6
Robustness Tests of the Main Results

We run a series of regressions in order to verify the robustness of our results. First, we use fuel retail margins instead of retail prices as a dependent variable. Second, we control for the competing fuel cost instead of controlling for its price. Finally, we create a measure of spatial competition between stations based on the geographical distance between them.

6.1
Fuel Margins

A common practice in the literature on gasoline retail markets in the United States is to use gasoline margins instead of gasoline prices as a dependent variable. For example, Borenstein (1991), Borenstein and Shepard (1996) and Johnson and Romeo (2000) all used retail margins as their relevant dependent variable. Borenstein (1991) goes further and argues that retail margins are a better measure of market power than markup over marginal cost. He claims that "…if market power is determined by the cost of switching sellers and that cost is not closely related to the wholesale prices of gasoline, then the margin is a better indicator of market power".

On the other hand, Shepard (1993) and Slade (1992), to mention just a few, used gasoline retail prices as dependent variable. In our main results, we chose to use fuel prices as dependent variable and control for the respective fuel costs. We preferred this approach because it imposes fewer restrictions in our reduced form model, i.e., using retail margins in our

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reduced form model would be the same as imposing the coefficients on fuel costs to be equal to one ($\lambda^a = \lambda^g = 1$). Nevertheless, our results are robust to the choice of the dependent variables, as we can see in tables 7 and 8 below.

The main regression of each table is presented in the last column (regression number 3). The dependent variables are now fuel retail margins. They are simply fuel prices minus fuel costs. Our priors are the same. This means that we expect fuel retail margins to fall as the percentage of flex cars rise. We also anticipate that an increase in the percentage of flex vehicles will augment the sensitivity between the two fuel margins.

The coefficients of the variable %Flex are both negative and significant at the 1% level, which confirms our prior that prices are being reduced. We can also verify that the effects on fuel margins are almost equal for both fuels; -0.00626 for gasoline against -0.00637 for ethanol. The sizes of the coefficients are smaller than the ones in the main regressions.

The coefficients on the interactions between fuel margins and the percentage of flex cars are both positive and significant at the 1% level, which is according to the interpretation of strengthened competition between the two fuels in the retail market. The coefficients are larger than in our main regression, showing that an increase in the percentage of flex automobiles has a greater effect in the sensitivity between fuel margins than on the sensitivity between fuel prices.

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Table 7: Regressions - Gasoline Margins

Dependent Variable: Gasoline Margin

	(1)	(2)	(3)
%Flex	**0.00597*** **	**-0.00595*** **	**-0.00626*** **
	(0.00039)	**(0.00048)**	**(0.00046)**
(%Flex) . (Ethanol Margin)	**0.01286*** **	**0.01532*** **	**0.01524*** **
	(0.00086)	**(0.00074)**	**(0.00075)**
Gasoline-Powered Cars	-0.01096***	-0.00644***	-0.00375***
	(0.00174)	(0.00116)	(0.00087)
Ethanol Margin	0.10119***	0.08227***	0.08102***
	(0.00342)	(0.00260)	(0.00264)
Minimum Wage			0.00048***
			(0.00003)
GDP per Capita			-0.00161***
			(0.00035)
(Total Stations)/(Gasoline-Powered Cars)			-0.00020***
			(0.00003)
Hotels per km²			0.12472***
			(0.03242)
Constant	0.32730***	0.30712***	0.08390***
	(0.01187)	(0.01490)	(0.01300)
Month Fixed-Effects	No	Yes	Yes
City Fixed-Effects	Yes	Yes	No
Brand and Station Fixed-Effects	No	No	Yes
Observations	147135	147135	146528
Number of Groups	2102	2102	2102

Robust standard errors in parentheses -

(robust to heteroskedaticity and to correlation of the residuals within a city in a given week)

* significant at 10%; ** significant at 5%; *** significant at 1%

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Table 8: Regressions - Ethanol Margins

Dependent Variable: Ethanol Margin

	(1)	(2)	(3)
%Flex	**-0.01345*** **	**-0.00701*** **	**-0.00637*** **
	(0.00067)	**(0.00087)**	**(0.00091)**
(%Flex) . (Gasoline Margin)	**0.04800*** **	**0.03980*** **	**0.03956*** **
	(0.00213)	**(0.00188)**	**(0.00199)**
Ethanol-Powered Cars	-0.01551***	-0.02547***	-0.02910***
	(0.00292)	(0.00237)	(0.00235)
Gasoline Margin	0.31459***	0.31819***	0.30590***
	(0.00983)	(0.00902)	(0.00909)
Minimum Wage			0.00001
			(0.00004)
GDP per Capita			0.00147***
			(0.00041)
(Total Stations)/(Ethanol-Powered Cars)			0.00003***
			(0.00000)
Hotels per km²			-0.06196*
			(0.03507)
Constant	0.16484***	0.13527***	0.15961***
	(0.01497)	(0.01435)	(0.01596)
Month Fixed-Effects	No	Yes	Yes
City Fixed-Effects	Yes	Yes	No
Brand and Station Fixed-Effects	No	No	Yes
Observations	147135	147135	146528
Number of Groups	2102	2102	2102

Robust standard errors in parentheses -
(robust to heteroskedaticity and to correlation of the residuals within a city in a given week)
* significant at 10%; ** significant at 5%; *** significant at 1%

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6.2
Fuel Costs

We do not observe all components that affect the pricing decisions of gas stations. For instance, Shepard (1993) analyzes the manufacturer-retailer relationship and finds evidence that retail prices of some gasoline products are lower when the station is allowed to control the retail price directly. She also finds evidence that some characteristics of fuel stations, like capacity, presence of a convenience store or presence of a repair center, significantly affects retail prices of some gasoline products.

The characteristics mentioned above may affect pricing decisions of gasoline and ethanol. Even though we include stations fixed effects in our main regressions, we do not control for changes of characteristics over time. This fact may be biasing our results since we use fuel prices as regressors in our reduced form model.

In order to diminish this bias and check the robustness of our results, we use fuel costs as regressors instead of fuel prices, since fuel prices and costs are highly correlated but characteristics of stations should not affect wholesale prices.

In general, this change of regressors raises the absolute value of the coefficients of interest in the equation that has ethanol price as dependent variable and reduce those same coefficients in the regression that has gasoline price as dependent variable.

One more time, we can see that that the coefficients of the variable %Flex are both negative and significant at the 1% level, as we expected. We can also verify that the effect on gasoline retail prices is smaller than the one calculated in our main results: -0.00569. However, the effect on ethanol prices is multiplied by more than three: -0.05407.

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Table 9: Regressions – Gasoline Price on Ethanol Cost

Dependent Variable: Gasoline Price

	(1)	(2)	(3)
%Flex	**0.03802*** **	**-0.00426*** **	**-0.00569*** **
	(0.00116)	**(0.00114)**	**(0.00104)**
(%Flex) . (Ethanol Cost)	**-0.02043*** **	**0.00252*** **	**0.00296*** **
	(0.00080)	**(0.00073)**	**(0.00069)**
Gasoline-Powered Cars	-0.02053***	-0.01453***	-0.00970***
	(0.00177)	(0.00140)	(0.00110)
Gasoline Cost	0.96598***	0.35109***	0.34401***
	(0.00391)	(0.00849)	(0.00851)
Ethanol Cost	0.08302***	0.02916***	0.02509***
	(0.00310)	(0.00213)	(0.00207)
Minimum Wage			0.00270***
			(0.00004)
GDP per Capita			-0.00162***
			(0.00036)
(Total Stations)/(Gasoline-Powered Cars)			-0.00024***
			(0.00003)
Hotels per km²			0.18078***
			(0.03328)
Constant	0.33320***	1.21190***	0.37090***
	(0.01632)	(0.02212)	(0.01648)
Month Fixed-Effects	No	Yes	Yes
City Fixed-Effects	Yes	Yes	No
Brand and Station Fixed-Effects	No	No	Yes
Observations	147135	147135	146528
Number of Groups	2102	2102	2102

Robust standard errors in parentheses -
(robust to heteroskedaticity and to correlation of the residuals within a city in a given week)
* significant at 10%; ** significant at 5%; *** significant at 1%

The coefficients on the interactions are both positive and significant at the 1% level. This means that the sensitivity between the price of one fuel to the cost of the other fuel rises as the percentage of flex cars increase. These coefficients indicate that as percentage of flex vehicles rise, stations start to pay more attention to ethanol cost while pricing gasoline. The converse is also true.

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Table 10: Regressions – Ethanol Price on Gasoline Cost

Dependent Variable: Ethanol Price

	(1)	(2)	(3)
%Flex	**-0.05486*** **	**-0.05559*** **	**-0.05407*** **
	(0.00674)	**(0.00670)**	**(0.00703)**
(%Flex) . (Gasoline Cost)	**0.02378*** **	**0.02471*** **	**0.02383*** **
	(0.00292)	**(0.00285)**	**(0.00299)**
Ethanol-Powered Cars	-0.03419***	-0.03736***	-0.03879***
	(0.00336)	(0.00307)	(0.00300)
Ethanol Cost	0.63260***	0.34342***	0.33613***
	(0.00438)	(0.00464)	(0.00446)
Gasoline Cost	0.36707***	0.11156***	0.10236***
	(0.00533)	(0.00902)	(0.00889)
Minimum Wage			0.00146***
			(0.00005)
GDP per Capita			-0.00220***
			(0.00047)
(Total Stations)/(Ethanol-Powered Cars)			0.00001**
			(0.00000)
Hotels per km²			0.11430***
			(0.03491)
Constant	0.04388*	0.69203***	0.24028***
	(0.02413)	(0.02316)	(0.01805)
Month Fixed-Effects	No	Yes	Yes
City Fixed-Effects	Yes	Yes	No
Brand and Station Fixed-Effects	No	No	Yes
Observations	147135	147135	146528
Number of Groups	2102	2102	2102

Robust standard errors in parentheses -
(robust to heteroskedaticity and to correlation of the residuals within a city in a given week)
* significant at 10%; ** significant at 5%; *** significant at 1%

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6.3 Competition between Stations

Spatial competition might be affected by the level of economic activity in each city, since this form of competition is related to entry and exit decisions of fuel stations. Since the proportion of flex cars in each city might also be affected by the level of economic activity, we expect a correlation between spatial competition and the proportion of flex cars. In order to control for this dimension of competition among stations, we created a variable that measures spatial competition between them.

Based on the address of each one the stations, we constructed the variable "Distance to Stations", which represents the average distance of a given fuel station to its three nearest competitors. We expect that the higher the average distance to the three closest competitors the lower the competition faced by this given station will be, i.e., we expect a positive correlation between this variable and fuel prices. This variable has a quarterly frequency. We also constructed other variables using different numbers of closest competitors, but the results are similar and, hence, omitted.

We were able to construct this variable only to a reduced number of observations for two reasons. First, we restricted the sample to cities in which we thought a census of fuel stations were more likely to be conducted by the ANP's survey[7]. Second, the program we used to calculate the latitude and longitude of each station, Google Earth, did not recognize most of the streets in some municipalities.

Google Earth also does not recognize addresses on Brazilian highways. So we were forced to create "new markets" apart from municipalities we originally used. More specifically, we divided the cities

[7] We did that by comparing the number of fuel stations in each city in a given quarter of year to the present number of fuel stations in this given city. This last information is available on ANP's website.

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we considered previously in two markets: stations on highways and stations off highways. We measured the distance between two stations on a same highway by calculating the absolute value of the difference between the positions of the two stations on the highway in km.[8]

Table 11: Regression - Gasoline Prices - Excluding Stations on Highways

Dependent Variable: Gasoline Price

	(1)	(2)	(3)
%Flex	**-0.01328*****	**-0.01381*****	**-0.01278*****
	(0.00389)	**(0.00392)**	**(0.00387)**
(%Flex) . (Ethanol Price)	**0.01390*****	**0.01440*****	**0.01389*****
	(0.00178)	**(0.00180)**	**(0.00177)**
Gasoline-Powered Cars	-0.25931***	-0.26761***	-0.27023***
	(0.03982)	(0.04102)	(0.03986)
Gasoline Cost	0.23561***	0.23537***	0.23607***
	(0.01336)	(0.01338)	(0.01336)
Ethanol Price	0.25142***	0.25412***	0.25203***
	(0.00831)	(0.00837)	(0.00829)
Minimum Wage	0.00239***	0.00238***	0.00238***
	(0.00009)	(0.00009)	(0.00009)
GDP per Capita	-0.01910***	-0.01910***	-0.01910***
	(0.00109)	(0.00109)	(0.00109)
(Total Stations)/(Gasoline-Powered Cars)	-0.00030***	-0.00031***	-0.00032***
	(0.00007)	(0.00008)	(0.00007)
Hotels per km²	0.27528***	0.28483***	0.27069***
	(0.09538)	(0.09732)	(0.09623)
Distance to Stations		-0.01985***	-0.02167***
		(0.00453)	(0.00468)
Constant	0.61493***	0.64443***	0.62750***
	(0.03364)	(0.03941)	(0.03363)
Month and Brand Fixed-Effects	Yes	Yes	Yes
Market Fixed-Effects	No	Yes	No
Station Fixed-Effects	Yes	No	Yes
Observations	26209	26209	26209
Number of Groups	187	187	187

Robust standard errors in parentheses -
(robust to heteroskedaticity and to correlation of the residuals within a city in a given week)
* significant at 10%; ** significant at 5%; *** significant at 1%

[8]Some highways had less than 4 stations in our sample. We calculated the variable "Distance to Stations" considering the available closest competitors.

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Table 12: Regressions - Ethanol Prices - *Excluding* Stations on Highways

Dependent Variable: Ethanol Price

	(1)	(2)	(3)
%Flex	**-0.00264**	**-0.00753**	**-0.00395**
	(0.01253)	**(0.01279)**	**(0.01249)**
(%Flex) . (Gasoline Price)	**-0.00305**	**-0.00167**	**-0.00283**
	(0.00430)	**(0.00438)**	**(0.00429)**
Ethanol-Powered Cars	1.02933***	1.08962***	1.06597***
	(0.18489)	(0.18881)	(0.18664)
Ethanol Cost	0.24049***	0.24357***	0.23975***
	(0.00774)	(0.00780)	(0.00774)
Gasoline Price	0.62447***	0.63091***	0.62492***
	(0.02165)	(0.02159)	(0.02165)
Minimum Wage	-0.00045***	-0.00048***	-0.00044***
	(0.00013)	(0.00013)	(0.00013)
GDP per Capita	0.00073	0.00072	0.00070
	(0.00146)	(0.00149)	(0.00146)
(Total Stations)/(Ethanol-Powered Cars)	-0.00002***	-0.00003***	-0.00002***
	(0.00001)	(0.00001)	(0.00001)
Hotels per km²	0.60452***	0.60547***	0.61005***
	(0.14558)	(0.14793)	(0.14509)
Distance to Stations		0.02654***	0.02966***
		(0.00594)	(0.00637)
Constant	-0.08878*	-0.08333*	-0.10066**
	(0.04605)	(0.05009)	(0.04595)
Month and Brand Fixed-Effects	Yes	Yes	Yes
Market Fixed-Effects	No	Yes	No
Station Fixed-Effects	Yes	No	Yes
Observations	22870	22870	22870
Number of Groups	186	186	186

Robust standard errors in parentheses -
(robust to heteroskedaticity and to correlation of the residuals within a city in a given week)
* significant at 10%; ** significant at 5%; *** significant at 1%

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We studied off highway and on highway markets separately. Tables 11 and 12 above present the results considering only stations *off* highways, while tables 13 and 14 below present the results considering only stations *on* highways.

Looking at last column of each table, we can see that the coefficients on %Flex are negative in all the tables, as we expected. Except in table 12 above, the coefficients are all significant at the 5% level, at least.

Regarding the coefficients on the interactions between fuel prices and the percentage of flex cars, they are all positive and significant at the

5% level (at least), except in table 12. In this last table the coefficient on the interaction is negative but is not significant at the 10% level.

There is a difference between the interpretation of the coefficients of the variable Distance to Stations in columns 2 and 3 of each table. As this variable is a station characteristic and we include station fixed effects in the last regression of each table, this variable is only capturing changes in the distance to the three closest competitors of a given station. Thus, this variable is capturing entries and exits in a given market.

It is more reasonable to interpret the coefficients on Distance to Stations in the second column of each table, since these regressions do not include station fixed effects. That is to say we are considering the cross-section variation of this variable between stations in column 2, while in column 3 we are not.

We can see that the coefficients on Distance to Stations are positive only in the regressions that have ethanol as dependent variable, tables 12 and 14. The coefficient is significant at the 1 % level only in table 12. In tables 11 and 13 the coefficients are both negative and significant at the 1% level.

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Table 13: Regressions - Gasoline Prices - Only Stations on Highways

Dependent Variable: Gasoline Price

	(1)	(2)	(3)
%Flex	**-0.02435*** **	**-0.01346*** **	**-0.01744*** **
	(0.00322)	**(0.00319)**	**(0.00299)**
(%Flex) . (Ethanol Price)	**0.01469*** **	**0.00638*** **	**0.00789*** **
	(0.00180)	**(0.00173)**	**(0.00167)**
Gasoline-Powered Cars	0.17333***	0.04556***	0.38817***
	(0.04896)	(0.01399)	(0.05070)
Gasoline Cost	0.16539***	0.23751***	0.16563***
	(0.01403)	(0.01425)	(0.01400)
Ethanol Price	0.21609***	0.31093***	0.20984***
	(0.00777)	(0.00684)	(0.00808)
Minimum Wage	0.00283***	0.00258***	0.00298***
	(0.00008)	(0.00008)	(0.00008)
GDP per Capita	-0.02676***	0.00321***	-0.02944***
	(0.00138)	(0.00034)	(0.00146)
(Total Stations)/(Gasoline-Powered Cars)	-0.00004	0.00009***	0.00003
	(0.00006)	(0.00001)	(0.00006)
Hotels per km²	1.01407***	0.97452***	1.17472***
	(0.33565)	(0.04437)	(0.37768)
Distance to Stations		-0.00045***	0.00028**
		(0.00010)	(0.00011)
Constant	0.50044***	0.23643***	0.42055***
	(0.02993)	(0.02675)	(0.03090)
Month and Brand Fixed-Effects	Yes	Yes	Yes
Market Fixed-Effects	No	Yes	No
Station Fixed-Effects	Yes	No	Yes
Observations	12852	11399	11399
Number of Groups	113	99	99

Robust standard errors in parentheses -
(robust to heteroskedaticity and to correlation of the residuals within a city in a given week)
* significant at 10%; ** significant at 5%; *** significant at 1%

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Table 14: Regressions - Ethanol Prices - <u>Only</u> Stations on Highways

Dependent Variable: Ethanol Price

	(1)	(2)	(3)
%Flex	**-0.01414**	**-0.01256**	**-0.02826****
	(0.01292)	**(0.01295)**	**(0.01375)**
(%Flex) . (Gasoline Price)	**0.00491**	**0.00579**	**0.01050****
	(0.00478)	**(0.00479)**	**(0.00518)**
Ethanol-Powered Cars	0.80457***	0.50242***	0.54570**
	(0.21729)	(0.07846)	(0.23057)
Ethanol Cost	0.22705***	0.29245***	0.23184***
	(0.00896)	(0.00946)	(0.00998)
Gasoline Price	0.68998***	0.77506***	0.65559***
	(0.02412)	(0.02016)	(0.02517)
Minimum Wage	-0.00098***	-0.00153***	-0.00086***
	(0.00012)	(0.00012)	(0.00013)
GDP per Capita	-0.00331*	0.00009	-0.00491**
	(0.00191)	(0.00035)	(0.00207)
(Total Stations)/(Ethanol-Powered Cars)	-0.00003***	0.00000***	-0.00002***
	(0.00001)	(0.00000)	(0.00001)
Hotels per km²	2.00795***	-0.02403	1.84627***
	(0.44907)	(0.06900)	(0.51543)
Distance to Stations		0.00019	-0.00025
		(0.00014)	(0.00016)
Constant	0.07544*	-0.03749	0.13958***
	(0.04107)	(0.03581)	(0.04327)
Month and Brand Fixed-Effects	Yes	Yes	Yes
Market Fixed-Effects	No	Yes	No
Station Fixed-Effects	Yes	No	Yes
Observations	10660	9380	9380
Number of Groups	111	98	98

Robust standard errors in parentheses -
(robust to heteroskedaticity and to correlation of the residuals within a city in a given week)
* significant at 10%; ** significant at 5%; *** significant at 1%

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