Automotive Fuel Demand in Brazil: Consumer Choice and Asymmetric Price Response

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OVERVIEW

- In Brazil the Otto-cycle segment (light passenger and cargo vehicles) is powered by Gasoline C (Anhydrous Ethanol blends on Gasoline A), Hydrous Ethanol and Compressed Natural Gas (CNG)

- The Flex-Fuel technology was implemented in Brazil on a commercial scale in March 2003

- Flex-Fuel Vehicles has changed the dynamics of competition between fuels – gasoline and ethanol

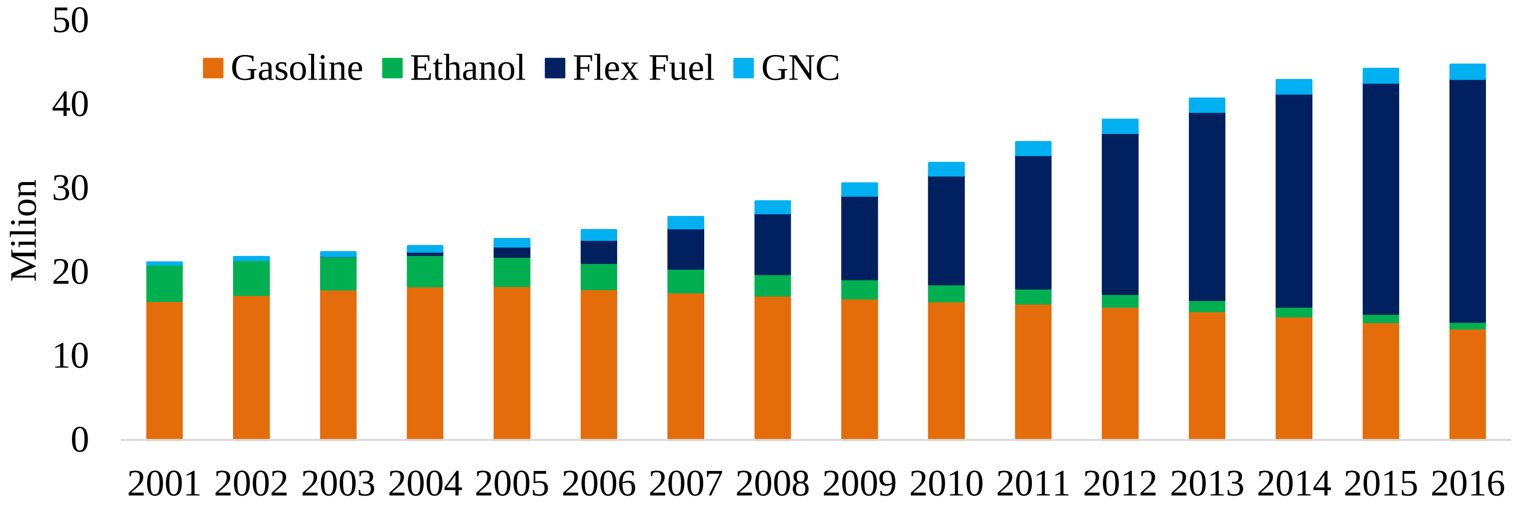
- Hydrous Ethanol has approximately 70% of the calorific value of Gasoline C

- Flex-Fuel Vehicles represent over 95% of new vehicles sold in Brazil

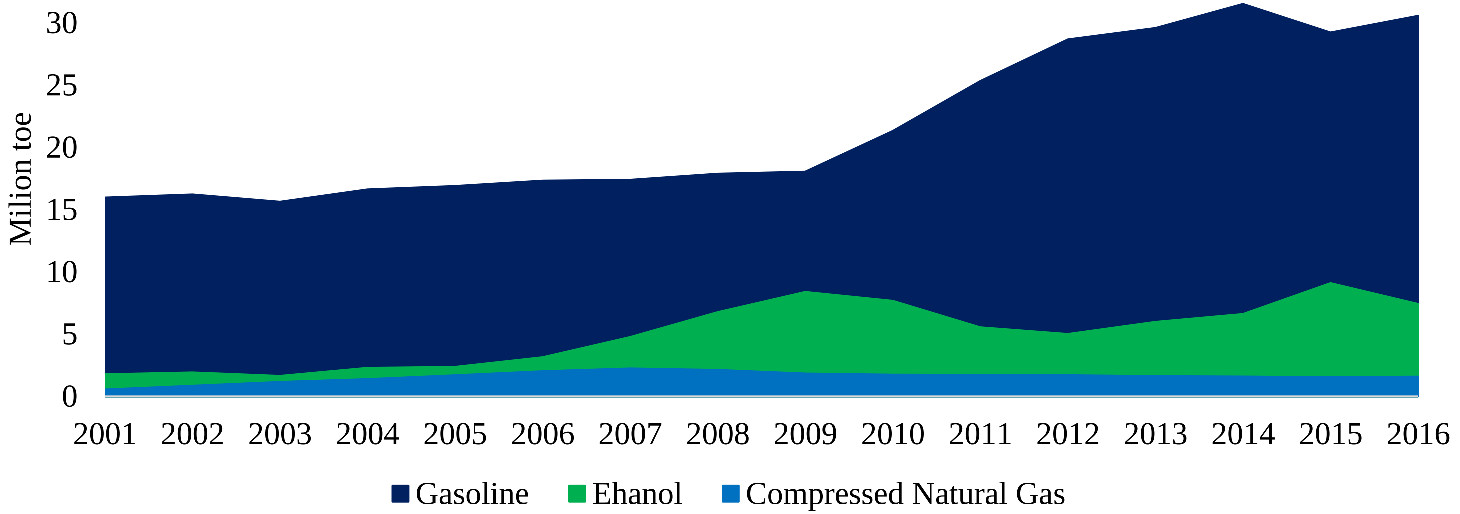
OVERVIEW

- CNG consumers have to install a kit which allows them to convert their vehicles between CNG as well as the original engine fuel
- CNG has a relatively minor share of the market – 5% overall
- Refinery capacity has not increased at the same pace of fuel consumption - gasoline imports reached 9.4 billion of liters in 2013

Share of vehicles by type of fuel in the Brazilian fleet of light vehicles

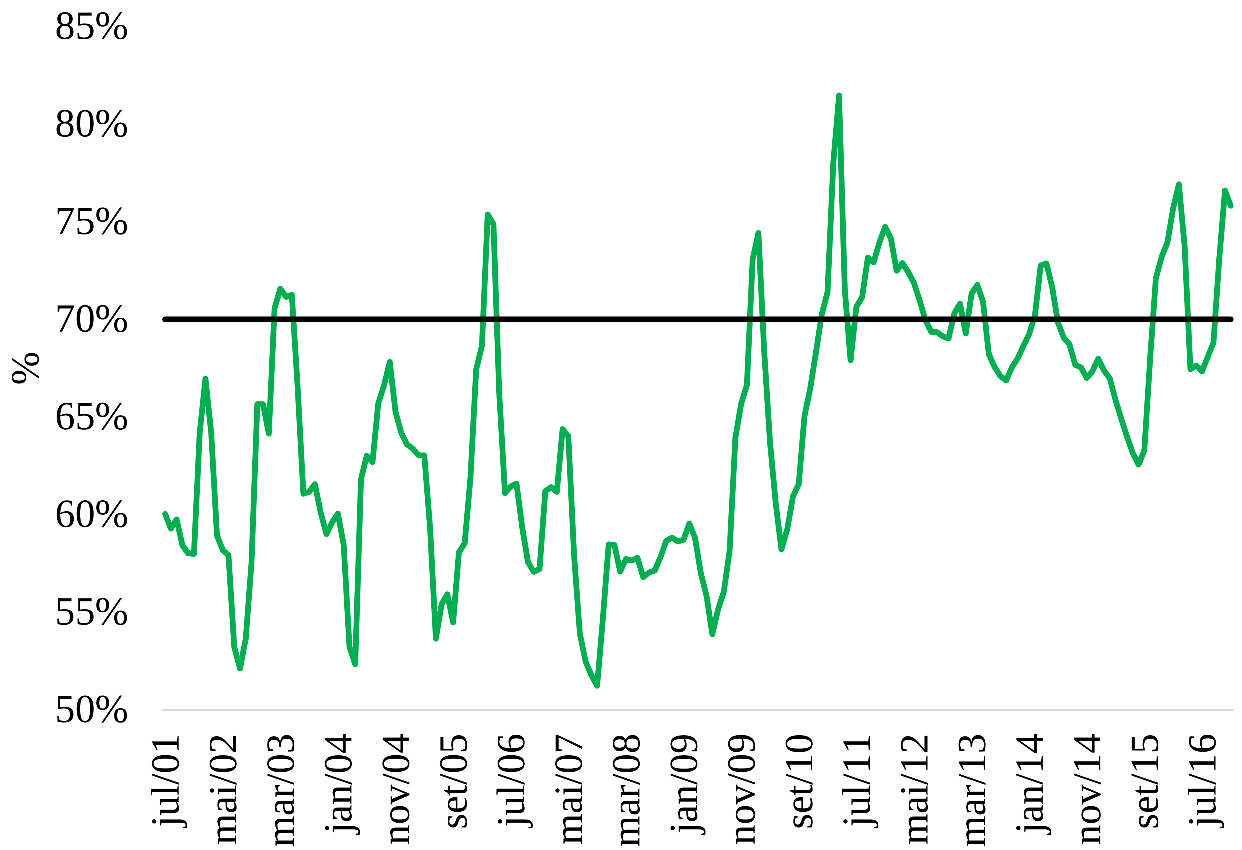


Fuel Consumption



OVERVIEW

Comparison of the real prices (Brazilian averages) of Hydrous Ethanol and Gasoline C ratio



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OVERVIEW

- **Technical progress and the Underlying Energy Demand Trend (UEDT)**

Energy is a derived demand

Models need to account for :

- Technical Progress (TP) / Efficiency Improvements

- Asymmetric Price Response
Price Elasticities (short-run and long-run)

Goal

- To study the determinants of vehicle fuel demand in Brazil
- To study if Underlying Demand Energy Trend (UDET) and asymmetric price responses (APR) has a role in modeling the demand for automotive fuel in Brazil

METHODOLOGY

- **Harvey's Structural Time Series Model (STSM)**

Autoregressive distributed lag model (ARDL) follows this specification:

$$A_i(L)e_{i,t} = \mu_{i,t} + B_i(L)p_{i,t} + C_i(L)y_t + D_i(L)f_{i,k,t} + S_i(L)\gamma_t + \varepsilon_t^i \quad (1)$$

$$; \qquad \varepsilon_t^i \sim IID(0, \sigma_\varepsilon^2)$$

$$\mu_{i,t} = \mu_{t-1}^i + \beta_{t-1}^i + \eta_t^i \; ; \qquad \eta_t^i \sim IID\left(0, \sigma_\eta^2\right)$$

$$\beta_t^i = \beta_{t-1}^i + \xi_t^i \; ; \qquad \xi_t^i \sim IID\left(0, \sigma_\xi^2\right)$$

$$S_i(L)\gamma_t = {\omega_t}^i \; ; \qquad \omega_t \sim IID(0, \sigma_\omega^2)$$

The trend component or UEDT, µt, follows a stochastic process

e – fuel demand

$i = gasoline\ C, ethanol\ and\ CNG$

p – fuel price

y- Income

f- $Fleet$

A_i, B_i, C_i, D_i and S_i are polynomial lag operators

METHODOLOGY

Estimates are obtained by maximum likelihood in conjunction with a Kalman filter using STAMP 8.3

Equation (1) assumes asymmetric price response (APR):

$$p_{i,t} = p_{i,\text{rise},t} + p_{i,c\text{ut},t}$$

$p_{i,\text{rise},t}$ is the cumulative rise in the log of prices

$p_{i,c\text{ut},t}$ is the cumulative decreases in the log of prices

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METHODOLOGY

Unrestricted Model
$A(L) = TIDE + B^{cres}(L)p_{cres} + B^{cor}(L)p_{cor} + C(L)y + D(L)f + S(L)\gamma + \varepsilon$
Restricted Model
Test 1: $H_0: \sigma_\eta^2 = 0$ e $\sigma_\xi^2 = 0$ Test 1.1: $H_0: \sigma_\eta^2 = 0$ e $\sigma_\xi^2 \neq 0$ Test 1.2: $H_0: \sigma_\eta^2 \neq 0$ e $\sigma_\xi^2 = 0$ $A(L) = \mu + B^{cres}(L)p_{cres} + B^{cor}(L)p_{cor} + C(L)y + D(L)f + S(L)\gamma + \varepsilon$ Test 2: $H_0: B^{cres}(L) = B^{cor}(L) = B(L)$ $F(L) = TIDE + G(L)p + H(L)y + I(L)f + J(L)\gamma + \varepsilon$ Test 3: $H_0: \sigma_\omega^2 = 0$

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METHODOLOGY

- The model for the analysis of the effect of Flex-Fuel vehicles:

Time Varying Parameter (TVP) Models

- $F_i(L)e_{i,t} = \mu_{i,t} + \lambda^1_{i,t}(L)p_{i,max,t} + \lambda^2_{i,t}(L)p_{i,rec,t} + \lambda^3_{i,t}(L)p_{i,cut,t} + H_i(L)y_t + I_i\ (L)f_{kt} + J_i(L)\gamma_{it} + \varepsilon_{i,t}$

State Equation:

$\lambda^n_{i,t} = \lambda^n_{i,t-1} + \nu_{i,t}\ ;\ n = 1,2\ e\ 3$

$\lambda^n_{i,t}$ is the parameter of the prices

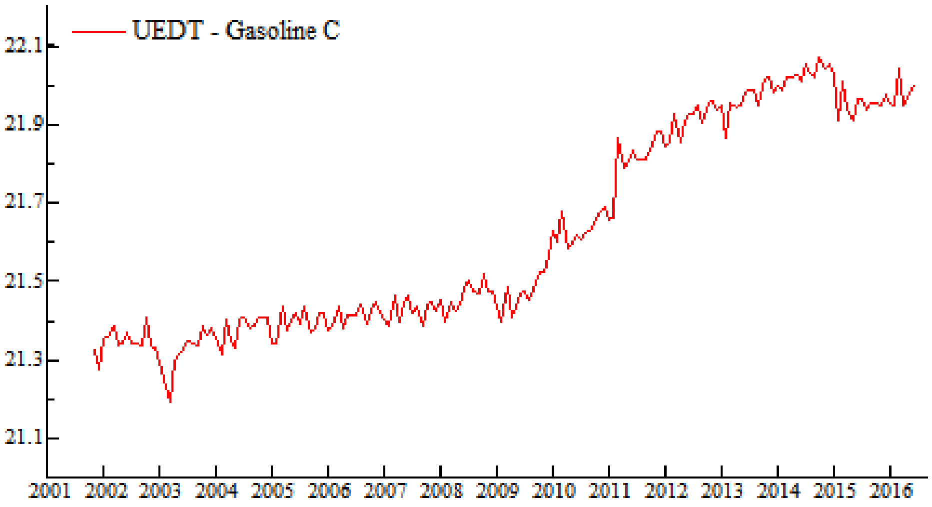
DATA

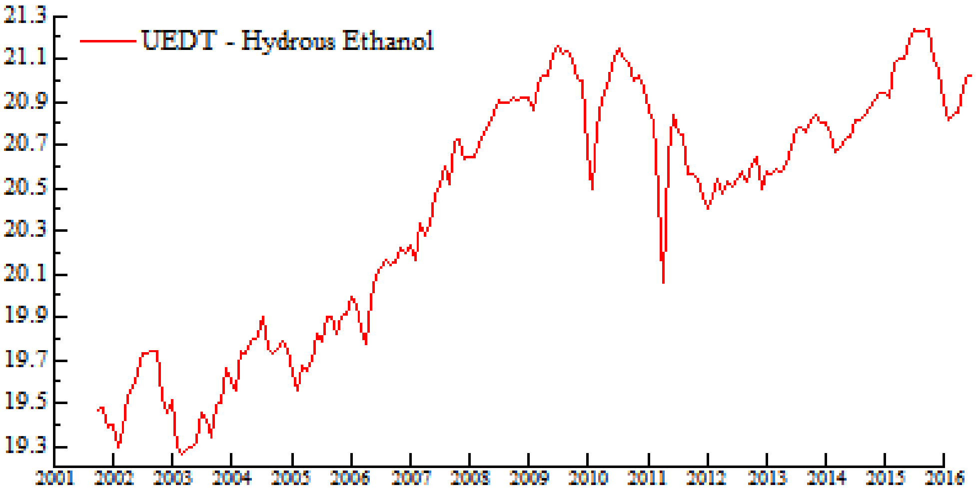
Variable		Source
Consumption	Toe	ANP e Abegás
Price	R$/toe	ANP
Fleet	-	DENATRAN, ANFAVEA e IBP
Price Index (2001.1=100)	% a.m.	IBGE/SNIPC

The fleet was calculated with a Gompertz type vehicle-scrapping curve using vehicle sales data

$$S_{i,t} = 1 - e^{-e^{(a_i + b_i * t)}}$$

RESULTS





The results indicate that the UEDT and APRs are complementary given they are both retained in the preferred models

UEDTs are clearly non-linear

RESULTS

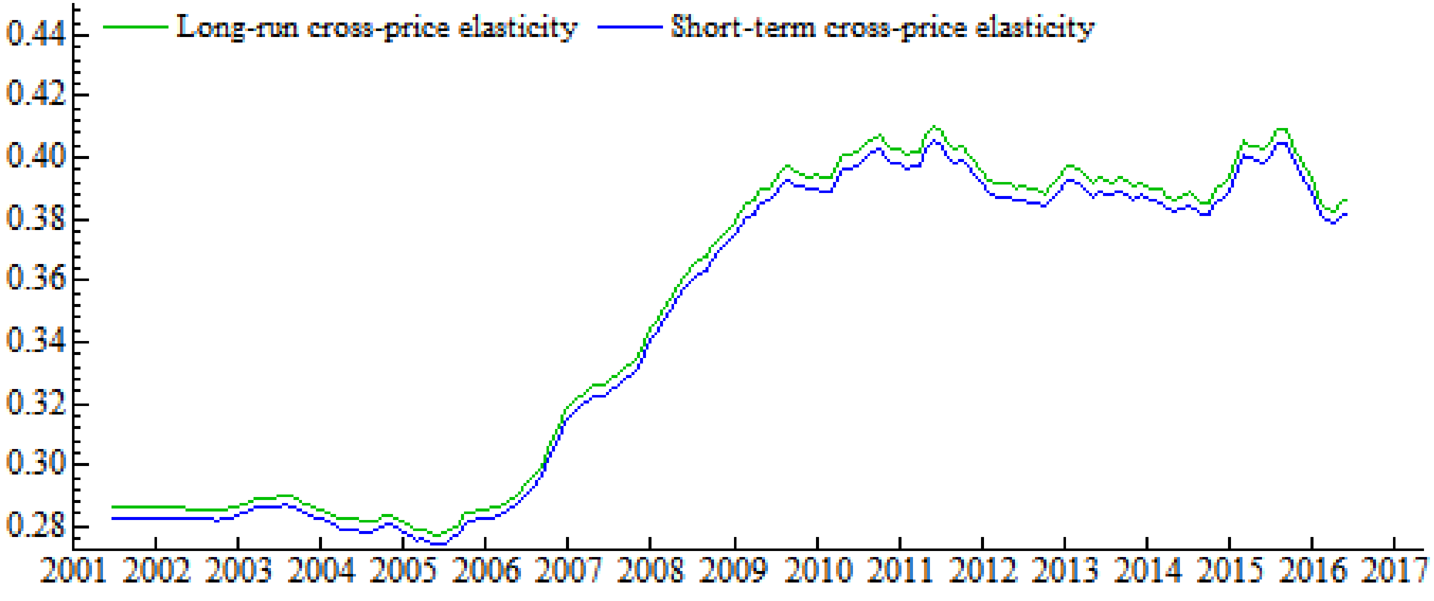
Long-term elasticity	Gasoline C
Y	0.58
$P_{g,rise}$	-0.70
$P_{g,cut}$	-0.53
$P_{e,rise}$	0.14
$P_{e,cut}$	0.34

Long-term elasticity	Ethanol
Y	1.77
$P_{e,rise}$	-2.25
$P_{e,cut}$	-1.34
$P_{g,rise}$	2.49
$P_{g,cut}$	0.84

Long-term elasticity	CNG
Y	0.32
$P_{CNG,rise}$	1.58
$P_{gnv,cut}$	0.0
$P_{g,rise}$	1.58
$P_{g,cut}$	0.67
F_{CNG}	0.60

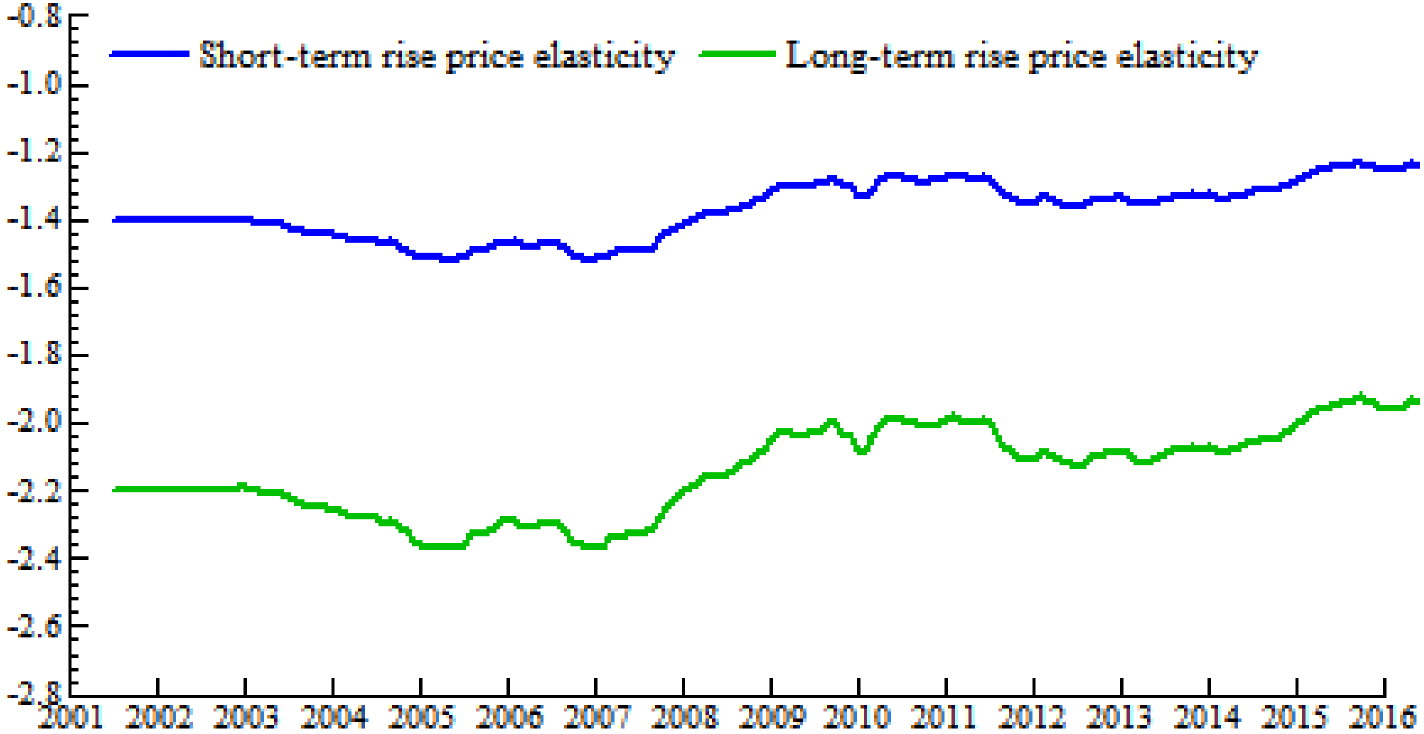
RESULTS

- Gasoline Demand



RESULTS

- Ethanol Demand



CONCLUSIONS

UEDT is an important extension to the more traditional methods used to model fuel demand elasticities

The inclusion of the UEDT, combined with APRs provided more detailed policy relevant information than models without such features

THANKS

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