Collusive Price Leadership in Retail Pharmacies in Chile

PRELIMINARY

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Abstract

I analyze price leadership among retail pharmacies in Chile during a case of price war and collusion in hundreds of blockbuster products. The leader during the collusive price increases was the smallest chain, while in the rest of the period the leader was the largest firm. I further show that the order of move of the followers during collusion was highly correlated with the chains' market share in each brand. I estimate the costs of being the collusive leader, which were significant although the difference in prices lasted only a few days. This implies that leadership mattered for the firms and that deviation profits in collusion models can be substantial when there are dynamic effects in demand, even when cheating can be detected quickly. I explain leadership by the small chain arguing that the leader was the firm that wanted the most to collude. Hence, price leadership served as a screening mechanism, where the followers decided how costly it should be for the leader to truthfully reveal that it was a collusive type. This is consistent with the empirical finding that in brand markets where the largest chain was relatively larger, the price increases in each brand occurred faster.

1 Introduction

Price leadership and its implications for antitrust policy have long been the focus of academic and policy interest, both in law and in economics. While a price leader arises naturally in many settings of oligopolistic competition, concerns that leadership may also be used as a mechanism to achieve collusive outcomes have gone practically unheeded by most judicial courts. As matter of fact, while courts often recognize that price leadership, or parallel conduct, may constitute a sign of a conspiracy, it is regarded as a plus factor, and thus not illegal per se.

Consequently, economists have long put effort to understand the reasons behind price leadership. In a seminal paper, Markham (1951) taxonomizes leadership into two types. The first type, competitive leadership, refers to the case in which a leader, usually the dominant or the best

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informed firm, is followed by its competitors because of the inherent competitive dynamics of the industry. The second type, collusive leadership, describes a situation where leadership takes place "in lieu of an overt agreement," and thus is used by the firms to reach collusive equilibria. More recent game-theoretic models have provided many insights regarding the conditions that allow either competitive or collusive leadership to arise, and who should be the leader in different circumstances. However, the literature does not yet offer a clear understanding about the empirical conditions that lead to either type of leadership arising in equilibrium, and the evidence on collusive leadership is still scarce.

This paper studies price leadership in a case of price war and collusion among retail pharmacy chains in Chile, where the pharmacies ended the price war coordinating on a more profitable equilibrium by means of large price increases in hundreds of medicines. While the industry leader in most of the period under study was the largest chain, the coordinated price increases were initiated by the smallest chain. Hence, the nature of price leadership during the coordinated price increases changed drastically, and also temporarily, since it returned to its previous state after the pharmacies were caught colluding.

The contributions of this work are as follows. First, the paper provides the first detailed study of price leadership during collusion with the hope that this should help us to better understand the function of price leadership. The paper documents extensively the characteristics of collusive leadership using the fact that collusion occurred in many different markets in order to infer the effect of various market characteristics. The main results are that the order of move of the three firms in each market is explained by each firm's market share, and that in markets where the largest firm was relatively larger collusion happened faster. Second, this work suggests an alternative motive for collusive price leadership. I argue that the leader chose to lead the price increases because it wanted to show its willingness to collude. I model this situation by assuming uncertainty about the leader's discount factor and by portraying leadership as a screening mechanism on the follower's part. Third, this paper provides evidence for two leadership regimes in the same industry and in different competitive states. These regimes match the competitive and collusive types of leadership described in the literature, and the paper studies the environment in which collusive leadership was put into practice. I find that collusive leadership was used by the firms *only* to switch to the new equilibrium, from the price war to the coordinated one. Changes in price leadership are important because they suggest that such events signal a break in conduct and they may be possibly used as an additional way to detect and punish collusive behavior. A final contribution is showing that leadership was costly for the leader. Although the large price gaps among the firms lasted a few days, the identity of the leader had a big impact on the distribution of future market shares. This finding, intuitive as it may be, had not been documented in the literature and it sheds light on the incentives firms in consumer markets have when colluding.

More specifically, this paper studies pharmacy chains that were engaged in a months-long price war in blockbuster brands, due to increasing reliance on loss-leading pricing as documented in Alé

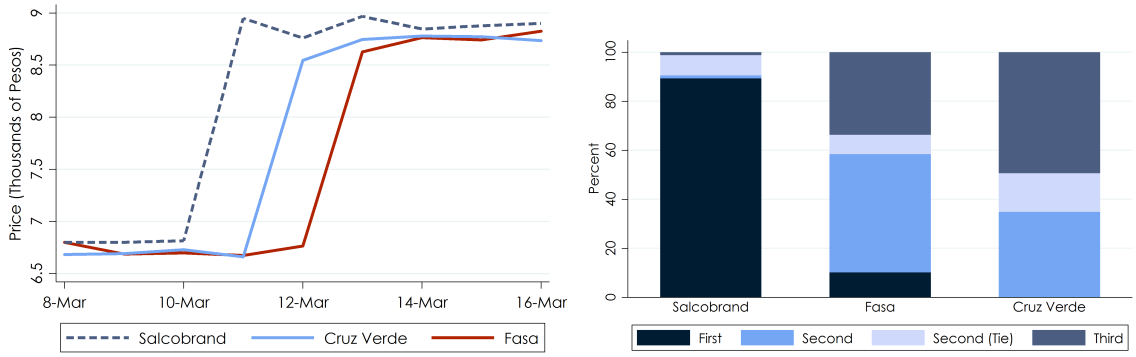
Chilet (2017). The price war escalated when the largest chain launched an advertising campaign of price comparisons. The campaign publicly compared the prices of a subset of the products in the largest chain itself with those of its main competitor, and was accompanied by price cuts that led to negative margins across all the pharmacies. A judicial court halted the campaign after complaints of unfair competition. Subsequently, a few weeks later, the three firms started increasing prices coordinately. The firms raised the price of each product by means of staggered, sharp price increases, which the smallest chain would typically lead, and the others follow. The scope of price fixing grew gradually to include more brands over a "coordination period" that lasted four months. The coordinated price increases lasted until the pharmacies realized that they were being investigated by the competition authority. By then, the firms had raised the prices of more than two hundred medicines, largely chronic, prescription-only drugs, and also the best-selling brands in their class. I show an example of a coordinated price increase in Panel (a) of Figure 1, and the order followed by the pharmacies during all coordinate price increases in Panel (b) of Figure 1.

I explain price leadership during the coordination period by arguing that the leader, Salcobrand, was the firm that wanted the most to collude. This was due to three reasons. First, Salcobrand changed ownership in the middle of the price war, and the new owners wanted to end the price war in loss-leader products in which the industry had been immersed in at least since December 2006. In addition, Salcobrand's competitors were in a better position to fight the price war: the other pharmacies, Cruz Verde and Fasa, had other sources of revenues besides the retail business; Cruz Verde was vertically integrated with a distributor, and Fasa had stores in Mexico and Peru. Finally, in many retail industries, economies of scale and of density cause marginal costs to decrease as the number of stores increase (e.g., Holmes 2011, Zheng 2016), and thus the two largest chains presumably had lower marginal costs.

Salcobrand's need to collude is the drive behind the theoretical framework I propose, in which the leader's type is private information. The leader raises price first. As a price difference between the firms entails a decrease in market share, the costs of leadership grow with the time it takes the follower to follow. Then, the follower can screen out impatient types by choosing the time it takes to follow the leader's price increase. Hence, leadership allows truthful revelation on the leader's part.

The empirical part of the paper is divided into three sections. First, I study the costs of price leadership. I find that being the last pharmacy to follow a coordinated price increase results in an increase in market share of roughly five percent, even a month after the increase happened. This finding is consequential because it means that leading the price increases was costly for the leader because of the loss in sales this entails. Thus, the identity of the leader matters for the firms, despite the briefness of the differences in price during coordination. In addition, the fact that short-lived price differences have large effects relates to our understanding of deviation gains in models of collusion. It shows that, even when monitoring technology is very good and deviation can be detected quickly, deviation profits can be substantial in markets in which there are dynamic

Figure 1 – Leadership in coordinated price increases



(a) A coordinated price increase.

(b) Order in coordinated price increases

Note: Panel (a) plots the prices and units sold of *Lady Ten x 21 coated tablets*, indicated for hormonal treatment therapy and manufactured by *Laboratorio Chile*, during a coordinated price increase in 2008. Panel (b) shows the order in which the pharmacies increased the price of each brand during the coordination period. There were 189 coordinated price increases. For simplicity, I exclude from the graph a few instances of ties in the first place.

effects in demand.

I proceed with the analysis studying changes in price leadership over time. I run brand fixed-effect regressions of price changes in each pharmacy on the weekly lags of price changes in all the pharmacies. Thus, I capture deviations from competitive leadership in changes in the effect of the large chain's lagged prices on the prices of other two pharmacies. I find drastic changes in leadership during coordination, and that Salcobrand became the price leader during this period. Yet, Salcobrand's leadership during coordination is mostly derived from leading coordinated price increases.

Finally, having shown the occurrence of the two leadership regimes in the data, I focus on collusive price leadership, where Salcobrand led the price increases. I study two of its outcomes, namely, the order in which the followers moved, and the time it took them to follow the leader. Apparently, the two larger chains took turns to follow the leader in a random order. Yet, I find that a strong predictor of the order they follow is the size of the largest firm, Cruz Verde. If Cruz Verde has a higher market share in a market, then it is more likely to be the last follower during coordination. This shows that size explains the order of move of the three firms, and it is consistent with the result from the theoretical literature that weaker firms move first in collusion among cost-asymmetric firms. Furthermore, I find a similar result regarding timing: Cruz Verde's dominance is also a strong predictor of the duration of the temporary price difference in each brand. In particular, if Cruz Verde is larger in a market, followers increase prices after the leader faster. In light of the model, I interpret this finding as the leader having to pay a higher cost in markets in which it may gain more from cheating the follower.

Related Literature

The literature on price leadership has a long history in economics, at least since Nichol (1930). Many of the early papers were spurred by changes in the stance of judicial courts regarding whether parallel conduct is in itself unlawful or not. In a very influential paper, Markham (1951) reacts to a Supreme Court's sentence in the case *American Tobacco Co. v. United States*,[1] and argues that not every type of parallel conduct should be deemed as forbidden by the Sherman Act.[2] Markham (1951) discusses different types of leadership, which were, subsequently, taken up by most of the literature on price leadership. Thus, Markham identifies a competitive price leadership in which the dominant firm is the leader, and a collusive price leadership that serves as a mechanism to collude.[3]

More recent articles have provided theoretical explanations for each type of leadership and have identified who the leader should be under the different cases. Work on competitive price leadership has tried to explain the reasons of the common empirical observation that the leader is the dominant firm in an industry. Among other contributions, Deneckere and Kovenock (1992) analyze capacity constrained firms, and van Damme and Hurkens (1999, 2004) use the risk dominance refinement of Harsanyi and Selten (1988) to find a unique equilibrium. These papers find that better positioned firms (larger or more efficient) act as the price leaders. Recent empirical evidence is provided by Byrne and De Roos (2016) that study how the largest firm in an Australian retail gasoline market was able to lead the industry to higher prices by means of price leadership.[4]

Models of collusive price leadership seek to understand how price leadership may facilitate collusion. Ishibashi (2008) argues that a collusive leader moves first to "demonstrate its commitment not to deviate." Also relevant, Mouraviev and Rey (2011) argue that collusion is sustainable provided that the follower can be rewarded with a high enough market share. The authors find that under cost asymmetry the firms can achieve greater collusive profits if the less efficient firm is the leader. The reason for this is that leadership relaxes the incentive compatibility constrains,

[1] 328 U.S. 781 (1946)

[2] Subsequently, in 1954, the Court refined its stance and argued that "this Court has never held that proof of parallel business behavior conclusively establishes agreement or, phrased differently, that such behavior itself constitutes a Sherman Act offense." (*Theatre Enterprises v. Paramount Distributing*, 346 U. S. 540-541, 1953.) See Kovacic et al (2011) for a thorough discussion of price leadership in antitrust law. Important Court rulings are Theatre Enterprises v. Paramount Distributing, 346 U.S. 537 (1953), Brooke Group Ltd. v. Brown & Williamson Tobacco Corp., 509 U.S. 209, 227 (1993), and Bell Atlantic Corp. v. Twombly, 550 U.S. 544 (2007) in the US; and A. Ahlström Osakeyhtiö and others v Commission of the European Communities, Judgment of the Court (Fifth Chamber) of 31 March 1993, in Europe.

[3] Markham, following Stigler, also identifies a third type, the barometric leadership, where the leader "commands adherence of rivals to his price only because, and to the extent that, his price reflects market conditions with tolerable promptness" (Stigler, 1947). In game-theoretic models of barometric price leadership, the leader has been found to be the firm that has more information (Cooper, 1997). Rotemberg and Saloner (1990) discuss the case of asymmetrically informed firms in a collusive setting.

[4] Other papers have studied competitive leadership in US gasoline stations (Lewis, 2012) and British supermarkets (Seaton and Waterson, 2013).

and the less efficient firm is the one for which this constraint is more likely to be binding.[5] The findings of my paper provide empirical support to Mouraviev and Rey's suggestion regarding the identity of the leader. Moreover, at the same time my results propose a mechanism (the endogenous delays in price increases) by which the leader may reward the follower with a market share large enough, which in Mouraviev and Rey is left unmodeled.

Empirical work on collusive leadership is almost nonexistent, despite its prevalence in antitrust cases.[6] A notable exception, and perhaps closest to this paper, is Clark and Houde (2013), who study a cartel of Canadian gasoline retailers. The authors find that the high-cost gasoline retailers moved first during coordinated price increases. Given that leadership by the same firms was recurrent, Clark and Houde argue that leadership was a way in which leaders transferred profits to other firms in order to incentivize them to comply with *supra* competitive prices. The authors claim that the followers had lower marginal costs because they were either owned by big-box retailers, which made most of their profits from sales of other products, or were vertically integrated. In my setting I argue that the larger firms were the strongest because they did not need to collude as much as the small firm. This was due to the income sources the larger firms had from other markets, either upstream or abroad, in a similar manner to Clark and Houde (2013). However, in contrast to paper by Clark and Houde, I am able to analyze price leadership more precisely due to the high frequency price data in hundreds of markets.[7] Also, while the former attribute costs of leadership to Edgeworth-type price cycles, I argue that in my setting costs are due to dynamic features in the nature of demand. These features make one instance of price increase having an effect on market shares in the medium run. Moreover, I can compare across many heterogeneous markets and, thus, I am able to correlate leadership outcomes with various market characteristics.

Besides the literature on price leadership, this work contributes to the literature on the internal workings of cartels, such as Porter (1983), Levenstein (1997), Scott Morton (1997), Genesove and Mullin (2001), and Roller and Steen (2006), and Asker (2010). This article also relies on the theoretical literature of collusion among cost-asymmetric firms. Relevant references to the latter are Bae (1987), Harrington (1991), and Miklós-Thal (2011). Some papers also study collusion among firms with different discount factors. See Harrington (1989) and, more recently, Obara and Zincenko (2017) for two examples. My discussion on the costs of leadership relates to papers in economics and marketing that have introduced persistence (due to, e.g., loyalty, brand image, or habits) into models of consumer demand, such as Erdem (1996), Keane (1997), Shum (2004),

[5] In the game Mouraviev and Rey describe, each period of the game firms play has two stages, as in Hamilton and Slutsky (1990). In the first stage, each firm can publicly set its price. Then, in the second stage, if a firm did not set its price, it must do so now, and demand is realized. Hence, price leadership is endogenous, in the sense that both simultaneous and sequential play may emerge.

[6] Davies and De (2013) discuss price leadership in their study of ringleaders based on 89 European cartels. Out of the 19 instances in which there was a ringleader, in 9 cases the ringleader was also a price leader that aggressively pushed to achieve higher prices. The authors do not refer to other instances of price leadership where the leader is not the ring leader.

[7] Clark and Houde (2013) infer leadership from precisely timed phone calls in two markets.

Dubé, Hitsch, and Rossi (2010), and Eizenberg and Salvo (2015). I show how market shares change in the medium-run after a large (one-sided) price increase.

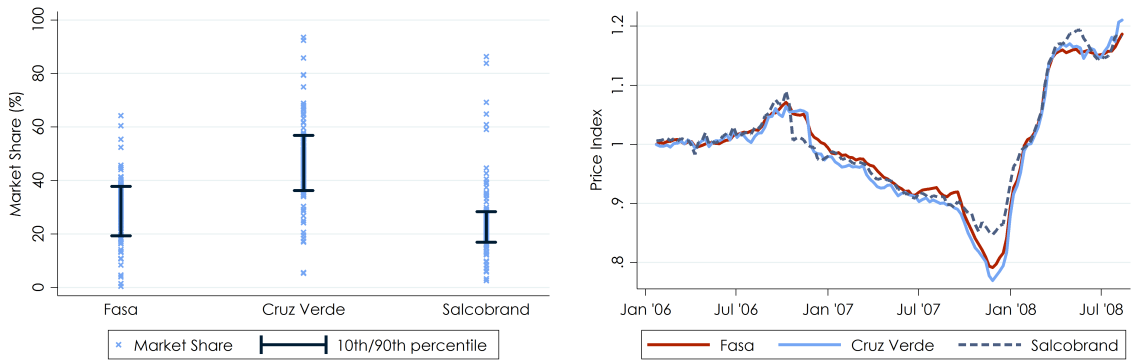
Finally, this paper studies the case of collusion analyzed in Alé Chilet (2017). The main difference between the two is that in my other paper I studied collusion *over* products, while this works studies collusion *within* products. More specifically, in Alé Chilet (2017) I studied the development of collusion over time, as the cartel moved gradually from a price war to a coordinated equilibrium, and I found that pharmacies started increasing prices of differentiated products and of products in which firms' market shares are more asymmetric. The interpretation of this result was that the firms built trust over time and, thus, they started cooperating on products in which is was safer to collude. In this paper, I look at how firms increased price in each brand, hence focusing on the behavior of the individual firms rather than on the behavior of the cartel as such.

2 Price Fixing among Retail Pharmacy Chains in Chile

The industry was reviewed in depth in Alé Chilet (2017). I provide here a brief description of the industry and of the antitrust case with a special focus on price leadership during the price fixing period. The retail drugstore market in Chile is controlled by three chains that jointly make up roughly 92 percent of the sales. The remaining 8 percent is shared by independent drugstores and small chains, which sell mostly generic drugs. The three large chains are Cruz Verde, Fasa (or Farmacias Ahumada), and Salcobrand. As of 2008, Cruz Verde was the largest chain, with 512 stores, while Fasa and Salcobrand had 347 and 295, respectively. Cruz Verde's market share had increased steadily between 2004 and 2007 from roughly 32 to 41 percent, while Fasa became an international drugstore chain in the past decade with stores in Chile, Mexico, and Peru, and with 37 percent of its revenues coming from the Chilean market. Salcobrand was formed from the merger of two chains, Salco and Brand, in 2000, and was sold to a large business group in August 2007. I plot in Panel (*a*) of Figure 2 the market shares of the three firms in each brand. The heterogeneity in the pharmacies' shares will be important in the next sections of the paper.

Starting in 2005, the pharmacies started relying heavily on a loss-leading strategy, which consisted of selling hundreds of chronic, branded, and best-selling drugs for prices close to or below their wholesale price. This period of low prices, which intensified in December 2006, was described by Chile's National Economic Prosecutor (NEP) as a price war, during which either sharp price cuts or continuous price undercutting in the loss-leading drugs were common. The price war escalated further in August 2007 as a result of a Cruz Verde's marketing campaign that openly compared prices between itself and Fasa, and claiming that Cruz Verde had the lowest prices in the market. The price declines only stopped in November 2007, when a court deemed Cruz Verde's advertising campaign to be unfair competition and halted it. Some weeks later, the pharmacies started coordinating price increases, which, by the time an antitrust investigation started in May

Figure 2 – The Retail Market



(a) Market Shares by Brand

(b) Price Indexes

Note: Panel (a) shows the average market shares of the pharmacies for the 222 drugs in the collusion case in October-November 2007. Panel (b) shows an average price index for each of the three firms by week for the same medicines over time.

2008, had led to an average price increase of almost 50 percent in 222 best-selling brands. I refer to the latter as the coordination period. These events can be seen in Panel (b) of Figure 2, which presents price indexes, an average over brands of normalized prices, for each of the three chains. The pharmacies were found guilty of colluding by the Competition Tribunal in January 2012.

During the coordination period the pharmacies would raise the price of each drug using a "staggered mechanism," in which typically Salcobrand would lead the price increase. Then, two or three days later, one of the other two chains would raise prices. Finally, the third pharmacy would raise its price either the same day or one to three days after the second pharmacy. Therefore, in a time period of roughly one week, the price in all three chains would be the same.[8]

Reasons for Salcobrand's Leadership

The NEP and the expert reports requested by the pharmacies agreed that Salcobrand's leadership during the coordinated price increases was exceptional.[9] In fact, the depositions and the argu-

[8] This mechanism was identified in an expert report commissioned for the trial (Nuñez, Rau and Rivera, 2010). The report looked at the 162 price increases in which all three drugstores increased the price of a drug within a period of four days. The authors studied price increases that lasted for at least three days and happened during the period December 2007 to April 2008. Their analysis showed that in 52 percent of the cases the order of the companies raising prices was Salcobrand-Fasa-Cruz Verde, while 40 percent corresponded to Salcobrand-Cruz Verde-Fasa. The remaining 8 percent corresponded to the other possible combinations (p. 48).

[9] The NEP saw a change in price leadership as well, and it was the subject of many reports. Observations to the evidence. NEP, p. 198; Cruz (2010). For example, Cruz (2010), in an expert report requested by Cruz Verde, examined Cruz Verde's own prices and the prices of its main competitor, Fasa, from Cruz Verde's internal monitoring data. Tellingly, the author claimed that she cannot examine the correlation between Cruz Verde's and Salcobrand's prices, because "for most of 2007, Cruz Verde thought that Salcobrand had not been able to position itself in the industry as relevant [player], and thus [Cruz Verde] monitored [Salcobrand's] products less."

ments of the defendants of the antitrust case portray Salcobrand as sending signals about its willingness to stop the price war by means of avoiding further price cuts and taking upon itself the position of market leader. I argue here that Salcobrand initiated the price increases because, as the weakest firm in the industry, it wanted the most to collude.

The main argument for Salcobrand's leadership position is its change in ownership in August 2007, in the midst of the price war, and subsequent change in strategy. The new owners thought they could increase margins by ending the price war in loss-leader products, in which the industry had been involved at least since December 2006, and requested the services of a strategy consulting group to give them advice about the matter. As Salcobrand's commercial manager explained in an internal email addressed to the CEO and other senior managers in December 19, 2007, the strategic actions that management undertook included: avoiding following price cuts in generics offered by Fasa in October; following the competitors' price increases, but not their price cuts; offering to lead the (coordinated) price increases; and setting prices of loss-leader products between those of Fasa and Cruz Verde.[10] The outcomes of this change of strategy are also seen in the price indexes in Panel (b) of Figure 2. Notice that in October 2007 Salcobrand's average price of the drugs involved in price fixing decreased less sharply than the price of its competitors, which led ultimately to a substantial gap between Salcobrand's prices and those of its competitors towards the end of the price war.

Importantly, the other pharmacies realized Salcobrand's new intentions.[11] As a former Cruz Verde board member noted, "Salcobrand's [new administration] came to change this dynamic (...) of big emotional aggressiveness between the companies, because, in fact, Salcobrand present[ed] itself as a neutral competitor that [made] its decisions mostly based on economic principles (...)"[12] Similarly, a former Fasa board member explained that "Salcobrand changed owner and the expectation was that (...) [the new owners] would introduce rationality into the levels of competition, that is, that not everything would be sold at negative margins, because it is a group that works professionally."[13]

In addition, the situation during the price war was better for the two largest chains, Cruz Verde and Fasa, because they had other sources of revenues besides the retail business: Cruz Verde was vertically integrated with a distributor, and Fasa had stores abroad.[14] These are similar reasons to the ones given by Clark and Houde (2013) to explain price leadership by some firms.

Furthermore, in many retail industries, economies of scale and of density cause marginal costs to decrease as the number of stores increase (e.g., Holmes 2001, Zheng 2016). Thus, Salcobrand's

[10] Observations to the evidence. NEP, p. 18.

[11] Harrington (2015) discusses the importance of the firms' beliefs in collusion.

[12] Deposition of Fernándo Suárez Laureda. Observations to the evidence. NEP, p. 224.

[13] Deposition of Pablo Lamarca. 75 Observations. Salcobrand, p. 64. Notice the similarity to reputation effects of, for example, Kreps and Wilson (1982).

[14] Salcobrand attributes Fasa's willingness to fight the price war explicitly to Fasa's profits abroad (75 Observations. Salcobrand, p. 64).

competitors were in a better position to continue the price war due their higher cash stock and presumably lower marginal costs. As another former Fasa board member testified, "as opposed to other price wars, Fasa had this time a competitive cost position" and, therefore, "it was suggested to resist [the price war]" in order to "avoid losing [market] participation."[15]

3 Theoretical Framework

In this section I suggest a theoretical framework of price leadership based on the institutional settings of the industry at the time. The main difference with previous explanations of price leadership is that the model introduces asymmetric information, as the leader's type is its own private information. Furthermore, although leadership is costly, a patient leader takes upon itself this task in order to reveal its type and show that it is willing to raise prices.[16] I claim that these features capture in a better way than alternative explanations the reasons for Salcobrand's leadership and point out at a fundamental issue in collusion, namely, the firms' beliefs at the onset of coordination (Harrington, 2015). Moreover, the model highlights how price leadership can be used to signal the leader's willingness to collude, as Salcobrand did. Finally, the model endogenizes the time it takes the follower to follow in a screening mechanism, which rationalizes the large heterogeneity observed in the delay. This last point will be discussed in more detail in Section 7.

There are two firms in the model, the Leader and the Follower, which play an infinitely repeated price setting game in a market of size 1. The firms sell to consumers who buy every period and who have no outside option. Suppose there are only two possible prices levels the firms can set, the competitive Nash price p^N and the collusive price p^C, $p^N < p^C$. The firms are asymmetric in size in the following way: if firms set the same price, the market shares of the Leader and of the Follower are $s_L = \alpha$ and $s_F = 1 - \alpha$, respectively. In addition, if there is a price difference between the firms, then the firm with the lowest price gets λ customers from the expensive firm as long as the price difference is not zero.[17]

There is one-sided asymmetric information in the following way. It is public information that the Follower's discount factor is close to one, but the Follower does not know the Leader's discount factor δ. Furthermore, the collusive price p^C is only sustainable for the firms if the Leader's discount factor is higher that a threshold δ^*.[18] How can, then, the two firms collude?

Suppose that until $t = 0$ the two firms have set a price p^N. Consider the following collusive mechanism. At $t = 0$ the Leader may increase its price to p^C. If there is a price increase, the Follower observes the increase and only follows it at $t = T$, which for now is assumed to be exogenous.

[15] Deposition of Ernesto Labatut. 75 Observations. Salcobrand, p. 48.

[16] In contrast, in previous work the market share transfer to the follower was seen as a way of paying off firms that do not want to collude (Mouraviev and Rey, 2011; Clark and Houde, 2013) or as a commitment device (Ishibashi, 2008).

[17] λ may include also future profit transfers between the firms.

[18] That is, the Leader does not undercut the collusive price of its competitor if the Leader is patient enough

As the following proposition states, conditional on the Follower's strategy, only Leader types that are patient enough will increase price at $t = 0$.[19]

Proposition 1. *The Leader leads a price increase that it takes T periods for the Follower to follow iff*

$$\delta^T > 1 - \frac{\alpha}{\lambda}\frac{p^C - p^N}{p^C} \equiv \hat{\delta}^T$$

Proof. Immediate from the condition that it is profitable for the Leader to raise the price at $t = 0$:

$$\frac{1}{1-\delta}\left[p^C(\alpha-\lambda) - p^N\alpha\right] - \frac{\delta^T}{1-\delta}\left[p^C(\alpha-\lambda) - p^N\alpha\right] + \frac{\delta^T}{1-\delta}\left[p^C\alpha - p^N\alpha\right] > 0$$

□

Consider, now, the Follower's choice of T and assume that the threshold is well defined, i.e., $\hat{\delta}^T > 0$.[20] The proposition above states that for any given T there is a threshold $\hat{\delta}$, such that any Leader with a discount factor greater than $\hat{\delta}$ prefers to lead the price increase to the collusive level rather than to stay at the competitive price. Notice further that $\hat{\delta}$ is increasing with T. Hence, we can think of the Follower's choice of T as a screening mechanism by which the Follower determines the Leader's types for which it is individually rational to lead the price increase. Then, the Follower may choose to follow the price increase at $T = T^*$ such that $\hat{\delta} \geq \delta^*$. This ensures that $\delta > \delta^*$ and that the Leader is patient enough to sustain collusion.[21]

I make two final comments. First, collusion among the pharmacies was gradual, which in Alé Chilet (2017) was attributed to trust building over time. It is also possible to introduce further uncertainty in the model so that the Follower does not perfectly learn the Leader's type after success in collusion in one product.[22] Second, suppose that the number of customers that switch firm λ equals $v\alpha(1-\alpha)$, where v is a constant. This is similar to the prediction of what the change in market shares would be in a logit model.[23] Then, T^* is decreasing in the Leader's market share α. In other words, if the Leader has a higher market share, then the Follower takes more time to follow the price increase, because the transfer needed to learn that the Leader's discount factor is at least δ^* is larger. [24] This would explain the empirical finding I present in Section 7 that Cruz Verde's market share is negatively correlated with the time it takes the firms to raise prices.

[19] Leadership in the model is exogenous, but it can be easily endogenized by assuming that the Follower can also initiate the price increase, but it does not do so due to the uncertainty regarding the other firm's type.

[20] If the threshold is not defined, then $\hat{\delta} = 0$.

[21] This screening mechanism is in the spirit of Maskin and Riley (1984).

[22] For example, because the Follower may actually prefer to follow the Leader at $T < T^*$ and take the risk of playing a type lower than δ^* once it has made sure that the Leader's type is not *too* low.

[23] This functional form entails that the Leader losses more customers when its market share is in a medium range. I provide empirical support for this assumption in Section 5 and in the Appendix

[24] I plot in the Appendix the values of $\hat{\delta}$ as a function of T for different values of the Leader's market share.

4 The Data

I use transaction data from the Competition Tribunal of Chile. They include every purchase in the three drugstore chains of the 222 brands that the chains were accused to be colluding on for the years 2006-2008. Since the three chains have a joint market share of 92 percent of the retail market, and because other drugstores sell mostly generics, the data include virtually every retail purchase of these drugs. The data contain the name of the purchased drug, the drugstore chain, a store code (only for two of the three chains), the date and time of purchase, the list price per unit, the final purchasing price, and the number of units sold. The brands in the data were manufactured by 37 different pharmaceutical companies, with a mean price of $30 and prices ranging from $1.50 to $180 US dollars.[25]

I aggregate transactions into daily and weekly data. Since price varies over transactions, I generate a revenue-weighted average price. For each time period, average price is calculated as the weighted average of the final transaction price for each drug in each chain, where the weights are the share that each purchase constitutes of the total revenues of the chain for that brand. The share of the population with a drug insurance plan was extremely low at the time. Therefore, the transaction price should be seen as an out-of-pocket expense.

5 The Costs of Price Leadership

The aim of this section is to present evidence that leading the coordinated price increases was costly. Admittedly, the large difference in retail prices across pharmacies lasted only a few days. Thus, given also a quite inelastic demand, the loss in sales during coordination was negligible with respect to the extra profits the firms could obtain from a price increase. Yet, as I will show next, these short-lived price differences produced a lasting effect in the demand.

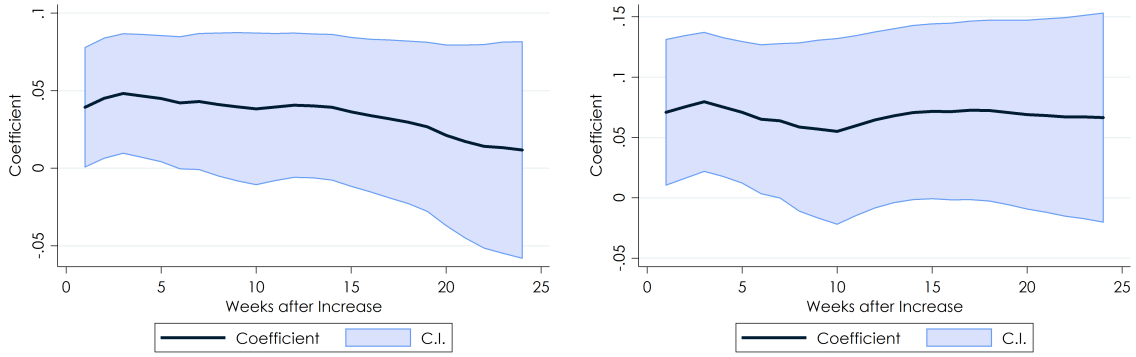
The data do not allow a full estimation of the dynamic effects of price increases on the demand (as in, e.g., Hendel and Nevo, 2006). Hence, I estimate the effects of being the leader or a follower in the previous month on the firm's current market shares while imposing a common price effect. I define the variables *First*, *Second*, and *Third* if the firm was the first, second, or third firm to increase price in a coordinated manner, respectively, during the previous weeks.[26]

The main specifications estimate the following regression:

[25] I drop observations that do not have a date, and observations for which price or number of units bought is zero or unknown. Also, I do not have geographical information on purchases. However, I can distinguish purchases in two geographical zones: stores in the far north and the far south, and stores in the rest of the country. I drop the former (following the expert report of Nuñez, Rau and Rivera, 2010, p. 19) because many drugs do not register sales in a number of months. These account for roughly 4 percent of the total amount of transactions and 3 percent of revenues. Prices in these regions are in average 4 percent higher due to the extra costs incurred. It is not possible to distinguish purchases in the extreme zones from the rest of the country in 2006 for Cruz Verde.

[26] I exclude the contemporaneous effect by dropping the weeks when the price increase occurs from the estimating sample.

Figure 3 – Persistence of Costs of Leadership on the log Market Share over Time



(a) All brands

(b) Homogeneous brands

Note: The figure presents the point estimates and the confidence intervals of the effect of being the last firm to follow a coordinated price increase on the firm's log market share of an increasingly large number of weeks into the future. Panel (a) presents the result of all brands, and Panel (b) only for brands in which pharmacies are more homogeneous. All regressions include a brand fixed effect. Standard errors are clustered at the brand level.

$$\ln Sales_{ijt} = \beta_0 + \beta_1 \Delta \ln p_{ijt} + \theta_1 First + \theta_2 Second + \theta_3 Third + \lambda_i + \mu_j + \delta_t + \epsilon_{ijt}, \qquad (1)$$

where $Sales_{ijt}$ represents the sales of brand i of firm j at time t; $\Delta \ln p_{ijt}$ denotes the price difference of firm j with respect to the average price of firm j's competitors; and λ_i, μ_j, and δ_t constitute brand, firm, and week fixed effects, respectively. Thus, θ_1, θ_2, and θ_3 capture the effect on future sales of having had raised price during a coordinated increase in the first, second, and third place, respectively. In the main specifications, I limit this effect to 4 weeks. Since the equation includes pharmacy and brand fixed effects, the θs are identified from the difference in sales just after a coordinated increase with the sales in the rest of the sample period. Therefore, to limit the effect of other price changes, especially those during the price war, I estimate Equation (1) for November 2007 to June 2008. In addition, δ_t controls for aggregated time-specific demand shocks.[27]

I show the results of the estimation of Equation (1) in Table 1. I present a number of specifications, and all regressions include pharmacy and brand fixed-effect, with standard errors clustered at the brand level. In Column (1) the dependent variable *Sales* is measured by the log number of units sold, and in Column (2) and the other specifications, it is measured by the pharmacy's market share, in logs or in levels. Column (3) includes week fixed-effects and is the main specification. These results show that the price follower increases its market share on average by roughly

[27] A possible concern is the lack of data on product advertising, since competitors advertising may counteract own brand loyalty effects (Shum, 2004). Yet, if the leader ramps up advertising after a price increase, my estimates would provide a lower bound of the cost of leadership. However, I do not think this is likely, since increasing advertising may have been seen as deviation from the collusive scheme.

5 percentage points as a result of a coordinated increase. Notice that the coordinated increases were a result of changes in the nature of competition in the industry, and thus were not due to unobserved pharmacy-specific demand shocks. This fact implies that the effects of leadership on market structure (the leader costs) cannot be undone by means of unilateral, uncoordinated price changes. I also show in the Appendix that when the model shown in Column (3) is estimated for each brand separately, the transfers due to leadership have a quadratic function with respect to Cruz Verde's market share. This finding provides support to the logit functional form suggested in Section 3.

In addition, Columns (4)-(8) of Table 1 show estimates for different subsets of the data. Column (4) presents results which include in the estimating sample only brands for which it took three or more days for all the firms to raise prices. As expected, if the followers delay their price increases, the effect of followship is stronger. This is interesting because, in large part, the cost of the leader is determined by the followers, as was highlighted in Section 3. Column (5) shows that excluding Cruz Verde from the sample entails a much larger effect. Column (6) includes only brands in which the pharmacies are more homogenous with respect to each other, as measured by the top half distribution of the cross elasticities estimated in Alé Chilet (2017). The effect of leadership in these brands is also larger. Column (7) shows that leadership is costlier in symmetric markets, that is, in brands in the bottom-half distribution of the difference between Cruz Verde's and Salcobrand's market shares. Column (8) shows results only for brands in which there was a coordinated price increase. Although the estimate of leadership is less precise, it is of the same magnitude as in the main specification (Column 3).

Finally, I estimate the persistence of the leadership effect on market shares over time. For this, I set the variables *First*, *Second*, and *Third* equal to 1 for an increasingly large number of time periods after the coordinated price increase. Thus, the coefficients of these variables capture the cumulative effect of leadership over time. I show the estimates of the coefficient of *Third* in Figure 3. Panel (*a*) shows the results for all the brands (Column 4 of the table) and Panel (*b*) those for more homogeneous markets (Column 7 of the table). For both samples, the average effect is significantly different from zero for roughly six weeks after the coordinated increase, but the effect on homogeneous markets seems to be more persistent over time.

The findings strongly suggest the presence in demand of dynamic linkages across demand in different periods,[28] and that a large price difference among the firms breaks the persistence that has been found in the literature.[29] The fact that price leadership is costly has important implica-

[28] Such demand linkages, which make temporary price changes costly in the long run, appear in a demand model where consumers buy drugs once a month from their preferred drugstore. If they notice a large price increase, then they switch drugstore only in their next purchase due to increasing marginal search costs, as in Stiglitz (1987). Also, Erdem (1996), Keane (1997), and models that followed them introduce state dependence in empirical consumer choice models.

[29] The persistence of brand market shares has been attributed to loyalty by Dubé, Hitsch, and Rossi (2010); and to early brand entry by Bronnenberg, Dhar, and Dubé (2009). Bronnenberg, Dubé, and Gentzkow (2012) provide evidence on the long-run effects of brand preferences.

Table 1 – The Costs of Price Leadership

	Ln Units Sold	Ln Market Share							Share
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Δ ln Price	-1.356***	-1.345***	-1.345***	-1.673***	-1.408***	-1.730***	-1.227***	-0.774***	-0.370***
	(0.238)	(0.238)	(0.238)	(0.315)	(0.164)	(0.408)	(0.297)	(0.157)	(0.068)
First	-0.030	-0.024	-0.030	-0.044	-0.087***	-0.061*	-0.077**	-0.002	-0.011*
	(0.025)	(0.023)	(0.023)	(0.036)	(0.018)	(0.033)	(0.038)	(0.013)	(0.007)
Second	0.006	0.007	-0.001	-0.020	0.068***	-0.020	0.026	-0.013	-0.002
	(0.025)	(0.018)	(0.019)	(0.028)	(0.022)	(0.031)	(0.027)	(0.016)	(0.006)
Third	0.052*	0.054***	0.047**	0.071**	0.139***	0.075**	0.058**	0.030*	0.011*
	(0.026)	(0.020)	(0.020)	(0.031)	(0.020)	(0.029)	(0.025)	(0.016)	(0.006)
Constant	5.304***	-1.436***	-1.429***	-1.417***	-1.340***	-1.446***	-1.297***	-1.449***	0.259***
	(0.031)	(0.028)	(0.029)	(0.046)	(0.008)	(0.045)	(0.045)	(0.016)	(0.009)
Pharmacy, Brand F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Week F.E.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample	All	All	All	Lengthy Increases	Fasa, SB	Homog.	Symmetric Shares	Coordinated Increases	All
N	22575	22575	22575	11322	15050	12372	11244	15810	22575
R-squared	0.350	0.391	0.391	0.320	0.138	0.399	0.243	0.550	0.475
No. of Brands	221	221	221	110	221	121	110	156	221

Note: The table shows the results of the estimation of Equation (1). The variables *First*, *Second*, and *Third* are dummy variables that indicate if the firm was the first, second, or third firm to increase price, respectively, in coordinated increases during the previous five weeks. If the two firms increase price on the same day, I assign equal (half) weights to the firms being in the first and the second, or the second and the third place. Columns (4)-(8) estimates the model on different subsets of the data. Column (4) includes only brands in which it took 3 days or more for all the firms to raise prices. Column (5) excludes Cruz Verde from the estimating sample. Column (6) includes brands in which the pharmacies are more homogenous. Column (7) shows results for symmetric markets, that is, brands in the bottom-half distribution of the difference between Cruz Verde's and Salcobrand's market shares. Column (8) includes only brands in which there was a coordinated increase. Standard errors clustered at the brand level in parentheses. * p<0.1, ** p<0.05, *** p<0.01

tions for my analysis. This is, first and foremost, because leadership mattered for the firms. Thus, the identity of the leader and the time the followers take to match the price increases were not outcomes of pure coordination problems. Costly leadership also reveals that there is a trade off between the profits from ending the price war first and the costs of being the leader, in a similar manner to that of a war of attrition. Finally, leadership means that the leader transferred profits to the followers when it increased prices, even in the absence of repeated price cycles as in Clark and Houde (2013).

Table 2 – Fixed Effect VAR

	Dependent Variable: Weekly Percentage Price Change											
	Price War			Coordination			Coordination excluding coordinated increases			Post Coordination		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Price	CV	Fasa	SB	CV	Fasa	SB	CV	Fasa	SB	CV	Fasa	SB
CV_{t-1}	0.026	0.113***	0.103***	-0.279***	0.232***	0.012	-0.190***	0.252***	0.068**	-0.296***	0.056***	0.054**
	(0.039)	(0.027)	(0.023)	(0.053)	(0.051)	(0.029)	(0.066)	(0.062)	(0.031)	(0.035)	(0.021)	(0.022)
$Fasa_{t-1}$	0.131***	-0.108*	0.005	0.389***	-0.202***	0.033	0.426***	-0.114*	0.052	0.094**	-0.164***	0.118***
	(0.026)	(0.064)	(0.034)	(0.064)	(0.052)	(0.042)	(0.084)	(0.067)	(0.042)	(0.046)	(0.045)	(0.033)
SB_{t-1}	0.029**	0.025***	-0.062**	0.198***	0.185***	0.015	0.078***	0.085***	-0.002	0.024	0.021	-0.140***
	(0.012)	(0.009)	(0.029)	(0.035)	(0.034)	(0.036)	(0.030)	(0.032)	(0.038)	(0.018)	(0.019)	(0.052)
CV_{t-2}	-0.159***	0.033*	0.100***	-0.185***	0.045**	-0.007	-0.143***	0.029	0.005	-0.066***	0.047**	0.036**
	(0.023)	(0.019)	(0.023)	(0.029)	(0.021)	(0.025)	(0.034)	(0.020)	(0.018)	(0.019)	(0.020)	(0.017)
$Fasa_{t-2}$	0.068***	-0.095***	0.050	0.040	-0.212***	-0.003	0.039	-0.145***	0.019	0.037	-0.174***	0.052
	(0.020)	(0.028)	(0.036)	(0.032)	(0.028)	(0.024)	(0.031)	(0.032)	(0.030)	(0.039)	(0.032)	(0.037)
SB_{t-2}	0.012	0.032**	-0.136***	0.036	0.033	-0.097***	0.059	0.040*	-0.135***	-0.015	-0.005	-0.192***
	(0.013)	(0.016)	(0.017)	(0.031)	(0.021)	(0.022)	(0.041)	(0.021)	(0.024)	(0.014)	(0.017)	(0.032)
Constant	-0.284***	0.095*	0.001	-21.706***	-16.119***	-3.444	-10.115***	-4.578**	9.931***	34.826***	-16.843***	12.381
	(0.048)	(0.048)	(0.057)	(3.664)	(3.441)	(4.262)	(2.251)	(1.967)	(3.290)	(8.848)	(6.090)	(7.861)
N	11173	11173	11171	5929	5929	5928	5369	5369	5368	4614	4614	4611
R-squared	0.059	0.038	0.033	0.158	0.107	0.027	0.130	0.087	0.028	0.086	0.049	0.068
No. of Brands	220	220	220	221	221	221	221	221	221	222	222	222
Avg. T by Group	50.786	50.786	50.777	26.828	26.828	26.824	24.294	24.294	24.290	20.784	20.784	20.770

Note: All specifications include a brand fixed effect. Standard errors clustered at the brand level in parentheses. * p<0.1, ** p<0.05, *** p<0.01

6 Changes in Price Leadership over Time

In this section I study changes in price leadership over time. In particular, my aim is analyzing the interaction of the dynamic pricing strategy of the pharmacies with each other, while imposing as little structure as possible.

My empirical strategy consists of estimating panel vector autoregressions (VAR) of the percentage price change of each pharmacy on the lagged percentage prices changes of all the pharmacies. This approach allows me to infer which firm's prices were followed by a greater extent by the other firms. [30] I estimate regressions of the following type:

$$Y_{it} = \beta_0 + \sum_{\tau=1}^{T} \beta_\tau Y_{i,t-\tau} + \lambda_i + f(t) + \epsilon_{it}, \tag{2}$$

where

$$Y_{it} = \left[\Delta p_{i1t}, \Delta p_{i2t}, \Delta p_{i3t}\right]'$$

and, with some abuse of notation, Δp_{ijt} is the percentage price change of brand i in pharmacy j at time t with respect to the previous time period, $\vec{p}$ is a vector of the prices of all the pharmacies, λ_i is a fixed effects for brand i, and $f(t)$ is a cubic polynomial of time. For estimation to be consistent, $E\left[\epsilon_t \epsilon_t'\right] = \Omega$, and $E\left[\epsilon_t \epsilon_\zeta'\right]$=0 for $t \neq \zeta$.

The main specifications in the estimation use weekly data to avoid serial correlation issues.[31] I present the results in Table 2. For each pharmacy, I estimate separate regressions for the price war, the coordination, and the post-coordination period. In addition, I also estimate the model for the coordination period excluding the weeks of the coordinated price increases.

The results show that the nature of price leadership changed during the coordination period. Thus, there were two types of leadership in the period studied. In the first one, the *competitive price leadership*, the dominant firm, Cruz Verde, led price changes possibly jointly with the second largest chain, Fasa. Competitive leadership occurred during most of the period in the data, both during the price war and during the post-coordination period. In the second type, *collusive price leadership*, the small firm, Salcobrand, led the coordinated increases. The latter was used by the pharmacies as the mechanism to switch from the loss-leading equilibrium to the coordinated one.

More specifically, Table 2 shows three main results. First, during coordination, all pharmacies follow each other's price changes more closely. Yet, the coefficient of Salcobrand's price changes on the price equation of the other pharmacies is almost seven times larger during coordination,

[30] An alternative strategy would consist of looking at time windows around price changes, such as the one presented in Panel (a) of Figure 1. Yet, although during the coordinated price increases the order in price increases is quite clear (in most cases the three pharmacies raised prices within days of each other), this was a particular attribute of the coordination period and it is not easy to identify price leadership in such a clean manner for the other periods.

[31] Given that the average number of time periods in each regression is at least 20, the Nickell (1981) bias should be small. See also, Judson and Owen (1999).

while that of the other pharmacies increases two or three times. This shows that the pharmacies followed Salcobrand much closer during the coordinated price increases. Also, although Salcobrand responds to its competitors' lagged prices, the coefficient during the coordination period is almost zero, which suggests that Salcobrand did not follow other firms' prices during coordination. Third, from the table it is not clear whether Cruz Verde or Fasa is the price leader. Yet, testimonies gathered in the trial show that Cruz Verde is more likely the price leader.[32] Finally, excluding coordinated price changes (Columns 7-9) results in almost the same coefficients as those during the price war and post-coordination, so that the findings described above not longer hold. This finding is stronger if all instances of large price increases are excluded from the estimating sample (the results are not reported). Thus, Salcobrand's leadership occurs almost exclusively during the coordinated increases.

Moreover, I also estimate 20-week rolling window regressions, the results of which I present graphically in Figure 4.[33] Panel (a) shows the sum of the coefficients of the regression of Cruz Verde's lagged price changes on Salcobrand's current price change. Notice the increase in Salcobrand's followship of Cruz Verde as a result of the price war, its decrease during coordination, and its return to the pre-price war period when coordination stops. To know whether these patterns are a result of changes in the behavior only of Salcobrand or also in that of Fasa, Panel (b) shows the difference in Salcobrand's followship to Fasa's. In particular, the panel plots the difference in the sum of the coefficients of the regression of Cruz Verde's lagged price changes on Salcobrand's and on Fasa's current price changes.[34] The results show quite strikingly that Fasa and Salcobrand behave in a very similar way almost throughout the period, which is seen in the difference in the coefficients not significantly different from zero. The exception of the pattern is during coordination, when Salcobrand stops following Cruz Verde and assumes the position of the leader. Since Fasa's followship of Cruz Verde almost does not change, the coefficient plotted in the Figure becomes negative and returns to zero only after coordination stops. In the Appendix, I show a similar figure for regressions of prices in levels.

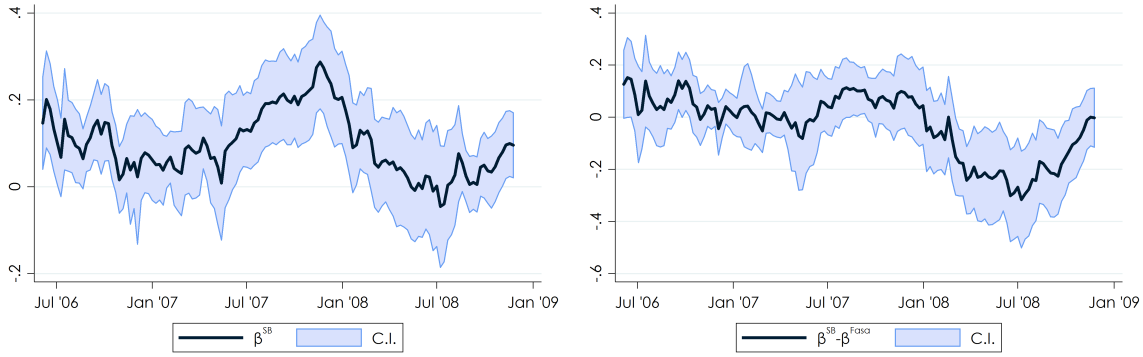
These findings present a clear picture of the correspondence between the leadership dynamics and the competitive state. During the price war and after the firms were caught coordinating price increases, Salcobrand follows Cruz Verde, the dominant firm, as we would expect from the abundant literature on competitive price leadership. Yet, during coordination, Salcobrand *stops* responding to the other firms' price changes. Price leadership by the small firm, therefore, has to be understood in a context of collusion, where the weak firm pays the cost of increasing price first

[32] For example, a Fasa executive explained that the increase in prices was due to the the fact that Cruz Verde "stopped lowering prices and responded increasing the prices of medicines (...) and *as we are price followers* we also followed its price increases" (cfr. 75 Observations, p. 50. Salcobrand.). Similarly, Fasa's CEO also claimed that Fasa's pricing strategy was one of "price followers of [its] two competitors" (75 Observations, p. 52. Salcobrand.).

[33] The regressions include two lags, a cubic time trend, and brand-fixed effects. Standard errors are clustered at the brand level.

[34] I estimate the two regressions jointly.

Figure 4 – Price Followship over Time



(a) Salcobrand's followship of Cruz Verde

(b) Difference in followship of Cruz Verde

Note: Panel (a) shows the effect of Cruz Verde's lagged price changes on Salcobrand's current price changes and its 95 percent confidence interval using a 20-week rolling time window. Panel (b) shows the difference between the effects of Cruz Verde's lagged price changes on Salcobrand's and on Fasa's current price changes, and the 95 percent confidence interval of the difference using a 20-week rolling time window. All regressions include two lags, a cubic time trend, and a brand fixed effect. Standard errors are clustered at the brand level.

Table 3 – Order in Coordinated Price Increases

	Order in Increase					
Firm	1	1 (tied)	2	2 (tied)	3	Total
Cruz Verde	2	1	72	23	91	189
Fasa	21	2	81	13	72	189
Salcobrand	163	3	9	12	2	189
Total	186	6	162	48	165	567

Note: The table shows the number of times a firm increases price in a given place in the staggered mechanism.

in order to benefit in future time periods from a collusive outcome.

7 Outcomes of Collusive Leadership

I have showed so far that price leadership during the coordination period was of a different nature than in the rest of the period. In this section, I focus on the characteristics of collusive price leadership. In particular, the next subsection delves further into the order followed by the firms, and the following one, on the time it took followers to follow the leader.

Determining the Order in Price Followship

As discussed in the Introduction, Salcobrand was the first pharmacy to increase prices and the other two chains took turns being the first follower in most coordinated price increases. Table 3 shows the number of times in which each firm was the first, second, and third mover, including instances in which there two firms that raised prices simultaneously. From this preliminary evidence, it would seem that the two followers randomized their position.[35] However, as I will show next, followship randomization is in part only apparent since the order of the two followers is highly correlated with Cruz Verde's market share. To see this, Panel (*a*) of Figure 5 presents in different bar graphs the number of times in which Fasa and Cruz Verde were the first, second, tied in second, and third firm to increase prices for drugs. For each pharmacy I show brands in which Cruz Verde's market share is in the bottom quartile (left) or in the top quartile (right) of Cruz Verde's market share distribution (<42 and >50 percent, respectively).[36] The figure shows quite clearly that when Cruz Verde is relatively larger, Fasa tends to move earlier, while Cruz Verde tends to move later.

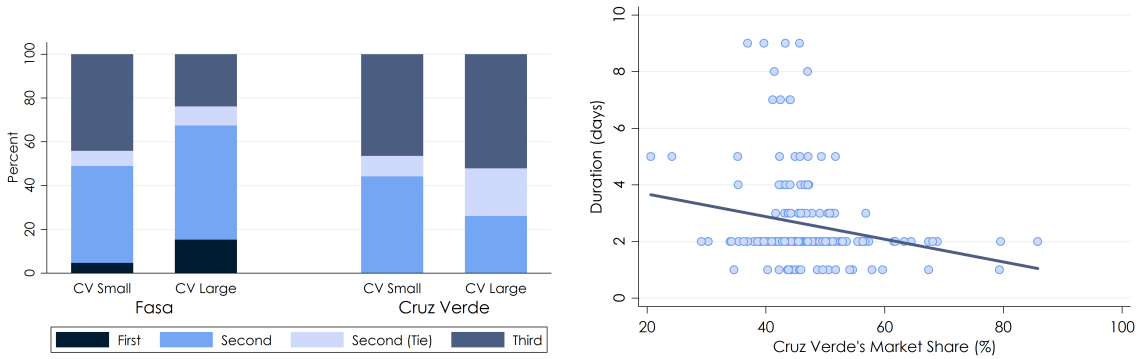
In order to check whether the effect of market dominance on price leadership is statistically significant, I estimate ordered probit models for each firm where the dependent variable is the order in which a pharmacy increases price. As Salcobrand is the price leader in the vast majority of coordinated increases, I limit the analysis to the order followed by the other pharmacies, Cruz Verde and Fasa. Regarding the independent variables, I measure Cruz Verde's market dominance using three different measures of market asymmetry: the difference in Cruz Verde's and Salcobrand's average market shares in the two months before coordination begins, Cruz Verde's own average market share, and the dummy variable *Cruz Verde Dominant*, which indicates brands in which Cruz Verde's market share is in the top quartile (>50 percent market share) of its shares distribution. In addition, all regressions include the variable Ln *Revenues* that controls for each brand's market size and is measured by the ln total units sold in 2007 multiplied by Salcobrand's wholesale price, so to exclude price effects from the market size calculation. Since there are cases in which two firms increased price the same day, I deal with ties by assigning equal (half) weights in the likelihood function to each firm being in the first and the second, or the second and the third place.

I show the results in Table 4. Columns (1)-(4) show the results for Fasa, and Columns (5)-(8), those for Cruz Verde. The table shows that when Cruz Verde's dominance is stronger, Fasa moves earlier, and Cruz Verde later, even if the effect for Cruz Verde is less significant. The results

[35] Leadership randomization has been suggested as an ex-post mechanism to transfer market shares (Harrington, 2006; Mouraviev and Rey, 2011), and observed to arise in lab experiments as a way that enhances cooperation when the different outcomes do not result in large differences in payoffs (Kaplan and Ruffle, 2012).

[36] More precisely, I plot separately the quartiles of the distribution of Cruz Verde's average shares in the last two months before collusion started (October-November 2007). The bars show separate leadership distributions for the bottom and top quartiles. The median market share in each of these quartiles is 39.7 and 54.1 percent, respectively.

Figure 5 – Order of Move and Duration of Coordinated Price Increases



(a) Order by Cruz Verde's Relative Market Share

(b) Duration of Price Increases

Note: Panel (a) shows the time difference between the last and the first collusive price increase for each brand plotted against the pharmacies' market shares. Panel (b) shows the order in which Fasa and Cruz Verde increased the price of each brand during the coordination period for drugs in which Cruz Verde's market share is in the bottom quartile (<42 percent) or in the top quartile (>50 percent) of the distribution. For simplicity, I exclude a few instances of ties in the first place.

for one pharmacy are not the mirror image for the other one because Salcobrand is not always the leader. Also, using my demand estimates from previous work, Columns (4) and (8) show that if we look only at the brands in which the cross elasticity among the pharmacies is higher than the median, the effect of Cruz Verde's dominance is stronger. The pharmacies in these markets are better substitutes of one another; thus, when one firm increases price first, the market stealing effect is stronger as we saw in Section 5. Hence, it seems that the pharmacies paid more attention to markets in which price leadership was more costly.

Hence, the results of the table are in line with Panel (a) of Figure 5. They show a strong dominant firm effect by which Cruz Verde pushed its main competitor, Fasa, to move earlier in markets in which Cruz Verde is more dominant. Therefore, it was not only the case that Salcobrand, the smallest firm, moved first, but also that Cruz Verde, the largest firm, moved last in markets in which it had a more important presence. Notice the similarity of these results, in which the largest firm moved last in the coordinated increases, to Clark and Houde's (2013) findings, where the strongest players in the cartel also moved last. In contrast, in the competitive leadership literature (e.g., Byrne and De Roos, 2016) the largest firm usually moves first and its price increases serve as a coordination device.

Duration of price increases

This subsection studies the time that it takes the followers to match the leader's prices. Time is an important outcome because, as I showed in Section 5, price increases that take longer are costlier

Table 4 – Order of Price Increase – Ordered Probit

	Dependent Variable: Order in Coordinated Price Increases							
	Fasa				Cruz Verde			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Range of Shares (CV-SB)	-1.362**			-2.111***	0.708			1.419**
	(0.622)			(0.750)	(0.565)			(0.664)
Share Cruz Verde		-2.035**				0.842		
		(0.990)				(0.876)		
Cruz Verde Dominant			-0.412**				0.358**	
			(0.185)				(0.177)	
Ln Revenues	0.101	0.079	0.066	0.002	-0.109	-0.096	-0.085	-0.055
	(0.103)	(0.103)	(0.104)	(0.136)	(0.108)	(0.108)	(0.108)	(0.143)
Cut 1	-0.756	-1.552*	-0.795	-1.737	-2.913***	-2.588***	-2.823***	-2.705**
	(0.802)	(0.940)	(0.808)	(1.066)	(0.896)	(0.989)	(0.904)	(1.169)
Cut 2	0.675	-0.120	0.635	-0.367	-0.782	-0.462	-0.681	-0.068
	(0.806)	(0.944)	(0.813)	(1.090)	(0.842)	(0.935)	(0.846)	(1.112)
Brands	All	All	All	Homog.	All	All	All	Homog.
N	204	204	204	102	213	213	213	108
No. of brands	156	156	156	81	156	156	156	81
Log-Likelihood	-181.05	-180.98	-180.89	-88.93	-140.81	-140.99	-139.90	-66.41
Pseudo R-squared	0.013	0.013	0.014	0.041	0.006	0.005	0.012	0.022

Note: The table shows the results of ordered probit models that estimate the effect of various covariates on the number of times a firm increases price in a given place in the staggered mechanism excluding Salcobrand. If the two firms follow a price increase on the same day, I assign equal (half) weights to the firms being in the first and the second, or second and the third place. Standard errors clustered at the brand level in parentheses. * p<0.1, ** p<0.05, *** p<0.01

for the leader. Since there are three firms in the industry, the analysis consists of studying total delays, that is, the delay of the last follower in raising prices after the leader's increase; and the intermediary delays, which are those between the first follower and the leader, and those between the last and the first follower. The explanatory variables are similar variables to those used in the previous subsection, and represent various measures of the potential gains of the followers from delaying collusion in each market.

Table 5 presents the estimates of regressions of the log number of days it takes the firms to match the leader's increases (usually Salcobrand's) on similar variables to those used in the previous subsection. The main finding is the presence of a similar dominant firm effect to that found in the previous section: the larger Cruz Verde is, that is, the more asymmetric the market, the more time it takes the firms to raise prices, and the less time it takes the followers to follow the leader. This correlation can be seen in a plot of the time it takes the two followers to follow a leader's increase against Cruz Verde's market share in a particular brand in Panel (b) of Figure 5. This result goes in line with the model of Section 3. Leadership is costlier when firms are more symmetric, as I showed in Table 1. If a follower is not sure whether the leader is going to maintain the price levels after the follower increases price, the follower may screen out impatient types. Thus, the follower may extract a higher payment from the leader in markets in which the leader benefits more from deviating, that is, symmetric markets, by waiting more before following the price increase. In addition, the results show that market size also determines the time of the increases: collusion takes more time in larger markets.[37].

Also, Columns (5) and (6) divide the results according to the identity of the last follower, excluding ties, and they show that the dominant firm effect was stronger if Cruz Verde is the last firm to raise price. They also show that the effect of market size is mostly derived for brands in which Fasa is the last firm to raise price. Column (7) present results for brands in which pharmacies are more homogeneous. There is no significant difference in the effect between these brands, in which pharmacies compete more with each other, and other brands.

In the second part of the analysis, I study the time spanned by the intermediate increases; that is, the time spanned between the first and the second firm, and that between the second and the third firm to raise prices. The aim of these regressions is determining which intermediate step drives the previous results. Since in many instances the two followers raise prices on the same day, I estimate Poisson regressions in order to account for the zero intermediate time of ties. I show the results in Table 6. I find that the dominant firm effect is equally present in both intermediate steps. More specifically, Column (1) shows the time between the first and the third firm to raise prices, mimicking the analysis in Table 5. Columns (2)-(5) study the time spanned between the leader's and the first follower's increase. Column (3) also includes a dummy variable indicating

[37] This is surprising because we would not expect to find scale effects. I attribute it to frictions that introduce transaction (coordination) costs to the collusion decision, which make delay in large markets a weaker screening mechanism than in small ones

Table 5 – Time of Coordinated Increases

	Dependent Variable: ln Time of Price Increases [Days]						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Range of Shares CV-SB	-0.956***	-0.694***	-0.727***		-0.918**	-0.383*	-0.712***
	(0.239)	(0.221)	(0.220)		(0.393)	(0.209)	(0.219)
Share Cruz Verde				-1.071***			
				(0.296)			
Tie		-0.741***	-0.732***	-0.730***			-0.684***
		(0.111)	(0.107)	(0.107)			(0.103)
Ln Revenues			0.099**	0.089**	0.174**	0.026	0.112**
			(0.039)	(0.039)	(0.074)	(0.040)	(0.055)
Constant	-7.248	58.855*	54.909*	55.067*	67.425	21.319	-25.623
	(33.350)	(34.306)	(33.087)	(32.998)	(50.690)	(30.676)	(27.291)
Brands	All	All	All	All	Last: Fasa	Last: CV	Homog.
N	186	186	186	186	71	89	91
R-squared	0.067	0.290	0.315	0.316	0.177	0.031	0.390
No. of Brands	154	154	154	154	67	82	79

Note: The dependent variable is measured in ln days. I exclude a few instances of two firms raising price first simultaneously. All specifications include a quadratic time trend. Standard errors in parentheses are clustered at the brand level. * p<0.1, ** p<0.05, *** p<0.01

whether the two followers increase price simultaneously. The effect is not significant, suggesting that ties are equivalent to the potential third follower raising price before its due time, as opposed to the first follower delaying a price increase. Finally, Columns (6)-(8) analyze the time spanned between the first and the second follower, considering ties as cases in which the dependent variable is zero.

8 Conclusion

In this paper I analyze collusive price leadership during a case of price war and collusion. The leader during the collusive price increases was the smallest chain. The explanation of leadership by the small firm is based on the institutional setting in which the small firm was the one that wanted the most to collude. Hence, costly leadership allowed the small firm to reveal its willingness truthfully. In addition, the change in leadership coincides with the change in competition. This is an important fact, because changes in price leadership may suggest a change in firms conduct. Furthermore, I estimate the costs of leadership, which were significant despite that the difference in prices lasted only a few days. This implies that leadership mattered for the firms and that, even when monitoring technology is very good and deviation can be detected quickly, deviation profits in collusion models can be substantial when there are dynamic effects in demand. Finally, I

Table 6 – Time of Coordinated Increase – Intermediate Increases. Poisson Regressions.

	Dependent Variable: Time between Intermediate Price Increases [Days]							
	1st-3rd	1st-2nd				2nd-3rd		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Range of Shares CV-SB	-1.003***	-1.236***	-1.225***	-1.173*	-0.560	-1.187***	-0.818*	-2.184***
	(0.281)	(0.389)	(0.387)	(0.646)	(0.378)	(0.393)	(0.441)	(0.465)
Tie	-0.691***		-0.0256					
	(0.125)		(0.143)					
Ln Revenues	0.133**	0.176**	0.176**	0.378***	-0.008	0.091	0.086	0.107
	(0.055)	(0.086)	(0.087)	(0.145)	(0.080)	(0.062)	(0.075)	(0.099)
Constant	70.83*	54.51	56.71	94.40	-62.71	-53.15*	-95.16**	-163.8***
	(37.99)	(43.75)	(47.67)	(94.18)	(70.51)	(29.75)	(38.28)	(55.20)
Last Follower	Any	Any	Any	Fasa	CV	Any	Fasa	CV
N	186	186	186	71	89	186	115	97
Log pseudolikelihood	-310.1	-263.4	-263.4	-108.6	-115.0	-222.5	-136.3	-108.4
No. of Brands	154	154	154	67	82	154	98	89

Note: The table present results of Poisson regressions. The dependent variable is measured in days. I exclude a few instances of two firms raising price first simultaneously. All specifications include a quadratic time trend. Standard errors in parentheses are clustered at the brand level. * p<0.1, ** p<0.05, *** p<0.01

show that the order of move of the firms was highly correlated with the chains' size in each brand. Also, when the largest chain was relatively larger, the price increases were faster.

This paper is among the first studies of price leadership during collusion. Much work needs still to be done to understand the ways in which leadership facilitates coordination. I suggest here that leadership is related to the firms' beliefs regarding the industry's willingness to collude. Another possible direction of further study is the relationship between price leadership and the role of communication in collusion. The collusive price increases were explicitly coordinated and, hence, price leadership too. Recent empirical work on tacit collusion–when there is no communication– suggests that it is mostly the dominant firm the one that can lead the industry to higher margins. Therefore, it would seem that in the absence of communication price leadership by the smaller firms is either too costly or not credible.

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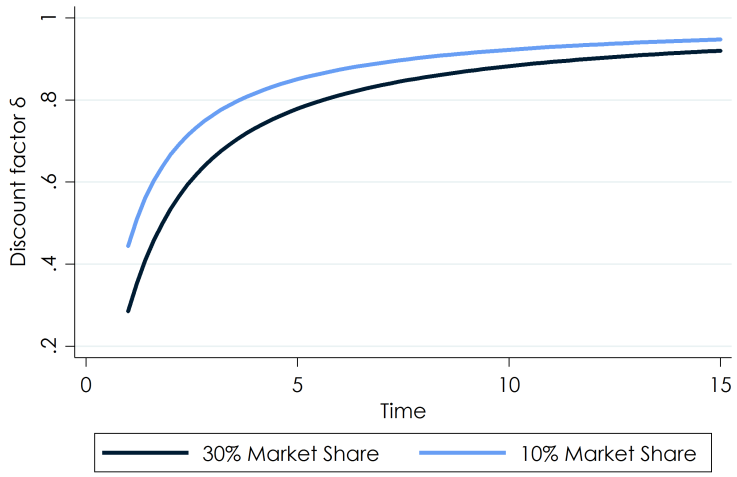
Appendix

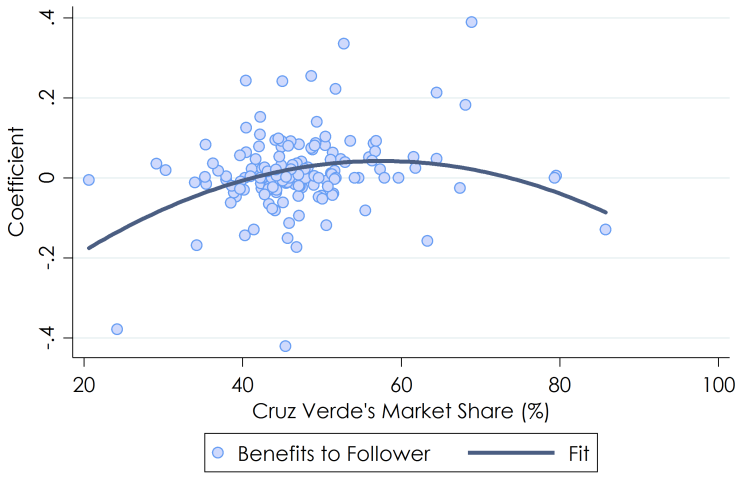
A1 Figures

Figure A1 – Thresholds in the Screening Mechanism



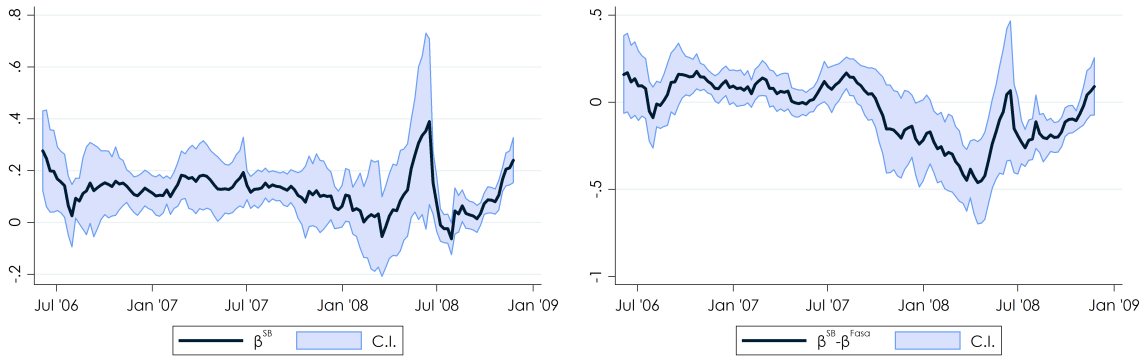
Note: The Figure shows the critical values of the discount factor above which the Leader prefers to lead the price increase $\hat{\delta}$ in the model of Section 3 for two values of the Leader's market shares. $\lambda = \upsilon\alpha(1-\alpha)$, $\upsilon = 1$, and $(p^C - p^N)/p^C = 0.5$.

Figure A2 – Benefits of Followship and Market Asymmetry



Note: The Figure shows the estimates of the benefits of being the follower from a model similar to Equation (1) where brands are estimated separately. The coefficients are plotted as a function of Cruz Verde's market share. To estimate the fits, I weight observations in an inversely proportional way to the variance of the coefficient. The quadratic and linear terms of the fit are statistically different from zero.

Figure A3 – Price Followship over Time – Prices in Levels



(a) Salcobrand's followship of Cruz Verde

(b) Difference in followship of Cruz Verde

Note: The Figure replicates the figure in the text but with price in levels. Panel (a) shows the effect of Cruz Verde's lagged prices on Salcobrand's current prices and its 95 percent confidence interval using a 20-week rolling time window. Panel (b) shows the difference between the effects of Cruz Verde's lagged prices on Salcobrand's and on Fasa's current prices, and the 95 percent confidence interval of the difference using a 20-week rolling time window. All regressions include two lags and a brand fixed effect. Standard errors are clustered at the brand level.