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ASYMMETRIC PRICE ADJUSTMENTS UNDER EVER-INCREASING COSTS

Evidence from the Retail Gasoline Market in Colombia[†]

Marc Hofstetter[*]

Jorge Tovar[**]

Abstract

There is abundant empirical evidence showing that asymmetric price adjustments exist in a wide variety of markets. Prices tend to grow faster when costs rise relative to the rate at which prices drop when costs fall. The objective of this paper is to empirically test whether asymmetric price adjustments exist in a scenario where costs are increasing every period. The Colombian retail gasoline market offers an excellent case study due to a specific regulation, something discussed further in this paper. Our results suggest that when costs rise above the reference price –a government suggested retail price– retail prices tend to rise less relative to when costs grow below the reference price. Thus, asymmetry does exist.

Keywords: Asymmetric price adjustments, Gasoline retail markets, Search, Reference Prices.

JEL Classification: D43, D82, D83

[†] We thank Andrés Cardona for his outstanding research assistantship. We are also grateful to *Unidad de Planeación Minero Energética (UPME)*, a Colombian government agency and subsidiary to the Ministry of Mining and Energy, for providing us with the required data. Finally, participants at the *Seminario CEDE* and the 2008 International Industrial Organization Conference, particularly Matt Lewis, are gratefully acknowledged. All remaining errors are ours.

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AJUSTE ASIMÉTRICO DE PRECIOS BAJO COSTOS SIEMPRE CRECIENTES.
Evidencia del mercado minorista de gasolina en Colombia. [†]

Marc Hofstetter[*]

Jorge Tovar[**]

Resumen

La existencia de ajuste asimétrico de precios se ha demostrado empíricamente en una gran variedad de mercados. Un incremento en los costos lleva a un crecimiento de los precios más rápido que la correspondiente caída cuando los costos caen. El objetivo de este trabajo es demostrar empíricamente que, aún en un escenario de costos exclusivamente crecientes, existe ajuste asimétrico de precios. Para tal efecto se explotan las particularidades del mercado minorista de gasolina en Colombia. Los resultados sugieren que un incremento de costos por encima de un precio de referencia (sugerido por el gobierno a los minoristas) conlleva a que los precios de venta al público crezcan menos con respecto al caso en que los costos crecen por debajo del precio de referencia. Por tanto, hay ajuste asimétrico de precios.

Palabras Clave: Ajuste asimétrico de precios. Mercados de gasolina, Búsqueda, Precios de referencia.

Clasificación JEL: D43, D82, D83

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1. Introduction

The recent and abundant empirical literature concludes that asymmetric price adjustment is common to a wide variety of markets. The pattern found is that prices tend to grow faster when costs rise relative to the rate at which prices drop when costs fall. Peltzman (2000), working with 77 consumer goods and 165 producer goods, finds evidence that asymmetric price adjustments do indeed exist in most markets. In a recent paper, Meyer et al. (2004) survey the literature, and note that such findings tend to be robust for the markets for agricultural products, interest rates and gasoline. Our paper focuses on the last one, the gasoline market.

The literature documenting asymmetric price adjustments is quite abundant, and contrasts somewhat with the relatively scarce literature on the causes of such behavior. As Peltzman (2000) puts it, "the results suggest a gap in an essential part of economic theory." Borenstein et al. (1997) fill part of this gap by providing three explanations for this phenomenon—specifically, for the gasoline market.[1] (i) It might be that firms, given a negative cost shock, tend to keep prices high because they do not observe a change in demand. When these changes are detected, prices do fall. This would explain the slow downward reaction to cost reductions. (ii) Alternatively, given a (sudden and potential) excess of demand, the effect on prices is quickly transmitted due to the existence of limited inventories and production lags—that is, production is not able to adjust instantly, thus prices increase. On the contrary, given a (sudden and potential) excess of supply, prices do not fall as quickly due to the existence of production lags and finite inventories—that is, there is an expected though not current excess of available output that can satisfy the market. (iii) Finally, during periods of high volatility, consumers might search less when they observe a price change, as they assume it reflects a change in costs rather than a change in margins. This might allow retailers to pass along quickly any cost increase to prices while delaying the transmission of cost decreases.

Recently, Lewis (2005) sophisticated the latter hypothesis by developing a theoretical *reference price search model*, which assumes that consumers' price expectations are based on observed past prices. The idea is that a consumer will not search for alternative retailers if the observed current price is lower than the observed price for previous periods, due to the small probability of finding an even lower price. As a result, less consumers search, retailers face a (temporary) inelastic demand, and margins grow. This type of consumer behavior implies that when costs rise well above expectations, firms increase prices (though not margins) and consumers will begin searching. On the contrary, when costs fall, firms lower prices, but only enough to prevent consumers from searching. Note that the latter implies that when costs fall, margins rise.[2]

The Colombian gasoline market offers a unique scenario for testing issues related to this topic. As explained in detail throughout the paper, the market in Colombia has a peculiar structure. Every month, the government announces a suggested (though not mandatory) retail price for gasoline. This price is heavily advertised by the local media. In local jargon, the price is known as the "reference price for gasoline." This reference price plays a crucial role in our story; we argue that consumers' expectations about the retail prices for gasoline are anchored to this reference price, something that determines the adjustment speed of retail prices following cost changes.

We take advantage of this market structure to test for an asymmetric price adjustment of a different sort than those commonly explored in the literature. We will *not* test whether cost

[1] Balke et al. (1998) and Brown et al. (2000) discuss other plausible causes, such as asymmetric consumer response or accounting practices.

[2] Other recent search related models are discussed in Tappata (2006) and Yang and Ye (2008).

increases trigger a different reaction in prices relative to cost decreases.[3] In fact, the Colombian gasoline market has the particularity that wholesale gasoline prices—that is, costs—have followed an upward trend throughout our sample period, thus making it impossible to test for traditional asymmetric price adjustments.

Our hypothesis is that when costs rise less than the reference price, we should observe fast price adjustments; conversely, slower adjustments should occur when costs increase more than the reference price. Why is this? Consider the former case—that is, costs rise less than the reference price. Under the plausible assumption that consumers do not observe costs, the retailer can quickly pass on the cost increment to retail prices. Consumers would find the retail price increment reasonable based on their expectations (as determined by the reference price). As a matter of fact, given that consumers might be willing to accept increments similar to those observed in the reference price, retailers face a temporary inelastic demand. This means we could even observe an overshooting of prices—that is, prices could increase more than costs. Conversely, if costs increase more than the reference price, the retailer could choose to delay passing on the increase. Hence, an asymmetry would arise.

We find that when costs grow more than the reference price, retail prices tend to increase slower relative to when costs increase less than the reference price. In other words, we find asymmetric price adjustments of the kind we hypothesized above. In this sense, reference prices do indeed appear to anchor the expectations of consumers. A rise in costs below the reference price allows retailers to quickly pass it on to prices (as consumers find it natural to observe higher prices); alternatively, a rise in costs above the rise in the reference price forces retailers to delay price increases. In the latter case—much as represented in Borenstein et al. and Lewis' stories—the behavior of retailers prevents consumers from searching for lower prices.

The rest of the paper is organized as follows. Section 2 describes the structure of the gasoline industry in Colombia. Section 3 describes the data used in the paper and takes a first broad look at it. Section 4 tests for price asymmetries, and section 5 presents several robustness tests. Section 6 concludes.

2. Industry Structure and Pricing Policy

Gasoline production in Colombia is a government-controlled monopoly. The *Empresa Colombiana de Petróleos (Ecopetrol)* controls the country's two major refineries, which account for almost 100% of domestic fuel production. Competition is further restrained by the fact that *Ecopetrol* is also the main gasoline importer, as well as the owner of the infrastructure required to transport it across the country.

Ecopetrol's gasoline production is sold downstream to privately owned wholesalers—multinational companies such as *Chevron-Texaco* and *Exxon-Mobil*, and domestic firms such as *Terpel* and *Brio*. These buyers pay *Ecopetrol* for the actual gasoline, as well as the right to use the infrastructure required to transport it. Once in their possession, wholesalers store the fuel in supply centers located throughout the country; from these centers, they are able to serve gas stations using transport services, generally provided by a third company.

[3] Aside from those authors explicitly mentioned throughout this paper, others, such as Duffy-Deno (1996), Eckert (2002), and Godby (2000) have studied the gasoline market in search of asymmetric price adjustments. Only the latter, working for the Canadian retail gasoline market, was unable to find evidence of asymmetric pricing.

Gas stations, the third link in the chain, buy the gasoline from wholesalers and sell it to final consumers using one of the existing brands in the country.[4] Cerón (2001) notes that although these brands are proprietary to wholesalers, only a small percentage of gas stations are directly owned by them; most are operated by independent owners, who use the wholesalers brands through various contractual mechanisms.[5] Figure 1 describes the market.

As inferred from the above discussion, the Colombian gasoline market is highly regulated over all of the various stages involved. Prior to 1999, when the government established a new regime for fuel prices in local markets, prices were set on a yearly (or sometimes shorter) basis, and adjusted by the inflation rate or other macroeconomic variables. In 1999, with the objective of inducing competition in both production and distribution, a new pricing policy was implemented. This new policy continued to regulate refiner and wholesale prices, but allowed retail gas stations in the major cities to set prices freely.[6] This policy, which tried to mirror the conditions faced by a hypothetical importer, determined that the price at the refinery—which is paid by wholesalers to *Ecopetrol*—should follow the international Mexican Gulf Coast price for gasoline, which is adjusted based on import costs.

The second stage, which entails the prices that wholesalers charge gas stations, is also regulated. More specifically, there is a maximum regulated margin, whereby wholesalers are allowed to sell at a price equal to or lower than the regulated one. In small cities, the third stage, which entails the price charged by gas stations—is also regulated. Nevertheless, in our paper, we focus on the data from major cities, where gas stations are free to set their own price.

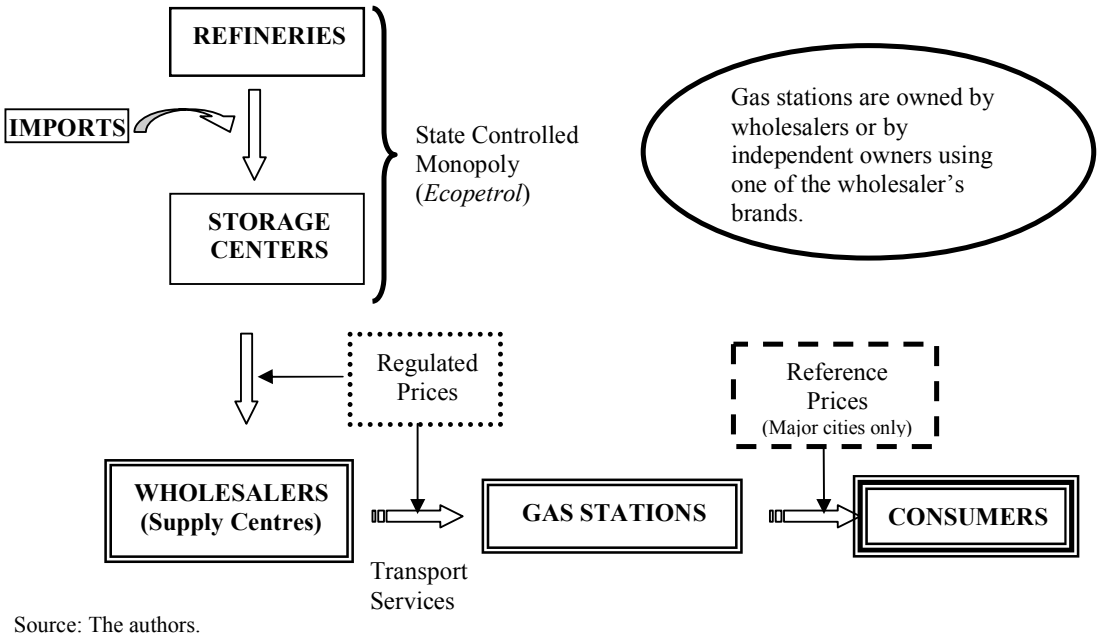
In major cities, the only role the government plays with respect to retail prices is to establish a suggested (that is, reference) price. Published at the beginning of each month, the reference price—which is city specific—is not mandatory, and.retailers may price above or below it. To be sure, the reference price is not a market price, but rather a suggested price which, according to the government, accounts for all costs in the production and distribution chain while allowing for retailers to make a reasonable profit. Specifically, this price accounts for producers' revenues, the international price, transportation costs, taxes, tariffs and retailers' margins.

[4] Current regulation forbids gas stations from buying gasoline directly from the refiner—that is, the wholesaler's channel must be used.

[5] Recently, new competitors have entered the retail market. For example, in 2006, the Brazilian multinational corporation *Petrobras* acquired all of *Shell's* gas stations; it is currently trying to push up its market share against competitors like *Exxon-Mobil*, *Chevron-Texaco* and the Colombian firm *Terpel*, the top three brands in the retail market.

[6] According to Gonzales (2004), major cities account for 60-70% of total gasoline consumption in Colombia.

Figure 1. The Structure of the Gasoline Industry in Colombia.



Source: The authors.

In 1999, shortly after this new pricing policy came into force, the government realized that matching domestic and international prices at the beginning of the production chain was not sustainable. The policy was implemented during a period when world oil prices were low, but a few months later, international oil and gasoline prices began to rise. The effect on domestic prices was immediate, fast and unexpected by the government, which decided to control the pace of the adjustment and match the international price only gradually.[7] Today, this gradual adjustment towards international prices is still under way.

3. Data: Sources, Description and Evolution

We use two set of prices in this paper, retail and wholesale. The information on retail prices originated in a monthly survey carried out by *Unidad de Planeación Minero Energética (UPME)*, a government agency that is a subsidiary of the Ministry of Mining and Energy. The survey collects retail gasoline prices during the first week of each month, directly from gas stations in ten major cities. Data on wholesale prices comes from our own calculations, based on the price regulations and monthly updates published by the Ministry of Mining and Energy for each of the 10 cities included in the gasoline retail price survey mentioned above. These prices vary by city, mainly due to transportation costs.[8]

[7] In addition to this, a new technical modification to the regulation on prices was recently introduced. As a measure aimed at reducing the contamination produced by CO_2 emissions, it is now mandatory to mix regular gasoline with a 10% content of ethanol fuel. Although the mixture of regular and ethanol fuel slightly modifies the calculations used by the government in establishing the monthly regulated price, the resulting prices have barely changed. During our sample period, which runs through December 2006, this new regulation was applied in only three cities (Bogota, Cali, and Pereira), but is expected to be applied/enacted in more cities in the near future. This new regime became operative in Cali and Pereira in November 2005. In Bogotá, it did not start operating until February 2006.

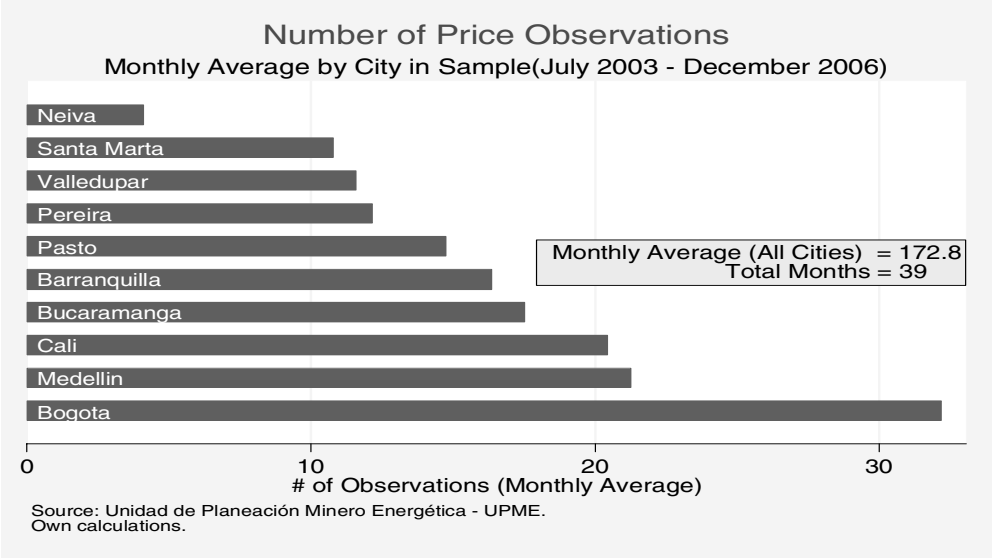
[8] Costs may also vary due to certain local taxes, as well as the existence of ethanol fuel in the cases of Bogotá, Cali and Pereira. In the case of border cities, such as Pasto and Valledupar, the regulation states that no tax is to be paid.

Despite the fact that we have information on regular and premium gasoline, we only consider the former, because consumption of the latter is relatively limited in Colombia.[9] For example, as reported by *Ecopetrol*, in 2005, regular gasoline sales (in gallons) accounted for 93% of total gasoline sales in the country.

Data on retail prices is available for 39 months, starting in July 2003 and running through December 2006.[10] It consists of an unbalanced panel of prices, as charged by over 200 gas stations in ten major cities. The methodology used to survey gas stations changed in mid-2004. Given the resulting compatibility problem, the data actually used in the econometric estimations runs from July 2004 through December 2006.

The econometric analysis below excludes all stations with less than five observations, leaving us with a sample that, on average, consists of 173.4 stations per month over the 30 month period of analysis. As shown in Figure 2, in major cities such as Bogotá, Cali and Medellin, a greater number of stations are surveyed relative to smaller cities like Neiva, Santa Marta and Valledupar. The ten cities surveyed not only account for 32.8 % of total gasoline sales in Colombia, but also represent 34.7% of the country's overall population according to the latest population census.

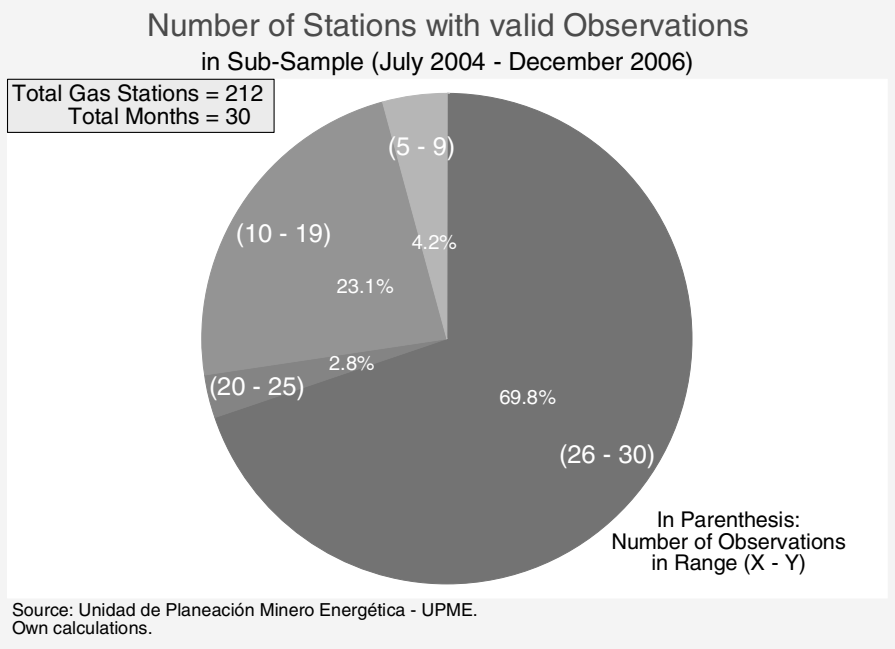
Figure 2. The Number of Price Observations.



As mentioned above, not all of the 212 gas stations being sampled register observations every single month.[11] Figure 3 shows how the data is distributed in more detail. For example, 154 stations, representing 69.8% of the total, have data for at least 26 (out of 30) months.

[9] Regular gasoline has a minimum of 81 octanes, while premium has a minimum of 87 octanes.
[10] Three months are missing in the original data—August 2003, December 2003, and June 2004.
[11] According to the Colombian Association of Gasoline Retailers (*Fendipetróleo*), the estimated number of gas stations in Colombia in 2004 was 2341; thus, the 212 gas stations used in our sample represent 7.7% of the total stations in the country.

Figure 3. Number of Stations with Valid Observations.



As Figure 4 shows, during our sample period, retail and wholesale prices exhibit a clear upward trend. Both retail average prices and wholesale prices in each of the 10 cities have grown steadily since July 2004, at monthly average rates slightly greater than 1%. While retail prices have grown—on average, 35.9% between the first and the last month of our sample—city wholesale prices have grown during the same time span by 33.4%. On average, higher retail prices have been spotted in Pereira and Cali, while lower prices have been found in Valledupar and Pasto.[12] Although prices are lower in these two border cities, the monthly average growth rate of their retail prices is greater than the national average.

[12] Recall that because Valledupar and Pasto are treated as border cities, consumers there do not pay taxes over gasoline.

Figure 4. Wholesale and Retail Prices

Source: Unidad de Planeación Minero Energética - UPME / Ministry of Mining and Energy.
Own calculations.

Despite the similar growing trends of costs and prices, price-cost margins—measured as the difference between retail prices without taxes and wholesale prices (as a percentage of price)—have been falling in most cities, with the exception of small ones, like Pasto and Santa Marta.[13] As Figure 4 shows, in larger cities like Bogota, Medellin, Barranquilla and Cali, price-cost margins are shrinking faster.

4. Asymmetric Price Adjustments

As mentioned above, the asymmetry we expect to find is conceptually different than traditional price asymmetries. We exploit the fact that in Colombia the suggested retail reference price of gasoline is publicly available and heavily advertised every month. Our hypothesis is that consumers' expectations about the retail price of gasoline are anchored to the reference price, and that this determines the adjustment speed of retail prices following a cost change.

What kind of an asymmetry would arise then? Under the plausible assumption that consumers do not observe costs, a rise in costs less than the increment of the reference price would allow retailers to quickly transfer the cost increase to prices. In such a situation, consumers would find the retail price increment reasonable based on their expectations. Conversely, if costs increase more than the reference price, retailers will have an incentive to not pass the whole cost increase on to consumers, or at least to delay the increase. Hence, an asymmetry would arise.

When referring to asymmetric price adjustments, then, we have in mind large vis-à-vis small increments in the cost (relative to the reference price) rather than positive or negative cost changes. A large change (*lc*) in cost occurs when wholesale prices increase more than the reference price. Similarly, a small change (*sc*) in cost refers to when the increment in the wholesale price is less than that for the reference price. This is defined on a per month and per city basis.[14] Note that, by definition, the reference price level is higher than the wholesale price. Therefore, we do not want to compare the level of costs relative to the reference price, as the latter is always higher.

[13] Here, taxes refer to the 25% tax charged on the retail price of regular gasoline.
[14] Recall that both reference prices and wholesale (regulated) prices are city specific.

Table 1 shows that the definition described above yields an evenly split sample between large and small changes in cost.

Table 1. The number of months with large and small cost changes per gasoline station.

# Months	$\Delta^{Small}C$	$\Delta^{Large}C$	$\Delta^{TOTAL}C$
Small/Large	139	140	**279**
%	49.8%	50.2%	

Source: UPME, own calculations.

Before attempting an econometric estimation of potential price asymmetries, we should first check a simple corollary of the hypothesis, one easily testable in our dataset. Our hypothesis states that large cost changes should be accompanied by a slow reaction of prices, while small cost changes should imply a fast price adjustment. As a consequence, large cost changes should go hand in hand with temporary low margins, while small cost changes should coincide with higher margins.

Table 2 reports simple averages of margins, calculated as the difference between retail and wholesale prices, excluding the taxes paid by retailers. This margin is presented as a percentage of the wholesale prices. The results go in the expected direction and the differences are statistically significant.

Table 2. Mean Margin Averages for Small and Large Cost Changes

Margins (%)	$\Delta^{Small}C^{*}$	$\Delta^{Large}C^{*}$	$\Delta^{TOTAL}C$
Mean	10,90%	10,70%	**10,80%**
N	2411	2712	**5123**

* The mean averages are statistically different (p-value = 0.02).
Source: UPME. own calculations

There are several econometrical approaches to the problem of estimating asymmetric price adjustments. Meyer et al. (2004) discuss what they call the pre-cointegration approach and the cointegration approach. The basic strategy of the former is to divide input prices into increasing and decreasing phases, by interacting them with the appropriate dummy variables. The cointegration approach, on the other hand, after establishing the long-run relationship between prices and costs, estimates error correction models for tracking price adjustments to (negative and positive) cost shocks. This is the approach followed by Borenstein et al. (1997), and Lewis (2005).

Borenstein et al. (1997) estimate an error correction model wherein, using a one stage approach, the change in retail prices is explained by the change in costs and a lagged error correction term. Lewis (2005), on the other hand, enhances the technique by using a two step approach, one that explicitly estimates the error correction term in the first stage. In this paper, we adopt the two stage approach.

Equation 1, which corresponds to the first stage of our empirical model, pools the data by city, and estimates the first step of the error correction model, wherein it is theoretically expected that, over the long run, prices and costs should be related.[15] In particular, we estimate that

[15] The first stage requires that both retail and wholesale prices be non-stationary, in order to test for cointegration. In the results (not reported here), we find that prices and cost series are non-stationary. In city-specific cointegration tests

$$P_{s,t} = \phi_1 C_{c,t} + \sum_{s=1}^{212} (EST_s) + \phi_2 t + \eta_{s,t} \quad , \qquad (1)$$

where $P_{s,t}$ stands for the retail price at station *s* for month *t* and $C_{c,t}$ represents the wholesale price in city *c* during period *t*.[16] The equation also includes a time trend (*t*). Station fixed effects (*EST*) are also included to capture the time invariant characteristics of gas stations, such as location and brand.[17] The estimates for Equation 1 generate the error correction term ($\eta_{s,t-1}$), which is used during the second stage of the model. The Equation 1 estimates are reported in Table 3.

Table 3. Estimates of Equation 1: The Price-Cost / Long-Run Relation.

P		Coefficient	Standard errors
ϕ_1	C	0.712***	(0.012)
ϕ_2	t	21.608***	(0.425)
N		5202	
Stations		212	
R-squared		0.98	

*** p<0.01, ** p<0.05, * p<0.1

Source: UPME, own calculations.

The results in Table 3 show that our estimate of ϕ_1 is relatively close to that obtained by Borenstein et al. (1997), who used a one step approach. Lewis (2005), however, fails to obtain a reasonable value for ϕ_1; moreover, based on a theoretical discussion, he decides to exogenously set it equal to one before proceedings to the second stage of the estimation. In the results reported in our robustness section, we also follow Lewis' approach—that is, we exogenously set $\phi_1 = 1$ during the first stage. We find that our main conclusions remain essentially unaltered.

Equation 2 corresponds to the second stage of the error correction model. In particular, we estimate that

$$\Delta P_{s,t} = \sum_{i=0}^{2} (\beta_i^{lc} \Delta C_{c,t-i}^{lc} + \beta_i^{sc} \Delta C_{c,t-i}^{sc}) + \sum_{i=1}^{2} (\gamma_i^{lc} \Delta P_{s,t-i}^{lc} + \gamma_i^{sc} \Delta P_{s,t-i}^{sc}) + \theta^{lc} \eta_{s,t-1} + \theta^{sc} \eta_{s,t-1} + \varepsilon_{s,t} \ . \ (2)$$

---

between wholesale and average retail prices, we find that there is cointegration at a 5% level in about half of the sample. Given the very short time span covered in our sample (something which makes the identification of cointegration difficult), we interpret the results as indicative of a long-run relationship between costs and prices, as our/the theory predicts. The cointegration tests were run using the monthly sample starting in July 2003 and ending in December 2006. The results are not reported here.

[16] Recall that wholesale prices are available only at the city level, whereas retail prices vary across stations. Therefore, no city fixed effects are included.

[17] It is true that stations might change brands at some point in time. However, in this case, it is an advantage to use a sample with a short period of time, as the assumption that brand and other specific gas station characteristics do not change then becomes more plausible.

The change in prices depends on lagged prices and cost changes, separated according to the relative size of the cost changes, as discussed above—that is, both the contemporary and lagged cost changes, as well as the lagged prices are split based on the large/small cost definition discussed above. Two lags in costs and two lags in prices are included. In the robustness section, we explore whether or not the results are sensible to the inclusion of additional lags; again we find that the main conclusions remain unaltered.

The equation also includes the error correction term estimated in equation 1. In order to further allow for an asymmetric adjustment, $\eta_{s,t-1}$ is allowed to affect price changes in different ways, depending on whether the costs are large or small ($\eta^{lc}_{s,t-1}, \eta^{sc}_{s,t-1}$). This distinction makes the asymmetrical adjustment of prices explicit, and allows for differences in the speed at which prices reach their long-run relationship with costs. We again later verify in the robustness section the impact of allowing only a single error correction term. As explained later, our conclusions remain unchanged.

A natural concern when estimating equation 2 is the possible endogeneity arising from retail prices looping back into wholesale prices. Fortunately, this endogeneity is not present in the Colombian case, inasmuch as wholesale prices are exogenously set on a monthly basis by the government using a publicly available formula, such that retail prices do *not* affect them in any way. The main rationale in the formula for setting wholesale prices is to establish a slow convergence towards international oil prices and, thus, slowly cut oil subsidies. Retail prices and internal demand conditions are not part of the formula in any implicit or explicit way.

The estimated coefficients of equation 2, crucial inasmuch as they are the necessary inputs for obtaining the impulse response functions of prices following cost shocks, are displayed in Table 4.

Table 4. Estimates of Equation 2: The Large/Small Cost Changes.

ΔP		Coefficient	Standard errors
γ_1^{lc}	$\Delta^{lc}P_{-1}$	-0.12701***	(0.01957)
γ_2^{lc}	$\Delta^{lc}P_{-2}$	0.06319***	(0.01942)
γ_1^{sc}	$\Delta^{sc}P_{-1}$	-0.10343***	(0.02274)
γ_2^{sc}	$\Delta^{sc}P_{-2}$	-0.07242***	(0.02222)
β_0^{lc}	$\Delta^{lc}C$	0.87698***	(0.01822)
β_1^{lc}	$\Delta^{lc}C_{-1}$	0.25995***	(0.02739)
β_2^{lc}	$\Delta^{lc}C_{-2}$	0.06897***	(0.02630)
β_0^{sc}	$\Delta^{sc}C$	1.26045***	(0.05066)
β_1^{sc}	$\Delta^{sc}C_{-1}$	0.35496***	(0.06444)
β_2^{sc}	$\Delta^{sc}C_{-2}$	0.44775***	(0.05828)
θ^{lc}	$\eta_{-1}{}^{lc}$	-0.20849***	(0.01392)
θ^{sc}	$\eta_{-1}{}^{sc}$	-0.22293***	(0.01565)
N		4544	
Stations		212	
R-squared		**0.75904**	

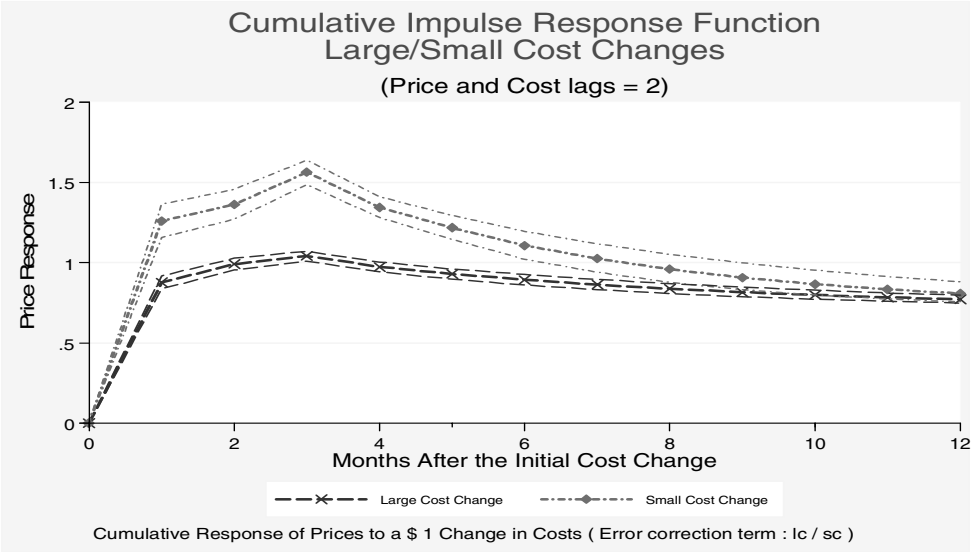
*** p<0.01, ** p<0.05, * p<0.1

Source: UPME, own calculations.

Following Borenstein et al. (1997), we depict cumulative impulse-response functions, tracking the adjustment path of prices given a one unit change in costs. The model allows for different short-

run reactions on the part of retail prices, depending on whether the cost shock was large or small relative to the reference price. Of course, being cumulative, the impulse-response functions converge to the long-run price-cost pass-trough. The complete adjustment process is illustrated in Figure 5. The plot includes 95% confidence intervals, calculated using a bootstrap method, to verify the statistical relevance of the (asymmetrical) adjustments.

Figure 5. The Cumulative Impulse Response Function: Large/Small Cost Changes.



An asymmetrical adjustment of the kind we hypothesize is recognizable in Figure 5. The results suggest that if costs rise above the increment in the reference price, retail prices will adjust to a lesser extent than when the opposite is true. If costs rise by 1 Colombian peso (COP$), and assuming a reference price increment above one, retail prices will increase by COP$1.26 a month later. Conversely, assuming a reference price increment below COP$1, a COP$1 increase in costs implies that, a month later, prices will rise by only COP$0.87.

An interesting finding is the overshooting of retail prices when cost increases are small (relative to changes in the reference price). This result suggests that, very early in the process, retail prices increase by more than the expected long-run adjustment. Later on, the price adjusts to the long-run pass–through. Based on Borenstein et al. (1997), this finding could be the result of a lack of competition. If this is the case, every increase in costs will immediately be transferred to retail prices, more than proportionally. Additionally,due to a lack of competition (and assuming a relatively inelastic demand), total demand will not significantly decrease. Another plausible explanation related to our hypothesis, is that consumers, unaware of the actual cost increase, find large price increases palatable as long as they are coherent with their expectations, formed on the basis of the reference price. In other words, if the reference price increases more than costs, retailers are able to increase their margins over the short run. Hence, overshooting arises.

To sum up, our results suggest that asymmetric pricing is a fact in the Colombian gasoline market. In our story, asymmetric pricing arises because of the role played by the widely available monthly reference price—consumers form their expectations based on the reference price. Based on these expectations, consumers decide whether to search or not for better retail prices, and retailers will behave as described in Figure 5. However, note that the existence of a reference price is not a necessary condition for asymmetric pricing to arise in ever-increasing market environment. Cabral and Fishman (2006), for example, argue that, assuming a price increase, consumers will not search for a better price if they perceive it to be moderate. If, on the contrary, consumers perceive the

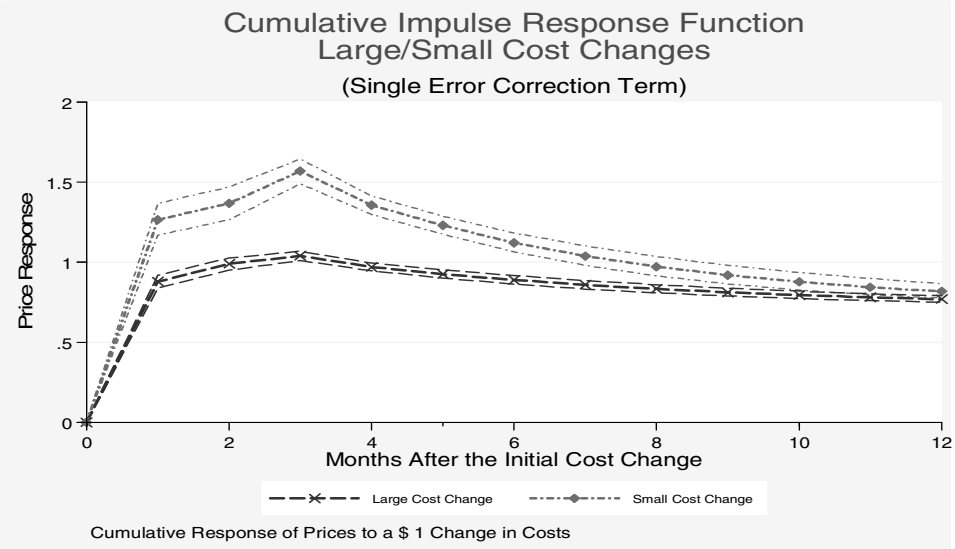
increase in retail prices to be overly high, they will have an incentive to search. The question now is, how can one define empirically what large and small price increases are? The Colombian market offers us a perfect answer—the monthly and widely publicized reference price. In our case, therefore, we are able to sustain that asymmetric pricing is in large part promoted by the existence of this reference price.

5. Robustness tests

This section tests the robustness of our results in face of alternative empirical specifications. In particular, we report the results with the following changes relative to the baseline model: (i) we estimate the impulse response functions allowing for a single error correction term, as opposed to separating its impact according to the relative size of the cost changes; (ii) we report the results with four instead of two lags; and (iii) we report the impulse response functions following Lewis' strategy of setting $\phi_1 = 1$, rather than using the estimate from the first stage of the model.

(i) Single Error correction term: In Figure 6, we depict the impulse response function using the estimates from Equation 2, where a single error correction term is used. If, compared with Figure 5, one concludes that the main result is virtually unaltered, i.e. large cost increases relative to reference price increases force retailers to delay price adjustments. On the other hand, small cost changes allow for a quick pass–through, with the same overshooting characteristics discussed earlier.

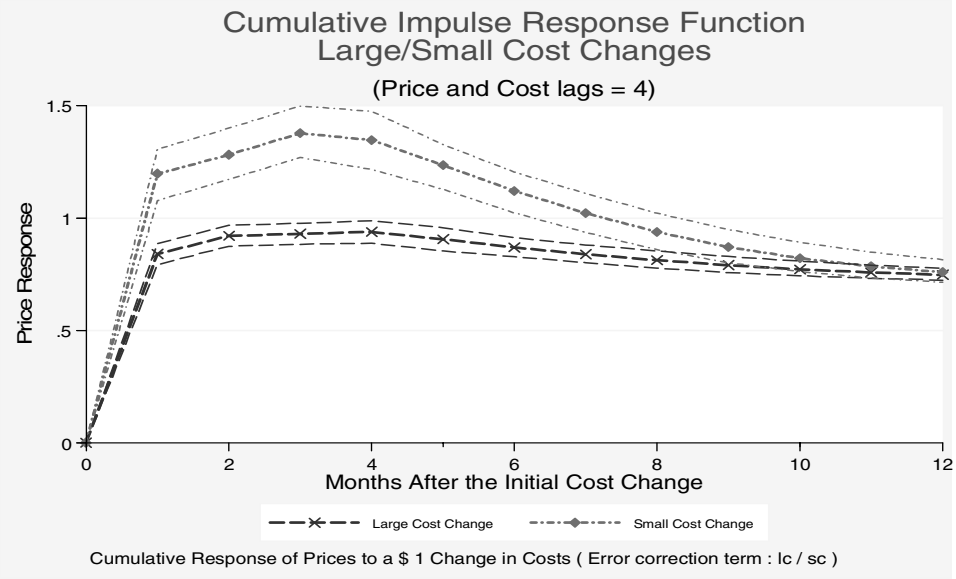
Figure 6. The Cumulative Impulse Response Function: Large/Small Cost Changes.



(ii) Lag structure: The second stage of our baseline model is estimated using using two lags for price and cost changes.[18] We check the robustness of our choice by replicating the exercise with alternative lag structures. For example, Figure 7 replicates the exercise using four lags. We find that the main results remain unaltered. In the results not reported, we tried other lag structures and found similar results. We conclude that our results are robust for the lag structure used in equation 2.

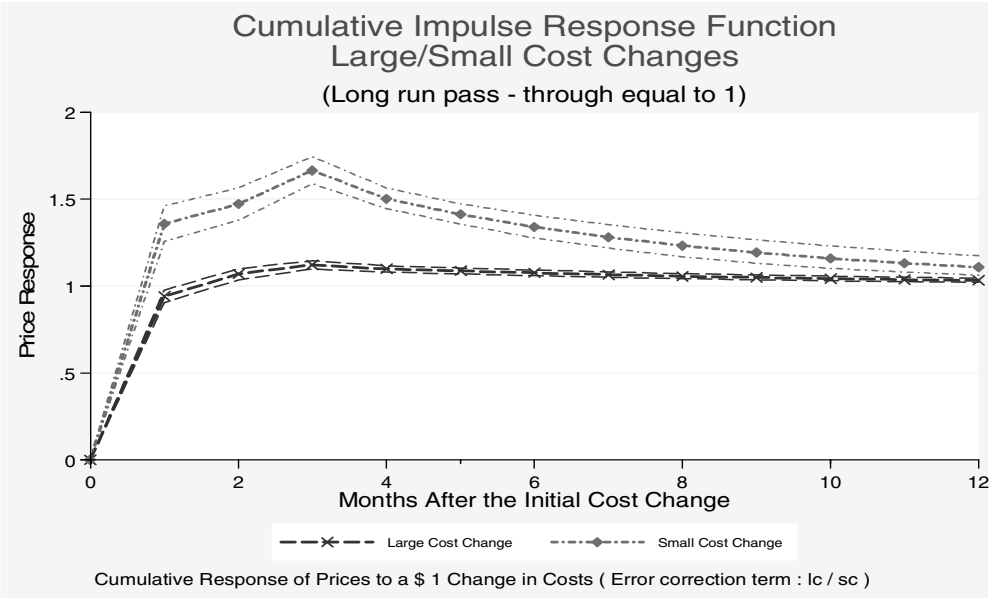
Figure 7. The Cumulative Impulse Response Function: Large/Small Cost Changes.

[18] Lewis (2005), for example, uses four lags, but he works with weekly data; our data are monthly.



(iii) $\phi_1 = 1$: The baseline model follows a two stage approach, wherein the first stage estimates the long-run coefficient linking prices and costs. The value reported in Table 3 is $\phi_1 = 0.71$. Nevertheless, as extensively discussed by Lewis, the theory suggests that ϕ_1 should be 1. It is conceivable that the coefficient we obtained is different from the one suggested by the theory simply because we use a short time-series dimension in our sample. Therefore, we re-estimate the impulse response function exogenously, setting $\phi_1 = 1$. We report the results in Figure 8.

Figure 8. The Cumulative Response Function: Large/Small Cost Changes.



As expected, a distinguishable difference in the baseline results is that, over the long run, an increase in costs of COP$ 1 raises prices by the same amount. This is naturally the consequence of having exogenously set the long-run pass-through as equal to 1. Other than that, all the patterns uncovered and discussed in the baseline scenario remain robust.

6. Concluding Remarks

The objective of this paper was to determine whether asymmetric pricing exists in a case where costs never fall. In order to test this hypothesis, we used data from the Colombian gasoline market where wholesale gasoline prices have consistently increased month by month over the course of our sample period. We exploit the existence of a widely publicized reference price to determine that, even in such a case, asymmetric pricing does exist.

The existence of asymmetric pricing is based on the manner in which consumers' expectations are formed. The reference price—a government suggested (that is, one that is not mandatory) retail price for gasoline—seems to play a key role in determining whether retailers adjust prices quickly or slowly following a cost increase. We show that when the reference price rises more to a greater extent than costs, retailers are able to quickly pass-through the cost increase to prices. Conversely, if costs rise more to a greater extent than the reference price, retailers delay the pass-through.

Our empirical strategy, though able to identify the described price asymmetry, is not designed to uncover the causes of this asymmetry. Nevertheless, the literature suggests several potential explanations for price asymmetries. Some of these are consistent with our results and the structure of the gasoline market in Colombia; others not.

One explanation for asymmetric pricing, suggested by Borenstein et al. (1997), represents a variation of Green and Porter's (1984) trigger price story. In that model, firms, when in equilibrium, restrict output to a level below the competitive equilibrium. The price is adjusted—that is, a price war begins—when sales fall below the threshold level. However, the trigger price story requires negative demand shocks and price cycles which were not observed during our sample period.

Similarly, the inventory argument explaining price asymmetries—that is, that sudden positive demand shocks quickly raise prices due to limited inventories and production lags, while sudden positive supply shocks usually imply future but not present lower prices (again due to production lags and finite inventories)—is based on the presence of unexpected demand or supply shocks. As mentioned in the previous case, we do not observe any sharp changes in demand over the course of our sample period. Analogously, a review of the historical record suggests that no sudden supply shocks were observed during our sample period. Thus, the inventory argument does not appear to provide a plausible explanation for the price asymmetries we identified.

Eckert (2002) argues that price asymmetries might be explained using Maskin and Tirole's (1988) alternating-move price setting duopoly model. This model predicts a price-cycle equilibrium, with retail prices being determined by two alternating regimes. The idea is that a price war is established in the undercutting regime up until the point where it is profitable for a firm to raise prices above the monopoly level. At that point, another undercutting regime starts. In the case studied in our paper, however, no price cycles were observed, even if defined broadly—that is, relative to the reference price.

In our view, our results are compatible with at least two theories. Firstly, they are consistent with Rotemberg's (2005) state dependent model, wherein firms choose the timing for adjusting prices so that it corresponds with those times when consumers find price changes most palatable; in our case, a large increase in the reference price (relative to costs) is the signal that a change would be palatable, and thus triggers more rapid price adjustments.

Secondly, our results seem to best fit the search story sketched by Borenstein et al. (1997), and further developed by Lewis (2005), Yang and Ye (2008) and Cabral and Fishman (2006). Consumers are potential seekers of better prices, and firms acknowledge this. The existence of

reference prices shape consumers' expectations and determines how quickly cost increases can be passed on to final prices. When costs increase to a greater extent than the reference price, retailers postpone the full adjustment of retail prices to avoid having consumers search out better prices. If no reference price existed, consumers would not necessarily be aware of the relative importance of price increments; hence asymmetric pricing, if present in the data, requires further explanation.

The main conclusion is that, under ever-increasing costs, asymmetric pricing does exist. Further research should expand our investigation to test whether in markets with similar characteristics—for instance, markets with widely publicized "suggested prices"—price adjustments following cost changes exhibit asymmetries as the ones we identified. If so, the existence of asymmetric pricing in a market with ever-increasing costs warrants additional theoretical work in order to enhance our understanding of the causes of such behavior.

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