \beta_2 Y_{it} + u_{it} \\ T_{it} \equiv P_{it} - (IP)_{it} \\ T_{it} = c + \bar{\gamma} Q_{i,t-1} + \bar{\lambda} T_{i,t-1} + \bar{\beta}_3 C_{it-1} + \bar{\beta}_4 (QC)_{it-1} + \bar{\beta}_5 (TS)_{it} + \xi_{it} \end{array} \right\}$$

or

$$\left\{ \begin{array}{l} Q_{it} = a + \gamma Q_{i,t-1} + \beta_1 P_{it} + \beta_2 Y_{it} + u_{it} \\ P_{it} = b + \delta P_{i,t-1} + \beta_3 C_{it-1} + \beta_4 (QC)_{it-1} + \beta_5 (TS)_{it} + \beta_6 (IP)_{it} + \eta_{it} \end{array} \right\} \quad (2)$$

where the price P is a function of the International price IP , (which is almost the same in all countries) and domestic tax T ². The tax T is assumed to be a function of gasoline consumption (Q_{t-1}) in the previous period (as a proxy for lobbying or median voter pressure)³, C_{t-1} number of passenger cars in the previous period (per capita), $(QC)_{t-1}$ Gasoline consumption per passenger car in the previous period, and TS tax as share of GDP. $\bar{\eta}_{it}$ and ξ_{it} are error disturbances. In the fixed effects setting, equation (2) can be estimated using 2SLS.

Data

The data used in this paper consist of 23 OECD countries 1978-2003. Total gasoline consumption⁴, Price⁵ and International price⁶, are taken from IEA statistics 2006 and GDP⁷ from National Accounts of OECD Countries. We also use data on transport-related variables including number of passenger cars⁸.

² When we assume that $T_{it} \equiv P_{it} - (IP)_{it}$ we effectively measure the effective tax as the difference between the domestic and international prices. Thus we ignore any small differences in profit margin for petrol stations and differences in transport costs between countries.

³ We strive for simplicity. The model could easily be made more complex to include further determinants of the tax rate and fuel demand, see Hammar et al (2004) or Fredriksson (1997).

⁴ Gasoline consumption is in 1000 metric tonnes.

⁵ Price is total end-use prices for households in US dollars using PPPs. It is weighted average of Premium Leaded, Regular Unleaded, Premium Unleaded.

⁶ International price for Rotterdam, are average of high and low quotes for spot purchases of oil products.

⁷ GDP is from National Accounts of OECD Countries, Volume 1, 2005 and converted using the yearly average 2000 purchasing power parities see Purchasing Power Parities and Real Expenditures, GK Results, Volume II, 1990, OECD 1993.

⁸ Data on number of cars from the International Road Federation (World Road Statistics). A few missing values were generated using exponential interpolation.

Results

Table 1>>

The results are shown in table 1. The single equation results give high long run price elasticities, while the simultaneous equation estimates give more conventional though still high values. The fact that the values are high could possibly be explained by the inclusion of more years and of a large number of fairly diverse economies. Earlier studies (such as Goodwin 2004) have found some tendency for higher elasticities over time. For our purposes the most interesting result is that the inclusion of a tax-setting equation gives somewhat lower demand elasticities.

Table 2>>

Table 2 shows the results from the price equation in (2) which are of more secondary interest in this context but we see for instance that the larger the number of cars the lower the price – which we assume to be an expression of the lobbying (or voting) power of the automobile owners.

Conclusions

Current estimates of fuel elasticities assume that the demand relationship is the only one present in the data. However there may be political factors determining the setting of fuel taxes such that it becomes politically more difficult to raise taxes in those countries with many cars and high consumption – which are of course in turn the very countries where fuel taxes are low and thus where the need to raise them is the highest. The tax levels become self-perpetuating or at least we can think in terms of different trajectories where countries which start with fairly low tax and high use levels find it hard to raise the tax while high tax level countries find they can continue to raise the tax (since people are beginning to find ways to lower their consumption and thus become less dependent on the fuel which lowers resistance to further rounds of tax increase and lower consumption).

We tested this hypothesis by estimating the same gasoline demand equation either in isolation or in a system of equations where the other equation embraces the reverse causality through which the process of tax (and thus price) setting depends on consumption levels. We find that the demand elasticity is decreased moderately although not trivially, by the inclusion of the

political tax equation. This implies we have to somewhat reduce our estimates of the direct efficiency of fuel taxes as an instrument of policy. It implies policies need to be tougher: taxes or prices need to be raised more in order to attain a given level of demand reduction (and thus corresponding carbon emissions). On the other hand we also find that there is a further political feedback which implies that fuel taxes are *more efficient* than normally believed: The reason is that the higher a tax and the lower the consumption levels, the smaller the resistance to future tax increases may be. Thus it may be important to start a policy which eventually gathers momentum as more and more consumers adapt and thus find the policy acceptable. In some sense the policy leads to the building of lobbies that then continue to expand the policies while the lobbies that resisted the policy are successively weakened.

References

- Basso, LJ and TH, Oum, 2006, Automobile fuel demands: a critical assessment of empirical methodologies. (Working paper, Sauder School of Business, University of British Columbia).
- Dahl, C. and T. Sterner, 1991a, Analysing gasoline demand elasticities: a survey, *Energy Economics*, 13, 203-210.
- Dahl, C. and T. Sterner, 1991b, A survey of econometric gasoline demand elasticities, *International Journal of Energy Systems*, 11, 53-76.
- Drollas, L., 1984, The demand for gasoline: further evidence, *Energy Economics*, 6, 71-82.
- Fredriksson, Per G., 1997, The Political Economy of Pollution Taxes in a Small Open Economy, *Journal of Environmental Economics and Management*, 33, 44-58.
- Goodwin, P., 1992, A review of new demand elasticities with special reference to short and long run effects of price changes, *Journal of Transport Economics and Policy*, 26, 155-163.
- Graham, D. and S. Glaister, 2002, The demand for automobile fuel: a survey of elasticities, *Journal of Transport Economics and Policy*, 36, 1-26.
- Graham, D. and S. Glaister, 2004, Road traffic demands: a review *Transport Review*, 24, 261-274.
- Hanly, M., Dargay, J. and P. Goodwin, 2002, Review of Income and Price Elasticities in the Demand for Road Traffic. (London: Department for Transport).
- Hammar, H, Löfgren, A, and T. Sterner, 2004, Political Economy Obstacles to Fuel Taxation, *Energy Journal*, ISSN0195-6574, July 2004, Vol 25(3)
- Oum, T., 1989, Alternative demand models and their elasticity estimates, *Journal of Transport Economics and Policy*, 23, 163-87.

Stern, T., 1990, Aggregate Production Functions: A Comparison between Weighted and Aggregate Elasticity Estimates, in Barker, T. and M. H. Pesaran (eds.), Disaggregation in Economic Modeling, (Croom Helm).

Stern, T., 2007, Gasoline Taxes a useful instrument for climate policy, Energy Policy, Vol. 35, Issue 6, June.

Figure1. Price on gasoline and gasoline consumption per capita during 1978-2003

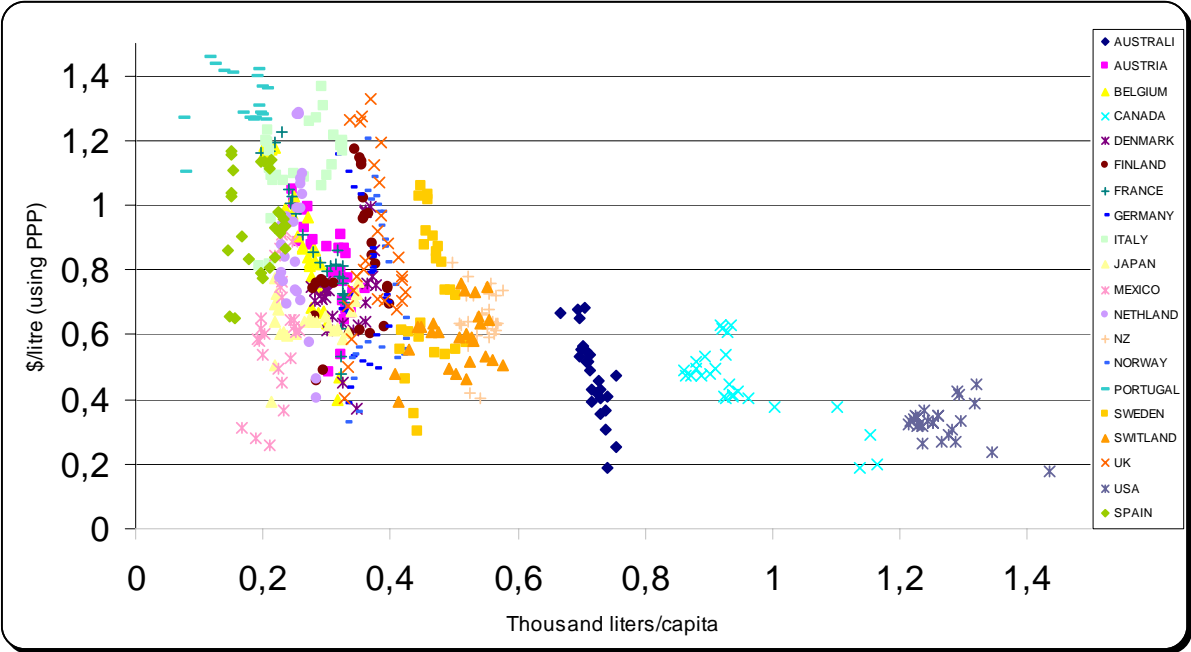


Table 1- Elasticity estimates with single and simultaneous equations model for 23 OECD countries (1978-2003)⁹

Estimation Techniques	SR Price Elasticity	LR Price Elasticity	SR Income Elasticity	LR Income Elasticity	Lag Endogenous	R Square
Single equation (Fixed effect OLS)	-.117 (.012)	-1.08 (.112)	.073 (.018)	.675 (.164)	.892 (.012)	0.995
Simultaneous equations (Fixed effect 2SLS)	-.077 (.014)	-.884 (.134)	.071 (.018)	.818 (.208)	.913 (.012)	0.996

Notes: Standard errors are in parenthesis. All specifications include time dummies.

Table2- Estimates of price equation in simultaneous equations model for 23 OECD countries (1978-2003).

Estimation Techniques	Lag(P)	Lag(C)	Lag(QC)	TS	IP
Simultaneous Equations	.757 (.028)	-.022 (.025)	.047 (.028)	.093 (.013)	.133 (.023)

Notes: Standard errors in parenthesis. Time dummies included but not shown.

⁹ All estimates are for 23 OECD countries (1978-2003) using lagged endogenous model.