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An analysis of gasoline demand elasticities at the national and local levels in Mexico

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ABSTRACT

The majority of evidence on gasoline demand elasticities is derived from models based on national data. Since the largest growth in population is now taking place in cities in the developing world it is important that we understand whether this national evidence is applicable to demand conditions at the local level. The aim of this paper is to estimate and compare gasoline per vehicle demand elasticities at the national and local levels in Mexico. National elasticities with respect to price, income, vehicle stock and metro fares are estimated using both a time series cointegration model and a panel GMM model for Mexican states. Estimates for Mexico City are derived by modifying national estimates according to mode shares as suggested by Graham and Glaister (2006), and by estimating a panel Within Groups model with data aggregated by borough. Although all models agree on the sign of the elasticities the magnitudes differ greatly. Elasticities change over time and differ between the national and local levels, with smaller price responses in Mexico City. In general, price elasticities are smaller than those reported in the gasoline demand surveys, a pattern previously found in developing countries. The fact that income and vehicle stock elasticities increase over time may suggest that vehicles are being used more intensively in recent years and that Mexico City residents are purchasing larger vehicles. Elasticities with respect to metro fares are negligible, which suggests little substitution between modes. Finally, the fact that fuel efficiency elasticities are smaller than vehicle stock elasticities suggests that vehicle stock size, rather than its composition, has a larger impact on gasoline consumption in Mexico City.

1. Introduction

Although there is an extensive literature on the effect that prices, incomes, and other factors have on the demand for gasoline, most studies use national data that produce elasticity estimates at the country level. There is, however, no *a priori* evidence to presume that gasoline demand elasticities estimated with national data reflect conditions at the local level.[1] Half the world's population now lives in urban areas, and the largest growth in population is taking place in cities in the developing world (UNFPA, 2007). Therefore, for rapidly growing cities to adopt sustainable policies to respond appropriately to urban and global environmental challenges from excessive use of the private car, it is of paramount interest to concentrate on the estimation of gasoline demand elasticities at the local level.

Data from the International Energy Agency show that Mexico is the 5th largest gasoline consumer among OECD countries, with total gasoline consumption comparable to that of Germany and the UK. Per capita gasoline consumption in Mexico City is equivalent to that of developed countries such as New Zealand and Switzerland, taking 6th place among OECD countries. Therefore, due to increasing concerns of the contribution of road transport to climate change, and the rapid rate at which cities in the developing world are growing, the aim of this study is to estimate and compare gasoline demand elasticities at the national and local level in Mexico.

In order to obtain reliable demand estimates for a specific transport sector, one cannot rely on average estimates for similar sectors or countries; a detailed study of that market must be performed, which is the aim of this paper. The study places special attention on the methodological issues and theoretical foundations of the latest econometric techniques developed in the recent literature.

Elasticities with respect to price, income, vehicle stock, and metro fares are estimated for Mexico at the national level with a time series cointegration model for the period 1980–2006 and a panel GMM model with data from 30 Mexican states over the

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[1] For instance, Wadud et al. (2010) found that rural households in the US are less responsive to gasoline price changes than urban households, perhaps showing the lack of alternative modes in rural areas.

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period 1993–2004. Even though monthly data on gasoline consumption for Mexico City are available since 1993, data on income at the Mexico City level are only collected annually and proxies for monthly income are either only available at the national level or for a very short time series. Therefore, due to lack of availability of a time series or panel data set for Mexico City, gasoline per vehicle demand elasticities for Mexico City are derived from national elasticities and mode shares at the national and local level, as suggested by Graham and Glaister (2006). We also estimate local elasticities with a panel Within Groups model with data aggregated at the Mexico City borough level where gasoline consumption per vehicle is derived from car kilometres and fuel efficiency per vehicle for the period 2001–2004.

The remainder of this paper is structured as follows: Section 2 presents a brief literature review of elasticities of demand for gasoline and presents the results from previous studies for Mexico. Sections 3 and 4 describe the gasoline market in Mexico and the data available for this study. Section 5 presents the econometric techniques used for the treatment of time series and panel data. Section 6 presents the results. The last section concludes.

2. Previous research

A wide range of studies has been conducted to explain how road transport gasoline demand is related to income, price, and other variables, such as vehicle stock and vehicle characteristics. Although there is a great variation in results of these studies, gasoline demand surveys show that generalisations can be made when the studies are classified by type of data used; either aggregate data collected at a region or country level (cross-section, time series, and cross-section time series), or disaggregate data that look at individuals' socio-economic features and travel behaviour. Elasticity estimates also differ depending on the time stratification of the data (monthly, quarterly, annually), model structure (static or dynamic), demand specification (functional form and variables included), and econometric approach.

Several gasoline demand surveys have been conducted, for studies before the early 1990s see, for instance, Dahl and Sterner (1991) and Goodwin (1992). For more recent surveys see Graham and Glaister (2002) and Goodwin et al. (2004). The findings from these studies are briefly summarised below.

Dahl and Sterner (1991) argue that the shorter the time period, the greater the emphasis on the short run character of the elasticity. However, monthly and quarterly data may produce biased long run parameters if seasonality is not captured correctly in the model. Traditionally, seasonal dummies are used to remove seasonal fluctuations in monthly and quarterly data; however, Abeysinghe (1994) shows that when seasonality is not deterministic (the underlying seasonal pattern is not regular throughout the series), the use of seasonal dummies leads to spurious regressions. In such instances, Hylleberg et al. (1990) suggest testing for seasonal cointegration.

The specification of the demand model also affects elasticity estimates. Static models usually give coefficients that fall between the short and long run estimates of dynamic models that capture the fact that adaptation takes time, due to costs of adjustment and imperfect information. Long run demand elasticity estimates tend to be more elastic than short run values, essentially capturing vehicle purchase decisions and changes in residence location.

Static models typically define gasoline per capita as a function of the real price of gasoline and real income per capita. Vehicle stock and stock characteristics, such as fuel efficiency, can also enter the model, as well as several other variables, for instance, public transport fares and measures of public transport infrastructure, as long as they are uncorrelated with price and income. In such cases income elasticity estimates are lower.

For dynamic models that include lags of the dependent and/or independent variables Dahl and Sterner (1991) argue that variables tend to have identical gradually diminishing effects through time, which is a strong model restriction. Alternatively, they suggest a gasoline consumption per vehicle demand specification where price and income elasticities do not include the changes in the number of automobiles, only the changes in utilisation. Gasoline consumption per vehicle models tend to give lower elasticities.

Different econometric models also affect the magnitude of the elasticities. Section 5 describes the most recent econometric techniques for the treatment of time series and panel data. In summary, there is no correct specification to be used for every demand model. It will depend on the correlation between explanatory variables, the information available, and the relevant features of each market. In some cases it will be sufficient to estimate fuel elasticities only with income and price as explanatory variables due to the fact that they tend to capture the confounding effect of other variables. Cameron and Trivedi (2005) argue that confounding takes place when the variables omitted from a regression are correlated with the observable explanatory variables.

The gasoline demand surveys of Graham and Glaister (2002) and Goodwin et al. (2004) find consensus on the range of elasticities found in the literature. Graham and Glaister (2002) argue that, in general, short run price elasticities lie between -0.2 and -0.3, whilst long run price elasticities tend to be between -0.6 and -0.8. Income elasticities in the short run are in the range 0.35–0.55, whilst long run income elasticities are typically greater than one, between 1.1 and 1.3.

With regards to gasoline demand in Mexico, Table 1 presents the elasticity estimates found in previous studies and shows the type of data used for estimation as well as its periodicity, the time period analysed, and the geographical scope of the data. In general, price elasticities are lower than those found in gasoline demand surveys, which are mostly based on developed countries. For income, most studies report higher elasticities than the range suggested in the surveys, especially for long run adjustments.

Although in most cases these studies were conducted with great academic rigour, the fact that some of the studies were published over 10 years ago poses two concerns. First, the data used for estimation are outdated. Elasticities may change over time for instance as a result of economic, political, or technological changes. Recent data must be used in order to obtain reliable elasticity estimates that reflect current market conditions. Second, new econometric techniques have been developed that treat the data more appropriately.

Three issues emerge with regards to the methodologies used: the treatment of seasonality with the use of monthly or quarterly data, the treatment of non-stationarity, and correlation between the lagged dependent variable and the error term with the use of dynamic panel models. As described above, without special treatment for seasonality the classical approach produces spurious results. Similarly, with the presence of stationary variables (means and variances differ across time) traditional econometric techniques generate spurious estimates. Likewise, correlation between the lagged dependent variable and the residuals in dynamic panel models violates one of the classical assumptions and produces biased and inconsistent coefficients. However, these methods were not widely available at the time most of the studies presented in Table 1 were conducted.

Berndt and Botero (1985) use time series and panel data to analyse the demand for energy in the Mexican transport sectors, focusing on rail, air transport, and motor vehicle modes. For road