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Elasticities of gasoline demand in Switzerland

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HIGHLIGHTS

- We estimate gasoline demand in Switzerland using quarterly data over 1970–2008.
- Gasoline price elasticity is −0.09 in the short run and −0.34 in the long run.
- Income elasticity is less than unity in the long run and insignificant in the short run.
- Gasoline consumption increases less than proportionally to the stock of cars.
- Oil shocks and gasoline tax increases have further impacts on top of their direct effect due to price increase.

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ABSTRACT

Using cointegration techniques, we investigate the determinants of gasoline demand in Switzerland over the period 1970–2008. We obtain a very weak price elasticity of −0.09 in the short run and −0.34 in the long run. For fuel demand, i.e. gasoline plus diesel, the corresponding price elasticities are −0.08 and −0.27. Our rich dataset allows working with quarterly data and with more explicative variables than usual in this literature. In addition to the traditional price and income variables, we account for variables like vehicle stocks, fuel prices in neighbouring countries, oil shocks and fuel taxes. All of these additional variables are found to be significant determinants of demand.

1. Introduction

Measuring the determinants of gasoline demand is essential to understand the evolution of energy consumption in the transport sector and to judge the impacts of economic and environmental policies. In Switzerland, transport is one of the major contributors to CO_2 emissions and the environmental objectives (e.g. in terms of emissions or noise) are particularly difficult to attain. In ratifying the Kyoto Protocol, Switzerland committed to reducing its greenhouse gas emissions between 2008 and 2012 by 8% compared with 1990 levels. Under likely scenarios, it seems this target will just be met (FOEN, 2013). A new CO_2 Ordinance, which entered into force in 2013, states that domestic greenhouse gas emissions must be reduced by 20% compared to 1990 levels by year 2020. Implementing policy instruments, like CO_2 taxes, requires information on the price sensitivity of gasoline demand.

The objective of this paper is to investigate the determinants of gasoline demand in Switzerland, and to assess their impact on consumption. Among others, we focus on the impact of prices and measure the price elasticities of demand in the short and in the long run. Thanks to the rich dataset we built, we are able to use several additional covariates. Contrarily to what is usually done in typical studies on gasoline demand, not only price and income are considered as determinants, but also vehicle stocks, gasoline prices in neighbouring countries, oil shocks, and fuel taxes. All of these additional variables are found to be significant drivers of gasoline demand.

Different approaches to analyse automobile gasoline demand are used in the literature. A first distinction can be made between studies using disaggregate versus aggregate data. The use of micro-level data allows modelling individual and household behaviour more precisely (see for example Eltony, 1993; Hensher et al., 1992; Nicol, 2003; and Rouwendal, 1996). However, given the data available in Switzerland and like the vast majority of gasoline demand studies, our paper is based on aggregate data. At the aggregate level, models can be distinguished by the type of data: time series, cross-section, or panel data. Because no data are available at the regional level in Switzerland, our choice is constrained to time series models.

A number of surveys provide summaries of the results on gasoline demand elasticities, such as Blum et al. (1988), Dahl and Sterner (1991), Graham and Glaister (2002), and Lipow (2008). These traditional literature surveys are complemented by meta-analyses. Brons et al. (2008) perform a meta-analysis on a dataset composed by 312

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elasticity estimates from 43 primary studies. The estimates of the short run price elasticity of gasoline demand fall between −1.36 and 0.37 and are in general lower in absolute value than the long run estimates, which fall between −2.04 and −0.12. The mean price elasticity of gasoline demand is −0.34 in the short run and −0.84 in the long run. Brons et al. (2008) also identify the characteristics driving different results. They show in particular that USA, Canada and Australia display a lower price elasticity; that price elasticity increases over time; and that time-series studies and models with dynamic specification report weaker elasticity estimates. Generally, price elasticities are lower than the corresponding values of income elasticities both in the short and in the long run (see Dahl and Sterner, 1991; Graham and Glaister, 2002).

Some studies on gasoline demand are available for Switzerland. Those using time-series are based on rather old data, while the more recent use alternative methodologies (i.e. surveys) or are limited to some parts of Switzerland. Wasserfallen and Güntensperger (1988) adopt a partial equilibrium model that explains the demand for gasoline and the total stock of motor vehicles simultaneously. Using annual data from 1962 to 1985, they estimate a short run price elasticity between −0.3 and −0.45, and find that demand has become more price sensitive after the first oil shock in 1973. They obtain an income elasticity of 0.7. Using a model merging econometric and engineering approaches, Carlevaro et al. (1992) explain the evolution of energy consumption in Switzerland using annual data from 1960 to 1990. They obtain a very weak short run price elasticity of −0.06. Paying particular attention to the problem of non-stationarity, Schleiniger (1995) uses cointegration techniques to estimate the demand for gasoline over the period 1967–1994. Surprisingly, he finds that only income per capita has a significant impact, while price changes do not explain any variation in gasoline demand. Using a stated preference approach (survey), Erath and Axhausen (2010) obtain gasoline price elasticity estimates between −0.04 and −0.17 in the short run and of −0.34 in the long run.

Banfi et al. (2005), (2010) focus on gasoline demand in the Swiss border regions to study the so-called "tank tourism" phenomena. Their results indicate that price elasticity in the Swiss border regions is about −1.5 with respect to Swiss gasoline prices. This value is much stronger than all other estimates, since car drivers can easily refuel in a neighbouring country if they live close to the border.

The remainder of the paper is structured as follows. We present the empirical approach in Section 2, and the data in Section 3. Section 4 discusses the results and Section 5 concludes.

2. Econometric approach

Our empirical approach is restricted by the data available in Switzerland. Gasoline consumption and prices are collected at the country level only and we cannot observe regional quantities and prices. Our study thus uses time-series econometrics.[1] Like the vast majority of the literature, we assume a log-linear demand of the form[2]:

$$\ln Q_t = \beta_0 + \beta_1 \ln P_t + \beta_2 \ln Y_t + \beta_3 \ln V_t + z_t, \tag{1}$$

where Q_t is gasoline consumption per capita in period t, P_t is real gasoline price, Y_t is real income per capita, and V_t is the number of vehicles per driver. In addition to gasoline demand, we also estimate a demand for automobile fuel, i.e. the sum of gasoline and diesel consumption, using a similar equation.

Following the seminal approach of Engle and Granger (1987), Eq. (1) is interpreted as a long run relationship. If a cointegration relationship is identified, the short run dynamic can then be investigated through an error correction model:

$$\Delta \ln Q_t = \alpha_0 + \alpha_1 \Delta \ln P_t + \alpha_2 \Delta \ln Y_t + \alpha_3 \Delta \ln X_t + \gamma \hat{z}_{t-1} + \varepsilon_t, \tag{2}$$

where X_t is a matrix of variables having an impact in the short run, but not in the long run, such as an increase in automobile fuel taxes or an oil crisis. The vehicle stock is not included in (2) because it is not expected to change in the short run.

Because all variables are in logarithms, the coefficients can be interpreted directly as elasticities. Long run elasticities are given by the β parameters in (1), while short run elasticities are given by the α parameters in (2). Parameter γ in (2) can be interpreted as the "adjustment speed" to the long run equilibrium given by (1).

3. Data

In the literature on gasoline consumption, samples are typically small and they contain annual data. Consequently, gasoline demand studies include a limited number of explicative variables, often merely fuel price and GDP per capita (as a proxy for income). We have been able to collect data at a higher frequency. We found monthly information on quantities of gasoline and diesel and on prices since 1970. Swiss GDP is however available on a quarterly basis only and the vehicle stocks are measured once a year. Hence, we transformed all the series in quarterly data by summing the monthly quantities, averaging the prices, and linearly interpolating the vehicle stocks. Our workable dataset spans the period 1970–2008, and contains 156 quarterly observations.

Fig. 1 shows the evolution of gasoline, diesel, and fuel consumption. The original series display substantial seasonal variations, and we deseasonalise the data before the analysis (thick lines in Fig. 1).[3] Quantities grew regularly until the beginning of the 1990s. Since 2000, gasoline consumption is however clearly decreasing while diesel consumption is on the rise. Compared to other European countries (cf. EEA, 2012), the share of diesel in total fuel consumption is still relatively weak in Switzerland, as it only represents about one-third of the total amount of transport fuels.

Several types of gasoline were delivered in Switzerland over the period 1970–2008.[4] To analyse gasoline consumption over the whole period, we aggregate the different types in a single series, and we define gasoline price (P_G) as the following weighted average:

$$P_G = \frac{Q_U P_U + Q_L (P_R + P_S)/2}{Q_U + Q_L} \tag{3}$$

where Q_U (P_U) is the quantity (price) of unleaded gasoline, and Q_L is the quantity of leaded gasoline, which is either "regular" gasoline with price P_R or "super" gasoline with price P_S.[5] This price is then deflated using the consumer price index (CPI) in December 2005

[1] For a detailed presentation of cointegration techniques, see for example Maddala and Kim (1998).

[2] Among the studies using cointegration techniques for the estimation of gasoline demand, see for instance: Akinboade et al. (2008), Alves and Bueno (2003), Bentzen (1994), Crôtte et al. (2009), Eltony and Al-Mutairi (1995), Polemis (2006), Rao and Rao (2009), Sentenac-Chemin (2012), Samimi (1995), and Schleiniger (1995).

[3] We used the command ESMOOTH in the software RATS to deseasonalise the series. An alternative strategy to analyse series showing seasonality would be to keep the raw data and introduce seasonal dummies in the regressions. This does not alter our results significantly (available upon request). Except the deseasonalisation, all empirical analyses have been conducted in Stata.

[4] "Regular" leaded gasoline was available in Switzerland until December 1984. Between October 1977 and December 1999, a more expensive type of leaded gasoline, called "super", was also available. Unleaded gasoline was introduced in January 1985. The standard type of unleaded gasoline has 95 research octane number (RON). Since May 1993, 98 RON is also available as a more expensive option.

[5] The price of unleaded gasoline (P_U) is approximated by the price of 95 RON alone, because we do not have separate data series for the quantities of 95 RON and 98 RON and consumption of 98 RON is known to be much smaller. We do not have separate data for "regular" and "super" leaded gasoline quantities either, but because none of these two types of leaded gasoline are available over the entire observation period, we must consider both prices to define a complete series. Over the period when both gasoline types are in the market (1977–1984), we use the unweighted average of their prices (P_R and P_S) as a proxy for the price of leaded gasoline. The price difference between "regular" and "super" is anyway very small; it amounts to 3 cents of CHF per litre in average over 1977–1984.