Price Asymmetry and Retailers Heterogeneity in Brazilian Gas Stations

Leonardo Chaves Borges Cardoso[*]
Maurício Vaz Lobo Bittencourt[†]
Elena Grace Irwin[‡]

Abstract

In a competitive market situation a symmetric price transmission is expected, the speed of adjustment of the market should be equal, no matter which direction input prices are going (up or down). Any deviation from this situation is called price asymmetry transmission. This study aims to answer three questions: i) Is there price asymmetry in Brazilian Gasoline Market? ii) Is asymmetry a firm or a market feature? iii) Which variables contribute to the likelihood of gas stations to respond asymmetrically? To answer these we run an AECM for more than 17,000 gas stations. Results indicate that there is heterogeneity across gas stations: 71% of them have no asymmetry, 23% have positive asymmetry and 6% have negative asymmetry. Gas stations with higher margins, less rivals nearby and non-white flags have higher probability to have positive asymmetry. Results reinforce the link between power market and positive price asymmetry and bring the novelty of relating positive price asymmetry to spatial competition.

Keywords: firms heterogeneity, asymmetric price, gas stations, gasoline.

Resumo

Em um mercado competitivo uma transmissão simétrica de preços é esperada, a velocidade do ajuste aos choques não deve ser diferente para choques positivos nos custos e para choques negativos. Qualquer desvio desse padrão é chamado de assimetria de preços. Esse trabalho objetiva responder a três perguntas: i) Existe assimetria de preço no mercado brasileiro? Assimetria é uma característica das firmas ou do mercado como um todo? iii) O que aumenta ou diminui a chande de um posto praticar assimetria? Foi usado um AECM para mais de 17 mil postos e os resultados indicam para a existência de heterogeneidade: 71% dos postos não responde assimetricamente, 23% responde positivamente e 6% negativamente. Postos com maiores margens e com bandeira diferente da branca possuem maior probabilidade de ter assimetria positiva. Os resultados reforçam o link entre assimetria positiva e poder de mercado e trazem a contribuição ao relacionar assimetria com concorrência espacial.

Palavras-chave: heterogeneidade das firmas, assimetria de preços, postos, gasolina.

JEL: C24, D22, L11, R32.

---

[*]Doctor by the Program in Economic Development from Federal University of Paraná (PPGDE/UFPR), e-mail: leonardocardoso005@gmail.com.

[†]Professor in the Graduate Studies Program in Economic Development at Federal University of Paraná (PPGDE/UFPR), e-mail: mbittencourt@ufpr.br.

[‡]Professor in Department of Agricultural, Environmental and Development Economics, The Ohio State University (AEDE/OSU), email:irwin.78@osu.edu.

1 Introduction

In a competitive market situation a symmetric price transmission is expected, and the speed of adjustment of the market should be equal, no matter which direction input prices are going (up or down). Any deviation from this situation is called price asymmetry transmission. When input prices increase, firms need to pass on costs to avoid negative profit situation. When they go down, firms reaction is in direction to avoid losses of market share (I am considering that inputs are common for the whole market, so, the other firms also face to a reduction in costs). But, how fast do firms react? Do they react always in the same way? Or the speed of reaction depends on the nature of costs shocks: positive shocks having different speeds than negative shocks? Answering these questions is precisely what we do when studying (a)symmetry transmission price.

The standard pattern (price symmetry) is when firms react fully and with the same speed in both situations: when input prices go up and when they go down. The most common deviation of that is when retailers adjust output prices faster when input price goes up than when it goes down. This situation is called as **positive asymmetry**, or a "rockets and feathers pattern"[1] (Tappata, 2009). Previously, positive asymmetry was only related to market power, being used to quantify the extent of that and motivating anti-cartel and antitrust policies. The intuition is that, as firms have more market power, more they delay input prices decreases and the more they accelerate input price increases. This behaviour allows to capture an extra consumer's surplus, providing extra profits in the short run.

Mainly after Peltzman (2000), price asymmetry is not addressed exclusively to market power or collusive behavior, being these only one of some possible explanations. Other recognized reasons are consumers search costs (Yang and Ye, 2008, Tappata, 2009), menu costs and inflation (Ball and Mankiw, 1994) and asymmetry in consumers search intensity (Bragoudakis and Sideris, 2012, Lewis and Marvel, 2011) [2].

In the empirical literature, each study defines what is input and output prices. Therefore, it is possible to investigate asymmetry into different points of market chains. It is possible to say that input price are oil prices and output prices are the gasoline pump prices or that terminals prices are the input prices and pump prices are output ones.

Specifically about gasoline retail market, Bacon (1991) found evidence of positive asymmetry in UK market in a specification that do not allow firms heterogeneity, hence, the conclusions are related for the whole market. Deltas (2008) addressed heterogeneity regarding US states (units are the 48 contiguous states, except Nevada) and concluded in favour of positive price asymmetry.

Regarding Brazilian market, there are three (known so far) important references for the price asymmetry studies. Uchôa (2008) testing price asymmetry between oil prices

---

[1]Price rises like a rocket, but falls like a feather.

[2]When gasoline price at pumps goes up, consumers tend to search more than when pump price go down. This search asymmetry allows, by itself, firms to have positive price asymmetry (Bragoudakis and Sideris, 2012, Lewis and Marvel, 2011).

and gasoline prices, concluding for the presence of positive asymmetric price. Canêdo-Pinheiro (2012), following the same econometric approach of Uchôa (2008), used an Asymmetric Error Correction Term to test asymmetric transmission between oil prices and diesel prices. He concludes for existence of positive asymmetry. Note that, so far, studies for the Brazilian market did not allow for heterogeneity across states, cities or any other more disaggregated spatial unit, so the conclusions are for the market as a whole yet.

The first study to allow for some heterogeneity in Brazil was da Silva et al. (2014). Authors investigated the asymmetry regarding distributors prices and pump prices. The study used a city-level dataset and the conclusions were that around 70% of the cities showed a symmetry transmission. The most important conclusion is to point that symmetric or asymmetric price is not an issue for the whole market, since there is heterogeneity across spatial units (states in this case). The point is: if it is possible the existence of two cities with different behaviors regarding price asymmetry, why not to have this heterogeneity also across firms? A city-level is an important novelty, but still suffer with bias summation, the effect of a gas station with positive asymmetry could be cancelled out by a gas station with negative asymmetry in an aggregated database.

Therefore our study tries to contribute to this literature arguing that price asymmetry is a firm-level feature, meaning that it should be tested at firm-level and not at country, state or city level. This contribution was possible just because we had access to a rich dataset that allowed firm-level information. The database is mainly from Brazilian National Petroleum, Natural Gas and Biofuel Agency (ANP) with data from 2004 to 2011, on weekly basis. Covering around 10% of Brazilian cities and including all state capitals, the database brings information such as purchase price (input prices), selling price (output prices), gas station address, gas station flag, brand of provider and other. The total of gas stations in Brazil is close to 35.000, after first screening, dropping observations with incomplete information, we still have more than 2 million observations and more than 17.000 gas stations covered by the sample. Around 40% of these 17.000 gas stations sampled are covered each week in all cities selected of our sample. Hence, regarding to city-level there is a balanced panel data, but regarding gas station-level we have an unbalanced one.

Having the physical address of each gas station allowed us to achieve the geographical coordinates of each observation[3]. To geocode the database allows to calculate distance based variables such as: distance to the closest neighbor, number of rivals within certain distance, to know if gas station has a white flag gas station nearby, and others. With all these information, this study tried to give one step ahead in the empirical literature of explanations for price asymmetry, relating that to spatial competition. Thus, this study aims to answer the following two questions:

Q1: Is there price asymmetry in the Brazilian Retail Markets at the firm-level?

---

[3]I strongly suggest a batch code tool to help in this task. Thanks to Chris Bell for providing the geocode tool and for gently answered users questions at his website (www.doogal.co.uk).

Q2: Which fixed effects increase (or decrease) probability of a firm to have asymmetric behaviour? Is there any distance related variable important on that? Can we support any relation between spatial competition and price asymmetry?

Procedures involve the use of an Asymmetric Error Correction Model (AECM) to define how firms respond to input prices changes and a logistic regression to verify which fixed effects impact the odds to have positive price asymmetry.

Results indicate that asymmetry is really a firm-level feature. Brazilian gas stations respond heterogeneously: 71% (8,015 gas stations) had no asymmetry, 23% (2,577) had a positive asymmetry pattern ("rocket and feathers") and 6% (633) had negative asymmetry. Regarding which fixed effects could explain the probability to have positive price asymmetry, higher margins, a minor number of rivals nearby and being a non-white flag increase the odds to have positive asymmetry[4].

The rest of this study is organized as follows. After this introduction, next section has a background of previous literature studies about price asymmetry. Third section presents the database, followed by the econometric strategy and results. Finally, the final considerations are made in the last section.

2   Background

In a perfect competitive market, decreasing costs should be transmitted instantly; the first seller to react decreasing output prices would get the whole market, forcing all sellers to decrease prices. In the same way, increasing costs should be transmitted instantly because firms are operating at the zero profit point, where small increases would be enough to put the firm in a negative profits area. Hence, changes in marginal costs are passed through price instantly and fully, no matter what signal of the shock (positive or negative). The fully and symmetric transmission is what the literature know as price symmetry transmission. Any deviation of this pattern, either to not fully transmit or to do not be symmetric, is called by price asymmetry.

How price asymmetry affects consumers will depend on the speed of adjustment to economic shocks, the sign of the shock (positive or negative) and the magnitude of the shock (Cramon-Taubadel, 1998, Meyer and Cramon-Taubadel, 2004). Price asymmetry necessarily causes changes in how surplus is distributed, being an issue with large impacts on the consumers welfare, stressing its importance for policies purposes. Before shows some examples how public policies can create price asymmetry, it is appropriate to highlight the definition of positive and negative asymmetry. So, as defined by Peltzman (2000) and summarized by Meyer and Cramon-Taubadel (2004), we have:

---

[4]The percentages were calculated regarding total of valid observations (11225). Valid observations are the gas stations with more than 50 observations and which showed a stable long run relationship between input and output prices. It is better explained in page 11.

i) **Positive Asymmetry**: When output prices react fuller or faster to an increase in input prices than to a decrease[5];

ii) **Negative Asymmetry**: When output prices react fuller or faster to a decrease in input prices than to an increase.

Returning to public policies creating price asymmetry, floor price policies, for instance, could generate positive asymmetry (Kinnucan and Forker, 1987). As far as the wholesalers believe that reduction in prices will be related with a trigger government intervention, if they know that reduction on prices will be just temporary, they do not need to adjust prices so fast, they can wait for the government intervention. In this case, public policy input some positive asymmetry into the market, rearranging welfare, transferring consumers' welfare to producers.

These concerns about effects of price asymmetry in consumers' welfare motivated studies from regulation agencies and other organizations, most of them relating positive price asymmetry to market competition. Bacon (1991), for example, studied the hypothesis of collusive behavior based on price asymmetry. He used data from 1982 to 1989 and concludes that, in his sample, for United Kingdom, there is evidence of rocket and feathers pattern. Note that the studied was supported by Monopolies and Mergers Commission.

As studied by Peltzman (2000), a price asymmetric behavior is not just an exception, actually he found a higher probability of a market to be asymmetric than symmetric. He studied 282 products(77 consumer and 165 producer goods) and concluded that there is a probability larger than 2/3 that prices react faster to an increase than a decrease in costs. He also found a negative correlation between asymmetry degree and input volatility price. Results showed that price asymmetry seems to be the rule and not the exception and it is, a priori, inconsistent with conventional microeconomic theory, which generated challenges for the theory (Yang and Ye, 2008).

These challenges pushed literature to look for explanations for price asymmetry, some of them independent of a competitive market assumption, which made a disruption between positive price asymmetry and market power or collusive behavior. The most common explanations for price asymmetry are summarized below:

i) Market Structure - if firms have some market power, it is natural to expect some positive asymmetry. Here the link between price asymmetry and market power is explicit (more market power is related to more positive price asymmetry practices);

ii) Consumer Search Cost - this factor is pointed frequently as reason for a non-permanent deviation from marginal costs, for a rocket and feathers pattern of price asymmetry (positive asymmetry) (Yang and Ye, 2008, Tappata, 2009). In Tappata (2009), partially-informed consumers and search costs are the main driven force

---

[5]Literature usually calls this asymmetry as **rockets and feathers asymmetry** or **rockets and feathers pattern**, because prices rise like rockets and fall like feathers.

to create price asymmetry. In Yang and Ye (2008), their model divided consumers into searchers and non-searchers and it leads to differences into knowledge of the true state, allowing a slow falling of prices. Note that, in both cases, the search cost generates some local market power;

iii) Consumer Behaviour - Bragoudakis and Sideris (2012) pointed that during increasing price periods, consumers tend to buy more gasoline (if they expect further increases), while in decreasing prices periods the opposite is not true, or it does not happen with the same speed. Other evidence comes from Lewis and Marvel (2011), who studied gasoline retail market using traffic statistics and conclude that consumers search more when prices rise than when they fall, providing a "search-based" explanation for positive asymmetry;

iv) Menu Costs and Inflation - Ball and Mankiw (1994) constructed a model where menu costs argument[6] in combination with inflation leads to positive asymmetric price. Once there are costs to change prices, it is possible that the best strategy to lead to costs reduction is to wait that inflation dissipates those costs reduction, specially regarding small cost decreases.

Cited examples are important to highlight the importance to avoid reaching foregone conclusions that price asymmetry is evidence of collusive behavior and/or power market abuse. A more supported statement is that price asymmetry is evidence to a deviation from a perfect competitive market, but not necessarily power market or collusive behavior.

Regarding to control heterogeneity agents into price asymmetry issues, more recently, using a database for lower 48 states in US, Deltas (2008) also found a rockets and feathers pattern (positive asymmetry) for some states. In this paper there is an attempt to relate price asymmetry with market power, and the author found that gas stations with high average margins have a slower adjustment and a more asymmetric response: "retail prices respond faster to wholesale price (i.e.,marginal cost) changes in states with smaller price-cost margins." (p. 614). Since this study provided evidence from a state-level sample, a welcomed agenda is to try to find similar evidence in gas station-level sample, such as the Brazilian dataset used here.

Faber (2009) studied the gas stations pricing behavior in the Netherlands in a gas station level and found that there is heterogeneity regarding price transmission. The sample has around 4,300 gas stations and it was provided by Althon Car Lease. The company leases cars with a "fuel card", from which information about price and location is provided. A bias selection could arise from this feature of the database, because only the gas stations chosen by drivers are sampled, if they do not care for price (drivers do not pay for the gas, their companies do), so gas stations with good extra services and higher prices could be oversampled. Results indicate that 38% of the gas stations (897 gas stations) showed positive asymmetric behavior, 7% has negative symmetric behavior and the rest

---

[6]Original argument is from Barro (1972).

(55%) has symmetric behavior. As far known so, this is the only paper addressed to treat asymmetry as firm-level feature.

Pinkse et al. (2002) did a deep investigation about the nature of competition in terminals. Terminals are not the same as retail gas stations. In the gasoline chain, terminals are located between refiners and gas stations, they store large quantities of gasoline and sell it to the gas stations. Their sample is a cross section with 305 terminals of fuel for 48 lower states[7]. Terminals may have global competition (prices of all rivals matter for each terminal price explanation) or a local competition (prices of closer rivals have a larger importance for each terminal price). In this question, distance has a central role and the georeferenced database is necessary. They found that terminals competition are localized. As highlighted by the authors, because of the database nature (a cross section), temporal effects could give a more global feature to the competition, therefore, a panel database is one of indications for future research.

Regarding studies related to the Brazilian market, Uchôa (2008) tested the asymmetric transmission from oil prices and exchange rate to gas stations' prices. He concludes that increases in costs (higher oil prices or higher exchange rates[8]) are fully transmitted to gas stations' prices in the next period in 90% of cases. Meanwhile, decreases in costs (lower oil prices or lower exchange rates) will be transmitted in the next period just in 5% of cases. Using similar approach, an Asymmetric Error Correction Model (AECM), Canêdo-Pinheiro (2012) studied transmission from wholesale diesel prices and final consumers prices (pump prices). He concludes that there is price asymmetry and surplus transmission from consumers to wholesalers.

Other important contribution regarding the Brazilian market is da Silva et al. (2014), This study investigates price asymmetry in the transmission from distributors to the pump prices for gasoline market. This is the most disaggregated study regarding price asymmetry using a Brazilian dataset. However, even in the city-level, it is not possible to accomplish all heterogeneity because it is possible to have many different price responses within a city, becoming possible that city-level samples suffer by bias summation. In a hypothetical city with just two gas stations, one with positive asymmetric behaviour and other with negative one, there is high chance that this city accepts the null of a symmetric behaviour. The present study will try to overcome this problem with a gas station level dataset.

---

[7]This term refers to the continental US, the connected 48 states, the other two states are Alaska and Hawaii.

[8]Exchange rate being defined as domestic currency divided by foreign currency, as Brazilian Central Bank publishes this data, and not as foreign currency divided by domestic currency as Federal Reserve Bank does.

3 Data

Our database is a weekly survey from National Petroleum, Natural Gas and Biofuel Agency (ANP). It is an unbalanced panel, units observed are not present in all periods. The level of disaggregation is larger than municipality level, and each unit is a gas station. Even though in small cities the sample covers all population (all gas stations are consulted every period), in larger cities the sample is a random sample of 30% of gas stations. The survey has information as purchase price and selling price for gasoline, name of gas station, address, brand, city, state and brand of provider.

The sample goes from 03 of January/2005 to 31 of September/2011 on weekly basis. There is no gas station with prices collected only once. It has 606 different cities (Brazil has around 5,500 cities, so it covers a little more than 10% of the country's cities), and all 27 federation units are represented, around 300 gas station flags and the total of 2,176,883 observations with complete information.

Units (gas stations) with less than 50 observations were dropped[9], resulting in a fi-

Table 1: Summary Statistics for the main variables to be used in the econometric estimations - AECM regressions

Variable	Obs	Mean	Std. Dev.	P25	P50	P75
Id (gas stations)	1466081	27029.57	12983.59	16055	26410	37134
Time(weeks)	1466081	17662.96	788.229	16999	17539	18322
P_{out} (R$)	1466081	2.564	.185	2.45	2.57	2.69
P_{inp} (R$)	1466081	2.206	.136	2.125	2.202	2.289
Brand	1466081	86.129	60.074	29	45	142
Latitude	1459042	-19.322	6.894	-23.329	-21.507	-16.329
Longitude	1459042	-46.115	5.742	-49.258	-46.763	-42.975
Margins (%)	1466081	.162	.049	.13	.162	.194
Frequency	1466081	124.714	62.168	78	109	154

Source: Authors with data from National Petroleum, Natural Gas and Biofuel Agency (ANP). Note: P25, P50 and P75 represent the bottom line for the 25, 50 and 75 percentiles.

nal sample with 1,466,081 observations and 17,273 different gas stations[10]. Statistic are summarized in (Table1).

Our sample indicated that Brazilian market has around 29% of unbranded gas stations (white flags), the 3 largest (Petrobrás, Ipiranga and Raízen[11]) representing 60% of

---

[9]Next section will detail the procedures to test asymmetry, because I run the model for each gas station, and a minimal number of observations had to be chosen.

[10]We choose to encode gas stations by geographic coordinates. Therefore, we may have wrongly excluded some units, observations with different company name, but the same coordinates. The other two options would be to encode by company name and by the address, but there are a lot of duplicate records with much similar names located at the same place, which would wrongly duplicate some observations (in small towns some street names, as streets with ex-presidents' names, are very common).

[11]Raízen is a joint venture of Shell and Cosan.

sample. The 4th in the ranking is Ale with just 3% of market (Table 2).

Table 2: Frequency of Market Leaders

Flag	Freq	Percent
Unbranded	429670	29%
Petrobrás	362030	25%
Ipiranga	298631	20%
Raízen	226371	15%
Ale	42467	3%
Total	1466081	100%

Source: Authors.

Unbranded firms have roughly the same margins $(P_{inp} - P_{out})/P_{inp})$ than the whole sample, with average margins around 16%. The value also do not change if the firm is part of the 3-largest companies. Regarding differences across states, Acre and Mato Grosso have the largest margins (around 21%), meanwhile, Rio de Janeiro e São Paulo have the smallest ones (less than 15%). Comparing ethanol and gasoline, ethanol firms has, on average, 3% higher margins.

4 Econometric Strategy and Results

4.1 Is price asymmetry a firm-level feature?

Our first goal is to test if price asymmetry is a feature of the whole market or a firm-level issue. In order to accomplish that we will test how gas stations pass-through input prices (values paid by each gas station to the distributors) to output prices (retail prices, pump prices). Departing from a simple equation relating both prices, we have:

$$P_t^{out} = \alpha + \beta.P_t^{inp} + \varepsilon_t \tag{1}$$

Equation 1 shows a long run relation between P_t^{out} and P_t^{inp}. The problem is that if both prices have unit roots (and it is true for our sample), we have a spurious regression. This problem can be overcome using a cointegration approach:

$$\Delta P_t^{out} = \theta + \gamma.\Delta P_t^{inp} + \rho.ECT_{t-1} + \varepsilon_t \tag{2}$$

Instead of estimating Equation 1 with I(1) prices, Engle and Granger suggest to estimate the first differences prices in Equation 2 followed by the one period lagged Error Correction Term (ECT). Once the first difference of a I(1) is I(0) the only problem regarding unit roots into Equation 2 is related to the stationary of ECT. **Note that ECT is the residual of Equation 1** and its stationarity means that there is a long run stable

relationship between input and output prices. Therefore, to guarantee that Equation 2 is not biased, ECT needs to be stationary, input and output prices need to be cointegrated.

Regarding Equation 2, parameters γ and ρ show the short run and the speed of adjustment of the model around a long run equilibrium, respectively. The greater is $|\rho|$, the faster the model return to the long run path. Note that Equation 2 just allows symmetric adjustment, in order to include asymmetric adjustment, ECT was divided regarding positive and negative residuals. The equation with this split becomes:

$$\Delta P_t^{out} = \theta + \gamma.\Delta P_t^{inp} + \rho_1.ECT_{t-1}^+ + \rho_2.ECT_{t-1}^- + \varepsilon_t \tag{3}$$

If residual of Equation 1 is a positive value (ECT^+), we are in a point where P^{out} is higher and/or P^{inp} is lower than long run equilibrium, consequently, margins are higher than long run equilibrium (consumers are in a worse position and firms are in a better situation, ceteris paribus). If residual has a negative value (ECT^-), it means that margins are lower than their long run path (firms are in a worse situation and consumers are in better situation, ceteris paribus).

Therefore, ρ_1 and ρ_2 are the measurement of speed of adjustment of the model when we have ECT_{t-1}^+ and ECT_{t-1}^-, respectively. As the direction of transmission is from input to output prices, ρ_1 **is the speed of adjustment for decreases in input prices and ρ_2 is speed adjustment for increases in input prices**. Hence, we have asymmetric adjustment around a long run path when ρ_1 and ρ_2 have different values, that is:

   i) $\rho_1 = \rho_2$, symmetric price transmission;

   ii) $|\rho_2| > |\rho_1|$, output prices respond slower to decreases in output prices than to increases, rocket and feathers pattern - positive asymmetry - consumers are in a worse situation than their long run path;

   iii) $|\rho_2| < |\rho_1|$, output prices respond quicker to increases in output prices than to decreases - negative asymmetry - consumers are in a better situation than their long run path.

Then, to check asymmetry at firm level, the Equation 3 will be estimated, including residuals of Equation 1, for each gas station in the sample and a F-test will be used to classify gas stations among symmetric transmission, positive asymmetry and negative asymmetry. Gas stations that we reject the null ($H_0 : \rho_1 = \rho_2$) with confidence higher than 95% is addressed to be asymmetric response; gas stations that we do not reject H_0 are considered gas stations with symmetric response.

We depart from 17,273 gas stations, and excluding gas stations with less than 50 observations we remain with 14,489 different gas stations. The next data filter is regarding gas stations that did not show a stable relationship regarding input and output prices. Hence, we dropped more 3264 observations using the Engle and Granger cointegration test in residuals of Equation 1.

Finally, remaining only the gas stations with cointegrated relation and with more than

50 observations (**total of 11,225, which hereafter I will call by "valid gas stations"**).
Therefore, running the AECM for each one of this 11,225 gas stations we found that price
asymmetry is not a feature of the whole market, where some gas stations showed positive asymmetry, some of them showed positive asymmetry and some of them showed no
asymmetry. This heterogeneity indicates that asymmetry should not be treated as market,
state or city feature, at least, for the Brazilian Market.

Detailing the results, around 29% (3,270) of valid gas stations showed asymmetric
price adjustment, 79% of them with positive asymmetry, a rocket and feathers pattern,
and just 6% of them with negative asymmetry. Hence, from the total of valid gas stations
we have 2,577 gas stations with positive asymmetry, 633 with negative asymmetry and
8,015 with no asymmetry. If I just consider $|\rho_2|>|\rho_1|$ (without to use the F-test), I
find that it is true for 58% of gas stations. Note that this number is reduced for 23%
in the main result because I consider as a positive asymmetry gas station units who had
$|\rho_2|>|\rho_1|$ and did not accept the null that $|\rho_2|=|\rho_1|$ using a F-test. Results are summarized in Table 3.

Trying to compare our results with the international literature, Faber (2009) found in

Table 3: Results regarding Asymmetry (5% of significance level)

	Units	% of valid observations*
Total of Gas Stations	17,273	
Gas Stations with more than 50 obs	14,489	
Gas Stations that cointegrated	11,225	100%
Gas Stations with No Asymmetry	8,015	71%
Gas Stations with Asymmetry Response	3,210	29%
Gas Stations with Positive Asymmetry	2,577	23%
Gas Stations with Negative Asymmetry	633	6%

Source: Authors.
* The Asymmetric Error Correction Model needs cointegrated relation, so "valid observations"
are those gas stations with a stable long run relation between output and input prices.

his study that 38% of firms has positive asymmetry, 7% has negative asymmetry and 55%
has no asymmetry. It seems that Brazilian gas stations have asymmetric price behaviour
in proportions close to the Netherland's ones.

Regarding sensitivity of the results to significance level of the test, if I chose 1% of
significance, the number of positive asymmetric firms is reduced to 2577 (23% of valid
observations) and the number of negative asymmetric firms is reduced to 693 (6% of
valid observations), so the reduction on the asymmetric firms would be compensated by
the increase in the symmetric ones which would be around 71% of valid observations
(7955 firms). On the other hand, if I decrease the rigour of the test (changing significance
to 10%), the number of positive and negative firms would increase. Number of positive
asymmetric firms would increase to 3956 firms (35% of valid observations) and the number of negative asymmetric firms would be 1303 firms (11% of valid observations). In

this case, the number of symmetric firms would decrease to 5966 firms (55%).

Regarding relationship between flag and asymmetric responses, the share of white flags (unbranded) is 5% smaller into positive asymmetric firms than into other two groups (negative and symmetric). The percentage of firms from one of the three largest companies is also around 5 or 6% higher in the positive asymmetry group. These differences make us to think about which attributes could explain the likelihood of a firm to practice positive or negative asymmetry. Which is the subject of next subsection.

4.2 Which fixed effects could explain positive price asymmetry?

Once pointed out that there is heterogeneity in how gas stations pass-through the cost shocks, in this next step I will try to contribute to bring some insights about what could explain the probability of having a positive asymmetric firm. To achieve this goal I constructed a dummy variable called "rockets":

$$rockets = \begin{cases} 1, & if \quad \mid \rho_2 \mid > \mid \rho_1 \mid; \\ 0, & otherwise. \end{cases} \tag{4}$$

The parameters used to construct rockets variable are those calculated in Equation - 3.

After that I constructed some variables that are time-fixed for each gas station, for example: the brand of the gas station, the brand of the closest rival, the average margins, the number of rivals within some selected distances and the distance to the closest rival. The idea is to check which of these variables can change the probabilities of gas stations to practice positive asymmetry (remembering that rockets = 1 means positive asymmetry).

In sum, I will use the rockets variable to run it against the fixed attributes of gas stations, and I will check if:

i) Does Spatial competition has a role in this probabilities? Number of rivals within selected distances and distance to the closest rivals are significant to explain the likelihood to be rockets=1?

ii) Is it possible to tie the link between market power and asymmetry? Margins and white flags are significant to explain the likelihood to be rockets=1?

For this regression I have the results of each valid gas stations (total of 11,225 valid units - only gas stations with a stable long run relationship are used, i.e., gas stations that show cointegration between output and input prices). The summary statistics for this second part are in Table 4.

Exploring a little more the data from Table 4, around 45% of gas stations (valid observations) has no neighbours within 0.5km, and the mean of rivals within 0.5km is 1.69. Regarding margins $(P_{inp} - P_{out})/P_{inp}$, they have mean of roughly 15%, less than 10% of gas stations has margins of 10% or less. On the other hand, just 10% of gas stations has

Table 4: Summary statistics for the variables used in the Logistic Regression

Variable	Obs	Mean	Std. Dev.	P25	P50	P75
Rockets(a)	11225	.23	.421	0	0	0
Distance for Closest Rival	11165	2.856	57.064	.239	.455	.861
Number of Rivals(0.5km)	11165	1.694	2.581	0	1	2
Number of Rivals (1km)	11165	5.174	5.586	1	4	8
White Flag	11225	.282	.45	0	0	1
Brand Equal	11225	.213	.41	0	0	0
Brand	11225	84.27	60.147	29	45	142
Frequency	11225	104.951	51.583	67	90	126
Margins (mean)	11165	.1575	.0377	.1343	.1566	.1811
City	11225	284.752	153.557	157	294	411
Zip Code	11153	4.52e+07	2.88e+07	1.81e+07	3.80e+07	7.38e+07

Source: Authors with data regressions of AECM for each gas station.
Notes: a)Rockets is the dummy variable constructed in Equation 4. b) P25, P50 and P75 represent the bottom line for the 25, 50 and 75 percentiles. c) Margins are relative to the liquid margins ($(P_{inp} - P_{out})/P_{inp}$).

margins higher than 20%, with less than 1% with margins higher than 25%. Regarding the dummy variables, the interpretation is straightforward, the mean is how much of the category represented by one we have in the sample, so, there are 23% of valid gas stations with positive asymmetry (rockets variable).

Note that I turned a F-statistic results into a binary variable and it was used to verify, with a logistic regression, which variables increase (or decrease) the probability to be a positive asymmetric gas station (rockets =1). Hence, I will procedure a logistic regression where $p(x)$ is the probability to have positive asymmetry (rockets=1) and $[1 - p(x)]$ represents the probability to have no asymmetry or negative one. The logistic regression is given by:

$$logit[p(x)] = \beta_0 + \sum_j \beta_j X_{ij} \tag{5}$$

Where the left side term, the $logit[p(x)]$, is the log of odds ratio between $p(x)$ and $1 - p(x)$. For example, if $p(x) = 0.20$, $1 - p(x) = 0.80$ and $logit[p(x)] = log(1/4)$. Substituting $logit[p(x)]$ by log[p(x)/1-p(x)]:

$$log[p(x)/1 - p(x)] = \beta_0 + \sum_j \beta_j X_{ij} \tag{6}$$

Taking exponential of both sides:

$$[p(x)/1 - p(x)] = exp(\beta_0 + \sum_j \beta_j X_{ij}) \tag{7}$$

In Equation 7, the first term (the odds ratio) is explained by explanatory variables X_{ij}. A logistic regression in the log form (Equation 7) is performed for two main reasons: i)It gives us rapid answers about what is happening, a positive β_j means that higher values of X_j increase $p(x)$ and negative β_j means that higher values of X_j decrease $p(x)$; ii) Only applying exponential on the coefficients, the odds ratios are easily reached. So, the results of Table 5 explain the probability of the firm to practice positive asymmetry (rockets=1) using the fixed effects cited in Table 4.

In Table 5, the odds ratios have the same significance levels and t values of the

Table 5: Logistic Regression - Rockets and Feathers Coefficients and Odds Ratios

	(1) Coefficients	(2) Odds Ratios
Number of Rivals(0.5km)	-0.0236**	0.97668
	(-2.02)	
Number of Rivals(1km)	0.0165***	1.0166
	(3.15)	
Dummy White Flag	-0.159***	0.85293
	(-3.10)	
Margins	0.0457***	1.0467
	(7.48)	
Distance Closest Rival	-0.00160	0.9984
	(-0.86)	
Constant	-2.031***	0.1311
	(-19.02)	
N	11165	

Source: Authors.
Notes: a) t statistics in parentheses. b) * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

respective coefficients, hence, we reported significance levels only for the coefficients. Results indicate that the number of rivals within 0.5 km decrease the probabilities of having a rockets and feathers pattern (positive asymmetry). It is the expected result, once the increase of spatial competition should decrease the possibilities of arbitrage. Other interesting result is related to white flags (unbranded gas stations): being white flag (unbranded gas stations) decreases the probabilities of having positive asymmetry. This result is in line with Hastings (2000), which argues that unbranded gas stations are correlated with a lower equilibrium price and with markets that are more competitive. Pricing strategy of white flags gas stations is not related only with lower prices (Hastings, 2000), but also with no differences regarding price transmission.

In the link between power market and positive asymmetry, higher margins are positively related with a higher odd of to have positive asymmetry, which again is an expected result. Other variables were used to explain the rockets variable, but they were not re-

ported here because they were not relevant for the regression, and these variables are: dummy for the 3 largest brands (1 when gas station has the same brand of the 3 market leaders, 0 otherwise), dummy for each of the 3 largest brands separately, dummy for the same brand of the closest neighbor and the brand of the closest neighbor. Controls as the number of cars and the population of the city were used and the results remained the same.

I tested some alternative specifications matching for the gas stations' zip code and for the city, and using the number of rivals between 1.0 and 0.5 km to avoid some overlapping (source of multicolinearity), but the results found were basically the same of those reported in Table 5.

Regarding the results from number of rivals within 1.0km, a counter-intuitive sign was found, the increase of number of rivals within this distance increases the probability to have positive asymmetry. We have some explanations for that:

i) It is possible that 1.0km is too far, meaning that there is no spatial competition within this distance. One evidence for that is the larger probability changes for rivals within 0.5 than 1.0 km (Table 5);

ii) All omitted variables that we do not have access with this database, presence of convenience stores and service bays, for example, are positive correlated with probabilities to have positive asymmetry. It means that omitted variables have clearly a positive bias. The inclusion of those would increase the magnitude of marginal effect of 0.5 rivals variable and likely change the signal of 1.0km rivals variable.

In other words, we cannot precise estimate the direction of rivals within 1.0 km, but once all omitted variables have positive bias, we can guarantee that the signal of rivals within 0.5km is really negative, concluding in favour of existence of a link between spatial competition and positive price asymmetry strategies.

To illustrate the impacts of each variable variable on the probabilities to have positive asymmetry, I calculated the probability of being rockets=1 for some selected percentiles (P10, P25, P50, P75 and P90). To construct Figure- 1 I did not use the central value of each percentile, but the threshold. Therefore, for P10, for example, it was used the value that divide the sample between P10 and P11.

In Figure 1 what matters is not only the value of probability, but how it changes when I vary only the value of variable itself, holding constant everything else. For those gas stations with lowest margins, around 11%, the probability that they are a firm that practice positive asymmetry is lower than 20%, when we compare with highest margins (P90), where this probability increases to more than 27%.

For white flags, I calculated the probability just for one and zero values. To be a white flag, firm decreases the probability of having positive asymmetry in more than 2%.

Regarding the rivals within 0.5 km, when I change from 0 to 10 rivals, the probability of having positive asymmetry decreases almost 4%. Note that these estimates are results from changes in only one explanatory variable, and using the average values of all other
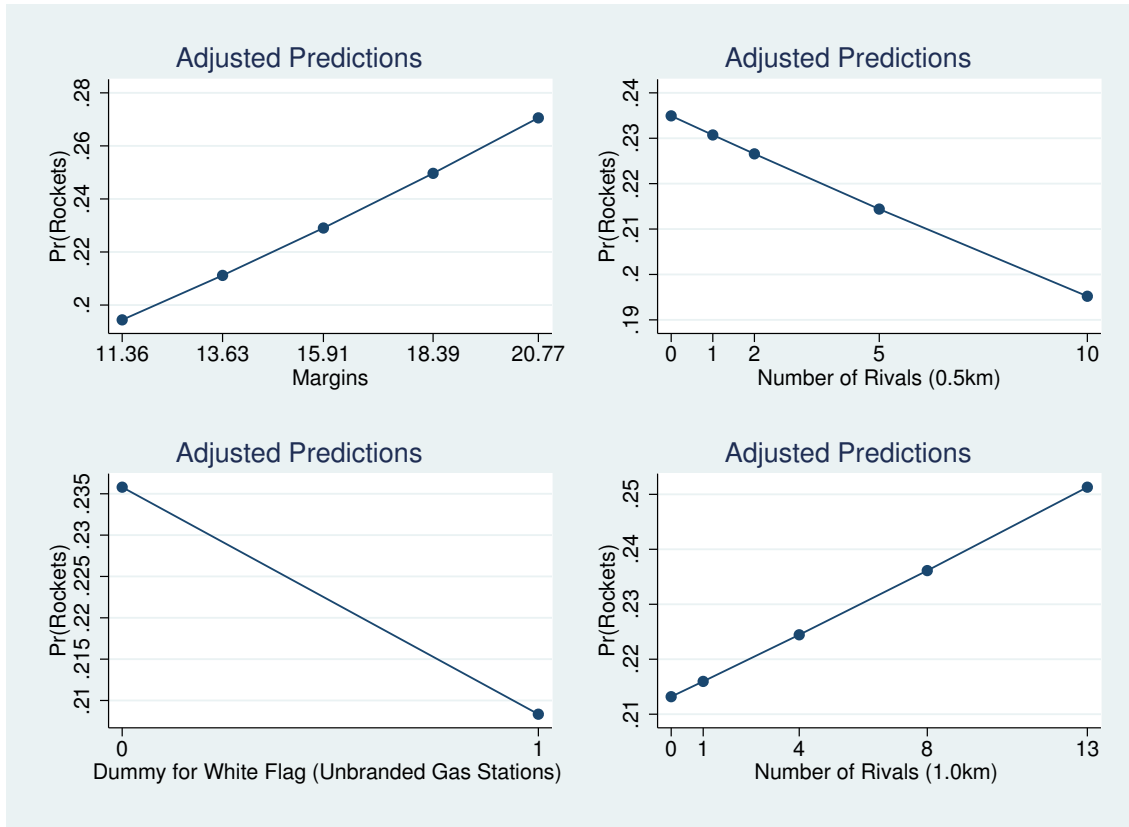
15

Figure 1: Probability to be rockets=1 (positive asymmetry) using values of P10, P25, P50, P75 and P90 for each explanatory variable.

Source: Authors.

controls.

One possible gap in our estimates is to consider the role of distance in a homogeneous way. For example, a distance from the closest rival could matter for rockets probabilities for gas stations exposed to lower number of rivals nearby (such as gas stations located at roads and small cities) but not for gas stations exposed to many rivals nearby (likely gas stations located at downtown in capital states). In addition, the number of rivals could matter for high competition observations and not for low competition gas stations. In order to test that, I divided the sample by number of rivals into 3 equal groups: low, middle and high number of rivals nearby.

The low density of rivals has no neighbors or just one rival within 1km (mean of 0.30); the middle density has between 2 and 6 neighbors (mean of 3.29); and the high density group has between 7 and some outliers with 50 rivals (mean of 11). The idea with this division is to verify if distance-based variables have different results according to the number of rivals, regarding competition intensity. Therefore, we used two dummies to separate the sample into 3 equal groups by competition intensity.

Results indicated that the coefficient of distance from the closest rival kept insignif-

icant for all 3 subsamples. Estimated coefficients for margins and the dummy for white showed the expected signs and they were strongly significant for all subsamples. The only result that changed the behavior across subsamples was the number of rivals within 0.5 km. For the low competition we already expected a non-significant coefficient, once the variable has low variability, being zero for the majority of the subsample. The surprising result was the insignificant coefficient in the middle competition intensity subsample, becoming significant and with expected sign just for high competition subsample. **These results indicate that the number of rivals nearby seems to be relevant just for high competition areas, not for the low and middle competition ones.**

5   Final Remarks

The first goal of this study was to test if there is price asymmetry in the Brazilian gas stations, more specifically, to test if pricing strategies regarding cost pass-through are not homogeneous across gas stations. Hence, we estimated an Asymmetric Error Correction Model for 17,273 gas stations, from which the relevant subsample was 11,225 (units with more than 50 observations and with cointegration relationship between input and output prices). Regarding these 11,225 gas stations, it was found symmetric pass-through in 71% of gas stations, positive asymmetric relation in 23% and negative asymmetry in 6% of gas stations. These results are in line with Faber (2009) and reinforce the assumption that price asymmetry should be treated as a firm-level feature.

The second goal was to explain in which extent some features fixed for each gas station (brand, brand of the closest neighbor, number of rivals within some distances, white flag dummy, leader market dummy (3 largest companies), distance from closest neighbor, average margins and others) can influence the probability to have a gas station with price asymmetric response. I constructed a dummy called by "rockets" to distinguish positive asymmetric gas stations from the other gas stations. After that I run this dummy against cited fixed effects. Results indicate that the number of rivals within 0.5km decreases the probabilities to be a positive asymmetric gas station, and white flags also seems to promote a more equal pass-through, in line with Hastings (2000). Hence, being a white flag (unbranded) decreases the probability of to be a firm with positive asymmetry. Positive price asymmetry (rocket and feathers pattern) seems to be closely related with higher margins (in line with Deltas (2008)), strengthening the most popular explanation for positive asymmetry, the market power.

This research is part of a larger agenda with many other questions that this study is not covering here, for instance:

i) How to explain the role of distance in price competition not just in the fixed effects (smaller sample), but in the whole sample, using a approach similar to Pinkse et al. (2002);

ii) How to measure the impact of a new rival in the neighborhood, relating this with potential entrance theories and/or spatial competition approaches;

iii) How to measure in which extent convenience stores and service bays could bias the results;

iv) I treated the probability of being a positive asymmetric firm (rocket and feathers - positive) as binary, but it is also possible to use the probabilities of F-tests to have a continuous variable of interest;

v) How to separate positive from non-asymmetric and negative asymmetric gas stations, giving more attention to negative asymmetric gas stations;

vi Here there is only one answer for asymmetry for each gas station, I am assuming that the gas station do not change the pricing strategy, which could be relaxed;

vii) Finally, our investigation dealt only with gasoline fuel, but information for diesel and ethanol fuels is also available. Therefore, investigating if gas stations define different strategies for each fuel is also an interesting question for future research agenda.

Acknowledgments

References

Bacon, R. W. (1991). Rockets and feathers: the asymmetric speed of adjustment of uk retail gasoline prices to cost changes. *Energy economics*, 13(3):211–218.

Ball, L. and Mankiw, N. G. (1994). Asymmetric price adjustment and economic fluctuations. Technical report, National Bureau of Economic Research.

Barro, R. J. (1972). A theory of monopolistic price adjustment. *The Review of Economic Studies*, pages 17–26.

Bragoudakis, Z. and Sideris, D. (2012). Do retail gasoline prices adjust symmetrically to crude oil price changes? the case of the greek oil market. *Economic Bulletin*, (37):7–21.

Canêdo-Pinheiro, M. (2012). Assimetrias na transmissão dos preços dos combustíveis: o caso do óleo diesel no brasil. *Revista Brasileira de Economia*, 66(4):469–490.

Cramon-Taubadel, S. (1998). Estimating asymmetric price transmission with the error correction representation: An application to the german pork market. *European Review of Agricultural Economics*, 25(1):1–18.

da Silva, A. S., Vasconcelos, C. R. F., Vasconcelos, S. P., and de Mattos, R. S. (2014). Symmetric transmission of prices in the retail gasoline market in brazil. *Energy Economics*, 43:11–21.

Deltas, G. (2008). Retail gasoline price dynamics and local market power*. *The Journal of Industrial Economics*, 56(3):613–628.

Faber, R. P. (2009). Asymmetric price responses of gasoline stations: evidence for heterogeneity of retailers. *Tinbergen Institute Discussion Paper*.

Hastings, J. S. (2000). Vertical relationships and competition in retail gasoline markets: An empirical evidence from contract changes in southern california. *UC Berkeley Competition Policy Center Working Paper No. CPC00-10 Revision*.

Kinnucan, H. W. and Forker, O. D. (1987). Asymmetry in farm-retail price transmission for major dairy products. *American Journal of Agricultural Economics*, 69(2):285–292.

Lewis, M. S. and Marvel, H. P. (2011). When do consumers search?*. *The Journal of Industrial Economics*, 59(3):457–483.

Meyer, J. and Cramon-Taubadel, S. (2004). Asymmetric price transmission: a survey. *Journal of Agricultural Economics*, 55(3):581–611.

Peltzman, S. (2000). Prices rise faster than they fall. *Journal of Political Economy*, 108(3):466–502.

Pinkse, J., Slade, M. E., and Brett, C. (2002). Spatial price competition: a semiparametric approach. *Econometrica*, 70(3):1111–1153.

Tappata, M. (2009). Rockets and feathers: Understanding asymmetric pricing. *The RAND Journal of Economics*, 40(4):673–687.

Uchôa, C. F. A. (2008). Testando a assimetria nos preços da gasolina brasileira. *Revista Brasileira de Economia*, 62(1):103–117.

Yang, H. and Ye, L. (2008). Search with learning: understanding asymmetric price adjustments. *The RAND Journal of Economics*, 39(2):547–564.