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Fuel demand in Brazil in a dynamic panel data approach

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ABSTRACT

The purpose of this paper is to evaluate the sensitivity of fuel consumers regarding price and income, taking recent changes in the Brazilian fuel market into account. In this market, new market rules, energy policy towards fuel diversification and introduction of flex-fuel engines have determined fuel competition among gasoline, ethanol and compressed natural gas. Using a dynamic panel data model, demand equations for these three fuels are econometrically estimated to obtain consumer adjustment coefficients, price, cross-price and income elasticities in the short and long-run. In addition, the effect of the introduction of flex-fuel engines in the market and the rationality of consumers towards efficiency constraints of the engines were tested. Apart from considerable competition, results show that the dynamics of the Brazilian fuel market revolves around ethanol instead of gasoline. While demands for gasoline and natural gas are inelastic to price, demand for ethanol is elastic in Brazil. Furthermore, after the introduction of the flex-fuel technology the sensitivity of consumers to fuel prices changed, and ethanol consumers take efficiency constrains into account when ethanol prices reach the threshold of 70% of gasoline prices.

1. Introduction

The Brazilian fuel market is considerably different from other markets due to diversity of alternative fuels. There are four main fuels in this market: gasoline, ethanol, natural gas – in its compressed form, thus known as compressed natural gas (CNG) – and diesel. Gasoline still remains as the main fuel, but it strongly competes with two substitutes: ethanol and CNG. The features of the Brazilian automobile fleet imply that diesel is only used by large road vehicles, not competing with other fuels in the short-run. Ethanol plays a historic role in the national energy policy, being an important alternative in periods of high oil prices or to face environmental enforcements. On the other hand, CNG has recently been introduced in the market and already competes with ethanol and gasoline. As a consequence of this diversified marked, the economic theory of consumer behavior suggests the hypothesis that consumers are more responsive to prices, and adjust faster towards desired demand levels. The estimation of price and income elasticities jointly with the adjustment coefficients of consumers might bring new insights about the Brazilian fuel market.

The literature on the estimation of fuel demand equations in the field of energy economics is considerably extensive. Surveys of the literature might be found in Dahl (1995) and Dahl and Sterner (1991), which summarized a set of principles, models and data requirements used for the estimation of the demand for gasoline and transportation fuels. Bentzen (1994), Eltony and Al-Mutairi (1995), Espey (1996a, 1996b, 1998), Graham and Glaister (2002, 2004), Goodwin et al. (2004), and Polemis (2006) also provided good insights on this subject. The estimation of fuel demand through panel data models can be found in Baltagi and Griffin (1983), Puller and Greening (1999) and Rouwendal (1996). For the Brazilian fuel market Alves and Bueno (2003), Azevedo (2007), Burnquist and Bacchi (2002), Freitas and Kaneko (2011), Iootty et al. (2004), Nappo (2007), Pontes (2009), Rogat and Sterner (1998), Roppa (2005), Silva et al. (2009) and Schünemann (2007) estimated demand equations using time series models. General results for Brazil showed that fuel demand is inelastic and that these fuels are imperfect substitutes.

International and national literature reviews are focused on the estimation of gasoline demand and the usage of time series models. Dahl and Sterner (1991) presented standard models to estimate price and income elasticities for gasoline mainly using monthly, quarterly and yearly time series. Eltony and Al-Mutairi (1995) estimated the demand for gasoline in Canada and Kuwait, using cointegration techniques. Bentzen (1994) estimated the demand for gasoline in Denmark using

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that same technique. Dahl (1995) also presented a survey on demand elasticities and their components regarding the demand for transportation fuels. Espey (1996a) explained the variation in elasticity estimates of gasoline demand in the United States through meta-analysis. Espey (1996b) analyzed fuel consumption through an international automobile fuel-saving model. Espey (1998) wrote a review on gasoline demand through an international meta-analysis of elasticities. Graham and Glaister (2002, 2004) analyzed various international researches on the responses of conductors to fuel price changes and the road traffic-related elasticity estimates reported in international literature; particularly the magnitude of the relevant income and price effects and new directions in relevant literature. Goodwin et al. (2004) give the main results of a literature review of empirical studies that have been published since 1990, updating work on the effects of price and income on fuel consumption, traffic levels, and, where available, other indicators, including fuel efficiency and car ownership. More recently, Polemis (2006) presented the determinants of road energy demand in Greece using cointegration techniques and vector auto regression analysis. The evidence presented shows important differences between long- and short-run price elasticities.

In Brazil, the use of time series models with cointegration techniques to estimate the price and income elasticities prevails over other models, as shown in Table 1. Rogat and Sterner (1998) estimated the price and income elasticities of gasoline demand for some Latin American countries, including Brazil, to be compared to those of OECD countries. They concluded that Latin America tended to have a very heterogeneous pricing policy, which has not necessarily followed international trends. Burnquist and Bacchi (2002) estimated demand equations for gasoline in Brazil using yearly time series. The main finding was that fuel consumption is more sensitive to income than price in both the short and long-run. Alves and Bueno (2003) also estimated a demand equation for gasoline using yearly time series and found that ethanol is an imperfect substitute for gasoline, even in the long-run. Roppa (2005) compared the competitiveness of gasoline to that of ethanol, also using yearly time series. Results showed that ethanol is an imperfect substitute for gasoline, whose consumers are indifferent to price increases in both the short and long-run. Iootty et al. (2004) compared the competitiveness between gasoline and CNG using monthly time series and found that CNG is an imperfect substitute for gasoline. In spite of that, the demand for CNG was found to be price inelastic. In the short-run consumers were more sensitive to price than they were to income and in the long-run this relationship was shown to be inverted.

Recent studies in Brazil also have applied time series models and some of them have explored beyond gasoline demand. Azevedo (2007) estimated the short and long-run price, cross-price and income elasticity of ethanol and CNG demand in Brazil. Despite specific results showing that ethanol demand is almost elastic to its price and elastic to the gasoline price, the general result showed that price elasticities are growing in Brazil. Schünemann (2007) analyzed the gasoline demand in Brazil estimating its elasticities and the impact generated by the introduction of flex-fuel vehicles. General results showed a high income elasticity and only a very small effect of the flex-fuel vehicles on the long-run gasoline demand. The same kind of study was developed by Nappo (2007) and showed a considerable increase in the price elasticity of gasoline demand after the introduction of flex-fuel vehicles. Pontes (2009) estimated the ethanol demand and showed a considerable change in its price elasticities caused by the flex-fuel engines. Silva et al. (2009) studied the impact of the growing ethanol market on the demand elasticity for gasoline in Brazil and results showed a considerable increase in the price elasticity and cross-price elasticity regarding ethanol. Finally, Freitas and Kaneko (2011) analyzed the characteristics of ethanol demand in the context of fuel mix diversification in Brazil. The study showed that during the last decade, ethanol has strengthened its position as both an independent fuel and a substitute for gasoline. In summary, this study showed that the growth in the Brazilian automobile fleet based on flex-fuel technology is a major driving factor of long-run ethanol demand.

Previous studies in Brazil still present some limitations which the present study was designed to overcome. Few studies consider the substitution among the three main fuels. From the Brazilian literature review, only Silva et al. (2009) consider the use of econometric tools other than time series, but without the substitution among the three main fuels. The country-level estimations from aggregated time series might affect the results. The fuel market in Brazil presents specific features than those of other countries due to its diverse fuel supply. In addition to fuel diversification, the Brazilian economy is considerably heterogeneous and marked by a high degree of concentration of economic activity. For this reason, there are different unobserved heterogeneities at the state level that may affect consumer preferences to use each type of fuel. Panel data models can account for these heterogeneities and at the same time capture the variations among the time periods and the cross-section units. The consideration of these elements is the starting point to future studies in Brazil designed to evaluate different patterns of consumer behavior by region in the presence of fuel prices, income variations or fuel taxes. In addition, new market rules and technological advances in the automobile industry, such as flex-fuel engines, are increasing competition between fuels. For this reason, the question that emerges is: how sensitive are the consumers in this new environment? No previous study

Table 1
Short and long-run price, cross-price and income elasticities of the fuel demand in Brazil from the literature.

Reference[a]	Dependent variable[b]	Period	Short-run				Long-run			
			Explanatory variables and elasticity[c]				Explanatory variables and elasticity			
			Gprice	Eprice	CNGprice	Income	Gprice	Eprice	CNGprice	Income
Rogat and Sterner (1998)	Gasoline	1960–1994						−0.980		0.900
Burnquist and Bacchi (2002)	Gasoline	1973–1998	−0.319			0.600	−0.230			0.960
Alves and Bueno (2003)	Gasoline	1984–1999				0.120	−0.464	0.480		0.122
Iootty et al. (2004)	CNG	01.2001–12.2003	0.100		−0.420	0.505	0.354		−1.010	0.181
Roppa (2005)	Gasoline	1979–2003	−0.073	−0.198		0.471	−0.634	0.401		0.163
Azevedo (2007)	Ethanol	01.2002–06.2006	1.301	−0.926		0.400	−0.364	−0.459		0.137
Azevedo (2007)	CNG	01.2002–06.2007		0.431		0.394			0.247	0.406
Schünemann (2007)	Gasoline	1980–2005	−0.122			0.747	−0.292			1.340
Schünemann (2007)	Gasoline	01.1991–02.2007	−0.488			0.857		−0.337		1.749
Nappo (2007)	Gasoline	08.1994–07.2006					−0.197			0.690
Pontes (2009)	Ethanol	7.2001–10.2008					1.374	−0.934		1.255
Silva et al. (2009)	Gasoline	04.2001–12.2006					−0.945	0.049		0.154
Freitas and Kaneko (2011)	Ethanol	01.2003–07.2010	1.987	−1.800			0.948	−1.413		

[a] References are ranked by the year of publication.
[b] Demand equation.
[c] Eprice, Gprice, CNGprice and income are real price of ethanol, gasoline, CNG and real income, respectively and the coefficients refer to elasticities in short and long-run.