Presentation Outline:

1. Introduction
2. Structural and Spatial Features of the Brazilian Fuel Market
3. Methodology
    1. Spatial Models and Tests
    2. Data
4. Results
5. Final Remarks

Introduction:

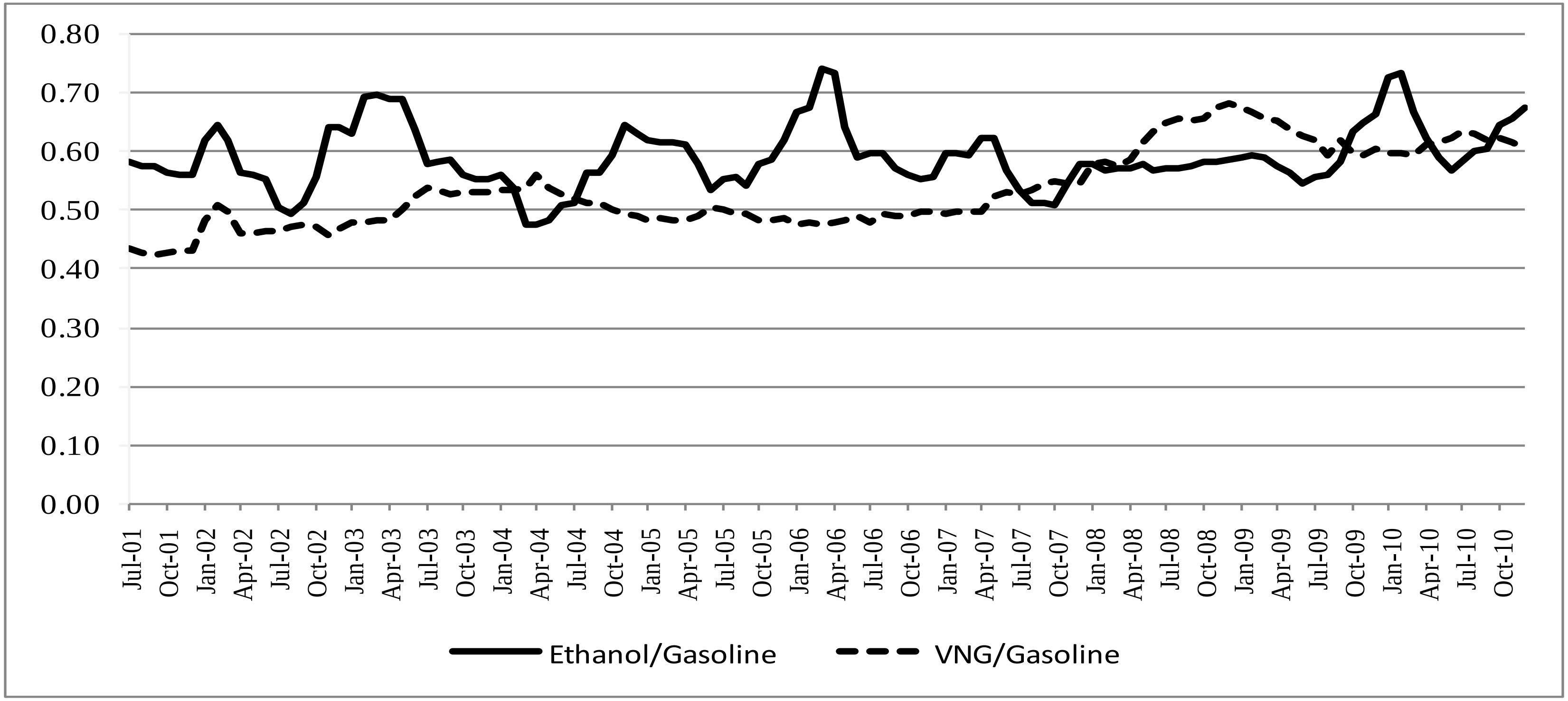
- There is a considerable amount of literature on the estimation of fuel demand equations in the Energy Economics literature:
  - Dahl (1995)
  - Eltonny and Al-Mutairi (1993; 1995)
  - Ramanathan (1999)
  - Polemis (2006)
  - Baltagi and Griffin (1983) – Panel Data
  - Rouwendal (1996) – Panel Data
  - Burnquist and Bacchi (2002) – Brazilian market
  - Alves and Bueno (2003) – Brazilian market
  - Roppa (2005) – Brazilian market
- General results for Brazil showed that fuel demand is inelastic and that these fuels are imperfect substitutes

Introduction:

Brazilian fuel market

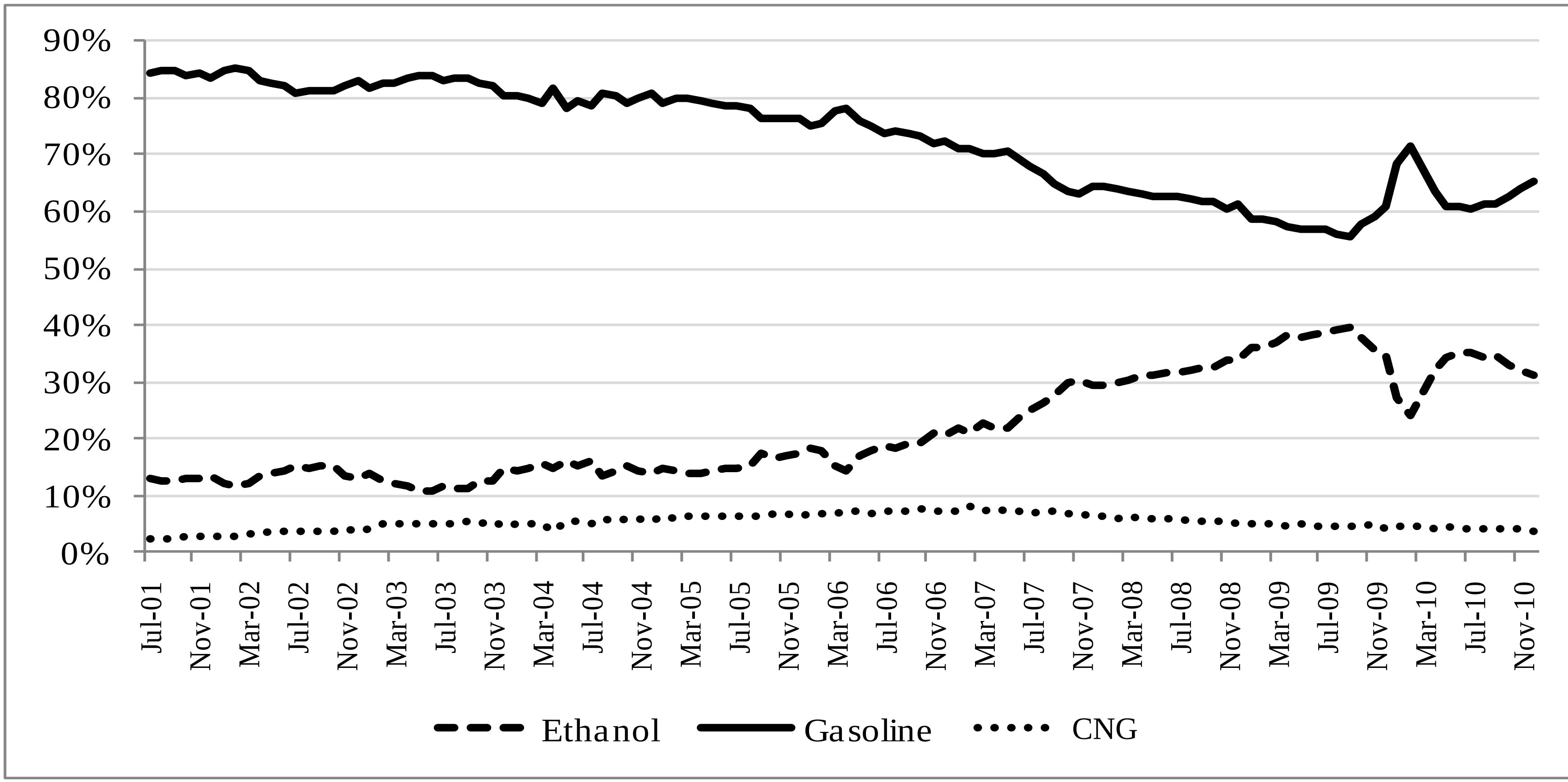
- Fuel diversification (introduction of ethanol in large scale)
- New market rules (liberalization after 1997)
- Technological advances in the automobile industry (flex-fuel engines)
- Increasing competition in the fuel market in Brazil (more choices to the consumers)

Price relations



- The calorific power of the ethanol is about 70% of the calorific power of the gasoline
- The competition still depends on the fuel tax subsidies to maintain the price relations of ethanol to gasoline around 70%

Market Share among Gasoline, Ethanol and CNG



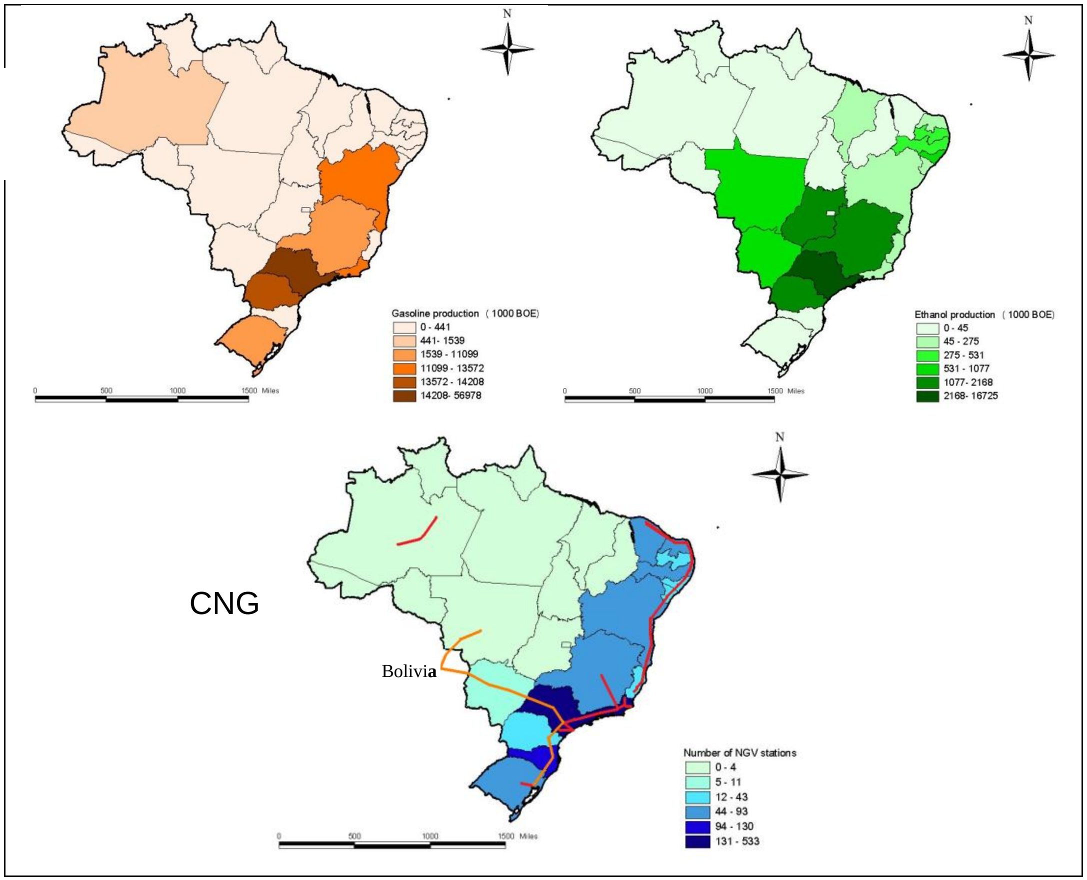
- Ethanol strongly competes with gasoline in the fuel market

Spatial Features of the Brazilian Fuel Supply

Gasoline Production

Ethanol Production

CNG

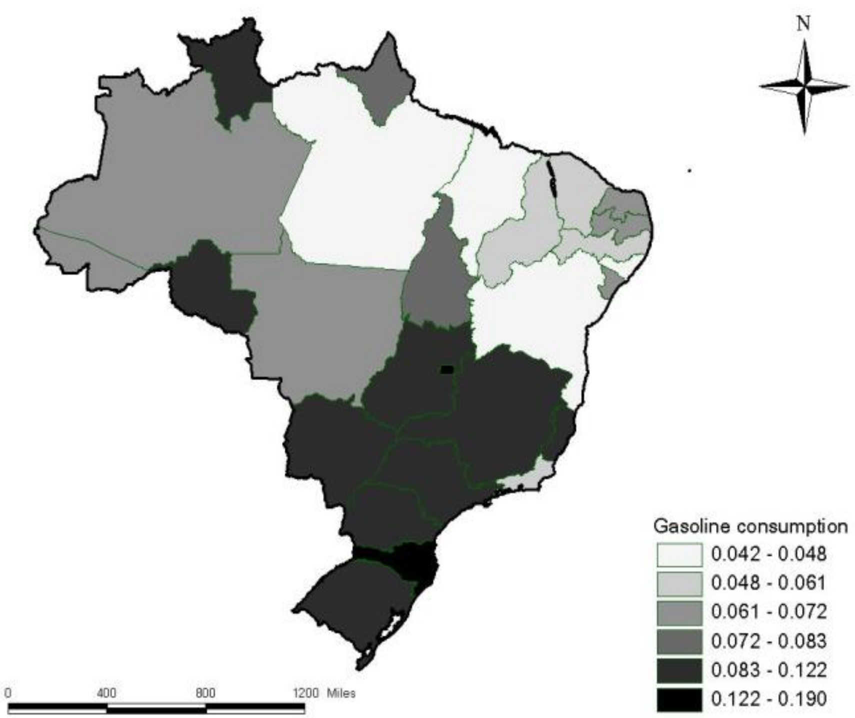


Spatial features of fuel supply, such as the concentration of ethanol and gasoline production in some states might influence the heterogeneity in the behavior of regional consumers

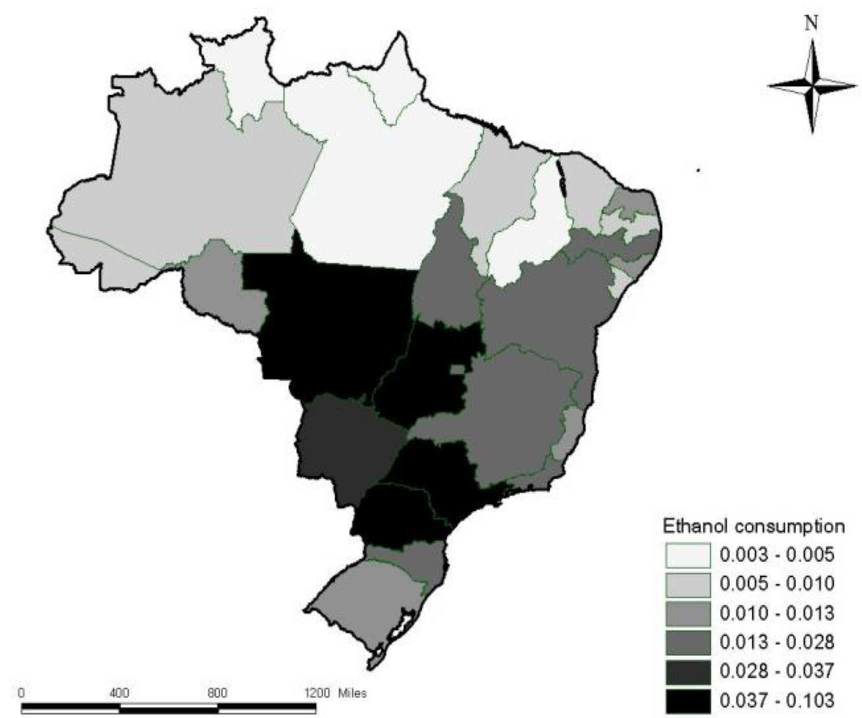
Spatial Features of the Fuel Demand

- Per capita consumption in 2010

gasoline



ethanol



- *We propose to control the spatial autocorrelation and individual heterogeneity of the Brazilian states in the estimation of gasoline and ethanol demand equations using spatial panel data models.*

Methodology:

- First, consider the standard fixed effects model, in which *i* is the cross-section unit index and *t* is the time index (Baltagi, 2001):

$$y_{it} = \alpha_i + x_{it}\beta + \varepsilon_{it} \qquad (1)$$

- The fixed effects spatial lag model in stacked form can be described as (Elhorst, 2003; Anselin *et al*., 2008):

$$y = \rho(I_T \otimes W_N)y + (i_T \otimes \alpha) + X\beta + \varepsilon \qquad (2)$$

Methodology:

- The fixed effects spatial error model can be written as (Elhorst, 2003; Anselin *et al*., 2008):

$$y = (i_T \otimes \alpha) + X\beta + u \quad (3)$$

$$u = \lambda(i_T \otimes W_N)u + \varepsilon \quad (4)$$

- The traditional model of random effects can be written as follows (Baltagi, 2001):

$$y_{it} = x_{it}\beta + \varepsilon_{it} \quad (5)$$

$$\varepsilon_t = \mu + v_t \quad (6)$$

Methodology:

- The demand equations to be estimated are:

$$lnG_{it} = \beta_0 + \beta_1 lnP_{G(it)} + \beta_2 lnP_{E(it)} + \beta_3 lnGDP_{it} + \epsilon_{it} \qquad (8)$$

$$lnE_{it} = \beta_0 + \beta_1 lnP_{G(it)} + \beta_2 lnP_{E(it)} + \beta_3 lnGDP_{it} + \epsilon_{it} \qquad (9)$$

- Variables *i* and *t* represent a panel composed by quarterly data set from the 27 Brazilian states for the period from Jul/2001 to Dec/2010, the period in which the National Agency of Oil collected data on fuel prices and consumption.
- A proxy variable, Product and Service Trading Tax (ICMS), had to be used to GDP

Results:

- Price-Elasticity of Demand for Gasoline: Estimates for Brazil

Methods	*Models*	*Constant*	*Rho (ρ)*	*Lambda (λ)*	*Gasoline Price*	*Ethanol Price*	*GDP*
Pooled OLS	*Non-Spatial Models*	0.068*** (0.004)			-0.031*** (0.004)	0.018*** (0.029)	0.760*** (0.005)
	Spatial Lag Model	0.607*** (0.028)	0.332*** (0.114)		-1.237*** (0.117)	0.514*** (0.077)	0.542*** (0.021)
	Spatial Error Model	-0.094 (0.130)		0.358*** (0.033)	-1.209*** (0.138)	0.536*** (0.090)	0.629*** (0.021)
Fixed Effect	*Non-Spatial Models*	0.046*** (0.002)			-0.003 (0.002)	0.007*** (0.002)	0.279*** (0.021)
	Spatial Lag Model		0.368*** (0.033)		-0.412*** (0.106)	0.069 (0.059)	0.169*** (0.035)
	Spatial Error Model			0.383*** (0.033)	-0.512*** (0.106)	0.153** (0.064)	0.149*** (0.035)
Random Effect	*Non-Spatial Models*	0.046*** (0.005)			-0.003* (0.002)	0.007*** (0.002)	0.287*** (0.021)
	Spatial Error Model	-1.270*** (0.133)		0.474*** (0.037)	-0.495*** (0.082)	0.214*** (0.057)	0.404*** (0.025)
	Spatial Lag Model	-0.122 (0.073)	-0.484*** (0.055)		-0.137*** (0.031)	0.026 (0.017)	0.146*** (0.013)
	Spatial Lag Model + Spatial Error Model (ML)	-2.188*** (0.125)	0.876*** (0.026)	0.585*** (0.027)	-0.250*** (0.082)	0.076 (0.048)	0.145*** (0.024)
	Spatial Model (GM)	-1.065*** (0.143)	0.357		-0.520*** (0.085)	0.177*** (0.058)	0.449*** (0.025)

Results:

- Price-Elasticity of Demand for Ethanol: Estimates for Brazil

Methods	Models	Constant	Rho (ρ)	Lambda (λ)	Gasoline Price	Ethanol Price	GDP
Pooled OLS	*Non-Spatial Models*	-0.007***			0.023***	-0.032***	0.334***
		(0.003)			(0.002)	(0.002)	(0.013)
	Spatial Lag Model	0.531***	-1.855***		3.316***	-3.040***	0.584***
		(0.020)	(0.202)		(0.211)	(0.144)	(0.034)
	Spatial Error Model	-4.236***		0.703***	3.920***	-3.705***	0.702***
		(0.249)		(0.021)	(0.264)	(0.162)	(0.040)
Fixed Effect	*Non-Spatial Models*	0.000			0.007***	-0.019***	0.564***
		(0.002)			(0.002)	(0.002)	(0.020)
	Spatial Lag Model		-0.035		2.828***	-1.730***	0.083***
			(0.038)		(0.280)	(0.157)	(0.094)
	Spatial Error Model			-0.059	2.854***	-1.703***	0.086***
				(0.040)	(0.278)	(0.154)	(0.093)
Random Effect	*Non-Spatial Models*	-0.001			0.008***	-0.019***	0.534***
		(0.002)			(0.002)	(0.002)	(0.019)
	Spatial Error Model	-3.899***		0.647***	2.819***	-2.037***	0.774***
		(0.389)		(0.027)	(0.263)	(0.184)	(0.081)
	Spatial Lag Model	-0.775***	-0.530***		0.377***	-0.362***	0.148***
		(0.147)	(0.059)		(0.069)	(0.038)	(0.032)
	Spatial Lag Model + Spatial Error Model (ML)	-4.865***	0.972***	0.006***	1.268***	-1.113***	0.138**
		(0.318)	(0.572)	(0.026)	(0.186)	(0.107)	(0.054)
	Spatial Model (GM)	-3.243***	0.531		2.769***	-2.106***	0.961***
		(0.408)			(0.274)	(0.189)	(0.080)

Results:

Tests

- Estimates of elasticities differ in sign and magnitude from one model to another
- There are specification tests for evaluating models that can assist in identifying the most appropriate model to be used

We used two tests:

- The first test is the Joint One-Sided Test to verify the joint significance of regional random effects and spatial correlation
- The second test is the Conditional LM Test which tests for the presence of spatial correlation.
- Both tests are based on the random effects model

Results:

- Baltagi, Song and Koh Tests for Regional Effects and Spatial Autocorrelation

Tests	*Description*	*Demand for Gasoline*	*Demand for Ethanol*
One-Sided Joint Test	*LM-H*	12931.990	4796.088
	p-value	1.00E-02	1.00E-02
Conditional LM Test	*LM-Lambda*	11.303	16.355
	p-value	2.2E-16	2.20E-16

- The Joint Tests for gasoline demand and ethanol demand were both significant at 1%, which suggests that the specification of random effects model is adequate and that spatial correlation must be taken into account

Results:

- The gasoline demand is inelastic. Its price elasticity is -0.250. It has the expected sign and is close to -0.319 for the short-run and to -0.227 for the long-run elasticities estimated by Burnquist and Bacchi (2002). It also is close to -0.464 for the elasticities estimated by Alves and Bueno (2003).
- The income elasticity of 0.156 has the expected sign and shows that gasoline consumers are a lower sensitivity to income. This value is close to that presented in Alves and Bueno (2003), who found a value of 0.122 for the short and the long run and close to results presented in Roppa (2005), who found a value 0.163 for the long run.
- The ethanol demand is elastic to prices. The price elasticity of -1.113 has the expected sign, but its value is considerably high for the elasticity energy pattern. The same occurs to cross-price elasticity regarding the gasoline demand of 1.268. This demonstrates that the consumption of ethanol has a very elastic demand in Brazil.

Final remarks:

- The fuel market for light vehicles in Brazil is considerably competitive because of the fuel diversification and the *flex-fuel* technology
- Spatial features of the fuel supply and regional factors might determine heterogeneities in the behavior of regional consumers and in the existence of spatial autocorrelation patterns for fuel demand
- Gasoline consumers were much less sensitive to ethanol prices than to gasoline prices, and also less income sensitive

Thank you

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